ORAL ABSTRACTS

DAY 1
Wednesday
7
December

Day 1 – Wednesday, 7 December 2016

Session	A1: Micro / Nano Biomedical Devices & Systems
Date	Wednesday, 7 December
Time	9:00am - 10:30am
Venue	Auditorium 2

ID: IN-0003 **A1 : 1**

COCKTAIL DRUG DELIVERY CHIP FOR CANCER DRUG SCREENING

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This study introduces a combinatory assay platform that allows high-thr oughput but low-drug-dosage screening of five anti-cancer drugs as a cocktail for personalized cancer treatment. Photosensitive PEGDA hydrogel is employed for drug dosage definition through drop array formation and selective UV crosslinking process. The finally defined cocktail drugs in hydrogel will be directly released in parallel when combined with cell chips. Combinatory drugs have been reported to have higher efficacy and lower individual drug dosage need in treating various diseases including cancers. However, the major issues of anti-cancer drug combinatory tests are the high drug cost owning to considerable volume wasting from manually pipetting process and limitation of dynamic range. In this abstract, we develop a combinatory drug assay platform for cocktail drug testing by employing UV crosslinked PEGDA hydrogel droplets to precisely release various cocktail ingredients from 5 anticancer drugs for in-parallel drug testing on cancer cells. The platform incorporated the techniques of drug/hydrogel micro-droplets self-formation and UV selective curing the desired dosage for testing, which is bio-compatible with high dynamic range for cocktail drug selection. The releasing rate of 3 different drugs carried by the same PEGDA hydrogels in 30 second was tested, and demonstrated a similar releasing rate with about 15% reduction for the drug with the largest molecule. The drug releasing time constants can also be engineered by adjusting the curing conditions of hydrogels to be ranging from 30 second to 5.5 hours for 80% drug releasing, which will be beneficial to controlled drug releasing test for different time paces amount 5 drugs. This device is capable to combine 5 drugs with 1000 folds dynamic range in 30 second with low drug consumption for in-parallel cocktail screening process.

ID: B2-0008 **A1 : 2**

MICROFLUIDIC CLUSTER ASSAY FOR PATIENT-DERIVED CIRCULATING TUMOR CELLS WITH RELEVANCE IN ANTI-CANCER TREATMENT

Bee Luan Khoo[1], Gianluca Grenci[2], Tengyang Jing[3], Ying Bena Lim[3], Soo Chin Lee[4], Jean Paul Thiery[5],Jongyoon Han[6], Chwee Teck Lim[5]

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We developed a novel microfluidic assay for primary circulating tumor cell (CTC) clusters, incorporating conditions to mimic the in vivo tumor microenvironment for label-free and high sensitivity expansion of CTCs from clinically relevant blood volumes. CTC clusters were successfully generated from >50% of clinical blood samples (n=73) in a short period of two weeks, displaying an efficiency superior to other reported assays (<20%).

CTCs are rare cells originating from either primary or secondary tumors. The ability to enrich CTCs from blood (liquid biopsy) is attractive as it is not invasive, and can be rapidly done on a regular basis. Current CTC enrichment techniques are limited in sensitivity, and present an underestimate of total CTCs (100s to 1000s per ml blood). Current attempts for in vitro expansion of CTCs still require pre-enrichment procedures as well growth factors, which limits clinical utility as they are selective for only some CTC sub-populations.

We report a unique methodology relying solely on the combinatorial use of hypoxia and specialized microwells to concentrate patient-derived blood cells and CTCs for mimicking the in vivo tumor environment. Flat-based cylindrical microwells did not achieve cluster formation. Blood cells provided 'goodies' (e.g. growth factors), in place of growth supplements. Incorporation of microfluidic parameters allowed screening for a wider drug range. Clusters might comprise single CTCs or microemboli.

This one-step protocol does not require pre-enrichment, thus enhancing cell recovery and maintenance of viability. Our clinical studies demonstrated the potential correlation of CTC cluster formation with patient

survival. This robust liquid biopsy technique can be incorporated into a non-invasive and inexpensive clinical assessment for drug screening. Studies are ongoing to compare the IC50 values of CTCs from various time points throughout the therapy regime, which may reflect the onset of drug resistance and prompt changes in treatment strategy.

ID: B2-0005 **A1 : 3**

DEVELOPMENT OF THE MICROFLUIDIC DEVICE FOR DYNAMIC LOAD STIMULATION OF BLOOD VESSEL TO HEMOGENIC ENDOTHELIUMS DERIVED FROM HUMAN IPS CELLS

Masahiro Narazaki[1], Susumu Kudo[1], Toshihiro Sera[1], Kazuhiro Nakashima[1], Tani Kenzaburo[2], Hiroshi Kohara[2]

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Hematopoietic stem cells (HSCs) are the cells which continue producing all blood corpuscles in marrow. Although HSCs transplant is already established, HSCs have been induced and amplified in vitro due to the donor shortage. Recently the human induced pluripotent stem cells (hiPSCs) were proposed, and so the method of inducing multipotent HSCs via hiPSCs has been investigated in vitro. HSCs differentiation from the vascular endothelial cell, such as the aortas of the aorta-gonad-mesonephros (AGM) region (hemogenic endothelium), may be regulated during endothelial-hematopoietic transition (EHT) at the midgestation. In EHT, the vascular endothelial cells are exposed to the various stimulations of the shear stress from blood flow and contraction - expansion of vessel wall. We hypothesize that these biomechanical stresses can improve the efficiency of HSCs differentiation in EHT. In this study, we developed the culture device which could load microfluidic flow and extension stimulation independently or simultaneously to investigate the effects of these biomechanical stresses to HSCs differentiation from hemogenic endotheliums derived from hiPSCs. The following specifications are required for culture device, 1) collection of HSCs which are induced from hemogenic endotheliums and carried away by the flow load, 2) study of blood corpuscle colony assay after dynamic load stimulation, 3) live imaging during flow load to evaluate EHT reaction with the difference in time, 4) high-throughput system in small size for molecular analysis. To achieve these requirements, our device consists of the microfluidic culture device and no flow chamber, and particularly, the chamber is used to collect HSCs induced in the microfluidic culture device. After flow load, we analyzed the kind of the blood corpuscle and the number of the colony forming cell in collected HSCs by flow cytometry analysis and colony assay, respectively.

ID: B2-0006 **A1 : 4**

MICROBEAD-BASED LAB-ON-A-CHIP FOR PATHOGEN DNA DETECTION

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As there are numerous viruses spreading rapidly around the world, the number of corresponding casualties and damages has been increased. Thus, an accurate and rapid diagnosis of pathogens DNA is crucial for protecting ourselves from the threats and developing the therapy. One of the most diagnostic approaches is Polymerase Chain Reaction (PCR) ; widely used for molecular diagnostic assays for detecting nucleic acid (DNA, RNA) of infectious disease. Although it performs high sensitivity and specificity, PCR-based systems require certain equipment and educated analysts that are too expensive for resource-limited environment in developing countries, and the systems' procedure time generally takes too long.

Thus, we developed a microbead based Lab-on-a-chip that can detect several pathogens at once with the small amount of sample. This system let us to detect pathogens with naked eyes using rolling circle amplification (RCA) in room temperature. What's more, it can perform POCT even in developing country without any preinstalled equipment. This is a way to detect DNA by inducing hydrogel based on RCA on the microbead surface while a sample fluxing in a tube filled with majority of microbeads. Once the microbeads are densely set in high concentration, the sensitivity increases as the reacting surface of RCA dramatically grows and the surface area increases correspondingly. Also, it is able to relatively quantitate target material's concentration by applying a method of measuring the sample's traveled distance until the gap is completely blocked depending on the amount of product formed based on the reaction of RCA. In addition, it can detect more than three pathogens at once in units of fM on the chip.

ID: B1-0019 **A1 : 5**

MICROFLUIDIC DEVICE FOR INVESTIGATION OF CELLULAR RESPONSES TO HETEROGENEITY OF OXYGEN TENSION

Kenichi Funamoto[1], Roger Kamm[2]

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In the tumor microenvironment, cells are exposed to spatial and temporal heterogeneity of oxygen tension. Hyperproliferation of cells causes a chronic hypoxic condition with a nonuiform spatial distribution of oxygen tension. In addition, immature vascularization in the tumor causes a temporal variation of oxygen tension due to ischemia and reperfusion. Hence, it is important to understand cellular responses and cell-cell interactions under temporal and spatial variations of oxygen tension. The authors previously developed a microfluidic device for observation of cell behaviors in a three-dimensional space under controlled oxygen tension. Oxygen tension inside the device was controlled by supplying gas mixture at a predefined oxygen concentration to the gas channels flanking the media and gel channels (cell culture channels). Although a uniform oxygen tension or an oxygen gradient were established, the lowest oxygen level was ~3% and it took more than one hour to establish a steady-state. In this study, the microfluidic device was modified to overcome those limitations in controllability of oxygen tension. Gas channels were repositioned to be above the media channels to enhance gas exchange between the gas channels and cell culture channels. Numerical simulations revealed changes of oxygen tension in the microfluidic device as a function of the system parameters such as device thickness, size, the media and gas flow rates. Then, oxygen tensions created with the appropriate settings were validated by using oxygen-sensing chemical complex on a bottom glass cover slip. The computational and experimental results showed more rapid change and lower level of oxygen tension than in the previous device. Usability of the developed device for cellular experiments was examined by observing the migrations of breast cancer cells under controlled oxygen tensions. When oxygen condition was switched between normoxia and hypoxia, an oxygen-dependent change of motility of the cancer cells was observed.

ID: B1-0009 **A1 : 6**

CENTRIFUGAL MICROFLUIDIC PLATFORM FOR MULTIPLEX FOODBORNE PATHOGEN DETECTION

Abkar Sayad, Fatimah Ibrahim, Thong Kwai Lin

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Foodborne bacterium is a drastic threat to society, business sectors and individuals and need to be put at high level alert. Conventional methods of foodborne pathogen detection are costly, time consuming and labor intensive. Therefore, to prevent foodborne outbreaks and ensure food safety, a cheap, portable, and easy-to-use microfluidic devices are strongly required. This paper presents a rapid multiplex pathogen detection using Loop Mediated Isothermal Amplification (LAMP) on centrifugal microfluidic compact disc (CD). LAMP amplification and pathogen detection are instantaneously integrated on this developed microfluidic CD. E.coli, Vibrio and Salmonella bacteria were targeted in this work and the DNA extraction was performed manually off-chip. The temperature for the DNA amplification on the microfluidic CD was generated by a small, cheap and easy-to-use hot air gun resulting in system miniaturization. The whole process started with loading LAMP reagent and samples into the microfluidic CD and then DNA amplification for 1 hour at 63ºC. Lastly, SYBR Green 1was used as detection reagent and to visualize the results. The results show that SYBR Green 1's color changes from orange color to yellowish green which indicate positive results, while the orange color remain orange as indication of negative results. All the process from sample loading to detection were automated on the disc offering a rapid and automated diagnostic platform. Therefore, reducing the time, manual steps, expensive operated equipment, results in reducing manpower and make this system accessible and affordable to poor source limited setting

Session	B1: Regenerative Medicine
Date	Wednesday, 7 December
Time	9:00am - 10:30am
Venue	LT50

ID: D5-0001 **B1 : 1**

GROWTH FACTOR MICROENVIRONMENTS TO HARNESS STEM CELL DIFFERENTIATION

Manuel Salmeron-Sanchez

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Most cells assemble rich protein matrices via an integrin-dependent mechanism that incorporates e.g. fibronectin (FN) molecules into matrix fibrils. The process involves integrin binding and activation of cell contractility to extend FN and expose cryptic domains that promote protein-protein interactions. We have shown that this process can occur by simple adsorption of individual protein molecules onto particular surface chemistries – in absence of cells. FN – material interactions would induce changes in the conformation of individual FN molecules to expose of self-assembly sites and drive FN assembly into nanonetworks at the material interface, a process that we have named material-driven fibronectin fibrillogenesis. This FN matrix assembled at the material interface involves conformational changes of FN upon adsorption that allows simultaneous availability of the integrin binding (FNIII9-10) and growth factor binding (FNIII12-14) regions.

The resulting material-driven FN matrix assembled at the material interface consists of a protein network with enhanced biological activity: it supports cell adhesion, matrix remodelling, and trigger cell differentiation. Moreover, it provides a robust platform to engineer advanced microenvironments in combination with growth factors to tune stem cell differentiation and promote tissue repair. Here we show the potential of the system to regenerate bone using BMP-2 as well as the ability to promote vascularisation by incorporating VEGF into the system.

ID: D5-0005 **B1 : 2**

ADDITIVE MANUFACTURING FOR 3D MICROFLUIDIC PERFUSION CELL CULTURE

Anik Islam, Ong Louis Jun Ye, Toh Yi-Chin

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Microfluidic 3D perfusion cell cultures are widely employed in developing organ-on-chip applications because they recapitulate tissue microenvironment and are amenable for multiplexed studies However, substantial technical expertise, sophisticated facilities as well as multiple processing steps are required to fabricate, assemble and operate conventional polydimethylsiloxane (PDMS)-based microfluidic perfusion culture device, which often results in the slow adoption of these devices in routine biological studies and industrial applications Additive manufacturing (or 3D printing) has been shown to offer faster and more accessible method for fabricating microfluidic devices for biological application, although there is no report on devices for microfluidic 3D perfusion cell culture In this study, we show a first instance of a portable 3D microfluidic perfusion culture device fabricated using 3D printing techniques Computer aided drawing (CAD) and computation fluid dynamics simulation (CFD) were used to optimize the design of the microfluidic device, which consisted of an orthogonal microfluidic channel network with microstructures to immobilize and culture cells in 3D The device assembly and operation were also designed to be compatible with fluorescence microscopy and independent of external pumps for portability Two modes of 3D printing, PolyJet and stereolithography, were explored for the device fabrication and compared based on the print quality, resolution and the consistency of the printed parts with the actual CAD model and we found that only stereolithography can generate functional prototypes Finally, we performed biological validation by demonstrating 3D perfusion culture of HepG2 (hepatocarcinoma) and patient-derived head and neck tumor spheroids The cell viability in the 3D spheroids were measured by live-dead staining using fluorescence microscopy while liver-specific synthetic functions of HepG2 were measured With this study, a robust design guideline for microfluidic perfusion culture device using 3D printing was established, which would allow for subsequent optimization and customization of microfluidic culture device using 3D printing technology

ID: D5-0007 **B1 : 3**

MESENCHYMAL STEM CELL-DERIVED EXTRACELLULAR VESICLES: AN OFF-THE-SHELF AND CELL-FREE THERAPEUTIC FOR CARTILAGE REPAIR

Shipin Zhang, Wern Cui Chu[1], Ruenn Chai Lai[2], Sai Kiang Lim[1,3], James Hoi Po Hui[1,4,5], Eng Hin Lee[1,5], Wei Seong Toh[1,5]

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Articular cartilage injuries as a result of excessive sports activities are very common Mesenchymal stem cell (MSC) therapy has demonstrated clinical efficacy for cartilage repair However, the mechanisms underlying the biological effects of MSCs in cartilage repair remain unclear Also, as with all cellular therapies, there exist logistic and operational challenges in maintaining cell viability and vitality Increasingly, the therapeutic efficacy of MSCs has been attributed to the secretion of paracrine factors Notably, exosomes are cell-secreted, nano-sized, bi-lipid membrane vesicles present in the MSC secretome found to possess potent immunomodulatory and regenerative properties Here, we hypothesized that MSC exosomes could promote orderly cartilage and subchondral bone regeneration in a critical-sized osteochondral defect model in immunocompetent rats The purified MSC exosomes were purified from conditioned medium of human embryonic MSCs and possessed all the defining characteristics of exosomes including a modal size of 100nm and presence of exosome-associated markers including CD81, TSG101 and ALIX In vivo, weekly intra-articular injections of MSC exosomes demonstrated potent ability in promoting orderly cartilage and subchondral bone regeneration By the end of 12 weeks, exosome treatment resulted in formation of a smooth continuous layer of hyaline cartilage and complete regeneration of the underlying subchondral bone On contrary, the contralateral control knees treated with saline showed poor repair with fibrous tissue and minimal matrix deposition Immunohistochemistry further revealed early cell proliferation at 2 weeks denoted by increased proliferative cell nuclear antigen (PCNA) immunoreactivity in synovium and reparative tissues of animals treated with MSC exosomes (P<0 001) In vitro, MSC exosomes induced proliferation of rat chondrocytes and suppressed the expression of genes associated with matrix degradation Our results show that MSC exosomes likely mediate cartilage regeneration through mechanisms of active cell proliferation and attenuated matrix degradation In summary, MSC exosomes are promising off-the-shelf and cell-free therapeutic for cartilage repair

ID: D5-0010 **B1 : 4**

REPLACEMENT OF FETAL BOVINE SERUM BY HUMAN BLOOD SERUM: FULLY AUTOMATED SERUM PRODUCTION AND EFFECT ON FIBROBLAST CELL PROLIFERATION

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Growth media for in vitro cell cultures are commonly supplemented with Fetal Bovine Serum (FBS) to enhance cell proliferation. Recent discussions regarding ethical concerns towards production, as well as high variations between batches of FBS highlight the need for a replacement. Human blood serum is discussed as a possible alternative especially for autologous cell-based therapies reducing the risk of infection and immunological responses initiated by xenogeneic materials. In this study we successfully produced human blood serum from whole blood with two approaches and tested the effect on cell proliferation compared to FBS.
Aiming at a high amount of growth factors and an uncomplicated production process two methods for serum production were investigated. Method 1: Platelet Concentrate (PC) was produced from citrated whole blood with a fully automated centrifugation system. Activation of platelets and release of growth factors were enhanced by a freezing and thawing cycle followed by further centrifugation. The supernatant containing the growth factors was used as FBS replacement 1. Method 2: Whole blood was dynamically incubated with glass beads resulting in activation of platelets, release of growth factors, and coagulation. Serum was then produced by removing the cellular and fibrin clot components with the same fully automated centrifugation system and used as FBS replacement 2. In both replacements 1 and 2 the amounts of PDGF and TGF-ß were measured using the ELISA method. Cell proliferation of fibroblasts cultivated with different amounts of replacement 1 and 2 as additives to the cell culture medium was compared to standard cultivation with FBS.

The results showed that stimulation of cell proliferation by human blood serum is comparable to the effect

of FBS. Thus the study indicates that replacing fetal bovine serum by human blood serum is a promising strategy especially for use in autologous cell-based therapies.

ID: D5-0011 **B1 : 5**

MICROPATTERNED HUMAN EMBRYONIC STEM CELL CULTURES FOR MODELLING NEURAL TUBE DEFECTS

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Neural tube defects (NTDs) are one of the most common human birth defects and arise from inappropriate differentiation and morphogenic cell movements of the neuroepithelium sheet when it undergoes apical constriction and folds into the neural tube. Although several factors, including folate and genetic mutations have been implicated in the neural tube closure, it is still unclear how they affect the neural tubulogenesis, in part due to the lackof a human-relevant neural developmental model. Human embryonic stem cells (hESC) display innate capability to undergo differentiation and self-organization processes that is similar to neural tube formation but current 2D monolayer and 3D embryoid body cultures cannot spatially control the resultant neuroepithelial tissue structures that can be used as a quantiative platform to study NTDs.
Here, we report a novel method to generate a spatially patterned hESC-based 3D neuroepithelial (NE) model, which can be used as a human-relevant phenotypic assay to study the effects of different genes and environmental factors involved in NTDs. We combined cell micropatterning and a multi-step induction protocol to achieve spatio-temporal control over hESC differentiation and organization into a uniform 3D annular NE structure, displaying positive expression of neural epithelial markers, Sox2, Nestin and N-cadherin. The formation of the micropatterned 3D NE was observed to capture similar aspects of in-vivo neural folding morphogenic processes, as indicated by positive expression of Nestin. In addition, a folic acid antagonist, Valproic acid, could elicit a dose-dependent disruption on the formation of the micropatterned 3D NE structure. This highlights the potential of using this model in screening NTD risk factors and quantitatively studying environmental and genetic factors involved in NTDs in a human relevant manner.

Session	C1: Cell Mechanics
Date	Wednesday, 7 December
Time	9:00am - 10:30am
Venue	LT51

ID: B1-0004 **C1 : 1**

CREATING COMPLEX FLOWS USING ULTRASONICS FOR NEW BIOMEDICAL DEVICES AND DIAGNOSTIC TECHNOLOGIES

Jonathan Cooper

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Microfluidics and Lab-Chip technologies are synonymous with the movement of fluids on or around microstructured surfaces, including channels. Flow is often driven by peristaltic pumps or through electrokinetic flows (including electro-osmosis, for example). Recently, pressure driven flow through the use of surface acoustic waves (SAWs) has attracted much attention. To better control the nature of the acoustic field when using SAWs, we have introduced the concept of using frequency dependent periodic arrays known as phononic crystals within microfludics. In doing so, we have enabled new "acoustic holograms" that result in waveguiding, reflectors, bandgaps and lenses, that shape the ultrasonic field and create new microfludic flows. We are able to demonstrate how we can create interesting liquid manipulations, including on-chip centrigugation, cell lysis through shear, cell separation, liquid heating and atomization. The applications of this technology are demonstrated through four "real-world" examples, namely (i) sample preparation and identification of malarial parasites in whole blood; (ii) the measurement of visco-elastic properties of blood; (iv) new techniques for NGS and (iv) the control of the size distribution of droplets during nebulization (a requirement in pulmonary drug delivery, for example).

ID: E2-0004 **C1 : 2**

ESTIMATION OF ENDOTHELIAL GLYCOCALYX LAYER DEFORMATION IN RESPONSE TO FLUID SHEAR STRESS

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It has been pointed out that glycocalyx layer (GL) covering the surface of vascular endothelial cells (ECs) plays pivotal roles in their biomechanical responses. Since GL is made of sugar chains coming up from the endothelial surface, it may be sheared by fluid flow and this may amplify the torque applied to mechanoreceptors on the cell membrane. However, to our knowledge, there is no quantitative data on the deformation of GL in response to fluid shear stress. In this study, we estimated shear deformation of GL with three different methods.

The GL of a murine vascular endothelial cell line F-2 was stained with DyLight 488 Tomato Lectin. We plated the cells in a laboratory-made laminar flow chamber to apply fluid shear stress under a confocal laser scanning microscope. If the GL is sheared, its thickness may decrease. By measuring its thickness with a 100x oil-immersion objective, we found that it decreased from 840 nm to 750 nm in response to shear stress of 6 Pa, which corresponds to 4.5°/Pa. When the GL with photobleached area is sheared, its borderline may become blurred. By measuring fluorescent intensity distribution across the borderline before and after application of fluid shear stress (6 Pa) and analyzing it with a simple physical model, we obtained shear deformation of 5.1°/Pa. We then measured the displacements of quantum dots (Qdots) bound to the top of heparan sulfate and PECAM-1 on the cell membrane in response to fluid shear stress (2 Pa), and found that displacement was larger by 200 nm for Qdots bound to the heparan sulfate than that bound to PECAM-1. This value corresponds to 7.1°/Pa if the GL thickness is assumed to be 800 nm. All of these methods gave similar results. The shear deformation of the GL might be 5-10°/Pa.

ID: E2-0005 **C1 : 3**

P. FALCIPARUM SEQUESTRATION: GETTING OUT OF THE STICKY SITUATION ONE BOND AT A TIME

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Sequestration of Plasmodium falciparum infected red blood cells (iRBCs) in host microvasculature is associated with multiple organ failure and cerebral malaria. Of the several endothelial receptors that iRBCs adhere to, CD36 and ICAM-1 upregulation has been correlated with severe disease pathology. Interestingly, ICAM-1 is able to mediate the rolling of iRBCs on endothelium and is also the only receptor identified to correlate with cerebral malaria. We first probed iRBC/ICAM-1 and iRBC/CD36 bonds at a single molecule level to understand the fundamental interactions between iRBCs and these endothelial ligands. Force spectroscopy experiments revealed catch bond interactions between iRBCs and ICAM-1. In contrast, slip bonds were formed with CD36. These findings explain why ICAM-1 mediates the rolling of iRBCs in in-vitro experiments while CD36 facilitates stationary adhesion. Next, we studied the effects of temperature on these interactions to provide greater insight on how the tertian febrile cycle experienced by a malaria infected patient may affect iRBC-ligand interactions. Understanding iRBC-ligand interactions at the single bond level can potentially help to unravel the mechanics involved in cytoadhesion, bringing us a step closer towards tackling this sticky problem.

ID: E2-0006 **C1 : 4**

INFLUENCE OF PRESSING FORCE ON ROLLING CHARACTERISTICS OF HL-60 CELL LINE ON A BUMPY SUBSTRATE MIMICKING THE ENDOTHELIUM TOPOGRAPHY

Atsushi Shirai[1], Jean-Paul Rieu[2], Ryota Sugimoto[3], Daisuke Yoshino[1]

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Neutrophils are known to roll on endothelium of post-capillary venules as the early event in their immune response. Numerous studies have been performed on the rolling characteristics of the neutrophils focusing on binding with selectins on the endothelium. In the post-capillary venules, axially accumulated erythrocytes which displace neutrophils toward the vessel wall and it would affect the rolling characteristics of the cells on bumpy surface of the endothelial cell layer. In this study, we focused on the correlative effects of the pressing force from the red blood cells and the surface topography of the endothelium on the rolling characteristics of neutrophils. For this purpose, we introduced an inclined centrifuge microscope system with which we can apply well-controlled pressing and driving forces to the cells. Motion of HL-60 cell line was observed under a variety of the pressing force on a PDMS substrate which has a hexagonal pattern which mimics surface topography of the endothelial cell layer. The substrate also has a stripe pattern for

the comparison of the motion of the cells with the hexagonal pattern. We examined influence of the pressing force on the traceability of the cells on the patterns. We measured velocity of the HL-60 cells on the substrate varying the applied pressing force from 23.5 to 70.5 pN while a constant driving force of 30 pN was applied. Mean cell velocity in the direction of the driving force on the hexagonal pattern relative to that on the stripe pattern decreased and the relative circular variance of the instantaneous cell velocity vectors increased with the increase in the pressing force. Obtained result implies that the pressing force by the axially accumulated erythrocytes, together with the bumpy surface topography of the endothelium, helps neutrophils to bind with selectins which express along border of the endothelial cells.

ID: E2-0007 **C1 : 5**

MECHANISM OF MORPHOLOGICAL CHANGES IN ENDOTHELIAL CELLS UNDER FLUID SHEAR STRESS WITH ITS SPATIAL GRADIENT

Daisuke Yoshino[1], Naoya Sakamoto[2], Masaaki Sato[3]

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Cerebral aneurysms are pathologic dilations of arterial walls that frequently occur around arterial bifurcations. Since local hemodynamics at such sites is complex, high shear stress (SS), and high shear stress gradient (SSG), it has been suggested that the unique hemodynamic conditions play a key role in pathology of aneurysm. Endothelial cells (ECs), lining on the luminal wall of blood vessels, are linked to the maintenance or breakdown of vascular homeostasis functions due to hemodynamic stimuli. Although the bulk of literatures have shown that ECs elongate and align to the direction of flow after exposure to physiological levels of SS, knowledge of morphological responses of ECs to combination of SS and SSG is still limited. In this study, we demonstrated vascular ECs exhibited morphological responses depending on magnitude relationship between SS and SSG. Although ECs exposed to lower SS with SSG were not oriented and were elongated to the flow direction, they started to exhibit orientation, elongation, and development of actin stress fibers, even under the condition of SS with SSG when SS exceeded a certain value. We also estimated strain field in ECs exposed to SS with/without SSG using a simple mechanical model. For the condition of laminar SS, tensile and compressive strains were distributed in upstream and downstream sides, respectively, of cell-cell border. In contrast, tensile strain was distributed in both sides of the border for the condition of SS with SSG. Less difference in magnitude of the strain between upstream and downstream sides of cell-cell border was also observed under the low SS conditions with SSG. We showed localization of a protein associated with SS mechano-sensing, corresponding to the estimated strain fields. Based on the results of this study, we finally suggested a mechanism of morphological changes in ECs under SS with SSG.

ID: E2-0011 **C1 : 6**

EXTRACELLULAR MATRIX MODULATES SMOOTH MUSCLE CELL PHENOTYPE AND MIGRATION

Toshiro Ohashi, Yasufumi Hagiwara

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Adherent cells are known to adhere to their extracellular matrix at focal adhesions, where actin filaments are indirectly connected to integrins via multiple proteins and integrins are in contact with the extracellular matrix mediating various cellular signals. Expression of integrins is very specific to the types of extracellular matrix such as fibronectin, vitronectin, collagen, etc. With this background, it is speculated that different types of extracellular matrix may modulate cell physiological functions. In this study, cell migration assays are performed with different types of extracellular matrix on smooth muscle cells. Cells were seeded with DMEM + 10% FBS in tissue culture dishes where a polydimethylsiloxane (PDMS)-made block was placed in the center of the dishes. After removing the PDMS block, cell migration was observed. Prior to cell seeding, the dishes were coated with fibronectin, vitronectin, and type I collagen. Under all the three conditions, cells migrated towards the space where the PDMS block had been placed. The total cell migration length for fibronectin was significantly higher than those for vitronectin and type I collagen. Since it was found that fibronectin could change smooth muscle cell phenotypes from contractile type to synthetic type, it is indicated that fibronectin-modulated smooth muscle cells could enhance cell migration. In summary, different types of extracellular matrix-mediated smooth muscle cell phenotype might modulate cell physiological functions possibly via integrin formation in a different manner.

DAY 1
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Session	YIA-01: YIA Session
Date	Wednesday, 7 December
Time	9:00am - 10:30am
Venue	LT52

ID: A2-0003 **YIA-01 : 1**

PHOTOACOUSTIC MONITORING OF ANTICOAGULATION THERAPY

Jesse Jokerst, Junxin Wang

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Heparin anticoagulation therapy is an indispensable feature of clinical care, yet has a narrow therapeutic window and is the second most common ICU medication error. The active partial thromboplastin time (aPTT) monitors heparin, but suffers from long turnaround times, a variable reference range, limited utility with low molecular weight heparin, and poor correlation to outcome. Here, we describe an ultrasound-based imaging technique to monitor heparin concentration in real time using methylene blue as a simple and FDA-approved contrast agent. We found a strong correlation between heparin concentration and photoacoustic signal measured in phosphate buffered saline (PBS) ($R2>0.98$), respectively. Clinically relevant heparin concentrations were detected in blood with a detection limit of 0.28 U/mL. We validated this imaging approach by correlation to the aPTT (Pearson's $r = 0.86$; $p<0.05$) using five samples with aPTT times within the clinically relevant range (<300s). The signal was also confirmed with protamine sulfate treatment—addition of this heparin agonist completely neutralizes the photoacoustic signal. This technique also has good utility with low molecular weight heparin (enoxaparin) including a blood detection limit of 72 µg/mL. Finally, we have developed a nanoparticle-based hybrid material that can immobilize methylene blue for potentially applications as a wearable/implantable heparin sensor to maintain drug levels in the therapeutic window. To the best of our knowledge, this is the first report to image anticoagulation therapy.

ID: E1-0010 **YIA-01 : 2**

ASSOCIATION OF SIMULTANEOUSLY MEASURED FOUR-LIMB BLOOD PRESSURE DIFFERENCES WITH ANKLE-BRACHIAL INDEX: A CROSS-SECTIONAL STUDY

Xiaorui Song[1], Gaoyang Li[1], Zhihui Chen[2], Aike Qiao[1]

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Background: Recent study reported that blood pressure difference between arms has been associated with peripheral artery disease (PAD), cardiovascular mortality and all-cause mortality. This study aims to investigate the association of simultaneously measured four-limb blood pressures with Ankle-Brachial Index.

Methods: 228 subjects (61 males, mean age, 63.92±10.72 years; 167 females, mean age, 59.47±7.33 years) were enrolled. Four-limb blood pressure measurements were simultaneously performed using a blood pressure and pulse monitor device in the supine position. Data were statistically analyzed with SPSS 17.0.

Results: ABI has significant differences with inter-arm difference in systolic blood pressure (SBP) and inter-ankle difference in diastolic blood pressure (DBP) (≥15mmHg VS <10mmHg and≥10 mmHg VS ≥15mmHg). ABI (<0.9; OR, 10.028; CI, (1.109-90.682); P=0.040) was independently associated with inter-arm SBP difference ≥ 10mmHg. ABI (<0.9; OR, 15.469; CI, (1.776-134.773); P=0.013) and (0.90-1.00; OR, 4.231; CI, (1.205-14.860); P=0.024) were independently associated with inter-arm SBP difference ≥ 15mmHg. ABI (<0.9; OR, 7.189; CI, (1.010-51.179); P=0.049) and (0.90-1.00; OR, 6.273; CI, (1.783-22.077); P=0.004) were independently associated with inter-ankle SBP difference≥ 15mmHg. ABI (0.90-1.00; OR, 4.331; CI, (1.039-14.330); P=0.016) was independently associated with inter-ankle DBP difference of ≥ 10mmHg. After excluding 99 hypertension patients, ABI (<0.9; OR, 246.330; CI, (5.442-11191.384); P=0.005) was still independently associated with inter-arm SBP difference ≥ 15mmHg.
Conclusion: ABI <0.9 was independently associated with inter-arm SBP difference ≥ 15mmHg, while these differences still existed after excluding 99 hypertensive patients. In addition, the cut off (0.90-1.00) of ABI was independently associated with inter-arm SBP difference ≥ 15mmHg and inter-ankle DBP difference ≥ 10mmHg or ≥ 15mmHg. Hence, detection of four-

limb blood pressure difference with simultaneous measurement may provide an aid for the non-invasive diagnostic method of PAD in clinical primary care.

Key Words: ankle-brachial index; non-invasive diagnosis; blood pressure; statistical analysis; peripheral artery disease

ID: E2-0001 **YIA-01 : 3**

VOLATILE BIOMARKERS AND CURCUMINOID INDUCED CELL DEATH ASSOCIATED VOLATILE SIGNATURES OF MULTICELLULAR GASTRIC CANCER TUMOR SPHEROIDS.

Gokula Krishnan Ramachandran, Chen Hua Yeow, Wei Peng Yong

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Gastric cancer has the highest mortality rate among all other cancers due to the lack of non-invasive and early detection methods. Various studies show volatile signatures of the cancer cells can be used as biomarkers for cancer detection. In this study we studied four gastric cancer cells-lines (SNU 484, IST 1, MKN 28, NUGC 3) and one normal gastric cell line (HS 738), for the identification of gastric cancer specific volatile biomarkers. We developed three dimensional multicellular spheroids of these cell lines and extracted the volatile compounds produced by these spheroids using salting out method. These extracted volatile compounds were identified using selected ion flow tube mass spectrometry (SIFT-MS). From these identified volatile compounds, biomarkers of the gastric cancer spheroids were deduced. Prior studies show curcuminoids as potential drug candidate for treating gastric cancer. We intend to decipher the curcuminoid induced volatile signatures of the gastric cancer spheroids. We treated the above mentioned multicellular spheroids with curcuminoids and identified the volatile compounds produced by these spheroids in response to curcuminoid treatment. Among the five cell lines mentioned above, three cell lines namely MKN 28, NUGC 3 and HS 738 (including normal cell line) were resistant to curcuminoid treatment whereas, remaining two cell lines namely SNU 484 and IST 1 were susceptible to the curcuminoid treatment which, led to the cell death. From this study, we deciphered curcuminoid induced cell death associated volatiles. Further, by considering these identified curcuminoid induced cell death associated volatiles as reference, it is possible to access the efficiency of curcuminoid treatment. Our future research direction is performing clinical study to identify the volatile biomarkers from the exhaled breath of the gastric cancer patients which leads to the early detection of gastric cancer via simple and non-invasive breath test.

ID: E3-0002 **YIA-01 : 4**

A 3D MULTISCALE MODEL OF THROMBOLYSIS FOR PATIENT-SPECIFIC APPLICATIONS

Andris Piebalgs, Xiao Yun Xu

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Thromboembolic events occur when an abnormal blood clot blocks blood supply to important human organs. This condition can be treated using thrombolytic therapy that dissolves the occluding blood clot via an infusion of a thrombolytic agent. However, in certain scenarios the treatment can be ineffective and cause life-threatening side-effects such as intracerebral haemorrhage. Mathematical modelling can provide insights into the lytic process and suggest possible means to optimise existing therapies. In this abstract, we present the first multiscale model that is capable of predicting the temporal dissolution of occluding clots during thrombolytic therapy in patient-specific geometries.

The occluding blood clot is treated as a fibrous porous medium whose macroscopic properties are determined by evaluating the dissolution of fibrin fibres on the microscale. The kinetics of clot lysis takes into account the reaction of lysis proteins on the clot surface. Blood flow is governed by modified fluid mass and momentum equations while the transport of lysis proteins is described by a set of diffusion-convection-reaction equations. Realistic models of the internal carotid bifurcation are built from medical images to simulate the treatment of ischemic stroke where an occluding blood clot is present in the middle cerebral artery. Physiologically relevant pulsatile flow conditions are applied at the model inlet and outlets.

Results show that detailed flow features are of paramount importance in evaluating clot lysis patterns during thrombolytic therapy. The transient behaviour of blood flow results in localised tPA hotspots that cause the development of an asymmetrical lysis pattern. This leads to the formation of small clot remnants that may detach from the main body of the clot and cause micro-occlusions in the downstream vasculature. Furthermore, the effects of clot properties, location and size have been examined to ascertain their influence on treatment outcome.

ID: D5-0004 **YIA-01 : 5**

A PUMP-FREE 3D MICROFLUIDIC PLATFORM

FOR LONG TERM DIFFERENTIATION OF HUMAN LIVER PROGENITOR CELLS

Ong, Louis Jun Ye, Chong Lor Huai, Jin Lin, Teng Yao Zhong Edward, Toh Yi-Chin

National University of Singapore, Singapore; Singapore Institute for Neurotechnology, Singapore

Microfluidic hepatocyte models are attractive for drug testing applications owing to their ability to mimic the liver sinusoid microenvironment and multiplexing capability Most microfluidic hepatocyte culture devices utilized primary human hepatocytes, which are limited by cell number and batch-to-batch variation Human stem cell-derived hepatocytes offer an alternative cell source although the differentiation and maturation of human stem cell derived hepatocytes in a microfluidic platform has not been demonstrated

Here, we report a first instance of differentiating a human liver stem cell source on a microfluidic 3D perfusion culture platform We developed a pump-free 3D microfluidic perfusion device, which contained a micropillar array to immobilize cells three-dimensionally in a central cell culture compartment flanked by two side perfusion channels Pump-free constant perfusion flow was achieved by sustained gravity driven flow from two horizontally-orientated media reservoirs, which were positioned at the inlet and outlet of the device at a fixed height difference The polydimethysiloxane (PDMS) microfluidic perfusion device was housed in a support structure fabricated by 3D printing to define the height difference between the inlet and outlet media reservoirs We tailored the device to suit for hepatocyte cultures using computational fluid dynamics simulation to estimate the height difference needed to achieve different perfusion flow rates, which were validated by experimental flow rate measurement using micro-particle image velocimetry To demonstrate that the pump-free 3D microfluidic perfusion device can support the generation of human stem cell derived hepatocytes, we performed on-chip differentiation of HepaRG cells, a human bipotent stem cell that can differentiate into hepatocytes and biliary cells, for up to 19 days. Compared to static 2D differentiated HepaRG-hepatocytes, HepaRG-hepatocytes derived under 3D perfusion exhibited higher liver-specific functions. The pump-free 3D microfluidic device potentially offers simple and robust platform to develop highly functional in vitro liver models incorporating human stem cell derived hepatocytes

Session	SYM-01: Special Topic Symposium: Bioengineering the Heart
Date	Wednesday, 7 December
Time	9:00am - 10:30am
Venue	Global Learning Room

ID: G2-0001 **SYM-01 : 1**

BIOINSTRUMENTATION DEVELOPMENT AT THE AUCKLAND BIOENGINEERING INSTITUTE

Poul Nielsen, Andrew Taberner

Auckland Bioengineering Institute, The University of Auckland, New Zealand

It is difficult to identify properties of living systems. Current approaches are typically reductionist, where experiments are performed on isolated and/or simplified parts of the system. Experiments are designed to yield measurements that are simple to interpret and can be readily associated with system parameters. Such approaches are inappropriate for systems that cannot be decomposed into subsystems without changing the system behaviour. In living organisms, isolating parts of the system can result in markedly changed behaviour because the subsystem is removed from its supporting environment.

We need to develop new ways of designing experiments that can enable us to efficiently and accurately identify parameters that characterise living systems while maintaining the organisms/tissues/cells in as natural environment as possible. One way to achieve this goal is to use complex preparations, but interpret measurements via models that represent the underlying biophysics. Identification of relevant parameters that characterise the system then becomes an optimisation problem where the objective is to find parameters which provide model predictions that best match observed measurements. In this way we can free ourselves from the constraints of requiring simple preparations, at the expense of more expensive analysis of measurements.

This talk will consider how such model-based approaches have guided the development of new bioinstrumentation developed at the Auckland Bioengineering Institute.

ID: G2-0003 **SYM-01 : 2**

ENERGETICS OF THE HEART: IN HEALTH AND IN DISEASE

June-Chiew Han, Denis Loiselle, Andrew Taberner

The University of Auckland, New Zealand

The heart is an engine. It consumes oxygen; it generates pressure-volume (or force-length) work; and it liberates heat. Any perturbation to its energy balance (such as from disease) will disturb its efficiency. If the perturbation is significant, the heart will fail.

Innovative experimental techniques and novel bioinstrumentation have allowed us to gain deeper insights into the energetics of the heart. In a basic-science experiment, the heart or its tissue strips are dissected from healthy or diseased animals. The preparation is mounted onto an apparatus with which to load it to various extents of pressure (or force), achieved by altering its volume (or length), under controlled experimental conditions. With such manoeuvres, the dependence of oxygen consumption (or heat), of work output, and of energy efficiency on pressure (or force) is revealed. These dependences of energy components change in the diseased heart.
In the heart experiencing diabetes-induced left-ventricular hypertrophy, prolongation of the duration of contraction reduces the time for filling, resulting in reduced capability to work at high afterloads. Consequently, the dependence of efficiency on pressure (afterload) shifts leftward. Nevertheless, its peak efficiency, which occurs at a lower afterload, is unaffected. In contrast, in the systemic hypertension-induced left-ventricular hypertrophic heart, peak efficiency is compromised given lower work output arising from reduced ability both to produce force and to shorten.

The coupling between the ventricles of the heart is clinically significant and is hence of current interest. When the right ventricle is pressure overloaded, as in pulmonary hypertension, the left ventricle, in response, shrinks. Despite this effect, when the high pressure of the right ventricle is removed, the left ventricle can exhibit normal energetics, having a normal efficiency-afterload dependency.
Understanding how the dependences of energy components change in the diseased heart, with respect to the healthy heart, is valuable for planning therapeutic strategy.

ID: G2-0004 **SYM-01 : 3**

STRUCTURAL CHARACTERISTIC OF HUMAN ATRIA AND ITS IMPLICATION IN ATRIAL FIBRILLATION

Jichao Zhao, Yufeng Wang, Alan Tang

The University of Auckland, New Zealand

Atrial fibrillation (AF) is characterized by rapid or irregular electrical activity in the upper chambers of the heart. AF is the most common cardiac arrhythmias. Recent studies suggest that the anatomical structure of human atria plays a key role in initializing and sustaining AF, of which atrial wall thickness variation is an important factor neglected in the past. Recently it is believed to influence AF activation patterns due to the source-sink mismatch. Furthermore, it may be an important indicator in determining the precise ablation region and predicting ablation outcomes. Estimating the 3D wall thickness across two atrial chambers in human hearts is a challenging task due to the inherited complex and thin atrial wall atrial geometries.

In this study, we have developed a novel Laplace approach to estimate the 3D wall thickness of the bi-atrial chambers. For atrial chamber geometry, we adopt the most established human atrial anatomical model imaged using MRI with a resolution of 0.33 mm3 of the Visible Female dataset (59 year old), as well as two Gadolinium-enhanced MRI dataset of in-vivo patients with AF with 1.25x1.25x2.5mm3 using 3T whole body scan from the Utah University. To estimate the 3D wall, first of all, atrial chambers will be closed. Then a region growing approach will be used to detect epicardial and endocardial surfaces, respectively. Finally, by solving the system of Laplace equation twice, we can obtain a robust 3D wall thickness solution for the two atrial chambers.

Our results indicate dramatic wall thickness variation in both chambers, especially in right atrium. This study suggests that the proposed Laplace solver is efficient and robust to estimate wall thickness throughout the atrial chambers by comparing with other approaches including center-surface, shortest distance and normal based approaches. The other structural characteristics of human atria is also reported in this study.

ID: E1-0012 **SYM-01 : 4**

DERIVING PATIENT-SPECIFIC VENTRICULAR MECHANICS REFERENCE MODELS WITH APPLICATIONS IN THE ESTIMATION OF MYOCARDIAL STIFFNESS IN HEART FAILURE.

Zhinuo J. Wang[1], Vicky Y. Wang[1], Chris P. Bradley[1], Alistair A. Young[1,2], Jie J. Cao[3], Martyn P. Nash[1,2]

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Personalised computational models of the human left ventricle (LV) can provide estimates of myocardial

tissue stiffness which are useful for investigating clinical hypotheses about the aetiology of heart failure. A significant limitation of such models has been the assumption that a stress-free mechanics reference geometry can be measured at some point during the cardiac cycle. This is typically measured at diastasis where the pressure inside the chamber is negligible. While this assumption may be reasonable for the healthy heart, it is problematic when dealing with heart failure (HF) patients since they often present with impaired relaxation kinetics and complications with hypertension, which means the LV never fully relaxes to its mechanical reference state during the cardiac cycle. We hypothesise that the assumption of negligible diastasis pressure masks important differences in model-based estimates of tissue mechanical properties between HF and control groups. This study presents a novel method for estimating the stress-free reference model of the LV and the passive tissue stiffness simultaneously. MRI and catheter pressure data recorded from HF patients were temporally aligned to provide simultaneous geometric and haemodynamic data at 3~6 time points from diastasis to end diastole. The reference LV model geometry was represented using principal component analysis dimension reduction techniques. The shape parameters of the reference model, and a tissue stiffness parameter were estimated simultaneously. The shape and stiffness parameters were optimised to minimise the projection between image-derived LV surface data and the model-predicted geometries at all time frames from diastasis to end diastole. The use of multiple time-points aims to improve the identifiability of the shape and stiffness parameters and alleviate their inter-dependence.

Tissue stiffness estimates were evaluated using the above approach on a per-patient basis, in order to investigate differences between different groups of heart failure patients and control subjects.

ID: G2-0002 **SYM-01 : 5**

DISCOVERABLE, REPRODUCIBLE, AND REUSABLE CARDIAC MODELS

David Nickerson

The University of Auckland, New Zealand

Computational models of the heart have evolved substantially since Denis Noble published his original 1962 modification of the Hodgkin & Huxley equations applicable to Purkinje fibre action and pacemaker potentials. As available computational power has grown the range of cardiac physiology and anatomy able to be represented by the mathematical models and numerical simulations has rapidly increased, to the point where we are now able to make use of multiscale and multiphysics cardiac models in scientific investigations. Models of cardiac electrophysiology, for example, are often used in the pharmacological industry as a screening tool for drug efficacy. While predictive cardiac models are not quite yet routine in clinical practice they are beginning to be utilised in specific situations. For example, ventricular mechanics models are used to help interpret cardiac MRI images and ventricular fluid flow observed using ultrasound.

While recent cardiac computational models can be very detailed biophysically and anatomically, scientists face many challenges when attempting to reproduce the results of a given modelling study - often as the first step in a desire to reuse an existing model. For instance, cardiac cellular models consisting of large systems of ordinary differential equations are frequently impossible to implement from the published paper alone. To address this problem, the Physiome and Virtual Physiological Human communities have developed standards for encoding model and simulation descriptions which enable scientists to archive and exchange their models in a reproducible manner.

The encoded model or simulation alone, however, is often not sufficient to enable scientists to discover and reuse the computational model. Here I will present recent developments aimed at improving the discoverability and reusability of cardiac models. Future work to encourage scientists to make use of these developments will also be presented.

Session	Plenary Lecture 1
Date	Wednesday, 7 December
Time	11:30am - 12:15pm
Venue	Auditorium 2

ID: PL-0004 **PL1**

CELL THERAPY OF DIABETES MELLITUS AND ITS COMPLICATIONS: HOW FAR ARE WE?

Bernat Soria

Andalusian Center for Molecular Biology and Regenerative Medicine, Spain

Due to the high prevalence and cost of diabetes in the world (more than 400 million people and more than 600 billion € of annual cost), diabetes has to be considered a Public Health problem. Diabetes describes a situation in which blood sugar is unregulated, is not a disease, but a group of diseases. Type 1 is an autoimmune disease in which pancreatic B-cells disappear, whilst type 2 is a lifestyle caused disease with a progressive decrease in B-cell mass and peripheral insulin resistance. Additionally there are less frequent forms such as monogenic diseases (MODY) or gestational diabetes. Regenerative medicine is a broad concept including not only Cell Therapy, but other strategies to recover tissue homeostasis. Either autologous or allogenic stem cells may be used to treat or alleviate diabetes and their complications, such as diabetic foot.
Strategies :
Immunomodulation and blockade of the lymphocytic attack on the B-cell
Transplantation of insulin producing cells derived from pluripotent stem cells and expansion from resident islet cells.
Regeneration from resident progenitors, and Neovascularization (angiogenesis and vasculogenesis) to avoid amputation and recovery from critical ischaemia of the legs in diabetic and non-diabetic patients

We will also discuss other strategies to generate vascular smooth muscle cells, corneal endothelium or the role of GATA-4 in liver fibrosis.

Session	Plenary Lecture 2
Date	Wednesday, 7 December
Time	1:15pm - 2:00pm
Venue	Auditorium 2

ID: PL-0001 **PL2**

BIO-INTEGRATED AND BIO-INSPIRED STRETCHABLE ELECTRONICS

Yonggang Huang

Northwestern University, USA

Recent advances in mechanics and materials provide routes to integrated circuits that can offer the electrical properties of conventional, rigid wafer-based technologies but with the ability to be stretched, compressed, twisted, bent and deformed into arbitrary shapes. Inorganic electronic materials in micro/nanostructured forms, intimately integrated with elastomeric substrates offer particularly attractive characteristics in such systems, with realistic pathways to sophisticated embodiments. Mechanics plays a key role in this development by identifying the underlying mechanism and providing analytical solutions to guide design and fabrication. I will present our research on stretchable silicon [1] and its applications to stretchable and foldable circuits [2], electronic-eye camera [3,4], semi-transparent and flexible LED [5], epidermal electronics [6], dissolvable electronics [7,8], injectable, cellular-scale optoelectronics [9], and soft, microfluidic assemblies of sensors, circuits and radios [10]. Review of stretchable electronics has been published [11].

Session	A2: Assistive Technology & Wearable Devices
Date	Wednesday, 7 December
Time	2:00pm - 3:30pm
Venue	Auditorium 2

ID: C5-0012 **A2 : 1**

AN EFFICIENT DEVICE TO HARVEST AMBIENT ENERGY FROM HUMAN MOTION

Chandan Kumar[1], Sanjay Saxsena[2], Sanjay Kumar Rai[1]

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Several methods have been tried to seize ambient energy, one of the most efficient and widespread ways is vibration source. Power harvesters built on the piezoelectric effect are more favorable in harvesting energy from ambient vibration.

A piezoelectric energy harvesting system broadly includes: a transducer to convert Kinetic energy to the electrical energy and an electrical circuit to manage this energy. An approach to energy recovery from mechanical vibrations is presented in this paper. PVDF/rGO cantilever has been used for the

mechanical impact and frequency up-conversion. The PVDF/rGO cantilever operates in the low-frequency range (15 Hz-40 Hz), which converts it to high-frequency vibration on the mechanical impact. This frequency conversion increased the -3dB bandwidth and the output increased in a considerable way within the operating frequency as well. An efficient rectifier circuit to harness the power is shown and a better electromechanical coupling are being achieved.

The proposed setup can be worn on the ankle and has the potential to power small portable devices from originated from human motion.

ID: C5-0014 **A2 : 2**

MINIATURIZING AN EEG RECORDING DEVICE USING WEEG: A WEARABLE 8-CHANNEL SYSTEM FOR BRAIN COMPUTER INTERFACES

Thong Vo Tri, Quang Nguyen, Nam Nguyen Phuong, Toi Vo Van

International University, Vietnam National University, Vietnam

Research-grade Electroencephalogram (EEG) instruments offer the brain's electrical activity recording with high accuracy and a wide range of functionalities. Due to rigorous component requirements, these devices are usually expensive and elaborate. Recent advancements in electronic enable smaller designs to achieve comparable measurement results with similar functions such as impedance measurement. In this paper, we present the design of WEEG – A Wearable 8-channel System EEG recording device with integrated hardware and software interface. The circuit board which is smaller than a credit card size contains a power management system, an ADS1299 Analog to Digital Converter (ADC) to capture brainwaves and a microcontroller to handle a part of digital processing tasks. It communicates with a host computer via Bluetooth/Serial. Extensive evaluations were deployed to evaluate the performance of WEEG . We compared the signal quality of WEEG to that of the Biosemi Active Two - a conventional high-quality EEG recording system. Results came out comparable, indicating a high accurate recording of the proposed system. Also, Steady State Visually Evoked Potential (SSVEP) based game was devised. The high performance of users in the game suggests usage of our device in a wider range of Brain Computer Interface applications.

ID: C4-0015 **A2 : 3**

BIOMECHANICAL STUDY OF GAIT REHABILITATION ROBOT

Hsiao-Ju Cheng[1], Pavithra Thangavel[2], Gong Chen[1], Vidhya S[2], Haoyong Yu[1]

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Walking is the most significant act of locomotion by humans. This ability can be compromised due to various diseases' such as spinal cord injuries, stroke, neurodegenerative diseases or brain injury. Patients with gait impairment are advised to undergo intensive rehabilitation therapy to restore their normal gait and improve their quality of life. Since manual therapy can be physically demanding for both the patient and the physiotherapist, a prototype of the gait rehabilitation robot was designed to provide assistance while walking and also be used for rehabilitation therapy to restore an individual's normal gait pattern. The Gait Rehabilitation Robot uses gait event based synchronization, which enables the exoskeleton to provide synchronous assistance during walking. The study performed deals with the evaluation of the robot's performance so it can further be tested in clinical trials. This evaluation was done by performing experiments on healthy subjects where they were asked to walk under the following conditions: Free Walk (FW, without robot), Zero Force (ZF, with the robot in no assist mode), and Assisted condition (AS, assistive torque provided by the robot). During the experiment the knee joint angles, the torque provided and the EMG pattern were recorded. EMG signals from Tibialis Anterior (TA), Gastrocnemius Lateralis (GL), Rectus Femoris (RF) and Semitendinosus (SM) were recorded. EMG showed overall decrease in muscle activity of the four muscles with the provision of assistive torque as the human will reduce their muscle activity to fully utilize the assistive torque provided. A significant improvement in the knee joint angles was also seen with the increase in the assistive torque. With higher torque the knee joint angle was closer to the knee joint angle in normal walking. The study found that the robot provided effective torque and it is further suitable for clinical trials.

ID: C4-0020 **A2 : 4**

WEARABLE ROBOT LEG FOR STROKE REHABILITATION

Raymond Tong[1], Ling Fung Yeung[1], Corinna Ockenfeld[2], Hoi Wah Wai[2]

[1]The Chinse Univesrity of Hong Kong, Hong Kong; [2]The Hong Kong Polytechnic University, Hong Kong

This Wearable Robot Leg is a light weight design and convenient to use for stroke and muscle weakness patients. It is an intelligent system with motion and force sensors to identify the user's intention to walk stairs and adapt to different walking speeds. Stroke patients underwent a 20-session robotic training, the results after the clinical trial showed improvement in the lower limb functions, and an increase in walking speed and distance.

Drop-foot and knee hyper-extension are gait abnormality that are common among stroke survivors. Patients show muscle weakness at the ankle dorsiflexors and knee control have experienced difficulty in lifting up the forefoot, resulting in foot dragging on the ground during walking, which would increase chance of fall and ankle sprain. Conventional gait rehabilitation consists of high intensity and repetitive walking exercises, which is physically demanding even for the physiotherapists. Stroke patients with leg problem could wear orthosis to passively support during walking. However, orthosis has limited therapeutic effect and imposes undesirable restriction to the joint range of motion.

In view of the above issues, we developed an interactive exoskeleton ankle robot which can assist stroke patients in gait rehabilitation by integrating electric motor, gear transmission system, accelerometer and pressure sensors. In our pilot clinical trial results, 20 chronic stroke survivors had 20-session robotic leg training and showed remarkable functional improvement in clinical scores (35% improved in FAC, 55% improved in FMA, 55% improved in MAS and 40% improved in BBS), and improved the walking speed and longer walking distance.

A live demo will be conducted in the oral presentation, to let the audiences to experience the function of this wearable robot leg during walking.

ID: C4-0019 **A2 : 5**

GRAPHITE-BASED RESISTIVE STRETCH SENSOR FOR FEEDBACK CONTROL OF SOFT ACTUATORS

Pravar Jain, Gokula Krishnan Ramachandran, Chen Hua Yeow

National University of Singapore, Singapore

Soft robotic actuators unlike rigid-link actuators are lightweight and easy to fabricate. However, these soft actuators lack suitable stretch sensing elements for feedback control. Commercially available sensors such as FlexiForce are flexible but not stretchable. Previously, researchers have developed soft sensors using conductive liquid, carbon nanotube, silver wires or by embedding rigid sensing elements in stretchable substrates. These sensors have complicated designs and are associated with high costs as they utilize materials like gold, silver wires, carbon nanotubes etc. Here, we present a simple, low cost, easy to fabricate, soft resistive sensor capable of stretch sensing. The proposed design utilizes graphite deposited on hyper elastic substrates to produce scalable stretch sensors. Using the technique of mixing, casting and curing, soft sheets of customized dimensions are fabricated using Eco-Flex. Graphite is deposited manually to obtain a conductive trace. The ends of the trace serve as terminals that are interfaced to the Analog-to-Digital (ADC) pin of the micro- controller via a voltage divider. The microcontroller is programmed to deduce the resistance of the sensor from the voltage measured. Using a Universal Testing Machine (UTM), the electromechanical behaviour of the sensor was ascertained and a model correlating the sensor resistance with the induced stretch was developed.

The linear correlation obtained was implemented on a microcontroller to predict the amount of stretch. Evaluations using a UTM indicate that measurements from the sensor are coherent and re- producible. The gauge factor of the developed sensor is comparable with other carbon based strain sensors. This sensor was used for the feedback control of soft pneumatic wearable rehabilitation actuators made from hyper-elastic materials. Due to the high degree of compliance, this sensor can potentially be integrated with soft surgical robots, wearables for monitoring joint kinematics and also with devices used in physiotherapy such as elastic exercise bands.

ID: B2-0011 **A2 : 6**

RESIST-FREE SOFT FABRICATION OF SILK ELECTRODE SENSORS: PAVING THE WAY FOR FLEXIBLE ELECTRONICS ON SILK

Anoop Patil[1,2], Lun-De Liao[1,2], John Ho[1,2], Toh Siew Lok[1], Yen Shih-Cheng[1,2], Nitish Thakor[1,2,3],

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We demonstrate, for the first time, silk bioelectronic sensors based on thin nontransient silk fibroin films

with selectively exposed metal contacts capable of sensing minute electrical changes in a physiological environment. The sensors are fabricated using SILK-SEAL, a new resist-free procedure based on micro-molding, stamping, and gluing that enables precisely patterned insulating silk films to be integrated with metallized silk substrates in a multilayer silk device. This is a first-of-its-kind effort to design an excellently biocompatible and sustainable film-based silk fibroin device, with an ultrathin metal deposit sandwiched between two thin silk layers serving as the conductive layer facilitating electrical sensing in a physiological medium. Impedance measurements under accelerated soak demonstrate the stability of the silk-based sensors. In vitro recording experiments serve as evidence for the potential use of this technology in implantable biosensing applications. Furthermore, the silk interfaces are flexible and are found to be conformal to the challenging non-planar geometries as demonstrated by the deployment of silk sensors on various tissue surfaces. The concepts reported here provide a platform for designing advanced multilayer bioelectronic devices on silk.

Session	B2: Biomaterials I
Date	Wednesday, 7 December
Time	2:00pm - 3:30pm
Venue	LT50

ID: E3-0003 **B2 : 1**

MECHANICAL PROPERTIES OF SILK FIBROIN AND ITS REINFORCEMENT BY GRAPHENE BASED ON MOLECULAR DYNAMIC SIMULATIONS

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Key Words: Silk fibroin, Graphene, Molecular dynamics simulation, Mechanical property.

Silk fibroin has attracted great attention due to its superior mechanical properties such as high stretchability and strength, biocompatibility, as well as its versatile biodegradability and processability.1 They can be made into various morphologies such as sponges, hydrogels, films, mats and particles, facilitate their wide applications as medical textiles, surgical sutures, tissue engineering scaffolds, drug carriers, optics, sensors, etc. Great efforts are demanded in order to understand and further enhance the mechanical properties of silk fibroin. In this study, intensive molecular dynamics simulations were carried out on silk crystalline and the interactions between graphene substrate and model peptides with different sizes extracted from different domains of silk fibroin.2,3 The simulation result on secondary structure component of peptides agrees well with the experimental data. Our study shows that graphene substrate has different impact on structural properties of different domains of silk fibroin. Tensile tests were also carried out on representative peptides to measure the mechanical properties of the peptides related to strength and resilience. It was found that the stregnth of the peptides are enhanced upon adsorption to the graphene surface. These results provide in-depth understandings in molecular structure-mechanical property correlation of protein upon adsorption to the substrate, and will serve as a guideline to future design of bio-inspired materials.

ID: D2-0017 **B2 : 2**

ORGANIC SEMICONDUCTING NANOPARTICLES FOR AMPLIFIED PHOTOACOUSTIC IMAGING AND PHOTOTHERMAL THERAPY

Kanyi Pu

Nanyang Technological University, Singapore

Optical theranostic nanoagents that seamlessly and synergistically integrate light-generated signals with photothermal therapy can provide opportunities for cost-effective precision medicine, while the potential for clinical translation requires them to have good biocompatibility and high imaging/therapy performance. Semiconducting polymer nanoparticles (SPNs) have emerged as a category of new optical nanomaterials that can be easily transformed from hydrophobic semiconducting polymers (SPs). As optoelectronically active SPs are completely organic and biologically benign, SPNs intrinsically circumvent the issue of heavy metal ion induced toxicity to living organisms and thus possess good biocompatibility. In this talk, we will demonstrate how to capitalize on the nanoparticle engineering approach to develop SPNs into theranostics for amplified imaging and therapy. In particular, the design principle will be revealed along with their biomedical applications in photoacoustic imaging and photothermal therapy of tumor in living mice. Our work not only introduces an advanced category of purely organic optical theranostics but also provides a molecular guideline to amplify the effectiveness of light-intensive imaging and therapeutic nanosystems.

ID: D2-0011 **B2 : 3**

DEVELOPMENT OF CONDUCTIVE FILM INCORPORATED WITH PHOTOTHERMAL NANOPARTICLES FOR CONTROLLED AND ACCELERATED NEURAL STEM CELLS DIFFERENTIATION

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In central nervous system, a mechanically obstructive glial scar tend to walling off areas of damage to protect the fragile brain tissue after injuries. However, the construction of the scar and the production of inhibitory molecules by astrocytes are contributing factors for regenerative failure. Transplantation of stem cells or mobilization of endogenous stem cells within the injury site, have been suggested as a potential therapies for CNS injuries. Yet, being able to control the proliferation and differentiation of stem cells into specific cellular phenotypes and to prevent tumour formation still remain challenges. In this study, an electrical conductive film composed of oxidative polymerized carboxyl-capped aniline pentamer (CCAP) and ring-opening polymerized tetra poly(D, L-lactide) (4a-PDLLA) was designed. In addition, nanoparticles based on polyaniline (PAni) and polyoxyethylene-stearate were embedded in the film as a photothermal (PT) agent. This conductive film was suggested to act as a substrate for endogenous electric fields transmission in tissue, resulting in the improvement of tissue regeneration. To accelerate the regeneration process, the PAni nanoparticles triggered by near-infrared were used as a heat source to create a mild heat environment. In the results of 1H NMR, CCAP and 4a-PDLLA were successfully prepared and characterized. The coupling of CCAP and 4a-PDLLA was confirmed by FT-IR. According to cyclic voltammetry and UV-visible spectrum, the transition between different oxidation state and doping/dedoping process of CCAP were achieved. PAni NPs showed excellent photothermal conversion efficiency under NIR with wavelength of 808 nm. In order to differentiate hNSCs into neurons, the cell response to electrical and thermal stimulus will be demonstrated.

ID: D2-0012 **B2 : 4**

THE INFLUENCE OF PARTICLE MORPHOLOGY ON BIOLOGICAL RESPONSE OF MACROPHAGES

Riku Yoshioka, Yuta Nakashima, Yukio Fujiwara, Yoshihiro Komohara, Motohiro Takeya, Yoshitaka Nakanishi

Kumamoto University, Japan

Several studies reported that ultra-high molecular weight polyethylene (UHMWPE) wear debris that generated from the bearing surface of artificial joints is phagocytosed by macrophages. Macrophages release cytokine that stimulate osteoclasts and the subsequent osteolysis. Artificial joint loosening is caused by the osteolysis. In particular, some reports showed that sub-micron size of the particles had a great effect on biological response of macrophages. There is possibility that the other parameters except for the particle size may regulate the macrophages activation and/or production of cytokines. In this study, polymethylmethacrylate (PMMA) particles with narrow particle size distribution were used instead of UHMWPE. Evaluation parameters to the activation of PMMAs are, particle size, Total volume of particles per cell, total surface area of particles per cell. In particle size, significant decrease of cell viability was observed when relatively large particles were tested (5.6–19.3 μm). Production of proinflammatory cytokines was observed with 5.6- and 9.6-μm particles. In total volume of particles per cell, cell death occurred when added volume exceeded 1×105 μm3 per cell. Proinflammatory cytokines were produced upon stimulation with added volume between 1×105 to 4.5×105 μm3 per cell. In total surface area of particles per cell, cell death was caused when the added surface area per cell exceeded 1×105 μm2 and proinflammatory cytokines were produced with the added surface area per cell between 1×105 to 3×105 μm2. These results suggested that biologically active factors exert their effect through total volume and total surface area of particles rather than through particle size. The results of this study is of use to anyone concerned with the design of artificial joints with greater longevity.

ID: D2-0014 **B2 : 5**

CHITOSAN AND GENIPIN CROSS LINKING IMPROVE BIOHYBRID CARDIAC ECM-BASED HYDROGEL PROPERTIES IN VITRO AND CARDIAC FUNCTION POST MYOCARDIAL INFARCTION IN A RAT MODEL

Hadar Sarig[1], Yael Efraim[2], Udi Sarig[1], Elio De-Berardinis[1], Su-Yin Chaw[1], Limor Baruch[2], Freddy Boey[1], Subbu Venkatraman[1], Marcelle Machluf[2],

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Injectable scaffolds for cardiac tissue regeneration are a promising therapeutic approach for progressive heart failure following myocardial infarction (MI). Their major advantage lies in their delivery modality that is considered minimally invasive due to their direct injection into the myocardium. Biomaterials comprising such scaffolds should mimic the cardiac tissue in terms of composition, structure, mechanical support, and most importantly, bioactivity. Nonetheless, natural biomaterial-based gels may suffer from limited mechanical strength, which often fails to provide the long-term support required by the heart for contraction and relaxation, and biological activity. Here we introduce newly-developed injectable scaffolds, which are based on solubilized decellularized porcine cardiac extracellular matrix (pcECM) cross-linked with genipin alone or engineered with different amounts of chitosan to better control the gel's mechanical properties while still facilitating biological activity. We demonstrate that these new biohybrid materials are naturally remodeled by mesenchymal stem cells, while supporting high viabilities and affecting cell morphology and organization. They exhibit neither in vitro nor in vivo immunogenicity. Most importantly, their use in treating acute and chronic MI in rat models clearly demonstrates the significant therapeutic potential of these gels in the long-term (12 weeks post MI). The pcECM-based gels enable not only preservation, but also improvement in cardiac function eight weeks post treatment, as measured using echocardiography as well as hemodynamics. Infiltration of progenitor cells into the gels highlights the biological remodeling properties of the ECM-based platform.

ID: D5-0021 **B2 : 6**

FUNCTIONAL NANOFIBROUS SCAFFOLDS COMBINED WITH STEM CELLS FOR ADVANCED BIOMEDICAL DEVICES AND THERAPIES

Nuno Neves

University of Minho, Portugal

The development of temporary scaffolds to help regenerating tissue defects is one of the most promising strategies for Advanced Therapies and in particular of Tissue Engineering. The scaffolds should be specifically designed to create environments that promote tissue development and not merely to support the maintenance of communities of cells. To achieve that goal, highly functional scaffolds may combine specific morphologies and surface chemistry with the local release of bioactive agents.

Many biomaterials have been proposed to produce scaffolds aiming the regeneration of a wealth of human tissues. We have a particular interest in developing systems based in biodegradable polymers. Those demanding applications require a combination of mechanical properties, processability, cell-friendly surfaces and tunable biodegradability that need to be tailored for the specific application envisioned. Those biomaterials are usually processed by different routes into devices with wide range of morphologies such as biodegradable fibers and meshes, films or particles and adaptable to different biomedical applications.

In our approach, we combine the temporary scaffolds populated with therapeutically relevant communities of cells to generate a hybrid implant. For that we have explored different sources of adult and also embryonic stem cells. We are exploring the use of adult MSCs, namely obtained from the bone marrow for the development autologous-based therapies. We also develop strategies based in extra-embryonic tissues, such as the perivascular region of the umbilical cord (Wharton´s Jelly).

This talk will review our latest developments of natural-based biomaterials and scaffolds in combination with stem cells for advanced biomedical devices and therapies.

Session	C2: Computational Bioengineering I
Date	Wednesday, 7 December
Time	2:00pm - 3:30pm
Venue	LT51

ID: KN-0001 **C2 : 1**

ROLE OF MECHANICAL FORCE FEEDBACK IN MULTICELLULAR MORPHOGENESIS: IN SILICO AND IN VITRO STUDIES

Taiji Adachi

Kyoto University, Japan

Mechanical forces play important roles in living tissues and organs to determine their functional shape and structure. In this presentation, by illustrating examples

of multicellular morphogenesis, we will discuss how locally generated mechanical forces and their feedback result in the macroscopic regulation of tissue/organ morphology, and how such multiscale approach based on modeling and simulation allows us to explore the roles of mechanical force feedback in determining the organ-level functional shapes.

In multicellular morphogenesis, tissue folding is controlled by local mechanical forces such as contractile (tensile) forces generated in actin-myosin networks and pushing (compressive) forces due to tissue volumetric increase by cell division and proliferation. Mechanical forces are sensed at microscopic cellular and molecular levels and integrated to determine the macroscopic tissue/organ morphology through multiscale interactions. To better understand such complex multiscale phenomena, mathematical modeling and computer simulation based on mechanics will give us a useful framework for conducting in silico experiments by combining with in vitro experiments.

ID: E3-0011 **C2 : 2**

HEMODYNAMIC INFLUENCE OF CONDUIT POSITION ON SYSTEMIC-TO-PULMONARY SHUNT: COMPUTATIONAL ANALYSIS OF PATIENT-SPECIFIC SURGICAL DESIGN

Jinlong Liu[1], Yi Qian[2], Mitsuo Umezu[3], Jinfen Liu[1]

[1]Shanghai Children's Medical Center, China; [2]Macquarie University, Australia; [3]Centre for Advanced Biomedical Sciences, TWIns, Waseda University, Japan

The systemic-to-pulmonary artery shunt is one kind of palliative procedure. It is the most preferred surgery used in the first staged therapy of cyanotic congenital heart defect (CHD). The blood flow in systemic circulation was introduced to pulmonary artery by a Gore-Tex conduit to promote oxygen saturation in this procedure. However, the position of the conduit implantation is one of contentious issues for surgeons in the design of surgery. Here, we report on our three-dimensional hemodynamic analysis of patient-specific researches of the conduit position by using the techniques of computational fluid dynamics (CFD). A series of continuous CT images were acquired for the reconstruction of the 3D vascular geometric models. Computer-aided design (CAD) was employed to create a conduit with 4 mm in diameter and virtually imitate the implantation of the conduit in different positions based on vascular anatomical structures. Three common applied surgical forms of systemic-to-pulmonary artery shunt in clinic were created to simulate the procedure of the modified Blalock-Taussig (mB-T) shunt, Center aorto-pulmonary shunt and Melbourne shunt, respectively. Pressure drops, wall shear stress (WSS), streamlines and blood flow distribution ratio were quantitatively compared to disclose the influence of conduit position. The results indicate the mB-T shunt is more effective to control the balance of blood flow distributed to systemic and pulmonary circulation. The relative higher pressure of pulmonary was generated in Center aorto-pulmonary shunt and Melbourne shunt. To control the high WSS created in the shunt may reduce the risk of thrombosis formation. The methods of CFD and CAD are a useful tool for patient-specific surgical design in the treatment of CHD.

ID: E3-0007 **C2 : 3**

THE COMPUTATIONAL STUDY OF THE EFFECT OF INDIVIDUAL DIFFERENCES IN CEREBRAL BLOOD VESSELS ON THE STRATEGY OF ACP

Lu Han, Jinlong Liu, Wei Wang

Shanghai Children's Medical Center, China

Antegrade celebral perfusion (ACP) is the most common used method of perfusion in aortic arch surgery. It includes two types of approaches; the unilateral perfusion and the bilateral perfusion. Human studies indicated that more than 90% of the human have the circle of wills (CoW), but still a few people are cerebral artery stenosis or Cow uncomplete. This increases the complication of ACP investigation. How to choose an appropriate method of ACP for the individual therapies becomes a complex issue in surgeries. In the present study, we introduced the method of computational fluid dynamics (CFD) to quantitatively study the effects of the two types of perfusion. The CT images were used to reconstruct an individual three-dimensional (3D) model of cerebral arteries. The pulsatile blood flow measured by Trans-Cranial Doppler ultrasonography (TCD) was applied as boundary conditions for CFD simulations. Hemodynamic parameters in the 3D cerebral vascular model were compared among the patients with the existence or absence Circle of Willis at the condition of the unilateral and bilateral antegrade selective cerebral perfusion. The effects of stenotic degree of the cerebral vessels and the

different stenotic positions were also investigated. The computational results indicated there were no obvious differences between the unilateral cerebral perfusion and bilateral cerebral perfusion in most patients. For few patients, the unilateral cerebral perfusion is not suitable to avoid brain injury.

ID: E3-0018 **C2 : 4**

SOFT BIOLOGICAL TISSUE CHARACTERIZATION IN HEALTH AND DISEASE

Satish Kumar Panda, Martin Lindsay Buist

National University of Singapore, Singapore

Over the past few years, mathematical models have frequently been adopted to quantify the healthy and diseased states of biological tissues. Certain diseases are known to cause tissue remodelling, and alter the biomechanical properties of the tissue. A mathematical modelling approach provides a succinct description of soft tissue biomechanical behaviour. Under normal mechanical loads, these tissues exhibit complex strain, strain rate and strain history dependent stress profiles. In the literature, the strain and strain rate dependencies are often modelled with a hyperelastic and a discrete (standard linear solid) or continuous spectra (quasi-linear) viscoelastic model, respectively. However, these models are unable to capture the material characteristics, because the hyperelastic models are unsuited for the time-dependent events, whereas, the above-mentioned viscoelastic models are insufficient for the nonlinear and three-dimensional tissue responses. Thus, in this context, a thermodynamically consistent finite nonlinear hyper-viscoelastic model was constructed and then implemented in a finite element package, so as to facilitate the mechanical assessment of complex biological tissues. The strain history dependency of stress was also incorporated in the constitutive equation through a continuum damage mechanics model. To demonstrate the efficacy and versatility of this approach, the model was used to recreate the experimental results performed on different types of soft tissues (e.g. gastrointestinal tissues, placental tissue, and skeletal muscles). In all the cases, the simulation results were well matched (R2 >= 0.993) with the experimental data. Furthermore, with the alteration of only a small number of model parameters, we were able to recreate the diseased tissue behaviour from its healthy condition. This modelling strategy offers a multitude of opportunities for further investigation of biological tissues in health and disease.

ID: E3-0027 **C2 : 5**

A THRESHOLD BASED APPROACH TO ATHEROSCLEROTIC PLAQUE GROWTH

Zi Hui Foo, Yier Li, Satish Kumar Panda, Martin Buis

National University of Singapore, Singapore

Atherosclerosis is the leading cause of mortality in the world. It is a vascular disease caused by the inflammation of the arterial wall, which results in the accumulation of low-density lipoprotein (LDL) particles, monocytes, and foam cells at the site of inflammation. The development of the disease, and in particular the influence of LDL concentration on the growth of atherosclerotic plaques, is still a poorly understood phenomenon. Here we apply a threshold based approach to describe the growth of an atherosclerotic plaque. The immersed boundary-lattice Boltzmann method was used to simulate the physics of the fluid flow and fluid structure interactions on a simplified two-dimensional non-axisymmetrically stenosed arterial geometry. This model uses the Navier-Stokes equations and Darcy's law as governing equations for the fluid dynamics, and convection-diffusion equations for modelling the mass balance in the lumen and intima. As the immersed boundary method permits the adjustment of boundary morphology during the solving process, the arterial wall is reshaped progressively according to local LDL concentration at the arterial wall. The simulation results indicated that the accumulation of LDL particles in the recirculation zone downstream of the plaque presents the conditions necessary for plaque growth initiation. The growth of the plaque causes the recirculation zone to shrink in size, resulting in a reduction in the rate of plaque growth as the local accumulation of LDL is reduced. The results show that the model is able to qualitatively capture the development of an atherosclerotic plaque with surface irregularities.

Session	D1: Orthopaedic Biomechanics I
Date	Wednesday, 7 December
Time	2:00pm - 3:30pm
Venue	LT52

ID: E5-0001 **D1 : 1**

COORDINATION, FUNCTION AND BIOFEEDBACK REHABILITATION OF THE HAND

Fong-Chin Su

National Cheng Kung University, Taiwan

The hand receives sensory stimuli and executes motor commands that are integrated in the various functional manipulations for daily tasks. Awkward and inefficient finger movements, poor force coordination and strength, sensation deficit of motor control of the affected hands are most common phenomena in patients. We developed the instruments for quantitative measurement of force coordination and sensation of the digits in performing daily activities including pinch holding and grasping. The custom-design simulator with five force transducers which position can be adjusted to record the applied force in natural grasping configuration was applied for understanding of the patients with trigger finger and carpal tunnel syndrome, respectively. As for the patients with carpal tunnel syndrome, they grasped with greater digit force associated with weaker pair-digit correlation and higher force variability on specific digits in different task demands. Also, the custom-designed computerized evaluation and re-education biofeedback prototype was developed to analyze hand grasp performances, and monitor the training effects on hand coordination for stroke patients with sensory disturbance and without motor deficiency. The biofeedback procedures provide visual and auditory cues to the participants when the interactive force of hand-to-object exceeded the target latitude in a pinch-up-holding task to trigger optimal motor strategy. The sensation, force coordination, and biofeedback re-education for the patients with sensory deficits will be presented from biomechanical aspects.

ID: E5-0002 **D1 : 2**

MEASURING THE RESTRAINING PROPERTIES OF THE FIBER BUNDLES WITHIN THE ACL AND PCL USING DOF RELEASE FIXTURE

Ryo Takeda, Keisuke Okuzumi, Keisuke Okuzumi, Katsuhiko Sasaki

Hokkaido University, Japan

The main focus of this study was to investigate the load capabilities of the anteromedial (AM) and posterolateral (PL) bundles of the ACL and the posteromedial (PM) and anterolateral (AL) bundles of the PCL A novel knee joint biomechanical testing platform was specially designed and developed for this study The platform consisted of a 6 axis force/torque sensor attached to a single axis material testing machine and a bespoke DoF passive fixture The fixture was designed to fix the femur and tibia bone of the knee joint specimen through bone cement and restaining bolts The passive fixture was capable of releasing or constraining two translational DoFs (medial-lateral (ML) and proximal-distal (PD)) and three rotational DoFs (internal-external (IE), varus-valgus (VV) and flexion-extension (FE) rotation) by means of bearings and locking screws The fixtures also contained two IMUs for measuring the rotational and translational motion of the femur and tibia attachments respectively 16 porcine stifle joints were used as knee joint specimens The specimens were subject to three different ligament states for each cruciate ligament : ACL and PCL intact (Intact), AM bundle cut (AM cut), AM+PL cut (ACL cut), PM bundle cut (PM cut) and PM+AL cut (PCL cut) at 90 deg of flexion In addition, the DoFs on the passive fixture was released sequentially Loads induced during anterior-posterior (AP) translation motion by the material testing machine were measured by the force/torque sensor and the secondary coupled motions by the IMUs As a result, the average AP directional load contributions for the ACL bundles were: 62% AM vs 37% PL The same results for the bundles within the PCL were: 5% PM vs 95% AL The developed platform was capable of quantifying the different functions of the fiber bundles within the cruciate ligament and relevant for evaluating methods of ligament reconstruction.

ID: E5-0005 **D1 : 3**

LASER BONDING TECHNIQUE FOR BONE SPECIMENS USING CERAMIC PASTE

Satoshi Yamada[1], Tomoki Komori[1], Masaru Kanaoka[2], Shigeru Tadano[1,3]

[1]Hokkaido University, Japan; [2]Mitsubishi Electric Corporation, Japan; [3]National Institute of Technology, Hakodate College, Japan

In orthopedic surgery, implants are widely used to fix bones until healing. The authors have developed an instantaneous bonding technique between bone and ceramics as an implant material by laser irradiation. Previously, the ceramic plate sintered with hydroxyapatite (HAp) and MgO-Al2O3-SiO2 glass powders with 80:20 wt% proportions (G-HAp powder) were immediately bonded onto the bone surface in vitro by fiber laser irradiation, generating a foam-like substance. Based on this, the current

study proposed a novel technique to bond bones directly using a ceramic paste toward bone fixation. The ceramic pastes were made of G-HAp and gelatin powders with distilled water by mixing and kneading: paste A (50% G-HAp, 10% gelatin, and 40% water) and paste B (50% G-HAp, 2.5% gelatin, and 47.5% water). HAp powder and both pastes were irradiated with a fiber laser under 400 W laser powers in a second, respectively. As a result, paste A generated the foam-like substance strongly during the irradiation, suggesting that the collagen component contributes to generate the substance and to bond bones and ceramics. Using the pastes, laser bonding of two bone specimens was examined. 20 bone specimens (approximately 15×40×4 mm) were taken from bovine femurs, and a 3 mm diameter hole was drilled. The specimen was divided two parts at the center of the hole, and the divided hole was filled with the pastes. A 5 mm diameter area at the boundary of the parts including the hole was irradiated under 200 and 400 W powers. As a result, the bone specimens were bonded under all four conditions. The bonding strength was maximized to be 0.95 N under 200 W powers with paste A. It depended on the gelatin contents of the paste. The study developed the ceramic paste and demonstrated the laser bonding of bone specimens.

ID: E5-0003 **D1 : 4**

MECHANICAL ANALYSIS OF PEDICLE SCREW FIXATION FOR ADOLESCENT IDIOPATHIC SCOLIOSIS

Michihiko Koseki[1], Tsubasa Sato[1], Hiroki Kanzawa[2], Jun Takahashi[1], Toshimasa Futatsugi[1], Hiroyuki Kato[1]

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Pedicle screw fixation is a surgical treatment used to treat patients with severe spine deformity such as adolescent idiopathic scoliosis. In this technique, pedicle screws are inserted to vertebrae and every screw are connected to a rod to correct the coronal and sagittal curves of the spine. Here, surgeons sometimes encounter bone fracture or screw back-out when the screws are connected to the rod, possibly because little is known on the precise mechanical conditions involved in the placement of screws. This study examined the placement and tightening order of screws to understand the mechanical states present in pedicle screw and rod systems.

In order to pursue the objective, a simple experimental spine model was constructed with seven resin vertebral bodies connected via a spring element to reduce error and increase measurement reproducibility. A triaxial strain gage was attached to each pedicle screw, and then the screws were fixed to vertebral bodies under the following three circumstances:
Case 1) Screws were inserted into all consecutive vertebrae.
Case 2) Screws were inserted into every second vertebra.
Case 3) Screws were inserted into every third vertebra.
Screws were tightened and maximum principle strain was computed from measured triaxial strains. Trials were performed five times for each case to ensure consistent results.

The examinations revealed that the mechanical stress on screws depended on the spacing and securing order during screw and rod fixation. In the case of skip pedicle screw fixation, the mechanical stress on screws was lower than that on screws inserted into every vertebra because the screws have a fewer number of constraints. In all cases, subsequently tightened screws displayed larger strains. Lower strains were generally observed in cases where vertebrae were skipped. These findings may help select the appropriate surgical approach when treating scoliosis patients with pedicle screw fixation.

Session	E1: Telemedicine & Healthcare
Date	Wednesday, 7 December
Time	2:00pm - 3:30pm
Venue	LT53

ID: A7-0006 **E1 : 1**

PROPOSAL OF INFANT AUTISM SCREENING SYSTEM BASED ON GAZE POSITIONS IN FACE MOTION PICTURE

Kiyotaka Fukumoto, Yoshinobu Ebisawa

Shizuoka University, Japan

We propose a type of quick screening system for infant autism based on the recent finding that infants with autism do not tend to look into mother's eyes, which performs by detecting in real-time where the infant tends to look at his/her mother's face. 3D coordinates of the mother's pupils are detected using a pupil detection system which we have developed. Two cameras in this system and a color camera are camera-calibrated. So, from the 3D pupil coordinates, the pupil positions on mother's face motion picture being simultaneously shot by the color camera are estimated. The mother's eyes- and the mouth-areas on the motion picture are determined based on the relative positions between the detected two pupils. The mother put the infant on her lap. The infants' gaze positions on the motion pictures presented on a PC screen are detected using our gaze detection system. In order to compensate the difference between the optical and visual axes of the eyeball, a gaze calibration procedure is accomplished by looking at just one quickly shrinking circular target presented at the center of the screen before the screening. This gaze calibration method would function well even if it applies to infants because the target strongly attracts the infant's attention onto it. The time ratios which the infant is gazing within the eyes- and mouth- areas are calculated automatically, and then are shown on the screen as autism indices. The time lag differences among the pupil and gaze detection systems and mother's face presentation are compensated. The experimental results showed that the detected gaze positions of infant's role healthy adult subjects concentrated in the small regions centering each of the eyes- and the mouth-areas of a mother's role subject even when the latter subject was moving the head laterally.

ID: A7-0005 **E1 : 2**

DEVELOPMENT OF TELEMEDICINE PLATFORM IN INDONESIA: A CASE STUDY OF TELEECG

Agung Setiawan[1], Astri Handayani[1], Yana Raharja[2], Richard Mengko[1]

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Cardiovascular disease is the leading cause of death in Indonesia (37% of the total number of deaths, WHO Non-Communicable Disease Country Profile, 2014). In 2014, 31% of this caused by coronary heart disease. In the treatment of coronary heart disease, there is golden hour, a period of 1 hour since the emergence of a heart attack in which medical interventions during this period can significantly affect the cure rate, life expectancy, and quality of life of patients. In conventional procedures, the patient treatment started in the emergency department of a hospital. Due to the distance and time to reach the emergency room, it provides delay time which reduces the effective period of the golden hour. US, Europe, and Japan began to introduce the concept of pre-hospital diagnostics for heart disease. Pre-hospital ECG to be very relevant to the situation in Indonesia where the death rate from heart disease is dominant and the location and traffic conditions, especially in large cities. Technically, the system is composed of the ECG signal measurement module that is connected to a management information system in emergencies through digital data communication devices. These systems have the ability to: (1) receive and delegate assignments ambulance units as reported cases of emergency admission, (2). facilitate communication between doctors at the referral hospital with the paramedics on the location of the patient (3). communicate the ECG signal measured in the ambulance online to doctors in hospitals, (4) to monitor the physical movements of the ambulance on the highway. The test bed will be conducted in Greater Jakarta. A sustainable business model for service telemedicine system has been designed in cooperation with third parties; as well as further system development framework in order to overshadow the management functions of a medical emergency wider in the future.

ID: A7-0008 **E1 : 3**

DEVELOPMENT OF PATIENT REMOTE MONITORING SYSTEM FOR EPILEPSY CLASSIFICATION

Sunil Kumar Prabhakar, Harikumar Rajaguru

Bannari Amman Institute of Technology, India

Epilepsy is one of the most commonly occuring neurological disorders and is characterized by hyper-synchronous neuronal firing. The unexpected and continuous electrical disturbances in the brain can be very disturbing to the patient thereby affecting the overall quality and happiness of the patient's life. Electroencephalography (EEG) signals helps in the analysis and diagnosis of epilepsy by recording the activities in the cortical regions of the epileptic patient. Epilepsy is characterized by the abnormal EEG signal flow. The recordings of the EEG signals are too huge to process and hence the necessity of dimensionality reduction is mandatory. The total number of epileptic patients analyzed in this work is twenty. Initially the

dimensions of the EEG data are reduced with the help of Fuzzy Mutual Information (FMI). The dimensionally reduced data is then transmitted with the help of a 2 x 2 Orthogonal Space Time Block Coded Multiple Input Multiple Output-Orthogonal Frequency Division Multiplexing (OSTBC MIMO-OFDM) system. As the OSTBC MIMO-OFDM System suffers a high Peak to Average Power Ratio (PAPR), a unique approach of Singular Value Decomposition Based Partial Transmit Scheme (SVD-PTS) is proposed to reduce the PAPR and Bit Error Rate (BER) at the receiver side. Also at the receiver side, Gaussian Kernel Based Support Vector Machine (G-SVM) with a Kernel value of 10 is utilized thoroughly in this work. The performance metrics such as Specificity, Sensitivity, Time Delay, Quality Value, Performance Index and Accuracy are analyzed here. Results show that an average accuracy of 95.38% is obtained, average perfect classification rate is 90.76%, time delay is 2.19 seconds and quality value is 20.53.

ID: A3-0006 **E1 : 4**

DESIGN AND PRELIMINARY ANALYSES OF A PPG BASED PULSE TRANSIT TIME (PTT) MEASUREMENT SCHEME

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An experimental prototype for measuring the pulse transit time (PTT) using two inline Photoplethysmographic (PPG) signals is presented in this paper. The measured PTT is employed to calculate the pulse wave velocity, which gives the proposed system an extensive utilization in monitoring arterial stiffness and continuous arterial blood pressure. The PPG sensors are placed in-line, 1.5 cm apart, over the digital artery. The time difference between PPG signals obtained from the two sensors is used to calculate the PTT. The signals from the sensors are band limited and amplified, which are then made TTL compatible to generate a rectangular pulse of width equal to the PTT. A phase-shifted sinusoid generated using an all-pass filter is used to validate the prototype. Measurements were done on 11 volunteers (4 Female and 7 Male volunteers in age group from 21 years to 52 years) for four consecutive cycles. The maximum relative error percentage of the experimental setup, when tested with phase shifted sinusoids was found to be 2.5% .The maximum deviation (standard deviation) in the measured PTT is 2.5 and the minimum deviation is 0.38.

ID: A4-0015 **E1 : 5**

PERFORMANCE ANALYSIS OF GMM CLASSIFIER FOR CLASSIFICATION OF NORMAL AND ABNORMAL SEGMENTS IN PPG SIGNALS

Sunil Kumar Prabhakar, Harikumar Rajaguru

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Photoplethysmography (PPG) is widely used to estimate the blood flow of skin by utilizing the infrared technique. Parameters such as blood pressure, oxygen saturation levels, blood saturation levels and cardiac output levels can be measured easily. As PPG is non-invasive in nature and it has a low production and maintenance cost, it is widely used in clinical practices. The performance analysis of Gaussian Mixture Model (GMM) as a post classifier is utilized in this paper for the classification of normal and abnormal segments in PPG Signals. The main objective of the paper is to identify normal and abnormal PPG Segments of the PPG waveform observed in the long time monitoring of the Physionet Database available online for a particular patient. The PPG Signals are sampled at 100 Hz. The PPG data sample length obtained is 1,44,000 and it is segmented into equal intervals comprising of 200 samples totally. Therefore the entire data consists of 720 segments. Totally ten different features such as mean, variance, standard deviation, skewness, kurtosis, energy, approximate entropy, peak maximum, maximum slope, and Singular Value Decomposition (SVD) are extracted and normalized. Based on the SVD values, each segment is labeled as normal or abnormal segment. The normalized features are given as inputs to the GMM classifier to classify the normal and abnormal segments in the PPG Signals. The performance metrics analyzed in this work are specificity, sensitivity, accuracy, precision and False Discovery Rate (FDR). Results show that

an accuracy of 98.97% is obtained, precision of 100%, nil FDR, specificity of 100% and sensitivity of 97.95% is obtained.

Session	SYM-02: Special Topic Symposium: Mechanobiology
Date	Wednesday, 7 December
Time	2:00pm - 3:30pm
Venue	Global Learning Room

ID: KN-0004 **SYM-02 : 1**

Sequences not confirm

MECHANOBIOLOGY OF MULTICELLULAR SYSTEM: MECHANOSENSITIVE ATP RELEASE IS A KEY MECHANISM THAT ORCHESTRATES COLLECTIVE CELL BEHAVIOR

Masahiro Sokabe

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In organisms mechanical forces regulate tissue and organ functions in a well-organized way, as typically observed in embryogenesis, would healing or local vasoconstriction. However, the underlying mechanism how cells are orchestrated remains elusive. Here we present an example in which mechanically induced cellular ATP release acts as a key signal that can orchestrate a multicellular system. ATP has been recognized as a ubiquitous autocrine/paracrine extracellular messenger regulating spatio-temporal behavior of a variety of tissues and organs. Interestingly, cellular ATP-release is often mechanosensitive, implying its important roles in mechano-signaling in multi-cellular systems. In lactating mammary glands, secretory epithelial (SE) cells form a milk-filling alveolus, and myoepithelial (ME) cells surround the alveolus in a basket form. In response to the increased serum level of the pituitary hormone oxytocin, ME cells undergo quick and strong contraction to squeeze milk out of the alveolus. One of the remarkable features of mammary SE cells is that they release ATP in response to mechanical stimuli. Stretched SE cells in an inflated alveolus filled with milk will release ATP. Thus alveoli are surrounded by a cloud of ATP when they are filled with milk. Extracellular ATP is known to lower the threshold serum concentration of oxytocin to induce ME cell contraction from 100pM to 10pM, via stimulating the metabotropic ATP-receptor P2Y1 expressed in ME cells. When a nipple is sucked by a baby, the peak level of serum oxytocin, which is originally secreted from posterior pituitary organ in response to mechanical stimuli (e.g., nipple sucking), is approximately 50pM. Thus only the milk-filled alveoli would contract and eject milk. This is a very smart mechanism to avoid abrupt depletion of milk in mammary glands at once, enabling continual breast feeding. ATP release and subsequent signaling are emerging factors indispensable for exploring mechanobiology of multicellular systems.

ID: E6-0004 **SYM-02 : 2**

THE CARDIAC INTERCALATED DISC: FROM CONTRACTION-EXCITATION COUPLING TO HEART REGENERATION?

Walter Hunziker

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The limited regenerative potential of the adult heart is a major challenge for the effective prevention of heart failure. Loss of cardiomyocytes (CMs) after heart injury such as myocardial infarction results in replacement of the wasted heart muscle with non-contractile fibrotic scar tissue, eventually leading to heart failure. N-cadherin based adherens junctions and desmocollin based desmosomes in the intercalated disc (ICD) provide mechanical coupling between CMs. I will discuss recent evidence that components of the ICD are not only important for mechanical coupling of CMs, but also suppress CM proliferation, possibly providing novel therapeutic targets.

ID: E6-0003 **SYM-02 : 3**

USE OF A LIGHT-INDUCIBLE ONCOGENE TO STUDY CELL COMPETITION

Isabelle Bonnet[1,2], Sarah Moitrier[1,2], Olivier Destaing[3,4], Pascal Silberzan[1,2],

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To preserve its function, epithelia must eliminate cells that undergo mutations. For example, when tumor cells are present in a healthy tissue, they will compete with the non-transformed cells. This competition results in the development of the tumor or its regression if the healthy tissue can overcome this threat via the extrusion of the transformed cells.

It is well accepted that interactions between transformed cells and their environment (including the normal neighboring cells) play an important role

in the early stages of the development of a tumor. However, the interplay of mechanical environment remains unclear as well as the understanding of the interactions between normal cells and a group of transformed cells.
We aim at studying the dynamics at the interface between normal and transformed cells in relation with its environment: mechanical state and oncogene activity. The key in these problems is to achieve a good control of the local environment and the initial conditions in space and time. Our strategy consists in a precise tuning of the oncogene transformation using a light-inducible oncogene combined to light patterning in order to create a precisely controlled interface between the two cell types.

We designed a stable MDCK "opto-Src" cell line: if these cells are not exposed to light, they behave like normal MDCK cells, but they overexpress Src oncogene when exposed to blue light. It is therefore possible to select a subset of cells to transform within a normal tissue, using targeted light. We observe that the activation of a circular patch of cells within a tissue gives rise to a budding 3D structure, and are currently characterizing this structure.

ID: E6-0002 **SYM-02 : 4**

ACTOMYOSIN CONTRACTILITY IS ESSENTIAL FOR CONTACT INHIBITION OF KERATINOCYTE PROLIFERATION

Hiroaki Hirata[1,2], Mikhail Samsonov[2], Masahiro Sokabe[1]

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Keratinocytes form multiple layers in the epidermis, providing a stable environmental barrier in the skin. Confluence-dependent inhibition of keratinocyte proliferation, termed contact inhibition, is crucial for epidermal homeostasis: loss of the contact inhibition in keratinocytes is thought to cause keratinocyte carcinomas, the second most common type of cancers in the United States. It has been appreciated that E-cadherin-mediated cell-cell adhesion plays a central role in inducing contact inhibition in epithelial cells. In addition, a growing body of research has revealed that intracellular and extracellular mechanical cues that modulate cytoskeletal tension affect proliferation of confluent epithelial cells. Here we report that among epithelial cells, keratinocytes possess a unique, actomyosin-dependent mechanism for contact inhibition. When actomyosin was inhibited, contact inhibition of keratinocytes was abrogated. While beta-catenin- and YAP-mediated gene transcription promotes proliferation of keratinocytes, actomyosin activity in confluent keratinocytes attenuated nuclear accumulation of beta-catenin and YAP, thereby inducing contact inhibition. Confluent keratinocytes developed E-cadherin-mediated punctate adhesion complexes, to which radial actin cables were connected via alpha-catenin. Eliminating the actin-to-E-cadherin linkage by depleting alpha-catenin increased proliferation of confluent keratinocytes. By contrast, their proliferation was attenuated by enforced activation of RhoA-regulated actomyosin or by external application of pulling force to ligated E-cadherin, suggesting that tensile stress at E-cadherin-mediated adhesion complexes inhibits proliferation of confluent keratinocytes. While proliferation of most adherent cells is regulated by mechanical interaction between cells and extracellular matrices, keratinocytes forming multiple epithelial layers might have developed a distinct mechanism mediated by tension at cell-cell junctions to regulate cell proliferation.

ID: D5-0002 **SYM-02 : 5**

MICROPATTERNED HUMAN PLURIPOTENT STEM CELLS FOR MODELING EMBRYONIC TISSUE PATTERNING AND PATHOGENESIS

Yi-Chin Toh

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Singapore Institute for Neurotechnology

Human pluripotent stem cells (hPSCs) have the remarkable differentiation and self-organization ability to mimic early embryonic tissue development. However, hPSC tissue patterning is often spontaneous in conventional spheroid or monolayer cultures, which limits their translation into standardized experimental models for developmental diseases and drug testing. Tissue patterning during embryonic development relies on the spatio-temporal control of soluble and mechanical environmental factors; although there are limited technologies that offer effective environmental control to spatially pattern stem cell fates.

We have recently demonstrated that stem cell

micropatterning can generate mechanical gradients via asymmetry in cell-cell and cell-matrix adhesions to direct the spatial organization of hPSC cell fates. Micropatterned hPSCs can undergo spatially organized differentiation and collective cell migration to form 3D ordered mesoendoderm and neuroepithelium structures. The micropatterned mesoendoderm structures were selectively disrupted by teratogenic (birth defect causing) compounds, which exemplifies its applicability as a teratogenic screening platform. In addition, we show that the micropatterned hPSC neuroepithelium structures can be related to neural tube morphogenesis to serve as a disease model for neural tube defects, a common class of human birth defects.

Session	A3: Wearable Devices
Date	Wednesday, 7 Decembe
Time	4:00pm - 5:30pm
Venue	Auditorium 2

ID: C5-0006 **A3 : 1**

NEXT-GENERATION SOFT ROBOTIC SOCK FOR ASSISTIVE DUAL-PLANE ANKLE EXERCISES

Fan-Zhe Low, Denise Kai Ying Eng, Jeong Hoon Lim, Chen-Hua Yeow

National University of Singapore, Singapore

Patients who suffer from stroke are often at risk of contracting the following medical conditions; Deep Vein Thrombosis where venous thrombus develops in the venous circulation of the lower extremity and occludes the normal flow profile, as well as increase spasticity of the joints of the lower limbs as seen by an increase in resistance to joint motion. These two conditions can affect the time to recovery post stroke resulting in necessary long term care provided by caregivers. One of the main reasons that these conditions can occur is due to long term lower extremity immobility as patients are bedridden, especially in the ankle joint where active ankle motion in a healthy person prevents such conditions from occurring. In this study, a new generation of soft robotic sock is presented where the device is able to provide assisted ankle dorsiflexion-plantarflexion and inversion-eversion exercises in a supine position to assist in the post-stroke recovery process. By using a combination of pneumatically controlled extension and bending actuators, the exercises can be provided to the patients starting from the moment the patients are warded in the hospital. Initial characterization of the actuators showed that when the actuators were inflated at 60kPa, the extension actuator constrained in a denim sheath extended by 62% of its original length and exerted a force of 29.8 ± 0.4N while the bending actuator exerted a force of 9.4 ± 0.3N. Subsequently, the device was tested on healthy subjects, where the device was able to achieve dorsiflexion-plantarflexion and inversion-eversion range of motion of 10.2 ± 3.2° and 19.7 ± 6.6° respectively. These data will be useful to determine the efficacy of such soft robotic targeted rehabilitation and its subsequent testing on stroke patients.

ID: C5-0004 **A3 : 2**

DEVELOPMENT OF A WEARABLE, EEG-BASED VIBRATION HEADBAND FOR ANXIETY AMELIORATION IN AIR-RIFLE SHOOTERS

Chaitanya Nair[1], Sharmila Jayakkumar[1], Edwin Chong[2], Chen Hua Yeow[1]

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Anxiety, a commonly occurring state of emotion in man, has been brought to attention by the scientific world today with finding new methods in battling stress given the foremost priority where electroencephalography (EEG) being one of the most recommended biomedical tests to monitor human emotions is currently in its advanced stage of research.In this work, we would like to share our findings about the cutting-edge hardware design proposed for stress monitoring and its alleviation in air-rifle shooters by recording the electrical activity of the brain followed by determining the mental state of the athlete from the readings obtained. A feedback-based network has then been implemented for the sole purpose of stress mitigation depending on the amplitude values, where a pair of vibrating motors has been used as a therapeutic measure. The newly devised EEG-based sports headband, comprises of a custom-made EEG sensor and a vibration motor circuit both driven on an Arduino-supported platform. The frontal lobe electrodes is responsible for picking brain signals which as a result are sensed and processed by the sensor circuit. The Arduino board, responsible for reading the sensor data, displays the data on a monitor screen wirelessly through a Bluetooth mode of communication where an RGB light emitting diode ingrained in the device serves as an indicator of signs of anxiety in the shooter. The motors, placed on either side of the head, precisely above the ears, simultaneously respond to the analog data from the

sensor by vibrating in a smoother fashion every time when the amplitude values exceed the threshold limit set in advance thus helping the shooter relax during the shooting trials and promising a higher performance.

ID: C5-0005 **A3 : 3**

MODULAR ORIGAMI-BASED SOFT PNEUMATIC ACTUATORS FOR A WEARABLE SUPERNUMERARY ROBOTIC ARM IN HUMAN-ROBOT COOPERATIVE TASKS

Khin Phone May, Marcelo H. Jr. Ang, Chen Hua Yeow

National University of Singapore, Singapore

Actuators, which are commonly used in conventional robotic technology, are assembled using “hard” materials such as metals. As such, these structures can weigh heavy and are rigid, making them unsuitable to perform delicate tasks or interact with humans. “Soft” robotic technology utilizes compliant materials to create “soft” actuators, which are commonly developed using elastomers as the functional material. The soft actuators would have internal chambers of variable design. Hence, when the actuator is activated by means of pneumatic or hydraulic source, the mode of actuation and the magnitude of force produced by the actuator can be controlled. The non-linearity of response enables the soft actuators to perform tasks such as grasping, which would otherwise be harder to achieve using conventional rigid actuators. This paper aims to further explore the materials, which can be used to build soft actuators. Thermoplastic polyurethane coated textiles are used to create modular units of origami-based airtight structures. Upon air pressurization, the pleated structure of each module of actuator would unfold and the inflated pleats would exert compressive force against the wall of the adjacent actuator unit. Upon serial arrangement of these modular pleated actuators, the mode of the actuation of the structure and the resultant force generated can be customized. Experimental analysis is carried out to analyze the behavior of the actuator, i.e. range of curvature and the force generated, under different pneumatic pressure. The array of pleated actuators can be integrated with inflatable beam modules to be further developed into a wearable supernumerary robotic arm for human-robot cooperative tasks.

ID: C5-0011 **A3 : 4**

3D-PRINTED SOFT WEARABLE ROBOTIC EXOSKELETON – TOWARDS A HIGHLY CUSTOMIZABLE AND PERSONALIZED ASSISTIVE AND REHABILITATION DEVICE

Hong Kai Yap, Chen Hua Yeow

National University of Singapore, Singapore

The last decade has seen developments of robotic technology with the ability to carry out repetitive tasks have long been in use to assist caregivers in the rehabilitation process. The exoskeleton is one of such devices but these devices are traditionally rigid and uncomfortable during the period of wearing. Additionally, it is currently limited to clinical environments, thus patients often have a hard time to continue receiving therapy when they go back home. Thus, there is a need to develop a device that can be used in a clinic at the beginning, and then can be brought back home to continue daily therapy. The development of soft robotic exoskeleton provides a more comfortable method of carrying out rehabilitative exercises. They are flexible in nature and does not restrict the movements for increased comfort during use. By enabling a low profile and lightweight device, the patients will have increase access to high doses of rehabilitation therapies and greater chances to recover.

This work presents a novel technique for direct 3D printing of soft wearable exoskeleton using 3D printers. Existing fabrication techniques for the components of wearable exoskeleton, such as soft pneumatic actuators, are normally time-consuming and involve multi-step processes. A low-cost open-source consumer 3D printer and a commercially available printing material were identified for printing soft pneumatic actuators with complex inner geometry and high degree of freedom. We characterized the performances of the actuators in terms of their bending capability, output forces, and durability. Using the 3D printed actuators, we have developed wearable hand and wrist exoskeletons that are highly customizable and personalized to the users. The proposed technique is the first-in-class approach to directly 3D print soft pneumatic actuators for wearable robotic exoskeleton applications.

ID: C5-0007 **A3 : 5**

FACTORS INFLUENCING PULSE PRESSURE IN RADIAL ARTERY TONOMETRY: A DEVICE DESIGN PERSPECTIVE

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Indian Institute of Technology Delhi, India

The technology for acquiring pressure pulses from

a peripheral artery using the principle of applanation tonometry has been around for a while now. Under stable conditions, arterial tonometry can faithfully give the right pulse waveforms that can be calibrated to a blood pressure (BP). Quite a number of products have come up in the market with varying degrees of accuracy and use case. This is because the focus now has started to shift from discreet two-value BP readings to pulse waveforms, as the latter is more representative of a number of hemodynamic and physiological parameters. However most of the available devices are very expensive and used only in physiology labs for the purpose of research. Moreover the devices are like black-boxes as neither the clinicians can calibrate them with a gold standard in case of spurious readings, nor the engineers can modify them to improve efficacy. Therefore there is need for a detailed study to identify factors influencing tonometric readings from a device development perspective. We have developed a device supported by detailed underlying computational analysis that enables measurement of pressure pulses in the radial artery using off-the-shelf tactile-based pressure sensor. In this work, we present some of the factors affecting pulse pressure reading from radial artery in the context of device design. Specifically, we evaluate factors such as sensor position on the artery, hold-down pressure and orientation, extension of the wrist, and material and geometry variability and its relationship with specific device design. Also the factors influencing calibration of pressure pulses to the BP are identified and discussed

ID: C4-0012 **A3 : 6**

THE DESIGN OF A RECONFIGURABLE TEXTILE-BASED BENDING ACTUATOR USING MODULAR BLADDERS FOR SOFT ROBOTIC EXOSUITS

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The action of externally mounted, pneumatic bladders, attached to a flexible air channel, is utilized as a soft robotic bending actuator. A series of these bladders are plugged into the actuator and are simultaneously inflated that cause interference between the inflated bladders. The interference generates pushing forces, which in turn facilitate the bending of the flexible, non-expanding air channel. The nature of the bladders allows them to be detachable, hence, enabling the actuator to be fully reconfigurable. Soft robotic bending actuators typically possess only one curvature profile such that if a different profile is desired, the actuator must be completely redesigned and reconstructed. In contrast, the use of modular bladders permits them to be interchanged as needed, which allows the textile-based bending actuator to be customized and specialized for a particular purpose. Bladders featuring varying geometries can also be combined to create a curvature profile with multiple bending radii and angles. Such features are beneficial to robotic exosuits as these suits can now be tailor fit to the various anthropomorphic variabilities between different users by simply removing the current bladders and installing more appropriate ones. The bladders are constructed out of laminated textile sheets, joined together by thermal bonding. This work discusses key design considerations as well performance metrics, describing the capabilities of the actuator.

Session	B3: Biomaterials II
Date	Wednesday, 7 December
Time	4:00pm - 5:30pm
Venue	LT50

ID: D2-0003 **B3 : 1**

SCAFFOLDS PRODUCED OF RECOMBINANT SPIDER SILK PROTEINS FOR TISSUE ENGINEERING

Tamara Bernadette Aigner, Stefanie Wohlrab, Kristin Schacht, Elise Desimone, Thomas Scheibel

Universitaet Bayreuth, Germany

Spider silk is an excellent material for biomedical applications as it is biocompatible, biodegradable and hypoallergenic. In order to provide consistent and reproducible material qualities, a biotechnological approach for the production of recombinant spider silk proteins has been developed using E. coli. Materials made of recombinantly produced spider silk protein eADF4(C16) (engineered Araneus diadematus fibroin 4) display low adhesion and proliferation properties when tested in presence of different cell lines such as mouse fibroblasts (BALB/3T3). These limitations were overcome by the genetic introduction of the integrin recognition sequence RGD into eADF4(C16). This resulted in a significant improvement in cell attachment and proliferation on spider silk films and hydrogels. Furthermore, structured eADF4(C16)-based scaffolds promoted directional growth in addition to enhanced cell attachment even in the absence of the RGD-domain. Another approach used non-woven meshes of eADF4(C16) to provide a topographic surface for fibroblasts allowing their adhesion and proliferation.

Building on these designed genetic and morphological features, new approaches can be investigated to control cell interactions.

ID: D2-0004 **B3 : 2**

TOWARDS BIOFABRICATION OF RECOMBINANT SPIDER SILK PROTEINS FOR BIOMEDICAL APPLICATIONS

Elise DeSimone, Kristin Schacht, Tamara Aigner, Gregor Lang, Thomas Scheibel

Universitaet Bayreuth, Germany

Traditional tissue engineering, the most widely accepted solution for tissue regeneration or replacement, has yet to be widely applied in the clinical setting. This is due to its many acknowledged disadvantages, for example low seeding density of cells, low control over scaffold architecture and tissue-like constructs are difficult to manufacture. A promising solution is biofabrication, the simultaneous processing of cells and biomaterials. However, there is a critical road-block to wide-spread use of biofabrication: there is a lack of process-compatible materials. Recombinant spider silk proteins have high biocompatibility, superior mechanical properties, and can be modified with cell adhesion motifs to further enhance their bioactivity. These proteins have thus far been processed into foams, fibers, particles, microcapsules and hydrogels. Additionally, thermally-gelled hydrogels have already been utilized as the biomaterial component of a bioink for 3D bioprinting. Therefore, recombinant spider silk proteins represent a versatile biomaterial for application in biofabrication. However, as with most biopolymers, most of the established processes for producing different scaffold morphologies are not cytocompatible due to extreme physical (e.g. high voltages, high salt concentration) and/or chemical (e.g. toxic solvents) conditions. Additionally, producing scaffolds from cytocompatible processes (e.g. aqueous solvent systems) is attractive due to the ability for safe-handling and often the resulting structures are softer, and therefore more tissue-like. The objective of the presented work is to modify and optimize the handling of recombinant spider silk proteins for their use in biofabrication, in particular towards 3D bioprinting and electrospinning. Results in materials characterization as well as cell culture studies indicate that recombinant spider silk proteins are promising to be implemented in biofabrication. It can therefore be concluded that these proteins could provide a valuable tool for various biomedical engineering applications in the future.

ID: D2-0007 **B3 : 3**

ENGINEERING STRIP-TYPE DEVICES FOR LOW-STIMULUS TEAR COLLECTION

Yong Chan Cho[1], Seung Ho Lee[2], Young Bin Choy[1,2,3]

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Non-invasive diagnosis and self-monitoring of diseases have been considered as a new paradigm in healthcare. In this sense, basal tear can be a promising target for its high correlation with many disease markers. However, collection of basal tear is uneasy as eye surface is very sensitive. With currently-available methods, collection is very slow (1 µl/min), needing a long-time contact, hence discomfort or pain to patients. Therefore, reflex tear production and tissue damage would be highly probable, which may dilute concentration of disease markers. For this reason, tear is collected with professionals in hospital, with topical anesthetics.
To resolve this, we sought to establish a proper design for the collector tip that is in contact with the eye surface for low-stimulus collection of basal tear. Considering less sensitivity, we chose inferior palpebral conjunctiva (IPC) as the region for tear collection. In this work, we fabricated the tip in round flat shape, where edges were also rounded. We prepared 3 distinct tip areas (i.e., A1 (area: 1π/4 mm2), A3 (area: 3π/4 mm2) and A4 (area: 4π/4 mm2)) and pressed each against the IPC at depths of 2, 3 and 4 mm. Area of damaged tissue and time for recovery were assessed.
Our findings showed that no tissue damage was inflicted by the A4 strip with pressing depth from and below 3 mm (pressure: 19.70 kPa). At 4 mm pressing depth, the tissue damage was not severe and was recovered in less than 4 h. For the A1 strip, severe tissue damage was observed from and above 3 mm, which took more than 8 h to be recovered. Our results, therefore, demonstrated that among the A1, A3, and A4 strips tested in this work, the A4 strip with the largest contact area was most promising for low stimulus tear collection from the IPC.

ID: D2-0019 **B3 : 4**

A NOVEL COATING TECHNIQUE FOR IMPROVING IN-VIVO BIOAFFINITY OF IMPLANT MEDICAL DEVICES

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Sciences, Tohoku University, Japan

Lifestyle-related disease, leading to arteriosclerosis, chronic kidney disease, and so on, becomes a serious problem in the aging society. Many kinds of implant medical devices are required for treatments of those diseases. Although cytotoxicity and biocompatibility of materials used in the devices have been evaluated, their bioaffinity, which indicates high cellular adhesiveness and tissue connectivity, has been treated as unimportant. Recently, surface modification by plasma or chemical processes has been used to improve bioaffinity of the implant devices. However, there are a lot of problems, for examples: these methods take cumbersome procedure; the target and the biological molecules possible to use for modification are limited. Considering these problems, we developed a novel coating technique of biological molecules for improving in-vivo bioaffinity of the implant devices. We can easily coat a biological molecule onto the surface of the target without the surface modification by treating and excessively charging an aqueous solution of the molecule with plasma discharge. We also verified the mechanism coating the biological molecule onto the target surface using measurement of contact angle of the treated solution. Based on the measurement of the contact angle, a mode of wettability transits from "adhesion wetting" to "immersional wetting" because of change in the surface tension of the solution charged with the plasma discharge. Consequently, the target surface can efficiently get a wetting for the solution of the biological molecule. Using the technique developed in this study, we evaluated its effect on cellular adhesiveness to a hydrophobic silicone coated cover glass. In the case of coating the hydrophobic cover glass with 50 μg/ml collagen solution, the developed technique led to significant increases in cellular adhesiveness and proliferation in comparison with coating of non-treated collagen solution.

ID: D5-0020 **B3 : 5**

DEVELOPMENT AND BIOLOGICAL EVALUATION OF A SPRAYING DEVICE FOR AUTOLOGOUS PLATELET-RICH BLOOD DERIVATIVES

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Autologous Platelet-Rich Blood Derivatives are used in a variety of medical fields, such as sports medicine, orthopedic surgeries and wound healing. Especially the enhancement of wound healing by applying growth factors released from platelets is a promising application. Chronic wounds often affect large areas and treating the whole surface with autologous platelet-rich blood derivatives can be achieved by spraying. Platelet activation during spraying should be held low to allow a physiological release of growth factors at the wound site.

In this study we present a compact, self-contained, and aseptic spraying device without any external connections such as a power supply or compressor. The biocompatible propellant R134a (1, 1, 1, 2-tetrafluoroethane) is used to aspirate and atomize the blood derivatives, which can be filled into a contained reservoir via a three-way valve. A two-substance nozzle designed for production using Multi Jet Modeling (MJM) functions as the operating unit, throttle, mixing zone and atomization unit. The valve of the aerosol can is directly connected to the nozzle enabling the release of R134a when operated. A diameter reduction of the propellant channel adjusts the inlet pressure using the Venturi principle and enables self-priming conditions for the blood derivative. The blood reservoir is connected to the nozzle by a flexible tube.

Biological evaluation was determined by flow cytometry comparing platelet activation in the blood derivatives before and after spraying. Scanning electron microscopy was used to determine the distribution of the platelets in the spraying process and the morphology of the sprayed blood cells.
The results indicate that the developed spraying device has low mechanical impact on the cellular components of the blood derivatives and is a promising tool for applying evenly distributed platelet-rich blood derivatives to large wound sites.

Session	C3: Computational Bioengineering II
Date	Wednesday, 7 December
Time	4:00pm - 5:30pm
Venue	LT51

ID: KN-0008 **C3 : 1**

PREDICTION OF RHEOLOGICAL MECHANICAL PROPERTIES OF INTERVERTEBRAL DISC USING QUANTITATIVE T2 MR IMAGING METHOD

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Background: The disc is an anisotropic biphasic

organ. The time-dependent behavior may result from interactions between the solid and fluid phase of tissue. The T2 mapping techniques can provide information about the interaction of water and the collagen networks, hence may be an indicator for the biomechanical properties of disc. The purpose of this study is to find the correlation of T2 relaxation time in respect to the rheological and viscoelastic properties of disc.

Materials and Methods: 55 healthy porcine thoracic discs were imaged using a 3T MRI scanner. The T2 relaxation time of NP and AF were acquired. After MRI scanning, discs were dissected for mechanical tests. To find the rheological properties of discs, the creep tests were performed (1 hour 0.8 MPa) and the linear biphasic model was used to find the aggregate modulus and hydraulic permeability. The Dynamic Mechanical Analysis tests were conducted to find the viscoelastic properties. The discs were applied with 0.1~0.8 MPa compressive stress at frequencies from 0.03 to 10Hz. The phase angle of discs was acquired after the test. Pearson correlation was performed to correlate between T2 and disc biomechanical properties. A p-value less than 0.05 was considered to be significant.

Result: Significant correlations were found between the disc permeability and T2 value of NP, but not in AF. No significant correlations were found between the aggregate modulus and T2 values of both NP and AF. The phase angle significantly correlates with the T2 values of AF, particularly at 0.03, 0.1, and 0.3Hz.

ID: E3-0020 **C3 : 2**

HEMODYNAMIC ANALYSIS OF CAROTID ARTERY BIFURCATION USING FLUID-STRUCTURE INTERACTION FRAMEWORK

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Carotid Artery Aneurysm is a diseased condition which results in a bulging out of the weaker area of carotid artery. Aneurysm possesses the risk of breakage which may lead to brain hemorrhage or stroke. Hence, patient specific numerical study to understand this disease progression is important. In this paper, we present a Fluid-Structure Interaction (FSI) method to numerically investigate the hemodynamics of a compliant patient specific carotid artery bifurcation model. A partitioned based strongly coupled two-way approach is used to separately interact the fluid solver and structural solver. Galerkin Finite Element Method is used to solve Navier Stokes Equation while an Arbitrary Lagrangian Eulerian (ALE) formulation is used to predict the mesh movement. Newmark scheme was employed to solve the dynamic equilibrium equations for linear elastic solid arterial wall. Blood was modeled as pulsatile, cyclic and Non-Newtonian fluid using Carreau model while the arterial wall is assumed to be linearly elastic, isotropic and incompressible. The role of flexible arterial wall thickness and wall material stiffness on the dynamics of the blood flow is investigated. The significance of wall shear stress, arterial wall deformation, velocity contours and pressure variation across the artery length are studied at the bifurcation and at critical locations such as aneurysm. The results obtained matches adequately with the general flow pattern observed in literature. In conclusion, this study shows the importance of numerical methods to study patient specific hemodynamics of arterial blood flow to better understand the disease progression.

ID: E3-0028 **C3 : 3**

NUMERICAL SIMULATION OF A SPERM CELL IN SHEAR FLOW NEAR AN INFINITE BOUNDARY WALL

Toshihiro Omori, Takuji Ishikawa

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Mammalian sperm cells must find and keep right swimming directions during their journey from ejaculation to fertilization to fin the egg cell. Though many researchers have investigated sperm motility and various long-distance navigation mechanism were proposed (eg. chemotaxis, thermotaxis), it is still not clear how sperm cells find the correct swimming direction. Recently, one possible mechanism, rheotaxis was observed experimentally, and fluid mechanics has become a subject of growing importance in sperm motility. In this study, we numerically investigated sperm cell locomotion in shear flow near a boundary wall, and clarified how fluid flows affect on the sperm motility.

Due to small size of sperm cells, fluid motion around the cell can be assumed as Stokes flow and flow field is described by a boundary integral equation, which was solved by a boundary element method. We also assumed force-free and torque-free conditions of sperm cell swimming. To mimic former experimental studies, the sperm cell near plane wall was simulated. The results showed that, under shear flow, the sperm is able to hydrodynamically change its swimming direction, allowing it to swim upwards against the flow. Which suggests that the upward swimming of sperm

cells can be explained using fluid mechanics, and this can then be used to further understand physiology of sperm cell navigation.

ID: E3-0006 **C3 : 4**

ANALYSIS OF THE INFLUENCE OF SUBSTRATE PROPERTIES AND FOCAL ADHESION FORMATION ON THE STRESS FIBRE GROWTH AND REORIENTATION IN CONTRACTILE CELLS

Pradeep Keshavanarayana[1], Rene De Borst[2], Martin Ruess[1]

[1]University of Glasgow, UK; [2]University of Sheffield, UK

Contractile cells play a prominent role in the adaptive nature of biological tissues. Contractility is mainly attributed to the growth of the tension dependent acto-myosin network called stress fibres within the cytoskeleton. Stress fibres extend along the length of the cell and end on the cell membrane at focal adhesions. Integrin proteins at the junctions of focal adhesions are capable of sensing the environment, thereby making the cellular behaviour dependent on the cell supporting substrate. The formation of the integrins, through a series of chemical reactions, influences the concentration of calcium ions in the cytoplasm. The growth of stress fibres is governed by the calcium thus present, and the contractile stresses. It has been observed that the growth of stress fibres influence focal adhesions and vice-versa, resulting in a continuous cross-talk between different processes in the cell. Recent experiments have shown that cells subjected to uni-axial cyclic loading reorient itself in a direction away from the loading direction, exhibiting strain avoidance.

Mathematical models are necessary to understand the dependence of cellular behaviour on the substrate properties along with the feedback mechanisms and are further used in designing the in-vitro experiments. The coupling of the models for stress fibres and focal adhesions results in a non-linear bio-chemo-mechanical problem.

In this contribution, we present the positive influence of the growth of focal adhesions along with a mechanosensitive feedback loop on the reorientation process. We use a non-linear Hill-type model to capture the growth of active stress involved in the evolution law for the stress fibres and a thermodynamical approach to model the focal adhesions. A highly stable monolithic solution scheme with flexible time steps is used to solve the governing coupled system. Finally we compare our simulation results with experiments in regard to different substrate properties and loading conditions.

ID: E3-0019 **C3 : 5**

TWO-DIMENSIONAL NUMERICAL SIMULATION FOR THE EFFECT OF CAPSULE ELASTICITY ON ITS BEHAVIOR NEAR A PLATE IN A FLUID UNDER AN INCLINED CENTRIFUGAL FORCE FIELD

Suguru Miyauchi[1], Toshiyuki Hayase[1], Luca Brandt[2], Fredrik Lundell[2], Shervin Bagheri[2]

[1]Institute of Fluid Science, Tohoku University, Japan; [2]KTH Royal Institute of Technology, Sweden

Blood flow in microcirculation plays an important role in mass transfer, such as the supply of nutrients and the collection of waste. In microcirculation, diameters of blood vessels are smaller than the size of an erythrocyte, and it is considered that complex interactions occur between the erythrocytes and the endothelial cells on the blood vessels. For elucidation of the interaction, frictional characteristics of erythrocytes on material-coated and endothelia-cultured plates were measured by an inclined centrifuge microscope. In our previous study, the frictional characteristics for the material-coated plates were properly explained by a numerical simulation mimicking the experiment. The study assumed a rigid erythrocyte model with a flat bottom surface, but the validity of this assumption has not yet been confirmed. It should, therefore, be clarified how a real erythrocyte deforms and behaves in the inclined centrifuge microscope. As the fundamental consideration, the purpose of this study was to clarify the behavior of an initially circular elastic capsule near a flat plate in a fluid under the effect of inclined centrifugal force by two-dimensional fluid-structure interaction analysis. An immersed boundary method was employed to treat the interaction between the fluid and membrane. Numerical results showed that the bottom side of the capsule becomes flat with an attack angle in the equilibrium state. These results support the assumption used in the previous study. Rotational motion, or tank-treading motion, was observed for the capsule. The present results also clarified the effects of elasticity on the translational and rotational velocities and the distance from the plate for the capsule.

Session	D2: Orthopaedic Biomechanics
Date	Wednesday, 7 December
Time	4:00pm - 5:30pm
Venue	LT52

ID: E5-0002 **D2 : 1**

MULTISCALE MECHANICS AT BIOLOGICAL INTERFACES

Guy Genin

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The effective interfacing of dissimilar materials is a key challenge in physiology, surgical repair, and engineering structures. A central issue at such interfaces is the point at which a phase of or a cell population within soft, active biological tissues reaches a percolation threshold. We believe that a number of physically based pathologies are associated with the approach to percolation. The talk will begin with a broad summary of pathologies of percolation, and proceed to detail our group's work on the attachment of tendon to bone. Here, the healthy body presents a smooth gradient in mineralization but a non-monotonic gradient in stiffness to ameliorate high stresses at the bi-material interface. Neither healing nor surgery recreates this attachment, possibly explaining the relatively high rates of reinjury experienced by patients with rotator cuff tears. We describe key toughening and strengthening mechanisms, and describe how these can be reconstituted in surgical grafts and repair.

ID: E5-0006 **D2 : 2**

THE STUDY OF THE EFFECT OF HIP ABDUCTOR STRENGTHENING EXERCISES ON BIOMECHANICS OF SUBJECTS WITH PATELLOFEMORAL PAIN SYNDROME

Desmond Y.R. Chong[1], Xueli Wu[2], Jason Y.M Choi[3], Raye C.H Yeow[2]

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Patellofemoral Pain Syndrome (PFPS) is one of the most common knee joint disorders affecting physically active individuals, with higher incidences in young adults and adolescents. Symptoms include pain around and behind the kneecap exacerbated during daily activities such as stair ascend and descend. More recently, hip muscle weakness was identified in PFPS patients. Following which, hip abductor strengthening was suggested as a viable alternative to traditional conservative treatments. However, very few researchers have quantified the effects of hip muscle strengthening exercises. Thus, the aim of the study was to investigate the effects of hip-abductor strengthening on kinematics and muscle activities of PFPS subjects during stair ascend and descend. Fourteen participants (8 female, 6 male) with PFPS were recruited and placed on a 6-week hip-abductor strengthening programme. Peak hip adduction and internal rotation angles, peak knee valgus angle, gluteus medius strength, vastus lateralis (VL) and vastus medialis oblique (VMO) onset time difference, iliotibial band (ITB) flexibility (measured by Ober test) results as well as pain and functionality scores were assessed on initial evaluation and at post-intervention. Paired t-test was used to assess the outcome measures between baseline and post-intervention ($p<=0.05$).
Pain, functionality, ITB flexibility and VL versus VMO onset time difference were significantly improved following the intervention. Gluteus medius muscle activity level was increased significantly. Peak hip adduction and knee valgus angles showed significant reduction from baseline, while no significant change was observed in the peak hip internal rotation angle post-intervention. In conclusion, the 6-week hip-abductor strengthening exercise was effective in relieving knee pain and improving functionality in PFPS subjects. Simultaneously, an increase in gluteus medius strength and ITB flexibility, altered VL-VMO onset time difference and a decrease in peak hip adduction and knee valgus angles were observed, leading to reduced lateral patella mal-tracking thus relieving knee pain.

ID: E5-0008 **D2 : 3**

FLUID STRUCTURE INTERACTION STUDIES OF THERMAL SPRAY COATING ON A TITANIUM ALLOY

Rohit Chaudhari, Vrushabh Sawant, Davidson Jebaseelan, Sreekanth Dondapati

VIT University, Chennai Campus, India

Titanium alloys are used widely as biomaterials in implants and are coated by thermal spraying process because of its several advantages. Thermal Spray coating is carried out at high temperature, which results in generation of residual stresses, the resulting thermal stresses and temperature difference. Literature indicates that coating thickness is an important parameter for thermal stresses and impact stresses also contributes amount of residual stresses. So this study makes an attempt to quantify the relationship between them.

Methodology: Impact analysis and Transient thermal cases are solved simultaneously in this technique, equivalent stresses are known to be residual stresses. Substrate material is taken as Ti-6Al-4V and coating material are taken as Yttria Stabilized Zirconia (YSZ), Hydroxyapatite and Mixture of both as Hydroxyapatite with 10%, 20% of YSZ. The computation of residual stresses by Fluid Structure Interaction(FSI) in done using LS-DYNA. Simulation is done for by varying the droplet sizes. Residual Stresses are computed for each case and compared among different coating Combinations.
Results: Residual stresses are maximum for YSZ for respective drop size whereas it is minimum for Pure HA. Mixture of HA with 10% YSZ shows residual stresses slightly greater than that of HA. Also, HA and 20% YSZ shows residual stresses than previous combination but less than pure YSZ. So, pure YSZ provides more rigidity than any other combinations and pure HA is quite brittle. Also, stresses generated are maximum at contact surface between substrate and sprayed material.

Conclusion: YSZ coating provides rigidity to substrate whereas HA is brittle. We can use mixture of both by varying quantity of both as per rigidity requirement. Hence quantity of YSZ can be varied as per rigidity requirement of an application.

ID: E5-0009 **D2 : 4**

DEVELOPMENT AND VALIDATION OF 3D FINITE ELEMENT MODEL OF THE HUMAN KNEE JOINT FOR TIBIO-FEMORAL CONTACT ANALYSIS

Shriram Duraisamy, Subburaj Karupppasamy

Singapore University of Technology and Design, Singapore

A three-dimensional (3D) finite element (FE) model of the human knee joint was developed and validated to study the biomechanical behavior of tibio-femoral contact forces and pressures in different loading conditions. Knee sub-structures including distal portion of femur, proximal tibia, lateral and medial meniscus, articular cartilage of both femoral condyles and tibial plateau, the anterior and posterior cruciate ligaments, and the lateral and medial collateral ligaments were semi-automatically segmented from the MR Images (Open Knee project) using an in-house developed medical modeling software program. 3D geometries of those sub-structures were reconstructed from the segmented data to build a 3D FE model. In the computational model, bones (femur and tibia) were modeled as rigid bodies, cartilage and menisci were modeled as elastic materials, and ligaments were modeled as isotropic and hyperelastic materials represented by an incompressible Neo-Hookean behavior. For all analyses, bones were meshed with tetrahedral elements, while the soft tissues were meshed with 8-noded hexahedral elements. For all the kinematic simulations, the femur component was not constrained in all degrees of freedom (three translations and rotations) except flexion, while the tibia was fixed. Contact forces and pressures in the tibio-femoral joint obtained from the developed computational model were validated with experimental measurements in the literature. At 1000 N load at 0° flexion and 15° flexion, the maximum contact pressures predicted on the tibial cartilages were 6.209 MPa (3.5% deviation from the experimental value) and 5.895 MPa (0.5% deviation from the experimental value). Such a validated model will facilitate in depth understanding of various joint injury mechanisms and their impact of knee sub-structures.

Keywords: biomechanics, finite element, human knee joint, contact pressure

ID: E5-0015 **D2 : 5**

COMPARING THE PRESSURES ON THE ARTICULAR CARTILAGE IN INTACT AND MENISCECTOMIZED KNEE JOINTS USING FINITE ELEMENT ANALYSIS

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Injuries to the menisci are the second most common injury to the knee. The higher level of contact stresses on the articular cartilage after meniscectomy predisposes the knee to an increased risk of osteoarthritis (OA). Prevalence studies have shown that injuries are more common in the medial meniscus than the lateral meniscus due to its inherent anatomical disadvantage of being less mobile and having smaller articular surface. In this study, we investigated the effect of total meniscectomy (complete removal of medial meniscus) on the articular cartilage pressures using an experimentally validated 3D finite element (FE) model of the human knee joint. MRI extracted 3D geometric model of the knee joint, from the Open

Knee project, was used to build the FE model. We have modeled the femur and tibia bones as rigid bodies, articular and meniscal cartilages as elastic materials, and ligaments as isotropic and hyperelastic materials. Three different conditions were considered: an intact tibio-femoral joint, a tibio-femoral joint after total meniscectomy with no pre-tension applied to the medial collateral ligament, and a tibio-femoral joint after total meniscectomy with pre-tension applied to the medial collateral ligament. The computed results showed that the cartilage pressure was significantly higher in tibio-femoral joints with total meniscectomy than in the intact tibio-femoral joint (8.11MPa Vs 7.70MPa vs 6.20MPa). When compared the two different conditions after total meniscectomy, the model with pre-tension applied to the medial collateral ligament provides balanced force distributions. These results could lead to understanding contribution of mechanical factors in cartilage degeneration after meniscectomy.

Keywords: cartilage pressure, finite element, knee joint, osteoarthritis

Session	SYM-03: Special Topic Symposium: Engineering Biology / Synthetic Biology
Date	Wednesday, 7 December
Time	4:00pm - 5:30pm
Venue	LT53

ID: KN-0011 **SYM-03 : 1**

SYNTHETIC BIOLOGY – BIODESIGN, WITH EXAMPLES FROM BIOMEDICINE

Richard Kitney

Imperial College London, UK

Since the turn of the century, a new field called synthetic biology is been developing - based on the confluence of engineering and biology. Synthetic biology is based on the engineering principles of modularisation, characterisation and standardisation - and a systematic design approach, using what is known as the synthetic biology design cycle. The rapid development of the field is based upon the ability to rapidly and accurately read DNA and, increasingly today, to accurately write chemically based DNA – the process of DNA synthesis.

Broadly speaking, the field of synthetic biology divides into the two fundamental areas of research and development (namely, platform or foundational technology), and applications. The development of platform technology relates to concepts in terms of bio design and the engineering principles of modularisation, characterisation and standardisation. Key elements of this approach will be described, particularly in the context of characterisation and the development of information systems and technical standards for synthetic biology. The development of a web-based information system (SynBIS) and a new technical standard for synthetic biology called DICOM-SB, based on the international DICOM standard will be described. These two areas are important because of the need for reliable components (BioParts) in the development of biologically-based devices. Hence, the accurate characterisation of components is the key to better design and reproducibility. In this context, DNA foundries are an important development because they allow much greater accuracy in terms of component description, leading to much better reproducibility and reliability. The improvements achieved with DNA foundries result from the use of standard operating procedures and protocols, together with extensive automation.

The presentation will also cover areas of application of synthetic biology, with examples biomedicine. These will include biosensors, bio-logic circuits and other applications, including vaccines. The potential for development of theranostic procedures will also be discussed.

ID: F5-0002 **SYM-03 : 2**

ENGINEERING E. COLI TO SENSE AND KILL VIBRIO CHOLERAE, HUMAN PATHOGEN CAUSING THE CHOLERA DISEASE

Chueh Loo Poh[1], Maciej Holowko[2], Prem Jayaraman[2]

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The cholera disease, caused by the Vibrio cholerae bacteria, is still claiming thousands of human life's every year in developing countries, particularly in Asia and Africa. However, being recognised by WHO as a major threat to public healthcare it still lacks a therapy

that would efficiently address the cause of the disease. Likewise, cholera preventive methods, including vaccines, are also characterized by low efficacy.

To address the problem, we are engineering a probiotic bacterium, Escherichia coli Nissle strain, which would be able to sense and kill V. cholerae in our human gastrointestinal tract. A key genetic module in such an engineered bacterium is the sensor which would be able to sense V. cholerae and produce a measurable output upon detecting V. cholerae. To this end, we have repurposed and rewired the native CAI-1 based quorum sensing pathway from V. cholerae in E. coli. We designed and constructed a synthetic genetic sensor to detect CAI-1, the quorum sensing molecules produced by V. cholerae. Results show that the sensor was able to produce detectable changes in the presence and absence of V. cholerae supernatant. As this quorum sensing pathway is activated in absence of V. cholerae and repressed in its presence, we have also developed and layered a CRISPRi based inverter to invert and amplify the signal. This enables the sensor to be activated in the presence of V. cholerae. This sensor would then be used to drive the expression of antimicrobial payload upon V. cholerae detection.

ID: F2-0001 **SYM-03 : 3**

NEW WINE FROM OLD BARRELS: REPURPOSING BIOLOGY THROUGH SYNTHETIC ENZYMOLOGY

Wen Shan Yew

National University of Singapore, Singapore
Yong Loo Lin School of Medicine, Singapore

Singapore Consortium for Synthetic Biology, Singapore

Synthetic enzymology is an enabling discipline within synthetic biology. One of the most commonly required functions of synthetic biology is the production of biochemicals such as polyketides. Polyketides are a large class of biomolecules that are naturally produced by bacteria, fungi and plants, and include many clinically important biomolecules with anti-cancer, anti-microbial, anti-oxidant and anti-inflammatory activities. They are biosynthesized from acyl-CoA precursors by polyketide synthases (PKSs), and due to their chemical complexity, are not easily synthesized and structurally manipulated by chemical means. In order to fully realize the potential and use of synthetic biology in the biochemical production of polyketides, toolkits for enzymatic biosynthesis (and the enabling platform technologies that describe these toolkits) must be developed and made available to the synthetic biology community. In this presentation, the utility of synthetic enzymology for the purposeful production and development of therapeutics will be discussed. The repurposing of polyketide synthases for the biosynthesis of another large class of biomolecules, the alkaloids, will also be presented to illustrate the potential of synthetic enzymology.

ID: F2-0002 **SYM-03 : 4**

ENGINEERING MICROBES FOR THE PRODUCTION OF HIGH-VALUE CHEMICALS

Zhi Li

National University of Singapore, Singapore

Microbial cells are useful factories for the productions of chemical compounds. While many cell-based bioproductions of bulk chemicals and fuels have been well developed, the engineering of microbial cells to enable non-natural cascade reactions for synthesizing high-value chemicals, such as chiral pharmaceutical intermediates, has received increasing attention. In this presentation, our recently engineered whole-cell cascade biocatalysis systems for the synthesis of several valuable and useful classes of enantiopure chemicals from easily available substrates including renewable feedstock will be highlighted. Examples are the asymmetric functionalization of alkenes or L-phenylalanine to 1,2-vicinal diols, alpha-hydroxyacids, alpha-aminoacids, and 1,2-aminoalchol. [1-3] These whole-cell based biotransformations are simple, one-pot, high-yielding, green, and sustainable, which avoid the expensive isolation of intermediates, the generation of large amount of wastes, and the use of toxic reagents/metal in the traditional multi-step chemical synthesis.

ID: IN-0007 **SYM-03 : 5**

ISOLATION OF NEW DRUG TARGETS WITH AN INNOVATIVE PROTEIN EXTRACTION TECHNOLOGY

Seth Hanson[1], Saikat Nandi[2]

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Co-immunoprecipitation (Co-IP) is a common

technique for observing protein-protein interactions; however, weakly- or transiently-bound species often go undetected. Aggressive or repeated wash steps in the Co-IP process can result in a loss of these interactions. Exclusion-based sample preparation (ESPTM) allows for rapid yet gentle washing of protein solutions during Co-IP, thereby creating an environment that retains these elusive interactions. In the presentation I will summarize recent progress in developing EXTRACTMAN®, an innovative biomolecule extraction platform that enables researchers to better study complex protein interactions that are critical for drug target identification and a wide variety of topics in proteomic research. I will also describe a comparison of a conventional Co-IP protocol with an EXTRACTMAN® protocol using ESPTM technology. While the conventional Co-IP protocol did not pull down the protein-protein complex, EXTRACTMAN® did, demonstrating the utility of ESPTM technology and EXTRACTMAN®.

Session	SYM-04: Special Topic Symposium: Surgical Robotics and Navigation
Date	Wednesday, 7 December
Time	4:00pm - 5:30pm
Venue	Global Learning Room

ID: KN-0003 **SYM-04 : 1**

COMPUTER AIDED SURGERY FOR ASSISTING MINIMALLY INVASIVE THERAPIES

Ichiro Sakuma

University of Tokyo, Japan

Minimally invasive therapy such as endoscopic surgery and catheter based intervention are being spread in many surgical intervention fields. Thus engineering assistance is important to realize safe and effective minimally invasive therapy. Computer Assisted Surgical guidance such as surgical navigation is one of key technologies. It is expected that application of robotic technology to minimally invasive surgery will provide the following functions:
(1) Precise manipulation of biological tissues and surgical instruments in narrow and confined surgical field.
(2) Precise and accurate localization of therapeutic devices using various pre and intra-operative medical information.

In the first mode of application, more compact system is required. It can be realized by introduction of novel mechanical design and application off a new mechanism as well as new materials. At the same time integration with various energy devices are also required. Intra-operative guidance utilizing various pre and intra operative information is necessary in the second mode of application. Image guided robotic system for RF ablation, laser ablation, intensity modified radiation therapy, and high intensity focused ultrasound. In this type of robot, various pre- and intraoperative information including functional information is used to navigate the therapeutic devices to the target lesion. Intra-operative identification of pathological state of the target tissue and evaluation of outcome after therapeutic intervention are also important.

Factors limiting the application of surgical navigation systems and medical robotics include limited usability requiring additional procedures for preparation, and high costs. Recent progress of computer vision technologies will solve part of these issues.

For wider spread of these technologies in clinical environment, further improvement of usability, cost reduction, and accumulation of clinical evidences demonstrating efficacy from both clinical and economical point of view are required.

ID: C3-0001 **SYM-04 : 2**

OPEN PLATFORM OF MEDICAL ROBOTS/ DEVICES WITH SMART CYBER OPERATING THEATER (SCOT): DESIGN CONCEPT AND PROTOTYPE ROBOT DEVELOPMENTS

Ken Masamune[1], Hideyuki Suenaga[2], Etsuko Kobayashi[2], Hiroshi Iseki[1,2], Yoshihiro Muragaki[1]

[1]Tokyo Women's Medical University, Japan; [2]University of Tokyo, Japan; [3]Institute of Advanced Biomedical Engineering and Science, Japan

Nowadays, several medical devices/systems including imaging machine, anesthesia, navigation system, bio-monitoring devices, surgical bed, medical robots, et al., are installed in the operation room, however, it is

unpleasant situation that all devices are performed in stand-alone mode, without time-synchronization, and it is difficult to combine/analyze some set of information from devices to make surgeon's decision during surgery. To improve this situation, we've been developing an integrated operating room named "Smart Cyber Operating Theater (SCOT) with middleware ORiN system. In this presentation, we introduce a current SCOT project and the design concept of new open platform architecture for the integration of master/slave robotic devices and information guided robot especially for oral and maxillofacial surgery. This design will accelerate the development of any types of robotic interfaces/end effectors with fast validation.

ID: C1-0001 **SYM-04 : 3**

AUGMENTED REALITY FOR SURGICAL NAVIGATION

Jaesung Hong

Daegu Gyeongbuk Institute of Science and Technology, South Korea

In these days, augmented reality (AR) has become a key technology for surgical navigation. Using the AR technology, the shape of invisible organs are overlapped to the visible endoscopic or microscopic images. Therefore the surgeon can avoid damaging the healthy tissue, and reduce the incision area. In the AR-based surgery, optical tracker and camera are generally used. Optical tracker can measure the position and pose of multiple markers, and the relationship between the camera and target organs of patient can be measured in real-time by tracking of the markers which are mounted on the camera body and the patient. In the AR display, finding the relationship between the optical marker mounted on the camera body and the center of camera (camera registration) is particulary important. This relationship strongly affects the overall accuracy of AR display. In this talk, the latest AR technologies applied for the surgical navigation are introduced.

ID: C1-0002 **SYM-04 : 4**

MR-COMPATIBLE ROBOTIC SYSTEMS: TOWARDS THE INTRAOPERATIVE MRI-GUIDED INTERVENTIONS

Ka-Wai Kwok, Ziyan Guo, Ziyang Dong, Kit-Hang Lee

The University of Hong Kong, Hong Kong

Advanced surgical robotics has attracted significant research interest in supporting image guidance, even magnetic resonance imaging (MRI) for effective navigation of surgical instruments. In situ effective guidance of access routes to the target anatomy, rendered based on imaging data, can enable a distinct awareness of the position of robotic instrument tip relative to the target anatomy in various types of minimally invasive interventions. Therefore, such MRI-guided robots will rely on real-time processing the co-registration of surgical plan with the imaging data captured during the intervention, as well as computing the relative configuration between the instrument and the anatomy of surgical interest.

This talk will present a compact robotic system capable to operate inside the bore of MRI scanner, as well as its solutions to technical challenges of providing a safe, effective catheter-based surgical manipulation. The proposed image processing system demonstrates its clinical potential of enhanced surgical safety by imposing visual feedback on tele-operated robotic instruments even under large-scale and rapid tissue deformations in soft tissue surgeries, such as cardiac electrophysiology and stereotactic neurosurgery. The ultimate research objective is to enable the operator to perform safe, precise and effective control of robotics instruments with the aid of pre- and intra-operative MRI models. The present work will be timely to bridge the current technical gap between MRI and surgical robotic control.

ID: C1-0001 **SYM-04 : 5**

TOWARDS MAGNETIC ACTUATED MICRO-ROBOTIC NEEDLESS INJECTION

Hongliang Ren

National University of Singapore, Singapore

The feasibility of a needleless magnetic-actuated device for the purpose of intravitreal injections is investigated using two different design prototypes, the first of which is a solenoid and the other is actuated by 2 pairs of E-shaped cores where the working principle is slightly similar to the concept of axial resilience in hybrid magnetic bearings

A needleless device could potentially significantly reduce patient anxiety levels and occurrences of needle stick injuries to both healthcare workers and patients Moreover, a magnetic-actuated device allows for control of the current supplied over time to the device and the corresponding depth of penetration of the drug

Substitutes for the sclera and vitreous region were used in the experiments where a blue dye was injected using the two separate devices to identify if these devices were able to eject the liquid with enough force needed to penetrate the sclera and deliver the liquid to within the vitreous region and whether there was a relationship between the current supplied to the devices and the depth of delivery The solenoid prototype injector was not able to eject the liquid at a force required to penetrate the sclera although, because the vitreous region was a lot softer, a follow through current of about 1 3A - 1 5A was predicted to be able to deliver the bulk of the liquid to the middle portion of the vitreous substitute used in this experiment Moreover, the addition of a controller to the system was able to produce a two part force to the liquid, the initial peak force meant to penetrate the sclera and a follow through force to deliver the drug to the vitreous region only The E-shaped pairing injector prototype however, could not generate enough force to fully eject the liquid out of the

Day 2 – Thursday, 8 December 2016

Session	Plenary Lecture 3
Date	Thursday, 8 December
Time	9:00am - 9:45am
Venue	Auditorium 2

ID: PL-0007 **PL3**

RECENT ADVANCES ON NATURE INSPIRED TISSUE ENGINEERING APPROACHES FOR THE REGENERATION OF DIFFERENT TISSUES

Rui L. Reis

University of Minho, Portugal
ICVS/3B's PT Government Associate Laboratory, Portugal

The selection of a proper material to be used as a scaffold or as a hydrogel to support, hold or encapsulate cells is both a critical and a difficult choice that will determine the success of failure of any tissue engineering and regenerative medicine (TERM) strategy.
We believe that the use of natural origin polymers, including a wide range of marine origin materials, is the best option for many different approaches that allow for the regeneration of different tissues. In addition to the selection of appropriate material systems it is of outmost importance the development of processing methodologies that allow for the production of adequate scaffolds/matrices, in many cases incorporating bioactive/differentiation agents in their structures.
Furthermore an adequate cell source should be selected. In many cases efficient cell isolation, expansion and differentiation, and in many cases the selection of a specific sub-population, methodologies should be developed and optimized. We have been using different human cell sources namely: mesenchymal stem cells from bone marrow, mesenchymal stem cells from human adipose tissue, human cells from amniotic fluids and membranes and cells obtained from human umbilical cords.
The development of dynamic ways to culture the cells and of distinct ways to stimulate their differentiation in 3D environments, as well as the use of nano-based systems to induce their differentiation and internalization into cells, is also a key part of some of the strategies that are being developed in our research group.
The potential of each combination materials/cells, to be used to develop novel useful regeneration therapies will be discussed. The use of different cells and their interactions with different natural origin degradable scaffolds and smart hydrogels will be described. Several examples of TERM strategies to regenerate different types of tissues will be presented.

Session	Plenary Lecture 4
Date	Thursday, 8 December
Time	9:45am - 10:30am
Venue	Auditorium 2

ID: PL-0005 **PL4**

INNOVATIVE HEALTHCARE IS IN THE PALM OF YOUR HAND

Luke Lee

Biomedical Institute for Global Health Research & Technology, National University of Singapore, Singapore
UC Berkeley

In this talk, I will present how to see the world's healthcare crisis and the fundamental problems of current medicine in a grain of iSAND (integrative Science, Arts, Nanomedicine, and Digital technology), and find solutions in nature for preventive medicine and healthy environment. Since the future of healthcare is in the palm of our hands, a few examples of creative healthcare innovations will be discussed along with the vision of smart digital healthcare in both developing and developed countries: smart mobile integrated molecular diagnostic systems (iMDx) for personalized precision medicine and microphysiological analysis platforms (iMAPs) for toxicology, drug discovery, and regenerative medicine. The rapid and accurate smart mobile iMDx comprises three key elements of precision medicine on chip: ultrafast multiplexed photonic PCR for the early detection of DNA and RNA biomarkers in blood, signal amplifications of protein markers, and a self-contained sample preparation from whole blood on chip, which allows a sample-to-answer readout platform with smart analytics. The progress on patient-specific iPSCs-based iMAPs, pancreatic islets and mini-brains in silicone for molecular pathogenesis will be discussed along with the vision of preventive precision medicine via precision engineering in medicine.

Session	A4: Computational Bioengineering III
Date	Thursday, 8 December
Time	11:00am - 12:30pm
Venue	Auditorium 2

ID: E1-0003 **A4 : 1**

FLUID-STRUCTURE INTERACTION SIMULATIONS OF BIOLOGICAL FLOWS

David Elad

Tel Aviv University, Israel

Most biological flows represent the problem of fluid-structure interaction (FSI) in which a moving fluid (internal or external) interacts with a structure that undergoes deformations due to the fluid pressures, and vice versa. This is a complex problem that requires simultaneous solution of the time-dependent equilibrium equations for the fluid and the structure, together with constitutive equations, and boundary and initial conditions. It is a complex problem for computer simulations that can nowadays be utilized with sophisticated commercial software and huge computing power. In this presentation we will demonstrate a three-dimensional (3D) computational model of infant feeding on the breast or man-made nipples designed to analyze mechanisms of milk extraction during bottle- or breast-feeding. In another example we developed a 3D model of the tubular embryonic heart of the chick in order to explore the pumping mechanism before development of the valves. The presentation will concentrate on modeling problems which prohibit direct mimicking of biological effects.

ID: E3-0012 **A4 : 2**

ASSESSMENT OF VERTEBRAL STRENGTH IN MULTIPLE MYELOMA PATIENTS: A FINITE-ELEMENT STUDY

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Multiple myeloma (MM) is a skeletal malignant disease, with a less than 50% 5-year survival rate. Although the current indications for MM is the bone mineral density (BMD), a threshold for an accurate diagnosis of MM has not been previously established. Radiographic scan procedures such as computed tomography (CT) are common in diagnosing MM through the detection of osteolytic lesions or significant diffuse bone losses, but herein lies high susceptibility to vertebral compression fractures (VCFs). Hence, this study assessed differences in FE-predicted fracture load between MM patients with and without VCFs in the thoracic and lumbar segments of the spine. Multi-detector CT (MDCT) images of two MM subjects (1 with VCFs and 1 without VCFs) were used to generate three-dimensional (3D) models of the whole spine. For each subject, the thoracic segments, 1 to 12 (T1-T12) and lumbar segments, 1 to 5 (L1-L5) were segmented and meshed. Heterogeneous, non-linear anisotropic material properties were applied by discretizing each vertebral segment into 10 distinct sets of materials. A compressive load was simulated by constraining the surface nodes on the inferior endplate in all directions, and a displacement load was applied on the surface nods on the superior endplate. The MM subject with VCFs had originally attained fractures in the T4, T5, T12, L1 and L5 segments whereas the MM subject without VCFs attained none. The former displayed large and abrupt differences in fracture loads between adjacent vertebrae segments, unlike the latter, which exhibited progressive differences instead. This was also further quantified by calculated relative changes in fracture load values. The abrupt changes that indicate instability enables ease of identification of segments at high fracture risk. Clinicians will be able to work with a pre-emptive treatment strategy as they can focus on a more targeted therapy at the affected vertebrae segments.

ID: E3-0024 **A4 : 3**

NUMERICAL STUDY ON MIXING AND PUMPING FUNCTIONS GENERATED BY PERISTALSIS IN A ZEBRAFISH INTESTINE

Jinyou Yang, Yuji Shimogonya, Takuji Ishikawa

Tohoku University, Japan

The intestine of zebrafish has been intensively used for investigating various biological phenomena, such as microbial flora, due to its transparency. Despite its biological importance, transport phenomena in the intestine of zebrafish have not been fully clarified. In this study, therefore, a numerical model was developed to explore transport phenomena caused by the peristaltic motion in a larval zebrafish intestine. Geometric data of the larval zebrafish intestine were extracted from Field et al. (2009) at different time after feeding. A model equation to describe contraction over long time was developed from the geometric data. By concurrently calculating the flow field generated by peristaltic motion and long time motion with the software CFX,

the mixing and pumping functions were discussed. The results illustrated that the retrograde peristaltic motion mainly contributed to the mixing function of chyme, and that peristaltic mixing became larger than the Brownian mixing when spreading particle was sufficiently large. The anterograde peristaltic motion, on the other hand, mainly contributed to the pumping function. Pressure decrease inside the intestine was generated by the anterograde peristaltic motion, which may reduce the maintenance energy of muscle to propel the chyme in the intestine. These new findings provide better understanding of mixing and pumping functions in the zebrafish intestine.

ID: E3-0014 **A4 : 4**

CLASSIFICATION OF URINARY DIELECTRIC PROPERTIES FOR DIABETES AND CHRONIC KIDNEY DISEASE USING SUPPORT VECTOR MACHINE

Hua Nong Ting[1], Peck Shen Mun[1], Seyed Mostafa Mirhassani[2]

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Diabetes mellitus is among the most common cause of chronic kidney disease. Urinary glucose is an essential non-invasive approach for diabetes. Meanwhile, monitoring of urinary protein is required as standard care in the diagnosis and prognostication for chronic kidney disease. Recently, dielectric properties measurement offers the potential to determine variability of urinary glucose or protein as a simple and non-destructive manner. However, the accuracy of the determination should be investigated. This study classifies the urinary dielectric properties of subjects with diabetes mellitus (DM), chronic kidney disease (CKD), and normal subjects at microwave frequency from 1 GHz to 50 GHz using support vector machine (SVM). The urinary dielectric properties measurements were conducted using open-ended coaxial probe at room temperature (25°C), 30°C and human body temperature (37°C). The highest classification accuracy was achieved at 88.72% to distinguish between diabetic and normal subjects. The urinary dielectric behavior was found optimal at 30°C for classification. The highest accuracy was achieved at 64.50% for three-group classification.

ID: B1-0023 **A4 : 5**

NUMERICAL SIMULATION OF MICRO-MIXING ENHANCEMENT UNDER PERIODIC ELECTROOSMOTIC FLOW

Abas Ramiar, Mohammad Alipanah Rostami, Amirhosein Ghasemi, Siamak Saeidi-Haghi

Babol Noshirvani University of Technology, Iran

In recent years, one of the most popular themes of interest was lab-on-a-chip (LOC) which has drawn many attentions due to a broad range of medical and chemical applications in which the micro-mixers do play a major role within the investigations. In this paper, a new kind of micro-mixer based on electroosmotic driving force has been studied which T-shaped geometry with two inlets were implemented for LOC applications due to its simplicity. The present simulation was done numerically by developing a code within the open source OpenFOAM CFD package. For simulating electroosmotic flow, Poisson Boltzmann (PB) model was used and the relevant equations were added to the base solvers of the OpenFOAM. Working fluids in the simulations were pure water and water with fluorescence.
Having a relatively low Reynolds number and the presence of laminar flow in micro-mixers, diffusion is not solely able to create an appropriate mixing in micro-mixers. As a result, to increase the mixing quality in micro-mixers, other kinds of methods should be applied. In this paper, a pulsatile electric field is used to improve the mixing of the fluids, where the most efficient frequency of the micro-mixer to achieve the highest mixing quality is also obtained. Moreover, the effect of conductive edges in micro-mixers has been investigated. Upon the presence of conductive edges, strong vortices were created, which led to better flow mixing and consequently an improved mixing.

Session	B4: Regenerative Medicine II
Date	Thursday, 8 December
Time	11:00am - 12:30pm
Venue	LT50

ID: D5-0017 **B4 : 1**

A NOVEL L-GLUTAMIC ACID LOADED CHITOSAN HYDROGEL AS AN IDEAL DRESSING MATERIAL FOR TREATING DIABETIC WOUNDS

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Hydrogels have been extensively studied for wound healing applications. Here, we have developed a novel hybrid hydrogel using chitosan (CS) and L-glutamic acid (LG) via physical cross-linking. We prepared chitosan hydrogels with different concentrations of L-glutamic acid (0%, 0.25%, 0.5%, and 1.0%), using 2% solutions of chitosan. Glycerol (50%) was added as a plasticizer to improve elasticity of the hydrogels. Scanning electron microscopy images showed smooth surface for CS hydrogels and fibrous architecture with sponge like rough surfaces for the CS+LG hydrogels. These hydrogels showed good in vitro biodegradation in PBS using 1 mg/mL of lysozyme. FTIR spectrum of CS+LG hydrogels showed characteristic peaks for LG confirming the blending with chitosan. Swelling ratio of hydrogels showed that they absorbed water more than 3 times their original weight. DSC study shows that the CS+LG hydrogels has higher glass transition temperatures compared to CS hydrogel. Thermogravimetric analysis also strongly substantiates these findings with four gradual weight losses from room temperature to 600°C. CS+LG hydrogels showed higher thermal stability than the CS hydrogel. To evaluate the biocompatibility of these hybrid hydrogels, we studied in vitro cell viability, cell attachment and proliferation using NIH 3T3 fibroblast cells. CS+LG hydrogels showed good viability and cell attachment. Therefore, these hydrogels were used as a wound dressing material in rats during diabetic wound healing. CS+LG hydrogels reduced the frequent wound dressing and inflammation. It accelerated cellular activity to heal the wounds faster, with minimal scar formation. These CS+LG hydrogels reduced the epithelialization time and enhanced the rate of wound contraction in diabetic rats. It also increased the collagen content and crosslinking of collagen. Hence, increased shrinkage temperature was observed. Histopathological findings also revealed these results like fibroplasia, collagen deposition and angiogenesis. Hence, CS+LG hydrogels could be an effective wound dressing material for chronic wounds like diabetic wounds.

ID: D5-0008 **B4 : 2**

REGENERATIVE MEDICINE: CONTEMPORARY PROGRESSION IN INDIA

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Regenerative medicine as translational research in tissue engineering and molecular biology holds the potential for enhancing organ function, repairing or replacing damaged organ and realizing regeneration of deteriorated organs and tissues. Regenerative medicine and biomimetic drug delivery has together have accelerated medical advancements and reformation. 3D biomimetic modeling in fields like cell-material interactions, tissue and organ manufacturing, anti-cancer drug delivery methods, and bioactive agent carrier systems has made astounding strides of development. The need for developing new ways to treat and manage chronic diseases such as diabetes, degenerative nerve, bone and joint conditions and heart failure has long been felt. Research and technological advancements in recent times are bringing regenerative medicines closer to reality. Regenerative medicine promises definitive, affordable health care solutions that heal the body from within. Stem cells, including adult and embryonic stem cells form a key component of regenerative medicine and Progenitor cells like umbilical cord blood and bioengineered cells i.e., induced pluripotent stem cells form promising study area. Engineering terminally differentiated and highly specialized cells i.e., rejuvenation, using healthy cells, tissues or organs from a living / deceased donor to replace damaged ones in a subject i.e., replacement, delivering specific types of cells or cell products to diseased tissues or organs, where they eventually restore the normal functioning of tissue and organ i.e., regeneration are crucial in Regenerative Medicine. The present review discusses the strategies and the contemporary developments of regenerative medicines in Indian subcontinent. It further attempts to delineate the constraints of the regenerative medicine that warrants special attention to realize full potential of the field.

ID: D5-0016 **B4 : 3**

THE BIOMECHANICAL BENEFITS OF CELLULARIZATION: TOWARDS MIMICKING THE NATIVE STATE WITH ECM REMODELING CELLS

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Functional tissue engineering' (FTE) – a tissue engineering (TE) subfield – employs various cellularized biomaterial scaffolds for the "engineering of load bearing tissues". To generate more biomimetic materials, various extracellular matrix (ECM) scaffolds were isolated through decellularization. However, decellularization represents a trade-off between excessive ECM damage and preservation of ECM ultrastructure and bioactivity. Indeed, vast research has identified biophysical effects of the ECM on cell survival, proliferation, migration, organization, differentiation and maturation, with clear implications for FTE. Surprisingly though, no study to date, to the best of our knowledge, provided clear methods and understanding on the reciprocal effects of cellularization on the cellularized ECM scaffolds biophysical properties, under physiological-like conditions. We hypothesized that by re-cellularizing porcine ventricular ECM (pvECM, serving as a model scaffold) some of the original myocardial tissue biophysical properties can be restored, concerning scaffolds surface and bulk modifications consequent to cellularization. We therefore performed a systematic biophysical assessment of pcECM scaffolds seeded with human mesenchymal stem cells, a common multipotent cell source in cardiac regenerative medicine. The results obtained were compared to acellular pcECM and native ventricular tissue serving as negative and positive controls, respectively. We report a new type of FTE study in which cell interactions with a composite-scaffold were evaluated from the perspective of their contribution to the construct surface (FTIR, WET-SEM) and bulk (DSC, TGA, uni-and bi-axial mechanical testing) biophysical properties. Such an approach yields important methodologies, understanding, and data serving both as a reference as well as possible 'design criteria' for future studies in FTE

ID: D5-0018 **B4 : 4**

MAGNETIC 3D BIO-PRINTING FOR DEVELOPING SALIVA-SECRETING ORGANOIDS TO TREAT DRY MOUTH PATIENTS

Christabella Adine[1], Hui Min, Adeline Koh[2], Riasat Hasan[1], Sujatha Muthu[1], Glauco R. Souza[3,4], Joao Nuno Andrade Requicha Ferreira[1]

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Radiotherapy, the preferred therapy for head and neck cancers, can irreversibly damage the salivary glands (SG) saliva secreting cells in about 40-60% of patients. This damage results in dry mouth, which increases the susceptibility to oral infections, decreasing the quality of life of patients. Current options for dry mouth therapies are heavily dependent on the limited number of residual SG secretory cells. Hence, organoid-based transplantation of secreting SG cells in a three-dimensional (3D) structure is potentially a viable option. Thus, our aim was to generate new saliva-secreting epithelial cells arranged in 3D organoids using a novel culture system, the magnetic 3D bio-printing (M3DB).
Methods: Human dental pulp stem cells were expanded as 3D spheroids followed by epithelial differentiation step using two systems: M3DB and force aggregation (a conventional 3D system). Cellular ATP and caspase 3/7 levels were assessed in the 3D spheroids to study viability and cell survival. Then, these spheroids were transplanted into decellularized SG biomatrices to create ex vivo organoid-like structures and assess viability and functional secretion (α-amylase). 3D organoids were also characterized using qPCR, immunofluorescence and flow cytometry.
Results: 3D spheroids using M3DB system exhibited higher proliferation after 3 days in vitro. Moreover, these 3D spheroids also showed similar viability when grown in decellularized SGs. The differentiated 3D organoids showed increase expression of α-amylase at gene and protein levels. Furthermore, these constructs also showed increase expression of K14 and Chrm3, which indicate the presence of ductal epithelial and cholinergic receptor markers in epithelial cells. In summary, our novel M3DB system was able to create differentiated cellular 3D spheroids that were feasible to transplant into biomatrices, and form 3D organoids with functional saliva secreting properties.
Conclusion: This project offers a promising 3D bio-printing therapeutic solution to alleviate dry mouth in cancer patients subject to RT.

ID: D6-0003 **B4 : 5**

DESIGN AND FABRICATION OF INDIVIDUAL SCAFFOLDS FOR BONE TISSUE ENGINEERING VIA 3D BIOPLOTTING

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3D bioplotting offers fascinating new possibilities for biomedical applications. In the last years we have designed and developed a number of 3D scaffolds with predesigned structures and functions suitable for tissues engineering application. Here, we presented three types of scaffolds with designed novel structures. First of all, alginate/nano-HAP composite scaffolds with designed pore parameters and core/shell structures were fabricated by using 3D plotting technique and in situ mineralization under mild conditions. In these scaffolds, a layer of nano-HAP, coating the surface of the alginate strands homogeneously and completely. The surface mineralization enhanced the mechanical properties and improved the cell attachment and spreading, as well as supported sustaining protein release. Secondly, novel porous scaffolds for tissue engineering applications consisting of hollow alginate fibers are prepared using shell/core plotting nozzles. Such materials open up the possibility to generate biodegradable tissue constructs with a preformed vascular system or can act as matrices for engineering of complex organs or 3D tissue models. In addition, hollow struts packed (HSP) bioceramics scaffolds with designed macropores and multi-oriented hollow channels via a modified coaxial 3D printing strategy. The prepared HSP scaffolds combined high porosity and surface area with impressive mechanical strength. The unique hollow-struts structures of bioceramic scaffolds significantly improved cell attachment and proliferation, and further promoted formation of new bone in the center of scaffolds, indicating that HSP ceramic scaffolds can be used for regeneration of large bone defects. Based on these three presented scaffolds fabricated via 3D bioplotting, we demonstrated that 3D bioplotting technology is not only able to tailor the morphologies, but also able to realize individual structures and functions for application in tissue engineering.

ID: F2-0001 **B4 : 6**

SYNTHESIS AND CHARACTERIZATION OF MICROBIAL ALGINATE ISOLATED FROM RHIZOSPHERE

Ramyaa Lakshmi T. Selvaraj, Meena Sethu

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Alginate is an exopolysaccharide secreted by selective microbes and also by seaweeds. In seaweeds they occur in the form of calcium, magnesium or sodium salts whereas, in microbes it is in the form of alginic acid. Bacterial alginate is a linear exopolysaccharide consisting of β-1,4-linked β-D-mannuronic acid and its C-5 epimer α-L-guluronic acid. Although seaweed alginates are commercially produced, its mechanical instability caused because of seasonal variation and osmotic swelling due to physiological conditions create variations in its productivity. Hence bacterial alginate is preferred which has high pseudoplasticity. The versatile nature of alginate may help the bacteria in nature to adhere the rhizosphere and act as an absorbant. In this study alginate producing microbes were isolated and 16sRNA sequencing was done to confirm the bacterial strains. The media composition was standardized for better yield of the polymer. Different batch cultures were done and the polymer production found was not uniform, the yield and appearance of the polymer varied among batches. It was found that the concentration of iron gave an impact in the yield and appearance. The synthesized alginate was characterized my DSC, GCMS, NMR, MALDI and FTIR spectra. The characterized alginate was successfully subjected to gel formation. Commercially alginates gain the importance because of the gelling property and its high viscosity. The gelling property is achieved in normal temperature of water and it doesn't require temperature variations.

Session	C4: Biomedical Imaging I
Date	Thursday, 8 December
Time	11:00am - 12:30pm
Venue	LT51

ID: A2-0008 **C4 : 1**

THERANOSTIC SYSTEMS BASED ON AIEGENS

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Traditional π-conjugated fluorophors are prone to aggregate with light emission quenching which is known as aggregation-caused quenching (ACQ). We have observed an opposite phenomenon termed "aggregation-induced emission" (AIE) and identified the restriction of intramolecular rotation (RIR) as the main reason for the AIE effect. Guided by the RIR mechanism, we have developed a series of new AIE materials with emission colors covering the whole visible spectrum, fluorescence quantum yields up to unity. Nanoparticles of the AIE materials with efficient fluorescence and excellent biocompatibility can be readily fabricated. The nanoparticles of the AIE materials with specific surface functional groups exhibit high emission efficiency, large absorptivity, excellent biocompatibility and strong photo-stability, endowing them ideal for targeting specific cells and/or tissues, and long-term non-invasive in vitro and in vivo cell tracing. Moreover, some AIE materials show aggregation enhanced photodynamic activity and the formulated AIE dots have been used for targeted and imaging-guided photodynamic cancer therapy.

ID: A3-0002 **C4 : 2**

AIE PROBES FOR BIOMEDICAL APPLICATIONS

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Fluorogens with aggregataion-induced emission (AIE) characteristics have recently aroused significant research interest. The unique AIE process offers a straightforward solution to the aggregation-caused quenching problem faced by traditional fluorophores. In this talk, we summarize our recent AIE work to highlight the utility of AIE effect in the development of new fluorescent bioprobes, which allows the use of highly concentrated fluorogens for biosensing and imaging. The simple design and fluorescence turn-on feature of the molecular AIE bioprobes offer direct visualization of specific analytes and biological processes in aqueous media with higher sensitivity and better accuracy than traditional fluorescence turn-off probes. The AIE dot-based bioprobes with different formulations and surface functionalities show advanced features over quantum dots and small molecule dyes, such as large absorptivity, high luminosity, excellent biocompatibility, free of random blinking, and strong photobleaching resistance. In addition, our recent discovery that AIE fluorogens with strong reactive oxygen species generation in solid state further expanded their applications to cancer therapy. These features enable cancer cell detection, long term cell tracing, and image-guided therapy in a noninvasive and high contrast manner.

ID: A2-0026 **C4 : 3**

REGION SEGMENTATION AND FEATURE EXTRACTION IN GASTRIC BIOPSY IMAGES FOR AUTOMATIC DIAGNOSIS SUPPORT SYSTEM

Emi Morotomi, Toshiyuki Tanaka

Keio University, Japan

Recently, the shortage of pathologists becomes serious problem in Japan, while the number of cancer patients has been increasing year by year. Therefore, it is required to construct pathological diagnosis support system. Specially, it is important that all the cases are classified into two groups: neoplastic lesion and non-neoplastic lesion. In this paper, we propose a method with image analysis to classify the gastric tumors into neoplastic lesion and non-neoplastic lesion.

Our proposed method mainly consists of image input, region extraction, feature calculation, and discriminant analysis. This study focuses on the region extraction in the whole flow. Our method has gland extraction method with a modified watershed algorithm, because pathologists take notice of glandular shapes and structures. We obtain several features from extracted regions, and perform discriminant analysis. By performing these processing, we try to improve the classification accuracy.

In order to extract glandular region, we use marker-controlled watershed segmentation. This method requires to set target domain marker and background domain marker. we set target domain marker based on extraction of lumen, and set background domain marker based on rough shape extraction of gland. The proposed method of lumen extraction contains removal of stroma, which is likely to be mistaken as lumen in the previous study.

Next, we compute features of obtained glandular shapes and structures. Several effective features of shape and structure is obtained by calculating the degree of separation. The results of our method shows that the classification ratio is approximately 4.5% better than the previous method in an experiment using 45 gastric biopsy images.

In the future, we will improve the accuracy of our algorithm by devising marker processing and introducing new effective features.

ID: A2-0031 **C4 : 4**

COMPUTER-AIDED DIAGNOSIS SYSTEM OF COLON CANCER BIOPSY BASED ON CONVOLUTIONAL NEURAL NETWORK

Motohiro Nagao, Toshiyuki Tanaka

Keio University, Japan

Although the number of cancer patients is on the increase, the number of pathologists is less than required. In addition to the shortage of pathological doctors, there is a gap of histopathological diagnosis skills among hospitals because it is often the case that only a single pathologist has to examine the whole set of biopsy samples in his/her hospital, or that a doctor who does not specialize in histopathology may study tissues. These issues can lead not only burdens of pathological doctors but also an inequality in medical service by hospitals. In order to solve these problems, there is a significant necessity of developing a computer-aided diagnosis system of cancer biopsy.
In the previous work, an entire HE stained image is classified into a single class. However, in case it has two or more types of atypia in it, for example a sample image labeled as cancer with both cancerous and benign areas, features extracted from it will weaken, which causes to underestimate the malignancy.
In this study, we divide a sample image into smaller rectangular patches and classify them into the histopathological classes by atypia so that we do not overlook local malignancy. We firstly perform an unsupervised recognition of unsuitable patches without a duct, the structure that indicates a degree of malignancy, based on Otsu's binarization and a 3-by-3 Laplacian filter with a 10-by-10 averaging filter. Next, we input the patches to the former layers of Alex Net as a feature extractor. Then each set of extracted features is applied to a fully-connected neural network, outputting a likelihood of its class. The true positive rates (sensitivities) of three classes; Group1 (normal tissue), Group3 (adenoma) and Group5 (carcinoma) are more than 80% respectively.

ID: A2-0012 **C4 : 5**

PIEZOELECTRIC COMPOSITES WITH SOFT ELASTOMER INCLUSIONS FOR BIOMEDICAL IMAGING APPLICATIONS

Christian Della[1], Kasem Chaisieng[1], Dong Wei Shu[2]

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1-3 piezoelectric composites or "piezocomposites" have been widely studied due to their practical applications in biomedical imaging and ultrasound therapy. The piezocomposite consists of a piezoelectric fibre and a polymer matrix. The long and thin fibres that are made of piezoelectric ceramics and are embedded in the piezoelectric or non-piezoelectric polymer matrix, which gives piezocomposites the flexibility to conform to curved surfaces. A major advantage of using piezocomposite materials over the conventional monolithic piezoelectric ceramic is its ability to be tailored for specific applications, particularly its electromechanical properties and figures of merit.

Previous analytical studies showed that the performance of the piezocomposite can be enhanced for biomedical imaging applications by adding porosity in the matrix of the piezocomposite. However, it can be a challenge to manufacture the piezocomposite with the suggested porosity orientation. In this research work, a soft inclusion is used as a substitute for the porosity. By using a two-step micromechanics model, the results of the study showed that the performance of the piezocomposite with soft inclusions in the matrix is comparable to that of the piezocomposite with porosity in the matrix. The performances of various piezocomposites with new relaxor ferroelectric materials, such as PMN-PT and PZN-PT, as fibre materials in the composite are also studied.

Session	SYM-05: Special Topic Symposium: Cardiovascular Flows
Date	Thursday, 8 December
Time	11:00am - 12:30pm
Venue	LT53

ID: E1-0001 **SYM-05 : 1**

PATIENT-SPECIFIC PREDICTION OF FALSE LUMEN THROMBOSIS IN TYPE B AORTIC DISSECTION

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Type B dissection is caused by the formation of a tear in the inner layer of the aortic wall. The thrust of diverted blood causes splitting of the wall layers and leads to the formation of a "false lumen" (FL). Partial FL thrombosis was identified as a significant predictor for late complications, due to increased FL pressure and hence an elevated risk for aortic dilatation and rupture. On the other hand, improved outcomes are associated with complete FL thrombosis, which can be achieved through endovascular repair (TEVAR).

This study presents the application of a novel computational model to predict FL thrombosis in medically treated and TEVAR patients under physiological conditions. Thrombus formation and growth are predicted through the evaluation of hemodynamic parameters and flow patterns. The model has been applied to several patient-specific geometries reconstructed from CT images and representing (i) medically treated patients with no thrombus; (ii) medically treated patients with partial thrombosis; (iii) TEVAR patients with partial thrombosis; (iv) TEVAR patients with complete thrombosis. All patients were kept under surveillance, and predictions of thrombus growth were compared with follow-up CT scans. Good agreement between predicted thrombosis and in vivo data was found in all cases. The model was able to predict how variations in morphology and flow led to different thrombus growth patterns, demonstrating its applicability to patient-specific prediction of FL thrombosis. The long term objective of this work is to identify key risk factors for maintenance of FL patency and predictors of FL thrombosis, in order to optimize treatment strategies.

ID: E1-0001 **SYM-05 : 2**

LUMPED PARAMETER MODEL OF THE MITRAL VALVE IN CIRCULATION SYSTEM

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Multiscale modeling of circulation system usually requires coupled a lumped parameter model of circulation system plus a local 3D CFD model. Mitral valve is usually considered a diode to control unidirection flow in the circulation model not reasonable for study of downstream cardiovascular hemodynamics because of passive limited backward flow during closing process which is a complicated fluid-structure interaction. This paper aimed to develop a new lumped parameter model of the heart valve based on the mitral valve hemodynamics. The new mitral valve model was a model of varied flow resistance allowing for a closing time, closing volume, blood inertia, and steady flow of opened and closed phases. The model included the varied resistance and blood inertia in a serial connection. The resistance was assumed to be an exponential function during the closing process, and otherwise a leaflet kinetic model allowing for the flow shear and pressure forces. The closing volume and closing time were obtained from experiment to reflect empirical dynamics of the mitral valve during valve closing. This model was used in the left heart circulatory system to simulate hemodynamics in the system with a Matlab code based on the system. The results were compared with the published results of mitral valve and indicated that the developed model revealed the characteristics of opening and closing of mitral valve. In conclusion, the new lumped parameter model of the mitral valve is developed successfully and accurately represents the valve hemodynamics in a relatively low computational cost. This model offers more reasonable boundary conditions for a local downstream 3D CFD study in the multiscale modeling of the cardiovascular system.

ID: E3-0002 **SYM-05 : 3**

COMPUTATIONAL ANALYSIS OF VASCULAR HEMODYNAMICS AND VENTRICULAR MECHANICS IN PULMONARY ARTERIAL HYPERTENSION

Lik Chuan Lee[1], Ce Xi[1], Byron Zambrano[1], Liang Zhong[2], Ju-Le Tan[2], Seungik Baek[1]

[1]Michigan State University, USA; *[2]National Heart Centre Singapore, Singapore*

Pulmonary arterial hypertension (PAH) is a complex cardiovascular disease that is associated with an elevated pressure in the pulmonary arterial system. Prolonged exposure to high pressure in pulmonary system produces structural and geometrical changes in both the right ventricle and the pulmonary vasculature. Here, we describe an image-based computational modeling pipeline to analyze patient-specific ventricular mechanics and vascular hemodynamics that are associated with PAH. Using magnetic resonance images and in vivo pressure measurements, we developed computational models and methods to describe biventricular mechanics as well as the (fluid-structure) interaction between hemodynamics and pulsatile wall motion of the pulmonary vasculature in PAH patients. These models were used to quantify ventricular strain field, regional ventricular mechanical properties (passive stiffness and myocardial contractility), myofiber stress, vascular flow field, wall shear stress, oscillatory shear index and pulmonary arterial compliance. We show that these quantities are substantially different from those found in a healthy subject, suggesting that long-term remodeling caused by PAH leads to abnormality in both ventricular and arterial wall mechanics, as well as vascular hemodynamics.

ID: E4-0001 **SYM-05 : 4**

REVERSAL OF STORAGE-RELATED MORPHOLOGICAL CHANGES IN RED BLOOD CELLS: WHAT IS THE IMPACT IN THE MICROCIRCULATION

Robert Flower[1,2], Marie Anne Balanant[1,2], Melinda Dean[1,2], Emilie Sauret[2], Suvash Saha[2], Yuan-Tong Gu[2]

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Introduction
The re-introduction of stored red blood cells (RBC) to the physiological environment following transfusion is a complex process. To minimise haemolysis, storage solutions are hypertonic. During storage RBC undergo morphological transformation from biconcave discocytes to stomatocytes. The shape change during storage and the extent to which this shape change can be reversed when RBC are returned to the physiological plasma environment was investigated.

Methods
The morphology of RBC stored in a "SAGM" a hypertonic solution was examined microscopically weekly for 6 weeks. At each time point RBC were equilibrated for 2 hours, at room temperature (RT) in compatible donor plasma. For each pack tested and each time point the size and shape of RBC were evaluated by microscopy for more than 200 RBC.

Results
"Spiky" echinocytes were evident from day 23 of storage these, however represented <10% of the RBC. A majority of RBC maintained a discocytic or curved stomatocytic morphology. When reconstituted in plasma, from day 23 onwards >70% of RBC assumed an echinocyte morphology and cell diameter was reduced.

Conclusion
The majority of RBC maintained a discocytic or stomatocytic morphology when stored in SAGM . Shape changes were observed when RBC were reintroduced cells to a physiological environment. After 23 days of storage, the majority of RBC returned to a physiological environment adopted an echinocyte morphology a change likely to change the behaviour of RBC in the microcirculation. Examination of the level of reconstitution of functions when RBC returned to a physiological environment provides a measure of RBC quality, and the utility of transfusion, that is more likely to reflect behaviour in the capillary microcirculation and, ultimately, clearance in the spleen.

ID: E1-0002 **SYM-05 : 5**

BLOOD-CONTACTING MEDICAL DEVICES, THE DOUBLE EDGED SWORD BETWEEN THROMBOSIS AND BLEEDING

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Cardiovascular disease remains the leading cause of death in industrialised nations and is becoming an increasing problem in developing countries. Common interventions involve blood-contacting medical

devices, which are at high risk for catastrophic failure through thrombosis (blood clots). To mitigate this risk, anticoagulant and antiplatelet drug regimens are co-administered. However, systemic anticoagulation can induce bleeding and exhibits limited efficacy, making it the leading cause of drug-related deaths from adverse clinical events in the United States. As an alternative to drugs, device designs can be altered. In this regard, thrombosis occurring on devices can result from 1) blood-material interactions and/or 2) blood-hemodynamic responses. New biomaterials are being developed in attempts to reduce blood-material interactions. However, blood components are also highly sensitive to a changing haemodynamic (blood flow) environment, especially pathophysiological environments found in medical devices. Yet, the precise response of platelets (primary instigator of thrombosis) remains poorly understand since activating platelets and lysing erythrocytes release soluble activation agonists, creating a feedforward loop supporting further platelet activation. Also, only recently, it was also demonstrated that platelets and plasma proteins respond to shear stress gradients involving elongational flow independently of shear stress magnitude. Furthermore, it is increasingly clear that thrombo-inflammatory responses involve heterotypic platelet-leukocyte interactions that are also highly dependent on the haemodynamic environment. Therefore, blood damage models are often overly simplified. In this work, we utilized microfluidics to simplify fluid dynamics and to isolate specific hemodynamic characteristics of devices. We show that platelets actively respond to changes in the flow environment, independent of soluble activation agonists, and that late stages of platelet activation lead to a haemodynamic-dependent pro-inflammatory environment. Perhaps, paradoxically, we also show that flow characteristics of devices can enhance bleeding risk. Understanding the relationship between flow and blood responses will allow better blood-contacting medical device design.

ID: G2-0005 **SYM-05 : 6**

VIRTUALLY BIOENGINEERING THE LEFT VENTRICLE: A FULLY COUPLED MULTIPHYSICS MODELLING APPROACH

Amr Al Abed, Azam Ahmad Bakir, Nigel H. Lovell, Socrates Dokos

The University of New South Wales, Australia

Computational cardiology is a rapidly evolving field in which in silico models are developed to simulate the function of the heart under healthy as well as diseased conditions. Virtually bioengineered hearts offer the opportunity for in-depth quantitative investigation of mechanisms underlying disease progression and the assessment and development of therapeutic devices and procedures.

The heart's efficient pumping function is driven by the interaction and synchrony of electrical, solid mechanics and fluid mechanics physics. However, traditional approaches to modelling the heart tend to focus on simulating one or two physics of these components, often limiting the models' predictive power.

Our group has recently developed a multiphysics electromechanical-fluid cardiac model for simulating the function of the left ventricle (LV) under baseline healthy conditions. The left ventricular geometry was based on a simplified half-ellipsoidal representation. The micro-architecture was formulated such that fiber orientation smoothly changes from -60° on the epicardium to 60° on the endocardium. A linear Purkinje fiber network, branching in 3-dimensional space, was incorporated to initiate electrical activation. In addition, the LV model was linked to a Windkessel-type model of the circulatory system. A fully coupled modelling approach was followed to virtually bioengineer the LV function; two-way electro-mechanical as well as two-way fluid-structural interactions were adopted.

The LV function was simulated under a rhythmic heart rate of 60 beats per minute. Despite the simplified geometrical representation of the LV, fiber orientation and the Purkinje network, it was able to reproduce human-realistic epicardial breakthrough times, electrical activation patterns, twisting motion of the ventricle, pressure-volume loop, and ejection fraction. We thus demonstrate the predictive power of our model under baseline conditions and attribute it to our fully coupled implementation of electrophysiology, solid and fluid mechanics. Future studies will utilize this virtual bioengineered LV to simulate pathological conditions and their treatment.

Session	SYM-06: Special Topic Symposium: Integrated Nano-biomechanics: Biological Flow
Date	Thursday, 8 December
Time	11:00am - 12:30pm
Venue	Global Learning Room

ID: KN-0007 **SYM-06 : 1**

THREE-DIMENSIONAL COMPUTATIONAL MODEL OF MULTIPHASE FLOW DRIVEN BY A BED OF ACTIVE CILIA

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Physiological fluid propulsion on the micro-scale is often accomplished through channels and tubes whose walls are lined with arrays of actively beating cilia. It is well-known that cilia arranged in arrays can spontaneously coordinate their beat patterns to form metachronal waves. However, while it is generally agreed upon that metachronal waves arise largely due to hydrodynamic coupling, their effects on fluid propulsion are still not thoroughly explored. There are at present complex, nonlinear models where cilia motion is modelled as a function of their internal biological mechanisms; however these models are often computationally challenging and expensive to perform. We therefore present a simplified computational model of a cilia array that has the ability to spontaneously produce metachronal waves. Each individual cilium is modelled as a one-dimensional elastic structure immersed in a stratified, two-fluid configuration. Such a configuration corresponds to physiological conditions similar to that on our respiratory epithelium, where cilia reside in a periciliary layer (PCL) below a mucus layer. Our model treats the mucus as a high-viscosity Newtonian fluid. Our model shows that, in the presence of surface tension between the PCL and mucus layer, the fluid velocity component perpendicular to the interface is suppressed. This suppression prevents the interface from deforming, leading to increased fluid flow along the cilia array and enhancing fluid transport. Conversely, in the absence of surface tension, the fluid velocity component perpendicular to the interface is not suppressed. The interface is severely deformed, forming a large interface area between the PCL and mucus layer, thus potentially resulting in enhanced mixing. We finally present a phase-space plot of viscosity ratio against surface tension, showing conditions under which fluid transport or mixing is enhanced.

ID: G1-0004 **SYM-06 : 2**

A NUMERICAL ANALYSIS OF THE LATERAL MIGRATION OF FLOWING CELLS

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Cells in the blood exhibit varying behavior depending on their mechanical properties. For example, red blood cells, which are quite deformable, are found to flow in the center of blood vessels, leading to the formation of a cell-free layer near the vessel wall. On the other hand, white blood cells, which are much stiffer than red blood cells, and platelets, which are much smaller, are disproportionately found to flow in the region near the wall. As white blood cells and platelets must interact with the vessel wall to perform their intended functions, it is physiologically advantageous for these cells to flow near the wall, but the factors leading to this flow behavior have not been sufficiently clarified. In this study, we investigate the hydrodynamic factors that affect the cell velocity in the direction perpendicular to the flow direction. By neglecting the effect of inertia, which is negligible in the microcirculation, the problem is reduced to a combination of two factors: the curvature of the flow and the presence of a wall. We show how these factors depend on hydrodynamic properties such as the shear rate and the viscosity ratio between the fluids inside and outside the cell, and we describe the relative effects of these factors as a function of the shape of the enclosing container.

ID: G1-0002 **SYM-06 : 3**

THE MECHANICS OF RELAXATION IN THE COLON

Martin Buist, Jing Wui Yeoh, Alberto Corrias

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Despite a growing wealth of experimental data, our understanding of the biomechanics of the gastrointestinal tract remains far from complete. The colon forms part of the lower gastrointestinal tract and gives rise to a variety of motility disorders. It is also relatively accessible such that biomechanical data can be obtained in vivo. As well as producing contractions to provide propulsion, of equal importance is the ability of the colon to relax, something that is controlled to a large degree by inhibitory enteric neurotransmission. Here, we have developed computational models to study the influence of enteric inhibitory neuromuscular

transmission on the electrophysiology of human colonic smooth muscle cells. We have constructed a biophysically based human colonic smooth muscle cell (hCSMC) model which can reproduce slow wave activity, along with a model to describe the role of a novel platelet-derived growth factor receptor alpha-positive cell in the purinergic inhibitory neural control of colonic motility. Third, we have extended the hCSMC model to incorporate a description of the nitrergic intracellular regulatory pathway. Finally, we integrated both inhibitory neuromuscular transmissions to reconstruct the experimentally observed biphasic inhibitory junction potential and examined the mechanical consequences using an active mechanics model. These models provide the basis for a more detailed understanding of the neurogenic inhibitory modulation of human colonic motility in health and disease.

ID: G1-0001 **SYM-06 : 4**

FLAGELLAR MOTION AND THE FINE STRUCTURE OF MOUSE SPERM

Hironori Ueno

Aichi University of Education, Japan

Cilia and flagella are microtubule-based organelles that extend from the surface of eukaryotic cells. The movement is generated by microtubule sliding with axonemal dynein motors, and plays important roles in cell migration and generation of external fluid flow. Since cilia and flagella have diverse roles in many tissues and organs in mammal, defects in ciliary and flagellar activity causes a number of diseases called ciliopathy. Especially, the motility of sperm flagella is rerated to reproduction, so the defect of the motility causes infertility. The mouse sperm is composed of three continuous pieces, mid-piece including spherical mitochondria, principal piece, and end piece. The glycolysis has an important role in providing the ATP required sperm motility.

In this study, we investigated the three dimensional structure of mouse sperm flagella using cryo-electron tomography and image analysis. We obtained some tomograms and calculated the averaged images. We found that the radial spoke structure in mouse sperm flagella was different compared to the structure of axoneme in the other organisms. We also try to analyze the motility of mouse sperm flagellar in the high-viscosity using methylcellulose. In order to understand the flagellar motion of mouse sperm in the high viscosity solution more precisely, we analyzed the motion using high speed camera, and calculated the beat frequency and the amplitude of the flagellar waveform. In the case of unloaded condition, the beat frequency and amplitude of principal piece was higher than mid-piece. While the beat frequency and amplitude of sperm flagella decrease in the high-viscosity condition, the beat frequency was not changed in the presence of 2-Deoxy-D-glucose (DOG) which is inhibitor of glycolysis. Therefore, the mitochondrial ATP production tends to maintain the beat frequency with decrease of the amplitude of sperm flagellar waveform.

ID: E6-0009 **SYM-06 : 5**

EXPLORING GRAVITY SENSING MECHANISMS OF CHLAMYDOMONAS REINHARDTII

Azusa Kage

Tohoku University, Japan

Chlamydomonas reinhardtii is a model organism of eukaryotic flagella. It has a nearly spherical cell body and two anterior flagella, and swims like human breaststroke with those flagella. Although it is a unicellular green alga that looks very different from humans, the basic “9+2” structure of its flagella is the same as that of human cilia and flagella observed in trachea, brain ventricles, oviducts and sperm, generating important functional flows in our body. Thus, investigating the mechanisms of motility and behavior of this tiny organism could contribute to biomedical engineering as well as basic biology. In addition, Chlamydomonas lives most of its life cycle as haploid: in normal conditions, it reproduces asexually, just divides and makes a genetically homogenous population. Because it is a haploid, genetic defects are straightforwardly reflected to the phenotype. Furthermore, Chlamydomonas starts sexual reproduction under a certain experimental environment, thus crossing between the given strains is possible. These characteristics make it easy to do genetic analysis: Chlamydomonas is an excellent model system to investigate flagellar structures and functions.

Like other protists, Chlamydomonas senses the environmental stimuli such as light, mechanical shock and gravity, and shows behavioral responses. Here, I explore gravitactic behavior of C. reinhardtii. Yoshimura et al. (2003, Plant Cell Physiol.) isolated 2 gravitactic mutant strains called gtx1 and gtx2, that showed weaker negative gravitaxis than the wild type but were normal in most of the other motility phenotypes. Initial reassessment showed some contradictory results to the original description. The relationship between gtx1 and gtx2 is being investigated using genetic and physiological methods.

Session	A5: Cell & Molecular Mechanobiology I
Date	Thursday, 8 December
Time	1:45pm - 3:15pm
Venue	Auditorium 2

ID: E6-0001 **A5 : 1**

CYTOSKELETAL DYNAMICS OF HUMAN RED BLOOD CELLS AND IMPLICATIONS IN PLASMODIUM INFECTION

Rajesh Chandramohanadas[1], Trang Chu[1], Ameya Sinha[1], Benoit Mallerett[2], Bruce Russell[3], Laurent Renia[2]

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Human red blood cells (RBCs) undergo remarkable morphological, biochemical and bio-physical transformations during maturation. Using a combination of bio-physical and bio-chemical techniques, we have documented the global differences in red cells, along their maturation from young reticulocytes to mature erythrocytes. Our data revealed comparable abundance for the majority of membrane proteins between reticulocytes and normocytes. However, higher abundance of a selected set of structural components, such as β- tubulin and talin-1/2 in reticulocytes and their loss upon maturation was observed and validated. These proteins could contribute to unique mechanical properties and nanostructure of the young reticulocytes. Furthermore, how infectious agents such as Plasmodium, manipulates the RBC cytoskeleton during asexual infectious cycle will also be discussed.

ID: IN-0002 **A5 : 2**

LARGE ROD-LIKE FORCE-BEARING PROTEINS AS MOLECULAR SHOCK ABSORBERS

Jie Yan

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Large force-bearing proteins that are comprised of a linear array of modular domains are often found as mechanical linkages at adhesion sites of a cell to its extracellular environment and to its neighboring cells. These proteins are subject to frequent stretch and relaxation during actomyosin contraction and relaxation. We show that such proteins can act as a force buffer, keeping the force in the force-transmission pathways they mediate within certain range depending on the mechanical stability of their internal domains. This force-buffering function is a result from a simple physical principle: increased tension during stretching of a protein drives unfolding of its internal domains, preventing tension accumulation. In contrast, during mechanical relaxation, the reduced tension drives refolding of the domains, preventing tension from dropping too fast. We demonstarte the principle using talin in cell-ECM focal adhesion sites and titin in sarcomere of muscles as examples. A tightly controlled tension range by such force-buffering proteins has an apparent advantage of allowing robust mechanosensitive interactions to take place.

ID: E6-0012 **A5 : 3**

CURVATURE EFFECT ON MONOLAYER CELL MIGRATION

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In vivo cell sheets constitute a variety of curved architectures such as lung alveoli, kidney nephron and breast acini. Notably, during certain organ development and wound healing processes, cell monolayers often advanced on a curved surface. While a considerable amount of effort has been made to study monolayer cell migration, most of the studies have primarily used 2D-cell culture systems, which fail to recapitulate the complex geometric nature of tissues and organs. The mechanistic basis of cell behavior on a 3D curvature also remains poorly understood. Here, we investigate monolayer cell migration on various curved surfaces. We study intra-cellular arrangements, cell polarity and cell sheet velocity. Our findings reveal interesting insights into migration of cell monolayer in response to extent of curvature and can assist in better understanding tissue morphogenesis.

ID: B1-0010 **A5 : 4**

DESIGNABLE REGULATION OF CELL FILTRATION THROUGH MICROPORE ARRAY

Yaoping Liu[1,2], Xiaolong Rao[3], Wengang Wu[1,4,5], Yan Sun[2,6], Wei Wang[1,2,5]

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Micropore-arrayed filter has been considered as the only technique for rare cell separation from a large volume of clinical sample (>10 mL) with a high recovery rate. However, all the present filtration was designed based on simply comparing the geometric sizes of the target cells and the micropore. As cells usually have a broad diameter distribution, the purity of the target cell after filtration is usually questionable, especially when the diameter distributions of target and background cells are overlapped. This work reports a designable regulation of cell filtration through the micropore-arrayed filter by tuning the cell deformability with cytochalasin D.

Cytochalasin D was thought to have defined effects on cytoskeleton depolymerization and actin aggregation. Cells treated with cytochalasin D had an increased deformability and passed through the micropore even if which is of smaller size. The effects of concentrations (0.5, 1.0, 2.0, 5.0, 10 μg/ml for 30 min) and durations (5, 10, 20, 30, 40 min at 5.0 μg/ml) on Hela cells were studied. Hela cells from solution before filtration and filtrate after filtration were imaged under a microscopy and diameters were extracted via Image J.

The decreased quantity and intensity of green fluorescence from filament with the increments of concentration and duration proved that cytochalasin D promoted the cytoskeleton depolymerization, which contributed to the deformability increase and caused the diameter distributions of cells after filtration to approach to those before filtration. Besides, the viability of cytochalasin D-treated cells was tested with trypan blue staining and were higher than 94%. This paper demonstrated a designable regulation of cell filtration through micropore-arrayed filter, which will be useful to establish an actively modulating method to facilitate a highly efficient rare cell separation with a high purity

ID: E1-0008 **A5 : 5**

DETERMINATION OF FLUID MECHANICAL EFFECTS CAUSED BY NEAR WALL BLOOD FLOW FIELD ON ENDOTHELIAL CELL DAMAGE: EFFECT OF RED BLOOD CELLS IN WORKING FLUID

Miria Suzuki[1], Toshiyuki Hayase[2], Suguru Miyauchi[2], Kosuke Inoue[2]

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Endothelial cells (ECs) that line the inner wall of blood vessels play vital roles in maintaining homeostasis of the circulatory system and damage to these cells is known to lead to vascular diseases including atherosclerosis. Former studies have focused on the effects of three types of mechanical forces that are applied to ECs in their local environment, which are shear stress due to blood flow, hydrostatic pressure due to blood pressure and cyclic stretch due to vessel deformation. This study, however, focused on forces that are applied to ECs due to interaction with the passage of red blood cells (RBCs) in the blood stream. To the best of our knowledge, EC flow load studies to date have used cell medium as the working fluid and have not looked at the effect of RBCs. The aim of this study therefore is to determine the effect of RBCs on the degree of EC damage under different flow conditions. ECs were cultured in a flow load chamber and flow load applied using cell medium with and without RBCs obtained from goat's blood as the working fluid. Damage to ECs were measured indirectly by the degree of cell peeling from the substrate at each incrementally increasing flow rate and staining with fluorescent dyes. Shear stress applied to the ECs was evaluated by measurement of the pressure difference inside the chamber. The effect of aligning ECs in the direction of flow on their viability, which replicates the state of ECs in vivo, was also investigated. By comparing the results of these experiments, this study has determined the effect of near wall blood flow of RBCs on EC damage.

ID: D5-0012 **A5 :6**

ANNULUS FIBROSUS REGENERATION: A LAYER-BY-LAYER ASSEMBLY AND MULTI-MODE MECHANOMODULATION BASED STRATEGY

Bin Li[1], Pinghui Zhou, Caihong Zhu, Qianping Guo, Feng Ling, Jibao He

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Degenerative disc disease (DDD) is the leading cause of low back pain, a serious global health problem which contributes to healthcare costs significantly. While it is promising to repair degenerated intervertebral discs (IVDs) using tissue engineering techniques, such an approach largely relies on the effective construction of annulus fibrosus (AF), a major load-bearing component of IVD. However, because of the tremendous cellular, biochemical, microstructural, and biomechanical heterogeneity of AF tissue, it remains challenging to fabricate AF replacements that are biologically and functionally comparable to native AF tissue. Recently, we started to employ a tissue engineering strategy based upon layer-by-layer assembly and multi-mode mechanomodulation in order to mimic the layered structure and to address the heterogeneity feature of AF tissue as well. In brief, we isolated multipotent AF-derived stem cells (AFSCs) for AF tissue engineering. We then synthesized a series of biodegradable polyurethanes and hydrogels with similar elastic modulus as AF tissue. We found that the biochemical and biomechanical profiles of AFSCs were markedly affected by the elastic modulus of scaffolds, implying the feasibility to induce differentiation of AFSCs into cells at different regions of native AF tissue. We also obtained AFSC sheets, i.e., cell monolayers together with the underlying matrix, using novel cell sheet culture techniques. Further, we applied dynamic mechanical stimulation to AFSCs and found that their anabolic and catabolic metabolisms were significantly dependent on the magnitude, frequency and duration of mechanical stimulation. Following these, we will assembly engineered AF tissue, through a layer-by-layer approach, using AFSC sheets primed with substrates of various elasticity and conditioned with appropriate mechanical stimulation. Findings from these studies may provide new insights toward developing engineered AFs whose biological features and mechanical functions approximate those of native AF tissue.

Session	B5: Cardiovascular Mechanics I
Date	Thursday, 8 December
Time	1:45pm - 3:15pm
Venue	LT50

ID: E1-0019 **B5 : 1**

A COMPUTATIONAL STUDY ON STENT GRAFT IMPLANTATION IN DESCENDING AORTA ANEURYSM

Chi Wei Ong, Pei Ho, Hwa Liang Leo

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Thoracic aortic aneurysm (TAA) is one of the serious cardiovascular diseases, which often leads to death if left untreated. Clinical observations showed that growth and progression of an aneurysm are closely linked to the hemodynamics condition of aneurysm sites, such as wall shear stress (WSS) and intravascular pressure. Thoracic stent grafts, commonly known as Thoracic EndoVascular Aortic Repair (TEVAR) can potentially promote recovery of aneurysm by altering the associated blood flow disturbances within the aneurysm besides isolation of aneurysm. However, such data on the hemodynamic impact of a microporous stent-graft on aortic aneurysm are limited. To investigate the hemodynamics changes of microporous stent graft intervention to the TAA, a patient-specific computational fluid dynamic (CFD) studies are performed in a TAA before and after microporous stent graft implantation. The blood was assumed as non-Newtonian fluid. Five cardiac cycles of these pulsatile flow and pressure waveforms were carried out to reduce the unsteady effect of initial cycles. The CFD results were presented and compared in terms of time-averaged wall shear stress (TAWSS), oscillating shear index (OSI) and relative residence time (RRT). Reduced TAWSS and OSI were found on the aneurysm wall after the deployment of microporous stent-graft cab that may reduce the chance of artery wall thickening. Elevated RRT on the aneurysms sac showed that red blood cells and platelets tended to stay longer in the aneurysm sac after implantation of the microporous stent graft. Our study showed that microporous stent graft can potentially alter the flow patterns within the aneurysm and leads to a beneficial hemodynamic environment for promoting recovery of aortic aneurysm.

ID: A2-0032 **B5 : 2**

COMPRESSIVE LAMINAR OPTICAL TOMOGRAPHY FOR ACTION POTENTIALS IN CARDIAC TISSUE

Takumi Harada, Naoki Tomii, Etsuko Kobayashi, Ichiro Sakuma

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Fluorescent tomography has been used for identifying tumor position which stays motionlessly. The propagation of electrical activity in the brain or the heart is the fast activity which propagates several tens of meters a second and the 2D activity on the tissue surface has been measured using the membrane potential sensitive dye. However, the conventional tomography system based on the raster scanning is time consuming measuring method and cannot measure

the 3D fast activity inside the tissue. In the area of cardiac electrophysiology, the arrhythmia is caused by abnormal electrical propagation in the cardiac tissue and the recent simulation studies have reported that the complicated propagation in the cardiac tissue is generated during arrhythmia. Recently, laminar optical tomography has developed for measuring 3D activity in the tissue; however, the measuring speed is not enough to record the arrhythmia.

Then, we proposed the new system which can measure in parallel and reconstruct the 3D data from fewer measurements. This system can irradiate the excitation light as various patterns using Digital Micro-mirror Device and is combined with compressive sensing. By combining the parallel measuring and compressive sensing, this system can measure several hundred times faster than the conventional method, though the recording speed depends on the detector performance. From the simulation experiment results, the rough 3D data can be reconstructed from several measured images and the high and low potential region can be discriminated.

This system can be extended to the multiwavelength measuring because the compressive sensing is used and there is a room for compressing the data. The unknown knowledge between the action potential and calcium ion in the cardiac tissue during arrhythmia may be made clear in the future.

ID: E1-0014 **B5 : 3**

INVESTIGATING RIGHT VENTRICULAR HEMODYNAMICS FOLLOWING TRICUSPID VALVE REPLACEMENT THERAPIES TO TREAT TRICUSPID REGURGITATION

Yen Ngoc Nguyen[1], Edgar Tay[1,2], Hwa Liang Leo[3]

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Recently, there has been a renewed interest in characterizing intraventricular flow patterns in different physiological and pathological conditions. Flow hemodynamics, especially the vortex structure formed and evolved inside ventricular chamber, has been linked to cardiac efficiency and adaptation. In this new perspective, flow alterations due to different cardiovascular procedures can affect the corresponding long-term outcome of these treatments. Especially, repairs and replacements performed on atrioventricular valves to treat valvular regurgitation are likely to exert direct impact on intra-ventricular flow pattern. Despite limited attempts to quantify flow patterns inside the left ventricle after mitral valve replacement and repair, similar flow description for the right side of the heart is currently lacking. In this study, a novel in vitro experimental mock circulatory system mimicking the right heart circulation was built to investigate hemodynamics of the right ventricle following different tricuspid regurgitation therapies. Particle Imaging Velocimetry was performed to visualize flow velocity field and quantify different hemodynamic parameters. The results provides a comparative analysis of the hemodynamic efficiency of different tricuspid valve replacement strategies to treat tricuspid regurgitation. The knowledge could encourage more effective pre-operative planning and better outcomes for current clinical practices.

ID: E1-0023 **B5 : 4**

EFFECT OF CAFFEINE ON INCREASING OF BLOOD VESSELS STIFFNESS MEASURED BY PHOTOPLETHYSMOGRAM

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Blood flow is highly dependent on blood pressure and resistance of blood vessels. Blood pressure is a major driving force so that blood can flow in the vessels. Many factors can increase blood pressure, one of which is the caffeine from coffee. This study measured the blood volume changes by using photoplethysmogram (PPG) placed on index finger to observe the effect of caffeine on subjects. PPG parameter included time delay (dT), stiffness index (SI), augmentation index (AI), pulse interval (PI) and inflection point area (IPA) [1]. The study was conducted on 12 healthy subjects with age ranges of 20-40 years old and weight range from 45-80 kg. Experiments conducted between 09.00am - 12.00 pm. The PPG measurements was performed before drinking coffee and subsequently after at minute 15, 30, 45, 60, 120, and 180. Results showed a decrease in dT along with an increase of SI and AI. Furthermore, coffee gave a maximum effect at minute 30 and its temporal effect then decline to normal state after an hour. There was a moderate increase of PI and IPA but the result is not conclusive. These results indicated that the blood vessels will tend to be more rigid during the caffeine effect. This change in blood vessel stiffness then return to its original state after about an hour. The change of blood vessel stiffness may effect on increasing the blood pressure.
Keywords: caffeine, coffee, blood pressure, photoplethysmogram, stiffness.

ID: E1-0009 **B5 : 5**

FATIGUE LIFE PREDICTION FOR A CORONARY STENT IN A REALISTIC STENOSIS MODEL

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Background The fatigue life of stents is closely related to its biomechanical environment. In this paper, a realistic stenosis model was built from a biomechanics perspective with clinical data. Based on this model, the mechanical performance of coronary stent was analyzed after it was implanted and working in the vessels, and the fatigue life of stents was predicted.
Methods Coronary artery stenosis model was built by using Mimics based on CT angiography (CTA) data. Finite element method (FEM) was used to simulate the stent expansion process after it was implanted into the realistic coronary stenosis model. Based on the mechanical analysis, the influence of cyclic loading effect on the fatigue life of the stents was studied. Stents fatigue rupture was determined by Goodman diagram, and the fatigue performance was analyzed based on parameters including number of fatigue cycles, fatigue life, fatigue safety factor (FSF), and cumulative fatigue damage rate, etc.
Results The maximum stresses of the stent, plaque, and the vessel wall were 413.8 MPa, 6.06 MPa, and 3.39 MPa respectively, and the maximum stress was always located at the bending area of the stent crowns. In the fatigue performance analysis, the stent would not fail for fatigue rupture calculated by Goodman diagram. The predicted number of fatigue cycles was 5.32*108 which was equivalent to fatigue life of 14 years, FSF was 2.8, and the maximum cumulative fatigue damage rate was 71.5%.

Conclusion The mechanical parameters (stress/strain) were associated with the realistic coronary stenosis model. It is feasible to use a realistic model to calculate the accurate stress/strain of a coronary stent, to predict the dangerous point and evaluate the accurate fatigue performance parameters. This study provided an approach to select and position a stent in order to minimize the risk of fatigue fracture.

ID: E1-0026 **B5 : 6**

FINITE ELEMENT ANALYSIS TO PREDICT OCCURRENCE OF CORONARY STENT FRACTURE BY CYCLIC BENDING MOTION

Xiaodong Zhu, Kiyotaka Iwasaki, Mitsuo Umezu
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Introduction
Coronary stent fracture (SF) is recognized as one of the causes of in-stent restenosis or stent thrombosis. Cyclic bending motion of coronary artery has been identified as the primal predictor of SF. The aim of this study is to investigate SF probability of current drug-eluting stents and elucidate the key factor of SF using finite element analysis (FEA).

Methods
Three-link CoCr L605 stent (Xience V, Abbott Vascular), two-link stainless steel SUS316L stent (Nobori, Terumo) and two-link PtCr stent (Promus Element, Boston Scientific) were chosen as subjects. Three-dimensional geometries of the stents were constructed based on micro-CT measurement. Referenced data of mechanical properties such as elastic modulus, poisson's ratio, yield stress, fatigue strength and ultimate tensile stress were used in the FEA. The processes of crimping and deploying the stent were simulated. The stent was crimped on a balloon by applying enforced displacement. Next, the stent was deployed into a hyper-elastic bended coronary artery model. Then, the coronary artery model was cyclically bended from the diastolic angle of 125° to the systolic angle of 105°. Fatigue safety factor (FSF) was calculated using stress amplitude and mean stress. The SF risk was evaluated using Goodman fatigue diagrams.

Results
The maximum values of 1/FSF were 1.16 and 1.53 for the CoCr and SUS316L stents, respectively, indicating that the SF risks were high. For the PtCr stent, the maximum value of 1/FSF was 0.83, indicating that the SF risk was low. The locations with higher SF risk identified by FEA were coincident with the fracture locations in the durability tests. Moreover, the FEA data indicated that stress amplitude had a greater effect on SF occurrence.

Conclusions
The FEA was useful to predict SF risk. It was elucidated that stress amplitude was the key factor of the coronary SF in cyclically-bended coronary artery.

Session	C5: Biomedical Imaging II
Date	Thursday, 8 December
Time	1:45pm - 3:15pm
Venue	LT51

ID: A2-0009 **C5 : 1**

ENABLING ULTRASOUND IMAGING FOR 4D IMAGING OF EMBRYONIC HEART

Sheldon Ho, Germaine Xin Yi Tan, Toon Jin Foo, Phan Thien Nhan, Choon Hwai Yap

National University of Singapore, Singapore

Understanding of embryonic cardiovascular fluid mechanics is important to understand the role of mechanics in congenital heart diseases. Detailed investigation can be performed if high resolution imaging on small animal embryos can be used to support computational fluid dynamics analysis. However, most methods of imaging are invasive and do not allow for repeated scans. Previously, older chick embryo cannot be analysed quantitatively due to poor imaging tehcnique. Ultrasound allows for good visualisation of chick embryos but suffer from excessive noise and poor contrast between tissue and blood. We present a novel technique to perform 4D imaging of chick embryos using an algorithm for spatial and temporal correlation, and show that this technique can be used for detailed quantification of geometry and various moving cardiovascular structures.

High-frequency 2D B-mode cine-ultrasound imaging was performed at multiple planes for a chick embryo at Hamburger-Hamilton (HH) stage 25. Images from 20-25 cardiac cycles within each plane were averaged into one ensemble-averaged cardiac cycle, using quadratic mean which resulted in good contrast between blood and tissue spaces. Spatial and temporal correlation was used to determine matching phases in the cardiac cycle between neighboring imaging planes, and heart beats within the same imaging plane thus creating a 4D image of the blood space within the embryonic cardiovascular system. Vascular Modeling Toolkit (VMTK), was used for 3D segmentation over 20-30 time points. Next, cardiac chamber volumes and vascular cross-sectional area over time were obtained and reported.

Processing of image using quadratic ensemble averaging allows for distinction to be obtained clearly. 4D image could be obtained through matching of the time points and allow quantification of peristaltic motion. This technique can be a powerful tool to use in studying older embryonic cardiovascular function, and could be used for future computational fluid dynamics analysis of embryonic cardiovascular system.

ID: A2-0017 **C5 : 2**

ACCURATE AND EFFICIENT TREATMENT OF TUMOR WITH OPTICAL COHERENCE TOMOGRAPHY-GUIDED LASER THERAPY

Wei-Chuan Chen[1], Hsin-Yi Chou[1], Chun-Chieh Wang[1,2], Meng-Tsan Tsai[1]

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Laser therapy has been widely implemented for various biomedical applications such as ophthalmology, dermatology, dentistry, and ENT. However, laser therapy may induce additional damages on the surrounding tissue and it is difficult to accurately identify the treatment region. In this study, we proposed to develop optical coherence tomography (OCT)-guided laser therapy for identification of lesion and real-time monitoring the treatment procedure as well as evaluation of tissue recovery. OCT enables reconstruct the microstructures of biological tissue without extra contrast agent. A functional OCT system was developed to simultaneously obtain the 3D structures and angiography of biological tissue. Moreover, a CW laser at 455 nm was integrated with the developed OCT system to induce tissue ablation. The developed OCT system can provide an axial and transverse resolutions of 7 mm and 5 mm respectively, enabling to differentiate the tumor development in the early-stage. In this study, the tumor cells were implanted in the skin of mice and the mice skin was scanned and treated by the integrated OCT-guided laser therapy system. The results showed that the tumor can be 3D visualized and the tumor region can be accurately exposed by the CW laser with minimized additional damages. Moreover, the treatment outcome can be in vivo monitored and evaluated. The results demonstrate that such OCT-guided laser therapy system can improve the treatment efficiency and reduce the additional damages, potentially enabling to implement for various biomedical applications

Keywords: optical coherence tomography, laser ablation, tumor, imaging-guided therapy, angiography

ID: A2-0005 **C5 : 3**

TWO-DIMENSIONAL ULTRASONIC-MEASUREMENT-INTEGRATED SIMULATION OF BLOOD FLOW IN A CAROTID ARTERY CONSIDERING DEFORMATION OF THE BLOOD VESSEL

Daisuke Harada[1], Toshiyuki Hayase[2], Suguru Miyauchi[2], Kosuke Inoue[2],

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Atherosclerosis is related to circulatory diseases and has a close relationship with hemodynamics. Therefore, hemodynamic information is crucial for elucidation of the mechanism and the development of a new diagnostic method for circulatory diseases. As a method to acquire hemodynamic information, Funamoto et al. proposed ultrasonic-measurement-integrated (UMI) simulation, showing its advantages over conventional numerical simulations. Aiming at clinical application, a two-dimensional UMI (2D-UMI) blood flow analysis system was developed. The system has functions necessary for automatic blood flow analysis of a carotid artery, which is a common site of atherosclerosis based on standard clinical ultrasonic measurement, such as extraction of the blood vessel configuration and inflow velocity estimation. The versatility of this system was shown for clinical measurement data. In this 2D-UMI blood flow analysis system, however, the blood vessel shape extracted from the ultrasonic measurement is a time-averaged shape and the deformation of the blood vessel synchronizing with the heartbeat is not considered. The rectangular grids used in the analysis also make it difficult to represent the curvature of the blood vessel shape and to evaluate the wall shear stress accurately. The purpose of the present study, therefore, was to establish a method of 2D-UMI blood flow simulation in a carotid artery with accurate consideration of the blood vessel motion and shape. For extraction of time-dependent blood vessel shape, a pattern matching technique was applied to sequential B mode images. A boundary-fitted grid was employed for accurate representation of the blood vessel shape and wall shear stress. The effectiveness of the proposed method was examined by experiment. The blood flow in a carotid artery of a healthy volunteer was analyzed by this new method and the existing one. The results of the both methods were compared with that of the ultrasonic measurement, showing the superiority of this new method.

ID: A2-0016 **C5 : 4**

ULTRASOUND SHEAR WAVE IMAGING: A QUANTITATIVE TECHNIQUE TO MONITOR THE PROGRESS OF AMYOTROPHIC LATERAL SCLEROSIS

Minhua Lu[1,2], Zhenzhou Li[3], Chaochao Zhu[1], Shuai Huang[1], Qingfeng Gao[1], Xiang Wu[1], Rui Mao[1,4]

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Amyotrophic lateral sclerosis (ALS) is a nervous system disease that causes muscle weakness and impacts physical function. Electromyography is regarded as the golden method for the early diagnosis of ALS. During the recent years, muscle ultrasound has been also involved in the early diagnosis and differentiation of ALS from other neuromuscular disorders. However, how to quantify the weakness of the muscles of ALS patients, is still remained as a challenge. Shear wave elastography is an ultrasound-based technique that characterizes tissue mechanical properties based on the propagation of remotely induced shear waves. Various ultrasound shear elasticity imaging techniques have been developed in the last two decades. In this study, we utilized focused comb-push induced shear wave method with an open research ultrasound system (Verasonics Inc., Redmond, WA), to quantitatively evaluate the biomechanical properties of the skeletal muscle noninvasively. A linear array transducer L7-4 (Philips Healthcare, Andover, MA) was used to produce the push beams (center frequency = 4.09 MHz, 600 us duration), and then immediately switched to plane wave imaging mode with all transducer elements (center frequency = 5.208 MHz), to track shear wave propagation inside the muscles, either along the muscle fiber or perpendicular to the muscle fiber. The shear wave speed was then estimated and used to calculate the shear modulus of the muscles. Elasticity of biceps brachii and soleus under different loading was evaluated in a healthy volunteer (aged at 24 years old) and three ALS patients (aged at 54 ± 17.8). It is found that the values of shear wave speed were significantly higher in both relaxed and contraction situation for the healthy volunteer than those of the ALS patients. The results were discussed and correlated with the progress of muscle weakness.

Session	SYM-07: Special Topic Symposium: Stem Cells and Organs-on-Chips
Date	Thursday, 8 December
Time	1:45pm - 3:15pm
Venue	LT53

ID: KN-0002 **SYM-07 : 1**

HUMAN KIDNEY ORGANOGENESIS FROM PLURIPOTENT STEM CELLS ON A CHIP

Justin Cooper-White[1,2,3], Nick Glass[2], Minoru Takasato[4], Pei Xuan Er[4], Ernst Wolvetang[1], Melissa Little[4], Drew Titmarsh[1]

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The differentiation of human pluripotent stem cells (hPSCs) towards kidney is of great interest for developmental biology, toxicology and regenerative medicine. Herein, directed differentiation into kidney cell populations and organoids have been explored using a microfluidic system and image cytometry in a systematic and quantitative manner. We have investigated this complex differentiation process under soluble factor perturbation using a full factorial 3 by 3 microbioreactor array (MBA) previously developed in the Cooper-White lab. This allowed for 27 unique soluble factor combination inputs. These inputs are then perfused through 10 serial wells allowing for the investigation of potential paracrine and autocrine signalling, generating 270 unique conditions within the MBA. Cells were differentiated towards intermediate mesoderm cell populations (PAX2+), before running several different factors across the MBA. Initial experiments examined the effect of known signalling pathways on the differentiation of hPSCs towards renal cell populations at day 9 and day 12 time points of the differentiation protocol. Results confirmed the essential factors for the differentiation towards kidney like cell phenotypes and the condensation of ureteric epithelial cells (GATA3+ECAD+). This effect was synergistically enhanced in the presence of some of the factors investigated but also gave rise to stromal/mesangial cell populations of renal origin (GATA3+ECAD-). Early nephrons (WT1+ECAD+) and metanephric mesenchyme (WT1+ECAD-) have also been observed to form around the ureteric epithelial structures. Image cytometry was then performed across the entire device to provide FACs-like data for the population within each well. Further parameters based on clustering structures of cells were also investigated and quantified with respect to soluble factor and paracrine signalling. Microfluidic-enabled factorial optimisation of directed differentiation into complex structures of the human kidney was confirmed. Important cell subtypes of the kidney were identified and quantified in many different conditions, providing novel insight into developmental pathways and kidney organogensis.

ID: B2-0005 **SYM-07 : 2**

DEVELOPMENT OF BIOMIMETIC MICRODEVICES TO RECONSTITUTE BONE MARROW FUNCTION

Yusuke Torisawa

The Hakubi Center for Advanced Research, Kyoto University, Japan; AMED-PRIME, Japan Agency for Medical Research and Development

Studies on hematopoiesis are usually conducted in animals because in vitro methods for culturing blood cells do not accurately model bone marrow physiology. Given the complexity of the bone marrow microenvironment necessary to support the viability and function of the hematopoietic system, there is currently no method to recapitulate the bone marrow microenvironment as well as blood forming functions in vitro. To overcome this challenge, we used a tissue engineering approach to first induce formation of new bone containing marrow in vivo, and then we surgically removed it whole and maintained it in a microfluidic device in vitro. New bone containing marrow was engineered by implanting a polymer device containing a cylindrical hole filled with bone-inducing materials subcutaneously on the back of a mouse. The engineered bone marrow was virtually identical to bone marrow isolated from a mouse femur and could be surgically removed intact and maintained viable in a microfluidic system in vitro. This bone marrow-on-a-chip microdevice continues to produce blood cells which are released into microfluidic circulation, while maintaining hematopoietic stem and progenitor cells in normal in vivo-like proportions inside the device. This microdevice could be used to mimic complex organ-level marrow responses to radiation toxicity normally only observed in vivo, and to detect the therapeutic responses of countermeasure agents that have been shown to accelerate recovery from radiation-induced toxicity in animals, whereas these responses could not be replicated by conventional bone marrow culture methods. It is because conventional culture methods do not recapitulate the bone marrow microenvironment which plays an important role in hematopoiesis as well as radiation responses. Therefore, the ability

to engineer a complex hematopoietic niche that is capable of maintaining functional hematopoietic stem cells offers a new approach for evaluation of drug efficacy and toxicities and study of hematopoiesis and hematologic diseases.

ID: B1-0003 **SYM-07 : 3**

HIGH-THROUGHPUT 3D CHEMOTACTIC ASSAYS REVEALS COMPLEX PATTERNS IN NEURONAL SENSATION TO MOLECULAR GRADIENT

Peng Shi

City University of Hong Kong, Hong Kong

Cell migration and neurite projection are key cellular processes in the development of nervous system. Progenitor cells migrate to targeted coordinates from different origins and neurite outgrowth are guided to allow wiring of brain circuits. These processes are suggested to be regulated by graded distribution of diffusive or substrate-bounded guidance cues, or chemotaxis. In the past few decades, great efforts have been made to reveal various chemotactic molecules, such as neurotrophin factors, netrin-1, semapherin, slit family, and growth factors etc. Though many of these cues are suggested to play shared roles in the guidance of migrating neurons and axonal projection, little has been done to elucidate the integration of migration and neurite guidance programs within individual cells; and we know even less about how different gradient profiles affect these regulations. In this study, we developed a microfluidic platform that incorporates arrays of matrigel-cylinders to allow high-throughput generation of a large library of molecular gradients with distinct steepness. When primary neurons were seeded into the hydrogel, we can establish a massive array of three-dimensional (3D) neuron cultures, each of which exposes to a particular gradient profile. In this way, hundreds of 3D chemotactic assays could be performed in parallel and the regulation of both cellular migration and neurite projection could be simultaneously investigated. As a proof of concept, we tested three classical types of guidance molecule, NGF, Netrin-1, and Sema3A, by using the 3D chemotactic assays, and revealed dramatically diverse and complex neuronal chemosensation in relation to the gradient steepness of different molecules.

ID: D5-0003 **SYM-07 : 4**

CELL FIBER TECHNOLOGY FOR ENGINEERING FUNCTIONAL 3D MODELS

Amy Hsiao[1], Hiroaki Onoe[1,2], Teru Okitsu[1,3], Midori Negishi[1,3], Shoji Takeuchi[1,3],

[1]The University of Tokyo, Japan; [2]Japan Science and Technology Agency, Japan; [3]ERATO Takeuchi Biohybrid Innovation Project, Japan Science and Technology Agency

The proper functioning of many organs and tissues greatly depends on the structural organization of the constituent cells. In particular, tissues such as linear muscles, long nerve networks, and tubular blood vessels are better modeled by long, fibrous-shaped cellular constructs as they are often made up of cells that precisely align or extend in the longitudinal direction. Here, we use the cell fiber technology to fabricate and culture functional 3D fiber-shaped cellular constructs from various types of cells. Using a double co-axial microfluidic device, different types of cells suspended in natural extracellular matrix (ECM) proteins possessing an optimized stiffness can be encapsulated in meter-long core-shell hydrogel microfibers. By allowing the cells to migrate and connect with each other within the 3D micro-tubular space, we show that these fiber-shaped cellular constructs reconstitute intrinsic morphologies and functions of living tissues. We further applied this technology to encapsulate multipotent stem cells and differentiate the cells into functional tissues. To expand the versatility of 3D fiber-shaped cellular constructs as useful tissue engineering building blocks, we further demonstrate various assembling techniques such as reeling and weaving the constructs into macroscopic cellular structures. Finally, primary pancreatic islet cells encapsulated in the hydrogel microfibers and subsequently transplanted into diabetic mice normalized blood glucose concentrations for 2 weeks. These microfibers can be used as functional 3D models of fiber-shaped tissues such as muscle fibers, nerve networks, and blood vessels for drug testing, regenerative medicine, and tissue engineering of larger organs.

ID: D5-0004 **SYM-07 : 5**

ENGINEERED BONE TISSUES: FROM REGENERATIVE MEDICINE TO DISEASE MODELS

Mark Chong

Nanyang Technological University, Singapore

Tissue engineering has traditionally been applied in the field of the regenerative medicine. Our group and others have reported that such approaches may be used to generate vascularized osseous tissue in vitro and further demonstrated their utility in the treatment of large fractures. Following on the observation that human tissue engineered bone (hTEB) recapitulate many physiological processes, we asked the question whether a similar strategy could be applied towards engineering biological models of diseased state. This talk will cover three platforms that are being developed in our group for the study of bone metastatic disease: (i) HuMice (Humanised Mice), where mice engrafted with hTEB provide systemic readouts (ii) BOnEMets (Bioreactors for the Observation aNd Evaluation of Metastasis), where macrotissue models of bone metastatic lesions are subjected to defined chemical and physical stimuli and finally, (iii) MiMiC (Migration and Metastasis in a Chip), where bone microenvironments are engineered onto microfluidic chips to study migration and extravasation events at single-cell levels.

Session	SYM-08: Special Topic Symposium: Health Informatics
Date	Thursday, 8 December
Time	1:45pm - 3:15pm
Venue	Global Learning Room

ID: A4-0001 **SYM-08 : 1**

TOWARDS THE ASSESSMENT OF RESPIRATION STATUS USING EIT AND AUSCULTATION

Paulo de Carvalho, Rui Paiva, César Teixeira, Jorge Henriques, Felipe Trenk, Luís Mendes

Universidade de Coimbra, Portugal

The analysis of the respiratory sounds is a valuable diagnostic tool for the detection and follow-up of respiratory diseases such as Chronic Obstructive Pulmonary Disease (COPD). Adventitious sounds, such as wheezes, stridors, squawks and crackles, refer to additional respiratory sounds superimposed on breath sounds and are highly correlated to the respiratory function and therefore have a high potential to deploy pHealth solutions for COPD management. EIT is another biosignal that potentially can allow the continuous assessment of the ventilation function. In this talk we shall present the auscultation sound and EIT processing modules developed in the context of the EU Welcome (FP7-ICT-2013-10) project related to the integrated care of COPD patients

ID: A7-0001 **SYM-08 : 2**

CURRENT PRACTICES AND FUTURE DEVELOPMENT OF HEALTH INFORMATICS IN TAIWAN - NCKU HOSPITAL AS AN EXAMPLE

Shyh-Hau Wang[1,2], Kuo-Sheng Cheng[1,2], Cheng-Ping Lai[2]

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In accompanying with the fast development of information and communication technology (ICT), most of hospitals in the world has transformed the use of written paper patient record into electronic patient record (EPR). Similar to those developed countries, it took three stages of efforts for Taiwanese hospitals to thoroughly achieve the development of EPR. Furthermore, following both the introduction of National Health Insurance (NHI) in 1995 and the deployment of fast wideband internet service, current health informatics tends to cover so tremendous varieties of information to be conveyed among diagnostic room, examining room, insurance providers, equipment providers, and others. With the availability of EPR and internet, the medical database becomes almost free of boundary between satellite and main hospital of NCKU. The telemedicine also is feasible and practicable. Nevertheless, the sharing of medical informatics to all of medical centers, hospitals or healthcare providers nationwide are still not fully available even though the infrastructure of cloud storage and computation is so well-developed. On the other hand, more efforts are undergoing to analyze the big data of the 20 years' medical record stored in Taiwanese National Health Insurance Administration, Ministry of Health and Welfare. Along with fast developments in wearable, Internet-of-Things (IoT), and robotic technologies, the health informatics in Taiwan certainly will be moved toward intelligent medicine in which it will not only be able to strengthen the establishment of whole health system to shorten variations of medical services between large cities and remote areas, but also hopefully be capable of connecting into all of healthcare system in the world. The process of current

development of health informatics at NCKU hospital will be summarized and that of the future planning will also be introduced.

ID: IN-0006 **SYM-08 : 3**

CYBERSECURITY CONCERNS IN HEALTHCARE DOMAIN

Shankar Krishnan

Wentworth Institute of Technology, USA

Rapidly emerging technological advances have been applied in healthcare systems, particularly involving medical devices and health informatics operating in cyberspace with the main aim of improving the quality and efficiency of healthcare delivery. Amounts and rates of transmission are increasing at unprecedented levels leading to “Big data” in Healthcare. While the positive effects of cyber-based applications are evident by increased usage in hospitals, clinics, doctors’ offices and senior living facilities worldwide, cybersecurity poses growing challenges to hospital personnel including clinical engineers as threats and vulnerabilities constantly evolve. The objective of the presentation is to provide an overview of the cybersecurity challenges in healthcare and suggest some solutions.

Attacks on X-ray equipment, blood gas analyzers, drug infusion pumps and other devices and prevalence of malware on medical networks constitute grave concerns in hospitals. Compromises of health data of millions and huge ransomware issues have been reported. Data breaches could occur in applications involving medical records, imaging, telemedicine, off-shore transcriptions, physician collaborations, clinical trials, post-discharge monitoring. FBI in the US has issued an alert warning about cybersecurity risks that networked medical devices and wearable sensors could pose to consumers and healthcare providers.
By following US FDA recommendation, working together with the device manufacturers and security experts and incorporating testing, training and prevention, appropriate safeguards can be put in place to reduce the risk of device failures due to cyberattacks and the required levels of cybersecurity can be achieved in the healthcare domain.

In conclusion, the networked medical devices and health information systems play vital roles improving the quality of patient care while some associated cybersecurity challenges arise. Appropriate defensive cybersecurity approaches must be implemented by associated personnel inside and outside the hospitals to render the operations in healthcare safe and efficient.

ID: **SYM-08 : 4**

ABSTRACT TITLE NOT AVAILABLE UPON PRINTING

Ratko Magjarević

University of Zagreb, Croatia

ID: A5-0002 **SYM-08 : 5**

WEB-BASED MEDICAL DEVICE EVENT SELF-LEARNING SYSTEM FOR CLINICAL ENGINEERING

Kang Ping Lin[1], Mei Fen Chen[1], Cheng-Lung Tsai[2], Tsiar Kao[1], Young-Xin Chen[1]

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[2]Metropolitan University

“Medical device safety” is an important issue in the medical care service system, especially in hospitals. Well-functioning medical devices could help physicians to make solid diagnose and treatment plan. The web-based medical device event education system for clinical engineer is an information collecting and education system based on repairing and maintenance medical device events. Functions of this web-based system included in-hospital experience of dealing with medical devices event collecting, level of event classification, event review by expert, event analytical reporting and self-learning from reports in database. This web-based system is a member limited web system; only hospital staff will be able to apply for membership. This web-based system provide a platform that clinical engineer could learn from analytical reports of medical device realistic events. As a result, the clinical engineer’s problem solving ability could be improved and medical device safety in-hospital can be increased simultaneously.

ID: IN-0009 **SYM-08 : 6**

DESIGN AND VALIDATION OF THE VOICE-DRIVEN EXPERT SYSTEM SUPPORTING PRANDIAL INSULIN DOSE CALCULATION IN PERSONS WITH DIABETES

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We developed the voice-driven client-server expert system (VoiceDiab) supporting prandial insulin dose calculation in persons with diabetes. The VoiceDiab consists of an Android controlled smartphone with the client application communicating with a set of three servers responsible for: (1) automatic speech recognition and transformation of the verbal description of meals into text, (2) analysis of the textual description of the meal to determine its composition, (3) calculation of the insulin dose compensating the meal.

The efficacy of the VoiceDiab system was validated on a group of 44 patients (30 female and 14 male) aged 17.3 ± 10.2 years with type 1 diabetes in the cross-over study. The study group was appropriately educated regarding the insulin therapy. Each patient estimated prandial insulin doses by herself / himself in one study period (Control), while in the other study period insulin doses were calculated by the VoiceDiab system (VoiceDiab). An order of the study periods (Control vs. VoiceDiab) was randomly assigned. Blood glucose was monitored continuously during both periods. The mean blood glucose (MBG_{tot}), mean postprandial blood glucose (MBG_{pp}), mean standard deviation of blood glucose (MSD_{BG}) and mean time of glycemia in the range 70-180 mg/dl ($\%BG_{norm}$) were analyzed.

Values of all the assessed parameters indicated slightly better metabolic control during the VoiceDiab period (Control vs. VoiceDiab): MBG_{tot} – 164 ± 31 mg/dl vs. 163 ± 30 mg/dl, MBG_{pp} – 169 ± 35 mg/dl vs. 167 ± 30 mg/dl, MSD_{BG} – 74 ± 15 mg/dl vs. 70 ± 15 mg/dl and $\%BG_{norm}$ – 54.9% ± 13.6% vs. 55.65 ± 13.8%.

The obtained results suggest that the outcome of the intensive insulin treatment in properly educated patients with diabetes is similar when prandial insulin doses are estimated by patients and when they are calculated by the VoiceDiab system based on the voice description of meals.

Session	A6: Cell & Molecular Mechanobiology II
Date	Thursday, 8 December
Time	4:00pm - 5:30pm
Venue	Auditorium 2

ID: E6-0001 **A6 : 1**

QUANTITATIVE ASSESSMENT OF CIRCULATING TUMOR CELL EXTRAVASATION IN A 3D MICROVASCULAR NETWORK SYSTEM

Jiho Song[1,2], Bee Luan Khoo[3], Giulia Adriani[3], Soo Chin Lee[4,5], Chwee Teck Lim[6], Roger D. Kamm[2]

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In the past two decades, several studies have shown that circulating tumor cells (CTCs) play a major role in cancer metastasis. Extravasation, the process by which CTCs escape from the vasculature in a remote tissue, is a critical step in the metastatic cascade. This involves tumor cell arrest on the endothelium, formation of dynamic contacts, tumor cell transendothelial migration and subsequent invasion into the surrounding tissue of secondary organs. Although extravasation is a recognized step in the metastatic cascade, the precise cellular interactions and molecular alterations associated with extravasation are poorly understood, especially in the case of patient-derived CTCs. Recent advances in microfabrication technologies and advanced biomaterials have allowed for the development of in vitro platforms that recapitulate more physiologically relevant cellular components and functions. In this work, 3D vascular networks with effective lumen diameters of 10 to 100 μm are formed in the central region of a microfluidic device measuring 1x3x20 mm. We introduced patient-derived CTCs previously cultured in laser-ablated microwells for 14 days by perfusing them into the microvasculature networks and observing them by time-lapse microscopy. In this way, CTCs could be visualized migrating across the endothelium in a precisely controlled and physiologically relevant microenvironment, providing important insights into extravasation mechanisms. We have also tested fluorescently tagged breast and lung cancer cell lines (MDA-MB-231 and A549) and observed their transmigration through the vessel walls in real time. Observations of the ability of CTCs

to extravasate could be used to assess the risk of a particular patient to form metastases at different stages in their disease. Furthermore, this approach may be useful for drug screening to assess the success of potential therapeutic treatments.

ID: E6-0007 **A6 : 2**

PROREIN KINASE C A TRANSLOCATION BY MECHANICAL STIMULATION IN SINGLE VASCULAR ENDOTHELIAL CELLS

Masataka Arai, Takumi Hasegawa, Kazuhiro Nakashima, Toshihiro Sera, Susumu Kudo

Kyushu University, Japan

Protein kinase C α (PKCα) is a signaling protein that regulates various cellular functions, including migration, differentiation, and apoptosis. Generally, PKCα is distributed uniformly in the cytoplasm. In addition, previous studies showed that PKCα is translocated to a plasma membrane with pharmacological stimulation.

Intracellular Ca2+ wave regulated several signal-transduction pathways. The translocation of PKCα by pharmacological stimulation occurred with an increase of intercellular Ca2+ concentration. A mechanical stimulation by micropipette also causes a transient rise in intracellular Ca2+ concentration and Ca2+ wave. However, the relationship beween PKCα and Ca2+ wave by mechanical stimulation is not understood well yet.

In this study, we developed an experiment system for simultaneous observation PKCα translocation and Ca2+ wave in single cell in response to mechanical stimulation. Futhermore, we investigated the signaling pathway of PKCα translocation and Ca2+ wave by the mechanical stimulation.

PKCα-Dronpa Green was transfected into bovine aorta endothelial cells by the lipofection reagent HilyMax. Ca2+ was measured using the fluorescent Ca2+ indicator fura-2 AM.

Fluorescence images ware captured at a rate of 146 msec per frame. The single cell was stimulated mechanically with a glass microprobe. The tip of the probe was pulled in less than 3μm in diameter and polished. For investigation of he signaling pathway of PKCα translocation, Go6976 was used for inhibitor of PKCα. Thapsigargin and EGTA were used for deplete of intra- and extracellular Ca2+, respectively.

Mechanical stimulation induced a rapid Ca2+ wave and PKCα translocation to stimulated region. Fluorescence of PKCα reached peak after stimulation in around 20 sec. PKCα translocation was inhibited with Go6976. And, when Ca2+ in the extracellular medium was chelated by EGTA, PKCα translocation was not observed. On the other hand, PKCα translocation was observed with thapsigargin. These results suggested that extracellular Ca2+ is necessary to PKCα translocation by mechanical stimulation.

ID: E6-0011 **A6 : 3**

OBSERVATION OF MEMBRANE LIPID IN BOVINE AORTIC ENDOTHELIAL CELL UNDER MECHANICAL STIMULUS

Satoshi Miyamoto, Masataka Arai, Kazuhiro Nakashima, Toshihiro Sera, Susumu Kudo

Kyushu University, Japan

Intracellular signaling occurs from G-protein coupled receptor (GPCR) in plasma membrane. Once GPCR receives extracellular stimulus, phospholipase C (PLC) is activated and hydrolyzes phosphatidylinositol 4, 5-bisphosphate (PIP2) to generate inositol triphosphate (IP3) and diacylglycerol (DAG). These processes are carried out at the plasma membrane, particularly PIP2 and DAG are known as membrane lipids. IP3 diffused into cytoplasm and activates Ca2+ store, which leads to increase the intracellular concentrations of Ca2+. DAG and Ca2+ are the activators of protein kinase C (PKC) family. On the other hand, the cellular sensing system to mechanical stimulus have been reported. For example, increase the intracellular concentrations of Ca2+ and PLC activation by poking stimulus. However, the response system has not been understood.

In this study, we focused on the PIP2 hydrolysis on the membrane to investigate the intracellular response as cellular sensing system to mechanical stimulus. To achieve this objective, we observed the activations of PIP2 and DAG in bovine aortic endothelial cells (BAECs) when poking stimulus was exposed. For observation of the membrane lipids in living cells, the fluorescent plasmids were transfected in BAECs. GFP-C1-PKCgamma-C1A and GFP-C1-PLCdelta-PH were used for DAG and PIP2 imaging, respectively. In experiment, the micropipette needle with tip radius of 1μm was used for poking stimulus to living cell, and the fluorescent change of the microscopic images was analyzed.

The fluorescent distribution change of GFP-C1-PKCgamma-C1A was observed in overall stimulated cell, which indicates DAG expression at the whole plasma membrane. Previous study reports that PKCα

translocation to stimulated point. DAG is necessary for PKCα translocation, however in this study the localized DAG distribution was not observed. These results suggested that DAG expression may have no relationship to PKCα translocation.

ID: E6-0010 **A6 : 4**

REGULATION OF CELLULAR CONTRACTILITY BY TGFB AND DYNAMIC STRETCH IN FIBROBLASTS

Namrata Gundiah[1], Ankur Kulkarni[1], Siddhartha Jaddivada[1], Reena Sayani[1], Paturu Kondaiah[1], Paul Watton[2]

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Cellular homeostasis is maintained by dynamic feedback with the local microenvironment and involves a complex interplay of biochemical and mechanical factors. Loss of homeostatic conditions is hypothesized to alter the cellular mechanobiology and lead to the progression of fibrosis through secretion and deposition of extracellular matrix proteins which alter the tissue mechanics. Fibroblasts in the connective tissue mediate these changes and are guided by chemical and mechanical signals such as profibrotic biochemical factors (TGFb) and the cyclic stretch. Earlier studies have investigated the effects of TGFβ on fibrosis; the mechanobiological response of cells to bio-mechanical stimuli is yet to be elucidated. We treated mouse fibroblasts with TGFβ in the presence or absence of cyclic stretch using a custom built biaxial stretcher. Changes in cell contractility were quantified using traction force microscopy. These results show that treatment with TGFβ increased stress fiber formation and yielded clear polarization in the cellular morphology. In addition, we cultured cells on polyacrylamide gels of varying stiffness and show, using a regularized Fourier Transform Traction Cytometry inverse approach, that TGFβ treatment affects cell contractility.

Lastly, we used a systems biology approach implemented via reaction-diffusion equations with results from the traction experiments to simulate the formation and de-adhesion of bonds between the cytoskeleton and the substrate in response to dynamic stretching. The model predicts changes in the dynamics of focal adhesion recruitment and acto-myosin contractility which are concomitant with an increase in stress fiber activation due to TGFβ. Ongoing investigations are aimed at measuring changes in cell contractility due to the combined effects of cyclic-stretching and TGFβ. Our studies provide further insight into the intricate interplay of chemo-mechanical factors which govern cell contractility and ultimately the fibrotic response; a better understanding of these will aid in the design of novel therapeutic regimes.

ID: E6-0002 **A6 : 5**

MICROTOPOGRAPHY INDUCES DIFFERENTIAL SENSITIVITY ON CANCER CELL PROLIFERATION VIA RHO-ROCK-MYOSIN CONTRACTILITY

Parthiv Kant Chaudhuri[1], Catherine Qiurong Pan[1], Boon Chuan Low[1,2], Chwee Teck Lim[1,2]

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The microenvironment that surrounds the cells is composed of the extracellular matrix (ECM) that provides myriads of mechanical and biochemical cues, which can dictate cellular behavior and phenotype. During breast cancer progression, the ECM fibers align themselves in parallel orientation that helps the migration of the cancer cells away from the primary tumor. Here, we examined the effect of microtopographic cues on cancer and non-cancer cell proliferation by fabricating micron scale topographic features. We observed that the proliferation response of non-cancer breast epithelial cells (MCF-10A) but not of metastatic (MDA-MB-231) and non-metastatic (MCF-7) breast cancer cells; decreases on the microgratings (gratings widths of 2, 3 and 4 μm) across all the ECM proteins, namely, fibronectin, collagen and laminin. Interestingly, microgratings mediated proliferation reduction is prevented in presence of acto-myosin contraction inhibitory drugs, namely, Y-27632 and blebbistatin, thereby confirming the activation of Rho-ROCK-Myosin contractility in this phenomenon. In conclusion, we observe the existence of Mechanically Induced Dormancy (MID) where topographical cues induces proliferation inhibitory response to the normal epithelial cells but the malignant cells could successfully overcome this inhibitory barrier and continue uncontrolled proliferation. This study reveals a novel mechanism by which normal cells sense external topographical cues and restricts their proliferation in an environment that promotes tumor growth and spreading. Determining how tumor cells bypass this mechanism of MID may be paramount in the development of novel anti-cancer strategies that target cellular mechanisms altered by physical or mechanical cues during cancer progression. Promising chemotherapeutic agents targeting cellular contractile machineries has already started to emerge, and more are expected to come.

ID: E6-0004 **A6 : 6**

REMODELING OF ACTIN CYTOSKELETONS INDUCED BY LOW-ENERGY SHOCK WAVE IRRADIATION

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Low-energy shock waves (LESW), peak pressure of which is 10-20 MPa, induce cellular responses in various cell types including endothelial cells and osteoblasts. Comparing with peak pressure in Extracorporeal Shock Wave Lithotripsy, 50-100MPa, energy flux density is around 1/10. In our previous studies, LESW induced cellular responses including intracellular Ca2+ increase and mitochondria remodeling. Furthermore, in those cellular responses, actin cytoskeleton was involved. Thus, it was suggested that LESW interact with actin cytoskeleton before inducing various cellular responses. Mechanical stimulations, such as cyclic stretch and shear stress, remodel actin cytoskeleton. Here we hypothesized that LESW also remodel actin cytoskeleton as well. In this study, actin cytoskeletons were visualized by expressing pLifeAct-mTurquoise2 in murine osteoblastic MC3T3-E1 cells. Remodeling of actin cytoskeletons was observed every 15 min for 30 min, i.e. three time points after shock wave irradiation. Dependent on peak pressure and shot number of shock wave irradiation, shock wave irradiation induced various remodeling of actin cytoskeletons. Among the remodeling, newly appearances of filopodia-like or lamelipodia-like structures were typically observed. However, no apparent remodeling in stress fibers was observed during the observation time of 30 min. In the remodeling of actin cytoskeleton with other mechanical stimulation such as stretch and shear stress, remodeling of stress fibers is typically observed. Thus, it was suggested that LESW could induce remodeling in actin cytoskeleton. However, type of the remodeling could be rather different from those induced by other mechanical stimulations. To explain the difference, other parameters in LESW irradiation should be studied. Furthermore, mechanism by which LESW interact with actin cytoskeleton could be different from other mechanical stimulations. The difference in the mechanism is required to be investigated both in physical and biochemical aspects.

Session	B6: Cardiovascular Mechanics II
Date	Thursday, 8 December
Time	4:00pm - 5:30pm

Venue LT50

ID: E1-0021 **B6 : 1**

QUANTITATIVE ANALYSIS OF INTRAVENTRICULAR FLOW DYNAMICS IN PATIENTS WITH ISCHEMIC HEART DISEASE

Bee Ting Chan[1], Hak Koon Yeoh[1], Yih Miin Liew[1], Yang Faridah Abdul Aziz[1,2], Kok Han Chee[1,2], Ganiga Srinivasaiah Sridhar[1,2], Zhen-Vin Lee[2], Einly Lim[1]

[1]University of Malaya, Malaysia; [2]University of Malaya Medical Centre

This study aims to investigate the intraventricular flow dynamics in ischemic heart disease (IHD) patients with varying degrees of left ventricular ejection fraction (LVEF). We recruited 47 subjects, including 20 healthy volunteers, 11 IHD patients with preserved LVEF (PPEF) and 16 IHD patients with reduced LVEF (PREF). Phase contrast magnetic resonance imaging (MRI) was used to assess flow energetic indices, which include energy dissipation, kinetic energy fluctuation (E') and vorticity fluctuation. Meanwhile, vortex flow parameters including vortex area, vortex circulation, vortex sphericity, vortex Reynolds number and vortex kinetic energy (KE) were also evaluated. The relationship between these flow variables and left ventricular function (indicated by LVEF) was investigated. LVEF was calculated from motion corrected 3D geometrical models reconstructed based on short axis and long axis cine MR images. Speckle tracking echocardiography was performed to evaluate global longitudinal myocardial strain (GLS) as well as the standard deviation of time-to-peak systolic strain (time SD) which indicates left ventricular dyssynchrony. Our results showed that while E' and vortex KE were significantly lower in PREF as compared to both healthy volunteers and PPEF, they have a substantially larger vortex area. One notable finding in this study is that while analyzing E' within and outside of the vortex core region, both healthy volunteers (0.77±0.08 vs. 0.65±0.07, $p<0.001$) and PPEF (0.76±0.12 vs. 0.64±0.06, $p<0.05$) demonstrated a significantly higher E' within the vortex core region, but opposite phenomena was observed in PREF. Using linear correlation analysis, LVEF showed a positive correlation with E' ($r=0.67$, $p<0.001$), vortex KE ($r=0.65$, $p<0.001$) and GLS ($r=0.54$, $p<0.005$) in IHD patients. However, we found no association between time SD and flow energetic indices. The present study indicates that both E' and vortex KE play significant roles in sustaining left ventricular function in IHD patients.

ID: E1-0002 **B6 : 2**

NUMERICAL ANALYSIS OF THE EFFECT OF THE INNER STRUCTURE OF LEFT VENTRICLE ON THE BLOOD FLOW FIELD: EFFECT OF THE NUMBER OF TRABECULAE CARNEAE STRUCTURES

Tomomi Yamada[1,2], Toshiyuki Hayase[1], Suguru Miyauchi[1]

[1]Tohoku University, Japan; [2]Graduate School of Biomedical Engineering, Australia;

Myocardial and cerebral infarctions are representative ischemia-related diseases, but the sites of thrombus formation have not been well identified. In previous studies of the left ventricle, internal structures were omitted, assuming a smooth inner wall surface. However, there are complicated internal structures such as papillary muscles and trabeculae carneae (TC) on the inner wall of a real left ventricle. Thrombus formulation in the left ventricle has not been investigated due to fast blood flow, but the blood flow can be stagnated by the effect of inner structures, resulting in thrombus formation. The purpose of this study was to clarify the effect of the inner structures of the left ventricle on the blood flow field by numerical simulation. Especially, the effect of the number of structures represented by TC models was investigated. We performed the simulations by changing the number of TC models and investigated the effects of the inner structures by comparing the results. A time-dependent left ventricle model was made by a reference shape extracted from magnetic resonance images at a reference time and its interpolations during a cardiac cycle. For incorporation of TC models in the calculation model, a simple cosinusoidal convex shape was generated by displacing the numerical grid. The mitral and aortic valves were set to open or close in response to the phases of the heart beat for the numerical simulation. We clarified the effect of internal structures on the blood flow by comparing the velocity vectors, wall shear stress and streamline between the results with and without models of various TC structures.

ID: E1-0020 **B6 : 3**

COMPARISON OF HEMODYNAMICS BETWEEN MIDDLE CEREBRAL ARTERY AND ANTERIOR COMMUNICATING ARTERY ANEURYSMS

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Since rupture of cerebral aneurysms is a major cause of life-threatening subarachnoid hemorrhage, it is important to identify aneurysms that are prone to rupture. However, prediction for aneurysm rupture is difficult since only a few pieces of information are known about risk factors of aneurysm enlargement and rupture. Therefore, we expect to identify additional risk factors. One important lead may be a difference in rupture rate among aneurysm location. It has been known that the rupture rate of anterior communicating (Acom) aneurysm is twice higher than that of middle cerebral artery (MCA) aneurysm, suggesting that hemodynamic factors determine the difference. Thus, examination of this difference may serve to clarify hemodynamic risk factors for aneurysm enlargement and rupture. In this study, we compared hemodynamic metrics between MCA and Acom aneurysms with computational fluid dynamics (CFD) analysis to examine their hemodynamic differences, which may be associated with the difference in rupture risk. Patient-specific 3D CT angiographic (CTA) images and flow velocities of 16 MCA and 12 Acom aneurysms were acquired in our multi-institutional prospective clinical trial “Computational Fluid Dynamics Analysis of Blood Flow in Cerebral Aneurysms: Prospective Observational Study (CFD ABO Study)”. Arterial geometries of the patients were reconstructed from the 3D CTA volume data set. Using a CFD software package, pulsatile blood flow was simulated based on the Navier-Stokes equations for incompressible fluid, under the patient-specific flow velocity boundary conditions. In both MCA and Acom aneurysms, time-averaged wall shear stress (TAWSS) was lower over the entire aneurysm than neighboring arteries, but higher at neck of the aneurysm. Low WSS over cerebral aneurysms has been reported to be closely associated with aneurysm rupture in previous studies. Our results showed that area-averaged TAWSS is significantly lower in Acom aneurysms than MCA aneurysm. This may be associated with higher rupture rate in Acom aneurysms.

ID: E1-0005 **B6 : 4**

QUANTIFICATION OF CHANGES IN BLOOD FLOW FLUID DYNAMICS IN LEFT VENTRICLES OF PORCINE HEARTS BEFORE AND AFTER MYOCARDIAL INFARCTION

Vivek Vasudevan[1], Low Jia Jun[1], Sarayu Parimal[2], Smita Sampath[2], Choon-Hwai Yap[1]

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Myocardial infarction (MI) is the leading cause of heart failure among cardiovascular diseases MI leads to changes to the heart's stroke volume, beating rate, and ejection fraction, leading to drastic changes to the fluid dynamics These fluid dynamics changes are incompletely understood, partly due to the lack of longitudinal subject-specific data before and after the disease Understanding these changes can improve our understanding of the disease, and help us fine tine diagnostic techniques, the timing of intervention, and inspire new treatments

In this study, MI was induced through permanent left circumflex ligation in two porcine subjects Multiple-slice Cine MR imaging was performed before, one week after, and four weeks after the procedure on the same subjects, providing longitudinal subject-specific data In each scan, 25 images of the heart were captured per cardiac cycle The LV geometry was digitally reconstructed and the radial motion of the LV wall from the centroid, as well as LV torsion was described with a mathematical model Dynamic mesh CFD simulations were performed to quantify the LV fluid mechanics

The scan results showed that the infarcted heart had a significantly enlarged LV chamber, with a faster heart rate and lower ejection fraction Vorticity dynamics was drastically enhanced after MI, where the primary vortex rings generated several secondary vorticity structures via its interaction with the walls, leading to an elevated wall shear stress The wall pressures of infarcted heart was almost twice higher than those observed in the pre-surgery heart, suggesting that additional cardiac work was done to supply sufficient inflow and outflow in the infarcted heart, most likely to overcome additional energy losses of enhanced vorticity dynamics

In conclusion, significant alterations in the fluid dynamics features were observed from before to after myocardial infarction, including enhanced vorticity dynamics, wall shear

ID: E1-0027 **B6 : 5**

PATHOLOGICAL ENGINEERING ANALYSIS OF HUMAN UNRUPTURED CEREBRAL ANEURYSMS FOR INVESTIGATION OF RELATIONSHIP BETWEEN HEMODYNAMIC STRESS AND SMOOTH MUSCLE CELLS

Yasutaka Tobe[1], Kenta Suto[1], Takanobu Yagi[1,2], Koichi Kawamura[1], Mitsuo Umezu[1], Hirotaka Yoshida[3], Yoshifumi Hayashi[3], Kazutoshi Nishitani[3], Yoshifumi Okada[3], Shigemi Kitahara[3]

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Cerebral aneurysm diagnostics currently do not reflect any pathological information because the causality of hemodynamics and growths are not elucidated. Recent studies of hemodynamics and pathology comparison studies reported that the impingement flow are located at the blood blister-like lesion with removal of endothelial cells. Therefore, this study investigated the effect of impingement flow on the smooth muscle cells (SMC) of aneurysm wall in an effort to elucidate the thinning mechanism of aneurysm.

21 aneurysms from 20 cases, average age of 63, were harvested by surgeons after clipping surgery. All samples were divided into blood blister-like (thickness less than 80 μm), transition (thickness between 80 to 100 μm), and hypertrophic (thickness greater than 100 μm). SMC densities were determined by counting the cell cores of every 200 μm segments. SMC properties were determined by observing the ultrastructure of core and cell surface. Hemodynamics of each case was analyzed by hemoscope (EBM Corp.).

The SMC densities of blood blister-like, transition, and hypertrophic lesions were 643±192 cells/mm2, 795±348 cells/mm2, 1103±317 cells/mm2, respectively. The SMC density of blood blister-like lesion was significantly less than the hypertrophic lesion (Tukey-kramer, $p<0.05$). The SMC property analysis showed that synthetic type, damaged, contracted, and necrotic SMCs were present in all lesions. The damage levels of SMCs showed strong correlation with the depths of the wall from the inner surface ($r=0.738$), but did not show any correlation with the thickness. The hemodynamic analysis showed that the blood blister-like, transition, and hypertrophic lesions had 76% impingement, 100% parallel, and 94% parallel types of flow, respectively.

The study suggested that the impingement type of flow interrupts/disables the survival and proliferation

of SMCs to delay/stop the thickening process of aneurysm wall and parallel type of flow allows the survival/proliferation of SMCs to progress the thickening of aneurysm wall.

ID: E1-0028 **B6 : 6**

ELECTROSPUN COMPOSITE SCAFFOLDS FOR CARDIOVASCULAR TISSUE ENGINEERING

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Introduction. Electrospinning is a popular method to produce composite nanofiber structures with using polymeric substances for a variety of applications such as tissue engineering and other biomedical applications [1]. Polycaprolactone (PCL) is one of the most preferred synthetic polymers for Electrospinning Technique due to its features such as having high mechanical properties, being biodegradable and easiness of the process [2]. Polymer blending is also contributes to the properties of the electrospun scaffolds. Blending a synthetic polymer together with a natural polymer may enhance the properties of the electrospun scaffolds by benefiting from their individual advantages [3].

Experimental. In this study, electrospinning technique (Fig.1) was used to produce nanocomposite structures for possible applications in cardiovascular tissue engineering using PCL, Ethyl Cellulose and Collagen. Produced samples were characterized by SEM, tensile strength and thickness measurements MTT assays, in-vivo, and in-vitro. Results are also supported with FT-IR and DSC analyses.

Results and Discussion. According to the test results using the synthetic polymer with the natural one to create new hybrid nanofiber structure increased mechanical and chemical properties of the material. Also presence of the Human Collagen which is a natural protein quite often found in the human body causes the composite nanofiber scaffolds to be more biocompatible, bioabsorbable and more desirable results from the in-vitro and in-vivo tests.

Conclusions. Nanofibrous scaffolds obtained are promising to use in cardiovascular tissue engineering.

Session	C6: Biosignal Processing
Date	Thursday, 8 December
Time	4:00pm - 5:30pm
Venue	LT51

ID: A4-0011 **C6 : 1**

APPROACH TO EXTRACT TWIN FECG FOR DIFFERENT CARDIAC CONDITIONS DURING PRENATAL

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Amrita Vishwa Vidhyapeetham, India

During multiple fetus pregnancy, degree of risk for distinguishing the information of mother and fetus health condition is high. A proper distinguishable ECG of each fetus and mother gives information about the health conditions of individuals. In case of multiple fetal condition, the heartbeat of the fetuses will be almost at the same rate. This algorithm has been aimed to separate mECG and the fECGs of the individual fetus. First, the signal for different medical conditions like Fibrillation, Apnea, Ventricular Ectopy, Singleton and Normal has been considered. The synthetic abdECG signal for the above mentioned cases has been formulated by preprocessing and considered as the input signal. R-Peak of mECG in the abdECG signal has been located using First Order Gaussian Differentiator and Zero Crossing Detector. QRS complex has been considered around the identified R-Peak of abdECG. Identified QRS has been removed from the abdECG signal to obtain fECG with residual noise. The QRS complexes of fECG are detected the same way as mECG QRS were detected, and is represented as binary signals. The separation of the fetal ECG is done based on the individual presence of the fetus in the signals using Inter-beat averaging and Inter-beat standard deviation of the binary signal. The algorithm has been tested for above mentioned different cardiac conditions during prenatal. The algorithm has been able to achieve 99% accuracy for particular cardiac condition with overall system accuracy of 80.4%. The standard cardiac signal of different cases have been sourced from Physionet database to construct the abdECG.

ID: A4-0018 **C6 : 2**

LEAP MOTION CONTROLLER BASED HAND TREMOR DETECTION AND ANALYSIS

Habib Ali, Mohammad Samheel, Venkateswara Venkatesan

Manipal Institute of Technology, India

Parkinson's disease and other neurological conditions often manifest in the form of tremors, especially hand tremors. Tremors can be due to various reasons and based on the type of the tremor, the condition can be diagnosed. Current clinical practice involves visual assessment of the tremor based on various rating scales, which is quite subjective and without any quantification. As a result, there is considerable variability among clinicians in the diagnosis as well. It has been found that the error rate in diagnosing tremors can be as high as 35% in developed countries. Attempts have been made to quantify tremors using accelerometers and Inertial Measurement Units (IMU), laser based systems, video based and magnetic induction based systems. Majority of the work related to tremors used accelerometers or IMU's. Studies showing the effect of load on tremor have raised concerns regarding change in tremor frequency and amplitude by attaching sensors to the body. In order to avoid any uncertainty in this regard, this paper attempts to use the Leap Motion Controller, which is a small, portable and contactless USB peripheral device which can measure hand position based on IR, to quantify certain frequency domain parameters of tremor. Almost all the existing methods use data from a single finger. This research takes advantage of the Leap Motion Controller's ability to detect all the five fingers and palm positon. Data from healthy volunteers and volunteers diagnosed with different neurological disorders has been collected and analyzed. The techniques, observations and findings are presented in the paper along with scope for further improvement.

ID: A4-0013 **C6 : 3**

DISCRETE WAVELET BASED STATISTICAL FEATURES FOR THE DROWSINESS DETECTION FROM EEG

Reddy Vamsi[1], Suman Dabbu[2,3], Nikhil Chettipally[1], Dr Malini Mudigonda[2,3]

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Drowsiness is a major patron to road accidents. Detection of drowsiness while driving is a challenging objective in accidents avoidance systems. This study reports a new index to assess the drowsiness state of drivers using Joint Time-frequency analysis of Electroencephalography (EEG). Twenty healthy male participants proffered in this study by performing a monotonous driving task on a static simulator for 60 min. The subjects are deprived of sleep for at least 18 hrs and sleep music (Delta waves) played in the background, induces sleep during the task. Acquisition of EEG signals was implemented by eight channel Octal Bio-Amplifier (AD Instruments) at a sampling frequency of 1000Hz with electrodes positioned at the four lobes of the brain namely Frontal, Temporal, Parietal, and Occipital lobes and further analysis has been carried out in MATLAB™ 2007b (Mathworks, Inc., USA). The EEG signals are de-noised by Chebyshev filter (0.5-40 Hz) and subsequently decomposed into various rhythms of EEG such as Beta (CD5: 14-30 Hz), Alpha (CD6: 8-13 Hz), Theta (CD7: 4-7 Hz), and Delta (CA7: 0.5-3.5 Hz). Two parameters viz., Relative Wavelet Packet Energy (RWPE) and Power within the RMSD (PRMSD) are computed in this study to analyse the driving performance of the subjects against the subjective assessment inferred from the video recordings. The parameters RWPE, PRMSD within Beta and Alpha has reduced relatively in the Parietal lobe, occipital lobe, and temporal lobe as the subjects fall into the drowsy stage. This analysis is clinically correlated as the cortical activity reduces slowly during the onset of sleep. It is clearly evident that these features are significant ($p < 0.05$) in the detection of drowsiness with Confidence Interval of 19. This study also reports a significant correlation ($p < 0.05$) between PRMSD of Total mean with Active mean and Drowsy mean ($R2 = 0.82$).

ID: A4-0021 **C6 : 4**

HEART SOUND FEATURES USAGE FOR CLASSIFICATION OF VENTRICULAR SEPTAL DEFECT SIZE IN CHILDREN

Kamran Hassani[1], Kamal Jafarian[1], John D. Doyle[2]

[1]Islamic Azad University, Iran; [2]Anesthesiology Institute, Cleveland Clinic Abu Dhabi, UAE

Ventricle septal defects (VSDs) are an important form of congenital heart disease. This study presents a new approach to VSD size estimation based on the discrete wavelet transform and artificial neural network classification of heart sounds. Heart sounds was recorded for 20 children with a VSD aged 19 ± 12 months when visiting the pediatric heart clinic of

Shaheed Modarres Hospital in Tehran. The detection system was trained using 70 percent of the data and evaluated using the remaining 30%. It was found to be 96.6 percent accurate for small-size VSD (dhole<0.3daorta) and 93.3 percent accurate for large-size VSD (dhole>0.7daorta). Our results suggest that this approach may offer clinical utility in detecting and classifying VSDs in children.Furthermore, it presents favourable results in taking features out of heart sounds regarding the unique audible features of each cardiac illness, sizes of VSD in particular. This research studied the subject of determining whether the VSD size is large or small among children. By employing minor changes, this approach might also be implemented on such heart disorders as aortic stenosis (AS), pulmonary stenosis (PS), atrial septal defect (ASD), and mitral stenosis (MS) both among children (the aim of this research) or among adults.

ID: A4-0003 **C6 : 5**

ACCURATE R PEAK DETECTION USING ELECTRO-MECHANICAL PHYSIOLOGICAL SIGNALS

Chee Teck Phua[1], Matthieu Hoël[2], Alexandra Delrieu[2], Gaelle Lissorgues[2]

[1]Nanyang Polytechnic, Singapore; [2]ESIEE, Paris

Accurate R peaks detection in electrocardiogram (ECG) is an important process to assess the cardiovascular health of an individual (e.g. heart arrhythmia, heart rate variability, etc.). Many studies have presented various methods to detect R peaks in ECG using single physiological signal (i.e. ECG) and are highly subjective to the quality of the ECG signal. In this paper, an accurate R peaks detection algorithm is proposed based on the use of electro-mechanical physiological signals (i.e. ECG and photoplethysmogram (PPG)). Concurrent processing of both ECG and PPG is able to reduce the need to have high quality ECG and allows the use of simple signal processing algorithms to identify the locations of R peaks in ECG signals. The flexibility of our method was demonstrated through concurrent implementation on a low cost platform (i.e. BeagleBone Black (BBB)) and FPGA platform (i.e. myRIO from National Instrument), achieving respective accuracy of 95% and 98%, using physiological signals acquired in real-time. The accuracy provided by our method is able to be applied on wearables and supports accurate real-time assessment of cardiovascular health

Session	SYM-09: Special Topic Symposium: Health Technology Assessment
Date	Thursday, 8 December
Time	4:00pm - 5:30pm
Venue	LT52

ID: KN-0010 **SYM-09 : 1**

IFMBE HEALTH TECHNOLOGY ASSESSMENT (HTA) - TRAINING SESSION

Leandro Pecchia

University of Warwick, UK

Health Technology Assessment (HTA) is a multi-discipline and multi-sectorial structured process aiming to inform decisions regarding healthcare technologies at different levels: from hospital level (i.e. inform the acquisition of costly medical devices), to Regional/ National level (i.e. recommend the adoption of a new healthcare technology to the NHS), or international levels (i.e. inform large-scale prevention/intervention campaigns).

The definition of health technology is very broad and refers to any application of organized knowledge and skills in the form of medicines, medical devices, vaccines, procedures and systems developed to solve a health problem and improve quality of life. Nevertheless, to date the majority of HTA training activities and materials are more focused on drugs (i.e. less on medical devices or ICT applications for healthcare) and oriented to medical doctors, health economists and pharmacologists.
However, although several training activities have been developed for medical doctors, health economists and pharmacologists, there is a lack of training opportunities specifically oriented to researchers and professionals with other technical backgrounds, who are daily involved in the design, validation, selection, maintenance and use of healthcare technologies, and particularly medical devices and eHealth.
This is the case of biomedical engineers (BME), working in research, manufacturing and/or National Health Systems/Services, interacting continuously with clinicians, health economists, hospital managers and patients.

This training session speaks directly to PhD students, early career researchers and academics, who are working on healthcare technologies, and aims to provide them with an introduction to theoretical and practical HTA methods and tools.

Moreover, the eLearning platform and contents developed by the IFMBE HTA Division will be presented. This platform, which will be open to all the IFMBE federated societies members in November 2016 (http://htad.ifmbe.org/)' target='_blank'>http://htad.ifmbe.org/">http://htad.ifmbe.org/) contains more than 40 hours of practical and theoretical lectures on HTA methods, tools and case studies.

Session	SYM-10: Special Topic Symposium: Flexible and Wearable Technologies
Date	Thursday, 8 December
Time	4:00pm - 5:30pm
Venue	LT53

ID: C5-0003 **SYM-10 : 1**

TWO DIMENSIONAL MATERIALS FOR WEARABLE ELECTRONICS

Jong-Hyun Ahn

Yonsei University, South Korea

Wearable electronics have undergone great progress through the advancement of smart watches and fitness trackers. Recently, their applications have been expanded by combining conformal electronics with skin-attachable sensors for monitoring various bio-signals and body movements. However, it is very difficult to accomplish such electronics with conventional, rigid electronic materials. Two dimensional (2D) materials such as graphene and MoS2 possess an extremely good mechanical property that should maintain a stable operation under a high strain, offering great electronic properties that make it a promising host for device applications. The recent advances in synthesis and fabrication technique of 2D materials are expected to enable various applications for flexible, stretchable and wearable electronics. In this talk, I present the application possibility of 2D materials for wearable electronics including skin-attachable sensor and energy harvesting devices.

ID: B2-0009 **SYM-10 : 2**

NUMERICAL SIMULATION IN DESIGN OF ARBITRARY-SHAPE 3D MULTIFUNCTIONAL INTEGUMENTARY CARDIAC MEMBRANES

Zhuangjian Liu[1], Yewang Su[2], Lizhi Xu[3]

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Multiparametric physiological mapping and stimulation can play an important role in both basic and clinical cardiology. A conformal electronic system, known as 3D multifunctional integumentary membranes (3D-MIMs), is developed using 3D elastic membranes shaped precisely to match the epicardium of the heart. This device is fabricated using 3D printing to create a platform for deformable arrays of multifunctional sensors, electronic and optoelectronic components. The integumentary devices are made to completely envelop the heart, thus providing conformal interfaces to all points on the heart as well as providing a mechanically stable biotic/abiotic interface during normal cardiac cycles. Numerical simulation is then performed to serve as a key parameter to evaluate the device designs. Also, a universal and easy-to-use model is developed to calculate the average pressure associated with integration of 3D-MIMs on the arbitrary organ shape. The average pressure is expressed in terms of the surface area and volume of the heart, apart from the material parameters and expansion strain. The prediction from this model agrees well with the results obtained from numerical simulation. These approaches provide a simple way to quantify the average pressure imposed by the devices as well as allow for design of high-definition implantable devices for diagnostics and therapy of lethal heart diseases.

ID: C5-0001 **SYM-10 : 3**

SKIN INSPIRED ORGANIC DIGITAL MECHANORECEPTOR

Benjamin Tee[1,2], Zhenan Bao[3], Karl Deisseroth[3], Alex Chortos[3]

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Electronic sensor skins is an active area of research for many groups over the world due to its potential to enable dramatic changes in how we interact with the digital environment. For example, 'robots' can don on sensor active skins to shake human hands with comfortable pressure, measure our health biometrics and possibly aid in wound healing. In my talk, I will discuss the development of electronic sensor skins with some historical context, followed by showcasing of several force sensitive electronic skin technologies with high sensitivity, stretchability and self-healing abilities1-3. More recently, inspired by human skin touch receptors, we demonstrated a power-efficient frequency encoded artificial mechano-receptor system4. We further used a channelrhodopsin with fast kinetics and large photocurrents as an optical

interface to neuronal systems for next generation opto-tactile prosthetic interfaces.

ID: C5-0008 **SYM-10 : 4**

HIGHLY FLEXIBLE AND WEARABLE TACTILE SENSORS FOR REAL-TIME HEALTHCARE MONITORING

Joo Chuan Yeo[1,2], Zhiping Wang[3], Chwee Teck Lim[1]

*[1]National University of Singapore, Singapore; [2]Singapore Institute of Manufacturing Technology, A*STAR, Singapore; [3]Singapore Institute of Manufacturing Technology, Singapore*

Real-time healthcare monitoring enables continuous snapshots of the patient's health condition This provides clinicians a more informed overview of patient's disease state and recovery progress Besides providing reliable data, these sensors have to be nonobtrusive and imperceptible to the user In other words, these sensors should be lightweight, highly deformable, flexible, conformable, stretchable, and stable over a wide range of pressures, so as to match the physical properties of the skin It also requires to be sensitive to very low pressures corresponding to the physiological signals Applications include vital parameters monitoring (e g pulse rate, heart rate, blood pressure), rehabilitation tracking progress (e g finger movement, grip strength), tactile sensing (e g object grasping, surface texture), and gait monitoring (e g foot pressure, gait analysis) Unfortunately, many conventional sensors are rigid, bulky, and limited in sensing range, rendering them undesirable for these body sensing applications Therefore, the research and development of flexible and wearable physical sensors open many possibilities in healthcare and biomedical technologies
To this end, our group has successfully developed a novel flexible microfluidic liquid-based tactile sensor that is simple and cost-effective to produce The sensor is fabricated using a unique combination of soft silicone rubber substrate and conductive fluid Specifically, a thin micro-patterned flexible silicone rubber is created through soft lithography techniques Conductive fluids were then injected into the enclosed microfluidic channels as the pressure sensing fluid Essentially, the conductive fluid is displaced in proportion to the mechanical forces exerted by the user, which corresponded to a change in its electrical resistance The electrical signals are transmitted in real-time via a customized wireless module attached to the sensor By selecting an appropriate silicone elastomer and conductive fluid, we are able to adjust the device sensitivity, specificity, material hardness, viscoelasticity and stretchability to suit different applications

ID: B1-0024 **SYM-10 : 5**

3D ORIGAMI PHOTONIC CRYSTALS PAPER-LIKE µPADS

Bing Bing Gao

Southeast University, China

POCT(point-of-care testing) has attracted broad attention recently. Microfluidic chip based on paper is one of the most potential strategy to realize POCT. Recently traditional paper chips presented insignificance as unable to quantify, low sensitivity.
We developed a microfluidic origami PCs paper-like µPADs based on blade-coating pattern strategy nitrocellulose inverse opal and it consists of two simple steps: (1) Printing on a PP plastic film to form hollow channels or patterns using a HP laser printer then blade coating of colloidal SiO2 nanoparticles with different diameters on the film to form patterned photonic crystals. (2) Nitrocellulose prepolymers were then immersed in the photonic crystals patterns, after baking on a hot plate and etching using HF the inverse opal nitrocellulose film was made. We used this method for fabricating microfluidic origami PCs paper-like µPADs for detection human IgG. We also fabricated PCs µPADs based on this for small molecule compounds detection.

Session	F1: Clinical Engineering
Date	Thursday, 8 December
Time	4:00pm - 5:30pm
Venue	Global Learning Room

ID: D2-0001 **F1 : 1**

FOCUSED ION BEAM - DIGITAL IMAGE CORRELATION ANALYSIS OF RESIDUAL STRAINS AT THE HUMAN DENTINE-ENAMEL JUNCTION INTERFACE

Tan Sui, Alexander Korsunsky

MBLEM University of Oxford, UK

As a hydrated biological mineral composite, human dental tissue mainly consists of dentine and enamel based on mass and volume, each one of which has a hierarchical structure and versatile mechanical properties. Durable bond between dentine and enamel is provided by the dentine enamel junction (DEJ), an important biological interface that is a life-long success story: while intact and free from disease, failure in this interface does not occur despite the

harsh thermomechanical loading in the oral cavity. It is still not fully clear of the underlying reasons for such remarkable strength and durability from structural and mechanical perspectives. One hypothesis is that a layer of inelastic strain forms adjacent to the DEJ during odontogenesis due to the presence and evolution of residuals tresses. However, significant experimental and interpretational challenges to date have limited any meaningful quantification of residual stress in the vicinity of the DEJ at the appropriate spatial resolution. In this study, a recently developed flexible and versatile method utilizing focused ion beam (FIB) milling with digital image correlation (DIC) is applied to measure the residual elastic strain at (sub)micron-scale. We report the results that span the transition from human dentine to enamel, and incorporate the material lying at and in the vicinity of the DEJ. Link between internal architecture and the residual elastic strain state at the micrometre scale is observed, which is useful for understanding the remarkable performance of the DEJ. This will further help improve or design biomimetic materials for clinical and engineering applications.

ID: A4-0017 **F1 : 2**

SVM CLASSIFIER OF MRI IMAGES FOR COMPUTER-ASSISTED DIAGNOSIS

Madina Hamiane, Fatema Saeed

Ahlia University, Bahrain

Magnetic Resonance Imaging is a powerful technique that helps in the diagnosis of various medical conditions. Detection of brain abnormalities, such as brain tumors, in brain MRI images are considered in this work. These images are often corrupted by noise from various sources. The images are first pre-processed using the Discrete Wavelet Transforms (DWT) along with thresholding techniques for efficient noise removal. Edge detection and threshold segmentation are next applied to the denoised images prior to the extraction of the segmented image features through the use of morphological operations. The images are finally classified using an improved Support Vector scheme. The results obtained in the pre-processing stage show that biorthogonal 1.3 wavelet of the first level DWT and hard threshold gave the minimum MSE, highest SNR and highest PSNR which were selected as performance metrics. Morphological operations are used to extract the region of interest whose features are subsequently calculated from the Gray Level Co-occurrence Matrix . These features are used to train an improved Support Vector Machine classifier that uses a Gausssian radial basis function kernel . The performance of the classifier is evaluated and the the results of the classification show that the proposed scheme accurately distinguishes normal brain images from the abnormal ones which are further efficiiently classified as exhibiting begin or malignant tumors. The accuracy of the classification is shown to be as high as 99% which is superior to the results reported in the literature.

The proposed accurate automatic classification of the SVM classifier can be used by neurologists to help them identify brain abnormalities that might be hidden due to the large number of slices that are obtained from MRI brain images.

ID: A5-0006 **F1 : 3**

PREDICTING RESURGERIES IN INTENSIVE CARE USING DATA MINING

Filipe Portela[1], Ricardo Peixoto, Manuel Filipe Santos, José Machado, António Abelha, Fernando Rua[2]

[1]University of Minho, Portugal; [2]Centro Hospitalar do Porto

The field of critical care medicine is confronted every day with cases of surgical interventions. When Data Mining is properly applied in this field, it is possible through predictive models to identify if a patient, should or should not have surgery again upon the same problem. The goal of this work is to use Data Mining techniques to predict future surgeries in a Intensive Care Unit. By knowing the common characteristics of the re-intervention patients it will be possible to help the physician to predict a future resurgery. For this study various attributes were used related to the patient's health problems like heart problems or organ failure. For this study it was also considered important aspects such as age and what type of surgery the patient was submitted. Classes were created with the patients' age and the number of days in admission. Another class was created where the type of surgery that the patient was operated upon was identified. This study comprised values of accuracy, sensitivity and specificity higher than 80%. The used variables, in addition to being provided by Hospital de Santo António in Porto, they are provided from the electronic medical record. As result a set of Data Mining models were induced in order to predict the probabaility of a patient be reinterved to the same problem.

ID: A5-0005 **F1 : 4**

PERFORMANCE COMPARISON OF ORAL CANCER CLASSIFICATION WITH GAUSSIAN MIXTURE MEASURES AND MULTI LAYER PERCEPTRON

Sunil Kumar Prabhakar, Harikumar Rajaguru

Bannari Amman Institute of Technology, India

One of the most commonly occuring cancers is oral cancer. The incidence of the oral cancer seems to be increasing exponentially in the world. The clinician has to undergo a higher level of dilemma every time in order to differentiate the cancerous lesions from other controversial and poorly defined lesions that are present in the oral cavity. Early stage carcinomas and its subsequent manifestations are highly misinterpreted because at the initial stage there is minimum discomfort in the patient and they simply mimic many similar benign lesions. The analysis to be done by the doctors is often delayed and therefore there is a high risk for the cancer to spread in the body. Squamous cell carcinoma is the most common malignant neoplasm present in the oral cavity. Therefore the accurate diagnosis and management of this particular Squamous cell carcinoma which originates from the surface of the oral muscle has to be done well. The main aim of this work is to assess the clinical features, diagnostic procedures and treatment required for oral cancer patients. The staging of the cancer is generally divided into two stages namely, clinical and pathological. In TNM (Tumour, Node, Metasis), a lot of novel prognostic tools have been traced and new methodologies for the prognostic factors have been drastically improved and developed. This paper compares the classification accuracy of the TNM staging system witht the aid of Multi Layer Perceptron (MLP) and Gaussian Mixture Model (GMM) classifiers. In this work, totally 75 oral cancer patients are studied. For both the classifiers, the input variables are nothing but the TNM variables such as tumour size, number of positive regional nodes, distance metastatis, hereditary etc. Out of the two post classifiers obtained here, GMM provides better result of 94.18% accuracy while MLP showed an accuracy of 89.5%.

ID: A5-0003 **F1 : 5**

A COMPREHENSIVE ANALYSIS ON BREAST CANCER CLASSIFICATION WITH RADIAL BASIS FUNCTION AND GAUSSIAN MIXTURE MODEL

Sunil Kumar Prabhakar, Harikumar Rajaguru,

Bannari Amman Institute of Technology, India

Cancer is a type of deadly disease where a particular group of cells display growth which becomes uncontrollable after a certain period of time. Breast Cancer is a type of cancer which affects the inner lining of the milk ducts. The symptoms of breast cancer include the shape alteration of the breast size, nipple discharge, swelling of the lymph node and pain in the nipple. There are several types of breast cancer like lobular carcinoma, ductal carcinoma, invasive lobular carcinoma, inflammatory breast carcinoma etc. The risk factor of breast cancer includes factors like sex, hormonal fluctuations, alcohol intake, environmental and genetic factors, other abnormalities in the human body along with a high fat diet. In this work, a simple, cost effective and non-invasive strategy to detect the breast cancer at an early stage is proposed with the help of techniques such as Gaussian Mixture Model (GMM) and Radial Basis Function (RBF). As cancer staging is divided into clinical and pathological stage, the TNM (Tumour Node Metasis) prognostic tools are identified and the TNM variables such as tumour size, history of breast feeding, menstrual cycle, hereditary, food habits, etc. are used as input variables for both the types of classifiers. The data collection was obtained from 75 breast cancer patients at the cancer centre of Kuppuswamy Naidu Memorial Hospital, Coimbatore, India. The Performance Metrics taken here are Specificity,Sensitivity, Accuracy, Perfect Classification, Missed Classification , False Alarm and Performance Index. Results show an average accuracy of 89.60% is obtained with GMM classifier and an average accuracy of 92.75% is obtained with RBF classifier.

Day 3 – Friday, 9 December 2016

Session	Plenary Lecture 5
Date	Friday, 9 December
Time	9:00am - 9:45am
Venue	Auditorium 2

ID: PL-0006 **PL5**

DROPLET MICROFLUIDICS FOR SINGLE CELL STUDIES

David Weitz

Harvard University, USA

This talk will describe the use of microfluidic technology to control and manipulate drops whose volume is about one picoliter. These can serve as reaction vessels for biological assays. These drops can be manipulated with very high precision using an inert carrier oil to control the fluidics, ensuring the samples never contact the walls of the fluidic channels. Small quantities of other reagents can be injected with a high degree of control. The drops can also encapsulate cells, enabling cell-based assays to be carried out. The use of these devices for biotechnolgy and diagnostic applications will be described.

Session	Plenary Lecture 6
Date	Friday, 9 December
Time	9:45am - 10:30am
Venue	Auditorium 2

ID: PL-0002 **PL6**

MAKING MRI SAFE FOR IMPLANTED DEVICES

John Pauly, Greig Scott

Stanford University, USA

An increasing number of patients have implanted devices, such as cardiac pacemakers and deep brain stimulators. These patients are often either excluded from MRI, or are scanned using low power “MR Conditional” protocals with compromised diagnostic quality. In addition, there are a wide range of interventional procedures that could be performed in an MRI, but are precluded by the possible interactions between the MRI scanner and the interventional devices. Attempts to address both of these areas have focused on making the devices safe for the MRI environment. This is difficult and expensive, and doesn’t address the millions of patients who already have implanted devices.

In this presentation, we will describe an alternative approach, that focuses on making the MRI system safe for devices. Many devices are already made from non-magnetic materials (nitinol, titanium, etc). For these, the major safety concern is device heating from the high power RF transmit from the MRI system. We have developed an array of methods to detect, quantify, and mitigate these interactions. Before the patient is placed in the magnetic, potentially dangerous interactions are detected by looking for characteristic resonancances. Then, before the scan, a low power study visualizes the interacting devices, and measures the currents produced to quantify the risk. This can also be done by measuring impedence changes in the RF coil elements. Finally, a multiple channel transmit system is used to produce a transmit field pattern that minimizes the device interactions.

This approach has a number of advantages. It is specific to each patient, device, and MRI scanner. Interactions can be monitored and corrected continuously, which is important for interventional procedures where the device geometry is constantly changing. Finally, the modifications to the scanner are relatively straight forward, particularly as two-channel parallel transmit is becoming more common.

Session	A7: Controlled Drug Delivery
Date	Friday, 9 December
Time	11:00am - 12:30pm
Venue	Auditorium 2

ID: D3-0006 **A7 : 1**

LOCAL DELIVERY OF FLAVOPIRIDOL IN POLY(LACTIC-CO-GLYCOLIC ACID) NANOPARTICLES REGULATES INFLAMMATION AND REPAIRS SPINAL CORD INJURY

Hao Ren, Min Han, Jing Zhou, Ze-Feng Zheng, Ping Lu, Jun-Juan Wang, Jia-Qiu Wang, Qi-Jiang Mao, Jian-Qing Gao, Hong-Wei Ouyang

Zhejiang University, China

Spinal cord injury (SCI) results in neuronal death, reactive astrogliosis, and extensive inflammation. The cell-cycle inhibitor flavopiridol has been shown to improve recovery from SCI in animal models.

However, the systemic dose of flavopiridol has side-effects and the mechanism of action is not clear. This study aimed to develop a strategy for the local delivery of flavopiridol and investigate its mechanisms of action. Poly(lactic-co-glycolic acid) (PLGA) nanoparticles (NPs) were used for the sustained delivery of flavopiridol. The spinal cord was right-hemisectioned and NPs were delivered into the injury site. Transparent Spinal Cord technology was used for the three-dimensional observation of anterograde tracing. The results showed that flavopiridol NPs had a sustained release of up to 3 days in vitro. Flavopiridol NPs significantly decreased inflammatory factor synthesis in astrocytes. For the first time we showed the different changes of diverse inflammatory cytokines systemically after SCI at protein level, using multiplex immunoassay. Flavopiridol NPs alleviated the reduction of the cytokines beneficial for SCI repair, such as GM-CSF, and the increase of the cytokines detrimental for SCI repair, such as IP-10. In-vivo study also demonstrated that flavopiridol NPs decreased cell-cycle activation, inflammatory expression and glial scarring, and facilitated neuronal survival and regeneration. The cavitation volume was decreased by ~90%. Administration of flavopiridol NPs also improved the motor functional recovery of injured animals. These findings demonstrated that local delivery of flavopiridol in PLGA NPs improves recovery from SCI by systemic regulation of inflammatory cytokines, and inhibition of astrocyte proliferation, migration and inflammatory factor synthesis.

ID: D3-0007 **A7 : 2**

NON-GENETIC AND TRANSIENT ENGINEERING OF MESENCHYMAL STEM CELL SECRETOME USING INTRACELLULAR CONTROLLED DRUG DELIVERY

Sudhir Ranganath[1,2,3,4,5,6], Zhixiang Tong[3,4,5], Oren Levy[3,4,5], Keir Martyn[3,4,5], Jeffrey Karp[3,4,5], Maneesha Inamdar[2,7]

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Cell therapy using exogenous mesenchymal stem cells (MSCs) has gained limelight recently given its secretome-mediated paracrine effects, especially via potent immunomodulatory and anti-inflammatory secretome. However, the complex host microenvironment is a major hindrance to controlling the MSC secretome post-transplantation. The resultant unpredictable MSC response hinders their clinical efficacy and often contributes to highly variable clinical outcomes. While genetically engineered MSCs have non-transient effects and regulatory hurdles towards clinical translation, the drug/cytokine preconditioned MSCs have highly transient effects post transplantation.

To address these, we developed an intracellular controlled drug delivery approach to non-genetically and transiently modulate the pro-inflammatory secretome in human MSCs (hMSCs). Poly-L-lactide-co-glycolide (PLGA) polymer was used to synthesize microparticles (~ 900 nm in size) and surface functionalized with a cationic polymer (poly-L-lysine) to enhance internalization kinetics into hMSCs. Under simulated inflammatory condition (stimulation by TNF-alpha), we demonstrate that intracellularly delivered TPCA-1 (a small molecule NF-kB inhibitor) via PLGA microparticles (TPCA-μPs) can attenuate secretion of pro-inflammatory factors from hMSCs for at least six days in vitro. On the contrary, soluble TPCA-1 preconditioning has a very transient effect on hMSC secretome. Conditioned medium (CM) derived from TPCA-μP-loaded hMSCs also showed reduced ability to attract human monocytes and prevented differentiation of human cardiac fibroblasts to myofibroblasts, compared to CM from untreated or TPCA-1-preconditioned hMSCs. In addition, Conditioned medium derived from TPCA-μP-loaded hMSCs attenuated collagen secretion from human and mouse cardiac myofibroblasts. These results demonstrate the potential utility of the microparticle-engineered hMSCs in the inhibition of cardiac fibrosis. Thus, we provide a broadly applicable bioengineering solution to facilitate intracellular sustained release of agents that modulate cell signaling. We propose that this approach could be harnessed to improve control over MSC secretome post-transplantation, especially to prevent adverse remodeling post-myocardial infarction.

ID: D3-0011 **A7 : 3**

PEG-MESOPOROUS SILICA FOR TOPICAL DELIVERY OF BRIMONIDINE TO THE EYE

Song Ah Ko[1,2], Se Na Kim[1], Seung Ho Lee[1], Beom Kang Huh[1], Young Bin Choy[1,3],

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Eye drop formulation for glaucoma drug is limited in very short drug residence time at the preocular space, hence very low drug bioavailability. To resolve this, we proposed polyethylene glycol (PEG)-coated mesoporous silica as carriers for topical delivery of a glaucoma drug, brimonidine to the eye. The amine-functionalized mesoporous silica (AMS) was fabricated via anionic surfactant-mediated synthesis method (S-N+~I- mechanism), which were then coated with PEG (MW = 6000) to give the PEG-AMS. Thus, the pores in AMS would serve as drug reservoir for sustained delivery and the PEG would allow a mucoadhesive effect. After loading brimonidine, we evaluated the in vitro drug release profile in pH 7.4 PBS. After a burst release of 70 % for the first 20 min, the drug was slowly released for 8 h. In vivo experiments were conducted by administrating the brimonidine-loaded PEG-AMS to the rabbit eye. As we measured the change in intraocular pressure (IOP), the period of lowered IOP was about 14 h after the administration of PEG-AMS and this was more than twice longer than that with a commercialized eyedrop medication of brimonidine, Alphagan P (6 h), indicating a greatly enhanced drug bioavailability with the PEG-AMS herein.

ID: D3-0002 **A7 : 4**

ENHANCED MRNA DELIVERY BY INFLUENZA A VIRUS NON-STRUCTURAL PROTEIN 1 FOR NON-VACCINE APPLICATIONS

Yi Liu, Kyle.K.L Phua

National University of Singapore, Singapore

Messenger RNA has shown great potential as an alternative tool for genetic modification of cells. However, transfection efficiency of in-vitro transcribed mRNA is known to be compromised by cell's innate immune response. Herein we show that non-structural protein 1 (NS1) derived from influenza A virus enhances transfection efficiency of mRNA. By cotransfection with mRNA encoding NS1 protein, higher expression of mRNA encoding green fluorescent protein was achieved in several cell lines compared to controls. Meanwhile, cell viability was unaffected. Enhanced transfection correlated with a reduced interferon response during transfection based on ELISA . In conclusion, we demonstrate that nature inspired anti-viral counter schemes such as NS1 is a powerful tool to facilitate the non-vaccine applications of mRNA.

ID: D3-0004 **A7 : 5**

PHASE-SEPARATED HYDROGELS WITH TUNABLE DOMAIN SIZE ENABLED LONG-TERM CONTROLLED DELIVERY OF PEGINTERFERON ALFA-2A AND IMPROVED ITS THERAPEUTIC EFFICACY

Ki Hyun Bae, Fan Lee, Keming Xu, Choong Tat Keng, Sue Yee Tan, Yee Joo Tan, Qingfeng Chen, Motoichi Kurisawa

*Institute of Bioengineering and Nanotechnology, A*STAR, Singapore*

Hepatitis C remains a significant global health problem that affects approximately 130–150 million people and causes over 50 thousand deaths each year. Although new drugs known as direct-acting antivirals have been introduced, Peginterferon alfa-2a is still extensively used for the treatment of hepatitis C. Currently, the standard treatment for hepatitis C consists of weekly injections of Peginterferon alfa-2a together with daily oral administration of antiviral drugs for 12-48 weeks. Such frequent injections not only increase patient discomfort, but also cause serious and sometimes life-threatening side effects. Hence there is an urgent need to develop a controlled drug delivery system which can improve the therapeutic efficacy of Peginterferon alfa-2a while reducing the need for frequent injections. Herein we report the development of phase-separated hydrogels with tunable domain size for long-term controlled delivery of Peginterferon alfa-2a. These hydrogels were formed by crosslinking-induced phase separation of initially miscible mixtures of dextran-tyramine conjugates and polyethylene glycol (PEG). The phase separation of the polymer mixtures led to the formation of micron-sized PEG domains as drug reservoirs. The existence of PEG domains enabled burst-free sustained release of Peginterferon alfa-2a over 3 months without compromising its bioactivity. Moreover, the rate of drug release could be regulated simply by tuning the size of PEG domains with variations in gelation rates. The phase-separated hydrogels prolonged the plasma half-life of Peginterferon alfa-2a up to 10 times, thereby enhancing its therapeutic efficacy in a humanized mouse model of hepatitis C. A one-time administration of the drug-loaded hydrogels prevented hepatitis C virus-induced liver damage as effectively as the clinically relevant formulation that necessitated eight weekly injections of Peginterferon alfa-2a. Our study demonstrated the capability of the phase-separated hydrogels to extend the duration of action of Peginterferon alfa-2a for more effective hepatitis C treatment without the need for frequent dosing.

ID: D3-0009	A7 : 6

GLYCOSAMINOGLYCAN-BASED BIOMATRIX EMBEDDED WITH POLYELECTROLYTE COMPLEX NANOPARTICLES FOR CONTROLLED SIGNALING REGULATION IN STEM CELL NICHE

Wei-Hong Jian[1], Tzu-Wei Wang[1,2]

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Neural stem cells (NSCs) provide potential therapeutic strategy for neural tissue repair after traumatic injury, stroke and degenerative neural disease. However, poor regenerative capability of NSCs in the lesion site due to the inflammatory response, loss of structural support and trophic factors limits their therapeutic efficacy. Normal extracellular matrix (ECM) is constructed by several molecules such as hyaluronic acid (HA) and proteoglycans which provide an ideal microenvironment for binding and stabilization of growth factors, chemokines and other ECM proteins from degradation by proteinases and serve as a niche for promoting NSC proliferation in vivo. In this study, we specifically develop an ECM-mimetic hydrogel composed of high molecular weight HA and glycosaminoglycan-based polyelectrolyte complex nanoparticles (PCNs) to deliver stromal cell-derived factor-1α (SDF-1α) and fibroblast growth factor-2 (FGF-2) in response to matrix metalloproteinase (MMP) activity within the injured site. SDF-1α bounded on heparan sulfate is known to optimize SDF-1α presentation and to recruit endogenous NSCs to the wound area. On the other hand, continuous expression of FGF-2 that is complexed with chondroitin sulfate plays a critical role in regulating injury-induced NSC proliferation and differentiation. The protection and sustainable controlled delivery of both growth factors are achieved by the conjugation of MMP-cleavable and MMP-inactive peptides linked on the PCNs in HA hydrogel. The combination of growth factor-loaded PCNs and biodegradable hydrogel is expected to enhance chemotactic recruitment and survival of endogenous NSCs and provide a stem cell niche to promote NSC proliferation and differentiation for neural tissue repair and regeneration.

Session	B7: Computational Bioengineering IV
Date	Friday, 9 December
Time	11:00am - 12:30pm
Venue	LT50

ID: KN-0005	B7 : 1

EXPERIMENTAL AND NUMERICAL INVESTIGATION OF STRAIN-RATE DEPENDENT MECHANICAL PROPERTIES OF SINGLE LIVING CELLS

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Living cells are the basic structural units existing in all known living organisms. It is well known that cells are sensitive to variation in their mechanical and physiological environments. Physiological loads are usually applied at varying rates to achieve optimal biomechanical and biochemical outcomes in the body. In this study, living chondrocytes, which are the mature cells in cartilage tissues, are target cells. The understanding of the strain-rate-dependent behaviour of single cells is arguably a significant contribution that would provide insight into chondrocyte health in particular and cartilage dysfunction in general. Therefore, this study aims to investigate the mechanical properties and relaxation behaviour of chondrocytes subjected to different strain-rates. Chondrocytes were collected, cultured, and prepared before AFM testing. The porohyperelastic(PHE) continuum mechanical model was used. Using the experimental results, the inverse FEA procedures were used to determine the model parameters. It has observed that the cells' stiffness increased with increasing of strain-rates. It was demonstrated that the intracellular fluid governs the behaviour of the cells at high strain-rates whereas the cytoskeleton plays an important role. In relaxation study, there were two phases in the force–time curves. In the first phase, a sudden drop of applied force. In the second phase, the applied force gradually reduces and reaches an asymptotic value. It can be explained that the intracellular fluid was blocked within the cells at high loading rates due to low permeability of the cells. When the cells were allowed to relax, the fluid started to exude out from the cells caused by fluid pressure gradient leading to the significant reduce of the applied force at the end of the transient phase. As a result, it can be concluded that the PHE model is suitable for capturing the behaviour of living chondrocytes.

ID: E3-0015 **B7 : 2**

FLOW VISUALIZATION FOR NASAL CAVITY FLOW IN AEROSOL EXHALATION THROUGH NOSE TREATMENT

Takahisa Yamamoto[1], Yoshiki Kobayashi[2], Shunpei Shikano[1], Masahiro Takeyama[1], Mikiya Asako[2]

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Aerosol medicine exhalation through nose (ETN) is one of promising and comprehensive treatment methods for Eosinophilic Chronic Rhinosinusitis (ECRS) with asthma. In this treatment, the patient inhales aerosol of inhaled corticosteroid (ICS) medicine from mouth using portable inhaler. Then a part of the aerosol still floats and remains in upper airway. When the patient exhales inhaled air through the nose, the aerosol is effectively transported on the walls of middle meatus and olfactory fissure. The mechanism of how ETN improves ECRS with asthma is still controversial even though ETN gets a lot of attention as a treatment method for ECRS with asthma. This study performed Computational Fluid Dynamics (CFD) and Experimental Fluid Dynamics (EFD) analysis for the transport phenomena of aerosol medicine during exhalation period to evaluate the curative effect of ETN numerically and experimentally. A 3D anatomically accurate patient-specific model was reconstructed from the data obtained using multidetector CT scanner. This study used a Euler-Lagrange particle transport model for aerosol transport in CFD analysis. In addition, Particle Image Velocimetry (PIV) measurement was conducted using living-body model of nasal-pharynx airway in EFD analysis. As results of CFD and EFD analysis, ETN formed impinging flow toward upper wall of nasopharynx, subsequently complex swirl and circulation flow in the nasopharynx region. In addition, main flow of ETN passed upper region of nasal cavity. Such the tendencies affected on aerosol transport characteristics; a part of aerosol particles moved into ethmoindal sinuses. Total aerosol deposition amount during ETN depended on flow rate of exhalation. This tendency was more remarkable on the upper wall of nasopharynx. On the other hand, deposition rate of aerosol on the ethmoidal sinuses did not appear strong correlation with flow rate of exhalation. These results imply that both aerosol transport and deposition during ETN has non-stationary characteristics.

ID: E3-0013 **B7 : 3**

ARTERY RUPTURE SIMULATION OF THE HUMAN THIGH BY GUNSHOT THROUGH A FINITE ELEMENT METHOD

Young Nam Jo, Gil Ho Yoon, Hong Hee Yoo

Hanyang University, South Korea

Gunshot injury is a great factor that affecting survivability of soldiers in battle field. When received gunshot wounds in the arm or leg, excessive bleeding is a significant cause of death. The purpose of the present study is to conduct artery rupture simulation when received a gunshot wound in the thigh through a finite element method.

To improve convergency and efficiency, the finite element model of a thigh is simplified into conic shape based on human 3D scan data. Gelatin is commonly used in bullet penetration experiments as a substitute of human soft tissue. So, we assumed that properties of human flesh is equal to that of 10% gelatin. The properties of gelatin are obtained through a indentation test. In this study, Ansys was used for finite element analysis. Kelvin solid model and Maxwell fluid model is used as the linear viscoelastic model. Mie Gruneisen equation of state and Johnson Cook failure model is also used. The analysis method we used is validated by comparing deformation of gelatin penetration simulation with experiment. We simulated artery maximum elongation according to gunshot position and bullet velocity. And we calculate artery rupture probability when receive a gunshot wound in the thigh by using artery yield elongation experiment results of other reference.

This study will useful to predict survivability of soldiers who received gunshot in the thigh. However, in this study, the simulation results is validated only in the case of bullet penetration of gelatin. So validation of the analysis method we used need to be complemented.

ID: A4-0023 **B7 : 4**

MULTICLASS CLASSIFICATION OF APG SIGNALS USING ELM FOR CVD RISK IDENTIFICATION: A REAL-TIME APPLICATION

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Cardiovascular diseases are one of the leading causes of deaths in the world today, accounting for 17.5 million cases every year. This paper presents a non-invasive method of classifying a subject's health as "Healthy" or "At Risk" of cardiovascular disease (CVD). The novelty of the work lies in recognizing the rare case of a young subject with cardiovascular disease as well as old subjects who are healthy, and the real-time implementation of CVD risk analysis. In the proposed work, 30 healthy and 30 pathological signals were considered. Empirical Mode Decomposition (EMD) was used to remove high-frequency noise, following which the analysis of the acceleration plethysmogram (APG) signals was carried out.

An APG signal is a second derivative of the PPG signal. APG allows more accurate recognition of the inflection points and easier interpretation of the characteristics/features. The signal is analyzed and seven features of the wave contour are extracted. With these features and considering the actual age of the subject, 4 classes were identified using an extreme learning machine (ELM) classifier, and we grouped them as, Healthy Young, Unhealthy Young, Healthy Old, Unhealthy Old. Implementation of the proposed system is done on a Raspberry Pi 2 using the Python programming language. The training of the classifier and prediction of CVD risk group, using the extracted features, takes on average 17.83 milliseconds. The overall accuracy of the system is 86%. Therefore, the developed system is suitable for real-time identification of CVD risk from APG signals.

Session	C7: Biomechanics
Date	Friday, 9 December
Time	11:00am - 12:30pm
Venue	LT51

ID: E3-0008 **C7 : 1**

EXPLORATION OF DESIGN GUIDELINES OF SUPPORTIVE UNDERWEAR TO IMPROVE PELVIC FLOOR RELAXATION USING A FE MODEL OF THE BUTTOCKS

Daisuke Tawara[1], Tomohiro Nishiki[1,2], Sanae Ninomiya[3], Hisayo Okayama[4], Kiyoko Naito[5], Kyoko Nakanishi[4], Shigehiro Morikawa[6], Jiro Sakamoto[7]

[1]Ryukoku University, Japan; [2]TAKARA BELMONT Corp., Japan; [3]Kyoto University, Japan; [4]Shiga University of Medical Science, Japan; [5]Biwako-Gakuin University, Japan; [6]Molecular Neuroscience Research Center, Shiga University of Medical Science, Japan; [7]Kanazawa University, Japan

Stress urinary incontinence, which is a well-known urological disease in postpartum women, progresses due to descent of organs in the pelvis induced by weakness in the pelvic floor muscles. It has been reported that it had been improved by lifting up the bladder neck using supportive underwear, suggesting that higher elevation of the bladder neck is important. In order to establish an appropriate design for underwear, it is necessary to clarify the relationship of the magnitude between pressures of supportive underwear and elevation of organs. In this study, first, finite element (FE) model of the pelvis, which simply consisted of pelvis, bladder and other soft tissue, of a middle-aged female Japanese which was constructed based on MRI images. Second, we experimentally measured the relationship between force and displacement for the soft tissue of the subject around the pelvis and explored Young's modulus of the soft tissue. We also analyzed magnitude of the elevation of the bladder neck under the application of pressures from the existing supportive underwear and compared it with the previous experimental results to validate our model. Third, we performed FE analysis changing the combination of pressures of the underwear to evaluate change in magnitude of elevation of the bladder neck and propose appropriate combination of pressures. As results, magnitude of the elevation of the bladder neck relatively increased when the pressure of the region from abdomen to pubis decreased and the region from perineum to coccyx increased. In addition, deformation of the bladder neck was consistent between the simulation results and the previous experimental results, meaning that our simulation method was valid. Therefore, decrease of the pressure of the region from abdomen to pubis and increase of the pressure of the region from perineum to coccyx are useful for an appropriate design of supportive underwear.

ID: E5-0014 **C7 : 2**

CARTILAGE CHANGES IN SHOULDER HEMIARTHOPLASTY

Maryam Imani Masouleh, Niloofar Ajdari, Ulrich Hansen, Daniele Dini

Imperial College London, UK

Osteoarthritis (OA) is a common form of arthritis that causes joint degradation and affects up to 15% of the adult population. It is characterized by chronic and irreversible degeneration of articular cartilage (AC). Hemiarthoplasty is a surgical procedure, where the diseased (OA) cartilage on one side of the joint is replaced with an implant, while the other side remains intact.

The main aim of this study is to analyse the mechanical and frictional response of different shoulder humeral component materials against the natural glenoid. This has been developed as a two stage process. Initially, friction and wear properties of four different grades of human osteoarthritic AC were measured using pin-on-disc technique against three major types of implant materials used in hemiarthoplasty including Cobalt-Chromium, ceramic and Polycarbonate-urethane (PCU) polymer. Mechanical and frictional properties of the samples were characterised by compression, shear tests and surface roughness measurements using white light interferometry (WLI). Results indicated that at the same stage of OA, the cartilage tribological and mechanical properties deteriorated when using COCR.

The second stage of this study focuses on creating a model more anatomically realistic of the hemi-replaced shoulder joint and assesses the cartilage mechanical behaviour. A custom made joint simulator has been built and will be used to investigate the response of shoulder joints under representative loads. The glenoid will be tested against different humeral component materials to understand the friction/wear response of the cartilage. The correlation between mechanically damaged and healthy cartilage will be investigated. Histological analysis will be performed on the tissue to observe any structural changes due to wear. The results from this study can aid the surgeons to choose the best possible material for hemiarthoplasty according to the disease state of the patient.

ID: E3-0022 **C7 : 3**

PARAMETRIC ANALYSIS ON PELVIC INJURY IN AN UNDERBELLY BLAST - A FINITE ELEMENT STUDY

Kwong Ming Tse[1], Dale Robinson[1], Melanie Franklyn[1,2], Peter Vee Sin Lee[1]

[1]The University of Melbourne, Australia; [2]The Defence Science and Technology Group, Australia

With the recent increase in underbelly (UB) blast attacks using improvised explosive devices (IEDs), severe injuries to the pelvis, which are often fatal or result in permanent impairment, have been reported to occur to occupants of military vehicles subjected to these events. In the current study, a finite element (FE) model of the pelvis was used in order to analyse the factors influencing pelvic injury potential from applied vertical loading, thereby providing an enhanced capability for risk assessment of military armoured vehicle occupants in UB blast events. Experimental boundary and loading conditions from high-speed pneumatically-driven impact tests using cadaveric defleshed pelves were applied to the FE pelvis model and experimental measurements such as seat force, pelvic rotation and pelvic displacement relative to the fixture were used for validating the model. Using the FE pelvis model, parametric analyses were then conducted to assess the effects of different variables such as the presence of muscle forces, thoracic mass, abdominal mass, bone density, seating postures and compliance of the sacroiliac and sacrococcygeal joints on pelvic injury potential.

A preliminary analysis of these simulations showed that the sacrum was highly susceptible to fracture, while muscle forces, which mainly contribute to intra-abdominal pressure and are acting inferiorly on the pelvis brim, increased the likelihood of pelvic bone fractures. A smaller pelvic tilt, which occurs when a vehicle occupant seats with his or her upper body flexed forward, resulted in a higher stress in the pelvis. The importance of intra-abdominal pressure in the loading path and fracture patterns in the dynamic blast event was also highlighted in the findings. The results of this preliminary work provide insights which can be used in the development of improved operational standards for the mitigation of complex pelvic injuries in UB blast events.

ID: E5-0016 **C7 : 4**

3-D RECONSTRUCTION OF PF JOINT FOR DESIGNING UNICOMPARTMENTAL KNEE PROSTHESIS FOR THAI PEOPLE

Warat Puttatananun, Chonrawan Kulchaisawat, Somprasong Kaewjumphot, Chamaiporn Sukjamsri, Wongwit Senavongse

Srinakharinwirot University, Thailand

Total knee replacement is a conventional surgical procedure to replace the knee prosthesis to the knee joint. However, the problem is Thai's knee sizes and other countries' knee sizes are different due to Thai's or Asian's have smaller sizes than the others (European, African, etc.) In addition, the difference sizes for gender (between male and female) add more difficulties as almost all knee implants are made for other countries. Although they have the smallest size of knee implant, it is still not suitable for some people in Thailand or Asian. Therefore, there have not been standard sizes for Thai people. Moreover, the popular knee replacement surgery is Total Knee Replacement (TKR) which loses a lot of bone tissues compared with Unicompartmental knee replacement technique.

Thus, TKR may destroy the good bony parts, take time to heal due to a lot of damage tissues and cost a lot more.

The objectives of this research were to study how to reconstruct 3D model of the patellofemoral joint from the MRI data, to measure size of Thai's knee joint that includes femur, patella and tibia for comparing proportion of the measured data in order to select the one that has the least errors and use Finite Element Analysis method to find mesh convergence for analyzing the stress in the knee joint. The findings will be used for designing the Unicompartmental knee prosthesis that is suitable for Thai population in the future.

ID: C4-0004 **C7 : 5**

MATERIAL CUSTOMIZATION OF SOFT ROBOTS FOR BIOMEDICAL APPLICATIONS

Yi Sun, Xinquan Liang, Marcelo H. Ang Jr., Chen Hua Raye Yeow

National University of Singapore, Singapore

The research field of soft robots is currently growing at a staggering rate due to its friendly interaction with human and delicate objects, and the superior capability in biomimicry. As a typical type of soft robot and actuator, silicone-based soft pneumatic robots and actuators (SPRA) are widely utilized in a multiplicity of applications such as rehabilitation and manipulation. However, one of the fundamental and challenging problems is how to utilize soft silicone of low viscosity to produce SPRAs capable of high force/torque output. From the prior art, it is believed that high force output highly relies on the high stiffness of the silicone rubber. However, high stiffness represents the high viscosity of silicone rubber prepolymer which usually raises the difficulty in fabrication greatly. In this work, we propose a method to mechanically program the soft silicone into hybrid materials of any stiffness. This approach, inspired by Pulse Width Modulation (PWM), is to combine two types of materials of different stiffness at certain ratio into a hybrid material with an aggregated stiffness. In our specific experiments, soft silicone (Ecoflex 0030) represents the soft material while non-stretchable fabric is chosen as the stiff material due to its strong adhesion with silicone rubber. To guide the elasticity customization, a generic model is established. Tensile tests were implemented on the hybrid materials of different fabric-silicone ratios. Results show that our method is able to modulate the elastic modulus of the hybrid material while the comparison between the model and experimental results indicates a proper accuracy of our model. Our future work will include the application of this material customization method to the fabrication of SPRAs and ultimately produce SPRAs of high force output from soft silicones.

ID: E5-0013 **C7 : 6**

PERSPECTIVE OF MUSCLE ACTIVATION AND MUSCLE FIBER CHARACTERISTICS IN AGING LOWER EXTREMITY MUSCLES FOR MOVEMENT MODALITIES PERFORMED AT DIFFERENT CONDITIONS

Chow Khuen Chan[1,2], Timothy Guojun Fu[1], Cai Lin Chua[1], Chen Hua Yeow[1]

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The sensorimotor performance in human movement with dissimilar conditions and age has not been established. Deterioration of the sensorimotor causes poor gait performance, peculiarly in muscle strength and muscle reaction timing. This further elicits that older people has lower ability to control their movement and speed, which causes instability and falling cases. Also, the sensorimotor decline affects the muscle activation and peak activation timing. Furthermore, deterioration of muscle properties (slow- and fast-twitching fibers) attribute to gait decline. Thence, forward gait is selected as the movement modality and this study ought to provide the threefold objectives. The main aim is to investigate the speed and age factors in manipulating the muscle recruitment by the realization of maximum muscle activation. The secondary objective is to examine the sensorimotor functionality associations in relation to ageing forward walking with different speed, particularly the time to peak muscle activation. The third aim is to investigate the modulation of muscle fiber type as the speed and age alters. Eighteen participants (9 young and 9 elderly) were recruited; electromyography (EMG) signals were recorded from the lower extremity muscles: rectus femoris (RF), vastus lateralis (VL), vastus medialis (VM), semimembranosus/semitendinosus (STSM), biceps femoris (BF), tibialis anterior (TA), gastrocnemius lateralis (GL), gastrocnemius medialis (GM), soleus (SOL) and gluteus maximus (GMax). Upon filtering and normalizing the EMGs, essential points were selected from stance and swing phases for evaluation. In assessing muscle fiber selection, EMGs were converted to frequency domain by utilizing mean frequency (MNF) variable; thereafter, extracted from both gait phases. As the age increases, there is a peak activation reduction in GM ($p<0.05$) and

slower reaction time in RF, BF and STSM ($p<0.05$). Additionally, there is reduction in fast-twitching muscles ($p<0.05$) in RF and TA as age heightens. This study is crucial for rehabilitation program and assistive device designation.

Session	SYM-11: Special Topic Symposium: Bioimaging I
Date	Friday, 9 December
Time	11:00am - 12:30pm
Venue	LT52

ID: A2-0002 **SYM-11 : 1**

ULTRAHIGH SPEED 3D OPTICAL COHERENCE TOMOGRAPHY IMAGING

Ping Xue[1,2], Xiao Zhang[1], Chengming Wang[1], Wenchao Liao[1], Shengnan Ai[1], Wenxin Zhang[1]

[1]Tsinghua University, China; [2]State Key Laboratory of Low-dimensional Quantum Physics and Department of Physics, Collaborative Innovation Center of Quantum Matter

Optical coherence tomography has attracted much attention and been widely used in clinic. In this talk, I will discuss and demonstrate that linear-in-wavenumber swept laser and all-optical 40MHz swept-source as the optical source, and compressed sensing and time serial optical computing play important roles to achieve real-time 3D imaging.

ID: A2-0003 **SYM-11 : 2**

MULTIPHOTON IMAGING OF CORNEA DEVELOPMENT AND PATHOLOGY

Chen Yuan Dong

National Taiwan University, Taiwan

Due to the high degree of corneal transparency, standard optical microscopy examination is of limited use in imaging superstructure in normal and pathological corneas. However, since the cornea is composed primarily of type I collagen, a combination nonlinear optical phenomena such as multiphoton-induced fluorescence and second harmonic generation (SHG) has been shown to be effective in visualizing three-dimensional superstructure and pathological changes in corneal specimens. In this presentation, I will show our results in investigating cornea development and pathology. I will also discuss future research directions and potential development in the clinical setting.

ID: A2-0005 **SYM-11 : 3**

STIMULATED RAMAN SCATTERING (SRS) MICROSCOPY AND ITS BIOMEDICAL APPLICATIONS

Minbiao Ji

Fudan University, China

Stimulated Raman scattering (SRS) microscopy is a nonlinear version of Raman microscopy. SRS has unique capabilities of label-free, high chemical specificity and sensitivity. It could selectively image the distributions of biomolecules (such as lipids, protein and DNA) based on their different vibrational spectra. This talk will introduce the basic principles of SRS, as well as a few biomedical applications, including in-vivo brain tumor detection, label-free imaging of DNA and protein misfolding.

ID: A3-0001 **SYM-11 : 4**

LABEL-FREE DETECTION OF CIRCULATING MELANOMA CELLS BY IN VIVO PHOTOACOUSTIC FLOW CYTOMETRY

Xunbin Wei

Shanghai Jiao Tong University, China

Melanoma is a malignant tumor of melanocytes. Melanoma cells have high light absorption due to melanin highly contained in melanoma cells. This property is employed for the detection of circulating melanoma cell by in vivo photoacoustic flow cytometry (PAFC), which is based on photoacoustic effect. Compared to in vivo flow cytometry based on fluorescence, PAFC can employ high melanin content of melanoma cells as endogenous biomarkers to detect circulating melanoma cells in vivo. We have developed in vitro experiments to prove the ability of PAFC system of detecting photoacoustic signals from melanoma cells. For in vivo experiments, we have constructed a model of melanoma tumor bearing mice by inoculating highly metastatic murine melanoma cancer cells, B16F10 with subcutaneous injection. PA signals are detected in the blood vessels of mouse ears in vivo. The raw signal detected from target cells often contains some noise caused by electronic devices, such as background noise and thermal noise. We choose the Wavelet denoising method to effectively distinguish the target signal from background noise. Processing in time domain and frequency domain would be combined to analyze the signal after denoising. This algorithm contains time domain

filter and frequency transformation. The frequency spectrum image of the signal contains distinctive features that can be used to analyze the property of target cells or particles. The processing methods have a great potential for analyzing signals accurately and rapidly. By counting circulating melanoma cells termly, we obtain the number variation of circulating melanoma cells as melanoma metastasized. Those results show that PAFC is a noninvasive and label-free method to detect melanoma metastases in blood or lymph circulation.

ID: A2-0011 **SYM-11 : 5**

MULTIMODAL NONLINEAR OPTICAL MICROSCOPY IMAGING FOR LABEL-FREE DIGITAL PATHOLOGY

Zhiwei Huang

Optical Bioimaging Lab, National University of Singapore, Singapore

We will report the development of a powerful multimodal nonlinear optical microscopy technique including coherent anti-Stokes Raman scattering (CARS), stimulated Raman scattering (SRS), two-photon excitation fluorescence (TPEF), second harmonic generation (SHG) and third-harmonic generation (THG), serving as an imaging platform for biomedical applications. We will show some results using multimodal nonlinear microscopy technique developed for optical diagnosis and characterization of pathologic tissues and cells without labeling.

Session	WS-01: IFMBE Workshop: Biomedical Engineering/Clinical Engineering Education
Date	Friday, 9 December
Time	11:00am - 12:30pm
Venue	Global Learning Room

ID: G3-0002 **WS-01 : 1**

CLINICAL ENGINEERING CURRICULA: THE IFMBE/CED PERSPECTIVE AND A FOCUS ON ITALIAN ACADEMIC CURRICULA

Ernesto Iadanza

University of Florence, Italy
IFMBE / Clinical Engineering Division

Clinical Engineering curricula can vary a lot all over the world. Often they are included in Biomedical Engineering curricula, but there are important differences and exceptions. The Clinical Engineering Division of the International Federation for Medical and Biological Engineering (IFMBE/CED) is running a project for defining the basic sets of requirements and skills that a Clinical Engineer should hold in order to be able to effectively act in the healthcare panorama in different clinical settings and countries. The project is aimed to define the core Body of Knowledge (BoK) and Body of Practice (BoP) that can be used as a starting point in designing local academic curricula that will address the national and local special needs. In this talk will be briefly described the project itself. There will also be a focus on two master courses in Clinical Engineering that have been delivered in Firenze, Italy, for ten years. These courses address the roles of Clinical Engineers in the italian clinical setting b) Are there any distinct differences in the Biomedical and Clinical Engineering educational programs in your country or your institution? c) Do share the BME/CE curriculum in your institution with the participants. d) What are the roles of an engineer in the clinical settings in your country? e) What are the basic requirements/skill sets/body of knowledge (BoK) which a clinical engineer should possess to function effectively in the clinical settings? f) how well does your undergraduate Biomedical Engineering and/or Clinical Engineering program/s prepare your graduates for the workforce? g) Does your educational program provide different career pathways for your graduates such as employment in (a) healthcare (hospitals) industry (b) medical device & entrepreneurship (c) medical technology sectors and (d) graduate studies? If so, what curriculum do you have in place for such pathways? h) Accreditation of your BME/CE

ID: G3-0003 **WS-01 : 2**

STATUS OF BIOMEDICAL ENGINEERING EDUCATION OF TAIWAN

Kang-Ping Lin, Mei-Fen Chen

Chung-Yuan Christian University, Taiwan

The development of biomedical engineering (BME) education in Taiwan is very flourishing. The first BME department, which was established in 1972, has more than 40 years history. There are 8 universities having established undergraduate departments, 18 universities providing master programs, and 8 universities having Ph.D. programs. Every year, there are around 700 students graduating from BME education institutes, and 60% of whom obtaining a bachelor degree, 35% of whom obtaining a master degree, and 5% of whom obtaining a Ph.D. degree.

Professionals involved in BME education are around 270 persons, including full-time faculty members (60%), and part-time experts (40%). Specialty and research topics for the faculty members and experts, including Biomedical Electronics (21%), Biomaterial (16%), Biomechanics (14%), Biomedical information (7%), Biomedical Image (12%) and others (30%). Regarding curriculum, bachelor education goal is to train students having basic knowledge of BME techniques, pragmatic working attitudes and capability to solve problems. For BS degree, students are trained to have medical and engineering ethical spirit, capability to analyze and organizational skills, and international outlook. In order to meet the needs of BME industry, most BME departments cooperate with hospitals and medical device companies to provide internship training programs, which helps undergraduate students obtain the concept of future employment market to prepare the required skills and capability in advance. Furthermore, the BME education system coordinate with the certification mechanism of biomedical engineers conducted by Taiwanese Society of Biomedical Engineering (TSBME), so the talent of BME field can be trained with a complete cultivation, training and validation system. Over the past 40 years, the curriculum contents of biomedical medical education have been changed dramatically. With the transformation of social structures, the development of science and technology, long-term care, assistive device and precision medicine will be important issues in BME education.

ID: G3-0005 **WS-01 : 3**

IS NOW THE TIME TO EMBRACE ACCREDITED UNDERGRADUATE CLINICAL ENGINEERING PROGRAMS IN THE USA?

Herbert Voigt

Boston University, USA

Undergraduate biomedical engineering education has had a meteoric trajectory in the U.S.A., whereas undergraduate clinical engineering education has remained essentially in limbo. In the U.S.A. today there are no accredited (or unaccredited) clinical engineering (CE) undergraduate programs, despite that fact that the number of accredited undergraduate biomedical engineering programs is fast approaching 100. A few biomedical engineering undergraduates, upon receiving their B.S. degree, work in hospitals or shared-service organizations, but they often lack experience in critical clinical environments to be effective immediately. They need additional training to become effective. According to the most recent definition of a clinical engineer by the American College of Clinical Engineering (ACCE) used at the recent Global Clinical Engineering Summit in Hangzhou, China on 23 October 2015, “A Clinical Engineer is a professional who supports and advances patient care by applying engineering, economics, communication and managerial skills to healthcare technology.” - modified ACCE definition, 1992.The CE profession needs practitioners with new skillsets - both for emerging graduates and people at all stages of their careers. Now is the appropriate time to consider a) the realm of knowledge required for CEs to be successful in clinical environments and b) more formal educational vehicles needed for achieving these outcomes, possibly through accredited undergraduate and graduate educational programs. In this talk, the question of whether or not now is the time to embrace accredited undergraduate clinical engineering programs is raised. The successful rise of the Occupational Therapy Profession is used as a possible model for promoting Clinical Engineering.

ID: G3-0001 **WS-01 : 4**

AN INTERNATIONALISED CURRICULUM FOR STUDENTS TO EXPLORE THEIR ENTREPRENEURIAL PASSIONS

Hin Chung Lau, Yong Ping Zheng

The Hong Kong Polytechnic University, Hong Kong

The 4-years Biomedical Engineering (BME) curriculum at The Hong Kong Polytechnic University is evolving to heighten students’ competencies to meet future needs. Research & Design (R&D) 1 and 2 are core subjects for Year-2 and Year-3 students, respectively. The subjects are inter-linked and span across four consecutive semesters, during which the students build a healthcare product for their R&D group projects. For students to understand the scope of R&D in healthcare products and the impact of BME solutions in a global and societal context, 16 students have been selected in 2016 to conduct their projects with students from partner institutions in UK, Singapore and China. 10 students from the partner institutions are also invited to visit Hong Kong for project sharing and cultural exchange with all BME students.

The curriculum introduce Year-1 students to practices of innovation and design thinking in real world through industrial visits and sharing sessions with start-up CEOs. These activities enhance students’ awareness of innovative solutions and real-life challenges in BME, which facilitate students to generate their own project ideas for R&D1 subject. Market research

and intellectual property are taught during R&D1 to establish a good foundation to develop an entrepreneurial culture among students. Student project teams present their proof-of-concept prototype during a project sharing event at the end of semester two. Entrepreneurs or angel investors are invited to provide feedback to the students before they proceed with their project idea in R&D2 subject. R&D2 students practice various entrepreneurial skills, such as crafting elevator pitch, poster presentation, product booth demonstration as well as business plan writing on their group project. Students are encouraged to extend their project idea to their Year-4 Capstone Project and to apply for Seed Funds to drive their project further to the business world.

ID: G3-0006 **WS-01 : 5**

THE STATUS OF CLINICAL ENGINEERING PROGRAMS IN LATIN AMERICA REGION

Martha Zequera Díaz

Pontificia Universidad Javeriana, Colombia

The aim of this paper is to present the status of Clinical Engineering Programs in Latin America Region. It was found at the region 60 Biomedical Engineering and Bioengi-neering programs established according with the literature re-view [1], [2], [3]. Due to the greater population ageing and the increase in the prevalence of chronic illnesses in Latin America, new technologies in healthcare emerged and showed to be more effective supporting the national health services. In addition demographic changes significantly influence the way health services are offered.

This field has evolved greatly since the 1960s when it emerged in Canada and the United States in response to the increasing amount of technology used to deliver health care. And the clinical engineers were focused on patient safety and medical devices assessment. [4], [5]. According to Mullally (2008) “Clinical engineering departments (CEDs) began to emerge in hospitals in the early 1970s, and CEs became inter-ested in equipment acquisition, user training, and user educa-tion”, in the other hand the budget restraints in health care spending saw CEs become involved in purchase and the as-sessment of emergent technologies. In addition the proliferation of clinical patient relevant information introduced management software for CED. Actually the CEs are involved in research and development activities and comprehensive technology assessments [7], [6]. Mullally (2008) reports that the main is-sues taking in account at the CEs are the following: a. Staffing: adequate staffing of both CEs and biomedical equipment techni-cians/technologists (BMETs), b. Special training of staff to employment in the CED, c. Administrative space with adequate workspace and storage space for equipment inventory, d. Com-puterized maintenance and management system, e. Test Equip-ment and Tools adequate to perform maintenance duties, f. Communications Equipment to facilitate communication be-tween CED staff and equipment users, manufacturers and ven-dors [7].

ID: G3-0004 **WS-01 : 6**

BME EDUCATION IN SINGAPORE AND SOUTH EAST ASIA

Alberto Corrias, Siew Lok Toh

National University of Singapore, Singapore

In this talk, we will present an overview of Biomedical Engineering (BME) education in Singapore and South East Asia at undergraduate and graduate level. The first BME programme in the region was established at the National University of Singapore (NUS) in 2001. Over a dozen BME programmes are now available in various other countries including Malaysia, Thailand, Indonesia and the Philippines.

We will focus on the NUS BME programme and try to identify similarities and differences among the various programmes in the region. In particular, we will look at the body of knowledge (BOK) that is deemed essential in the educational approach to BME.

Session	A8: Biosensors, BioMEMs & Lab-on-Chip
Date	Friday, 9 December
Time	1:45pm - 3:15pm
Venue	Auditorium 2

ID: KN-0006 **A8 : 1**

ORGANIC ELECTROCHEMICAL TRANSISTOR ARRAY TO STUDY ELECTROPHYSIOLOGY OF EXCITABLE CELLS

I-Ming Hsing, Xi Gu

The Hong Kong University of Science and Technology, Hong Kong

In this talk, we will discuss the development of bioelectronics to study brain- and cardiovascular-diseases. Specifically, we will highlight a new

extracellular physiological recording platform, Organic Electrochemical Transistor (OECT) [1-3]. This OECT-based device can be manufactured on a flexible substrate [2] and arranged in a high-density array format [3] and it seems to be a promising technology platform to study excitable cells (e.g., neurons and cardiomyocytes). In the long run, OECT based devices could be made in flexible shape using flexible materials and could potentially be an interesting in-situ platform to prognose neurodegenerative and cardiovascular diseases.

ID: B1-0008 **A8 : 2**

DEVELOPMENT OF ASSAY FOR CTDNA DETECTION USING SPR SENSOR

Sera Park, Daeho Jang, Sehyun Shin

Korea University, South Korea

Early detection of cancer greatly increases the chances for successful treatment. The development of non-invasive methods to detect and monitor tumors continues to be a major challenge in oncology. For most tumors, a tissue biopsy is costly, painful, or potentially risky for the patient. Liquid biopsy with circulating biomarkers such as circulating tumor cells (CTCs), exosomes and circulating tumor DNA (ctDNA) is a simple and non-invasive alternative to surgical biopsies which is easy repetitive sampling and whole mutation representation. These circulating biomarkers can be easily obtained from biofluids such as blood. ctDNA liquid biopsy allows us to understand specifically what kind of mutations are happening in the tumor in real time. Although various methods for detecting ctDNA have been introduced such as NGS (Next Generation Sequencing) and Real-time PCR (Polymerase Chain Reaction), there are still unmet needs; cost, time for the applications.

We applied novel SPR (Surface Plasmon Resonance) based approaches to detect one of the ctDNA; EGFR (Epithermal Growth Factor Receptor) gene mutations with ultra-high sensitivity and multiplexing. SPR used to detect biomolecules without labeling via changes in the refractive index on the sensing film of the SPR sensor in real time. This tool is suitable to detect small molecules; ctDNA. Optimizing the selectivity between mutant and wild-type is challengeable in the case of the ctDNA detection. To provide selectivity enhancement for the sensing approach, we designed the surface of SPR gold chip with various SAM (Self-Assembly Monolayer) considered the steric hindrance between nucleotides. Additionally, we applied proper buffer to control the condition;pH, NaCl for DNA duplex stability. As a result, the limit of detection (LOD) of EGFR mutant in our system was determined to be 500pM without acquiring false-positive wild-type signals.

ID: B1-0011 **A8 : 3**

SURFACE ROUGHNESS DISCRIMINATION USING BIOINSPIRED TACTILE SENSORS

Zhengkun Yi, Yilei Zhang

Nanyang Technological University, Singapore

Surface texture discrimination using artificial tactile sensors has attracted increasing attentions in the past decade. However, as a major component of texture, roughness was rarely explored. This paper presents an approach for tactile surface roughness discrimination, which includes two parts: (1) design and fabrication of a bioinspired artificial finger; (2) tactile signal processing for tactile surface roughness discrimination. The bioinspired finger is comprised of two polydimethylsiloxane (PDMS) layers, a polymethyl methacrylate (PMMA) bar, and two perpendicular polyvinylidene difluoride (PVDF) film sensors. The artificial finger mimics human fingers in three aspects: (1) Elastic properties of epidermis and dermis in human skin are replicated by the two PDMS layers with different stiffness, (2) The PMMA bar serves the role analogous to that of a bone, and (3) PVDF film sensors emulate Meissner's corpuscles in terms of both location and response to the vibratory stimuli. Various extracted features and classification algorithms including support vector machines (SVM) and k-nearest neighbors (kNN) are examined for tactile surface roughness discrimination. Eight standard rough surfaces with roughness values (Ra) of 50 μm, 25 μm, 12.5 μm, 6.3 μm 3.2 μm, 1.6 μm, 0.8 μm, and 0.4 μm are explored. The highest classification accuracy of (82.6 ± 10.8) % can be achieved using solely one PVDF film sensor with kNN (k = 9) classifier and the standard deviation feature.

ID: B1-0020 **A8 : 4**

PERSONAL PHOTOMETER "PHOTOPETTE" WITH "LAB-IN-A-TIP" TECHNOLOGY FOR LIFE-SCIENCE APPLICATIONS

Dieter Trau[1], Tobias Arnold[2], Shihao Li

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Here, we demonstrate a novel "Lab-in-a-Tip" technology which is based on colorimetric reaction with an analyte within a disposable measurement tip. The "Lab-in-a-Tip" is combined with our personal hand-help photometer, the "PHOTOPETTE" for optical

read out. Less sample volume required and instant on-spot detection are the advantages of this technology. We demonstrated pH, protein and nucleic acids measurements in our "Lab-in-a-Tip design" combined with a personal hand help photometer developed by our collaborator Tip Biosystems Pte Ltd. (This work is supported by National Research Foundation Singapore, NRF2014NRF-POC002-045).

ID: B1-0006 **A8 : 5**

RECEIVING MODE ENHANCEMENT OF CAPACITIVE MICROMACHINED ULTRASONIC TRANSDUCERS BY MEMBRANE STRUCTURE MODIFICATIONS

Xiao Jiang[1,2], Yuan Yu Yu[1,2], Jiu Jiang Wang[1,2], Xin Liu[1,2], U Kin Che[2], Sio Hang Pun[2], Mang I Vai[1,2], Peng Un Mak[1]

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Similar to traditional piezoelectric transducer, Capacitive Micromachined Ultrasonic Transducer (CMUT) is a kind of MEMS-based ultrasonic transducer which can act either as a transmitter or a receiver. In comparison, it owns several advantages over the traditional piezoelectric transducer. As to the reception performance, it is important to the overall performance and very few published papers researched on the behavior of receiving mode of CMUTs.

This paper presents FEA models (via COMSOL Multiphysics) of receiving CMUTs working as conventional mode in water with two modified membrane structures: namely slotted membrane and corrugated membrane. By modifying the membrane structures, effective membrane thickness will decrease. This will decrease overall system stiffness and hence increase the membrane deflection. With the modified membrane structures, both static membrane deflections biased by DC voltage and dynamic membrane displacement caused by external acoustic pressure will increase. These will lead to the enhancement of reception performance.

Initial FEA simulations show that by using the modified membrane structures in given configurations, the collapsed voltage and center frequency will reduce. Moreover, both the electromechanical coupling coefficient and receiving sensitivity are improved up to 20.9% & 50.5% for slotted membrane and 5.0% & 38.3% for corrugated membrane, respectively.

Session	SYM-12: Special Topic Symposium: Advances in Microfluidics and Nano-fluidics I
Date	Friday, 9 December
Time	1:45pm - 3:15pm
Venue	LT50

ID: KN-0013 **SYM-12 : 1**

NANOSENSORS USING FLIGHT-TIME IDENTIFICATION OF MONONUCLEOTIDES FOR SINGLE-MOLECULE DNA SEQUENCING

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We are generating a single-molecule DNA sequencing platform that can acquire sequencing information with high accuracy that is built from a single-molecule sequencing process. The technology employs high density arrays of nanosensors that read the identity of individual mononucleotides from their characteristic flight-time through a 2-dimensional (2D) nanochannel (~20 nm in width and depth; >100 μm in length) fabricated in a plastic via nano-imprinting (NIL). The mononucleotides are generated from an intact DNA fragment using a highly processive exonuclease, which is covalently anchored to a solid support contained within a bioreactor that sequentially feeds mononucleotides into the 2D nanochannel. The identity of the mononucleotides is deduced from a molecular-dependent flight-time through the 2D nanochannel. The flight time is read in a label-less fashion by measuring current transients induced by a single mononucleotide when it travels through a constriction with molecular dimensions (<10 nm in diameter) poised at the input/output ends of the flight tube. In this presentation, our efforts on building these nanosensors using NIL will be discussed and the detection of single molecules using electrical transduction with their identity deduced from the associated flight time. Finally, information on the manipulation of single DNA molecules using nanofluidic circuits will be discussed that takes advantage of forming unique nano-scale features to shape electric fields for DNA manipulation.

ID: B1-0015 **SYM-12 : 2**

ELECTRIC MANIPULATION OF MICROSCALED FLUID FLOWS

Anderson H.C. Shum

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Manipulation of fluids has attracted interests due to the beauty of its fundamental dynamics, as well as its importance in different applications, such as materials processing and printing. Control over fluids is enhanced when the lengthscale of the fluid is miniaturized; hence, microfluidics has established itself as a promising platform for engineering fluid flows. In this talk, I will discuss how electrical charging can be incorporated into microfluidic flows to manipulate not just the size and shape, but also the dynamics of multiphase structures, such as droplets and jets. The electrical charging can impose a stress to the liquid-liquid interfaces, offering an additional control parameters to the final structures of the liquids. I will present our understanding of these electro-microfluidic systems, and demonstrate how they can be used to characterize liquid-liquid interfaces, and to extend the range of structures that can be printed using an extrusion-based approach.

ID: D6-0001 **SYM-12 : 3**

3D HYDROGELS WITH ELECTRICAL MANIPULATIONS OF PREPOLYMERS AND CELLS

Shih-Kang Fan

National Taiwan University, Taiwan

3D hydrogel architectures recapitulating biological structures are obtainable by formation and assembly of hydrogel building blocks with reorganized encapsulated cells or particles on an electromicrofluidic platform. This electromicrofluidic platform adopt electrowetting and dielectrophoresis to access varied objects (a) in multiple phases such as prepolymer liquid droplets and crosslinked hydrogels, (b) on a wide range of scales from micrometer cells or particles to millimeter assembled hydrogel architectures, and (c) with diverse properties such as conductive and dielectric prepolymer droplets that are photo, chemically, or thermally crosslinkable. We demonstrate 3D hydrogel architectures, composed of (i) varied particles or cells reorganized in programmable patterns and (ii) biomimetic hydrogels of designed properties and in adjustable geometries, are accessible for the subsequent studeis. We expect the electromicrofluidic platform to be a generic and alternative technique to manipulate cells and hydrogel for reconfigurable 3D bioprinting.

ID: B2-0010 **SYM-12 : 4**

A NOVEL PLATELET ASSAY ON A MICROFLUIDIC SYSTEM

Sehyun Shin[1], Hoyoon Lee[1], Byoung-Kwon Lee[2,3], Chae-Seung Lim[4]

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Aggregation and adhesion of platelets to the vascular wall are consequences of platelet activation and these cascade processes play critical roles in hemostasis and thrombosis at vascular injury sites. In this study, we designed a simple and rapid assay of platelet aggregation and adhesion in a microfluidic system. To activate platelets, either shear stress or agonists was selectively chosen for the required test. For shear-induced platelet activation (SIPA), a rotating stirrer in a circular chamber was designed with considering shear generation with secondary-flow-induced mixing. Agonists such ADP, epinephrine and arachidonic acid were carefully combined with collagen or fibrinogen. When platelets were activated in whole blood, they were driven through the microchannel under vacuum pressure. Activated platelets adhered to a collagen or fibrinogen-coated surfaces on microchannel, causing blood flow to significantly slow and eventually stop. In order to conduct the above whole test with quick and easy operation, a microfluidic chip was carefully designed with mimicking in vivo environment. To measure platelet adhesion and aggregation, the migration distance (MD) of blood through the microchannel was monitored. As degree of platelet activation increased, MD gradually decreased. For platelet-excluded blood samples, the blood flow did not stop even at the end of microchannel. These findings imply that either SIPA or agonist-induced platelet activation can be examined with the present proposed microfluidic system. Also, the MD is a potentially valuable index for measuring the degree of platelet activation and aggregation. Our microfluidic system is quick and simple, while providing a precise assay to measure the effects of shear or drug response on platelet aggregation and adhesion.

ID: B2-0004 **SYM-12 : 5**

A NEW USE OF SOUND WAVES TO ENHANCE INHALED STEM CELL, GENE AND DRUG DELIVERY

Leslie Yeo

RMIT University, Australia

Capitalizing on our recent discovery of a new class of sound waves—the first in over 60 years, we demonstrate an acoustofluidic nebulization platform for pulmonary drug, gene and stem cell delivery. In this talk, we specifically focus on the use of the device for inhaled DNA vaccination against influenza, although we also show that this generic platform technology can easily be adapted for the administration of both small molecule and macromolecular drugs such as RNAi, peptides and proteins (e.g., monoclonal antibodies) to treat a wide range of respiratory diseases including lung cancer, as well as stem cells for lung tissue regeneration and repair. Additionally, the technology is also a rapid, efficient and straightforward means for synthesizing 100 nm biodegradable polymeric particles within which the therapeutic molecules can be encapsulated. Finally, the ability to synthesize multiple polyelectrolyte coatings encapsulating these biomolecules is shown as a fast and efficient alternative to conventional layer-by-layer assembly. The low cost, particle size control, low power requirement, delivery efficiency, and miniaturizability altogether suggests the platform constitutes an attractive alternative to current nebulizers and inhalers, which we envisage could comprise the next-generation of devices that will revolutionize pulmonary drug and gene delivery for needle-free vaccination therapeutics.

Session	SYM-13: Special Topic Symposium: Biomedical Nanotechnology
Date	Friday, 9 December
Time	1:45pm - 3:15pm
Venue	LT51

ID: KN-0012 **SYM-13 : 1**

NANO-ENABLED ELECTROCONDUCTIVE HYDROGELS FOR ABIO-BIO INTERFACES

Anthony Guiseppi-Elie

Texas A&M University, USA
ABTECH Scientific, Inc., USA

The emergence of printable polymeric inks for 3-D printing of tissue engineered constructs allows the exploration of a wide range of biopolymers and synthetic polymers for cell seeding. We have been concerned with the nascent properties of electroconductive hydrogel nano-composites fabricated from in-situ synthesized polypyrrole nano-spheres and or ex-situ synthesized polyaniline nanofibers as the one-dimensional organic semiconductors within biocompatible hydrogels such as chitosan and poly(HEMA-PEG) hydrogels. We report here on the role of type and distribution of water within these constructs, the role of porosity on electrical properties as determined by electrical and electrochemical impedance spectroscopy, the mechanical properties, and the cell growth and proliferation of a wide range of cells seeded on these constructs.

ID: B3-0002 **SYM-13 : 2**

OSMOLYTE FLOCCULATION FOR VIRUS PURIFICATION AND DETECTION

Caryn L. Heldt[1], Xue Mi[1], Ashish Saksule[1], Pratyusha Paidikondala[1], Eugenia Yeo[2], James Chen Yong Kah[2]

[1]Michigan Technological University, USA; [2]National University of Singapore, Singapore

As medicine advances quickly, there is a great need to purify viral particles for medical applications, as well as detect indigenous viral infections to avoid antibiotic use on such infections. Our team has recently discovered that osmolytes (i.e. sugars and amino acids) have the ability to flocculate viruses while leaving proteins in solution. This flocculation by FDA approved compounds has been applied to viral particle purification processes and a gold nanoparticle (AuNP) aggregation assay for viral detection without the use of expensive and short shelf-life immuno-recognition elements.

Flocculation is a common purification unit operation of virus species for vaccine and gene therapy applications. However, it is novel to use osmolytes as a flocculant. Both an enveloped and non-enveloped virus can be retained by a 0.1 µm filter after flocculation with 1 M mannitol while proteins are removed. Many different filtration properties were explored to optimize the purification. This is an inexpensive method that could be applied to future vaccine products as more production of vaccines shifts to southeast Asia.

Osmolyte flocculation can also be applied to induce AuNP aggregation and detection. Virus particles that are non-specifically adhered to the surface of a AuNP have a different aggregation pattern upon addition of

1 M mannitol or 1 M glycine than the control protein bovine serum albumin (BSA). The plasmon resonance of the aggregated AuNPs creates a noticeable shift in the UV absorbance, which can aid in the detection of viral particles. This demonstrates that upon osmolyte addition, virus containing solutions can be identified. Future work will explore the effect of other buffer conditions as well as the limit of detection of this virus sensing system.

ID: B3-0001 **SYM-13 : 3**

FACILE SURFACE MODIFICATION OF GOLD NANOPARTICLES FOR CLOSED-TUBE COLORIMETRIC DETECTION OF ISOTHERMAL DNA AMPLIFICATION

Thomas Ming-Hung Lee, Ailin Qin, Lok Tin Fu, Jacky Kwun Fung Wong, Li Yin Chau, Shea Ping Yip

The Hong Kong Polytechnic University, Hong Kong

Gold nanoparticles (AuNPs) have attracted considerable interest for solution-phase colorimetric DNA detection. Two oligonucleotide-modified AuNP probes (each being complementary to half of a target sequence) are typically included. The two AuNP probes are dispersed in the absence of the target (appear red) while cross-linked/aggregated by the target (turn purple). The limit of detection (LOD) is in the nanomolar range, which is not practical for direct target detection (attomolar level). In view of this, efforts have been devoted to their integration with enzymatic DNA amplification. Despite the resulting high sensitivity, there are two main issues that limit their widespread use. The first one is associated with oligonucleotide-modified AuNPs that their preparation is laborious, time-consuming, and expensive. The second one is the high risk of carryover contamination. This is caused by the fact that the incorporation of AuNPs into an amplification reaction mixture would result in enzyme inhibition, thereby necessitating post-amplification open-tube addition of AuNPs. Our group developed two new AuNP probes, featuring facile and low-cost preparation, for closed-tube loop-mediated isothermal amplification (LAMP) assay: (1) 11-mercaptoundecanoic acid-modified AuNPs (MUA–AuNPs); (2) thiolated poly(ethylene glycol) and MUA co-modified AuNPs (PEG/MUA–AuNPs). In essence, magnesium ion (enzyme cofactor) in a negative sample (absence of the target) as well as magnesium pyrophosphate (LAMP reaction by-product) in a positive sample (presence of the target) resulted in different behaviors (dispersion, aggregation, or precipitation) of the AuNP probes. Our assay platforms possessed the advantages of cost-effective probe, simple temperature control, and ultrasensitive detection. They are readily applicable to decentralized DNA testing for various applications such as medical diagnostics, food safety control, and environmental surveillance.

Acknowledgements: This work was supported by the General Research Fund from the Research Grants Council (Project Number: PolyU 501413).

ID: D3-0001 **SYM-13 : 4**

PHOTOTHERAPEUTIC FUNCTIONALITY OF BIOCOMPATIBLE GRAPHENE OXIDE/ DENDRIMER HYBRIDS

Toyoko Imae

National Taiwan University of Science and Technology, Taiwan

Graphene oxide (GO) is an oxidized graphene chemically functionalized with oxygen-including groups such as hydroxyl, carboxylic acid and epoxide. Hybrid materials of GO have been investigated as new promising materials for biomedical applications including cellular imaging, drug delivery, and photodynamic therapy. Poly(amido amine) (PAMAM) dendrimers, highly-branched polymers with a multi-functionalized peripheral surface, have high degree of molecular uniformity, monomolecular weight, and specified size and shape. PAMAM dendrimers also possess a strong fluorescence emission. It has been confirmed by the visual observation of fluorescent dendrimers that fluorescent dendrimers-bound avidins interact selectively with biotins immobilized on the patterned substrates. The fluorescent PAMAM dendrimers have revealed lower in vitro cytotoxicity than the non-fluorescent ones toward rat C6 glioma cells.

In this study, hydroxyl-terminated fourth generation PAMAM dendrimer and folic acid were chemically bound on graphene oxide. The resultant hybrids exhibited one-photon and two-photon fluorescence emission, since the excitation irradiation at 390 and 780 nm on the hybrids brought a fluorescence emission in the visible region around 450 nm. In addition, the photocytotoxicity study revealed that under the two-photon excitation at 780 nm, the hybrids can absorb near-infrared light and generate reactive oxygen species which can oxidize the HeLa cells and cause their death, suggesting the phototherapeutic behavior. Cytotoxicity measurement revealed the high biocompatibility of the hybrids toward HeLa cells. Thus, the present biocompatible hybrids consisting of

only dendrimer, folic acid and graphene oxide have potentials as photodynamic therapeutic agents for medical treatment.

ID: B1-0017 **SYM-13 : 5**

BIOLOGICAL DETECTION USING FUNCTIONAL GOLD NANOCLUSTERS

Dongil Lee

Yonsei University, South Korea

Gold nanoclusters with atomic precision, for example, Au25(SR)18, Au38(SR)24, Au67(SR)35 and Au144(SR)60, where SR is organothiol, have attracted much attention in recent years because of their importance in both fundamental science and technological applications. These molecule-like nanoclusters display unique properties, such as quantized single-electron charging and molecule-like redox activities, that differ substantially from those of the corresponding atoms and bulk materials. This presentation reports electrochemical and optical properties of these nanoclusters and their use in electrochemical sensing. Voltammetry of these nanoclusters exhibited well-resolved, reversible redox peaks and size-dependent electrochemical HOMO-LUMO gaps that could be correlated to optical and calculated energy gaps. These nanoclusters also showed excellent electrocatalytic activity toward oxidation of biologically relevant analytes. The modified electrode film prepared with Au25 nanoclusters exhibited excellent mediated electrocatalytic activity that was utilized for amperometric sensing of dopamine and glucose. The electron transfer dynamics in the Au25 film was examined as a function of Au25 concentration, which manifested the dual role of Au25 as an electronic conductor as well as a redox mediator. The electron transfer study has further revealed the correlation between the electronic conductivity of the Au25 film and the sensing sensitivity.

Session	SYM-14: Special Topic Symposium: Bioimaging II
Date	Friday, 9 December
Time	1:45pm - 3:15pm
Venue	LT52

ID: A2-0001 **SYM-14 : 1**

FROM OPTICAL SPECTROSCOPY TO SPECTROSCOPIC IMAGING

Quan Liu

Nanyang Technological University, Singapore

My research has been focused in the field of biomedical optics. My group not only explores novel optical technology but also develops biomedical devices based on those relatively mature optical technologies and investigates the applications of such devices in targeted disease management and biological science research. In particular, I will talk about our contributions in the following topics related to optical spectroscopy and spectroscopic imaging.

1. Development of experimental and numerical methods for depth sensitive optical spectroscopy
Epithelial tissue is layered but most optical probes average signals from a large tissue volume. This limits the accuracy of optical diagnosis in epithelial cancers and precancers. In response to this challenge, we published one of the first papers in depth sensitive fluorescence spectroscopy using an angled fiber-optic probe design. To overcome the limitation of the fiber-optic probe in optical coupling uncertainty, we have proposed multiple lens based systems to perform depth sensitive optical spectroscopy. Moreover, relevant numerical tools based on the Monte Carlo method were also developed to facilitate the optimization of such systems.

2. Development of fast spectroscopic imaging for biomedical applications.
While the power of Raman spectroscopy and imaging has been recognized in biomedical fields, slow Raman acquisition has become a critical issue that prevents Raman techniques from being widely adopted. We have been investigating a unique approach to address this issue, which is narrow-band imaging for the quick collection of required data followed by spectral reconstruction to recover high spectral resolution. This approach has the advantages of snapshot imaging and rapid post data processing to speed up spectroscopic Raman imaging. We have developed a series of relevant methods to implement this approach. Results from both phantoms and cells will be shown.

ID: A2-0009 **SYM-14 : 2**

PHOTOACOUSTIC IMAGING—NEW PHYSICS, NEW CONTRAST, AND DEVELOPMENT TOWARDS CLINICAL TRANSLATION

Liang Song

Shenzhen Institutes of Advanced Technology, China

Photoacoustic imaging is a novel hybrid biomedical imaging technology that has experienced rapid growth during the past decade. It uniquely combines the advantages of optical absorption contrast (sensitive to molecular conformation and thus the early development of many diseases) with ultrasonic resolution for in vivo imaging as deep as several centimeters. Here we will discuss state-of-the-art technology progress in the area and its development towards clinical translation. In particular, we will present the development of: (1) intravascular photoacoustic endomicroscopy capable of imaging the thin-cap, composition, and other key features of atherosclerotic plaques for vulnerable plaque identification; (2) real-time handheld photoacoustic multimodality imaging technology capable of imaging tumor vasculature label-freely and sentinel lymph node noninvasively; (3) fully integrated in vivo photoacoustic/two-photon microscopy with a resolution as fine as 300 nm and multiple contrasts—absorption, second-harmonic, and fluorescence—for tumor microenvironment imaging and study.

ID: A2-0004 **SYM-14 : 3**

ULTRASOUND CAROTID ELASTOGRAPHY FOR DETECTION OF VULNERABLE ATHEROSCLEROTIC PLAQUES

Jianwen Luo

Tsinghua University, China

Ultrasound-based carotid elastography has been developed to estimate the mechanical properties of atherosclerotic plaques. The objective of this study was to evaluate the in vivo capability of carotid elastography in vulnerable plaque detection using high-resolution magnetic resonance imaging as reference. Ultrasound radiofrequency data of the carotid plaques were acquired and inter-frame axial strain was estimated with an optical flow method. The maximum value of absolute strain rate for each plaque was derived as an indicator for plaque classification. Magnetic resonance imaging of carotid arteries was performed on the same patients to classify the plaques into stable and vulnerable groups for carotid elastography validation. The maximum value of absolute strain rate was found to be significantly higher in vulnerable plaques than in stable plaques ($p < 0.0001$). Furthermore, four quantitative features, i.e., Contrast, Homogeneity, Correlation and Angular second moment (ASM), describing different aspects of the textural characteristics in the strain rate images, were derived based on the gray level co-occurrence matrix (GLCM) in the manually segmented plaque regions. All the four textural features of strain rate images were significantly different between the two groups of plaques (all $P < 0.0001$), implying a higher level of heterogeneity, contrast or variation of the strain rate distribution in the vulnerable plaques. The results demonstrated the usefulness of textural information in strain rate images for plaque characterization, and indicated that larger local deformations and higher level of complexity in deformation patterns (associated with the elastic or stiffness heterogeneity of plaque tissues) are more likely to present in the vulnerable plaques. Therefore, the in vivo capability of carotid elastography to detect vulnerable plaques, validated by magnetic resonance imaging, was proven, revealing the potential of carotid elastography as an important tool in atherosclerosis assessment and stroke prevention

ID: A2-0007 **SYM-14 : 4**

MUELLER MATRIX MICROSCOPY FOR QUANTITATIVE ASSESSMENT OF MICRO- AND MACRO-STRUCTURE OF BIOLOGICAL SPECIMEN

Ma Hui

Tsinghua University, China

Polarization techniques are powerful tools for probing the micro- and macro- structure and optical properties of complex anisotropic turbid media since the polarization states of the scattered photons are affected by the size, shape, orientation and alignment of the scattering particles as well as the absorption, refraction and optical activity of the interstitial substance of the media. Various polarization techniques have been used in different applications ranging from material characterization to clinical diagnosis. Mueller matrix represents a comprehensive characterization of polarization properties of the scattering sample. Parameters of all the existing polarization techniques can be expressed as functions of the Mueller matrix elements. In this paper, we report our recent efforts to develop a Mueller matrix microscope for imaging thin slices of clinical tissue samples and to identify new polarization parameters for quantitatively

characterizing the structural features of pathological abnormalities for diagnosis applications.

ID: A2-0006 **SYM-14 : 5**

DEEP FLUORESCENCE IMAGING IN BIOLOGICAL SAMPLES BY WAVEFRONT SHAPING

Wei Gong[1], Ke Si[1,2]

[1]Institute of Neuroscience, Zhejiang University, China; [2]State Key Laboratory of Modern Optical Instrumentation, College of Optical Science and Engineering Zhejiang University

Fluorescence imaging has revolutionized biomedical research over the past three decades. However one key challenge in all light-based imaging techniques is the fundamentally limited penetration depth of light in biological tissues, as random scattering in biological tissues causes exponential attenuation of the ballistic component of a light wave. Here we present wavefront shaping techniques to address this limitation. One is acoustooptic imaging technique which uses scattering light to achieve high resolution fluorescence imaging up to 2mm deep inside highly scattering media, such as brain slice. The other is deep tissue high resolution technique, in which we use adaptive optics to compensate the wavefront aberration generated by the optical system and the biological sample. These technologies pave the wave for many important applications in both fundamental biology research and clinical studies

ID: A2-0010 **SYM-14 : 6**

COMBINING WIDE-FIELD AND SCANNING LASER MICROSCOPY FOR FAST 3D IMAGING

Nanguang Chen

National University of Singapore, Singapore

A wide range of light microscopy methods have found their applications in various biomedical researches. Different microscopy techniques have different advantages and disadvantages. For example, wide-field optical microscopy has the advantages of being convenient and high imaging speed. It lacks the depth sectioning capability, however, as axial high-frequency components in its 3D optical transfer function is missing. Therefore, it is impossible to use a wide-field microscope to obtain 3D structures of a specimen. Laser scanning microscopy method, such as confocal microscopy can achieve excellent optical sectioning as well as high axial resolution. While conventional confocal microscopy is a standard tool for 3D visualization of fixed samples, their long image acquisition time and excessive photobleaching make it less suitable for real-time in vivo imaging of live samples. We have developed a novel method to effectively combine the information from both scanning microscopy and wide-field microscopy imaging modes. A prototype hybrid microscope has been designed and implemented. We have verified imaging performances of the hybrid microscope with imaging results acquired from various live samples. The reduced photobleaching, improved imaging speed, and improved optical sectioning have been demonstrated.

Session	A9: Nanobiotechnology
Date	Friday, 9 December
Time	4:00pm - 5:30pm
Venue	Auditorium 2

ID: KN-0009 **A9 : 1**

OBTAINING FDA APPROVAL FOR NANOTECHNOLOGY-DERIVED MEDICAL DEVICES: TWO DECADES OF EXPERIENCE

Thomas Webster

Northeastern University, USA

There is an acute shortage of organs due to disease, trauma, congenital defects, and most importantly, age related maladies. The synthetic materials used in tissue engineering applications today are typically composed of millimeter or micron sized particles and/or fiber dimensions. Although human cells are on the micron scale, their individual components, e.g. proteins, are composed of nanometer features. By modifying only the nanofeatures on material surfaces without changing surface chemistry, it is possible to increase tissue growth of any human tissue by controlling the endogenous adsorption of adhesive proteins onto the material surface. In addition, our group has shown that these same nanofeatures and nano-modifications can reduce bacterial growth without using antibiotics, which may further accelerate the growth of antibiotic resistant microbes. Inflammation can also be decreased through the use of nanomaterials. Finally, nanomedicine has been shown to stimulate the growth and differentiation of stem cells, which may someday be used to treat incurable disorders, such as neural damage. This strategy also accelerates USA FDA approval and commercialization efforts since new chemistries are not proposed, rather chemistries already approved by the FDA with altered nanoscale

features. This invited talk will highlight some of the advancements and emphasize current nanomaterials approved by the USA FDA for human implantation.

ID: B3-0001 **A9 : 2**

UNDERSTANDING THE EFFECTS OF THE PROTEIN CORONA ON NANOPARTICLE PERMEABILITY WITH AN IN VITRO MICROFLUIDIC PLATFORM FOR VASCULAR PERMEABILITY

Yan Teck Ho[1,2], Nurul Ain Azman[1], Giulia Adriani[3], Sebastian Beyer[3], Roger D Kamm[2,4], Phan-Thien Nhan[1], James Chen Yong Kah[1]

[1]National University of Singapore, Singapore; [2]Singapore-MIT Alliance for Research and Technology, Singapore; [3]Singapore MIT Alliance for Research and Technology, Singapore; [4]Massachusetts Institute of Technology, USA

Recent work in nanoparticle (NP) drug delivery systems has seen efforts in using the protein corona as an indigenous vector for payload loading and delivery. Translational efforts however have seen obstacles arising in part from the lack of understanding in how the corona can affect NP permeability when introduced in vivo, which in turn could have a profound effect on the NP's drug delivery efficacy and efficiency. By studying the aggregation profile of protein coronas formed from four major constituent proteins – apolipoprotein-A1, albumin, fibrinogen, and immunoglobulin-G – in serum on gold NPs, we observed through measurements of the NP's aggregation index and hydrodynamic diameter that the corona leads to NP aggregation in a manner dependent on protein concentration and its physiological function in vivo. Furthermore, evidence in the literature suggests that the presence of a protein corona can also affect a NP's cellular uptake. Taken together, the corona could therefore have a profound effect on a NP's para and trans-cellular permeability. To investigate this, we have successfully developed an in vitro microfluidic platform for probing NP permeability with human umbilical vein endothelial cells (HUVECs) cultured in the device. Using 10 and 70 kDa dextran as model probe molecules, we successfully demonstrated the tunability of HUVECs permeability with angiopoietin-1 (Ang-1) and cyclic adenosine monophosphate (pCPT-cAMP) treatment. Untreated and 25 µg/mL pCPT-cAMP treated devices were also shown to approximate cancer and normal physiological permeability values obtained in vivo respectively. Probing the permeability of polystyrene NPs with both untreated and 25 µg/mL pCPT-cAMP devices also yielded a non-linearly decreasing trend with increasing particle size similarly observed in in vivo systems. Our developed platform could therefore be used to provide valuable insight into NP-corona systems that could help promote through better design, the translation of NP based systems in vivo.

ID: B3-0006 **A9 : 3**

APTAMERS-FUNCTIONALIZED NANOPORE FOR HIGLY-SENSITIVE SPECIFIC PROTEIN DETECTION

Yong Chin Seow, Slaven Garaj

Graphene Research Centre, National University of Singapore, Singapore

Early detection and treatment of diseases has be revolutionised by the research efforts in proteomics and genomic research, and the development of the underlying biosensing technologies. Nanopore sensors are prominent example of such technology, capable of analysing individual biomolecules with high accuracy, even capable of reading long DNA sequences. Here we demonstrate a new nanopore-based sensors, capable of specific protein detection with unmatched sensitivity; reusable, inexpensive and easy to implement.

A nanopore sensor consists of nanometre-scale pore in a membrane separating two chambers filed with electrolyte. The ionic current through trough the nanopore is highly sensitive on the nanopore's geometry, and has been previously used to detect and analyse translocating biomolecules. Our device consists of a nanopore functionalised with specific aptamer receptors, and we could precisely detect the binding of proteins as a change in nanopore's electrical conductivity due the change in its geometry. By applying voltage across the membrane, we electrophoretically concentrated the proteins, and were able to sample comparatively large volume of the analyte solution. This leads to the ultra-high sensitivity, in range from nanomolar to femtomolar, rivalling the capability of the FET protein sensor without their complex fabrication process. The localized electric field at the mouth of the nanopore facilitated the formation of stable bond between the functionalized layer and protein molecules leading to the accumulative binding of protein molecules at the surrounding pore region. The cycling of electric fields enables fast reversible molecules detachment, and the fast regeneration of the sensor. We present a systematic study on various factors affecting the behaviour and the detection speed of the sensor. The aptamer-functionalized nanopore sensor holds enormous potential in commercialization

of low cost and high performance protein sensors catering the global need for early diseases dignostic and personalized medical theatments.

ID: B3-0004 **A9 : 4**

ENGINEERING GRAPHENE OXIDE-BASED NANOFUNCTIONAL SURFACES FOR BIOLOGICAL AND BIOMEDICAL APPLICATIONS

Kenry Kenry, Kian Ping Loh, Chwee Teck Lim

National University of Singapore, Singapore

Graphene oxide (GO) is the oxygenated derivative of two-dimensional (2D) graphene being actively explored for numerous biological and biomedical applications [1, 2]. It is a hydrophilic nanomaterial with different oxygen functional groups decorating its basal planes and peripheries. These oxygen functionalities and aromatic domains enable GO to interact with different biomolecules, such as amino acids, peptides, and proteins [3, 4]. Additionally, through electrostatic interaction or π-π stacking, GO can serve as a pre-concentration platform for biomolecules. As such, the exceptional biomolecule adsorption on GO coupled with its large specific surface area and excellent biocompatibility may be utilized for engineering application-specific nanofunctional surfaces. Here, we evaluate the nano-bio interactions between GO and a plethora of biomolecules, including albumin, fibrinogen, insulin, and fibronectin. Several aspects of the GO-biomolecule interactions, specifically, protein adsorption and conformational stability, are investigated. We observe that GO has a high affinity and loading capacity for these biomolecules. In light of the high biomolecular adsorption on GO, we engineer and demonstrate GO-based nanofunctional surfaces for various bioapplications [5, 6], such as antithrombotic coating, cell culture platform, and antimalarial therapy.

ID: D3-0010 **A9 : 5**

PROFILES OF IONTOPHORETIC TRANSPORT OF NANOPARTICLES ACROSS IN VITRO RABBIT CORNEA

Jae Yeon Lee[1], Se-Na Kim[1,2], Young Bin Choy[1,3],

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Iontophoresis is a non-invasive technique used to transport substances of interest across tissues and this has drawn interest in ophthalmic fields to enhance delivery efficiency of topically administered drugs. Thus, there has been several trials to deliver small molecules across cornea into the eye tissue using iontophoresis; however, few were reported to transport the nanoparticles. The purpose of this study was, therefore, to profile an iontophoretic transport of the nanoparticles made of a biodegradable polymer, poly(lactic-co-glycolic acid) (PLGA), where we varied the conditions of iontophoresis applied via the cornea of in vitro rabbit eyes. For this, we applied the formulation of fluorescence-tagged PLGA nanoparticles onto the cornea and varied the factors, such as the size of nanoparticles, amplitude of electric current and time for iontophoresis application. After the iontophoretic application of the nanoparticles, we observed the fluorescence intensity of each of the cross-sections of the cornea with confocal fluorescence microscopy to assess the distribution of PLGA nanoparticles. The work is now in progress to mathematically model the iontophoretic movement of PLGA nanoparticles into the cornea.

Session	SYM-15: Special Topic Symposium: Advances in Microfluidics and Nanofluidics II
Date	Friday, 9 December
Time	4:00pm - 5:30pm
Venue	LT50

ID: B1-0002 **SYM-15 : 1**

FLOATING LIQUID MARBLE AS A DIGITAL MICROLFUIDICS PLATFORM FOR THREE-DIMENSIONAL CELL CULTURE

Nam-Trung Nguyen, Chin Hong Ooi

Griffith University, Australia
Queensland Micro- and Nanotechnology Centre, Griffith University, Australia

We report the use of liquid marbles, liquid droplets coated with hydrophobic microparticles, floating on another liquid surface as a digital microfluidics platform especially suitable for culturing three-dimensional cell spheroids. We first reports fundamental insights on the floating mechanisms of liquid marbles by analysing the shape of the liquid marble and the angles at the three-phase contact line (TPCL). For small liquid marbles, the contact angle varies with volume due to the deformability of the interface. We next developed actuation mechanisms for floating liquid marbles. The first mechanism is magnetic actuation of floating

liquid marbles filled with magnetic particles. We varied the magnetic flux density, flux density gradient, concentration of magnetic particles and speed of the marble to elucidate the relationship between the acting forces. We subsequently determined the suitable operating conditions for the actuation and derived the scaling laws for the actuation parameters. The second mechanism is based on Marangoni solutocapillary effect using liquid marble containing a volatile substance such as ethanol. We derived the scaling laws relating the dynamic parameters of the motion to the physical properties of the system such as the effective surface tension of the marble, the viscosity and the density of the supporting liquid, the coefficient of diffusion of the ethanol vapour, the geometrical parameters of the marble, the speed, the trajectory and the lifetime of the autonomous motion. Finally, we show the proof of concept for the use of floating liquid marbles for culturing three-dimensional cell spheroids. Floating liquid marbles allow the cells to freely associate and interact to produce OEC spheroids with uniform shapes and sizes. Co-culture of different cell types into a three-dimensional spheroid was also demosntrated.

ID: B2-0002 **SYM-15 : 2**

SINGLE CELL ASSAYS FOR PERSONALIZED AND PRECISION MEDICINE

Yu-Hwa Lo, Roger Chiu, Wei Cai, Yi-Huan Tsai

University of California, San Diego, USA

Single-cell analysis promises to unveil the underpinnings of biological processes that have evaded detection because it enables sensitive and accurate quantification of single-cell properties amidst biological samples with known, but difficult to quantify, heterogeneity (e.g. cancer stem cells in tumor tissue). In the era of personalized and precision medicine, increasing evidence has shown the critical roles of "significant minorities" as they are often responsible for drug resistance, metastasis, and activation/ suppression of immunoresponse while the unique characteristics of these minority cells are masked by measurements of ensemble average.With the rapid advances in high throughput assays and genomic analyses including qPCR and next generation sequencing technologies, the idea of studying individual cell properties is now within reach.However, there still exist substantial technological challenges to produce single cell assays to unleash its full potential for applications in biomarker discovery, drug design, and precision and personalized medicine.What is missing in today's single-cell assays is a high-throughput, hierarchical and rational cell selection and screening process to determine "what type of cells" are of biological and pathological significance and therefore worth detailed genomic analysis: the phenotype-genotype problem. Another blind spot for today's single-cell assays is that few single-cell assays can relate cell secretion phenotype to genomic analysis even though it is widely recognized that cytokine and exosome secretion play critical roles in cell behaviors

Our presentation will be focused on the above challenges with the goal of developing a low-cost single-cell assay that can generate diverse single cell phenotype information to support the rationale of final selection for genomic analysis. This phenotypic information includes cell viability, morphology, proliferation rate, exosome production, surface protein markers, gene expression, and secretion of proteins, cytokines, etc. The approach will enable a single-cell assay that produces end-to-end results to support personalized and precision medicine.

ID: E2-0001 **SYM-15 : 3**

ENGINEERING CELL MICROENVIRONMENT USING NOVEL HYDROGELS FOR BIOMEDICAL APPLICATIONS

Feng Xu

Xi'an Jiaotong University, China
Bioinspired Engineering and Biomechanics Center, Xi'an Jiaotong University, China

With advances in micro- and nanoscale technologies, it has been possible to manipulate cells in microscale volumes with precision comparable to the natural systems to address challenges in medicine. In this talk, I will present the unique opportunity of microengineering in solving significant clinical problems in medicine, especially 3D microscale tissue engineering. I will begin by introducing engineering of cell microenvironment to generate 3D tissue constructs by assembling micro-engineered tissue blocks (mesoscale cell-laden hydrogels) using several approaches including magnetic force, acoustic power and electrostatic interaction. The tissue assembly process recapitulates the native tissue formation from repeating functional units (i.e., myofiber, lobule or nephron). Several bottom-up approaches (e.g., cell printing, microgel assembly) are demonstrated for engineering complex 3D tissue constructs with delicate microarchitecture, cell-cell interactions and internal vascular-like network that have not been achieved by conventional 'top-down' tissue engineering approaches. Examples of applying these approaches in tissue engineering, biomechanics,

cancer biology, stem cell niche, cell-based biosensor, and high throughput drug screening will also be presented. The approaches for manipulating cells in microscale volume presented here hold great promise for developing complex tissue substitutes and cell-based systems for bio-sensing and drug screening.

ID: IN-0008 **SYM-15 : 4**

ACOUSTICAL DROPLET FLUIDICS: HIGH-THROUGHPUT MANIPULATION OF CELLS AND DROPS

Thomas Franke

University of Glasgow, UK

The use of acoustics in microfluidics has become very popular for the past few years because it provides an extremely versatile tool to manipulate small amounts of fluid on a chip in a highly controlled manner. Mixing, pumping, focusing and deflection has been successfully demonstrated and already included in commercial available products.

Here, we present the power of surface acoustic wave driven microfluidics for droplet fluidics. We have developed a surface acoustic wave (SAW) driven microchannel drop-maker that can generate pressures up to 2 kPa and apply this to control the size of droplets produced in a microfluidic crossjunction dropmaker in real time at high speed.

Moreover, we show other useful operation that can be carried out on our hybrid acoustofluidic platform including high-throughput sorting of cells and drops as well as merging, trapping and pumping in closed looped channels.

ID: G1-0003 **SYM-15 : 5**

APPLICATION OF HYDROELASTICITY AT MICROSCALE FOR FLOW CONTROL AND MICROMIXING

Zhiping Wang[1], Huanming Xia[2]

*[1]Singapore Institute of Manufacturing Technology, A*STAR, Singapore; [2]Nanjing Univesity of Science and Technology, China*

Hydroelasticity is concerned with the deformations of elastic bodies responding to hydrodynamic excitations and simultaneously the modification of these excitations owing to the body deformation. The problems of hydroelasticity are coupled, which implies that the elastic deformations of the body depend on the hydrodynamic forces and vice versa. Hydroelasticity has been used in our microfluidics design for flow control and micromixing. A pressure driven passive micro-oscillator, making use of the interactions of hydrodynamic, elastic and inertial forces, has been developed to convert stead laminar flow to oscillatory flow in microchannels. A simple geometric design with a diaphragm generates an alternating flow with a frequency between 10 Hertz to 1000 Hertz. Analog to an electric circuit, the micro-oscillator consists of a fluid capacitor and a fluid resistor, for which the fluid resistance changes with the deformation of diaphragm. Under a given geometry, oscillation takes place when the flow pressure reaches a critical value and the system is biased into a negative differential resistance region.

The micro-oscillator is a basic element of a fluid circuit. The oscillation flow can be designed for rapid mixing when it meets with another stream of liquid. This phenomenon has been used for anti-solvent precipitation of solid-lipid nanoparticles. It shows that within a wide concentration range from 10 to 300 mg/ml, solid lipid particles of 50~240 nm can be produced with the polydispersity index ranging from around 0.16 to 0.26.

In this talk, the latest design of a hydroelasticity-based micro-oscillator, its mechanism and applications will be presented.

ID: B1-0001 **SYM-15 : 6**

SINGLE ADHESIVE CELL PROTEOMIC SECRETION ANALYSIS BY USING MICROFLUIDICS

Chia-Hung Chen[1,2], Ming Wang[1], Ee Xien Ng[1], Liang Leo Hwa[1], Chwee Teck Lim[1,3],

[1]National University of Singapore, Singapore
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[3]Mechanobiology Institute, Singapore

Secreted enzymes in individual adhesive cells are associated with the cascades of cellular signaling that determine their biochemical states and fates. Morphologically identical cells with the same genotypes can exhibit strikingly distinct enzyme profiles due to attached matrix stiffness and chemical environment. At present, most single adhesive cell assays are based on microwells, dielectrophoresis (DEP), or hydrodynamic trappings, which are unable to effectively quantify single adhesive cell enzyme

activities. Recent studies have shown that droplet technology has the potential for high throughput single cell enzyme secretion measurement. Despite the advantages of this approach, the challenge in adhesive cell measurement remain, which entails the essential step of flowing suspended cells through an aqueous solution during droplet encapsulations. In this study, we introduced a novel approach involving the encapsulation of single-cell-adhered hydrogel particles, coupled with high throughput continuous time-point analysis of the adherent cancer cells with single cell precision. Monodispersed gelatin hydrogel particles of 30 μm in diameter were first prepared using the droplet-based technology. After demulsification, these gelatin particles were suspended in aqueous phase. This process was then followed by chemical crosslinking of the particles with genipin to form a robust gelapin (genipin crosslinked gelatin) shell that is stable at 37˚C during cell incubation. The capability to control extracellular matrix for individual cells and to monitor their enzymatic secretions effectively make this integrative system a potentially powerful platform to address the intricate interaction between matrix properties and biochemical signals at the single cell level. The system also enables standardization of single adhesive cell measurement for systematic analysis and benchmarking cell phenotypes in epithelial mesenchymal transition (EMT) by monitoring different parameters, such as integrin/cadherin adhesion, enzymatic activities, or matrix stiffness.

Session	SYM-16: Special Topic Symposium: Bioelectronic Devices
Date	Friday, 9 December
Time	4:00pm - 5:30pm
Venue	LT51

ID: B2-0007 **SYM-16 : 1**

INTEGRATED CIRCUITS AND MICROSYSTEMS FOR EMERGING BIOMEDICAL APPLICATIONS

Minkyu Je,

Korea Advanced Institute of Science and Technology, South Korea

Many factors such as extended average life span, prevailing obesity, and globally aging population are increasing the healthcare cost dramatically. Recent advances in semiconductor technologies, as well as innovations in IC design techniques, have led to microsystems with sensing and processing capabilities that can supplement, improve, or even entirely replace, traditional biomedical diagnostic and therapeutic procedures. Integrated biomedical solutions based on IC technologies can offer extremely effective ways of timely diagnosis, treatment, and management of diseases at very low cost never seen before.

In this talk, it will be presented how IC technologies and integrated microsystems enable emerging biomedical applications such as life-saving/changing miniature medical devices, surgical procedures with less invasiveness and morbidity, low-cost preventive healthcare solutions in daily life, effective chronic disease management, point-of-care diagnosis for early disease detection, high-throughput bio sequencing and screening for new discovery, and groundbreaking brain-machine interface from deep understanding of human intelligence. It will be also shown that the vital role of the IC technology in biomedical microsystems is providing seamless interface to various sensors and actuators, high-efficiency operation with various energy sources (especially, renewable ones), high-level integration and miniaturization, embedded intelligence, and connectivity.

ID: A1-0002 **SYM-16 : 2**

AN EXPLORATION ON HOW SEQUENCING OF SINGLE CELLS AND CIRCULATING CELL-FREE RNA IN PLASMA ARE ENABLING RNA-BASED MOLECULES AS CLINICAL BIOMARKERS

Lian Chye Winston Koh

Stanford University, Singapore

Clinical research of human diseases is challenged by the high cost of testing experimental therapeutics in human subjects. There is a need for biomarkers capable of identifying at risk subjects and accurate means of measuring treatment outcomes that will enable cost efficient “proof of concept” trials. Discovery of circulating RNA in plasma has sparked interest in their use as this form of quantifiable diagnostics across human diseases. In this talk, we will explore using sequencing to profile circulating RNA in maternal blood and its potential as a tool for monitoring pregnancy and fetal development. Using sequenced cell-free RNA transcriptome, we will delve into the development of multiplex qPCR assays focusing on brain tissue specific circulating RNA expression profiles as diagnostics for neurologic diseases especially Alzheimer’s disease. Heterogeneity in terms of composition and genetics of diseased tissues can confound the interpretation of biomarker levels and patient responses to therapies. Here, we will explore single cell resolution sequencing methods in uterine tissue during pregnancy (RNA-seq) and acute lymphoblastic leukemia (DNA-seq), with

the possibility of using these data for development of targeted diagnostic approaches using circulating nucleic acids.

ID: A4-0002 **SYM-16 : 3**

AN ON-CHIP PATIENT-SPECIFIC EEG CLASSIFICATION AND RECORDING PROCESSOR FOR WEARABLE ENVIRONMENTS

Jerald Yoo

Masdar Institute of Science and Technology, UAE

Classification of EEG under wearable environment faces many challenges including motion artifact, electrode DC offset, noise and limited available energy source. This presentation describes the design consideration of a "patient-specific", multi-channel machine-learning based EEG classification and recording processors for wearable form-factor sensors. The goal is to optimize the detection performance while balancing the analog and digital signal processing to optimize its energy consumption. On-chip classification significantly helps achieving energy-efficiency by reducing the communication overhead of the data. With epileptic seizure detection and recording system examples, we start from choosing number of channels, the sampling rate, and how to effectively extract features out of the down-sampled data. After that, classification algorithms to achieve patient-specific detection are also discussed in detail. When verified with the Children's Hospital Boston-Massachusetts Institute of Technology (CHB-MIT) EEG database, based on Repeated Random Sub-Sampling validation, the seizure detection sensitivity and specificity of the Non-Linear SVM (NL-SVM) are improved by 12.4%P and 3.56%P, respectively, compared to the Linear-SVM (LSVM). The LSVM and NLSVM processors are fabricated in 0.18μm 1P6M CMOS and consume 1.52μJ/classification and 1.34μJ/classification, respectively. We will also discuss the hybrid type Dual Detector Architecture, which adopts two LSVM to balance the superior hardware efficiency of LSVM, while maintaining the detection accuracy. Finally, the on-chip memory requirements for storing the raw seizure data will be discussed.

ID: IN-0005 **SYM-16 : 4**

ELECTROSPUN NANOFIBERS FOR TISSUE ENGINEERING APPLICATIONS

Ling Ling Tian

Singapore Institute for Neurotechnology, Singapore
National University of Singapore, Singapore

Electrospinning, with the advantages of wide ranges of applicable biocompatible polymers and tunable physio-chemical properties of the final products, is a straightforward and low-cost technique for the fabrication of nanofibrous scaffolds for tissue engineering applications. Diverse polymers including sythetic polymer PLA, PCL, PLGA, PLACL, etc and natural polymer collagen, gelatin, chitosan, etc have been electrospun into nanofibrous scaffolds with various forms such as random fibers, aligned fibers, 3D fibrous scaffold and core-shell fibers, which could be applied for nerve, bone, cardiac, vascular tissue engineering applications. The diversity and versatility of electrospinning technique, together with functionalizing cues (such as growth factors), conductive polymers, and stem cells have gained considerable success for tissue engineering applications.

ID: B2-0001 **SYM-16 : 5**

PHYSIOLOGICAL MODULATION WITH SMALL-SCALE WIRELESS BIOELECTRONIC DEVICES

John Ho

National University of Singapore, Singapore
Singapore Institute for Neurotechnology, Singapore

Recent technological advances now enable electrical, thermal, or optical modalities for controlling processes with far greater spatiotemporal resolution than devices clinically used today. Devices that leverage these sophisticated capabilities can mediate effects targeted at the level of individual functions of specific organs, and are now widely anticipated to play a central role in future medicines more effective and precise for some currently intractable disorders than drugs. In this talk, we describe methods for powering bioelectronic devices deep within the body that enable miniaturization of devices at the scale of a single millimeter, and demonstrate applications of these devices to cardiac stimulation, optogenetics, and phototherapy.

Session	SYM-17: Special Topic Symposium: Rehabilitation Robotics
Date	Friday, 9 December
Time	4:00pm - 5:30pm
Venue	LT52

ID: C4-0004 **SYM-17 : 1**

A NOVEL SYNCHRONIZATION CONTROL STRATEGY FOR GAIT REHABILITATION ROBOTS

Haoyong Yu

National University of Singapore, Singapore

In order to provide effective assistance during gait training, it is important for the rehabilitation robot to achieve synchronized motion with the human gait. We developed novel control strategy based on an adaptive oscillator . The adaptive oscillator estimates the stride percentage of gait based on the gait events information, which is detected in real time with a hidden Markov model (HMM). Synchronous reference trajectories for the robot are then generated with a look-up table. An impedance controller is implemented to provide assistance based on the synchronous reference. The proposed synchronization method is implemented in a portable knee-ankle-foot robot and tested in 15 healthy subjects. The experimental results demonstrate that the proposed control strategy is efficient in achieving human–robot synchronization and feasible for rehabilitation robotics application.

ID: C4-0002 **SYM-17 : 2**

AN IMPEDANCE CONTROL METHOD OF A ROBOTIC ORTHOSIS FOR GAIT REHABILITATION

Juan Li, Weida Li, Xiaowei Cai, Haitao Zhou

Soochow University, China

Gait rehabilitation robots are of increasing importance in neurorehabilitation. Conventional devices are usually limited to reproduce predefined movement patterns. Research on patient-cooperative control strategies aims to improve robotic behavior. Robots should support patients only as much as needed and encourage them to make maximal voluntary efforts. This paper presents an impedance control algorithm that allows patients to modulate their leg movements. By this control strategy, compliant virtual walls keep the patient's legs within a "tunnel" around the desired spatial path. Furthermore, in order to modulate control parameters with patient conditions, human-robot coupling force is measured to evaluate the active participation force. Experiments show that the robot can modulate impedance control parameters according to human-robot interaction force, and carry out effective rehabilitation training for the patients.

ID: C5-0002 **SYM-17 : 3**

DESIGN AND CONTROL OF A TRANSPARENT LOWER LIMB EXOSKELETON FOR WALKING ASSITANCE.

Viet Anh Dung Cai[1], Philippe Bidaud[2], Viet Thang Nguyen[1], Consuelo Granata[2], Aurélien Ibanez[2], Minh Tam Nguyen[1]

[1]Ho Chi Minh City University of Technology and Education, Vietnam; [2]Institut des Systèmes Intelligents et de Robotique, Université Pierre et Marie Curie, France

The authors aim to present a robust gait phase detection method which is developed for the control of a multi-contacts lower limb exoskeleton. The device comprises passive mechanical linkages connecting the user limbs to an external rigid mechanical structure. This approach allows not only a more effective control of the system's transparency but also provides the possibility to use different kinds of sensors to capture the user's kinematic data, which can be used to detect the gait phases. For this purpose, a Principal Component Analysis (PCA) is applied to each measure. The resulting vector of the principal components is then compared to the reference ones in order to identify the actual gait phase using K-Nearest Neighbors algorithm. A Discrete Time Markov Chain (DTMC) is also used to define the phases shift probability during the gait cycle. This gait detection algorithm was tested experimentally with a percentage of success of more than 95% for repetitive gait cycles. As a result, these principles can now be used to program knee assistance exercises. To this end, a hybrid predictive control, which relies on a robust locomotion phases detection algorithm, will be implemented on the exoskeleton device, providing torque assistance precisely at specific gait phases.

ID: IN-0004 **SYM-17 : 4**

PREDICTIVE CONTROL TECHNIQUES IN BIPODAL LOCOMOTION

Philippe Bidaud

ONERA, France

Active lower limb orthoses are devices intended to provide additional physical ability to the human musculoskeletal system or stimulate/correct human motor control activities. The implementation of these functions make that primarily a synergistic operation with the musculoskeletal system of the user must be insure, this of course for all activities involving the musculoskeletal system during which the orthosis braced is used. It is obvious that larger the spectrum of these activities is more the interest grew.

The mechanical system ensuring these locomotion function can be seen as a hybrid dynamic system and its control be considered through predictive control techniques. The evolution of the system's state and the iterative optimization over a finite-horizon formulation of its control allows the inclusion of different objectives that are combined during its evolution (postural stability, stability of support, energy consumption, etc.) and all the constraints that act on the system (joint limits, saturation of generalized forces, etc.).

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The presentation proposes an original approach to capture the hybrid form of the system in a predictive control framework.The resulting MPC problem takes the form of a quadratic, linearly constrained mixed-integer program (MIQP) which allows to determine, over a preview horizon, an optimal strategy between changes in the BoS and CoM behavior, subject to multiple constraints, maximizing balance and performance of a walking activity

ID: IN-0001 **SYM-17 : 5**

FULLY-FABRIC SOFT WEARABLE ROBOTICS

Raye Chen-Hua Yeow, Hong-Kai Yap, Xinquan Liang

National University of Singapore, Singapore

Soft robotics is a growing field of robotics, where soft materials are used to fabricate robots capable of providing compliant actuation, giving rise to a wide range of applications including rehabilitation and industrial manipulation. Soft wearable rehabilitation robotic devices are typically powered using soft silicone-based elastomeric actuators, which are lightweight, highly compliant and able to provide sufficient assistive forces to the joints of interest, compared to traditional 'hard' robotic devices. In this work, we present our recent developments on a new class of fully-fabric soft actuators that are more advantageous over the silicone-based actuators in terms of relative cost, weight and compactness. We demonstrate a fully-fabric bidirectional soft robotic glove that can assist hand-impaired patients with conducting rehabilitation exercises and activities of daily living. The glove can provide robot-assisted finger flexion-extension, through its embedded fabric-based actuators. These new actuators are able to attain smaller bend radius and output adequate force and torque to assist finger flexion-extension at lower air pressures. Fully-fabric soft wearable robotic devices present an enhanced approach towards developing very low-cost and lightweight soft robotic devices for affordable rehabilitation.

ID: C4-0001 **SYM-17 : 6**

BRAIN-COMPUTER INTERFACE-BASED ROBOTIC SYSTEM FOR STROKE REHABILITATION

Kai Keng Ang

*Institute for Infocomm Research, A*STAR, Singapore; Nanyang Technological University, Singapore*

Recent advances in analysis of brain signals and improvements in computing capabilities have enabled people with motor disabilities to use their brain signals for communication and control without using their impaired neuromuscular system. This technology called Brain-Computer Interface (BCI) is useful to stroke survivors by providing them with an alternative means of stroke rehabilitation through motor imagery, the mental process of imagination of movements without physical movement. By integrating BCI with robotic

systems, concomitant motor imagery and physical practice can be performed during stroke rehabilitation. This talk gives an introduction on BCI, and presents the BCI-based robotic systems projects developed jointly by the Institute for Infocomm Research A*STAR and Tan Tock Seng Hospital in Singapore. Finally, the results from 3 of the clinical trials conducted using BCI-based stroke rehabilitation in Tan Tock Seng Hospital and National University Hospital in Singapore from 2007 to 2014 will also be presented.

ID: C4-0003 **SYM-17 : 7**

REHABILITATION ROBOTICS: AN OCCUPATIONAL THERAPIST PERSPECTIVE.

Vishwanath Deshmukh

Tan Tock Seng Hospital, Singapore

Occupational Therapy is an art and science, based on one of the core principles of restoring the functional abilities of the patients, primarily by using restorative, compensatory or adaptive strategies. In order to achieve the therapeutic goals, Occupational Therapist's (OT's) tends to alter between conventional therapy and various other modalities. In recent years, OT's have had the privilege to try new technological advancements such as 'Rehabilitation Robots' as one of the intervention tool, especially in the field of the Neurological Rehabilitation. In this symposia, the speaker will touch base and share his experience of using Robotic and Gaming technology as one the treatment tool in day to day clinical setting and will attempt to address the challenges and evidence gaps pertaining to Rehabiltation.

Day 4 – Friday, 10 December 2016

Session	B8: Ergonomics & Human Factors
Date	Saturday, 10 December
Time	9:00am- 10:30am
Venue	LT50

ID: C2-0004 **B8 : 1**

DEVELOPMENT OF AN INTELLIGENT PILLOW WITH MULTIPLE FLEXIBLE ACTUATORS

Akisue Kuramoto[1], Wataru Inoue[1], Yasuhito Otake, Sacha Krivokuca[2], Tomu Ichikawa[3], Hiroyuki Ono[3], Naoto Sekiyama[3], Hitoshi Kimura[1], Norio Inou[1]

[1]Tokyo Institute of Technology, Japan; [2]Polytech Paris UPMC, France; [3]Fujibedkogyo Co.,Ltd.

From the standpoint of biomechanics, this study aims to establish a design method of optimized bedding which provides the condition of comfortable sleep. In the present situation, for general users, it is not easy to find comfortable bedding without consultation with experts. In addition, the consultation requires several measurements and it takes a long time. This study aims to develop an intelligent bedding that automatically provides a comfortable position and pressure distribution. This paper focuses on pillow as the one of important bedding. A unique prototype pillow which consists of multiple flexible actuators is examined to investigate comfortable position and pressure distribution. The actuators are driven by air pressure and each actuator works as stuff of the pillow. Each actuator has two kinds of sensors; an internal pressure sensor and five contact pressure sensors. These sensors are used for monitoring the support condition of user's head and neck. Because the internal pressures of each actuator can be controlled by the user, it is easy to find comfortable configuration. The error of the internal pressure was less than 0.5 kPa. With the prototype pillow, the contact pressure distribution is measured with several subjects in supine position under the comfortable condition. The result showed that the center of contact pressure was slightly located in neck side than the maximum pressure point (usually the back of skull). Because the prototype pillow can be used as a flexible pillow with automatic deformation, we developed a feedback control system. Based on the sensor information, the control system calculates target values of internal pressure and contact pressure of actuators to realize comfortable condition. The pillow system successfully controlled the center of contact pressure to provide target condition.

ID: C2-0003 **B8 : 2**

THE PREVALENCE OF COMMON PATHOMECHANICAL FOOT DEFORMITIES IN SINGAPOREAN YOUNG ADULTS

Heow Pueh Lee[1], Saurabh Garg[1], Joo Cheng Nicolette Chhua[2], Lian Kheng Frederick Tey[2]

[1]National University of Singapore, Singapore; [2]DSO National Laboratories, Singapore

Flexible flatfoot and high-arch foot are the two most common pathomechanical foot deformities. A flexible flat foot occurs when the medial longitudinal arch (MLA) of the foot is under-developed and collapses when standing leading to complete or near complete contact with the ground. High-arch foot occurs when MLA is overdeveloped leading to a higher arch than usual. High-arch foot is much less common than flatfoot and is more likely to be associated with an abnormal orthopedic or neurological condition. Unlike flexible flat-foot, high-arch is typically painful because reduced contact area with the ground increases pressure on the heel and toes making it difficult to wear shoes. Characterizing foot arch is therefore important for the design and construction of shoes, in particular the design of combat boots due to their more severe external loadings and shocks.

The main objective of this study is to determine the prevalence of flat-foot and high-arch in Singapore population. We used the arch index and the Clarke angle to characterize MLA of 480 male and 480 female subjects. All of them are between the age of 16 and 30. We found that more females have high-arch compared to men while more men have flat-foot compared to women. We also discovered that arch height decreases with age irrespective of gender.

The secondary objective of this study was to determine if there is any relation of MLA with parameters such as weight, height, BMI, foot length, or foot width. We did not find any linear correlation between any of these parameters and the arch index or Clarke angle. In particular, there is no correlation between BMI and flat-foot or high-arch for Singapore population as has been reported by many previous studies for different populations.

ID: C2-0006 **B8 : 3**

DEVELOPMENT OF A DETACHABLE NASAL STENT TO FACILITATE NASOALVEOLAR MOLDING

Franz Bauer[1], Hannes Dikel[1], Markus Eblenkamp[1], Florian Guell D[2], Denys J Loeffelbein[2]

[1]Institute of Medical and Polymer Engineering, Technical University of Munich, Germany, Germany; [2]Technical University of Munich, Germany

Nasoalveolar Molding (NAM) allows to presurgically treat Cleft Lip and Palate, one of the most frequent facial deformities. It aims to reduce and facilitate surgical interventions by reducing the cleft gap and lifting the flattened nose wing. Therefore, a patient-individual palatal plate promotes the growth of the alveolar segments towards a harmonic alveolar ridge. After the reduction of the cleft gap below 6 mm, the nasal stent is added to the plate to erect the flattened nostrils towards a natural nose wing occurrence. During the treatment of 3 to 4 month the palatal plate and the nasal stent have to be adjusted by replacing the plate within the range of 3 to 4 weeks by a bigger one according to the infant's growth. The nasal stent can be adjusted by deforming the stainless steel wire, connecting the nasal stent with the plate. Hence, the nasal stent can be reused for each plate.

Therefore, an interface for a detachable nasal stent was developed as a three-part device: a connector pin integrated in the plate, a nasal stent and a nut to fixate the nasal stent to the plate. The bent wire is plugged into the connector pin and fixated by the nut, to prevent the nasal stent from moving. The plate with the integrated pin and the nut were manufactured using the PolyJet©-Photopolymer MED610. The material is licensed under USP, Class VI.

The connection system allows a quick and easy change from one to the next plate, instead of the time-consuming attaching process of the wire by polymerizing. The design and handling was evaluated by clinicians to be easy in handling and equivalent to the traditional device.

ID: A3-0003 **B8 : 4**

INDIVIDUAL MODELING FOR EMG-CT METHOD TO DETECT ACTIVITY OF EACH MUSCLE IN FOREARM

Naoki Toyota[1], Satoshi Yamada[1], Masahide Harada[2], Harukazu Tohyama[1], Norimasa Iwasaki[1], Shigeru Tadano[1,3]

[1]Hokkaido University, Japan; [2]Harada Electronics Industry Limited, Japan; [3]National Institute of Technology, Hakodate College, Japan

The authors have proposed the electromyography computed tomography (EMG-CT), which provides the activity of individual muscles within a cross section of the forearm by using surface EMG signals and an EMG conduction model. In the previous study, the cross section of the subject's forearm was approximated by a circle in the EMG conduction model and the bone effects were not considered. Hence, the current study added the subject's forearm shape and bone effects to the EMG conduction model for further improvement of the method and investigated the muscle activities during finger and thumb loadings. In the experiments, three subjects participated. The outer shape of subject's forearm was obtained by a handy 3D scanner and bone regions in the cross-section were determined from an MRI image. Loadings were applied to the thumb and middle finger respectively, and the subjects were instructed to maintain the posture during the loadings. The surface EMG signals from the forearm were detected with 40 pairs of bipolar electrodes embedded in a customized EMG-CT band. In the EMG conduction model, it was assumed that EMG signals were not generated from the bone regions and could not pass through the bone. As a result, high muscle activities were detected in FDS and EDC regions during outer loadings to the middle finger at the distal phalanx. During inner loadings to the middle finger at the proximal phalanx, EDC and EDM regions were active. The strength of activity increased with the loadings. These results correspond to the expectation based on the anatomical knowledge. By this method, the distribution of the muscle activities became clearer than that from the previous method. Further, it was also confirmed that high signals were not generated from the bone regions even by the previous methods.

Session	C8: Sports Biomechanics & Human Performance
Date	Saturday, 10 December
Time	9:00am - 10:30am
Venue	LT51

ID: E7-0004 **C8 : 1**

A COMPARATIVE STUDY TO QUANTIFYING THE SPORTS-RELATED EYE INJURY VIA A COMPUTATIONAL FLUID-STRUCTURE INTERACTION MODEL

Alireza Karimi[1], Toshihiro Sera[1], Susumu Kudo[1], Kazuhiro Nakashima[1], Reza Razaghi[2], Mahdi Navidbakhsh[3]

[1]Kyushu University, Japan; [2]Basir Health Center; [3]Iran University of Science and Technology, Iran

Sports-related injuries provide a combination of extensive and inevitable problem as they are responsible for 25% of severe eye injuries worldwide. Most of these injuries are preventable if the information regarding the detail of injury is available. Each sport induces its own injury to the eye owing to the variation in the ball's size, speed, and mechanical properties. In this study, various types of ocular trauma in relation to certain sports, such as handball, football, volleyball, futsal, and basketball, were numerically investigated. So far the injury to the eye components due to the ball impact has not been well determined. Therefore, the goal of this study was to determine the stresses and deformations of the human eye components, including the cornea, aqueous body, iris, lens, intra and extraconal fats, sclera, retina, ciliary body, vitreous body, optic nerve, and muscles, attributable to ball impact via a Lagrangian-Eulerian computational coupling model. Nonlinear dynamic Finite Element (FE) simulations were accomplished using the explicit dynamics FE code to simulate the collision of the ball and the eye. The stress results were found to be various according to different sports. The cornea, aqueous, iris, lens, and sclera experienced the highest amount of stress when impacted by soccer balls. Furthermore, the intra and extraconal fats, ciliary body, vitreous body, muscle, and optic nerve bear the highest stress once impacted by basketball. The results also showed that basketball triggers the highest displacement in the optic nerve with 0.458 μm compared to the other balls. The examined sports based on the highest stresses/injury induced in the eye components were ranked in order as, basketball, futsal, volleyball, football, and handball, from the highest to the lowest that would put injury to the eye. It is, therefore, suggested to wear goggles in these sports to minimize the amount of injury.

ID: E7-0005 **C8 : 2**

CONTRIBUTION OF TRUNK SEGMENT AND UPPER EXTREMITY TO BALL SPEED AT RELEASE OF OVERARM THROWING

Nurhidayah Omar

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Introduction: The overarm throw is a sequential body movement where the proximal joints increase their speed first followed by the more distal segments. During pitching, the angular momentum generated in the proximal segments is transferred to the distal segments resulting in a high ball speed at release.
Purpose: The purpose of this study was to investigate contribution of trunk segment and upper extremity to ball speed at release.

Method: An eight-segment three-dimensional simulation model was developed with a view to modelling overarm throwing. The accuracy of the model is evaluated by comparing the simulation values of the ball speed at release with the corresponding values obtained from performance data of fifteen trials of fastball pitching. Vicon Motion Analysis System was used to collect the kinematic data of an elite fastball pitcher.

Results: Reasonable agreement was found between the simulation model and the performance with root-mean-square (RMS) differences of 0.7% for the ball speed at release. Subsequently, the simulation model was used to investigate contribution of trunk rotation and throwing arm to the ball speed at release. Allowing one segment to be constant for every simulation denoted decreased of 23%, 30%, 47% and 7% for the ball speed at release for trunk, shoulder, elbow and wrist, respectively.

Conclusion: During pitching, the angular momentum of the trunk is transferred to the ball through the kinetic chain. At maximum shoulder external rotation, the angular velocity of the shoulder increased first followed by angular velocity of the elbow extension, completed by wrist flexion to neutral position resulted in high velocity of the ball at release. Results indicated that elbow joint has a strong influence on the ball speed at release. This study provide information which is useful for performance enhancement, rehabilitation, and injury prevention.

ID: E7-0008 **C8 : 3**

A SMART SOCCER SENSOR MAT TO IMPROVE AND TEACH SOCCER KICK TECHNIQUE

Luis Hernandez Barraza[1], Yeow Chen-Hua[1,2]

[1]National University of Singapore, Singapore; [2]Advanced Robotics Center, National University of Singapore, Singapore

Wearable technology has become very popular in the sports industry, and soccer is one of the sports which has been benefited from the improvements in this area. The present study sought to develop a smart training mat sensor suite to improve soccer players' kicking technique. Three amateur players with (23±2 years old; 1.70±0.05m; 80.0±7.5 kg) were recruited and instructed to perform soccer kick in the gait laboratory. The sensor mat was made of forty-nine force resistive sensors (Interlink, USA) each of them with a sensitive area of 6.25 cm2 . Force sensing resistors are thin isometric force sensors whose resistance decreases with the force applied in a non-linear way. As a visual feedback indicator, five hundred eighty-eight LEDs were used on the mat to indicate trough different colors the force applied. As well, besides to measure forces, our sensor mat can show different foot placement to teach the players on how to step correctly. As validation method, the values obtained from the mat were compared to the vertical force of the force plate (AMTI, UK). From the comparison, we obtained an accuracy of 92% respect the force plate values. The maximal vertical forces obtained were 1.0(±0.1) %BW, 1.1(±0.1) %BW and 1.3(±0.2) %BW. Our results were similar by those reported in the literature. Our invention showed to be an accurate and portable sensor suite which can help the coaches to monitor the performance of their players, and as well, it can help younger soccer players to learn about how to do a proper soccer kick and, over the time increase their skills.

ID: E7-0006 **C8 : 4**

A BIOMECHANICAL ANALYSIS OF TRADITIONAL JAVANESE DANCE STYLES

Luis Hernandez Barraza, Yeow Chen-Hua[1,2], Miguel Escobar Varela[1]

[1]National University of Singapore, Singapore; [2]Advanced Robotics Center, National University of Singapore, Singapore

Dance is one of the most important aspects of Javanese intangible heritage. Its academic study has a long history but it has been limited to qualitative descriptions. We believe that a more systematic, quantitative analysis of dance is needed in order to better understand the evolution of dance forms, create more effective cultural policies and train future generations of dancers. For this purpose, we investigated the kinetic and kinematic differences between Javanese dance styles at the gait analysis laboratory of a local Singaporean university. One professional Javanese dancer (36 years old, 1.70 m, 65 kg) was recruited and instructed to perform movements that correspond to different character types in the Sendratari dance-drama: vigorous (gagah), ogre (raksasa) and refined (lanyap). The dancer stood up from a kneeling position in the way that befits each character type. A motion capture system and force plates were used to measure the kinematics and kinetics of each standing movement. One factor ANOVA was used to compare the movements. Our results showed that the only character type which had a significant differenc was the vigorous character. The vigorous character motions showed a peak right knee flexion angle of 152° (±2.5°) and a peak right vertical ground reaction force of 101.5 %BW(±0.5%). These results suggest that this character type requires a higher knee flexion angle and higher vertical forces. This result is surprising since a qualitative analysis of the characters would describe the vigorous and refined characters as being more closely related. However, our results show that the underlying structures of the movements of refined characters and ogres are actually very similar. This insight into Javanese dance can only be obtained through quantitative analysis. Thus, the results provide a scientific understanding of the biomechanical signatures of the different character types.

Session	D3: Tissue Mechanics
Date	Saturday, 10 December
Time	9:00am - 10:30am
Venue	LT52

ID: E2-0002 **D3 : 1**

MULTI-SCALE STUDY OF DEEP TISSUES INJURY UNDER PROLONGED BIOMECHANICAL AND BIOCHEMICAL STRESSES

Arthur Mak, Yifei yao, Singwan Wong, Daniel Xiao

The Chinese University of Hong Kong, Hong Kong

Deep tissue injury due to prolonged excessive loadings can lead to clinical pressure ulcers. We assessed the

duration-dependent damage thresholds of muscle cells in compression using myoblasts in-vitro, and studied the effects of hydrogen peroxide as extrinsic oxidant and the effects of the biowastes released from other damaged cells on such damage thresholds. We examined the effects of oxidative stress on cytoskeletal actin polymerization and used AFM to monitor the corresponding temporal changes in cell stiffness. We used femtosecond laser to evaluate how oxidative stress affected the pre-tension in the cytoskeletal fibers and the ability of cells to repair submicron-pores on their plasma membranes. Using a confocal image based finite element model, we simulated the effects of the biochemically compromised cytoskeleton on the tensile strain in the cell membrane when the myoblast was subjected to compressive loading. Comparing the in-vitro results with a Weibull-distribution damage model suggested that the damage threshold was roughly equivalent to a 6% critical tensile strain in the cell membrane. Our findings suggested interesting implications of damage vulnerability when cells were exposed to biowastes released from other damaged cells in their neighbourhood, or when cells are subjected to prolonged oxidative exposures, such as during chronic inflammation. Using a pseudo-3D finite element model of a human buttock on an elastic cushion, we simulated the effects of the biowastes and the effects of the post-ischemic reperfusion oxidative stress on the development of the deep tissue lesions around a loaded bony ischial tuberosity to become full-thickness ulcers.

ID: E4-0001 **D3 : 2**

QUANTIFICATION OF WALL SHEAR STRESS IN HUMAN FETAL UMBILICAL VESSELS: AN IN VIVO STUDY

Shier Nee Saw[1], Dawn Chia[1], Citra Nurfarah Zaini Mattar[1,2], Arijit Biswas[1,2], Choon Hwai Yap[1]

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Introductions:
It is widely known that endothelial cells (ECs) are highly responsive to shear stress and is important in regulating vascular growth and remodeling. Umbilical vascular ECs are also popular cell sources in mechanobiology studies, but detailed measurements of their native WSS environment is not comprehensively done. Understanding the native environment of umbilical ECs can provide clues for treatment of diseases such as intrauterine growth restriction where flow resistance in the placenta is high.

Methods:
This study included 28 pregnant women who underwent routine growth scan from 32nd to 33rd week gestational age in NUH, Singapore. Blood velocities were quantified through pulsed- wave Doppler and cross-sectional vascular areas were quantified through 3D reconstruction from 3D B-mode ultrasound images. Poiseuille's equation was used to compute WSS in umbilical veins (UV) while iterative scheme of Compuutational Fluids Dynamics (CFD) simulations was adopted in computing the WSS in umbilical arteries (UA). Effect of bending of the umbilical cord was also investigated using CFD.

Results and Discussions:
Ultrasound measurements showed that there is no correlation between blood flow velocities and diameters in both UAs and UV. CFD studies showed that UA's WSS had negative correlation with its diameter, but it was not statistically significant; UV's WSS demonstrated a stronger and statistically significant negative correlation with the vessel diameter, suggesting that UV and UA might utilize different cues for vascular remodeling. In a straight vessel like the UV, bending caused elevation of WSS and vascular resistance, but it did not affect the helical-shaped UA much.

Conclusions:
There are essential differences in hemodynamics environments of the UA and UV. UA helical geometry provides a more stable hemodynamics condition compared to straight bend geometry, allowing UA to sense hemodynamics flow rates without being interfered by cord bending.

ID: E4-0004 **D3 : 3**

OBSERVATION OF MECHANICAL RESPONSES OF MINERAL AND COLLAGEN PHASES IN BONE TISSUE BY LASER RAMAN IMAGING

Masahiro Todoh, Shigeru Tadano

Hokkaido University, Japan

Bone is often regarded as a composite material consisting of mineral particles and organic matrix of mainly Type I collagen in microscopic scale. The mechanical properties of bone tissues in macroscopic scale depend on the structural organization and properties of constituents in the microscopic scale. Raman spectroscopy is known as useful tool for the analysis of material at ultra-structural level. The aim of this study are to observe the mechanical behaviors of mineral and collagen phases in bone tissues by using Raman imaging system and to investigate the effect of structural anisotropy of cortical bone on the mechanical responses.

Cortical bone specimens of bovine femoral diaphyses (Age: 23 m.o.) were prepared with a size of 10.0(L) x1.0(W)x0.5(T) mm, where the longer edges of specimens were aligned to the parallel or perpendicular to the femoral axis. Raman microscope system was used for the analysis of mechanical response of bone tissue under tensile loading by the micro-tensile device. Imaging area was 60x60 μm and measurement points were 41x41 at 1.5 μm intervals. Raman shifts of specific seven Raman peaks were calculated from apatite crystal and collagen molecule in bone matrix. From all experiments, the Raman shifts of mineral and collagen phases to lower wave numbers were observed with increase of applied tensile stress. The changes in Raman shifts under femoral axial stress were relatively smaller than that under circumferential stress. Also, the changes in Raman shifts against applied tensile load was distributed as gaussian distribution in the measurement area. From these results, the Raman shifts distribution of mineral and collagen phases in bone tissues were well related to the applied tensile stress. In addition, those relationships were dependent to the structural anisotropy of cortical bone.

ID: D1-0005 **D3 : 4**

DEVELOPMENT OF A PULSATILE CIRCULATORY SIMULATOR DUPLICATING MOVEMENT OF MITRAL ANNULUS AND PAPILLARY MUSCLES FOR THE ASSESSMENT OF A STENTLESS MITRAL VALVE

Kazuaki Usui[1], Jumpei Takada[1], Hitoshi Kasegawa[2], Mitsuo Umezu[1], Kiyotaka Iwasaki[1]

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BACKGROUND: A novel stentless mitral valve (Normo valve) consisted from an anterior and a posterior leaflet using autologous pericardium sutured around a flexible ring (Duran, Medtronic), which possesses physiological annulopapillary continuity. AIMS: The aim of this study is to develop a pulsatile circulatory simulator for the assessment of mitral valves and to evaluate hydrodynamic performances of the Normo valve in comparison with those of the prosthetic valve (Mosaic valve, Medtronic). METHOD: A novel pulsatile circulatory simulator we have developed consists of an elastic left ventricular model which shape was made based on a patient's CT data (LVEF□0.6, volume□110 ml), an overflow tank, a mechanical valve, a compliance tank and a resistive unit and mimics flow and pressure environment in patients. It also reproduces mitral annular movement and relative distance between annulus and papillary muscles. The Normo valve (27 mm) and the mosaic valve (27 mm) were mounted to the ventricular model. The ventricular model was driven at 70 bpm using a pneumatic driver. The hydrodynamic performances were investigated (n =6). RESULT&DISCCUSION: Mean mitral flow was comparable between the Normo and Mosaic valves (3.9 ± 0.1 L/min, 3.9 ± 0.1 L/min; N.S.). Forward flow and regurgitation of the Normo valve was higher than that of the Mosaic valve (Forward flow: 67.8 ± 1.7 ml/beat, 60.9 ± 2.0 ml/beat; $P < 0.01$, regurgitation: 10.2 ± 0.6 ml/beat, 3.1 ± 0.4 ml/beat; $p < 0.01$), respectively. The diastolic mean pressure gradient of the Normo valve was lower than that of the Mosaic valve (1.9 ± 0.9 mmHg, 3.1 ± 0.5 mmHg; $P < 0.05$). CONCLUSION: The pulsatile circulatory simulator for the assessment of the Normo valve with a function of chordae tendineae was successfully developed. It was found that the hydrodynamic performances of the Normo valve were equivalent to those of the Mosaic

ID: D1-0006 **D3 : 5**

REAL-TIME VISUALIZATION OF THROMBOGENECITY IN IN VITRO BLOOD CIRCUIT USING OPTICAL COHERENCE TOMOGRAPHY: OBSERVATION OF EFFECT ON THROMBUS GROWTH BY THE DIFFERENCE IN CONNECTOR DESIGN

Yuki Matsuhashiu, Yoshiki Yamamoto, Kei Sameshima, Mitsuo Umezu, Kiyotaka Iwasaki

Center for Advanced Biomedical Sciences, TWIns, Waseda University, Japan

Background: Thrombus formation in blood contacting medical devices is an unsolved issue, especially at gaps or interphase between different materials.

Aim: The purpose of this study is to investigate the influence of different connector design, tapered and non-tapered, on thrombogenecity by real-time thrombus visualization method using optical coherence tomography (OCT).

Methods: 6 mm inner circumference and 8 mm outer circumference connecter with 1 mm tip step (connecter A) and same inner and outer circumference dimension with 30°taper angle with 100 μm tip step (connecter B) was connected to the in vitro air-contactless blood circulation circuit. Blood flow rate was set to 100 ml/min, and pressure was set to 70 mmHg. The total volume of the circuit was 50 ml. The blood contacting surfaces were coated with 2-methacryloyloxyethyl phosphorylcholine. Human whole blood, which

activated clotting time was adjusted to approximately 160±20 (n=6) seconds by heparin, were circulated in the circuit for 60 minutes. OCT images were taken in a vertical direction of the interface between tube and inlet connecter, and tube and outlet connecter in ten minute intervals by OCT.

Results: Thrombus was formed in both designs of inlet and outlet parts of the connecters within the first 10 minutes of the experiment. The increasing rates of thrombus area at inlet and outlet of non-tapered and tapered connecters were 2.9 % and 0.7 %, and 4.7% and 2.3%, respectively. These results suggest that the taper design tend to increase the overall thrombogenecity rate, especially at the inlet. This result may be due to the wide flow separation caused from the taper design.

Conclusion: Thrombus was formed without regard of the connecter design, and the thrombus growth were affected by the difference in the existence of the taper.

ID: D1-0004 **D3 : 6**

INVESTIGATION INFLUENCE OF RAPID PACING ON THE ROTATION OF FENESTRATED STENT-GRAFT IN DEPLOYMENT PROCESS USING A PULSATILE CIRCULATORY SIMULATOR

Hiroki Ito[1], Tomoya Fujii[1], Miyuki Uematsu[2], Takashi Azuma[3], Yoshihiko Yokoi[3], Azuma Takahashi[1], Mitsuo Umezu[1], Kiyotaka Iwasaki[1]

[1]Center for Advanced Biomedical Sciences, TWIns, Waseda University, Japan; [2]National Institute of Health Sciences, Japan; [3]Tokyo Women's Medical University, Japan

Background
Fenestrated stent-graft is an endovascular device for thoracic aortic aneurysm. Fenestrations in the stent-graft has a roll to preserve blood supply via the arch vessels. However, stent-graft received hydrodynamic load under its deployment, which makes the treatment complicated. We hypothesized that decreasing blood flow and pressure by rapid pacing may reduce the hydrodynamic load applied to the stent-grafts, which may induce the rotation of stent-graft.

PURPOSE
The aim of this study is to investigate the influence of the rapid pacing of left ventricle model on the amount of the rotation of stent-grafts using the pulsatile circulatory system.

METHOD
Using CT data of a patient before treatment with a fenestrated stent-graft, the patient specific three-dimensional artery model was reconstructed. Then, the patient specific thoracic artery and a iliac artery model was duplicated using silicone. Stent-graft was deployed in the pulsatile circulatory simulator using a catheter inserted from iliac artery model. Using CT images after stent-graft deployment, the rotation angles was calculated. The stent-graft was deployed in the control condition (Mean flow 5.0 L/min, Pressure 120/80 mmHg, Heart rate 70bpm) and in rapid pacing condition (Mean flow 4.2 L/min, Pressure 100/60 mmHg and Heart rate 180 bpm).

RESULT & DISCUSSION
The stent-graft rotation was80.0±12.0° at the control condition and rapid and 64.9±2.6° at the rapid pacing condition, and was significantly decreased using the rapid pacing condition(p=0.02, n=6). Aortic forward flow and flow energy at the rapid pacing condition decreased by 68% and 42% in comparison with those at the control condition.

CONCLUSION
We found that the rapid pacing is elective to reduce the rotation of the stent-graft during its deployme

Session	Plenary Lecture 7
Date	Saturday, 10 December
Time	11:00am - 11:45am
Venue	Auditorium 2

ID: PL-0003 **PL7**

NEED DRIVEN INNOVATION IN MEDICAL TECHNOLOGY:- FROM I TO I

Khek Yu Ho

National University Health System, Singapore

The last century has seen the world being transformed through massive discovery and sharing of new knowledge. This century is likely to see how the new knowledge can be effectively utilised to create new values and sustain the transformative process. I believe one way to do this is to ensure that innovation and new knowledge addresses a key issue, and result in a big impact, the so-called closing the loop. I would like to share my personal journey with developing 3 technologies all the way from need (issue) to impact.
The first technology is the Master and Slave Transluminal Endoscopic Robot (MASTER), a ground breaking invention, which was successfully used to perform the world's first flexible robotic endoscopic

submucosal dissection in human patients. Its significance lies in the potential of the platform in enabling 2-arm technique and telemedicine for future complex endoscopic procedures.

The second technology is the world's one-of-a-kind In-Vivo Molecular Diagnostic System, which can be used to make realtime diagnosis of GI cancer simpler. Its significance lies in the ability of the technology to (i) obviate subjective structural recognition of images by operators, (ii) shorten learning curve, and (iii) reduce lag time in making the diagnosis.

The third technology is the weight loss capsule, which is an ingestible and expellable dose adjustable capsule able to help the patient to lose weight. It is still in the developmental phase.

In this talk, I will use these examples to illustrate how translational research can create value on top of the values already added by existing medical advancement. The talk will also explore some key success steps for translational research, innovation, and enterprise:- the 6 Is.

POSTER ABSTRACTS

Day 1 – Wednesday, 7 December 2016

Session	Poster Session 01 (PO-01)
Date / Time	Wednesday, 7 December 2016 / 12:15pm – 1:15pm

ID: A1-0002 **PO-01 : 01**

MUSCULOSKELETAL CONTROL SIMULATION IN FUNCTIONAL ELECTRICAL STIMULATION

Douglas Canone Garcia[1,2] and Paulo Marcos De Aguiar[1,2,3]

[1]São Paulo Federal Institute of Education, Science and Technology, Brazil; [2]Robotics and Rehabilitation Laboratory (Labore), Brazil; [3]Imperial College London, UK

Through the use of Musculoskeletal Modelling Software (MSMS) together with Matlab - Simulink, a tool called Control Model and Musculoskeletal Simulation (CMMS) has been developed, which allows the simulation of an electrical stimulation generator in conjunction with a PID controller, acting on the musculoskeletal model simulated by computer Thus, it is possible to simulate the muscle response to an electrical stimulus, helping to reduce the use of human beings in the preliminary stages of the development of Functional Electrical Stimulation (FES) orthoses As an example of application, a FES orthosis is simulated which acts on the muscles of the biceps and triceps to achieve the angular position of the arm relative to the forearm of a person

Important concepts about muscle activation caused by electrical impulse, its applications and limitations are explored, allowing understanding details of the development of CMMS, where the simulated arm is positioned at different angles

To achieve this result, the gains of the PID controller were obtained through the experimental methods proposed by Ziegler-Nichols making use of two criteria of calculations, to determine the best approach for the tuning of PID gains resulting in a more realistic behaviour

From the tests performed to preset positioning angles, trend curves were generated for PID gains, where it is assumed that the variation in gains between known points can be represented by a straight line, which allows calculating the value of gains at intermediate angular positions These relations contribute to the development of a controller for automatic tuning of the PID gains starting from predefined angles
It was found a PID gains that allows a more coherent movement with the concept of functionality expected for an FES orthosis, generating a significant contribution for developing biomechanical devices, which allows greater motor independence.

ID: A2-0004 **PO-01 : 02**

A FEASIBILITY STUDY OF NEW MR IMAGING SEQUENCE FOR DYNAMIC ASSEEMENTS OF INFLAMMATORY MYOPATHIES

Jing Fang[1], Chengyan Wang[1], Rui Zhang[1], Xiaodong Zhang[2], Kai Zhao[2], Jue Zhang[1] and Xiaoying Wang[2]

[1]Peking University, China; [2]Peking University First Hospital, China

Assessment of neuromuscular disorders using MRI has become widely available in recent years, since it can offer both anatomical and functional images with high spatial resolution, as providing valuable information for diagnosing inflammatory and metabolic myopathies. The T1/T2-weighted imaging and T2/T2* quantification have been recognized as the useful MR techniques to evaluate intensity of inflammatory infiltrate, to help muscle biopsies, and to monitor disease/rehabilitation progression. The purpose of this study is to develop a new MR imaging sequence for simultaneous measurement of the signals R2 (1/T2) and R2* (1/T2*), with high temporal resolution, which should be helpful to evaluate muscle activity for the patients with neuromuscular diseases.

Ten healthy volunteers (23.9 ± 1.9 years) and eight patients (23.4 ± 2.7 years) were enrolled in this IRB-approved study. For gastrocnemius (GAS) muscle, R2 and R2* increased to 101 0 ± 2 6 % and 111 9 ± 2 5 % of the baseline value during the cuff occlusion, and decreased to 94 9 ± 2 3 % and 94 4 ± 3 1 % of the baseline value shortly after cuff deflation. Similar results were found also in soleus (SOL) muscle. For a typical PM patient, the muscles with inflammation showed 98 2% increase in T2 compared to the unaffected muscles, and 87 8% increase in T2* signals. The MRI parameters measured by the proposed sequences are sensitive to the muscle oxygenation and inflammation, which shows the potential to diagnose metabolic and inflammatory myopathies with higher accuracy. Because the MR imaging acquisition speed reaches 2 second/frame with the new sequence, it is possible to dynamically evaluate muscle reactions to the tasks as ischemia, isometric contraction, and exercise for the patients with neuromuscular disorders in rehabilitation progress.

ID: A2-0006 **PO-01 : 03**

PRECISE QUANTIFICATION OF MITRAL REGURGITATION WITH A COMBINATION OF ULTRASOUND AND 3D VOLUME IMAGE

Srabanti, Monisha Ghosh, Abanti Shama Afroz, Md. Mosiur Rahman, Ratul Hassan, Akib Khan

American International University-Bangladesh, Bangladesh

The objective of this study was to find out the approximate mitral valve regurgitation condition of a heart from Ultrasound data. Echocardiograph data of a heart with mitral regurgitation was processed to collect blood velocity information. It was later incorporated in a 3D heart model for performing FSI for calculating regurgitation probability. In the next phase, a geometric 3D model of the left side of the heart will be generated which includes left atrium, left ventricle and mitral valve. After that using combined CFD (computational flow dynamics) and FEA (finite element analysis) mitral valve regurgitation probability will be computed. In last step, the theoretical data will be compared with the initial observation from echocardiograph data for evaluating the proposed method.

ID: A2-0007 **PO-01 : 04**

A NOVEL IMAGING FOR MICROCIRCULATION ASSESSMENT BASED ON AMPLITUDE MODULATION AND NAKAGAMI PARAMETER DIFFERENCE OF MICROBUBBLES

Huang-Chen Lin, Yi-Hsun Lin, Shyh-Hau Wang

National Cheng Kung University, Taiwan

Quantitative imaging for assessing the tissue microcirculation is crucial for interrogating the perfusion of tumor growth, tumor progression, and lesion distribution. Previous studies showed that the visualization of microvasculature was better achieved by combining Doppler imaging with the administration of microbubble ultrasound contrast agents (UCAs). Yet the overall conclusion for the effectiveness of quantitative differentiation between malignant and benign lesions is still not drawn. In addition, the envelope of ultrasonic signals backscattered from tissues has been statistically analyzed using Nakagami parameter to quantitatively characterize the tissue properties. Thus, further efforts were made to develop a novel imaging method able to assess microcirculation using amplitude modulation and Nakagami parameter difference from backscattered signals of UCAs. Experiments were performed from the UCAs suspensions in a tissue-mimicking phantom using a 15 MHz wideband-focused transducer. A 3-cycle sinusoidal wave was amplitude modulated for exciting the transducer to generate the transmitted ultrasound pressures ranged from 0.5 to 2.8 MPa. The Nakagami parameter was estimated for quantitating the statistical distribution of signals backscattered from UCAs and phantoms. The Nakgami parameter difference image was then calculated by subtracting the Nakagami parameter of signals of each transmitted ultrasound pressures from that of 0.5 MPa pressure. Results show that as the transmitted ultrasound pressures increase from 1.12 to 2.8 MPa, the differences of Nakagami parameter for UCAs and tissue-mimicking phantoms decrease from -0.06 ± 0.02 to -0.11 ± 0.10 and -0.05 ± 0.02 to -0.06 ± 0.03, respectively. Nakagami parameter difference imaging was subsequently formed and that the region of UCAs and phantoms could be readily distinguished. This suggests that currentnovel imaging methodcould be applied to sensitively differentiate the regions with or without the perfusion of UCAs for better quantifying tissue microcirculation.

ID: A2-0008 **PO-01 : 05**

FEASIBILITY OF A NOVEL TECHNIQUE TO QUANTIFY MITRAL REGURGITATION COMBINING NUMERICAL SIMULATION AND ECHOCARDIOGRAPHIC ACQUISITIONS

Muhammad Jamil[1], Omar Ahmad[2], Poh Kian Keong[1], Choon Hwai Yap[1]

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Mitral regurgitation (MR) is one of the most frequent valvular lesions and is linked to left ventricular dysfunction and significantly higher risk of mortality. It occurs because of the incomplete closure of the mitral leaflets and a portion of the left ventricular stroke volume is ejected retrograde into the left atrium. Accurate quantification of MR is very important since different etiologies may require different prognosis, treatment and severity parameters. Doppler echocardiography is routinely used to noninvasively quantify the MR. 2D PISA is considered as the gold standard but the technique is well-known to have limited accuracy due to over-simplification. In this study we propose a new method that combines numerical and ultrasound acquisitions to obtain accurate quantification of the MR and has the potential to overcome the limitations faced by 2D PISA. In our technique, we first obtain

the patient specific mitral valve geometry from B-mode from clinical ultrasound for computational fluid dynamics (CFD) analysis. Next, we compare the velocities obtained from Color Doppler scan of the same valve, VUS, to the velocities from the CFD simulations, VCFD. The ratio of the two velocities, rm= VCFD/ VUS , was used to adjust the CFD flow rate,QCFD, to obtain the final predicted regurgitation flow rate estimate:QP =QCFD/rm. We performed in vitro validation testing with an artificial flow loop, which simulated regurgitation flow through (a) a simplified flat plate with round orifice; and (b) a 3D printed realistic mitral valve and regurgitation orifice geometry based on clinical ultrasound scan. Our method showed marked improvement in both accuracy and precision compared to the clinical gold standard 2D PISA method. Flow rate quantification error were found to be less than 5%. Our proposed method thus proved to be robust and outperformed the current gold standard technique.

ID: A2-0020 **PO-01 : 06**

PSO BASED DENSITY CLASSIFIER FOR MAMMOGRAMS

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DAY 1 Wednesday 7 December

Breast cancer is the most common cancer diagnosed in both, developed and developing countries. Early detection and treatment of breast cancer is necessary to reduce the associated mortality rates. Mammography is the widely accepted modality for screening breast cancer. Breast density is considered one of the major risk indicators for breast cancer. Nevertheless, low contrast and subtle nature of abnormalities reduces the sensitivity of mammograms, especially in dense breast. In this paper we present an automatic method for breast density classification based on two level cascaded support vector machine (SVM) classifiers. PSO has been employed for SVM parameter optimization that resulted in a low set up time for building the system. The proposed system was tested on mini-MIAS database, and an overall classification accuracy of 82% was achieved. Also the system could prompt the radiologists on high-risk cases, thereby gaining more attention from them for diagnosis of such cases.

ID: A2-0022 **PO-01 : 07**

A HYBRID CLASSIFIER FOR THE DETECTION OF MICROANEURYSM IN DIABETIC RETINAL IMAGES

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Diabetic Retinopathy (DR) is a chronic, progressive ocular disease in which the human retina is affected due to an increasing amount of insulin in blood. The prevalence and incidence of DR is associated with people having prolonged hyperglycaemia and other symptoms linked with diabetes mellitus. DR, if not detected and treated in time poses threat to the patient's vision ultimately causing total blindness. Among the various clinical signs, microaneurysms (MAs) appear as the early and first sign of DR. The accurate and reliable detection of microaneurysms is a challenging problem owing to its tiny size and low contrast. Successful detection of microaneurysms would be more useful for a proper planning and appropriate treatment of the disease at the early stage. The work mainly envisages the improvement of the classification accuracy by employing a hybrid classifier which combines Support Vector Machine (SVM), Naïve Bayes Classifier and the decision tree. In contrast to many other classifiers the proposed classifier works efficiently, proves to be simple in terms of computational complexity and also gives good results. The performance is evaluated using publicly available retinal image database DIARETDB1.The hard decision fusion among the three classifiers carried out using the majority voting rule gives accuracy, sensitivity and specificity of 82.2916%, 82.692%, 81.818% respectively.

ID: A2-0023 **PO-01 : 08**

DEPTH-DEPENDENT BURN SEGMENTATION WITH AUTOMATIC GROWCUT USING FUZZY C-MEANS

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In severe burn injury treatment, the most important step is to identify degree of the burns to provide initial medical intervention immediately. However, there is a risk for them to provide unsuitable treatment with their patients because non-specialist doctors often misdiagnose degree and area evaluation of burn.

To solve these problems, we propose the fully automatic burn segmentation system that does not need specification of the burn regions by the users. In the first step, in order to acquire the foreground region for growcut, an interactive segmentation algorithm, we convert the original image from the RGB-space to the YCbCr-space and perform histogram equalization to the Cr component image to emphasize the burn regions. Then, fuzzy c-means clustering segments the candidate cluster of second degree burn from healthy skin and the other degree of burn using the equalized Cr compoment image. In the second step, we acquire the background region of growcut by thresholding the Mahalanobis distance image between original Cr values and the candidate regions. In the third step, we perform automatic growcut; note that the strength of fore- and background is determined according to the pixel value of their images. Finally, we use multi-scale superpixel based morphology processing to eliminate error regions.

The primary advantage of this study over previous work is that our system does not need a user's designation of burn regions by unique automatic growcut algorithm. Moreover, our system is effective to the images having different burn degrees.

System performance, measured as segmentation accuracy, was evaluated by the positive predictive value (PPV) and the sensitivity (S). We compared the performance of the proposed method with k-means clustering and fuzzy c-means algorithm. As a result, the proposed method obtained segmentation accuracies; the PPV and S are 0.648 and 0.911 for second degree burn, respectively.

ID: A2-0027 **PO-01 : 09**

ANALYSIS OF PUPIL DIAMETER FLUCTUATION FOR STRESS EVALUATION DURING COLD PRESSOR TASK

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The pupil has both a parasympathetic innervation and a sympathetic innervation. The objective of this study is to develop a stress evaluation method using measurements of the pupil diameter. To study pupil responses for stress, comparison of the change in the pupil diameter during the resting and cold pressor test was performed. The test consists of a baseline period of 70 seconds and the task period of 60 seconds, with a recovery period of 180 seconds. During the task period, participants were asked to immerse their hand into an ice water container. Pupil diameter and heart rate was recorded throughout the test. Also blood pressure was measured three times (at the beginning of baseline and task period and at the end of recovery period). Pupil images were acquired using a near infrared camera at the framerate of 200 fps with an image resolution of 2040x1088. The pupil diameter was calculated from a binarized image using image analysis. In this data, there were several parts where the pupil diameter became zero due to eye blink. Thus, eye blinks were detected using a time derivative of diameter and reconstructed using cubic-spline interpolation. Finally, pupil diameter fluctuations were analyzed by fast Fourier transformation. In the 3Hz to 10Hz frequency range, pupil fluctuations tend to increase during the cold pressor test, then tends to decrease after the cold pressor test. The results seem to indicate that high frequency pupil fluctuation is increased when the sympathetic nervous system has been activated by the cold pressor test.

ID: A2-0030 **PO-01 : 10**

OBJECTIVE EVALUATION OF SKIN TEXTURE CONDITION BY IMAGE ANALYSIS

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A traditional skin evaluation is performed by subjectively visual evaluation of cosmetic experts. Recently, an objective evaluation is required in the cosmetic fields according to development of skin measurement technology. However, since most of the technology require large or expensive devices for evaluation, they are not adequate for personal use of skin evaluation. Recent image processing techniques receive attention from many cosmetic researchers, because they are better suited for personal skin evaluation.

In this study, we propose an analyzing method by which we can extract the features of skin texture and unevenness of skin color from magnified images of skin. In addition, we got effective feature quantities for evaluation of skin condition by conducting two-sample t-test on those of cheek and back of a chin. As a result, for skin texture, we got the result that the total number of cristae cutises, the mean and standard deviation value of those area are effective. For unevenness of a skin color, the maximum value of an a* image, the standard deviation and kurtosis value of a b* image are effective. In addition, we create frequency images of colors of each L*, a* and b* images, and

analyze the distribution and depth of the color. In this way, we got the features of unevenness of colors, especially the gathering of colors which corresponds to blotches and skin pores. The test result shows that the standard deviation of area based on the frequency of a* component, the mean and standard deviation of color unevenness area are effective features for the skin texture analysis.

In this paper, we obtained the results from the test subjects that are twentysomething. We will try to perform the further study to a wide age group for objective skin texture analysis.

ID: A2-0033 **PO-01 : 11**

IMPROVEMENT OF CELL COUNTING ALGORITHM BY USING IMAGE ENHANCEMENT METHODS

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Introduction: Cell counting is a time-consumed task and it needs the expertise. Image processing technique is an interesting solution to solve those difficulties. Using image processing technique can further improve the accuracy of cell counting including the specificity and sensitivity of cell types. Objective: To increase the accuracy of living and dead cell number that existed in one sample of the hemocytometer. Materials and methods: Image enhancement and morphological operations such as image guided filtering technique which is used to remove small debris and noise that exist in an original microscopic image background. Image contrast must be adjusted and image quality performance can be evaluated and compared with the original noisy images. The filter can be applied directly on RGB (Red, Green, Blue) image that will not be converted into other image types. Image smoothing level can be evaluated by increasing the size of the rectangular neighbourhood around each pixel used in guided filtering.But the size of the neighbourhood [M, N] must be positive integers that are specified as a scalar or a two- element vector.Structure element creates detecting disk shapes in the image and then subtracts the background from the original image to remove small noises. Results: The edges of the cells in the original image can be preserved and image is not blurred even though filtering is used.Maintaining edges and blurring are major disadvantages of noise filtering in medical imaging because blurring has the ability to lose some important information,meanwhile,filtering is performed.Thus, image performance can be calculated by using mean square error formula that is an image quality metric for calculating the error of two difference images.The lower the mean square error value, the better the image quality. Conclusion: Guided-image filtering and morphological operation of image enhancement techniques are effective methodologies for noise filtering and the counting algorithm

ID: A2-0034 **PO-01 : 12**

ANALYSIS OF EYE FATIGUE AND EYE BLINK PARAMETERS IN WATCHING ULTRA HIGH DEFINITION VIDEO

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In this paper, we analyzed eye fatigue and eye blink parameters in watching ultra high definition (UHD) video in normal volunteers and in dry eye patients. Both groups showed the increased blinking during and after watching UHD video and this correlated with the subjective discomfort. In normal group, the cause of eye fatigue came from watching UHD video, so they tried to overcome it as closing their eyes more longer and frequently. In dry eye patients, on the other hand, eye fatigue from dry eye syndrome was dominant than from watching UHD video. Therefore, we can not decide that watching UHD video harms eyes in both dry eye and normal people

ID: A2-0036 **PO-01 : 13**

CORTICAL BONE THICKNESS AT DENTAL IMPLANT SITES USING DENTAL CONE BEAM COMPUTED TOMOGRAPHY

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The survival rate of dental implants is influenced by the alveolar bone quality and quantity. The objective of this study was to evaluate the cortical bone thickness on the occlusal side at potential dental implant sites in different regions of the jawbone of Asian population using dental cone-beam computed tomography (CBCT) images. Two hundred and forty-one potential implant sites (41 in anterior mandible, 72 in anterior maxilla, 73 in posterior mandible, and 55 in posterior maxilla) in the jawbone of 111 Asian subjects were

selected in this study. The cortical bone thickness at the potential implant sites were measured by using medical image software. The Kruskal-Wallis test was used to assess the correlation between cortical bone thickness and jawbone region. The experimental results show that the cortical bone thickness in the four regions decreased in the following order: posterior mandible (1.07+0.47) >= anterior mandible (0.99+0.36)> anterior maxilla (0.82+0.30)> posterior maxilla (0.70+0.35). The CBCT data demonstrate that the cortical bone thickness varies markedly with the potential implant site in the anterior and posterior regions of the maxilla and mandible. This confirms the importance of evaluating the host cortical bone thickness in a site-specific manner prior to implant placement.

ID: A3-0001 **PO-01 : 14**

WEARABLE PULSE WAVE MONITOR RESISTANT TO MOTION ARTIFACTS

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The aim of this study is to create a wearable device for long-term pulse wave monitoring as well as to investigate the possibility of using adaptive noise cancellation approach for reducing motion artifacts occurred during the real life recording. In our study wearable monitoring device have acquired pulse wave by using photoplethysmography approach and human movement with triaxial accelerometer. The electrical design of wearable device was based on synchronous demodulation and using 24 bits sigma-delta analog-to-digital converter.

To achieve effective and robust motion artifacts reduction we create the pulse wave signal processing method based on band-pass filtering and adaptive noise cancellation. Pulse wave signals were initially pass-band filtered at 0.5–10 Hz to remove noise, electrical and physiological interferences, using a zero-phase forward and reverse digital filter, which first filtered the raw signal in the forward direction, and subsequently filtered the reversed signal, thus the resultant signal has zero-phase distortion.

Adaptive noise cancellation was implemented by using a recursive least squares algorithm based on the solution of the Wiener-Hopf equation. Our studies have shown that the best results of pulse wave signal processing are achieved for the following parameters of the algorithm: the forgetting factor of 0.99; filter order of 16.

Performance of proposed processing technique was evaluated by assessing signal-to-noise ratio of the filtered signal and compared with other approaches such as wavelet multiresolution decomposition and moving average filtering. For correct estimation of SNR we used robust approach based on the eigenvalues of signal autocorrelation matrix.

This study indicates that designed wearable device based on principles of photoplethysmography for unobtrusive and noninvasive recording of pulse waves and using advanced digital processing technique for removing motion artifacts could provide an effective and performance tool for improving the long-term healthcare monitoring of human vital signs.

ID: A3-0009 **PO-01 : 15**

ASSESSING THE CORNEAL MECHANICAL PROPERTIES BY WAVEFORM FEATURES OF LOCAL DISPLACEMENT INDUCED BY ACOUSTIC RADIATION FORCE

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The techniques for accurately characterizing corneal mechanical properties in vivo in a nondestructive fashion will be widely applicable in clinical ophthalmology. The objective of the study is to propose a new method to differentiate the corneal mechanical properties based on waveform feature of local displacement induced by acoustic radiation force (ARF).

The 24 fresh bovine corneas were divided equally into four groups. Group N1 were kept untreated, and Group H1~ H3 are firstly immersed in 0.1% Riboflavin for 5min, 5min and 30min, respectively, and then followed by UV exposure for 5 min, 10min and 5min, respectively. A customized confocal transducer was utilized to excite the corneal vibration by ARF and track local displacements of cornea by the pulse-echo technique. Three excitation mode, i.e. single push (SP), multiple push (MP) and double push (DP), were investigated and a set of parameters were extracted from local displacement waveform, such as relaxation time constant (τ, relative elasticity (RE) and relative viscosity (RV).

Results show that the τ and RE obtained from three excitation modes are highly correlated each other (all $r>0.95$, $p<0.05$) while the RV are not highly correlated. There is significant difference among N1, H1 and H2 for τ and RE in all three modes while no significant difference between H1 and H3 group which has same duration of UV exposure. Area under receiver-operator curve (AUROC) analysis shows that the τ and RE of MP has best performance (area = 1) in differentiating the treated and untreated corneas and DP has similar performance (area =0.99). Taking the energy safety and measurement efficiency into account, τ from DP are considered as a better choice in further application. The study demonstrates a promising method to assess the individual difference of corneal mechanical properties by means of ARF-induced local displacement waveform.

ID: A3-0010 **PO-01 : 16**

AUTOMATED REPETITIVE SALIVA SWALLOWING TEST USING MAGNETIC SENSORS

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In the area of rehabilitation and treatment at home, there is a growing interest in dysphagia. The videofluoroscopic examination of swallowing and the videoendoscopic examination of swallowing are widely used as a definitive diagnosis of dysphagia. However these methods are invasive. In addition, special facilities and technique are required. Therefore, a noninvasive screening test is required in the field of initial diagnosis. Conventionally a physician has conducted the repetitive saliva swallowing test (RSST) by palpation. The advantage of this method is that a skilled physician can noninvasive operate without special facilities. On the other hands, this system can be operated by only a skilled physician. In addition, objective diagnosis is desired.

Purpose of this study is to automate the RSST, and to establish an evaluation method with standard evaluation criteria. In this study, authors developed a measurement device for the laryngeal movement associated with swallowing using a neodymium magnet and three-dimensional magnetic sensors. Number of swallowing can be counted automatically using this device. The device includes sensor module and target marker. Magnetic sensors are fixed on thorax as the sensor module. A magnet is fixed on the laryngeal prominence as the target marker. Subjects' tasks are same as RSST, modified water swallow test (MWST), and food test which are representative screening test. In this experiment, a matched filter is applied to change of magnetic field. Template of the matched filter is representative waveform of single swallowing of standard subject. The matched filter is used to obtain the swallowing moment. Number of swallowing can be counted automatically using this system. It is suggested that screening test can be conducted objectivity without special facilities using this proposed method. Furthermore, similarity of the template and measurement results is expected to evaluate quality of swallowing.

ID: A3-0011 **PO-01 : 17**

DEVELOPMENT OF BIOELECTRICAL IMPEDANCE MEASUREMENT DEVICE FOR DISCRIMINATION OF THE MAMMARY TUMOR USING SWITCHING CIRCUIT

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In the breast cancer screening, mammary tumors is ascertained whether breast cancer or fibroadenoma by clinical breast examination, mammography and ultrasonography. The tumor tissue is sampled by biopsy for definitive diagnosis. In the case of tumor size is small, the patient is forced to wait until the tumor size becomes sufficient to sample because it is difficult to prick biopsy needle. Therefore, the patient's mental burden is large.

The purpose of this study is support to breast cancer screening by measuring bioelectrical impedance before carrying out biopsy for small tumor. Thereby the mental burden of such patients can be lighten as early as possible.

The authors proposed a method that discriminate breast cancer and fibroadenoma by using difference of bioelectrical impedance between healthy breast tissue and breast tissue including mammary tumor. Bioelectrical impedance distribution on the mammary is measured on several positions which are changed from breast tissue including mammary tumor to healthy breast tissue. The difference of bioelectrical impedance between each of measurement positions

and reference position that healthy breast tissue were calculated. As a result of a computer simulation, it may be possible to determine the fibroadenoma and breast cancer by measuring multiple frequencies.

In order to realize this method, a measurement device was achieved the changing of the measurement positions by incorporating a switching circuit. The measurement device's electrode unit consists of 16 electrodes. 4 electrodes of them are selected by swiching circuit because bioelectrical impedance measured by four-terminal method. Functional evaluation was carried out by measuring the Japanese radish as a phantom with capacitive component. As results of experiments, it was capable to detect difference of surface potential up to 1mV. In addition, the measurement device was able to draw Cole-Cole plot of the phantom.

ID: A4-0001 **PO-01 : 18**

NOVEL SPECTRAL APPROACH FOR PULSE WAVES CONTOUR ANALYSIS

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This paper considers novel techniques for pulse wave contour analysis. Classical morphological pulse wave analysis by using stiffness index and reflection index does not provide the required accuracy of diagnosis for patients with severe arterial stiffness due to indistinguishable dicrotic peak of pulse wave.

We proposed a novel approach for pulse wave contour analysis based on spectral analysis of replicated single pulse waveform. To obtain spectral index for pulse wave morphology assessment we perform Fast Fourier Transform for the sequence formed by consecutive replication of a single pulse waveform with removed dc component. The newly developed spectral index was defined as the amplitude ratio of the first two harmonics of the amplitude spectrum.

Comparative analysis of sensitivity and specificity for various indices for a set of 45 volunteers of different age and arterial stiffness was carried out. It was found that the proposed spectral index has the highest values of sensitivity (89%) and specificity (86%) compared to the existent indices defined in the time domain.

The results of our study indicate that using spectral analysis for sequence of replicated pulse waveform is a powerful method for noninvasive arterial vessels diagnostics based on the pulse wave contour analysis. The clear advantage of using proposed spectral approach in comparison with classic time domain methods is no need for accurate detection of the pulse wave's dicrotic peak that is crucial in case of assessment arterial stiffness for elderly people with severe cardiac diseases and almost indistinguishable dicrotic peak.

The disadvantage of the suggested technique may include the need for correct extraction of the single pulse wave, which in practice may be difficult due to present baseline wander and movement artifacts, heavily distorting the shape of the pulse waveform.

ID: A4-0002 **PO-01 : 19**

MODELING DIGITAL PULSE WAVEFORMS BY SOLVING ONE-DIMENSIONAL NAVIER-STOKES EQUATIONS

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This paper considers the mathematical model for composition distal arterial pulse wave in the blood vessels of the upper limbs by solving one-dimensional Navier-Stoles equations. Mathematical simulation of hemodynamic processes in the distal arterial vessels would allow researchers and clinicians to create novel efficient methods for arterial stiffness estimation based on noninvasive recording and processing pulse waves.

One-dimensional Navier–Stokes equations could be used to describe the pulse waves propagation along the human arterial bed. To obtain the strict mathematical dependencies that describe processes of distal pulse waves (DPW) formation, we used a well-known formal analogy between the propagation of pulse waves along the arterial bed and propagation of oscillations in electrical transmission lines with distributed parameters.

The mathematical model of the relatively short segment of human artery could be represented by an appropriate segment of an electrical transmission line that has an input source of electrical oscillations and terminated by load impedance. In this model the input source of an electrical oscillations simulates a pulse wave pressure that occurs during systole and leads to the blood ejection from the left ventricle.

Analyzing the simulated DPW revealed that upon an increase in the arterial stiffness (in the proposed

mathematical model it corresponds to increasing the Young's modulus of the arterial wall) the pulse wave's contour changes significantly: the amplitude of the pulse wave increases, the time interval between the first and the second peaks decreases, the signal slope increases, while the second peak becomes less distinguishable.

To verify the proposed mathematical model we compared the reference pulse waveforms, recorded from people with various conditions of arterial vessels, with appropriate model pulse waveforms, obtained upon different values of Young's modulus of the arterial wall.

ID: A4-0004 **PO-01 : 20**

EYE-BLINK REJECTION BASED ON INDEPENDENT COMPONENT ANALYSIS AND MACHINE LEARNING IN ELECTROENCEPHALOGRAM

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During electroencephalogram (EEG) recording, eye-blinks contaminate the signal as a result of the large amplitude and unpredictable timing. Recently, EEG studies dealing with communication between humans, and between human and machine in a natural situation with eye-blinks have increased. Removing the noise is important for extracting the precise neural activity from the EEG data. The purpose of this study is to develop a novel method to reject eye-blink noise during EEG recording. It is based on independent component analysis (ICA) and K-means, which is a type of unsupervised machine learning. We measured sixty channels of data for each situation: when contaminated with eye-blinks and in the resting state. First, the data epoch was extracted from the -500 to 800 ms range by the reference of a latency showing an amplitude peak associated with the eye-blink at Fp1 in the left prefrontal area. These were averaged to construct an eye-blink template. This template was superimposed on a resting state EEG without eye-blinks for all channels with decreasing amplitude of the template towards the posterior position. Then, ICA was performed on the superimposed EEG and sixty independent components were generated as output. K-means was conducted in terms of a combination of parameters, namely standard deviation, skewness, and kurtosis for each component were used to identify a cluster of components associated with eye-blinking. Lastly, the cluster, including the first component, was rejected from the superimposed EEG and the cross correlation between the resting state and rejected EEG was calculated. As a result, the highest cross correlation was 0.99 when the cluster consisted of only the first component, of which the cluster number set in the K-means procedure was greater than 5.

ID: A4-0005 **PO-01 : 21**

STATE SPACE MODELING OF BIOIMPEDANCE

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Haematocrit (HCT) is defined as the volumetric ratio of the packed-cell (erythrocyte) in blood. It is a very useful clinical indicator to estimate the fluid shift between the extracellular and intracellular areas. Significant changes in the blood Haematocrit are recorded during artificial dialysis resulting in remarkable changes in the blood conductivity that can reach up to 20%.

Traditional methods for HCT-measurement like centrifugation or photometry are well known and precise. The drawback of the first method is the need for extracting a blood sample out of the closed loop system, which takes time and increases the cost. The latter method requires an optical window to access the blood and therefore it does require an additional precision fabricated disposable component. In order to eliminate the disadvantages of the mentioned HCT-measurement methods a new approach for blood bioimpedance modeling is presented.

The principles of functional identification of electrical impedance of biological tissues are considered. To determine the frequency characteristic of the electrical impedance the method of transient functions is proposed. Transient function of electrical impedance registered as a response on unit step-current. The frequency characteristic is defined as the Carson—Heaviside transform of the electrical impedance transient function. Functional identification realized by Levy method.

For modeling the component analysis of a biological tissue the electrical impedance frequency characteristic is considered in the state space of parallel RC circuits, where the state variable has the meaning of electrical charge. The modeling of electrical impedance in blood samples with different haematocrit level is carried out. The dependences of the equivalent circuit parameters upon the haematocrit level are obtained. The obtained dependences of the frequency characteristic of impedance modulus and the equivalent scheme parameters upon the haematocrit level may be used for the haematocrit level determination in a blood sample.

ID: A4-0006 **PO-01 : 22**

QUANTITATIVE ANALYSIS OF PET IMAGES OF THE BRAIN WITH PARKINSON'S DISEASE

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Patients suffering from Parkinson's disease (PD) have no structural damage found in the brain. Doctors diagnose PD based on medical history, physical and neurological exam, in order to rule out other possibilities of dementia-like symptoms. Recent developments in Positron Emission Tomography (PET) show that dopamine receptors in the striatum region could be inactive in PD patients, which can be quantified with the help of a dopamine transporter (DAT) radioligand [18F] FE-PE2I. The aim of this study is to develop an image processing toolkit to analyze the dopamine receptors' density level in the striatum region by combining PET and Magnetic Resonance Imaging (MRI) modalities. PET images provide the functional information of DAT density of the striatum while the MRI images provide the structural information of the striatum. We have successfully developed an image processing toolkit with MATLAB for quantifying the DAT density in the brain striatum. The developed toolkit consists of various functions including extraction and analysis of ROI from the MRI images, color segmentation of the PET images, batch processing for 3D analysis and graphical representation of the DAT density with graphical user interface (GUI). The application of this toolkit can be further extended to analyze different type of disease conditions and for other imaging modalities as well.

ID: A4-0007 **PO-01 : 23**

DISCRIMINATION IN SCAN PATH DURING VISUAL SEARCH FOR SPATIAL FREQUENCIES ON IMAGES WITH CHECKERED ARRANGEMENT BASED ON MACHINE LEARNING

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To design novel displays such as media content and buildings, it is important to know how visual search affects the perception and cognition of objects. The purpose of this study was to clarify the characteristic of visual search that are controlled by spatial frequency. We measured the detection time, accuracy rate, and scan path during eye movement in response to a target stimuli, which was embedded in a 6 ´ 5 area in a background image with a checkered arrangement, while changing the parameter of spatial frequency in the target stimuli. Six healthy men with normal vision (aged 21–22 years) participated in the experiment. β, which is a spatial frequency parameter and corresponds to the slope of the luminance power spectrum in the target stimuli, with a value ranging between 0.0 to 0.4 was revealed as the indiscriminable range between the target and the background (i.e., the discrimination rate was 0%), while the range of greater than 0.5 to 1.0 was discriminable (i.e., the discrimination rate was 100%) from the view of an objective evaluation by a support vector machine applied to the deviation of the scan path from the target stimuli. The results showed consistency with those of accuracy rate and detection time. From these results, we suggest the existence of a visual search threshold corresponding to approximately 0.4–0.5 of β.

ID: A4-0008 **PO-01 : 24**

POSSIBLE DETECTION OF DROWSINESS THROUGH ELECTROCARDIOGRAPHIC ANALYSIS

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Drowsiness during driving can cause serious accidents. In this study, we investigated the possibility of detecting drowsiness from electrocardiogram (ECG) data. Five healthy volunteers participated in this study. At the beginning of the experiment, the subjects sat on a chair and read a book or used a computer at a desk. They were instructed to close their eyes when they became drowsy. During the experiment, the signals from an ECG sensor on the subject's chest, an electrooculogram (EOG) sensor on the outside of the subject's eyes, and an electroencephalogram (EEG) sensor on the subject's forehead were measured at a sample speed of 1 kHz. The R-R intervals (RRI) were calculated from the ECG data, and then 30-s RRI data sets were extracted from the start to the end of the experiment. The starting point of each data set was set at 1-s intervals. Time-frequency analyses were performed for the RRI data sets. The analyses were used to calculate the powers of the low frequency (LF) components (0.04–0.15 Hz), and high frequency (HF) components (0.15–0.4 Hz).

Similarly, time-frequency analyses were performed for the EEG data sets, and the delta, theta, alpha, and beta waves were calculated. The amplitude of the HF and RRI waveforms increased during most periods of drowsiness that were identified from the EOG and EEG analyses. However, the relationship between LF/HF waveforms and drowsiness was not clearly established in this study. Therefore, it is possible that drowsiness can be detected by real-time monitoring of the dynamics of the HF and RRI.

ID: A4-0010 **PO-01 : 25**

DEVELOPMENT OF BIOMETRIC PERSONAL IDENTIFICATION SYSTEM WITH HIGH FREQUENCY ELECTROCARDIOGRAM BY MULTI-RESOLUTION ANALYSIS

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The purpose of this study was the development of personal identification system using a high frequency electrocardiogram (HFECG) as a novel biometric identification system. We are using a comparison of the waveform patterns as an individual recognition technique. HFECG waveforms are quantized along the time axis and the amplitude axis and compared with the registered waveforms. Quantizing resolution affects the discrimination rate and noise resistant performance. In this study, we optimized two system parameters (Resample Rate (RR) and Quantization Level (QL)) to the resolution conversion processing. Original ECG was sampled at 600Hz. RR represents the rate between original sampling frequency and resampling frequency. QL shows amplitude quantization level for each polarity. For example, QL=3 means that signal amplitude is divided into seven levels including zero. System performance was evaluated with noise free HFECGs from five subjects. Then, noise added HFECGs were also tested for the next step. We determined an artificially noise to HFECG and was determine the optimum system parameters in noisy environment.

From the results with noise free HFECG, 99.4% of maximum identification rate in this study was obtained when RR=1 and QL=2 or QL=3. Therefore, it was possible to obtain an optimal system parameters in the noise free HFECG. In noisy environment, signal to noise ratio (SNR) in this study was calculated with following values. Signal amplitude is defined as a maximum peak amplitude of HFECG of four subjects, Noise level is defined as RMS value of the amplitude of artificially generated Gaussian noise. When SNR=0.40, RR=1.0 and QL=3.0 gives 43.75% of identification rate, and RR=1.0 and QL=5.0 gives 41.50%. These results shows that adaptive control of QL can maintain optimum system parameters that gives the best result.

ID: A4-0012 **PO-01 : 26**

THE DIFFERENCE BETWEEN COMPRESSED SOUND SOURCE AND UNCOMPRESSED SOUND SOURCE GIVE EEG OF THE HUMAN

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In recent years, the music market has changed from CD to digital distribution MP3 that is the representative compressed sound source of online music services. However, MP3 formatted sound source is inferior to uncompressed sound sources such as CD formatted sound source. Because MP3 format has less information as compared to CD format.

There are many researchers who investigate EEG of the human that is affected by music. However, there are few studies about the EEG that is affected from compressed and uncompressed sound. The objective of this study determine whether people are correctly recognizing such differences between compressed and uncompressed music by analyzing EEG. In the experiment, electrodes were set on the subject's head according to international 10-20 method, and 16 channels measured. Ten subjects(Healthy adults, 5 Males,5 Females, Average age 22.2 years old) were studied. We used five types of the music with different formats LPCM(16bit/44.1kHz,1411kbps) formatted sound source and 4 types of MP3(64kbps,128kbps,256kbps,320kbps) formatted sound source. Each subject listened these formatted sound for 24 second at the same point and their EEG were measured. Measured EEG were analyzed using wavelet transform. We have analyzed measured data into two types of the subject group. Subjects of one group stick to the sound quality and other group did not stick to the sound quality. In the results of this experiment, we found patterns EEG from two subjects who stuck to the sound quality. So we report the progress of this study.

ID: A4-0016 **PO-01 : 27**

MEASURING NEURAL, PHYSIOLOGICAL AND BEHAVIORAL EFFECTS OF FRUSTRATION

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We conducted a computer-based visual search study to investigate frustration and attention. Its objective is to explore the correlation of mental and affective states with the corresponding neural, physiological and behavioral performance. The experiment was designed to imitate tasks in a postal office (sorting of postal codes into groups for delivery according to locations) via a response pad. Eight participants (2F/6M, median age = 30) took part. The tasks given to the participant varied in difficulty from low (baseline) to high difficulty, over 8 levels in total with 40 trials each. Factors which contributed to task difficulty include response time, and visual search activity.

Total number of correct responses (CR) and response times (RT) were collected continuously throughout the experiment (behavioral response data). The participants' feedback on the workload demands of the experiment was collected electronically at the beginning and selected intervals based on the NASA Task-Load-Index (NASA TLX) self-reporting instrument, which measures the perceived demands of the experiments (mental, physical, temporal, performance, effort and frustration). Furthermore, Electroencephalographic signals (EEG, non-invasive scalp recordings), eye gaze patterns (using a commercial eye-tracker), and Galvanic Skin Response (GSR or electrical skin response sensitive to emotional states) were captured for analyzing physical and physiological responses. High resolution video of the participants was also recorded to permit the analysis of their reactions and facial expressions in response to the different stages of the experiment.

Preliminary findings are encouraging and indicate the elicitation of increasing levels of frustration with task difficulty and reduced CR rates, which was consistent across participants. Details will be presented and discussed in the full paper. Future directions will involve the identification of frustration signatures and their use for improving work-flow processes in various work settings, and risk management using EEG and eye-tracking.

ID: A4-0019 **PO-01 : 28**

EEG SOURCE LOCALIZATION USING ECCENTRIC ELECTRODE ARRANGEMENT AND SLORETA

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EEG (electroencephalography) source localization is one of the convenient methods to analyze brain activity because of non-invasiveness and high temporal resolution. It is expected to be applied to various fields, such as support of disease diagnosis and brain machine interface. But large number of electrodes should be necessary for accurate source localization because the number of electrodes is insufficient to obtain high resolution potential map on the scalp.

The goal of this study is to realize accurate source localization using small number of electrodes. Relationship between localization accuracy and eccentrically located electrode arrangement is investigated. When the region of the source is known in prior to measurement, it could be unnecessary that electrodes are evenly located the whole head. Several electrode arrangements using electrodes near the target region are proposed. In addition, localization accuracies for proposed electrode arrangements are examined by computer simulations.

In present simulations, the region of the source was supposed as left somatosensory cortex. 12 electrode arrangements, consisting 4 to 25 electrodes, were examined. Scalp potentials for a current dipole are calculated by use of three-shell spherical head model. sLORETA (standardized low resolution brain electromagnetic tomography) was used for source localization. Localization errors for proposed electrode arrangements and standard electrode systems, such as 10-20, 10-10 and 10-5 system were compared. Number of electrodes is 19, 73, 316 in 10-20, 10-10, 10-5 system correspondingly.

As a result of the simulations, it was confirmed that source localization accuracies using proposed electrode arrangements were higher than that of standard electrode systems although number of electrodes in the proposed arrangements were smaller than that of standard electrode systems.

ID: A4-0020 **PO-01 : 29**

ESTIMATING THE CORRELATION BETWEEN ABP AND PPG WAVEFORMS

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Photoplethysmographic waveform (PPG) and Arterial Blood Pressure waveform (ABP) are good indicators of cardiovascular performance. Although ABP is more widely employed, the invasive procedure for signal acquisition may cause skin rashes and inconvenience to the patients. PPG, on the other hand, uses infrared light to measure the blood volume changes, which is simple, non-invasive and hence can be used for continuous measurement. This paper focuses on analyzing the similarity between ABP and PPG using various features like average slope, peak instant, time period, elasticity, and amplitude of the signal. A segmentation algorithm is used to segment out cycles of ABP and PPG from MIMIC database taken from 19 patients with respiratory failure and the values of each feature are extracted for each person. Considering the population, using Pearson's correlation coefficient, the coefficient for the average slope of the PPG and peak to peak amplitude of ABP is found to be 0.55 indicating that other factors such as vessel diameter, thickness must be considered. The upstroke time period of both ABP and PPG is found to have a difference in the range of 0.02s to 0.1s, whereas the time period of the heart cycles remained the same. The peak instant of both ABP and PPG occurs with a constant time difference. The correlation for elasticity with peak to peak amplitude of ABP and systolic pressure is found as 0.822, and 0.8345 respectively. When considered for individuals, parameters like the diastolic average slope of PPG and systolic blood pressure are found to have a good correlation coefficient ranging from 0.6 to 0.96 among other parameters which include systolic average slope, maximum and minimum slope of PPG, and the diastolic blood pressure.

ID: A4-0025 **PO-01 : 30**

A COMPARATIVE STUDY BETWEEN PIEZOELECTRIC PRESSURE SENSOR AND DOPPLER RADAR FOR NONCONTACT MONITORING OF RESPIRATION RATE

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Noncontact monitoring of respiration rate plays an important role on diagnosis of respiratory disorders, not only in hospital settings, but also in home healthcare. Piezoelectric pressure sensor (PPS) and Doppler radar have been developed for noncontact measurement of tiny body movements caused by spontaneous respiration. Such noncontact biosensors, unlike contact-type sensors, suffer from sensitivity to random motion artifacts. A hybrid PPS and Doppler radar sensor was considered as one of the solutions for addressing the issue of motion artifact. Hence, prior to the coupling of respiration signals from PPS and radar, a comparative study was conducted between these two sensors on five subjects with supine and lateral positions in a lab environment. We compared the respiration rates detected by noncontact sensors i.e., PPS and Doppler radar with reference contact-type respiratory effort belt, respectively. We observed that Doppler radar performed slightly better than PPS on supine position, whereas PPS was better on lateral position. This result implies that it is preferable to combine the two sensors in order to provide more accurate respiratory monitoring.

ID: A5-0004 **PO-01 : 31**

KINEMATIC ANALYSIS OF TREADMILL WALKING IN YOUNG AND OLDER ADULTS

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Age-related changes in spatiotemporal gait parameters and joint kinematics have been investigated in an attempt to clarify the mechanism underlying the increased risk of falling associated with aging, as well as to develop effective fall prevention measures for elderly. However, age-related changes in gait characteristics that are critical to the increased risk of falling have still remained unclear. In the present study, we experimentally investigated differences in gait kinematics between young and older adult during treadmill walking. Five young and five older adult male participants were asked to walk on a treadmill at 4 km/h (1.1 m/s) at a self-selected frequency, and walking kinematics was measured using an eight-camera motion capture system. Our results demonstrated that the older adults walked with significantly shorter stride length and higher cadence than the young adults. In addition, the ankle joint was found to be significantly

less dorsiflexed in the late stance phase in the elderly than in the young adults, because the heel was lifted significantly earlier and foot-flat period was maintained for a shorter period in the elderly. This restricted ankle dorsiflexion during walking in the older adults is possibly due to the age associated increase in the tightness (stiffness) of the ankle plantarflexor muscles such as soleus and gastrocnemius. Furthermore, it was also found that variability of the toe trajectory in the early stance phase was comparatively larger in the elderly possibly due to the difference in the leg kinematics in the late stance phase, as it affects the size and orientation of the manipulability ellipsoid. Therefore, the restricted ankle dorsiflexion in the late stance phase in the elderly may be linked to the larger variability of the toe trajectory in the early stance phase, and hence the higher risk of tripping and falling in the elderly.

ID: A7-0003 **PO-01 : 32**

DEVELOPMENT OF URINALYSIS APPLICATION USING SMARTPHONE CAMERA

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A urine test strip is a non-invasive test tool use for the determination of patient's pathological changes. For solve the problem, some devices have been developed. Current methods could not satisfy convenience and portability. The drawback of the existing methods are solved by analyzing the urine test strip taken by a smart phone camera.

ID: A7-0007 **PO-01 : 33**

THE DESIGN OF THE HOG-SVM ALGORITHM OF MOVEMENT TRACING FOR ELDER CARE IN HOME

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Nowadays, Aging is a serious phenomenon in many countries all over the world. Within the health issues among older people, the injuries caused from falling are more common significant causes of morbidity and mortality. In this study, a image chip-based image surveillance system was proposed to monitor the daily activities of elder who is cared in home. These variances of background in home, such as the illumination and the moved furniture, would be solved by using the adaptive background updating and the shadow elimination algorithms. The movement of the elderly need to be traced by the proposed algorithm. the Histogram Oriented of Gradient (HOG) was applied to calculate the eigenvectors of the image gradient for characterizing the human body-shape information. The HOG could keep the factors of scale and illumination invariance. A linear Support Vector Machine (SVM) structure was then designed for establishing the classification model with the suitable vector set. With the tests in simulated real environment, our experimental results showed that the proposed HOG-SVM algorithm could successfully extract the traced people from the background. The accuracy is up to 99.10% and the miss rate less than 1.28%. This proposed image tracing system for elderly was rapid and stable for elderly indoor surveillance. How to build the robust system will be the challenge in the development of this study. We hope the proposed system could be applied in the practical application for healthcare and homecare for the elderly in home in the near future.

ID: B1-0001 **PO-01 : 34**

RAPID AND VISIBLE BLOOD TYPING DEVICES

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A portable and cost-effective colorimetric diagnostic device was fabricated for rapid ABO and Rh blood typing. The polymeric chip system mainly contained a manual syringe pump, low-aspect-ratio filters and micromixers. Using microfluidic construction on a thermoplastic chip, blood antibodies were preloaded into a reaction channel and exposed to blood samples to initiate a haemagglutination reaction. Downstream high-aspect ratio filters for blocking agglutinated red blood cells (RBCs) to turn the reaction channel red, indicating the presence of the corresponding blood antigen. We manually use a simple manual syringe pump to actuate the blood sample that drives the solution through serpentine reaction channels and chaotic micromixers for maximum interaction of the preloaded antibodies with the blood sample antigens. The required blood volume for the test is just 0.5 μL, which can be obtained by the less invasive finger pricking method. As a result, unambiguous blood

typing tests can be distinguished by the naked eye in 1 min. The low reagent consumption, manual driving force, low-cost, high yield, and robust fabrication process make this device sensitive, accurate, and simple enough to use without specialized training in resource constrained settings.

ID: B1-0004 **PO-01 : 35**

LAMINAR FLOW MICROFLUIDIC SPERM SORTING DEVICE FOR PRE-CONCENTRATION OF SPERMS FOR EFFECTIVE IN-VITRO-FERTILISATION

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Sperm sorting is of critical importance in various aspects of the In-vitro fertilization process. It can enhance the success rate of fertilization for samples obtained from men with low motile sperm counts while avoiding traditional centrifugation techniques. It is also useful for cryopreservation of semen samples and in intracytoplasmic sperm injection. In this paper, a microfluidic lab-on-chip device which can efficiently sort motile human sperms from semen sample is proposed. The PDMS device is fabricated using soft lithography techniques. It consists of a K shaped channel with two inlets and two outlets. Clinically treated semen sample from the patients was injected into one of the inlets and G-MOPS medium into the other inlet. The flow rate for each fluid was set to 0.5µl/min resulting in the formation of a laminar flow boundary between the two fluids. The motile sperms being active, swim across the fluidic boundary into the medium in the main channel and are collected at the oblique outlet of the K channel while the non-motile sperms are washed away through the straight outlet. The motility at the K channel outlet and straight channel outlet was recorded to be 81% and 54 % respectively for an inlet sample motility of 69 %. Results confirm that a good proportion of motile sperms with lateral activity were able to swim across the fluidic boundary into the medium. Use of such passive microfluidic device enhances the active/motile sperm concentration in the sample which can further be used in In-Vitro fertilization, leveraging the possibility of effective fertilization. Two- dimensional flow simulation of the system was also carried out in order to ascertain the optimal flow distribution across the inlet and outlet of the microfluidic device.

ID: B1-0013 **PO-01 : 36**

DETECTION OF ADIPOCYTE DIFFERENTIATION AND LIPID ACCUMULATION USING ELECTRICAL IMPEDANCE MEASUREMENT

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It has been considered that obesity and metabolic syndrome would be caused by the accumulation of lipid droplets in the body, and leads to one of the major healthcare problems. For this reason, functional foods to suppress the lipid accumulation have been actively developed all over the world, and the functionality of those foods have been reported. However, the quantitative and accurate evaluation methodology of functionality have not been established yet. Since fat tissue has a high electric impedance values, it is considered that the amount of lipid droplets in adipocytes affect the impedance value. Therefore, culturing adipocytes and monitoring their electric impedance simultaneously would enable to evaluate the amount of lipid droplets, and to establish the screening system for functional foods. In this study, mouse fibroblasts were cultured on comb-shaped indium-tin oxide electrodes and the electric impedance was measured to evaluate adipogenesis and lipid accumulation. Briefly, the 3T3-L1 cells were cultured under two conditions (with and without adipogenesis factors) for 14 days and the real and imaginary parts of impedance were measured by connecting the electrodes to an impedance meter. The values of electric impedance at 1 MHz were normalized by the value at 10 kHz. As the results, the cells were successfully cultured on the ITO electrode-array, and the electrical impedance of cells under adipogenesis condition showed different response compared to that under without adipogenesis condition during the adipogenesis and lipid accumulation phases. This result indicated that the change in electrical impedance could be related to lipid accumulation and adipogenesis respectively. In conclusion, our novel monitoring device showed the possibility for screening system of functional foods.

ID: B1-0014 **PO-01 : 37**

INTELLIGENT SELF-DIAGNOSIS SYSTEM FOR EARLY DIAGNOSIS OF PANCREATIC CANCER

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Background: Since survival rate of 5-year is extremely low in pancreatic cancer, early diagnosis is considered important. There are many cases that patients mostly visit hospital only when their symptom became serious, therefore they usually miss the period of treatment. For this reason, diagnostic kits involving biomarker of pancreatic cancer have been developing but its not reasonable. To supplement these problems, reflecting results of numerous patients' self-symptoms and blood tests is required including intelligent diagnosis. Intelligent diagnosis system of IBM Watson was applied to hospital Memorial Sloan-Kettering Cancer Center, MD Anderson Cancer Center etc. This system provides objective advises regarding diagnosis to medical doctor. However, there are no intelligent diagnostic systems specialized to early diagnostic pancreatic cancer.

Methods: Bio marker CA19-9 for early diagnostic pancreatic cancer has been developing in the shape of diagnostic kit, however accuracy is not high enough. Additional pancreatic self-symptom(stomachache, jaundice, loss in weight, diabetes etc.) and blood test(CA19-9 value, bilirubin value, etc.) result should be reflected. By studying plenty of patients' information, we can obtain the pancreatic cancer rate on each value. And by applying Bayesian network, it's available to diagnosis and inducts pancreatic cancer and obtains increased accuracy more than before.

Result: Additional intelligent self-symptom and blood test result including CA19-9 biomarker shows more than 80% accuracy. In order to obtain the experimental result, we are cooperating with National Cancer Center of South Korea and applied information of National Cancer Information Center(www.cancer.go.kr) to the system.
Conclusion: Bayesian probability of diagnostic method is also used IBM Watson which shows very high accuracy. By specializing in pancreatic cancer, we could classify the diagnosis to the self-diagnosis·blood test·total diagnosis, then it's available to easy early diagnosis of pancreatic cancer, thus we can increase the survival rate of pancreatic cancer.

ID: B1-0016 **PO-01 : 38**

SILICON-BASED-PHOTODETECTOR WITH POROUS FILM FOR BIOMEDICAL SENSING APPLICATIONS

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The article proposed a bio-sensing system by dual-wavelength incident lighting and photo-detecting device, results of the measured bio-samples showed more accuracy data. The proposed dual-wavelength silicon-based photo-detector with multi-layer structure, was fabricated and characterized with short wavelength enhanced operating. The dual-wavelength response of the detector, which can be enhanced by introducing thin porous silicon layer as the base region of transistor. The device process of manufacture is suitable in design of visible-light sensitive bio-photo-detectors. The experimental summary showed that the dual wavelength responses in the developed devices were enhanced as compared to the conventional silicon-based photo-detectors in optical parameters, which indicated that the developed bio-photo-detector showed potential for practical silicon-based biomedical device and system applications.

ID: B1-0018 **PO-01 : 39**

DEVELOPMENT OF TRANSPARENT SENSOR OF THREE-AXIS STRESS DISTRIBUTION FOR HAPTIC INTERFACE

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Touch panel is widely used for detections of contact conditions between fingers and screen in operating portable terminal devices and notebook PCs as human interface. These sensing units have the functions of both the detection of contact area and screen display by using transparent sensing elements. Especially touch sensor technology used in smartphone has greatly improved in recent years. Currently the touch panel can recognize not only detections of contact position but also change in pressure. However these previously proposed touch panels could not measure shear stress. On the other hand, we have developed a thin and flexible sensor that can measure the contact

pressure and the bi-axial shear stresses at the contact position in human body. The measurements of shear stress could realize more sensuous and functional operation for the touch panel control.

In this study, we developed a sensor composed of transparent and thin materials. The sensing device that can measure the distributions of three-axis stresses was constructed for use in touch panel. The transparent electrodes were made of indium tin oxide. And a couple of electrodes is located at the both sides of the pressure-sensitive conductive polymer layer by means of photo lithography process. The stress calibration tests were performed under combined stresses with the contact pressure and the shear stress applied by multi-axis loading device. Furthermore, the developed sensor was applied to touch panel operations. The contact pressure and the shear stress were simultaneously measured under several kinds of finger operations. Transparency of the sensor was confirmed by recognizing the characters on PC display through the sensor thickness. We also produced display software for visualizing the distribution of stresses including both the amount of contact pressure and the vector information of shear stress on the surface. Usefulness of the sensor systems was discussed as haptic interface.

ID: B1-0021 **PO-01 : 40**

DNA SENSOR FOR DRUG RESISTANCE DETECTION

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The clinical diagnostic in drug resistance which has been done by conventional susceptibility technique will be established in high sensitivity detection via optical technique. In this work, the gene of antimicrobial resistance was studied by nanoparticles system in concept of multiplexes of both gold nanoparticle (AuNPs) and magnetic nanoparticle (MNPs) on probe-analyte for drug resistance detection. The possibility of applying the multiplexed nanoparticles to DNA detection in biomedical application was demonstrated. With a good magnetized property of MNPs and chemical function of AuNPs, the formed a MNP-analyte-AuNPs conjugate is not complicate to remove from the solution and leaded to the NPs suspension, respectively. The characteristics of these NPs are studied by transmission electron microscopy (TEM) and UV-Vis signal is monitored while multiplexed nanoparticles are interacting in solution. A number of serum samples are analyzed and monitored the background signal from the non-specific binding in patients' serum.

ID: B1-0025 **PO-01 : 41**

NANOPORE DETECTION OF DNA MOLECULES IN CROWDED POLYMER SOLUTIONS

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The analysis of biomolecules using nanopore sensors is a promising technique for ultrafast, portable and cheap genome sequencing. In a nanopore microscope, a single molecule is electrophoretically driven through a nanometer-scaled pore, linearized, and interrogated using different electrical detections schemes. The major bottleneck in the development of the solid-state nanopore technology is the lack of control of the speed and dynamics of the biomiolecules in the nanopore. We investigated a new method for controlling the speed and dynamics of a double stranded DNA, by immersing it in crowded solutions of polymers of different sizes and shapes. In general, we observe longer average translocation time, lesser translocation frequency and spatially confined DNA translocation events. DNA molecules interacting with the polymers were elongated, exhibiting only the single-file translocation through the pore, without any folding that is customarily observed for free DNA.The observed rich parameter space of the DNA-polymer-nanopore interaction offers the opportunity to control the behavior of the DNA molecule, and could shed light on the behavior of biomolecules in crowded environments, such as the one found in biological cells.

ID: B2-0001 **PO-01 : 42**

THE DETECTION OF KETAMINE IN ORAL FLUID ON PAPER-BASED DEVICES

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Ketamine was first developed in the 1965 as an anesthetic drug with dissociative, analgesic and psychedelic properties. It has remained the most common seized substance of abuse in Taiwan since 2006 and has been on a rising trend in recent years. Here we proposed two oral fluid testing platforms based on lateral flow immunoassay (LFA) and microfluidic paper□based analytical devices (μPAD). Both of them have been studied for on-site high-throughput monitoring of driving under the influence of drugs (DUID). A key advantage of the proposed technology is the ability to simultaneously and effectively measure low concentration of multiple drug compounds in oral fluid without the need of complex equipment, power sources and long processing time. Oral fluid is chosen as an adequate alternative matrix than urine and blood for drugs identifying and quantifying for DUID settings. A portable optical imaging device was chosen to take images of the calorimetric results based on its portability, light weight and on-site image recording and data transmission capabilities. As a result, a ketamine assay with a detection limit of 10 ng/mL, and a single assay can be completed in 6 min.

ID: B2-0002 **PO-01 : 43**

EFFECT OF STENT MESH STRUCTURE ON ITS FLEXIBILITY, TRACKABILITY AND CONFORMABILITY

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The mesh structure determines the mechanical characteristics of a balloon expandable stent, such as its flexibility, conformability and trackability. The assessment of these characteristics must be performed before starting clinical trials. This paper develops a series of simulation to assess stent flexibility, conformability and trackability using finite element method. Three stent mesh structure are included in the simulation: Palmaz, Sinusoidal and Asymmetric stent. Palmaz stent type is representative of a symmetric balloon expandable stent with rigid mesh structure and Sinusoidal is representative of that with more flexible mesh structure. Asymmetric stent is included in the simulation as a representative of balloon expandable stent with asymmetric mesh structure. Transient nonlinear analysis is performed in ANSYS to conduct the assessments. Flexibility assessment is performed for both unexpanded and expanded stents. Determination of flexibility is obtained by measuring stent deflection after subjecting similar moment loading to all stents types. Conformability assessment is conducted by expanded the stent inside artery module with 120deg curvature. Determination of conformability is obtained by comparing residual stress within the vessel wall. The last assessment, i.e. trackability assessment, is carried out by subjecting multiple moment load to an unexpanded stent, in order to generate `S` shape pattern of unexpanded stent. Determination of trackability is obtained by recording stent deflection. Material properties of 316 stainless steel are utilized for all stent types, while polyethylene terephthalate for balloon and hypocellular for the plaque and artery module. The material models are defined as multilinear isotropic for stent and hyperelastic nearly incompressible for the balloon, plaque layer and arterial module. 3D symmetrical model is implemented to reduce computational time. This research work is expected to succesfully develop a valid FEM simulation procedure in assessment of flexibility, conformability and trackability of balloon expandable stent.

ID: B2-0003 **PO-01 : 44**

CAPTURE OF TARGET CELL USING A NUCLEIC ACID APTAMER-MODIFIED DEVICE

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This paper presents capturing technique of the target cells using a nucleic acid aptamer. Capturing the target cell from biological solution is very important for medical diagnostics by liquid biopsy. The presented device is fabricated by coating the Au to the substrate and modifying a nucleic acid aptamer to the created Au surface. A nucleic acid aptamer has specific adhesion ability like antigen-antibody binding to

particular molecules. Therefore, this device permits the capturing of the various target cells by selection of nucleic acid aptamers. In this paper, cancer cells are used as target cell. The cancer cells has epithelial cell adhesion molecule (EpCAM) in the cell membrane. A nucleic acid aptamer that is able to specifically adhere to EpCAM was used for capturing the cancer cells. The specific adsorption test of a nucleic acid aptamer and mammary gland cancer cell (MDA-MB-453) was carried out for verification of principle by fluorescently-labeled aptamer and fluorescently-labeled scrambled DNA. As results, the nucleic acid aptamer specifically adhered to MDA-MB-453, and the scrambled DNA did not adhere to MDA-MB-453. Also, cancer cell capturing test was carried out using a fabricated nucleic acid aptamer-modified device. In the result of the evaluation, MDA-MB-453 was successfully captured by the nucleic acid aptamer modified on the substrate, and adsorption of healthy cell (HEK-293T) was successfully inhibited. These results indicate that this nucleic acid aptamer modified device is able to apply to the medical diagnosis and health diagnosis based on liquid biopsy.

Day 2 – Thursday, 8 December 2016

Session	Poster Session 02 (PO-02)
Date / Time	Thursday, 8 December 2016 / 12:30pm to 1:45pm

ID: C2-0001 **PO-02 : 01**

A FOLDABLE SOFT ROBOTIC SPIDER WITH FABRIC-BASED PNEUMATIC BENDING ORIGAMI ACTUATORS

Sivakumar Kandasamy, Chen Hua Yeow

National University of Singapore, Singapore, Singapore

Bio robotics, a rapidly emerging field, delves into the design of robotic systems that simulate living organisms found in nature. Bio robots, otherwise called biologically inspired robots, have been dubbed as the future of biomedical engineering. In this work, we explain a soft robotic spider design developed using pneumatics and origami techniques, where the purpose of the spider is to aid in surveillance operations. The robotic spider prototype is designed with four legs forming parts of a pneumatic body so as to simplify the actuation required. Each leg is isolated into two limb segments with fabric soft bending origami actuators attached externally. The pneumatic spider body is compact and when inflated, the spider grows nearly 5 times its initial size. Depending on the actuation input, each actuator which is pre-positioned to an angle of 450 can achieve a bending angle of 1800 at 100 kPa. This in turn helps the spider execute multiple movements in 2 axes by controlling the different segments in a pre-determined order. The spider is able to move at 10% of its leg-to-leg length for each complete actuation cycle of the four legs. The prototype is also able to support a load of 200% in proportion to its weight. The unique characteristics of this soft robotic spider are the range of motion of the bidirectional bending actuator and weight-to-size ratio of the spider. Moreover, the size and limb quantity of the robotic spider are highly customizable, depending on the application requirements.

ID: C2-0002 **PO-02 : 02**

AN OPTIMAL SHIRT SIZING SYSTEM FOR SINGAPORE POPULATION USING PARTITIONING AROUND MEDOIDS

Saurabh Garg, Heow Pueh Lee, Wee Kee Ng

National University of Singapore, Singapore

Wearing appropriately sized clothing is important not only for comfort and fashion but also for carrying out daily activities ergonomically (efficiently and safely). The US shirt sizing system is one of the common shirt sizing systems currently in use by large number of clothing retailers. However, due to variations of the body shape inherent to different ethnic groups it does not provide a good quality of fit for Singapore population. In this paper, we have developed an optimal shirt sizing system for Singapore population using the method of partitioning around medoids. We show that the proposed shirt sizing system provides a significant improvement in quality of fit compared to the US shirt sizing system.

The proposed shirt sizing system was developed from body dimensions obtained from 1091 males and 1138 females with age between 16 to 60 years old. Three measurements (chest, waist, and hip circumference) were used for females and six measurements (chest, waist, and hip circumference, shoulder width, shoulder to knuckle length, and neck circumference) were used for males. Similar to the US shirt sizing system, the proposed sizing system has two levels. In the first level, a primary measurement (chest circumference for females and neck circumference for males) was used to partition subjects into a number of groups. In the second level, for each group the remaining measurements were used to further divide the subjects into sub-groups such that all subjects in the same sub-group have similar size. We used the method of partitioning around medoids to determine the sub-groups.

ID: C3-0001 **PO-02 : 03**

THE DEVELOPMENT OF SOFT GRIPPER FOR NERVE REPAIR SURGERY

Jin Huat Low, Chen Hua Yeow

National University of Singapore, Singapore

Majority of the conventional surgical tools are made of stainless steel which provides robustness to the tools. However, it is not necessary for all surgical tools to be hard and robust, particularly the surgical graspers or forceps. They have to be used very cautiously during surgery because due to the “hard” surface of the tools, damage to the grasped tissue can occur easily if excessive forces were applied. The purpose of this study is to develop a soft hybrid nerve gripper system that will be useful in preventing tissue trauma during surgery through compliant gripping. The system consists of a three-joint robotic arm and a soft hybrid nerve gripper. Each robotic joint is made of two 3D-printed half cylindrical casings that house a male and a female connector. The fabrication process of the nerve gripper involved the processes of making the soft gripping component and 3D-printing of a rigid casing with hook-shaped nerve retractor. Ecoflex 0030 silicone rubber was chosen for the fabrication of the soft gripping component due to their hyperelastic properties. A pneumatic channel with 1 mm diameter was positioned at the middle of the rectangular soft gripping component and the entire gripping component was encased in a rigid casing with an opening area at both ends of the casing. One end will be connected to the external air source while the soft gripping component will inflate at the other end upon pressurization. The inflated elastomer can then be used to hold nerve tissues. The results showed that soft gripping component generated less compressive forces, compared to the forceps. It could be useful in minimizing the risk of tissue damage caused by hard surface.

ID: C3-0002 **PO-02 : 04**

INTERFERENCE MEDICAL CARE – USE OF ROBOTIC ACTUATED DUAL ARM PNEUMATIC SYSTEM AS MEDICAL RESTRAINT FOR PERIOPERATIVE MANAGEMENT OF PATIENT

Hwan Ing Hee[1], Hao Yong Yu[2], Kiang Loong Ng[3], Kiang Loong Ng[3], Kavitha Raghavan[1]

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Physical restraints are used in exceptional circumstances in clinical setting to control patients in order to facilitate safe delivery of medical treatment Physical restraint for patient care management is referred to as medical restraint Medical physical restraint is used when alternatives such as behavior therapy or pharmaceutical restraint with sedative failed or are not feasible The types of physical restraint used include belts (lap/wheelchair), safety vest, posy vest, papoose board These physical restraints have led to complications notably choking episodes and poor limb circulations

We propose a robotic actuated pneumatic system to aid safe restraining of combative patient onto the bed module by limiting movements of patient’s upper arms and torso This restrainer module consists of two arms that can open and close as human arms A layer of soft inflatable pockets encircled the arms In resting conditions, these pockets are deflated During operation, the pockets are inflated in a controllable manner in terms of speed and pressure to secure the patient in a gentle and firm manner The pockets are actuated by a portable pneumatic system powered by batteries in the electronics and power module This system combines the features of human arm and air bags to hold on to patients and limit their movement This is one of key novel aspects of this design It is a cost effective solution to achieve quick and safe physical human machine interaction The pneumatic system is controlled by an electronic and power module This module controls the dial arm movement as well as the pneumatic system by switch mechanism on the electronic control panel We explain the construction and the working principle of our new design

This restrainer module is part of a specialized motorized vehicle prototype developed by KKH with NUS and Hopetechnik with Singhealth Foundation

ID: C4-0001 **PO-02 : 05**

DEVELOPMENT OF AN EMG-BASED HUMAN-MACHINE INTERFACE ON OPEN-SOURCE LINUX PLATFORM FOR EVALUATING THE MOTOR SKILL ACQUISITION PROCESS

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Human-machine interface (HMI) not only assists the disabled people to perform tasks and activities, but also help in acquisition of motor skills for rehabilitation. Therefore, it is critically important to make a qualitative

assessment of the motor skill acquisition process during operation of HMI. Some of recent studies indicated that observe and analyze the changes of bio-signals were closely related to the improvement of motor skill. In this paper, we present a HMI for balancing control of virtual inverted pendulum using electromyography (EMG) signals. The proposed HMI was developed using an open-source control software RTAI (Real Time Application Interface) on Linux platform. EMG signals from forearm were recorded using two EMG electrodes placed around the extensor carpi radialis longus and flexor carpi ulnaris muscles. Moreover, the motor skills were evaluated by classifying the EMG signal patterns (i.e., muscle activation patterns), and measuring the motion of inverted pendulum including angular position, speed, and acceleration. An experiment was conducted using the proposed HMI with 8 normal subjects in laboratory. The results show that the proposed HMI are useful to examine the motor skill acquisition process; the skillfulness from EMG signal patterns closely related to human motor process.

ID: C4-0003 **PO-02 : 06**

DESIGN OF A MOBILE GAME-ASSISTED REHABILITATION PLATFORM FOR FROZEN SHOULDER PATIENTS

Cai Lin Chua[1,2], Kai Kei Cheng[3], Jeong Hoon Lim[1,4], Bimlesh Wadhwa[1], Atreyi Kankanhalli[1], Chen-Hua Yeow[1,2,5]

[1]National University of Singapore, Singapore; [2]Advanced Robotics Center, National University of Singapore, Singapore; [3]Appbition Pte. Ltd., Singapore; [4]National University Hospital, Singapore; [5]Singapore Institute for Neurotechnology, Singapore

Frozen shoulder, characterized by pain and stiffness in the shoulder joint, is one of the most common orthopedic conditions seen in 2% of the general population. Often, the clinical complications of frozen shoulder are severe enough to reduce the patient's quality of life. Physiotherapy shoulder exercise programs are reported to be effective in alleviating these complications; however, poor patient adherence to the exercise program at home due to the patient's lack of motivation is often observed. To address this, a home-based GamE-Assisted Rehabilitation (GEAR@Home) platform was developed. GEAR@Home comprises: a wearable wristband containing an Inertial Measurement Unit (IMU) that senses the wearer's arm movements; a mobile game involving the shoulder rehabilitation exercises; a cloud-based database for storing all users' game data; and a dashboard where doctors obtain information about their patients' home rehabilitation performance and progress.

The nine degrees of freedom IMU used gives angular output of roll, pitch, and yaw (RPY). When worn like a watch, the smart wristband can give information about shoulder angle changes. The mobile game is a "pluck-the-fruit" game, where a virtual fruit will be plucked only when the user has successfully performed the shoulder exercise shown on the screen. An action is considered successful when the RPY values, which are streamed from the smart wristband to the mobile game wirelessly via Bluetooth, detected during the game approximately match or outperform those captured during calibration. Preliminary studies of GEAR@Home involving healthy young adults showed that the average shoulder ranges of motion encouraged by the game are -51o to 160o flexion-extension and -49o to 143o adduction-abduction. Linear regression relation between pitch and flexion-extension angles was also found to be the strongest, with R2 values ranging from 0.846 to 0.956.

ID: C4-0005 **PO-02 : 07**

DEVELOPMENT OF SOFT ROBOTIC SIT TO STAND TRAINER SEAT

Azmall Fraiszudeen, Chen Hua Yeow

National University of Singapore, Singapore

This abstract presents the design of a soft robotic sit to stand (STS) trainer seat, for the partial retraining of STS postural transfer in patients with mobility disability. The device majorly consist of a soft pneumatic actuators, made with polyurethane, and control electronics, for controlling the inflation and deflation, and operating wirelessly from a Smartphone's Android App. This helps to track the angle of elevation and other useful parameters of the patients when operating the device, which can be monitored remotely by healthcare providers. Hence, this aids healthcare providers to oversee the progress of the patients using the device for STS retraining. Unlike the current devices, the presented design is compact, lightweight and more user friendly in independent handling and operating. A mathematical model of the force of the actuators developed is found to be reliable and validated using experimentally determined values. Experiments to also test the functionality of the design in lifting 20kg dead weights and 20kg manikin revealed that a 35°-45 ° elevation from the horizon is achieved with a pressure of 2 bar in less than 10seconds. In future, the load lifting capacity of the design will be further tested, with 20kg-40kg dead weights and Manikins and 50kg-75kg

human subjects. In addition to the trainer function of the device for STS postural transfer, more operational features will be added to the device, such as trainer for lower body muscular balance, and automated massage feature around the buttock region.

ID: C4-0006 **PO-02 : 08**

EVALUATION OF THE SUTURE STRENGTH OF THE ASYMMETRIC SIX-STRAND CORE SUTURE BY CYCLIC LOAD TESTING IN FLEXOR TENDON REPAIR

Chika Miyamoto, Raita Miyaji[1], Takeshi Shimoto[1], Satoru Ikebe[2], Atsushi Ishikawa[3], Hidehiko Higaki[3], Gou Miake[3], Naoya Kozono[3], Takamitsu Okada[3],

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For the medical treatment of damage or rupture in the flexor digital tendon, finger flexor tendon suture surgery is used. In previous studies, various core suture methods have indicated that important factors affect biomechanical properties, including the number of suture strands. Recently, asymmetric sutures have been reported to be effective. However, it has not been studied what is the optimal asymmetry or required degree of asymmetry.Therefore, this study was aimed to evaluate the strength evaluation and gap formation in asymmetric core suture under cyclic load testing. Porcine flexor tendons were used in this study. We sutured porcine flexor tendon using combination of six-strand core suture and interlocking cross-stitch peripheral suture. Six-strand core suture was 1 type of symmetry and 5 types of asymmetry. As reference to the suture purchase (10mm) from the end of the porcine flexor tendon, an asymmetric suture were shifted to 1mm, 2mm, 3mm, 4mm and 5mm from the reference position, respectively. This experiment were performed under cyclic load testing using an evaluation simulator our research group developed. A 2 N preload was applied to each of the sutured tendons. The tendons were tested with an initial load of 10 N for 500 cycles. If no evidence of failure was noted after the 500 cycles, the force was increased by 5 N for each additional 500 cycles. This procedure was continued until rupture. The sutured tendons were pulled at a constant distraction rate of 300 mm/min. In result, the tendons with 2mm or more asymmetry had significantly smaller gap formation and greater the number of cycles than the tendons with symmetry. About gap formation, 3mm asymmetry gives a significant difference between data with the other. Our results support that 3mm asymmetry is needed to produce beneficial effects than the other.

ID: C4-0009 **PO-02 : 09**

A DEVELOP OF GRIP POWER FEEDBACK SYSTEM FOR ARTIFICIAL HAND USERS

Kyoko Asakura, Kazushige Magatani

Tokai Uiversity, Japan

We are developing the grip power feedback system for amputee. This system uses some EMG signal which are measured from the forearm of the amputee. Because there are many kind of muscles in the forearm and hand motions are dominated by them, using these EMG signals we can estimate many kind of hand motions. Therefore, many type of electric artificial hands which estimated hand motions using EMG were experimentally developed. However, these artificial hand controlled by EMG can only move according to estimated results, and they cannot display power according to the hand motion. So, the artificial hand which can display grip power to the amputee has experimentally developed by us. In this system a pressure sensor which is set on a finger of the artificial hand senses grip power. This system can display variation of grip power of the artificial hand as variation of air pressure of a cuff which is set around of the upper arm. In a previous system this cuff pressure was controlled by an electric air pump and a solenoid valve. This pump was not able to provide air quickly. For this characteristic, the cuff pressure was not able to display changes in grip power in real time. In our new system, air is reserved in a small tank at high pressure, and this air is used for controlling cuff pressure. By this structure the rise time of the cuff pressure in the new system has become faster than the previous system. Some normal subjects were experimentally studied in our developed new system. In all experiments, our new system was able to display variation of grip power in real time. From these result, our developed system will be a powerful tool for the amputee.

ID: C4-0011 **PO-02 : 10**

DESIGN OF A SILENT SPEECH INTERFACE USING FACIAL GESTURE RECOGNITION AND ELECTROMYOGRAPHY

Vidhya S., Aishwarya Nair, Senthil Kumar Kirthikam, Niranjana Shashikumar

VIT University, India

A Silent Speech Interface (SSI) aims to substitute natural speech production using various electronic/

mechanical techniques, to be used as an aid to the vocally-challenged or vocally-impaired. Such devices show significant promise as replacements for natural oral communication in persons with vocal disabilities or impairments. SSIs have been experimentally developed in both unimodal and multimodal systems with the help of several technologies, including optical and ultrasound imaging of the lip, tongue and throat regions; mapping of articulatory information using an electromagnetic articulograph; direct mapping of electroencephalogram details; Brain-Computer Interfaces and lip tracking mechanisms. This paper puts forth an SSI implemented via optical facial imaging and lip region segmentation, with additional exploration of the potential of an integrated system using facial electromyographic input. The entire interface is implemented using MATLAB computing software. This interface requests a test video from the speaker in which various words are mouthed without any audio input. Chan-Vese segmentation algorithm segments the lip region within frames of maximum relevance, following which features are extracted from the processed frames. Recognition of the mouthed word is performed by a Multi-Class Support Vector Machine classifier; trained using similarly obtained data from controlled speech databases. The classifier displays the recognized word as text, following which a Text-to-Speech module provides synthesized speech output. The interface as described currently operates at a recognition accuracy of 97.5% for four words. For further refinement and to boost accuracy, a multi-modal system with surface EMG input of the jaw, laryngeal and pharyngeal is proposed, in which the EMG data serves to differentiate optically similar words as well as validate the classification done using optically extracted features.

ID: C4-0013 **PO-02 : 11**

DEVELOPMENT OF THE PULLING SENSATION DEVICE USING LINEAR OSCILLATORY ACTUATORS FOR THE DISABLED

Takashi Suzuki, Kazushige Magatani

Tokai Uiversity, Japan, Japan

The objective of this study is the development of the device gives a pulling sensation for the disabled. Development of the haptic devices has been attempted over the years for the visually impaired. We have considered that we need to develop a simple device which served high fidelity haptic sense for the visually impaired. In addition, we have developed the electromyogram prosthetic hand. Therefore, in order to be possible for physically handicapped people to accurate control the EMG prosthetic hand, the developed device is also designed to feedback the haptic sense of EMG prosthetic hand. The purpose of this study is developing such device and evaluating it. We can feel a pulling sensation toward specified direction using this device. The device made up of 4 stack Linear Oscillatory Actuators on each 3-axis (X-axis, Y-axis, Z-axis). The Linear Oscillatory Actuator generates linear reciprocating motion from the internal moving magnet. We obtained a pulling sensation toward specified direction by PWM driving the magnet toward specified direction and braking magnet toward inverted specified direction. These actuators are mounted on the acrylic base plate. This base plate was embedded in the resin sphere with a diameter of 50mm. Angles intended to display are transform to the spherical polar coordinate in our device. The microprocessor makes PWM signals based on the spherical polar coordinates. These PWM signals drive 12 actuators. We evaluated the device with a three axis acceleration sensor. The result of our evaluation clearly shows that a pulling sensation toward arbitrarily direction was confirmed. In the future, it will be possible to guide the visually-impaired in arbitrary direction and to feedback the haptic sense of EMG prosthetic hand.

ID: C4-0014 **PO-02 : 12**

A REAL-TIME SYSTEM TO ENSURE COMPLIANCE IN HOME-BASED TELE-REHABILITATION

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[3]Advanced Digital Sciences Center, Singapore

The inability to monitor compliance is a major drawback in current home-based tele-rehabilitation systems for physical therapy. A prescribed regimen of exercises may be performed incorrectly or not performed at all, and there is no immediate feedback on compliance to the patient. We present a Microsoft Kinect camera-based system that can monitor compliance in home-based tele-rehabilitation. The participants perform exercises and the positions of salient joints are captured by a Kinect camera. The joint information is input to a machine-learning algorithm that can assess the accuracy of the movements as compared to a training set of normative or expected movements. Incorrect movements are reported in real-time, making it possible to provide feedback to the patient. To build this intelligence into the system, 20 healthy adults

performed ten exercises which are meant for Multiple Sclerosis patients and the movements were sfs captured by a Kinect camera. This dataset was divided into a training dataset consisting of 10 participants' data and a testing dataset consisting of the remaining 10 participants' data. The training dataset was used to train the prediction algorithm, while the testing dataset was used to test the algorithm's prediction accuracy. Different feature extraction methods were applied to the training data for different exercises based on which features best helped to differentiate correct movements from erroneous movements. After preprocessing the extracted features, the data were used to train different supervised and unsupervised learning methods, and in each case the classification performance and generalization capability of each method were measured. The k-means clustering algorithm was selected for the final real-time system since it was computationally light, in addition to being accurate. The final system was capable of ensuring compliance in real-time as the participants performed the exercises. The system will enable doctors to remotely view and track physical therapy and assess

ID: C4-0021 **PO-02 : 13**

LATENCY CHARACTERIZATION OF POSTURAL RESPONSE OF STANDING HUMANS TO UNPREDICTABLE ARM PERTURBATIONS

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Humans constantly interact physically with the world around them using their hands while standing. These interactions involve unpredictable forces that not only disturb the focal task, but also destabilize balance. The results of the present study show that when the arm of a standing human is perturbed in an unpredictable direction, postural muscles are activated at latencies as short as 50-110 ms with respect to the perturbation onset. These latencies are shorter than the mean voluntary reaction time and, hence, the changes in muscle activation must be automatic. While the motion of the body clearly progresses in hand-to-leg sequence such that the ankle joint rotation occurs at the latency of 159±20 ms, there is no systematic muscle activation sequence from the rostral to the caudal muscles, suggesting that the activation of the muscles is not likely the result of autogenic stretch reflexes. In fact, the lower limb muscles are activated before the upright posture is significantly disturbed. We propose that pathways similar to those of inter-limb reflexes, originating from sensory receptors innervated by the cutaneous nerves in the hand or the muscle spindle afferents of the perturbed arm might underlie the response. The results of this study provide insight into the underlying control mechanisms and coordination of arm movement and balance and can be used as a baseline for diagnosing pathologies that might disrupt such coordination.

ID: C4-0022 **PO-02 : 14**

KINETIC ANALYSIS OF GAIT IN HEMIPLEGIC PATIENTS USING AN INSTRUMENTED CANE WITH A TRIAXIAL FORCE SENSOR

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Understanding biomechanics of cane-assisted gait in hemiplegic patients is important for developing better therapeutic interventions in rehabilitation medicine. However, in kinetic gait analysis, if the foot and the cane in the ipsilateral hand are placed on a force plate simultaneously, the forceplate cannot separate the forces acting on the foot and the cane as it records the sum of the forces. To overcome this indeterminancy problem of the reaction force and the center of pressure (COP) in cane-assisted gait analysis, we developed an instrumented cane with a triaxial force sensor. The triaxial force sensor was inserted in the tip of the cane shaft and the forces acting on the cane tip was triaxially measured. Six reflective markers were attached to the cane to obtain the spatial orientation and the tip position of the cane during gait, so that the foot and cane forces and COPs can be partitioned based on force and moment equilibrium. Errors associated with the force and the COP measurements were confirmed to be within the range of about 1.0 N and 1.3 mm, respectively, indicating that the separations of the force and COP were reasonably accurate. Using the instrumented cane, a motion capture system and force plates, cane-assisted gait of hemiplegic patients were measured every four weeks from the time when they were able to walk with cane assistance, and changes in the COP trajectory during cane-assisted walking were analyzed. Our preliminary result showed that improvement in gait speed was correlated with the increase in the amplitude of the mediolateral COP movement during walking, possibly indicating that ability to laterally transfer the COP is the key for the restoration of walking ability in hemiplegic patients.

ID: C4-0023 **PO-02 : 15**

SENSOR-BASED ASSISTIVE TECHNOLOGY TO AID ARM RECOVERY IN STROKE AND ITS EFFECTIVENESS: A SYSTEMATIC REVIEW

Aneel Kumar Maheshwari, Paulette Van Vliet

University of Newcastle Australia, Australia

Background: Improving upper limb function is a core element of stroke rehabilitation needed to maximize patient outcomes and reduce disability. This review combines information about overall devices and to evaluate the effectiveness of these methods in improving upper limb motor control. Objective: To identify all existing sensor-based assistive technology targeted at improving motor control of the upper limb following stroke; to investigate the effectiveness of current sensor-based assistive technology for improving the motor control of the upper limb following stroke. Search methods: The search included The Cochrane Central Register of Controlled Trials (CENTRAL) (The Cochrane Library); MEDLINE; EMBASE; CINAHL; AMED; IEEE Explorer; ProQuest Dissertations and Theses (International), and ISI Proceedings (Conference) databases. The search spanned from 1950 to 2015 and was limited to publications in English only. Data collection and analysis: Two review authors independently categorized retrieved papers according to inclusion and exclusion criteria. The quality of evidence within each comparison in each review was determined using the Pedro levels of evidence scale. We systematically tabulated data extraction, and the effects of the intervention have been summarised in tables. The information was accumulated in RevMan and results to described as Forest plots. Results: Our searches identified 3444 records, out of which 1080 duplicate records were removed. 2364 records were screened and excluded based on titles and abstracts. These records were assessed against the inclusion criteria (types of studies, types of participants, types of interventions, and type of outcomes measures) by review authors. Finally, 82 studies for objective 1, and 31 randomized controlled trial studies for objective 2 were divided into 7 groups; Computer gaming (3), EEG and MRI (2), EMG and electrical simulation (5), Mechanical arm training (2), Spring-based system (2), Telehealth system (2), and Virtual Reality system (15). Meta-analysis was performed where studies used the same outcome measures.

ID: C4-0025 **PO-02 : 16**

THE MOTION RECOGNITION OF UPPER LIMB BASED ON SURFACE ELECTROMYOGRAPHY FOR THE ROBOTIC ARM CONTROL

Hongmiao Zhang, Jiali Yu, Fumei Tu, Hao Guo, Zhiyuan Zhao, Lining Sun

Soochow University

With the demand of prosthetic control and intelligent robotic arm driven, the recognition of motion modes based on surface electromyography(sEMG) signals have receiving more and more attention. Some techniques of sEMG researches such as stable signals collecting, ambiguity of electrodes location, motion-related feature selecting of sEMG still need to be improved for the application of robotic arm on the disabled people. We study three upper limb motions and collect corresponding sEMG signals by the patch electrodes. The locations of the electrodes were selected based on topographic anatomy and the collected signal was compared. After noise-removal processing, wavelet transform was applied to extract features of upper limb motion. The variance and singular value of wavelet coefficients were extracted to compose the feature vector. And then the BP neural network classifier were applied to recognize the three different upper limb motion modes, and reaches 86.6% accuracy rate of recognition.

ID: C4-0026 **PO-02 : 17**

DIFFERENCES IN SPATIAL DISTRIBUTION AND ACTIVE/INHIBITED FREQUENCY BAND OF HEMOGLOBIN INFORMATION IN THREE MOVEMENT SPEED LEVELS.

Chunguang Li, Shaolong Kuang, Juan Li, Weida Li, Hao Guo, Hongmiao Zhang

Robotics and Microsystems Center, Soochow University, China

Patients with motor dysfunction and aged persons with low motor function need to perform rehabilitation training for improving self-care ability. In order to increase training flexibility and rehabilitation effect, adaptive speed at any time rather than a fixed speed during a certain interval of time are preferable. Therefore, our project considered a method to adjust movement speed based on brain hemoglobin information. 10 subjects performed bicycling movements in three speed levels. The start and stop of movement, and the speed were all controlled by the

subjects themselves. Hemoglobin information in each channel was decomposed to different frequency bands with an interval of 0.03Hz. The amplitude and changing trend of 'oxy-deoxy' (difference in the variation rate of oxygenated and deoxygenated hemoglobin) in each frequency band were analyzed. Then, spatial distribution features were summarized based on the features of each channel. This is advantageous to discover spatial characteristics compared to averaging regional values directly. The results are as follows: SMAL (left region of supplementary motor areas), the inhibition frequency-band were 0.06-0.09Hz, 0-0.03Hz, and 0.09-0.12Hz, respectively in the slow, moderate, and fast speed levels, and 0.09-0.12Hz was the significantly active frequency-band in the slow and moderate speed states; SMAR(right region of SMA), the inhibition frequency-band were 0.06-0.09Hz, 0-0.03Hz, and 0-0.03Hz+0.09-0.12Hz respectively in the slow, moderate, and fast speed levels, and 0.09-0.12Hz was the same active frequency-band in the three speed states; PMC (premotor cortices), as for the slow, moderate, and fast speed levels, the inhibition frequency-band were 0.06-0.09Hz, 0.06-0.09Hz, and 0-0.03Hz respectively, and the active frequency-band was 0.09-0.012Hz, 0.09-0.012Hz, and 0.06-0.12Hz respectively. The results showed that the active/inhibited frequency bands of hemoglobin concentration have a significant difference in spatial distribution for different speed states. This lays an important foundation for identifying subjects' voluntary movement speed, and further to improve adaptability of rehabilitation training.

ID: C5-0010 **PO-02 : 18**

DAY 2
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DEVELOPMENT OF A SPECIALIZED EEG HEADSET FOR ANXIETY DETECTION DURING AIR RIFLE SHOOTING

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The ability to survive stress and anxiety is the most essential feature of any sport. The elite are expected to tackle their emotions and face the situation. An eminent research has been piloted examining the equation between anxiety and performance, especially among the air rifle shooters.Electroencephalography (EEG) is one of the most acclaimed biomedical tests to monitor human emotions . The key areas of the brain that are said to be affected among people experiencing social anxiety are the occipital and the frontal lobes. In this paper, we would like to shed lights on the wearable EEG head set recommended for anxiety monitoring and its consequence on air-rifle shooters by collecting data from the activity of the brain and then investigating the mental state of the shooter from the data obtained. This custom devised EEG headset, encompasses two custom-made EEG sensors for frontal and occipital lobes, both driven on an Arduino platform. The electrical brain signals are acquired and processed using a system which has circuit level components including the frontal electrodes, occipital lobe electrodes , EEG amplifiers and aurdino pro mini. The processed data is then sent to the monitor screen wirelessly through an Arduino-bluetooth system, from which we can detect the anxiety level by studying the alpha (8Hz – 15Hz) , beta (16Hz-31Hz) , theta (4Hz-7Hz) and delta (< 4Hz) peaks of the data acquired.

ID: C5-0013 **PO-02 : 19**

DEVELOPMENT OF CPR PARAMETERIZATION SYSTEM BASED ON 3-AXIS ACCELEROMETER

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Introduction
Cardiopulonary resuscitation(CPR) is one of the simplest first aid methods to resuscitate cardiac arrest patient and its importance is being emphasized in these days. CPR must be performed correctly to increase resuscitation rate of the patient and there are important parameters related to CPR accuracy such as chest compression axis, compression depth and compression rate. However, there is no standard for CPR evaluation and conventional systems that measure above parameters has a disadvantage that the systems should be placed on patient's chest directly. In this paper, therefore, wrist-type wearable CPR parameterization system based on 3-axis acceleration signal was developed for measuring chest compression axis, compression depth and compression rate.

Method
3-axis accelerometer was calibrated for measuring accurate chest compression axis, compression depth and compression rate. First, chest compression axis can be estimated by calculating arctangent value of contained angle between two acceleration signals. Second, chest compression depth can be estimated by integrating acceleration signal twice using Trapezoidal method to minimize integral error. Third, chest compression rate can be estimated from peak-to-peak interval of chest compression depth signal.
To evaluate the accuracy of the system, CPR

mannequin was used to compare the estimated chest compression axis, compression depth and compression rate with real values.
Conclusion
This study proposed wearable CPR parameterization system based on 3-axis acceleration, and chest compression axis, compression depth and compression rate were estimated within ±2% error rate. It is possible to evaluate the accuracy of CPR with the developed system. In the future, 3-axis accelerometer will be combined with 3-axis gyroscope to increase the accuracy of the system.

ID: C5-0015 **PO-02 : 20**

SMARTWATCHES AS CHEST COMPRESSION FEEDBACK DEVICES DURING INFANT CARDIOPULMONARY RESUSCITATION

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Background: According to American Heart Association (AHA) 2015 guidelines, the use of feedback devices likely helps the rescuer optimize adequate chest compression rate and depth during infant cardiopulmonary resuscitation (CPR). However, there were no chest compression (CC) feedback devices for infant CPR. In this study, we suggest a smartwatch based CC feedback application for infant CPR.

Methods: We made a CC feedback application by double integrating of acceleration signal from smartwatch. This application provided feedback of CC depth and rate based on color and text, according to 2015 AHA guidelines for infant CPR. To evaluate the effectiveness of application, 12 participants were randomized into two groups based on whether CC was performed with or without the assistance of the smartwatch application. Both groups performed hands-only CPR on an infant manikin laid on the rigid table for two minutes. We collected CC parameters from the manikin, including % correct depth (%CD, % of the number of 3.5 cm ≤ CC depths ≤ 4.5 cm/total number of CCs), CC rate (CCR) and CC depth (CCD). Results: Demographics between the two groups were not significantly different. The median (IQR [range]) %CD was 99.5 (94.7–100 [88.0–100]) with and 69.0 (42.5–96.2 [20.0–100]) without feedback (p = 0.041). The CCR was no significant difference between the two groups (p = 0.937). The CCD of the feedback group was significantly deeper than that of the control group (feedback vs. control: 41.7 (39.4–42.4 [37.5–42.6]) mm vs. 36.5 (34.2–39.3 [32.2–40.3]) mm; p = 0.015).

Conclusion: We estimated that real-time visual feedback provided by a smartwatch might help to maintain adequate CCs during infant CPR.

ID: C5-0016 **PO-02 : 21**

LOWER LEG MUSCLE ACTIVITY DURING GAIT CYCLE PHASES USING H-GAIT SYSTEM WITH EMG TELEMETER

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EMG is used to detect muscle activity and evaluate walking performance. In the previous study, a three-dimensional gait analysis system using wearable inertial sensors based on quaternion calculations, H-Gait system, was proposed. The current study combined H-Gait and an EMG Telemeter, a wireless surface EMG measurement system, which allowed for gait analysis and EMG to be conducted without limitation to space or time. Simultaneous gait analysis with EMG could provide muscle activity timings in association with various lower limb postures during a gait cycle. This can then be used to assess abnormalities or the risk of fall during specific gait phases. Seven H-Gait sensors, were attached to seven lower limb body segments (pelvis, both thighs, both shanks and both feet) of the volunteers recruited for this study. Moreover, dipole surface electrodes were attached to five muscles of the lower right legs (tibialis anterior (TA), soleus (Sol), gastrocnemius medius (GM), biceps femoris (BF) and vastus lateralis (VL)). The measured acceleration and angular velocity data were used to estimate three-dimensional kinematic parameters of volunteers during level walking on the treadmill. Heel contact timings were used to divide the measurement data into gait cycles. Synchronization of the H-Gait system and EMG Telemeter in the time domain was achieved via electrical triggers at the start and end of swing phase. As a result, BF and VL acted at the initial of stance phase and the end of swing phase. TA acted at the initial of stance phase and the swing phase. GM and Sol acted at the medial of the stance phase. Kinematics and EMG data were similar to typical patterns in many previous studies. These

results proved that the proposed system was capable of detecting clinically relevant muscle activity profiles of the lower leg simultaneously with gait kinematics.

ID: C5-0017 **PO-02 : 22**

DIAGNOSIS SUPPORT SYSTEM OF PARKINSON'S DISEASE BASED ON GAIT TRAJECTORY

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[Introduction]
Parkinson's disease (PD) is known for motor disorder, such as rhythm generation impairment or brachybasia. A wearable sensor system to measure gait trajectories is effective to monitor gait in PD easily and continuously. In the previous studies gait trajectories have been analyzed, but not applied to diagnosis support. Therefore, the purpose of this study is to apply gait trajectory data to diagnosis support of PD for the first time.

[System Configuration]
We proposed the gait measurement system, which consists of a tablet device and two wearable IMU sensors worn on both the ankles1. Furthermore, we realized gait analysis system that estimates gait trajectories using measured acceleration and angular velocity2. In this study, we develop diagnosis support system based on the above systems.

[Method]
In this study, 30 patients with PD (Hoehn & Yahr Stage 1-2) and 24 healthy elderly people participated the measurement experiment. Firstly, we measured their waking using the above measurement system. From the reconstructed gait trajectories, we extracted six features, such as stride length and foot clearance. We contracted them to two dimensions with principal component analysis. In the feature space which is composed of the first and second principal components, we developed a classifier using support vector machine.

[Result]
Evaluation of the classifier using 10 fold cross-validation showed that the accuracy of the classifier differentiating patients and healthy people was 92.6%.

[Discussion]
The result indicates that gait trajectory data is useful for diagnosis support of PD in the proposed system.

ID: C5-0018 **PO-02 : 23**

A FABRIC-BASED SOFT WEARABLE ROBOTIC BELT FOR ACTIVE HIP PROTECTION

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The hip joint is one of the most essential human joints responsible for stability and locomotion in man, but are more susceptible to joint fractures and dislocations. Therefore, the hip joint demands for good amount of protection and medical care, especially in a growing elderly population who are at a risk of unpredicted falls on the lateral region of the hip. This work involves the development of a fabric-based soft robotic belt that can be worn around the waist and activated based on a pneumatic mechanism for active hip protection. The pressurized air is pre-stored in the on-belt air storage system. Upon detection of a fall, pressurized air exits the storage system and inflates the soft fabric actuators, which then cushion the hip from impact with the ground. The fall detection can be sensed using an accelerometer and the command signal from the microcontroller controls the actuation. The device can be recouped into its original structure post inflation. Since the air is pre-stored, it avoids the situation of carrying a pump making it weightless and portable.

ID: C5-0019 **PO-02 : 24**

A PORTABLE PHOTOTHERAPY GARMENT (PPG) USING BLUE SURFACE-MOUNTED-DEVICE (SMD) LIGHT-EMITTING DIODE (LED) FOR NEONATAL JAUNDICE

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Neonatal jaundice is the yellowing of the skin, sclera and other tissues that occurs in newborn infants due to excessive bilirubin in the blood and the limited ability of the infants' liver to excrete bilirubin. Phototherapy is widely used to treat jaundice in newborn and utilizes specific light source (fluorescent tubes, halogen lamps, fiberoptic system & light-emitting diodes (LED)) to reduce bilirubin level in infants which is discreted from the infants' bodies through their feces and urine. Despite the proven capability to treat neonatal jaundice, the efficacy of available phototherapy devices may be limited to several conditions. The broad wavelength light output from the conventional lights may cause

harmful nauseous effects to healthcare personnel and generate considerable amount of heat that may lead to thermal injury to the infants' skin. Phototherapy require continuous uninterrupted treatment time and due to the fixed structure of most conventional units used in hospitals, it is difficult for breastfeeding mothers to comfortably breastfeed their infants. Blue LEDs are used in phototherapy devices due to its unique characteristics which include high sensitivity towards bilirubin reduction, power efficient, light in weight, less heat production, low in cost and a longer lifetime. The Portable Phototherapy Garment (PPG) is proposed using blue surface-mounted-device (SMD) LEDs which are arranged on a garment and equipped with a body temperature and alert system to indicate any abnormal temperature during the treatment and to notify completion of treatment. The rechargeable power supply is small and light which allows phototherapy to be carried out anywhere. Experiments were conducted to compare the efficiency of the PPG in reducing bilirubin level in Artificial Bilirubin Standard Solution (ABSS), compared to fluorescent tubes (commonly us in hospitals). Results show that the PPG was more efficient (11% -37%) in bilirubin degradation compared to the fluorescent tubes (3% - 17%)

ID: D1-0001 **PO-02 : 25**

INFLUENCE OF THE BULGING SINUS SIZE OF THE LIVESIZED EPTFE VALVE CONDUIT ON THE VALVE OPENING AREA AND FLOW FIELD

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Good clinical records seem to show ePTFE valve conduits may be a good choice for treating right ventricular outflow tract (RVOT) reconstruction in congenital heart defects Preceding study showed that bulging sinus of the aorta model used as enlarged ePTFE valve conduit seem to have favorable effect on hemodynamic performance particularly on opening area of valve Vortex inside the bulging sinus seems to play a key role on valve opening mechanism This research aims to study the effect of the bulging sinus size of the ePTFE valve on the valve opening area and flow phenomenon inside the conduit

Five valve conduit models with different bulging sinus sizes were prepared Considering the degree of the bulging sinus of aorta being normal, 0.2 times model, 0.4 times model, 0.7 times model, normal size model (1 times model), and 1.2 times model were constructed Effect of the bulging sinus size on a flow field inside the valve conduit was analyzed using Dynamic PIV system running at 1000 frames/s and valve opening areas were directly recorded using high speed digital camera running at 240 frames/s

Comparison of flow field results showed that the flow field of valve conduits with normal size and 1.2 times model generated majority of strong vortex inside the bulging sinus. Valve opened and closed early with normal and 1.2 times model compared to other smaller sized bulging model Direct observation of the opening area of the valve showed that wider opening area was observed with normal and 1.2 times model Based on these experimental results, proximity of vortex center to the valve leaflet location associated with normal and larger bulging sinus seems to play important roll on valve open and close mechanism.

ID: D1-0003 **PO-02 : 26**

INVESTIGATE INTO FUTURE OF PROSTHETIC WITH SENSATION

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The Objective of work carried out in this project was to investigate how the brain resolves conflicting multisensory evidence during perceptual interference. The Rubber hand illusion and mirror hand illusion are two most famous examples of experiments in which illusionary body ownership is convinced by tactile stimulation of participant's hand. To identify the functional anatomy of these experiments, we used multichannel EEG. Brain response was investigated in 20 healthy (no amputated) candidates, (10 men. 10 women age between 20-42)
First experiment rubber hand illusion (RHI) carried out under four conditions; hand of volunteer stroke on presents of the artificial hand while real hand was hidden from the participant's vision, stroking real hand and rubber hand at the same time but different angels, stroking hand and artificial hand without hiding real hand,also,stroking hidden real hand without presents of artificial hand, also known as invisible hand illusion. Second experiment, mirror hand illusion (MHI), also carried out in two conditions, no mirror, looking at physical hand and, mirror, the illusion that hands were stimulated.

EEG results suggest that gender difference exist in perception of body transfer illusion. Visual input can be induced to trick the brain as 100% of participant had confirmed the statement of "the fake hand feel like my hand".

Using results of above experiments and implementing learning mechanism, new system was fabricated. the system intended to produce an accurate representation of human hand sense of temperature consisting of three modules. The first module should communicate with the Headset and get EEG signals during different experiments, the second module should process those signals and make input parameters for the third module, which should be senses and noises with different frequency and communicate with the brain with varies input parameter.

ID: D2-0002 **PO-02 : 27**

EFFECT OF PRECISION MACHINING FOR BEARING SURFACE IN ARTIFICIAL JOINT ON REGULATION OF MACROPHAGE ACTIVATION

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The reduction of tissue reactions in an artificial joint composed of an ultra-high molecular weight polyethylene sliding on a Co-Cr-Mo alloy, was investigated. To control the specific wear rate and morphological features of wear debris of the polyethylene, micro slurry-jet erosion was used as a precision machining method for the bearing surface of a Co-Cr-Mo alloy. This method constitutes a type of wet blasting technique, which uses alumina particles as an abrasive medium, along with compressed air and water, to create textured surfaces. Pin-on-disc wear tests, involving multidirectional sliding motion, resulted in a decrease in the polyethylene wear and changes in the morphological features. Primary human peripheral blood mononuclear phagocytes were incubated with the debris, and the wear debris generated on the textured surface changed the secretion of the IL-6 proinflammatory cytokines. However, the hydration state of debris in the culture medium had an effect on the results, and therefore the incubation conditions must be investigated in further detail.

ID: D2-0005 **PO-02 : 28**

LAYER-BY-LAYER CONSTRUCTION OF LIPID BILAYER ON MESOPOROUS SILICA NANOPARTICLE TO ENHANCE ITS HEMOCOMPATIBILITY

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Mesoporous silica nanoparticles (MSNs) have been repeatedly demonstrated as potential drug-delivery system with good biocompatibility and targeted drug delivery. While their aggregation phenomena and hemolysis effect limit their applications in biomedicine. To address this challenge, we developed a silica-based protocell with PEG-lipid on outside surface by modification of MSNs and subsequent hydrophobic interaction. N-[N-(3-Triethoxysilyl)propylsuccinamoyl] dihexadecylamine, a organoalkoxysilane lipid was synthesized and employed for hydrophobization of MSNs. The lipid bilayer coated structure was characterized by TEM, IR, TGA, DLS, and BET. IR and TGA gave a quantitative evidence for surface modification, the lipid coating of MSNs was observed under TEM after negatively stained with phosphotungstic acid. DLS analysis gave a more little average size with narrower size distribution (219.7 nm (PDI=0.08) vs. 287.5 nm (PDI=0.16)), as well as a excellent suspension stability with no size variation within 24 hours. The nitrogen absorption by BET method showed that the protocells have a smaller surface area (165 m2 g-1) as compared to MSNs (1091 m2 g-1). To investigate its biocompatibility of the protocell, we conducted HSA absorption and hemolysis assay. The protocell showed decreased nonspecific protein absorption (2%) and hemolysis effect (1.3%, 1000 μg mL-1) when compared with MSN (19% and 57.9%). These results suggest that the protocell is safety to be used as anti-tumor drug delivery system.

ID: D2-0006 **PO-02 : 29**

CYTOTOXICITY TEST OF E-GLASS FIBER REINFORCED COMPOSITES FOR FIXED DENTURES ON FIBROBLAST LINE CELLS (MTT ASSAY)

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Objectives. Fiber-reinforced composites are composite material consisting of combination of a polymer matrix

that is reinforced by fine fibers, which have high tensile strenght and high flexural modulus. This material has been used for dental applications such as fixed bridgework dentures, endodontics posts, periodontal splints and others. One of fibers that can be used is e-glass fibers. E-glass fibers have good properties such as resistance to acids and chemicals. The aim of this study was to evaluate the cytotoxicity of e-glass fiber-reinforced composite on fibroblast line cells with MTT assay.

Methods. Fibroblast line cells were cultured for 24 hours in DMEM (Dubelcco's Modified Eagle Medium) as culture medium. Composite resin Masterflow® (Biodinamica, Brazil) and e-glass fiber-reinforced composites were made into powders, dissolved in DMSO (Dubelcco's Phosphate-Buffered Saline) and diluted with culture medium. Cultures were exposed with the extracts for 24 hours, and tested by the MTT assay. The results from the experiments were statistically analyzed by independent samples t-test ($\rho<0.05$).

Results. Fibroblast line cells that exposed with composite resins showed viability between 60-90% (slightly cytotoxic). Fibroblast line cells that exposed with e-glass fiber reinforced composites showed viability more than 90% (non-cytotoxic).

Conclusion. It can be concluded that e-glass fiber-reinforced composites induced no cytotoxicity and safer to fibroblast line cells than composite resins.

Keywords : E-glass Fiber-reinforced Composite, Cytotoxicity, Fibroblast Line Cells, MTT assay.

ID: D2-0009 **PO-02 : 30**

BONE LIKE COATINGS FOR MEDICAL IMPLANTS CREATED BY ATMOSPHERIC PRESSURE PLASMA

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A common approach to optimize osseointegrative properties of bone implants is the application of coatings with bone like materials such as hydroxyapatite. Hydroxyapatite is bioactive and one of the main components in human bones.

In the present study hydroxyapatite spray coatings were created from a sol by using an atmospheric pressure plasma jet (APPJ). The APPJ features high flexibility, operating in ambient conditions, low costs, easy integration in in-line processes and a reduction of equipment compared to low pressure systems. As the precursor for the hydroxyapatite coatings, a sol was used consisting of water, triethylphosphite and calciumnitrate. The deposited coatings show a high porosity and a structure, similar to the cancellous bone. To evaluate the chemical composition and the topography of the coating, XPS, SEM and XRD were performed. The chemical analysis leads to the conclusion that the coating indeed consists of hydroxyapatite by showing the presence of calcium and phosphor in the required ratio (Ca/P 1.67). Also carbonates could be detected at the surface by XPS measurements, which however could be reduced by a post thermal treatment. The XRD measurement showed a crystallinity at calcination temperatures higher than 400°C. The wettability was determined by contact angle measurements, which was approximately 25° and thus indicates hydrophilic properties of the surface. Cytotoxicity test according to DIN EN ISO 10993-5 as well as cell adhesion and proliferation test were applied. The coatings were proved to be non-cytotoxic. Adhesion and proliferation of cells was tested with the cell line SAOS-2 (human osteosarcoma cells). The tests showed that the cells adhere, spread and proliferate on the coated surface. The results indicate, that the novel deposition method combining APPJ and a sol precursor is a very comfortable and efficient method to create bone like hydroxyapatite coatings with good biocompatible properties to optimize medical bone implants.

ID: D2-0010 **PO-02 : 31**

ACCELERATED WOUND HEALING BY A NOVEL SELF-ASSEMBLING CELLULOSE BIOMATERIAL IN A RAT IN VIVO STUDY

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Development of biomaterials for tissue regeneration and regrowth researches has been devoted for years. Many results have been validated and proof-of-concept via in vitro experiment, however, the in vivo experiment validated is highly needed in order to provide a complete insight of these developed materials. According to this, for the first time, we report a new cellulose film material to accelerate in vivo wound healing in rat skin model. The corresponding rat skin wound model is established by creating two 1 x 1 cm2 wounds on the back of the rat skin, and two types of cellulose film with different shapes (type 1 and

type 2) were treated on the wounds on the day it was created. The size of the wounds was monitored for the consequent 7 days in order to evaluate the healing speed. Our data showed that the type 1 cellulose film with hollow microspheres efficiently accelerated the wound healing process comparing to that of control group. The size of the wound treated with type 1 cellulose film on day 7 significantly declined to 24.42 ± 0.36 % (n = 3) of the original size, whereas the size of the wound in control and sham groups on day 7 were 37.17 ± 4.58 % (n = 4) and 39.96 ± 8.33 % (n = 3) respectively. The result of the wound treated with type 2 cellulose film (35.34 ± 3.44 %, n = 3) showed no significant difference on day 7 comparing to that of control or sham groups. Our results indicate that the new developed cellulose film is a proper material for wound healing accelerating, and shed lights in revealing a potential new treatment in clinics that would improve the patient comfort and satisfaction.

ID: D2-0015 **PO-02 : 32**

HEMOCOMPATIBILITY EVALUATION OF COBALT-CHROMIUM ALLOY FOR IMPLANT APPLICATION

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Nowadays, Cobalt Chromium (CoCr) alloy becomes one of the most used metals for implant application. Implant devices in the body require hemocompatible property. Hemocompatibility evaluation can be performed by contacting the devices on blood or blood components. The purpose of this study was to evaluate the hemocompatibility of CoCr implant material by hemolysis test and platelet aggregation activity. The material used under research was CoCr L605 (Remanium Star, Germany). Alloys were shaped as discs with 10 mm diameter and 2 mm thickness (n=20). For hemolysis test 6 discs were powdered by diamond dental bur. Hemolysis test was done on rabbit (Oryctolagus cuniculus) blood by 3 groups (treatment, positive, and negative control). The treatment group exhibited 2.5, 5, 10, 20, 40, and 50% CoCr powdered induction. The test was based on ASTM-F075 hemolysis test. Evaluation of platelet aggregation was based on ISO 10993:4. Venous blood was drawn from medial cubiti vein of 7 healthy subjects. The drawn blood from each subject was divided into 2 groups: control group (without induction) and treated group (contacted to CoCr L605 discs). The hemolysis test was analyzed by Kruskall-Wallis. The platelet aggregation activity were analyzed by t-test. The result showed that CoCr L605 performed no hemolytic property at concentration of 2.5, 5, and 10 %; slightly hemolytic at 20%; and hemolytic at 40 and 80%. The average percentage of platelet aggregation activity were 89.96±17.93 (control), 80.16±22.04 (CoCr L605). The Kruskall-Wallis analysis revealed $p<0.05$. The t-test showed $p>0.05$. In conclusion, variety concentration of CoCr L605 induction to blood affected the hemolysis percentage. CoCr L605 did not affect platelet aggregation activity on healthy subjects.

ID: D2-0016 **PO-02 : 33**

CYTOTOXICITY OF STAINLESS STEEL 316L AND COBALT-CHROMIUM AS STENT MATERIALS

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Objective: Stainless steel (316L SS) and cobalt-chromium (CoCr) were the early alloys used in medical devices including cardiovascular stents, and till today these materials are still very popular. The failure of stent device due to stress corrosion fatigue remains as one of the challenging clinical problems. The corrosion of stent materials releases toxins into the body which might trigger immune responses and inflammatory reactions. The basic requirement for choosing stent material is that it be biocompatible, not exhibiting any toxicity to the biological system. The cytotoxicity test is an initial part in identifying the harmful effects of a developed material. The objective of the research was to study the acute toxicity of 316L SS and CoCr for stent material, in vitro.

Methods: The test was performed using fibroblast cell line (LPPT UGM). Cells were treated for 24 hours with three different concentrations (100,1000,10000 µg/mL) of 316L SS and CoCr (Otocompo, Sweden) in powder form. Three plates were prepared for each group. The cytotoxicity test (number of viability cells) was measured with the MTT assay.

Result: The number of viability cells of 316L SS showed an average of 93.41±1.90% (100µg/mL); 93.25±1.40% (1000µg/mL); 78.99±2.46% (10000µg/mL) and CoCr 85.52±0.88% (100µg/mL); 84.00±1.68% (1000µg/mL); 81.46±2.01% (10000µg/mL). Statistical analysis using the ANOVA showed there was a significant difference ($p<0.05$) in the number of the viability cells among the three concentrations from the two different materials.

Conclusion: Based on ISO 10993-5, a tested material is considered non-cytotoxic if the percentage of the

viable cells is equal to or greater than 70%. It can be concluded that the three concentrations of 316L SS and CoCr showed no indication in eliciting acute toxicity, in vitro.

ID: D2-0018 **PO-02 : 34**

HIGHLY SPECIFIC IN-VIVO GENE DELIVERY FOR P53-MEDIATED APOPTOSIS AND GENETIC PHOTODYNAMIC THERAPIES OF TUMOUR

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Anti-cancer therapies are often compromised by non-specific effects and challenged by tumour environments' inherent physico-chemical and biological characteristics. Often, therapeutic effect can be increased by addressing multiple parameters simultaneously. Here we report on exploiting extravasation due to inherent vascular leakiness for delivery of a pH sensitive polymer carrier. Tumours' acidic microenvironment instigates a charge reversal that promotes cellular internalization where endosomes destabilize and gene delivery is achieved. We assess our carrier with an aggressive non-small cell lung carcinoma (NSCLC) in-vivo model and achieve greater than 30% transfection efficiency via systemic delivery. Rejuvenation of the p53 apoptotic pathway as well as expression of KillerRed protein for sensitization in photodynamic therapy (PDT) is accomplished. A single administration greatly suppresses tumour growth and extends median animal survival from 28 days in control subjects to 68 days. The carrier has capacity for multiple payloads for greater therapeutic response where inter-individual variability can compromise efficacy.

ID: D3-0003 **PO-02 : 35**

EVALUATION OF SKIN PERMEATION ENHANCEMENT OF TRANSDERMAL PATCH BY SOLID LIPID NANOPARTICLES (SLNS) CONTAINING VITAMIN E

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The aim of this study was the skin permeation comparison of solid lipid nanoparticles (SLNs) prepared by vitamin E with oleic acid (OA) as a conventional chemical enhancer for transdermal drug delivery. Vitamin E was used as oil phase to produce SLNs by water in oil nanoemulsion preparation method. DLS and TEM were used to determine the size, zeta potential, and structure of SLNs. Cephalexin was used as model-drug. The transdermal drug delivery patch was obtained by drug dispersion in poly-iso-butylene (PIB) adhesive. FTIR analysis was used to determine the interaction between drug and other materials in the formulations. Blank- SLNs in three different weight percent of formulation (0, 5, and 10%) and OA in two weight percent (0, and 10%) were added in six different formulations. The effect of penetration enhancers on the rate of cephalexin release through rat skin was studied in vitro with static Franz diffusion cells. HPLC method was used to analyze the amount of released drug.

The result showed that the amount of drug release is depended upon SLNs concentration, strongly. The amount of released drug in formulation without enhancers is 228µg/cm2. However, it was enhanced to 260µg/cm2 and 692µg/cm2 in formulations with 10% OA and 10% SLNs, respectively. SLNs increase release rate 2.5 times more that chemical enhancers. In addition, increasing the concentration of both enhancers (OA and SLNs) in a formulation caused to decline the release rate into 351µg/cm2. It shows that the interaction between enhancers could have adverse effects on release rate. Also, the nanoparticles containing vitamine E as an antioxidant lipid helps to increase penetration of drug into the percutaneous layer of skin.

ID: D3-0005 **PO-02 : 36**

VASCULARIZATION POTENTIAL OF VEGF-RELEASING SILK MICROPARTICLES

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Vascularization continues to be an important challenge in tissue engineering. The diffusion of oxygen and nutrients in vivo is limited to about 100-200 µm, and in turn this limits the allowed distance of cells from the nearest blood vessel. Therefore in order to attain thicker tissue-engineered constructs, a vascularization strategy has to be adopted to prevent necrosis after implantation. Microparticles have been identified as a vehicle to deliver angiogenic growth factors. They can protect, transport and target biological and

chemical payloads and can be delivered in various ways. In addition, they can be incorporated into scaffolds to obtain a controlled spatial and temporal release pattern. In this study, silk microparticles were fabricated using calcium carbonate coprecipitation. Using characterization techniques, the process was shown to be simple and resulted to uniform particles that can be easily purified from calcium carbonate using gentle conditions. The compatibility of these particles to deliver VEGF was then evaluated by studying their drug loading and release properties.

ID: D3-0013 **PO-02 : 37**

THERMALLY RESPONSIVE HYDROGEL-COATED GOLD NANOPARTICLES FOR DRUG-DELIVERY VEHICLES TO INHIBIT ADIPOCYTE

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Obesity grows when energy intake exceeds energy expenditure. As the incidence of obesity continues to increase, the development of effective therapies is a high priority. The hormone leptin has been presented to be an afferent indicator in a negative-feedback loop regulating body weight, and consequently the administration of the genetic product for the treatment of obesity has attracted extensive attention. Furthermore, leptin is produced by adipocytes in response to increased trigyceride storage, and appears to affect body weight principally through target cells in the hypothalamus. However, the intravenous or oral administration is difficult due to its inconvenience or low efficiency. The thermos-responsive behavior of a methylcellulose hydrogel (MC-H) has used a drug-loading carrier for sustained delivery system. The aim of this study is to develop a light-sensitive MC-H incorporated with gold nanoparticles (MC-H-i-GN) for localized leptin delivery. In the described approach, gold nanoparticles in MC-H-i-GN generated a thermal effect when irradiated at 908nm for 5 min. Consequently, the gold nanoparticles-generated temperature considerably damaged the structure and stability of MC-H-i-GN and then directly delivered the leptin into 3T3-L1 cells. In the other application, a chemotherapeutic drug as doxorubicin was incorporated into MC-H-i-GN for localized tumor therapy. In comparison with the experiment controls with doxorubicin only, the MC-H-i-GN significantly enhanced the rate of cell death via apoptosis at the additional 72 hour when illuminated at 908nm for 5 min.

ID: D3-0014 **PO-02 : 38**

HYDROGEL-BASED NANOPARTICLES FOR THE CONTROLLED RELEASE OF NEUROPEPTIDE Y (NPY) AND NEURTURIN (NRTN) TO RESCUE SALIVARY GLAND RADIATION DAMAGE

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Introduction:
Literature studies have shown that around 64% of survivors of radiotherapy treatment for head and neck cancer are experiencing Xerostomia. This arised as radiotherapy administers high radiation dose to the Salivary Gland (SG) bilaterally. Xerostomia can be defined as a 'dry mouth' which affects the oral health and quality of life. Conventional treatments only relieve the temporary SG hypofunction. A more effective treatment should concentrate on stimulating the remaining peripheral neurons and epithelium to regenerate the SG.

Objectives:
Neuropeptide Y (NPY) is known to exert strong NPY receptor 2-(NPY2R) mediated neuronal survival and angiogenic stimulatory effects during in vivo organogenesis in the cerebral cortex. Human SG epithelium expresses high levels of NPY2R and NPY. Neurturin supports the survival of neurons in the dorsal root ganglia. It is encoded by the NRTN gene located on human chromosome 19. Therefore, we propose to have NPY and NRTN administered to the SG before radiation will protect the neuro-epithelial tissues from radiation damage.

Methods:
We have studied the cytotoxicity, viability data on our ex-vivo embryonic SG tissue and cells which were categorised into irradiated (15 Gy) and non-irradiated groups with different concentrations of NPY and NRTN. We have determined the pharmacokinetics cumulative drug release study of poly (lactic-co-glycolic acid) (PLGA) nanoparticle loaded with NPY and NRTN for 37 days in-vitro.

Results:
Our preliminary data provides evidence that NPY and NRTN induce branching morphogenesis and has protective effect after irradiation. This is by promotion of neuro-epithelial survival in ex-vivo embryonic SG models and cells.

Conclusion:
Our data suggests that NPY and NRTN could have a

therapeutic function of the SG before irradiation and it helps to prevent the radiation induced xerostomia condition in cancer patients.

ID: D4-0001 **PO-02 : 39**

AN EFFICIENT SYNTHESIS OF NANOMEDICINE FERUMOXYTOL INDUCED BY ALTERNATING-CURRENT MAGNETIC FIELD

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Ferumoxytol (FerahemeTM), as one kind of nanomedicine and super-paramagnetic iron oxide nanoparticles (SPIONs), was approved for iron deficiency anemia in clinical application in USA and widely used as magnetic resonance imaging agent in tumor and inflammation for preclinical diagnosis. So ferumoxytol has a great potential for research in biomedical engineering field. However, there are several inevitable drawbacks for traditional chemical co-precipitation method in ferumoxytol synthesis. As we all know, SPIONs can produce efficient heat in the alternating-current magnetic field (ACMF) mainly by Neel Relaxation and Brown Relaxation for cancer hyperthermia. In this study, we took advantage of this endogenous heating mechanism and explored a novel synthesis of ferumoxytol induced by ACMF. As-synthesized ferumoxytol was characterized by transmission electron microscopy, particle size analyzer, fourier transform infrared spectrometer, X-ray diffraction, vibrating sample magnetometer and heating measurement in ACMF. Relative characterization results proved that as-synthesized ferumoxytol demonstrated better quality than FerahemeTM that was prepared by ordinary chemical co-precipitation on particle size distribution, crystallinity and magnetism. Cytotoxicity test also showed that as-synthesized ferumoxytol exhibited no inhibition for U251 cells the same as FerahemeTM. Above all, this ACMF induced synthesis may offer a better strategy for ferumoxytol and other magnetic nanomedicine preparation.

ID: D4-0002 **PO-02 : 40**

EFFECTS OF PHOTOFRIN-MEDIATED PHOTODYNAMIC TREATMENT ON SENSITIVITY TO CISPLATIN IN HELA CELLS AND THE RESISTANT SUBLINE

Yuichi Miyamoto

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Cisplatin (CDDP) is a largely employed platinum-based compound that exerts clinical activity against a wide spectrum of solid neoplasms. Although CDDP often leads to an initial therapeutic success associated with partial responses or disease stabilization, many patients are intrinsically resistant to cisplatin-based therapies. Possible mechanisms of acquired resistance to cisplatin have been reported, in particular, enhanced drug inactivation by metallothionine and glutathione . The essential cytotoxic factors of photodynamic treatment (PDT) are reactive oxygen species (ROS) such as singlet oxygen, hydroxyl radicals, and superoxide anions. The reaction of the ROS with cytoplasmic peptides and proteins may reduce degree of inactivation of the CDDP.

In the present study, we applied low-level PDT, which demonstrated no remarkable cytotoxic effects alone, on CDDP –resistant HeLa cells (HeLa/CDDP) and examined whether PDT can reduce the resistance level for CDDP.

HeLa/CDDP cells were established by Takara's method. HeLa or HeLa/CDDP cells were seeded into a 96-well culture plate and incubated at 37ºC overnight. The medium in each well was replaced with 10 μg/mL Photofrin®-containing F-10 medium and incubated for 15 minutes, and then replaced with CDDP-containing medium (CDDP: 0.001 μM–100 μM). The cells were irradiated in the medium using a laser at a wavelength of 637 nm. The laser irradiation was carried out with an average fluence rate of 5 mW/cm2 at light dose of 0.5 - 3.0 J/cm2. The cytotoxic effects of PDT alone, CDDP alone, and CDDP combined with PDT (HeLa-PDT or HeLa/CDDP-PDT) were estimated by XTT viability assay.

ID: D5-0001 **PO-02 : 41**

SUPPRESSION OF MRNA TRANSFECTION BY SMALL MOLECULE COMPOUNDS INHIBITING INTERFERON-BETA PRODUCTION

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In vitro transcribed (IVT) messenger RNA (mRNA) is increasingly applied in lieu of DNA to deliver reprogramming genes to fibroblasts for stem cell derivation. However, IVT mRNA induces interferon response from mammalian cells that compromises transfection efficiency. We hypothesize that small molecule compounds which are reported to inhibit interferon responses may contribute to the promotion of IVT mRNA transfection. Herein we screen a selected

list of small molecules known to inhibit interferon production for their potential to enhance mRNA transfection in human BJ fibroblasts. Cytotoxicity of small molecules is evaluated by Alamar Blue assay to determine the suitable and effective concentrations for transfection studies. Using GFP mRNA as a reporter gene, transfection efficiency is quantified via flow cytometry based on mean fluorescence intensity of GFP expressed in transfected cells. Interferon-beta production during transfection is measured using enzyme-linked immunosorbent assay (ELISA). Our results show unexpected reductions of GFP expression in cells transfected in the presence of all tested small molecules even though the production of interferon-beta is inhibited. Our results suggest the presence of parallel mechanisms suppressing the transfection process and that the application of small molecules inhibitors may not be a promising strategy for mRNA transfection enhancement during reprogramming. Mechanisms underlying the suppression of delivered IVT mRNA by small molecules will be investigated in our future studies to explore effective methods leading to the enhancement of mRNA-based gene therapy.

ID: D5-0002 **PO-02 : 42**

WHOLE GENOME EXPRESSION ANALYSIS REVEALS OSTEOGENIC DIFFERENTIATION PROMOTION EFFECT OF IRON OXIDE NANOPARTICLES ON MESENCHYMAL STEM CELLS

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The tissue repair effects of iron oxide nanoparticles (IONPs) had been demonstrated in previous studies, meanwhile, stem cell-based therapies show promising prospect in tissue engineering and regenerative medicine. However, whether IONPs could modulate stem cell fate to promote tissue repair is still unclear. In current study, the response of human bone marrow-derived mesenchymal stem cells (hBMSCs) to IONPs in vitro exposure is studied through gene expression. Microarrays and gene functional annotations revealed that IONPs promoted osteogenic differentiation of hBMSCs. Long noncoding RNAs (lncRNAs) play crucial roles in various biological processes. However, little is reported in regulating biological effects of nanomaterials. To deeply explore the underlying molecular mechanism of osteogenic differentiation effect of IONPs, coding-noncoding co-expression network analysis was employed. The results implied that lncRNAs would influence RTKs/MAPK pathway, BMPs/Smads pathway, magnetic response and cytoskeleton rearrangement to regulate osteogenic differentiation via their co-expressed coding genes. In summary, the present study elucidates a molecular basis explaining how IONPs effect on hBMSCs, which could have many meaningful impacts for stem cells application in regenerative medicine.

ID: D5-0003 **PO-02 : 43**

SUBSTRATE STIFFNESS AFFECTS THE MULTIPOTENCY OF NEURAL CREST DERIVED ECTOMESENCHYMAL STEM CELLS

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Neural crest cells are a transient stem cell population in the developing embryo, which give rise to cell types including the craniofacial skeleton and the peripheral nervous system. Human embryonic stem cell derived neural crest stem cells (NCSCs) potentially offer a more accessible source of neural crest derivative cell types, in particular, those of ectomesenchymal lineages for craniofacial regeneration applications. However, the environmental control of NCSC differentiation remains underexplored. Here, we investigated the role of substrate stiffness mediated mechanical cues on the differentiation of NCSCs into musculoskeletogenic ectomesenchymal stem cells (eMSCs). We demonstrated that NCSC derived eMSCs had higher osteogenic but lower adipogenic and chondrogenic potential than MSCs from the bone marrow. eMSC derivation was then performed on tissue culture polystyrene plates (TCPS- stiffness 1 GPa) as well as polydimethylsiloxane (PDMS) substrates of varying stiffness (ranging from 3 kPa to 1.8 MPa) in order to evaluate the effect of substrate stiffness on the differentiation efficiency and multipotency of the derived eMSCs. The eMSCs derived on the various substrates were differentiated into osteocytes, adipocytes and chondrocytes and characterized.This was done using Alizarin Red, Oil Red and Glycosaminoglycan assays respectively, as well as qPCR to show lineage specific gene expression. Our results showed that derivation on softer substrates resulted in the upregulation of specific MSC markers (i.e. CD 44 and PDGFRa) at the transcriptional and protein level, while majority of neural crest and MSC marker expressions were insensitive to substrate stiffness. Interestingly, eMSCs derived on softer PDMS substrates exhibited greater multipotency than those derived on TCPS, with higher

adipogenic and chondrogenic ability and comparable osteogenic ability. Our results demonstrated that biophysical environmental factors such as substrate stiffness played a substantial role in the control of NCSC fate in vitro.

ID: D5-0006 **PO-02 : 44**

DEVELOPMENT OF SPHEROID-FORMATION SYSTEM FOR CELLS CONSTRUCT

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This research group has established technology to produce three-dimensional cell constructs by using only cells and not using supports, such as scaffolds. A special feature of this method for producing a cell construct is that it uses cultured spheroids. However, if spheroids with identical shapes cannot be obtained, it is impossible to construct the intended cell construct. Thus, this study was aimed to development of spheroid-formation system to produce reproducible spheroids. A 2×2 channel-chip detachable pipette was attached to the tip of the fourth joint of a scalar robot to enable handling of cells by mounting disinfected chips. The system control software consisted of a touch-panel, with a program screen capable of being operated easily in a clean environment. Enter the number of cells in cell suspension prepared to software, and select one of the 2×104, 3×104 and 4×104 cell/well. The spheroid-formation system adjusts the cell suspension automatically and dispense cell suspension onto the specialized 96-well plate to produce the spheroids. To prevent damage to cells, the motions performed by the spheroid-formation system to mix the cell suspension and to do the seeding were programmed with reference to motions performed by specialized technicians. The cells used were rabbit mesenchymal stem cells. We were shooting every 24 hours for 5 days and analyzed the quantitative evaluation, i.e., area, diameter and degree of circularity, with the images of spheroid. Degree of circularity of spheroid to be produced by spheroid formation system was significantly higher than degree of circularity of spheroid to be produced by technician. It is presumed that incorporating the motions of a technician permitted the production of spheroids without damaging the cells. This system will enable to regulate the size of the spheroid by designating the diameter of spheroid in future.

ID: D5-0009 **PO-02 : 45**

BENCHMARKING THE FUNCTIONALITY OF PLURIPOTENT STEM CELL DERIVED ENDOTHELIAL CELLS TO PRIMARY ARTERIAL AND VENOUS ENDOTHELIAL SUBTYPES

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Endothelial cell sources are a necessity for vascular clinical applications, including therapeutic vascular angiogenesis, organ revascularization and tissue engineered vascular grafts. Primary donor endothelial cells are limited in number, have donor variability and their in vitro phenotype varies over time. Human pluripotent stem cell derived endothelial cells (PSC-EC) have recently emerged as an alternative cell source, which can be easily expanded and are potentially autologous if derived through induced pluripotent stem cell (iPSC) technologies. Although PSC-ECs have been shown to express typical endothelial markers, such as CD31 and VEGFR2, the lineage specification of PSC-EC compared to arterial and venous endothelial cells is currently unknown. Here, the goal of this study is to establish a panel of phenotypic and functional assays to benchmark PSC-EC with human coronary artery endothelial cell (HCAEC) and human saphenous vein endothelial cell (HSaVEC).

The expressions of arterial markers (EphrinB2, Notch-1 and Notch intracellular domain (NICD)) and venous markers (EphB4 and COUP-TFII) were examined in PSC-ECs, HCAECs and HSaVECs by immunofluorescence imaging. Quantification of marker expressions revealed that while PSC-ECs expressed both arterial and venous markers, their expression levels were significantly lower as compared to the primary arterial and venous cells. Similarly, the functionality of PSC-ECs, indicated by acetylated low density lipoprotein (Ac-LDL) uptake, nitric oxide (NO) formation and angiogenic capability were not well established as compared to primary arterial and venous cell types, suggesting that these cells are functionally immature. Our data indicated that PSC-ECs are a heterogeneous population of functionally immature cells with unspecified lineage. Hence, future differentiation strategies are required to enhance the functional maturity of the PSC-ECs into arterial or venous subtypes to make them more valuable for clinical applications.

ID: D5-0015 **PO-02 : 46**

POLY(E-CAPROLACTONE) NANO FIBER FOR VASCULAR SCAFFOLD BY NEEDLE LESS ALTERNATING CURRENT ELECTROSPINNING.

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Poly(ε- Caprolactone) bioabsorbale nanofibers have been fabricated by uncommon advanced Needle & collector less Alternating Current Electrospinning at higher rate of production using green solvents (formic acid, formic acid/acetic acid 4/1). The effect of solution concentration (5%,10%15% and 20%) and applied voltage (10 - 36KV) solvent effect on viscosity, conductivity, fiber formation and morpology have been investigated. Since, numerous polymers have been electrospun using common Direct Current Electrospinning. Least number of polymers only have been fabricated using uncommon Alternating Current needle and collector less Electrospinning. Because of it is quite complicate to spin the polymer solution.Productivity of fibers in AC Electrospinning is much more higher than DC Electrospinning.Though Needle & collector less AC Electrospinning setup is fairly simple and straight forward,for wide spread commercial viability many important question to be answered like1) why common polymers and solvents are not spinnable in AC Electrospinning but only with DC Electrospinning? 2) Is the viscocity,conductivity and applied voltage playing any major role?

Key words: Needle & collector less AC Electrospinning, PCL, Viscosity, Conductivity.

ID: D5-0019 **PO-02 : 47**

ADVANCED 2D AND 3D GRAPHENE CONSTRUCTS FOR THE EXPANSION OF SALIVA-SECRETING PRIMARY CELLS TO SCALE UP SALIVA PRODUCTION

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Radiotherapy for head and neck cancers may cause irreversible damage to the salivary gland (SG) secretory epithelia, and a loss of saliva secretion leading to dry mouth. Dry mouth produces a significant decrease in the quality of life of these patients due to recurrent oral infections. Hence, researchers have focused on replacing the damaged SG with novel saliva-secreting 3D tissue constructs using cell-based therapies. The development of these therapies requires sufficient primary SG epithelial cell (SGEC) numbers, and thus the creation of in vitro bioplatforms to support the expansion of SGC. Our aim was to develop a novel bioplatform for expansion of SGC using 2D and 3D graphene–based substrates.

METHODS: Conventional methods of primary SGEC isolation were (1) enzymatic tissue digestion and (2) explant culture for non-adherent/floating and adherent SGC, respectively. We compared the growth of untagged non-adherent SGEC versus tagged with magnetic nanoparticles on 2D graphene under a magnetic force using a dye-exclusion method with Hoescht/propidium iodide. Graphene 2D sheets were then used to assess the expansion and growth of the adherent SGEC using MTS assays. Cell morphology was determined by cytoskeletal rearrangement using fluorescently-tagged viral vectors to stain actin filaments. Immunofluorescence and enzymatic assays to quantify saliva secretion were also used. Statistics were conducted using t-test and one-way ANOVA.

RESULTS: A significant difference was found in cell growth among magnetized nano-tagged non-adherent SGEC when compared to untagged (p=0.004). Adherent SGC seeded on graphene sheets and plastic (positive control) showed no difference in viability at day 3 (p=0.99) and 8 (p=0.35) of culture with no differences in epithelial morphology. Experiments on 3D graphene constructs are ongoing and will be presented at the meeting.

CONCLUSION: This study shows promising outcomes in the development of an effective graphene-based bioplatform to expand saliva-secreting SGEC for in vivo transplantation and SG regeneration.

ID: D6-0002 **PO-02 : 48**

A PREDICTIVE MODELING FOR PRINTING PATTERN CHARACTERISTICS OF A HYDROGEL BASED BIOPRINTING SYSTEM

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Bioprinting techniques have been an interest for constructing tissue or artificial organ in complex 3D structure because of its repeatability and high precision in printing resolution at macro- and micro-scales. A novel unique concept nozzle head based multi-nozzle system and a 3-axis (spatial position coordinate 3 axes) bioprinting system for 3D bio-structure fabrication has been developed in this study. The positioning resolutions of the x- and y-axis are both 0.05 μm, and z axis, 0.125 μm. System control and motion control algorithms were also developed utilizing high performance workstation for better precision control. To implement minimal pattern width in a hydrogel-based bioprinting system, a study on the printing characteristics has been performed by varying printer control parameters. The purpose of this paper is to determining the printing pattern characteristics using a predictive modeling for a novel hydrogel based bioprinting system and to study on novel control algorithm for the bioprinting system, leading to the confirmation of the feasibility of this system through a verification experiments. Accordingly, a prediction model for determining the printing pattern characteristics was tested by comparing the experimental results. Through the experimental results, the printed pattern width control was able to be achieved ranging from approximately 250 to 780 microns. The results will be helpful for optimizing printing control parameters for desired pattern output. Also, a prediction model for determining the printing pattern characteristics was tested by comparing the experimental results. The results proved that the predictive model shows significantly similar results to the experimental results. As a result, compensation schemes adjusting the printed volume itself with flow rate control were devised and successfully utilized

Day 3 – Friday, 9 December 2016

Session	Poster Session 03 (PO-03)
Date / Time	Friday, 9 December 2016 / 12:30pm to 1:45pm

ID: E1-0003 **PO-03 : 01**

ARTERIAL STIFFNESS ASSESSMENT USING MAGNETIC-BASED PULSE SENSING TECHNOLOGY AND ELECTROCARDIOGRAM SIGNAL

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Arterial stiffness is an important indicator for prognosis, treatment and prevention of cardiovascular diseases. The non-invasive industry gold standard measurement system of arterial stiffness utilizes pulse wave velocity method. However, the desktop device is expensive and requires trained professional to operate. There is portable device that measures arterial stiffness utilizes cuff blood pressure waveform analysis which does not require trained professional to operate and enable self-assessment, but is not as accurate and cannot be utilized for clinical research. The main objective of this research is the proof of concept of the proposed non-invasive method which uses magnetic-based pulse sensing technology (BioS) and electrocardiogram (ECG) signal for measuring arterial stiffness. The method could enable accurate and easy self-assessment of arterial stiffness at home, and to help doctors in research, diagnostic and prescription in hospitals and clinics. A platform for assessing arterial stiffness through acquisition and analysis of radial artery pulse waveform and ECG signal has been developed based on the proposed method. Radial artery pulse waveform is acquired using BioS technology, while ECG signal is acquired using dry contact single-arm ECG electrodes. The measurement only requires the participant to wear a wrist strap and an arm band. Participants were recruited for data collection using both the developed platform and the industry gold standard system. The results from both systems underwent correlation assessment and Bland-Altman analysis. A strong positive correlation between the results of the two systems is observed. This study presents the possibility of developing an accurate, easy to use and affordable measurement device for artrial stiffness assessment.

ID: E1-0004 **PO-03 : 02**

MULTI-SCALE MODELING OF THE HUMAN CARDIOVASCULAR SYSTEM AND THERMOREGULATION

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An important but little understood function of the human cardiovascular system (CVS) is the heat transfer between the inner body tissues, organs and the skin to maintain internal temperature within a narrow range under different heat-stressed conditions. The CVS as a key heat-exchange pathway inside the body plays a crucial role in thermoregulation because the heat stress may result in significant cardiovascular adjustments that are necessary to maintain adequate cardiac output and skin blood flow through adjusting heart rate, cardiac contractility, and peripheral vascular resistance. We here propose a novel multi-scale model to predict the interplay between the CVS and thermoregulation by coupling a multi-scale hemodynamic model of the CVS and a multi-compartment thermal model of the whole body. The CVS model is composed of one-dimensional representation of the large systemic arteries and veins, and zero-dimensional lumped-parameter representation of the heart, the cardiac-pulmonary circulation, the cardiac and venous valves and the microcirculation. The thermal model is constructed with a total of seven cylindrical elements to represent the thermal characteristics of the main parts of the whole body including head, thorax, abdomen, arms and legs. The thermoregulation model is validated capable to reasonably predict cardiovascular functions and thermal responses under varying environmental conditions. Moreover, the effects of different individual body characteristics on thermoregulation, such as aging, obesity, and cardiovascular diseases, are also taken into consideration in the model. Our model has been proven to be capable of evaluating human thermal responses with different individual characteristics including various cardiovascular diseases as well as heat stresses (Zhang et al 2016). As one of the ultimate clinical applications, we aim to

provide a useful clinical tool, through incorporating a recently developed anesthesia model into the multi-scale CVS-thermoregulation model, to evaluate individualized human thermal responses for the anesthetized patients during surgery environment.

ID: E1-0006 **PO-03 : 03**

MORPHOLOGICAL EFFECTS OF THE BICUSPID AORTIC VALVE ON AORTIC HEMODYNAMICS: A LEFT VENTRICLE-AORTA COUPLING MODEL

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Bicuspid aortic valve (BAV) is one of the congenital heart diseases. Previous studies have reported that BAV shows specific association with the development of aortic aneurysms and the valve morphology as well as its orientation seems to play a crucial role. The BAV-induced aortic aneurysms have been studied by means of computational mechanical and image-processing approaches but merely focusing on the aortic hemodynamics without consideration of any influence from left ventricle. In this study we built up a patient-specific left ventricle-aorta coupling model, which, based on multi-modality images of MRI and CT, is capable to model morphologies and movements of the left ventricle, the aortic valve as well as the aorta and to predict the left-ventricle-aortic hemodynamics in an integrated manner. An extended study is further conducted to investigate the valve morphology effects of both normal TAV and abnormal BAV on the aortic hemodynamics. An in-house computational fluid dynamics code is utilized for the three-dimensional simulation of blood flows in the left-ventricle and aorta. Pressure waveforms in the aorta, the left ventricle and the left atrium are given through a lumped-parameter model, which are imposed as boundary conditions of the image-based left-ventricle-aorta model. With respect to opening and closing of the valves a simplified valve model is introduced to treat the valves with two-dimensional movements. Moreover, several valve morphologies associated with BAV are modeled to evaluate the influence of valve phenotypes. Our results indicate that wall shear stress distributions are more concentrated at ascending aorta in the BAV model rather than in the TAV model. Furthermore, it is found that valve orientation dominates the direction of systolic jet and hence wall shear stress distributions at aortic arch. Such heterogeneous wall shear stress distributions in the aorta with BAV may be associated with aortopathy in terms of the aortic aneurysms.

ID: E1-0011 **PO-03 : 04**

SURGICAL TIMING PREDICTION OF LONG SEGMENT CONGENITAL TRACHEAL STENOSIS WITH BRIDGING BRONCHUS BY USING COMPUTATIONAL AERODYNAMICS

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In recent years, the technology of image processing and numerical analysis has played an increasingly important role in the areas of medical diagnoses and therapies, which improves the possibility of pre-operative evaluation of aerodynamic outcomes of congenital tracheal stenosis (CTS). Although the slide tracheoplasty (STP) is a versatile and reliable technique associated with low morbidity and mortality recently, it is still the most challenge to find an appropriate way to treat long segment congenital tracheal stenosis (LSCTS) with compromise of the carina and main stem bronchi. Here, we investigated a patient-specific model of LSCTS with complete tracheal rings and bridging bronchus (BB). Based on medical images, a three-dimensional model of LSCTS with complete tracheal rings and BB was reconstructed. We applied the technique of computer-aided design (CAD) to imitate four stages of stenosis growth of CTS. And, we also used computational fluid dynamics (CFD) to analyze local aerodynamic characteristics for evaluating the impairment of airflow in trachea and bronchus. An obvious interaction between the main segments of stenosis and the bronchus of stenosis was observed. Average pressure drop, wall shear stress (WSS), streamlines and energy loss at the inspiration phase and expiration phase were calculatedThe result indicated when the main stenosis arrived at 20%, an abnormal pressure gradient was generated to create rotating flow at the connection area of BB to trachea during the phase of expiration. Meanwhile, we noticed that an out-of-proportion pressure drop occurred when stenosis got to 80% of the cross-sectional area of the tracheal entrance. This implied airflow at the trachea and BB became more turbulent in expiration phase than that in inspiration phase. The combination of CAD and CFD for patient-specific studies is a potential noninvasive tool. It can provide airflow information in trachea for the management of LSCTS treatment and surgical timing prediction.

ID: E1-0013 **PO-03 : 05**

MORPHOLOGICAL ANALYSIS AND COMPUTATIONAL FLOW DYNAMICS STUDY OF PULMONARY ARTERY WITH TETRALOGY OF FALLOT

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Tetralogy of Fallot (TOF) is one of the most common complex cyanotic congenital heart diseases (CHD). It can be caused by the right ventricular outflow tract progressive muscle hypertrophy. The heart with TOF usually has the right ventricular overload and pulmonary hypoperfusion. The non-oxygenated blood enters the left ventricle through the non-restrictive ventricular septal defect, which causes the insufficiency of the oxygen supply of the systemic circulation organs. Hence, the key to the success of the surgery is to deal with the right ventricular outflow tract and pulmonary artery (PA) in a timely and proper way. The detailed morphological study of PA is critical for quantitative diagnosis and surgical design of TOF. Here, we report our medical image-based morphological analysis of patient-specific three-dimensional (3D) reconstructed PA models. The centerline of each PA model was created. The method of computational fluid dynamics (CFD) is employed to disclose the relationship between the PA morphology and local hemodynamic characteristics. 10 cases of 3D normal PA models and PA models with TOF were investigated, respectively. Local pressure, blood flow distribution ratio, streamline distribution, energy efficiency and lung perfusion were calculated. The results implied that there is homogeneity among normal PA models, with a "Y" shape in top view. The centerline of the PA trunk was various deviations with PA branches in the PA models with TOF. The remarkable different hemodynamic characteristics were observed in these models. This will be helpful for the surgical design of TOF. The methods of the morphological analysis combined with CFD simulation also may be applied to another CHD for quantitative diagnosis and surgical design.

ID: E1-0015 **PO-03 : 06**

ZERO-DIMENSIONAL SIMULATION OF INTERNAL AND EXTERNAL BLOOD FLOWS CONSIDERING AUTONOMIC NERVOUS SYSTEM

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In the field of forensic medicine, the development of a simulation model of bleeding to assist in clinical observations is desired. Various kinds of one-dimensional (1-D) and zero-dimensional (0-D), or lumped parameter model, simulations have been performed for blood flow in the whole human body. However, bleeding has rarely been considered in such simulations. Since 1-D simulations usually result in a relatively high computational load, 0-D simulations are considered to be realistic for long-term analysis of the whole circulatory system with bleeding. In a previous work, the authors proposed a 0-D simulation model incorporating internal and external bleeding models. A numerical simulation was performed for two bleeding models, showing the process of bleeding and the corresponding decrease of blood pressure in the whole body. However, the previous simulation model ignored the effect of the autonomic nervous system as a first step, and the results should be considerably different from those of a real case. The purpose of the present study, therefore, was to develop a 0-D simulation model autonomic nervous system. Control of the autonomic nervous system due to bleeding was modeled by varying the pulse rate in accordance with the amount of bleeding. By considering the pulse variation caused by the autonomic nervous system, the effect to recover the rapid blood pressure decrease just after the bleeding, and the effect to increase the blood pressure against decreasing due to bleeding were confirmed. Bleeding simulations were conducted using the present model and the previous one for cases of multiples wounds and cardiac arrest due to bleeding being considered. Results for both models were evaluated based on clinical knowledge. It was confirmed that the present simulation with consideration of the autonomic nervous system results in more reliable results than the former one without such consideration.

ID: E1-0016 **PO-03 : 07**

FUNDAMENTAL STUDY OF MR-MEASUREMENT-INTEGRATED SIMULATION OF HEART-AORTA SYSTEM: NUMERICAL EXPERIMENT FOR MR-MI SIMULATION OF BLOOD FLOW IN AN AORTA

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It is very important to clarify hemodynamic parameters

in blood vessel because hemodynamics in blood vessel is closely related to development of cardiovascular disease. Today, magnetic resonance imaging (MRI) is widely used as medical measurement technology. However, it is difficult to obtain hemodynamic parameters accurately because the resolution of MR data is comparatively low. In a previous study, numerical validation of MR-measurement-integrated (MR-MI) simulation of blood flow in a cerebral aneurysm was done. MR-MI simulation accurately reproduced the blood flow and hemodynamic parameters by integrating MR measurement and numerical simulation. This study aims to perform MR-MI simulation of a heart-aorta system to accurately obtain blood flow field and hemodynamic parameters in heart-aorta system. This presentation aims to conduct a numerical experiment for MR-MI simulation of a blood flow in an aorta as the first step. A blood vessel model was created from MR data, and a blood flow simulation was performed for the model by commercial software FLUENT. Numerical experiment for MR-MI simulation of the blood flow was conducted by feeding back the velocity field obtained from the numerical simulation with the different boundary condition, confirming the effectiveness of the proposed method.

ID: E1-0017 **PO-03 : 08**

DEVELOPMENT OF A QUANTIFICATION METHOD OF THREE-DIMENSIONAL AORTIC ARCH SHAPE WITH ANEURYSM FOR EXPLORING FACTORS INDUCING ENDOLEAK

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Background
Stent-graft is a medical device to prevent rupture of aneurysm by blocking inflow into the aneurysm. Residual inflow into the aneurysm after stent-graft deployment called endoleak is a matter of concern. Especially in the aortic arch, the risk is higher because the vessel shape is comparatively complicated.

PURPOSE
The aim of this study is to develop a quantification method of three-dimensional aortic arch shape with aneurysm for exploring factors inducing endoleak.

METHOD
First, within the longitudinal length of 60 mm proximal and distal from the aneurysm, the centroids of the aortic cross-sections were calculated at 20-mm intervals. Then, a spline curve was obtained using the centroids. Second, the perimeters of the aorta were measured at 1-mm intervals along the spline curve. Then, the inflection point of changes in the perimeters was defined as the neck of the aneurysm. Third, a cylinder was modelled based on the diameter and taper of patient's aorta within 20-mm proximal and distal from the aneurysm along the spline curve. The volume by subtracting the cylinder from patient's aorta with aneurysm was defined as the aneurysm.

RESULT & DISCUSSION
As the potential factors of endoleak, 1.) the entrance length of the aneurysm in the aortic longitudinal direction, 2.) the aortic diameter in 20 mm proximal from the aneurysm, 3.) the radius of aortic arch curvature, and 4.) the distance along with the vessel wall between the side branch preserving blood flow and the aneurysm were quantified using the CT data of 5 aortic arch aneurysm patients. The average values were 1.) 54 mm, 2.) 33 mm, 3.) 55 mm, and 4.) 12 mm, respectively.

CONCLUSION
We successfully developed the quantification method of three-dimensional aortic arch shape with aneurysm. The method presented here would be useful for future investigation of factors inducing endoleak.

ID: E1-0018 **PO-03 : 09**

A NOVEL STRAIN MEASUREMENT METHODOLOGY TO EVALUATE THE STRAIN IN THE AORTIC VESSEL MODEL

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Background: Understanding of the strain at the vascular lesions caused by the biomechanical interaction between the blood vessel and medical devices is important to evaluate the risk of the complication and vascular disease. The three-dimensional strain measurement methodology has already used for some applications. In previous study, a new strain measurement methodology using tomographic particle image velocimetry was proposed to measure the strain in vascular lesions. In this study, the measurement by new methodology was compared

with finite element analysis to validate the accuracy of the new methodology.

Method: The cylindrical aortic vessel model with inner diameter, thickness, elastic modulus of 25 mm, 2 mm, 2.61MPa, was manufactured. At the flow rate of 60 ml/min using a syringe pump, the lumen of the aortic model was pressurized from 0 mmHg to 250 mmHg. The effective strains under the six different luminal pressures were measured using the new methodology. The effective strains at the six luminal pressure were analysed using finite element analysis. The Moony-Rivlin model was used for aortic vessel property.

Results: Using the new measurement methodology, the phenomena that the strain within the vessel wall decreased from inner to outer circumferential direction were detected. The correlation coefficient on effective strains between the new method and the finite element analysis was over 0.69.
Conclusion: The results indicated that a novel strain measurement methodology would have adequate accuracy.

ID: E1-0024 **PO-03 : 10**

COMPARISON BETWEEN DIAMETRIC AND VOLUMETRIC CHANGES IN TRUE LUMEN FOR STANFORD TYPE B AORTIC DISSECTION PATIENTS

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The present study aims to compare the diametrical and volumetric changes in the true lumen (TL) of thirteen Stanford type B aortic dissection patients after stent grafting procedures. Each patient went through several computed tomography angiography (CTA) scans, from pre-treatment up to a period of 12 months after the insertion of stent graft. Aortic changes were quantified by percentage of maximal diametric and volumetric changes from pre-treatment. The TL was divided into three parts: the stented area (Segment 1), distal of the stent graft to the celiac artery (Segment 2), and between the celiac artery and bifurcation (Segment 3). Due to the presence of stent, all patients showed drastic TL expansion in Segment 1 based on both volumetric and diametrical measurements. As compared to diametric changes, substantially higher volumetric changes were observed in most patients at post-treatment, 6- and 12- months (volumetric: 108%, 123% and 158%; diametric: 46%, 56% and 57%), respectively. Meanwhile, the differences between volumetric and diametric changes at Segment 2 (i.e. diametric changes: 35%, 47% and 67% versus volumetric changes: 27%, 56% and 102.8%) and Segment 3 (i.e. diametric changes: -1%, 11% and -14% versus volumetric changes: -4%, 21% and -18%) were not evident for half of the total number of patients. Based on the results, diametric changes were almost proportional to volumetric changes. Thus it can be deduced that it is sufficient to assess aortic remodeling using the diameter alone. However, the diametric changes were always smaller compared to volumetric changes particularly in the stented Segment 1 as diametric changes only reflect a part of the constant expansion of the entire lumen region of interest measured by the volume changes.

ID: E1-0025 **PO-03 : 11**

PROPOSAL OF MATHEMATICAL AUTO-REGULATION MODEL FOR CEREBRAL BLOOD FLOW RATE PREDICTION OF CEREBRAL BYPASS SURGERY

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Cerebral ischemia and hyper-perfusions for cerebral bypass surgery have high risks of unexpected complications due to its high invasiveness. In cerebral bypass surgery, prediction of the post-operative blood flow condition is difficult due to complex auto-regulation mechanisms in human brain. Therefore, this study aimed to construct the mathematical flow regulation model of cerebral bypass patients for prediction of blood flow condition before and after surgery.

A subject of 72 years old female underwent middle cerebral artery (MCA) – superficial temporal artery (STA) bypass treatment for large aneurysm was investigated. The blood flow rates of anterior cerebral artery A1 segment and MCA M1-M2 segments at 1 month and 3 months after the operation was calculated by substituting the pre-operative blood flow rates into increasing or decreasing blood flow regulation models depending on the location of the target artery. These blood flow regulation models were constructed from

the chronological blood flow rate data of 20 arteries from 7 cerebral bypass patients. The data were compared with the measured value and the predicted value.

The difference between the prediction and the measurement flow rates at 1month and 3 months for M1, A1, and M2 were 2.20 ml/min and -4.99 ml/min, 12.68 ml/min and 15.55 ml/min, and 1.89 ml/min and 1.75 ml/min respectively. A1 showed largest flow rate difference as compared to M1 and M2 segments. Prediction in A1 was slightly off because the flow regulation models were constructed based on the neighboring arteries around bypass graft. It suggests that the flow regulation models used in the proposed method should consider the location of the predicting vessel and the bypass graft. In conclusion, the proposed method showed the potential for accurate prediction of post-operative blood flow condition for cerebral bypass patients.

ID: E2-0008 **PO-03 : 12**

DEVELOPMENT OF A BIOMECHANICAL MODEL OF CELL BEHAVIOR SUBJECTED TO CYCLIC STRETCH

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Cells change their shapes in response to mechanical stimuli from the environment. For example, endothelial cells tend to orientate vertically to the direction of cyclic stretching, while they orientate parallel to the flow direction. Here, we develop a biomechanical model of cell behavior subjected to cyclic stretching. We assume that cell dynamics is induced by the force balance among the ligand-receptor bindings of adhesion molecules, the cell membrane, and the actin polymerization at cell edge. Ligand-receptor bindings are modeled stochastically by using the Monte Carlo method based on Bell model. A spring network model is used for cell membrane. Actin polymerization is modeled by pseudopodial forces. We show how the cell shape and orientation change with the frequency of the cyclic stretch.

ID: E2-0010 **PO-03 : 13**

DENTAL MESENCHYMAL CELL DIFFERENTIATION OF INDUCED PLURIPOTENT STEM CELLS FROM DENTAL PULP STEM CELLS

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Objective: To verify the dental mesenchmal cell differentiation potential of induced pluripotent stem cells (IPSC) from dental pulp stem cells.

Methods: 1 x 105 IPSC were seeded in matrigel coated-6 well plates and cultured with StemMACS-brew XF culture media. After 5 to 6 days, IPSC clones were picked up and transferred into suspension six well plate for embryonic body (EB) formation in the next 7 days, which was maintained by Aggreewell media (EB culture media). Following, EBs were treated with either odotogenic condition media (OM) supplemented with BMP-4 (25, 50 or 100 ng/ml) or culture media (CM, negative control) up to 20 days. Dental pulp stem cells were used as controls. The genetic expression of DMP-1, MSX-1, DSPP and MEPE were evaluated after 10 and 20 days by RT-PCR. Assays were performed in triplicates and statistical analysis with Mann-Whiteney (α=0.05)
Results: There was a significant increase in the gene expressions of DMP-1, MSX-1, DSPP and MEPE after both 10 and 20 days with OM supplemented with BMP-4, as compared to the controls. OM with 100 ng/ml of BMP-4 presented the significantly higher gene expressions at day 10 compared to all other groups. At day 10, OM with 100 ng/ml of BMP-4 significantly increased the expression of DMP-1 (3.24 times), DSPP (3.82 times), MEPE (4.17 times) compared with DPSC only.

Conclusions: The iPSC treated with OM supplemented with BMP4 (100ng/ml) presented high expression of the odontogenic-related genes at 10 days.

ID: E2-0012 **PO-03 : 14**

EFFECT OF CYCLIC STRESS STIMULATION ON THE EXPRESSION OF OSTEOGENIC GENES IN MG-63 CELLS

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Distraction osteogenesis is considered as alternative therapeutic treatment especially for skeletal deformity correction or orthodontic treatment in orthopedics and dentistry in decades. It also has been widely applied to cranio-mandibular disorders in recent years. The main principle of this treatment is to apply cyclic or mechanical stretching to the skeletons, smoothly and slowly inducing the translocation of bones. The distraction velocity and frequency are critical during the distraction process. However, the expression of osteo-related genes or proteins as well as the related mechanisms is still unknown. In this study, a well-developed cyclic stress stimulator was applied to human osteosarcoma cell line (MG-63) for 5 minutes at 0, 6, and 9 V, individually. MG-63 cells were cultured with alpha-MEM containing 2% fetal bovine serum and 1% penicillin streptomycin. Once cells reached 80% confluence, cells were subcultured to 3.5-cm petri dishes at an initial seeding cell number of 500,000 cells. After one day of culture in an incubator, cells were exposed to the cyclic stress stimulation for 5 min with the frequency of 0.5 Hz. The intensities of stimulation were 0, 6, and 9 V. To determine the osteogenic gene expression, total RNA was extracted and isolated at 0, 6, and 24 h after 5-min cyclic stress stimulation. Alkaline phosphatase (ALP), osterix (OSX), and bone sailoprotein (BSP) were examined by RT-PCR and agarose electrophoresis. The results showed that ALP, OSX and BSP expressed higher levels at the intensity of 9 V than others. Besides, all these genes expression increased after the cyclic stress stimulation, especially at 24 h. It concluded that the osteogenic genes expression was related to the short-term cyclic stress stimulation.

ID: E3-0001 **PO-03 : 15**

EVALUATION OF HEAD INJURY BY BALLISTIC HELMENT IMPACT USING THE FINITE ELEMENT METHOD

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Ballistic helmets play important roles in protection of human head. Performance of helmet has became better, but still, injuries of head occur. Most studies on this topic considered the head only. However, cervical tissue also affects the movement of head, and sometimes cervical tissue is damaged by ballistic impact. The purpose of this study is to evaluate injury of head and cervical tissue and to indentify the effect of considering cervical tissues through the finite element model considering cervical system. For a detailed finite element model of the human head and neck, 3 dimensional scan data from digital Korean based on standard male was used. 8 muscle group concerning cervibal tissue were modeled as Hill-type muscle model. Vertebrae and intervertebral disk were also modeld. A woven fabric-reinforced aramide laminates of helmet (Kelvar 29) was modeld using a Chang-Chang Composite Filure model. A 8-g bullelt was modeled as rigid with same properties of lead. It was assumed that the bullet is shooted in 360m/s. Properties of each model was used from other references. Commercial software packege LS-dyna was used for simulation, and 10ms of termination was assumed. Stress in the skeleton, strain in the brain tiessuek pressure in the brain, and deformation of the helmet shell were estimated as results. For evaluation of head injury, HIC score was employed. It was revealed that the maximum von Mises stress in the skull bone, and pressure in the brain decrease as including cervical tissue. Effect of roation of bullet will be considered in further study.

ID: E3-0003 **PO-03 : 16**

FUNDAMENTAL STUDY ON GENERATION OF A 3-D ALVEOLAR CAPILLARY NETWORK MODEL BASED ON THE BUBBLE MESH METHOD

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Our group has conducted a numerical investigation of passage of neutrophils through a pulmonary capillary network using a simple lattice network in order to gain a fundamental understanding of their behavior and increase in concentration in the network. The in vivo network has randomness in arrangement of the capillary segments and in the length of each segment. Since having such a geometrical reality is essential for precise investigation of the passage of the neutrophils, a methodology to generate a random capillary network was proposed in our former study based on the bubble mesh method. In the proposed methodology, nodes of irregular type with a variety of radii were packed together with regular nodes of the bubble mesh method in a domain to give a variation of the node size, and the capillary network was generated by the Voronoi tessellation of the nodes. In that study, a network on a 2-D plane was generated to compare variation of the capillary length to that experimentally measured. It was found that treatment of the capillaries on border of the domain affects statistical data of the capillary length. In the present study, a network was generated on a sphere which mimicked an alveolus to eliminate the effect of the border. Here, weighted centroids of

the Delaunay triangles, which were obtained giving reciprocal of the node size as the vertex mass, were introduced for the segmentation to compare with the Voronoi tessellation. It was found that the Voronoi tessellation gave wider variation in the capillary lengths but effect of insertion of the irregular nodes on the variation was limited. Then the square of the vertex mass was given for the weighted centroids of the triangles. This model gave wider variation in the capillary length, also reflecting concentration of the irregular nodes.

ID: E3-0004 **PO-03 : 17**

PARTICLE SIMULATION AND PREDICTION OF CANCER DECAY BY ANTICANCER DRUG FROM 2D ANGIOGRAPHY IMAGE

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In the diagnosis of cancer, advances in imaging technology are remarkable. But the diagnosis and treatment often rely on the experience. Numerical simulation might help the diagnosis and treatment.
We propose a particle model. It has been used to predict cancer growth and angiogenesis in the past work. There, the motion and increase of the cancer particle and blood vessel particle was expressed. While blood vessel supplies nutrition to cancer cells, cancer cells attract blood vessel simultaneously. Thus they interacts each other.

In this study, we model cancer shrinkage by remedy, not cancer growth as past work. The particle model is applied to estimate cancer status and to predict the effect of the anticancer drug.

First, from the image (quoted from the National Cancer Center for Cancer Control and Information Services Japan http://cir.ncc.go.jp),' target='_blank'>http://cir.ncc.go.jp/">http://cir.ncc.go.jp), the tumor tissue and blood vessels were recognized and they were divided into a calculation point. Next, the cancer status was analyzed by calculating the distribution of pressure and nutrition. Furthermore, the model was applied to the case with anticancer drug. The effect of anticancer drug on the cell was modeled by cell death ratio. The simulation result show that the cancer shrinks and blood vessels recede.

In the future, the simulation results might help understanding and explanation to patients. Also it might support the prediction of other treatments and combination such as immunotherapy.

ID: E3-0009 **PO-03 : 19**

UNDERSTANDING THE FLUID DYANMICS OF THE HUMAN FETAL RIGHT VENTRICLE – AN ULTRASOUND IMAGE-BASED COMPUTATIONAL FLUID DYNAMICS STUDY

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Congenital heart diseases is a prevalent birth-defect and is the main cause of birth-defect related deaths. There are evidences from studies on human and animal models which suggest that flow forces can affect the malformation of embryonic heart, therefore emphasizing the importance in understanding the flow dynamics in fetal heart. We have recently developed novel techniques to use Computational Fluid Dynamics (CFD) to elucidate the flow dynamics of fetal cardiac chambers ventricle based on patient-specific 4D ultrasound scans. In this study, we applied this technique on three 20-weeks old fetal right ventricles to elucidate their flow dynamics, mechanical forces and energetics.

Results showed that diastolic flow dynamics of the fetal right ventricle were influenced by the presence of two vortex rings, corresponding to E-wave and A-wave, which interacted with one another. The two rings caused elevations in the wall shear stress (WSS) as the moved near to the walls. Vortex structures did not fully dissipate at the end of diastole and were ejected, giving helicity to systolic outflow. These helical flow, however, did not significantly elevate systolic WSS, as elucidated by simulations with and without diastolic vortex structures, where surface-averaged WSS was changed by only 6.0%.

Additionally, intra-ventricular pressure gradient (IVPG) had been used as a measure for normal systolic ejection and diastolic filling in adult heart. In this simulation, it was found that fetal IVPG were in the range of be 0.2-0.9 mmHg during systole, and 0.1-0.2 mmHg during diastole. These results can be used as a baseline comparison against diseased heart.
Further, contrary to prevailing theory, diastolic vortices did not significantly alter the work done by the heart for ejection despite storing approximately 25.0% of the peak diastolic kinetic energy over to systole.

ID: E3-0010 **PO-03 : 20**

FORWARD DYNAMIC SIMULATION OF PRECISION GRIP BASED ON A RECURRENT NEURAL NETWORK MODEL.

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Humans can stably hold and skillfully manipulate an object by coordinated control of complex and redundant musculoskeletal system. However, how human central nervous system actually realizes precision grip tasks by coordinated control of fingertip forces applied to an object still remains unclear. In the present study, we aimed to construct a neural network model that can spontaneously generate precision grip motions without a priori planning trajectories. The nervous system was modeled as a recurrent neural network model prescribing kinematic and kinetic constraints that must be satisfied in precision grip tasks in the form of energy functions. The recurrent neural network autonomously behaves such as to decrease the energy functions; therefore, given the estimated mass and center of mass location of the target object, the nervous system model can spontaneously generate muscle activation signals that realize stable precision grips due to dynamic relaxation of the energy functions embedded in the nervous system. In addition, fingertip forces are assumed to be modulated by sensory information about slip between object and fingertip. Two-dimensional musculoskeletal model of the human hand with a thumb and an index finger was constructed. Forward dynamic simulation of the precision grip task was performed using the proposed neural network model. Our results demonstrated that the proposed neural network model could stably pinch and successfully hold up the object in various conditions while spontaneously avoiding the motor redundancy problem. Furthermore, the nervous model autonomously generated greater fingertip forces when the object surfaces are tapered upwards, and vice versa, as actually observed in human physiological experiments. The proposed neuro-computational model may possibly explain fundamental control strategy of precision grip in humans.

ID: E3-0016 **PO-03 : 21**

INTERVERTEBRAL DISC BULGE BEHAVIOUR OF INTACT/DEFECTED FUNCTIONAL SPINAL UNIT: A FINITE ELEMENT STUDY

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INTRODUCTION: Impingement of nerve root are often caused by mechanical failure of intervertebral disc which is related to disc bulging. It is known that, depending on the loading direction, the disc exhibits different bulging pattern circumferentially in vitro (Heuer et al., 2008). In finite element (FE) studies related to intervertebral disc, stress and strain behaviour has been the major concern while limited attention was paid for the disc bulging. The aim of this study is to develop FE model for intervertebral disc bulging deformation analysis. Disc bulge behaviour was examined for different models from the full-defect model of vertebral body disc unit to the intact model of functional spinal unit (FSU) by adding constitutive components of FSU – anterior and posterior longitudinal ligament, vertebral posterior element, facet capsular, flavum, interspinous and supraspinous ligament, one by one.

METHOD: From a CT image, bone was segmented for L1-L2 and L4-L5 units. Vertebral bone was discretised in hexahedral elements. Annulus and nucleus were interpolated from vertebrae mesh, and a quadratic bulge profile was introduced. Annulus fibre orientation was specified by angle variability along circumferential direction. Linear elasticity was assumed for vertebral bodies with posterior elements and endplates, and hyper-elasticity was chosen for nucleus and annulus. Compression of 200 N and moment up to 10 Nm were applied to the superior face of the unit. Bulge displacement was calculated based on the translation of associated nodes relative to the disc centroid. Computational analysis was performed with FEBio.

RESULT: Higher degree of bulge (3-7%) was exhibited at the lower spinal unit than the upper unit. Highest bulge was predicted at the ventral region under anterior bending while posterior bending exhibited significant bulge at the dorsal-lateral region. The absence of ligaments was significant in the increase of the bulge displacement.

ID: E3-0017 **PO-03 : 22**

RELATIONSHIP BETWEEN PERISTALTIC CONTRACTION AND GASTRIC MIXING

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We investigated the relationship between the peristaltic contractions and gastric mixing using a numerical model. A computational fluid dynamics model of gastric mixing was developed using an anatomically-realistic geometric model of the stomach, and two-phase flow and moving boundary modeling of gastric flow. A finite volume method (FVM) was used with a volume-of-fluid (VOF) method and an immersed boundary method (IBM). All the procedures were fully implemented in graphics processing unit (GPU) computing. When the peristaltic contraction approached to the pylorus, retropulsive flow was generated, and flow separation occurred behind the contraction. An increase in the propagation velocity of the contraction or a decrease in the food viscosity increased the extent of flow separation, resulting in the enhancement of gastric mixing. We also discussed the effect of contraction frequency and acceleration on gastric mixing.

ID: E3-0025 **PO-03 : 24**

FINITE ELEMENT ANALYSIS OF BREAST COSMETIC DEFORMATION BY BRASSIERE WEARING

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In order to clear the relationship between the compressed shape of the brassiere-wearing breast and the soft material distributions of the breast, the finite element (FE) simulations were applied to the two women's inidividual breast shapes. Three dimentional shape of bare breasts and wearing-brassjere geometory were reconstracted by MR imaging. Mammary tissues and fat were assumed as hyperelastic materials in order to reproduce the compressive deformation. The lift-up simulations of two kind of brassieres, 3/4-cup type and full-cup one, were tried with changing the occpation ratio of the mammary glandular in the breast under gravity loading. The FE simulation results using bare models which considered the mammary glandular ratio, had good agreements with the MRI measurements in wearing conditions . These results indicate the importance not only the shape of breast but also inside distributions of the soft tisses for more cosmetic wearing designs.

ID: E3-0026 **PO-03 : 25**

THE EFFECT OF VARIATIONS IN CARTILAGE MATERIAL PROPERTIES ON PREDICTING RADIOCAPITELLAR CONTACT MECHANICS OF THE HUMAN ELBOW JOINT

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INTRODUCTION: There is currently no agreement in cartilage material properties used in Finite Element Analysis(FEA) for the study of elbow joint contact mechanics. This study aims to investigate the effect of variations in cartilage material properties on the prediction of radiocapitellar contact mechanics using a three-dimensional FE model of the human elbow joint.

MATERIALS AND METHODS: A 3D FE model was reconstructed from CT images of a healthy elbow joint (male, 26 years). The bone structures were assigned material properties based on a modulus-density relationship (E=8346ρapp1.5) with Poisson's ratio (υ) of 0.3. Cartilages were modelled as linear elastic compressible (E=10MPa and υ=0.4, denoted LE1), less compressible (E=12MPa and υ=0.45, denoted LE2), and nonlinear incompressible hyperelastic neo-Hookean material model (Bulk modulus=0.31MPa, Shear modulus=0.37MPa, denoted NH). To simulate the force of daily living through the elbow, a 160N compressive load was applied to the proximal surface of the radius, while the elbow joint was configured at a full extension position, and the humerus and ulna were constrained in all degrees-of-freedom.

RESULTS: FE-predicted values for NH showed less than 5% difference in contact area and average contact pressures to the published experimental literature values (Bachman, 2015). Use of LE1 and LE2 resulted in a decrease in contact area by 62% and 70% respectively. Also, for average contact pressure, NH was up to 3.5 times lower than LE1 and LE2 models.

DISCUSSION: The results of this study suggest that proper selection of material properties is critical in predicting joint contact mechanics using FEA. The differences in FE output variables between neo-hookean hyperelastic and linear elastic models can be attributed to the anisotropic, viscoelastic and non-

homogenous nature of biological articulating cartilages. We concluded that previous models that employ linear elastic cartilages may have underestimated contact areas and overestimated average contact pressures.

ID: E3-0029 **PO-03 : 26**

NANOPARTICLE DEPOSITION IN A NASAL HUMAN CAVITY

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Flow simulation in the human respiratory tract is a great challenge, because of its complex geometry the nasal cavity with only 10 cm length feature a wide range of flow phenomena. Large eddy simulation (LES) give capability to simulate laminar to transient regime, here a constant flow rate of Q=20L/min is considered.

Nanoparticle transport and deposition are simulated through Lagrangian method, the nanoparticle deposition considered here is with a effective diameter 1 < dp < 150 nm.
This work shows the potential of simulations to better understand the flow dynamics of human nasal cavity and to study the drug delivery of aerosols as well as exploring new treatments and diagnosis.

ID: E3-0031 **PO-03 : 27**

A NOVEL METHOD TO ESTIMATE THE BIOMECHANICAL PROPERTIES OF THE CORNEA IN VIVO WITH APPLICATION TO GLAUCOMA

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Purpose
To determine the in-vivo nonlinear viscoelastic biomechanical properties of normal and glaucoma corneas using a novel inverse finite element modelling method.

Method
The corneas of 47 subjects (14 normals and 33 glaucoma subjects) were deformed using a tonometer with an imaging system (Oculus, Wetzlar, Germany). The images taken allows each patient's cornea to be modelled using the finite element (FE) method. A nonlinear viscoelastic constitutive material model (Veronda Westmann) was used to describe the FE model's deformation. Using an optimization method (differential evolution), we could vary the material properties of each subject's modelled cornea until the deformations matched those derived experimentally. This method allows us to determine a unique set of corneal material properties for each patient.

Results
The optimised finite element models matched the experimental results obtained from the Corvis Tonometer. The 14 normal subjects had a mean intraocular pressure (IOP) of 15.06+-2.03 mmHg and a mean central corneal thickness (CCT) of 553.6+-24.4 microns; the 33 glaucoma subjects had a mean IOP of 15.31+-2.15 mmHg and mean CCT of 551.9+-36.1 microns. The average corneal mechanical properties C1 (matrix stiffness), C2 (collagen uncrimping), (viscoelastic coefficient) and (relaxation rate) for the healthy subjects were 4.54*10^2 Pa, 1.91*10^2, 1.46*10^1 and 3.38*10^-1 sec, respectively. For the glaucoma subjects, those parameters were 9.54*10^2 Pa, 1.87*10^2, 1.51*10^1 and 2.06*10^-1 sec. The mean tangent modulus (at 2% strain) of healthy subjects was 2.52*10^6 Pa while that of the glaucoma subjects was 2.92*10^6 Pa. This suggests that glaucoma corneas are stiffer in general when compared to healthy corneas.

Conclusion
Our novel methodology allows us to estimate the complex biomechanical properties of the cornea in vivo. Our work may help us identify whether corneal biomechanics is a biomarker for glaucoma.

ID: E4-0002 **PO-03 : 28**

EFFECTS OF GROWTH FACTORS ON SHRINKAGE PROCESS IN THREE-DIMENSIONAL DERMIS CELL CULTURE MODEL

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During wound healing process, dermal fibroblasts infiltrate into wound site and secrete collagen to repair the wound. Fibroblasts also generate a shrinkage force stimulating cell infiltration and proliferation to accelerate the wound healing by decreasing the surface area of the wound. The disorder of this shrinkage force has risks to cause a skin disease called "keloid" induced by excessive cell proliferation and secretion of collagen. Keloid is sometimes accompanied with severe itchiness and pain. However, there is not ideal treatment method because the occurrence mechanism has been still unclear. Therefore, it is important to monitor the shrinkage

force during wound healing process and to evaluate the effect of the several growth factors working in the healing process on the force. For simulating dermis tissue in vitro, three-dimensional dermis fibroblasts culture model has been used frequently. Usually, the dermis tissue is reconstructed by embedding the fibroblasts in collagen gel and cultured in vitro. This dermis tissue model would shrink during in vitro culture to simulate the wound shrinkage phenomena under the healing process. In this study, we developed the culturing device for three-dimensional dermis tissue model to enable monitoring the shrinking force. This device consisted of vertical cantilever baems with strain gauges to measure and record the shrinkage force, and allowed the culture of dermis tissue model by simulating the condition of CO2 incubator using the glass heater and gas controller. We also evaluated the effects of ascorbic acid, FGF-2 and cell concentration on shrinkage process using this device. As the results, ascorbic acid and FGF-2 were related to the increasing rate of shrinkage force, and the cell concentration were related to the max value of shrinkage force. In conclusion, it was suggested that some growth factors were related to shrinkage process in three-dimensional dermis tissue model.

ID: E5-0004 **PO-03 : 29**

KINEMATIC ANALYSIS OF SHOULDER JOINT USING 2D-3D REGISTRATION TECHNIQUE

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The shoulder joint has a wide range of motion, and it achieves various daily activities. Therefore, it is important to kinematic analysis for the shoulder joint and the disease shoulder joint. The purpose of this study was to evaluate kinematics of shoulder joint using 2D-3D registration technique.

This study consisted of ten healthy subject and five patients with rotator cuff tears. Rotation activity was defined as motion from maximum internal rotated position to maximum external rotated position. Elevation activity was defined as from the resting position to the maximum elevation. Continuous coronal x-ray images of rotation and elevation activities for each subjects were taken using a flat panel detector. Each subjects was scanned by computed tomography to generate digitally reconstructed radiographs (DRR). The DRRs were then compared with the serial X-ray images acquired using the flat panel detector. The 3D positions and orientations of bones of shoulder joint were determined by the 2D-3D registration technique using image correlations.

In rotation activity, the largest displacement was internal/external rotation. The average of it motion range was 113.6±11.1 degrees in healthy shoulder and 61.4±11.4 degrees in rotator cuff tears shoulder. In elevation activity, the largest displacement was adduction /abduction rotation. The average of it motion range was 97.9±3.0 degrees in healthy shoulder and 61.4±11.4 degrees in rotator cuff tears shoulder. Both activities, the largest displacement of rotator cuff tears shoulder were smaller than healthy shoulder. Other degrees of freedom are not significantly displacement, but it was possible to evaluate the kinematics in detail. We were able to analyze movement of the shoulder joint in vivo using 2D-3D registration technique. Kinematics' data during activities of daily living may provide important insight into the evaluation of pathological and reconstructed shoulder.

ID: E5-0007 **PO-03 : 30**

BIOMECHANICAL EVALUATION OF NOVEL AND STANDARD PLATE FIXATION FOR SYMPHYSIS FRACTURE OF THE MANDIBLE

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Symphyseal fracture of the mandibular is commonly caused by traffic or daily accident. The incidence of symphyseal fractures of the mandible have been reported between 9% and 57%. With the improvement of scientific and surgical techniques, various fixation approaches were developed to treat mandible fractures. However, the fixation of symphyseal fracture of the mandible is still controversial. The objective of this study is to evaluate the biomechanical stability of novel and standard fixation for symphyseal fracture of the mandibular. In each group of plate fixation, five artificial mandibles were applied for stability evaluation. The standard plate fixation was to place a 4-hole straight plate at the fracture site. The novel plate fixation was to put a 2-hole plate at the fracture site and another 2-hole plate at the bottom of the mandible symphysis. 2.7 kg force was exerted on bilateral mandibular angle to simulate the function of masseter. The displacement of the fracture site was recorded by digital image correlation measurement.

Mann-Whitney U test was adopted for comparison and the significant level was set to 0.5. Both groups revealed valgus deformation under the masseter force. The results showed that the novel plate fixation for symphyseal fracture of the mandible provided significantly less displacement than standard plate fixation. As a result of two-dimensional stability offered by the novel plate fixation, its performance would be better than standard plate fixation for the symphyseal fracture of the mandible.

ID: E5-0012 **PO-03 : 31**

A NUMERICAL STUDY ON THE MECHANICAL PERFORMANCE OF DIFFERENT CONFIGURATIONS OF MAGNESIUM ALLOY DYNAMIC COMPRESSION PLATES FOR VARIOUS GAIT LOADS

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Dynamic compression plates are used for the fracture fixation treatment and made up of medical grade stainless steel and titanium alloys. Biocompatible magnesium alloys gets degraded inside the body, thereby no secondary surgery is required to remove the plates from the body after healing of the fractured bone. Stress shielding effect can be seen when the plates are made of stainless steel or titanium alloys. Use of magnesium alloys for dynamic compression plates prevents the stress shielding on the bone. So currently, magnesium alloys are being studied to a greater extent for orthopaedic applications as potential biodegradable material for the implants.

The objective of the present study is to compare different configurations of magnesium alloy plates for various gait loads and the life estimation. In an earlier experimental study, a four point bending test showed the magnesium alloy to have the required strength and ductility. Further, continuing with a numerical study, the results showed the load distribution through bone, thereby making it more suitable to overcome stress shielding effects. These studies were done for different configurations, with 6 holes and for different thickness of plate, as 3mm and 5 mm with variation in the width of the plate. The variation of the width was 1.2, 1.3 and 1.4 times larger than initial dimensions of 12mm. Continuing the previous work, the present study tries to understand the mechanical performance for three stance stages of gait (10%, 30% and 45% gait) and during swing (70% gait). Also the study discusses the life estimation for various configurations. The study has found the areas of possible re-design based on the gait loads and the life estimation study would be helpful for clinicians to take a call on possible redundancy of the plate post fracture healing.

Keywords: Dynamic Compression Plate, biodegradable, magnesium alloys, gait cycles

ID: E6-0005 **PO-03 : 32**

THE BIOMECHANICAL EFFECTS OF THE DEFORMATION AND TRAPPING OF THE NUCLEUS ON CELLULAR FUNCTIONS

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Cells sense external forces and then translate them into biochemical signals that induce various responses. The nucleus itself has been proposed to act as a cellular mechanosensor, and the changes in nuclear shape or its deformation possibly affect the regulation of cell functions. Recently, we demonstrated that mechanical deformation and trapping of the intracellular nucleus using polydimethylsiloxane (PDMS)-based microfabricated substrates with an array of micropillars inhibited by cultivation on the micropillar substrates. In the present study, we further investigated the effects of nuclear deformation on the physiological function, such as cell migration, DNA synthesis, and contractile differentiation of vascular smooth muscle cells (SMCs). We found that the mechanical trapping of the SMC nuclei with the micropillars significantly inhibited cell migration, and they also prominently inhibited DNA synthesis. It has generally been suggested that contact inhibition of cell proliferation occurs when a cell culture reaches confluence. However, the proliferation of SMCs was significantly inhibited in the micropillar substrates even though the cells did not reach the confluent state. We also found that not only the migration and cell proliferation of SMCs but also their contractile protein expression was dramatically inhibited on the micropillar substrates. A detailed image analysis with confocal microscopy revealed that expression of lamin A/C was significantly decreased in the region deforming along the pillar surfaces, and underlying DNA distribution became more heterogeneous. These results may indicate that lamin A/C has a role of mechanosensor to detect an excessive deformation of nucleus, and they switch the cell state from an “active phase” to a “resting phase”.

ID: E6-0008 **PO-03 : 33**

EFFECTED OF UV IRRADIATION ON MECHANICAL PROPERTY OF SKIN CELL-SEEDED COLLAGEN GEL

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Recently, the field of anti-aging treatment to improve QOL of aged people is receiving a lot of attention. Particularly, the skin health became one of the most important points for anti-aging. The skin tissue consists of epidermis layer, dermis layer and hypodermis. The firmness skin was maintained by collagen fiber, elastin fiber and hyaluronic acid secreted by fibroblasts in dermis layer. The wrinkles would be generated if these consistents of skin are degenerated. It is considered that the wrinkles are sometimes induced by ultraviolet A (UVA) irradiation to reach the dermis layer and cause the tissue degeneration, however the mechanism is still unclear. For this reason, many studies about the effect of UVA irradiation on the skin fibroblasts have been reported. However, the material properties of skin tissue have not been studied. Therefore, the purpose of this study is to construct an in vitro skin model subjected to UVA irradiation and to evaluate the effect of UV on the change in material properties of skin model. To simulate a dermis layer in vitro, human fibroblasts-populated collagen gels were constructed and subjected to the UVA irradiation before in vitro culture. After the culture, cell viability and mechanical property of the specimens were evaluated. The specimens subjected to UVA irradiation showed higher ratio of cell death. On the other hand, the fibroblasts in control specimens were alive during the culture time. The elasticity of the reconstructed skin tissues differed depending on the UVA irradiation condition. From the results of our study, it was suggested that material properties of the skin tissue changed depending on the UVA irradiation condition and these changes might be related to the wrinkle formation.

ID: E6-0013 **PO-03 : 34**

PROBING THE MECHANICAL PROPERTIES OF CANCER CELLS ARISING FROM GEOMETRICAL CONSTRAINTS USING ATOMIC FORCE MICROSCOPY

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Cancer is one of the leading causes of death worldwide. Initiation and progression of cancer is usually accompanied by alterations in mechanical properties of the cells and their environment. Understanding these biomechanical changes can not only help us to better understand the mechanisms of this disease, but can also serve as baselines for its diagnosis and even treatment. One of the state-of-the-art technologies used to study cell mechanics is Atomic Force Microscopy (AFM). AFM is a powerful tool that can be used to study cell response to locally applied force. However, most of the current AFM studies use models with assumptions that oversimplify the complex nature of the cell, or they report elasticity values regardless of the differences in adhesion area of the studied cells. In this paper, we seek to examine the effect of adhesion area and shape on elasticity of the cancer cells with different metastatic potential. More specifically, we have used microcontact printing to control cell area and shape and related their elasticity from AFM to their cytoskeletal organization. We also incorporate a model that more realistically portraits the viscoelasticity nature of the cells.

ID: E6-0014 **PO-03 : 35**

CORRELATION BETWEEN EXTRACELLULAR MATRIX (ECM)-STIFFNESS AND CANCER METASTASIS

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Metastasis is responsible for more than 90% of cancer death in humans. As such, cancer metastasis is a significant hurdle in curing cancer. Previous studies have shown that stiff extracellular matrix (ECM) may promote migration of cancer cells and induce cancer metastasis. To elucidate the specific impact of ECM stiffness on cellular migration, we investigated the changes of cellular behaviors on different stiffness. Polyacrylamide gels were prepared in various stiffness (0.3 kPa ~ 153.6 kPa) and were coated with collagen to culture human lung carcinoma cells (A549). We

allowed the cells to adhere and grow on the gel-substrate in incubator for 24 hours, then imaged them with microscope to track the position every 5 minutes for another 24 hours. Proliferation, morphology, migration trajectory and speed were measured. We found that the cells on soft ECM (0.3 kPa) migrate 60% less than those on stiff ECMs (19.2 kPa & 153.6 kPa). Also, cells spread 52% less on soft ECM compared to the ones on stiffer ECM. However, cells did not show significant differences in proliferation across different ECM stiffnesses in 24 hours. Then, we inhibited Rho/ROCK pathway using y-27632 to study the stiffness sensing mechanism.

ID: E7-0002 **PO-03 : 36**

COMPARISON OF EEG DURING MOTION IN REAL SPACE AND VIRTUAL REALITY

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Enjoying virtual motion indoors has become possible in recent years thanks to the Nintendo Wii videogame console, which can be played using body motion controls. However, the difference between actual motion and motion that takes place in virtual reality in a game setting has not yet been studied in detail. The objective of this study is to measure and conduct a comparative analysis of EEG upon real motion and under virtual reality (VR), focusing on alpha waves and beta waves.

The EEG electrodes were placed at six positions. For motion in VR, we used a Nintendo Wii. The activities considered were Wii Sport Resort Table Tennis and a real table tennis game. The Wii game was played soon after the real table tennis game, in order to avoid inadvertent differences in EEG measuring positions. Using MATLAB, a and b waves extracted from signals obtained with the brain wave sensor were analyzed, and a comparative study was conducted for each situation.

It was found that in both real space and VR, a waves had statistically significantly higher values than b waves. It is worth noting that when real space is compared with VR, whereas in VR it is possible to return a ball by simply adjusting the timing of the swing, in real space a variety of information is necessary to return a ball, such as the depth, height, and force, in three dimensions. Therefore, the brain may be required to work more actively in order to process such information. Thus, we believe that moving the body in real space activates the brain in a more effective way than playing virtual sports in VR. These facts suggest that exercise effects can also be expected in VR, although not at the same level as in real space.

ID: E7-0003 **PO-03 : 37**

POSSIBILITY OF QUANTIFYING A KENDO DAN GRADE BASED ON EEG POWER SPECTRAL AND EEG-EMG COHERENCE ANALYSIS

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Kendo has been known as a Japanese martial art. There are some form practices used in examination for promotion judged by not only body movements but also mental attitudes. Although few studies show power spectral analysis of EEG in which the subject imagine the performance, it has been unclear how EEG and EMG signals represent during actual performance still. Our objective is to analyze affinities and differences among grades (dan) in a Kendo form in the presence of power spectral density and coherence estimated from EEG and EMG signals.

In this study, a veteran person with eighth-dan (elite) and people with third-dan (control) were performed. Each subject performed a form, 'Men kaeshi do', iterated for five trials. A portable multi-channel EEG/EMG measurement system was applied to record these signals simultaneously. The EEG electrodes were set at variable locations following international 10-20 system, while the surface EMG electrodes were set at the right flexor carpi and the right triceps brachii with a sampling frequency of 1024 Hz. The performance was divided into three sessions; especially the second one corresponds to try hitting. The power spectral density (PSD) and the coherence between EEG and EMG was estimated per session. Frequency components such as alpha (8-12 Hz) and beta (13-40 Hz) band were extracted from each PSD. The average values for each component among trials were calculated.

We have shown that the averaged PSD in alpha and beta range maximized at the second session in all the subjects respectively. Moreover, the results show that the magnitude of coherence between C3 and right flexor carpi in alpha and beta components in elite was significantly higher than that in control people at the second session.

These findings can accelerate our understanding of possibility of grade quantification of Kendo within mental and neuro-muscular coordination.

ID: E7-0007 **PO-03 : 38**

EFFECT OF A SINGLE BATTLE ROPE TRAINING ON HEART RATE AND METABOLIC EQUIVALENTS

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Purpose:Battle rope training is a new way for exercise, battle rope interval training mode, can increase heart rate in the shortest possible time. Therefore, it is possibly being the best choice for the person who do not love long time performing aerobic exercise. However, no studies have pointed out how high heart rate can be raised and how much energy will be consumed in single battle rope training. Method: 12 healthy university students, age 24.42+-2.06, height 167.83+-6.42cm, and weight 63.01+-7.01kg were recruited. Before training, VO2max with Meta max system was evaluated, then performed the battle rope training with Meta max system only for the first time. A single battle rope training was including 8 movements (1movement exercise 15 s and rest 15 s) as 1 set total 4 sets, each set rest 5 min, total duration was around 31 min. Result: According to ACSM indicators, subjects had VO2 max 40+-6.66 ml/kg/min, HRmax 185.83+-6.72 bpm , HRmax during the battle rope training 181.08+-7 bpm, mean HR 142.17+-7.46, METS 9.24+-1.96, equal to jogging one hour with eight kilometers in distance. Conclusion: We found that in a single battle rope training, energy consumption was very high in a very short period of time. Moreover, battle rope can combine with other equipment to enhance muscle strength in various parts of the body. Future battle rope training will be able to promote health not only in athlete but also in healthy people.

ID: D6-0005 **PO-03 : 39**

DEVELOPMENT OF A NOVEL STRETCHABLE AND TOUGH HYDROGEL TOWARDS 3D PRINTABLE LOW-COST ARTIFICIAL MENISCUS

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Introduction
Meniscus tear is a common knee injury in the general population. It is a major risk factor for osteoarthritis because meniscus cannot heal by itself once injured. At the end stage of knee osteoarthritis, patients often end up with total knee replacement surgery, a major operation that results in significant morbidities and complications. In this project, we aim to develop a 3D printable artificial scaffold to replace the damaged meniscus and to prevent osteoarthritis subsequently.

Method
To fabricate a 3D matrix similar to the meniscus physiologically, an analogous mechanical environment is a key component. Therefore, groups of hydrogel were prepared for investigation, which consisted of PEGDA with different molecular weight, UV initiator (Irgacure 2959), sodium alginate of various concentration and DI water. After mixing the pre-gel uniformly, all of the pre-gel was exposed to UV light in a shape of a cylinder. Later, all hydrogel was soaked in 1M CaCl2 solutions for different duration. Mechanical tests were performed after the immersion.

Results and Discussion
Our data showed that the group of 20,000Da PEG and 5% alginate is mechanically robust substitute of the meniscus. It achieved a 92.3% compressive strain and its Young's modulus reached 131.27kPa at 12% strain, which is comparable to human meniscus at equilibrium. Meanwhile, the estimate cost for fabricating this artificial meniscus was approximately US$40.

Conclusion
Our data indicate the feasibility of a 3D printable and biocompatible hydrogel artificial meniscus with stretchability and comparable toughness to human meniscus. It might provide an alternative and more cost-effective treatment for the patients with meniscus tear.

Keywords: 3D Bioprinting, Hydrogel, Meniscus, Biomaterial

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