INTERNATIONAL REVIEW OF THE ARMED FORCES MEDICAL SERVICES

REVUE INTERNATIONALE DES SERVICES DE SANTÉ DES FORCES ARMÉES

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Official organ of the International Committee of Military Medicine
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Quarterly: September 2016 • Trimestriel : septembre 2016

VOL. 89/3

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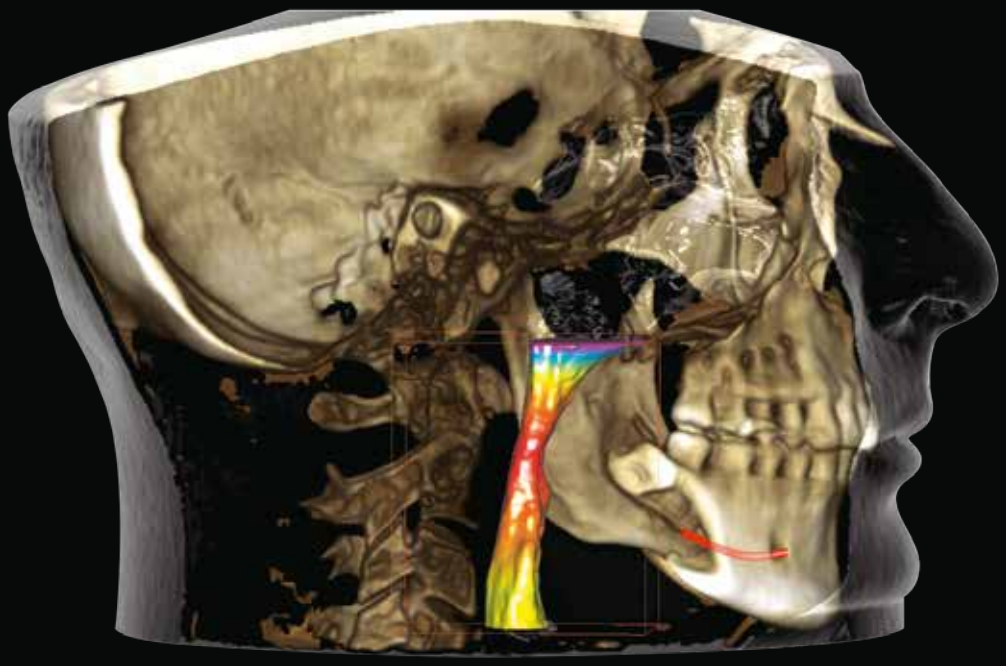

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Revue Internationale des Services de Santé des Forces Armées

Official organ of the
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VOL. 89/3

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High-Performance Lower Limb Amputee Rehabilitation: The Canadian Armed Forces Lessons Learned 2008-2015.*

By P. GODSELL[1], M. BESEMANN[2] and E. H. SINITSKI[3]. Canada

Pauline GODSELL

Captain Pauline GODSELL, BSc (PT), was appointed the Rehabilitation Physiotherapy Coordinator for the Canadian Forces Physical Rehabilitation program from August 2010 to January 2015. She joined the Canadian Armed Forces in 2003 and received her BSc (PT) from the University of Ottawa in 2007. Upon graduation, she was the recipient of the Physiotherapy Foundation of Canada Entry-Level Student Research Award. In 2012, she was awarded the Queen Elizabeth II Diamond Jubilee Medal for her significant contributions and achievements in physical rehabilitation. Her attention to detail and motivating work ethic ensure the highest standards in the delivery of outstanding rehabilitative services to serving personnel.

RESUME

Réadaptation des amputés du membre inférieur, un programme de haute performance : Connaissances acquises par les Forces armées canadiennes 2008-2015.

Les membres des Forces armées canadiennes (FAC) qui subissent des blessures traumatiques attendent la même intensité dans leur récupération et leur réadaptation qu'ils appliquent à leur entraînement militaire. Le Programme de réadaptation physique des FAC a été créé en 2008, basé sur le cadre de l'Organisation mondiale de la santé pour la santé et l'handicap, la Classification internationale du fonctionnement, du handicap et de la santé. Une équipe de réadaptation hybride civilo-militaire favorise un environnement de réadaptation stimulant afin de répondre aux objectifs de haute performance, remise en forme et retour au travail des militaires. Cet article mettra en évidence les meilleures pratiques et les leçons cliniques apprises dans la réadaptation d'amputés suivant les quatre piliers du programme de haute performance des FAC. Des considérations pour la physiothérapie d'amputés du membre inférieur fondées sur les preuves seront également examinées aidant à réduire l'apparition de conditions physiques secondaires ou bien des complications associées à l'utilisation de prothèse à long terme. Les connaissances acquises contribuent à optimiser les résultats fonctionnels et cliniques chez le personnel amputé des FAC. Ils pourraient être appliqués à certains patients de la population civile, avec des profils cliniques similaires dans des pays démographiques similaires.

KEYWORDS: Amputee, Rehabilitation program, Canadian Armed Forces.

MOTS-CLÉS : *Amputé, Programme de réadaptation, Forces armées canadiennes.*

INTRODUCTION

The World Health Organization's (WHO) International Classification of Functioning (ICF), Disability and Health, defines Participation as the involvement in a life situation[1]. The loss of a lower limb has severe implications for a person's mobility, and ability to perform activities of daily living[2]. In order to meet high-performance fitness and return-to-work rehabilitation objectives, the Canadian Armed Forces (CAF) established a hybrid civilian-military rehabilitation program[3]. The CAF Rehabilitation Program was launched in 2008 with seven military sites matched with civilian rehabilitation

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* Presented at the 41st ICMM World Congress on Military Medicine, Bali, Indonesia, 17-22 May 2015.

Centres of Excellence across Canada. The mission of the CAF Physical Rehabilitation Program is to provide the clinical expertise, coaching and resources to assist CAF personnel in the re-integration of meaningful activity[4]. The ultimate goal of physical rehabilitation after limb loss is successful ambulation with the use of a prosthesis[5] while returning to the highest level of social reintegration[6]. CAF personnel are often referred to as tactical athletes and thus when injured expect the same intensity of their rehabilitation as they applied to their military training. With CAF members' unique service requirements and many current prosthetic technological advances, CAF members require a collaborative team approach to ensure high quality prosthetic services are delivered to Canada's fighting Force wherever they may serve. The 2004 Canadian Forces Medical Clinic Model states "the goal of Collaborative Practice is to successfully integrate the skills and knowledge of health care providers from different disciplines to optimize patient care". Typically, CAF physiotherapists direct a CAF amputee's physical rehabilitation process[7] at military medical clinics located throughout Canada. CAF physiotherapy clinicians adopted the WHO ICF framework to describe function and disability in relation to a health condition. This framework helped foster clinical reasoning; developed patient-centered therapy goals; clarified team roles; and provided a common language for documenting information on the functional changes associated with interventions. The WHO ICF framework also includes amputee specific elements[8], which were incorporated into CAF amputee's physical rehabilitation process. This article will highlight clinical best practices and lessons learned in amputee rehabilitation within the CAF Physical Rehabilitation Program High-Performance framework. The insights gained help maximize function and clinical outcomes in injured CAF personnel and could be applied to select patients in civilian and military populations, with similar clinical profiles and demographics.

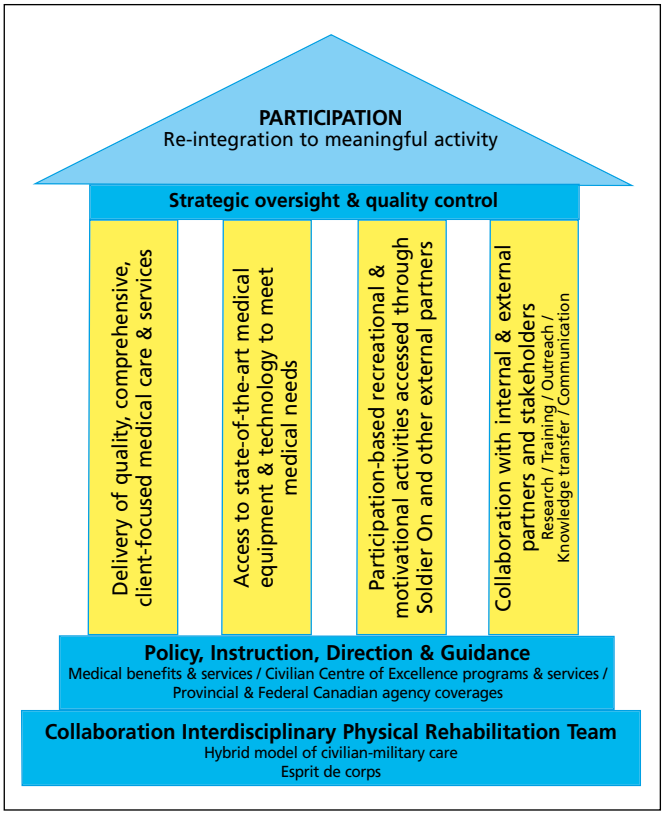
CANADIAN ARMED FORCES PHYSICAL REHAB PROGRAM HIGH-PERFORMANCE FRAMEWORK

The CAF Physical Rehabilitation Program High-Performance framework consists of four pillars (Figure 1), bound together by sustainability measures to achieve optimal participation for CAF members post-amputation. This framework was established to meet high-performance fitness and return-to-work objectives of our service members with a lower limb loss.

COLLABORATIVE INTERDISCIPLINARY PHYSICAL REHABILITATION TEAM

The success of the CAF Physical Rehabilitation Program High-performance framework was the implementation of a collaborative interdisciplinary rehabilitation team. This comprehensive care approach was achieved through military clinicians augmenting or supplementing civilian rehabilitation resources. Rehabilitating CAF amputees must be challenged beyond what is conventionally administered in standard civilian rehabilitation settings in order to reduce the risk of losing motivation and in the process becoming

Figure 1: Pillars to Canadian Armed Forces Physical Rehabilitation Program High-Performance Framework.



"civilianized". This occurred when CAF members lost their discipline and esprit de corps from lack of regular exposure to uniformed personnel, military pace and expectations and military life. Clearly, the longer the civilian rehabilitation component, the greater the risk of "civilianization". CAF clinicians serve as a strong military presence throughout the rehabilitation continuum providing clear guidance to the civilian rehab teams with respect to the higher-than-average pre-morbid fitness levels, CAF work environments, physical and mental demands, and any other areas of the CAF lifestyle that assist in developing appropriate, realistic and measurable goals and/or discharge criteria.

Through our collaborations with the Defence Medical Rehabilitation Centre Headley Court in the United Kingdom and the United States Armed Forces Amputee Patient Care Program[9], the importance of realistic and measurable goals and discharge criteria was emphasized early to our program. Ongoing patient education and prosthetic training is required to accommodate the dynamic nature of individualized goals and technology. Additionally, shorter bursts of intensive goal-orientated rehabilitation phases to promote attainment of optimal potential while also promoting community and family re-integration have proven most effective. Both Colonel (Ret.) Paul Pasquina[10] and Lieutenant-Colonel Markus Besemann[3] emphasized the importance of grouping casualties from similar geographical area together in same facilities to improve morale, motivation and effort. Injured military members expect to be rehabilitated with the same challenging environment and intensity at which they were initially trained[3, 10]. Limiting convalescent leave was also identified in order to promote functional independence and respecting

established treatment goals and a patient's planned return-to-work or transition to civilian life objectives[3, 10].

POLICY, INSTRUCTION, DIRECTION & GUIDANCE

The Canadian Armed Forces is federally mandated to provide health care services for CAF members. Furthermore, these services are comparable to those provided by Canadian provinces and other federal Canadian agencies. These publically funded health services are outlined in the CAF Spectrum of Care, administered by Canadian Forces Health Services (CFHS). In order to ensure sustainability and equitable care for all CAF members, it was critical to maintain strategic oversight, and quality control on an on-going basis.

Current CAF policy allows for a maximum of four prostheses per limb to be considered. The initial three prostheses include: a Primary limb (including microprocessor/bionic/myo-electric components as required); a Back-up limb (usually mechanical components); and a Shower/Swim/utility or activity-specific limb. A fourth prosthesis may be requested for work or sports-specific activities commensurate with CAF member's level of function. A Prosthetic Review Committee serves as a quality control measure and assists in attaining informed decision-making on the choice of prosthetic devices delivered and fitted to individuals. However, as we have noted on multiple occasions, technology alone does not achieve fulfilling life re-integration. Aggressive therapy and education is also required to achieve maximum function, but above all, an adequate grieving process and a certain acceptance of loss is necessary in order to move forward in a healthy way.

DELIVERY OF QUALITY, COMPREHENSIVE, CLIENT-FOCUSED MEDICAL CARE & SERVICES

The first pillar of the CAF high-performance rehabilitation framework is to provide standardized, uniformed, high-quality programs and services which enable the attainment of optimal potential following injury. Providing quality, comprehensive gait training is a vital component to any rehabilitation process in order to minimize secondary physical conditions[11] associated with lower limb amputation and long term prosthetic use. Secondary physical conditions associated with lower limb amputation and long term prosthesis use may include: degenerative changes at the knee and hip joint of the intact limb due to altered biomechanics; osteopenia and subsequent osteoporosis due to insufficient loading through the long bones of the lower limb; and low back pain linked to poor prosthetic fit and alignment, postural changes, leg-length discrepancy, amputation level and general deconditioning[11]. However, amputee rehabilitation interventions can target several known modifiable factors including, muscle strength and power; range of motion, balance strategies and proprioceptive control; gait pattern and ability to navigate stairs/obstacles; weight and waist circumference; and the choice in prosthetic components – ankle/foot assemblies and knee units[12]. When one considers an everyday repetitious task, such as going from sitting to standing which occurs a minimum of 50 times per day, the need for functional prosthetic training is quickly illustrated. Research has also identified that a more equal weight distribution is a vital component in the prevention of secondary conditions[13].

CAF physiotherapists adopted a prosthetic training[14, 15] framework based on Dr. Robert Gailey's research and literature to ensure therapeutic education and therapeutic exercises[16, 17, 18] were delivered consistently to CAF lower limb amputees and to maximize biomechanical performance in each treatment session. The framework ensures:

1. Members have a well-fitting and stable socket. Socket interface alignment and fit issues are the primary reason amputees are dissatisfied with their prosthesis. A proper prosthetic fit increases the probability of equal force distribution across the intact and prosthetic limbs during ambulation, thus decreasing the risk of secondary physical conditions[11];

2. Proper height and alignment of the prosthetic limb is achieved considering equal weight distribution through sound and affected limb as well as possible pelvic tilt in above-knee amputees (AKA) where core strength and hip extension range of motion are both essential components to assess and monitor;

3. Hip stability is trained. An AKA or below-knee amputee cannot rely on an ankle strategy thus the speed and quality of the hip strategy[19] must be retrained;

4. Transverse pelvic rotation of member's center of mass over his base of support is restored eliminating poorer gait habits in forward and backward walking and facilitating trunk rotation;

5. Toe loading is occurring in the prosthesis;

6. Step width is restored to 5-10cm with particular attention to an often seen sound limb at midline strategy (adducted sound limb, abducted prosthetic limb) which does add significant stresses to the intact hip and knee;

7. Trunk rotation and arm swing occur as this does contribute to efficient gait;

8. Sit-to-stand is trained with an unstable surface under the sound limb (to discourage compensatory strategies through the intact limb) while cueing and/or pushing into the prosthetic limb to restore better movement symmetry;

9. Ramp training is provided ensuring posture is maintained with cues of "rolling over the toes" while ascending and pressure in the back of the socket [hip extension] when descending; and

10. Stair training is provided ensuring ability to reciprocally navigate stairs ascending and descending one step at a time and being able to ride the knee down as in ramps.

ACCESS TO STATE-OF-THE-ART MEDICAL EQUIPMENT & TECHNOLOGY TO MEET MEDICAL NEEDS

Access to state-of-the art devices is an important component of our high-performance rehabilitation framework to help obtain optimal potential following injury.

Figure 2: Canadian Armed Forces member familiarizes himself with the Escape to Cover task in completing the six Common Military Task Fitness Evaluation (CMTFE), part of Fitness for Operational Requirements of Canadian Armed Forces Employment (FORCE) standards. The Minimum Physical Fitness Standard (MPFS) for the Escape to Cover task is 1 min 08 sec.

Prosthetic care is a specialty, requiring a collaborative team approach to decision-making. Wherever a CAF member is posted, a team advocating for their medical needs and assisting in developing sound medical justifications is available. CAF physiotherapists, alongside civilian Canadian certified prosthetists, organize clinical trials and collect the objective data required. The notes and prescriptions produced by a physiatrist specializing in amputee care must corroborate with the military practitioners' clinical data.

A medical need justification comprehensively takes a military member's unique needs into consideration. The main goal of such a justification is informed decision-making in the choice of prosthetic devices delivered and fitted to an individual. A complete justification stems from the quality, comprehensive, client-focused medical care and services provided and should consider/include:

- Client history, functional goals, family roles, current CAF work requirements, meaningful activities, interests and accomplishments;
- Total prosthetic care to date with accurate breakdown of prostheses currently used and maintained by CFHS, identified prosthesis to be replaced or any frequent recurrences (e.g. sockets or maintenance requirements);
- Objective and subjective clinical findings and measures;
- Medical needs linking technology's advantages to clinical findings (e.g. metabolic energy expenditure, activity level, cognitive demand, gait mechanics, environmental obstacle negotiation, safety (stumble, falls and balance), personal factors (preference, satisfaction and perception), health, quality of life, and financial considerations (future care);
- Clinical research and/or proof of Canadian provinces or other Canadian federal agencies funding such prosthetic devices; and a
- Clearly outlined request including an expected treatment plan and equipment requirements with detailed cost estimates.

Standardizing physical rehabilitation clinical tools is another key component of the CAF amputee rehabilitation framework. Reliable and valid physical rehabilitation outcome measures are collected throughout a continuum of care as evidence to differentiate the impact of therapeutic services and/or technology provides an individual. However, many of the lower limb amputee outcome measures[20, 21] routinely administered in civilian rehabilitation centres did not meet the demands of a relatively fit, high performance military population. This was a phenomenon observed by other military allies and as such a North Atlantic Treaty Organization (NATO) Working Group convened in 2010 in an attempt to standardize functional outcome metrics in assessing patients with combat-related extremity trauma. Lessons learned from this working group and experience gained in assisting CAF members' in meeting their unique life goals and service requirements led to the compilation of the following preferred measures to be collected:

- Six Common Military Tasks Fitness Evaluation (CMTFE)[22]
- Comprehensive High-Activity Mobility Predictor (CHAMP)[23, 24, 25, 26, 27]
- Military-specific functional tasks
- Computer Assisted Rehabilitation Environment (CAREN)
- Activity Monitoring (e.g., pedometer, diary, Step Watch)
- Activities-Specific Balance Confidence (ABC) Scale[28]
- Single Limb Stance (SLS)
- Timed Up and Go (TUG)[29]
- Socket Comfort Score (SCS)[30]
- Modified Oswertry Low Back Pain Disability Questionnaire[31]
- Amputee Mobility Predictor (AMP)/(AMPnoPRO)[32]
- Prosthesis Evaluation Questionnaire - Mobility Section (PEQ-MS)[33]
- Trinity Amputation & Prosthesis Experience Scales - Revised (TAPES-R)[34]
- Locomotor Capabilities Index (LCI)[35]
- Prosthetic Limb Users Survey of Mobility (PLUS-M™) version 1.2[36]
- Four Step Square Test (FSST)[37]
- Five Times Sit-to-Stand Test (FTSST)[13, 38]
- Timed Stair Ascent[39]
- 6 Minute Walk Test (6 MWT)[40]
- 2 Minute Walk Test (2 MWT)[41]

In order to meet the demands of a relatively fit, high performance military population, the CAF acquired the state-of-the-art Computer Assisted Rehabilitation Environment (CAREN) therapeutic tool. The CAREN is a virtual reality environment that supports traditional

rehab modalities and allows clinicians to present unique environments difficult to simulate in an office or clinic setting. The CAREN includes a multi-axis tilting platform that can provide a variety of surfaces including, steep incline/decline, side slopes, and other challenging activities such as induced tripping and perturbations. Additionally, the large curved projection screen can be used to provide busy, interactive environments and concurrent cognitive tasks. An advantage of this virtual reality environment is the ability to quickly and easily add both physical and cognitive challenges appropriate to the members' needs and functional ability. Additionally, motivation and effort can be easier to enhance in a virtual reality setting to push our members beyond their normally perceived comfort zones. The CAREN systems at The Centres of Excellence (CoEs) in Ottawa, Ontario and Edmonton, Alberta have provided world-class, state-of-the-art virtual reality rehabilitation services to CFHS allowing the attainment of optimal potential following illness or injury.

Figure 3: Canadian Armed Forces member completes an assessment on the CAREN virtual reality system at The Ottawa Hospital Rehabilitation Centre as part of his preparedness training for Nijmegen 2012.

PARTICIPATION-BASED RECREATIONAL & MOTIVATIONAL ACTIVITIES – SOLDIER ON

Sports and recreation activities have been linked to successful rehabilitation, and games and sports encourage socialization[14]. CAF members with traumatic amputation still express the same dreams, drives and needs of their peers and others their age. Without new goals and challenges over a lifetime, the benefits of any activity are quickly lost. Ongoing goal-setting and attainment is essential in the rehabilitation and re-integration of injured personnel[42]. Therefore, the CAF High-Performance Rehabilitation framework also incorporates participation in recreational and motivational activities. The CAF established the Soldier On[43] program in 2006 to empower both visible and non-visible injured and ill military personnel to adopt an active lifestyle by providing resources and opportunities to participate in physical, sport and recreational activities. This program offers the opportunity to socialize, explore common interests, share learning experiences and increase one's independence while on a journey to develop and showcase re-acquired skills. Soldier On events foster core military values such as leadership, teamwork, camaraderie and endurance, which can also serve as goal-setting in the management of physical rehabilitation patients. CAF members must apply their therapy/rehab education to self-manage throughout general tasks and demands associated in attending an event, while maintaining welcomed interpersonal interactions and relationships, in a social community environment. Our interprofessional team collectively empowers participants to change behaviours through constant messaging and normalizing of their concerns. Soldier On participants were given training goals which naturally lead to increased physical activity levels. Subsequent team building promoted trust and provided participants with a role definition or a sense of identity within the CAF, many are searching to re-establish. Additionally, goal achievement and goal renewal were natural outcomes of such inspiring activities, which opened doors to other life opportunities.

The presence of CAF Physical Rehabilitation Program clinicians at Soldier On events lends itself to the provision of timely, enabling, in-house, efficient, realistic and goal-orientated therapeutic treatment programs to a complex, CAF ill and injured population throughout their rehabilitation continuum. These interprofessional events also provided unique networking and knowledge acquisition opportunities to rehabilitation clinicians. Many evidence-based programs, services and technologies offered to CAF members today stem from such cross-pollination opportunities with military allies.

COLLABORATION WITH INTERNAL & EXTERNAL PARTNERS AND STAKEHOLDERS

The final pillar of the CAF Physical Rehab high-performance framework encompasses research, training, outreach, knowledge translation, and communication between internal and external partners and stakeholders. Communication between partners and stakeholders is a vital component to the successful management of CAF lower limb amputees. Collaborations foster stimulating and successful learning opportunities. Efforts

Figure 4: Soldier On participants at the Centre for the Intrepid: 4th Annual Mini-Try organized by the CAF Physical Rehabilitation Program in May 2011.

are combined through research to attain new knowledge or deepen one's understanding of an issue in order to promote continual innovation and proactive change. A key component in fostering collaboration and effective knowledge transfer is the Canadian Institute for Military and Veteran Health Research (CIMVHR)[44]. CIMVHR facilitates new research using existing academic research resources across Canada to guide evidence-informed practices, policies and programs.

The acquisition of the state-of-the-art CAREN therapeutic rehabilitation tool for CAF Physical Rehabilitation Program is one initiative that led to the creation of a Canadian CAREN Research Consortium and participation in the International CAREN Expert Advisory Panel network. The Canadian CAREN Research Consortium consists of civilian and military research teams across Canada who work together in addressing military rehabilitation research objectives. Current research areas include evaluation of lower limb prosthetic devices[45]; investigation of lower limb amputee gait over a variety of non-level walking activities to guide development of quantifiable stability metrics for rehabilitation assessment[46, 47]; establish comparison datasets from our non-injured members[48, 49]; and use of a virtual reality environment for rehabilitation for our members with mild traumatic brain injury[50] and non-specific chronic low back pain[51, 52]. Additionally, we recently completed a study to examine the use of the CAREN virtual environment as a rehabilitation tool in our high-performance amputee rehabilitation program. Walking up and down slopes can be a difficult task for lower limb amputees; some amputees may also find it easier to ascend or descend slopes through side stepping strategies, while others may use aids and rails to navigate slopes. Functional gait training sessions and education individualized to participant's needs in a consistently challenging therapeutic environment (e.g., CAREN), can easily be created through the use of standing balance applications, non-level walking surfaces, variable walking speeds and slopes, perturbations, induced tripping and dual-tasking scenarios (such as Stroop or right and left discrimination exercises) to add both physical and cognitive challenges appropriate to the participants' needs and functional ability. Biofeedback capabilities help address gait asymmetries and compensations efficiently in real-time. These functional gait training sessions are feasible and well tolerated with no indication of adverse-effects. Members gain confidence in mobility as well as greater endurance. Results from our research studies will be instrumental in further improving evidence-based care for our high-performance rehabilitation program. (Box 1).

CONCLUSION

Every day, CAF members sustain neuro-musculoskeletal injuries both at home and abroad that could potentially end their careers. Continued access to internal, well-structured and well-delivered physical rehabilitation programs is key to health protection and operational readiness. CAF members who sustain lower limb amputation often demonstrate physical capabilities, high-level goals and aspirations beyond those commonly witnessed in a civilian population. This likely stems from skills acquired during basic training, annual fitness testing, operational requirements and a natural need to perform at a high level due to healthy peer pressure and camaraderie. CAF members are used to working, training and playing hard, thus when ill or injured expect the same intensity of their physical rehabilitation. CFHS institutional credibility has been achieved in lower limb amputee rehabilitation through the many cross-pollination opportunities the CAF Physical Rehabilitation Program has contributed to and learned from. However, this institutional credibility first and foremost comes from the CAF amputees themselves and their clinicians; a team which works tirelessly together in order to achieve re-integration of meaningful activity.

Acknowledgements

The authors would like to thank both the Defence Medical Rehabilitation Centre Headley Court in Epsom, Surrey, United Kingdom and the United States Armed Forces Amputee Patient Care Program composed of three distinct centers: the Military Advanced Training Center located at Walter Reed National Military Medical Center, the Center for the Intrepid at Brooke Army Medical Center, and the Comprehensive Combat and Complex Casualty Care program center at the Naval Medical Center San Diego clinicians for their leadership, knowledge transfer and collaborations in creating the CAF Physical Rehabilitation Program's High-performance Rehabilitation framework. They would also like to thank Dr. Robert Gailey for all his expertise, insight and contributions. Finally, the CAF Physical Rehabilitation Program would not be where it is today without devoted clinicians at all Centre of Excellence[3] locations providing high quality care and The War Amputations of Canada providing professional education and expertise in lower extremity

Box 1. Key elements to a successful military high performance amputee rehabilitation program:

1. Consistent military presence during in-patient rehabilitation phase (firm but fair expectations of recovery and rehabilitation)
2. Engagement of Mental Health Professionals to ensure healthy adaptation and acceptance of the "new normal"
3. Allow and encourage grieving of loss
4. Adjudication of technology through a Prosthetic Review Committee (PRC) to ensure judicious use of resources
5. Medical needs justification required prior to approval of new technology
6. Use of standardized, reliable, and valid clinical tools to measure progress
7. Goal-oriented program (as defined by the member)
8. Sports and recreational activities to encourage motivation and lifelong engagement
9. Continued collaboration, effective communication (no one individual has all the answers)
10. Conduct research in parallel to provide evidence-informed best practices and to justify PRC decision making

limb loss advocacy to CAF personnel and their families throughout Canada.

SUMMARY

Canadian Armed Forces (CAF) members who sustained traumatic injuries expect the same intensity of their recovery and rehabilitation as they apply to their training. The CAF Physical Rehabilitation Program was established in 2008 and is based on the World Health Organization framework for health and disability, the International Classification of Functioning, Disability and Health. The CAF developed a hybrid civilian-military rehabilitation team to foster a challenging rehabilitation environment to meet high-performance fitness and return-to-work objectives. This article will highlight clinical best practices and lessons learned in amputee rehabilitation within the four pillars of the CAF Physical Rehabilitation Program High-Performance framework. Evidence-based physiotherapy considerations to mitigate secondary physical conditions or complications associated with long-term prosthetic use in lower-limb amputees will also be reviewed. The insights gained help maximize function and clinical outcomes in injured CAF personnel and could be applied to select patients in civilian populations, with similar clinical profiles, and in other countries with similar demographics.

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Submental Intubation versus Tracheotomy for the Medical Evacuation of Maxillofacial War Trauma.

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RESUME

Avantages de l'intubation sous-mentale sur la trachéotomie pour l'évacuation des blessés de guerre atteints de traumatismes maxillo-faciaux.

Les conflits modernes induisent une augmentation du nombre des blessures des extrémités et de la tête. La gestion des voies aériennes supérieures (VADS) et la nécessité d'un champ opératoire libre pour la thérapeutique en traumatologie maxillofaciale constituent un challenge pour le médecin anesthésiste réanimateur et le chirurgien maxillofacial[1]. Le problème est augmenté en cas de fracas facial avec atteinte des trois étages, à cause du risque de fausse route intracrânienne en cas d'intubation nasotrachéale. L'intubation orotrachéale rend impossible le rétablissement de l'articulé dentaire en per opératoire. Une trachéotomie est réalisée dans les cas de traumatismes faciaux nécessitant un blocage inter maxillaire, avec impossibilité d'intubation naso-trachéale, lors de traumatismes de la région centro-faciale.

La trachéotomie à une morbimortalité propre d'autant plus que chez certains patients elle est de durée limitée. L'intubation sous-mentonnière (ISM), peu utilisée en chirurgie maxillofaciale, pourrait représenter une alternative à la trachéotomie. L'intubation sous mentale semble être une alternative intéressante à la trachéotomie. Les avantages sont : une réalisation simple pour tous chirurgiens (visceraliste, orthopédiste), de durée courte (5 à 10 minutes). Les risques sont de deux types : 1 traumatiques per procédure (lésion du 7 nerf facial et du canal de wharton), 2 infectieux si durée prolongée (supérieure à 3 jours). Elle nécessite une coopération entre l'anesthésiste et le chirurgien. L'utilisation de cette technique n'a jamais été utilisée en traumatologie militaire sur les théâtres d'opérations. Elle pourrait y trouver sa place chez les traumatisés faciaux dont la durée de ventilation mécanique invasive prévue est courte.

KEYWORDS: Submental Intubation, Tracheotomy, Medical Evacuation.
MOTS-CLÉS : *Intubation Sous mentale, Trachéotomie, Evacuation médicale.*

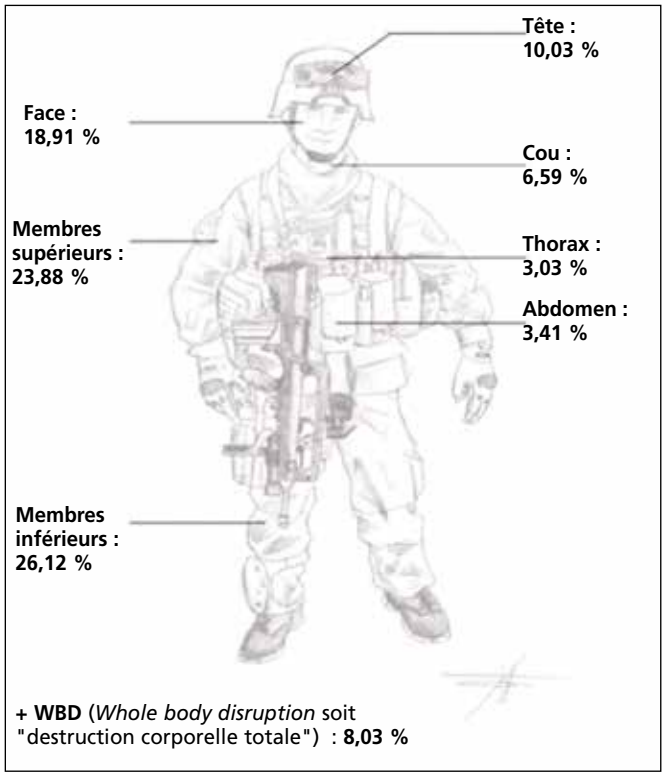
The American military operations in Iraq known as Operation Iraqi Freedom (OIF) and in Afghanistan as Operation Enduring Freedom (OEF) are responsible for numerous casualties. Ballistic protection equipment (Kevlar helmets and bullet proof vests) have been effective in modifying the type of combat wounds.

There has been an increase in the number of wounds to upper and lower limbs, as well as to the head and neck resulting from the use of ballistic vests which successfully protect the chest and abdomen[13].

Figure 1: Frequency of combat traumas by site during recent conflicts.

Translation. Face: 18.91%, Head: 10.03%, Neck: 6.59%, Chest: 3.03%, Abdomen: 3.41%, Upper limbs: 23.88%, Lower limbs: 26.12%, Whole Body Disruption (WBD): 8.03%.

Source: Ambroise Fournier, General Medicine Thesis, Faculté Lyon-Est, 2014.



The management of upper airways, in addition to the need for operative access in maxillofacial trauma treatment, can be a challenge for the resuscitating anesthesiologist and the maxillofacial surgeon. This problem is magnified in cases of facial trauma with extension to the third stage. Nasotracheal intubation is not possible because of the risk of creating a false intracranial passage. Orotracheal intubation renders the surgical restoration of dental articulation impossible. A tracheotomy is often established in cases of central facial trauma requiring an intermaxillary fixation and where there is no possibility for nasotracheal intubation. In the field, surgeons are prone to relegating this technique to a secondary treatment level. This technique is taught, using suture or fixation screws, in a class focused on the cephalic extremity (Module 3) which is part of an 'advanced surgery in the field' course known as Cours Avancé de Chirurgie en Mission Extérieure or CACHIRMEX (École du Val-de-Grâce, France).

In addition to tracheotomy's associated morbidity and mortality, in certain patients, its duration is time limited. Submental intubation, not often used in maxillofacial surgery, could present an alternative to tracheotomy[2-3]. Our goal here is to describe this new technique and discuss its advantages in the safe evacuation of wartime maxillofacial trauma patients.

TRACHEOTOMY

Tracheotomy is the opening of new respiratory channels in the cervical trachea. It is carried out via a surgical opening. In 1909, Chevalier Jackson described modern tracheotomy's surgical principles using an open surgical technique. The surgical tracheotomy is placed between the second and fourth tracheal ring by way of a cutaneous incision extending between the cervical strap muscles and the cervical fascia that enables the uncovering of the muscular area under the hyoid. The thyroid isthmus will then be sectioned in order to access the trachea and insert the tracheotomy tube. The consequent perioperative complications specific to the surgical tracheotomy are: a laryngotracheal injury from an accidental laceration of cartilage or membrane, a hemorrhagic injury usually involving the inferior thyroid veins, a large vessel in an abnormal position (fairly uncommon), and finally an esophageal wound.

Tracheotomy is a risky technique. The overall perioperative mortality is estimated at 1%[4, 5]. In a meta-analysis, the rate of serious complications (pneumothorax, pneumomediastinum, cardiac arrest, and perioperative death is 0.86% for surgical tracheotomies carried out on a group of 3,512 patients[5]. The study showed that 0.46% of complications classified were intermediate (arterial desaturation, hypotension, injury of the posterior wall of the trachea, malposition of the tube and bronchial aspiration) and 1.75% of complications were minor (hemorrhage, difficult insertion or false passage of the tube and subcutaneous emphysema)[6].

SUBMENTAL INTUBATION

In 1986 Hernandez Altemic[7] described the technique of submental intubation. This technique enables control of the airway while permitting access to the buccal cavity and nasal structures. It allows for the treatment of nasal trauma without resorting to tracheotomy.

The patient is orotracheally intubated with a Fastrach® endotracheal tube[8]. After locating the inferior border of the probable pathway of the mandibular branch of the facial nerve, the surgeon makes a right or left para-media skin incision of 1.5 to 2cm in length. He next dissects subcutaneously the curtain of muscle forming the mylohyoid. The surgeon then accesses the sublingual space. He/She makes certain to stay alongside the length of the media face of the mandible to avoid injuring the salivary duct

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opening (Wharton's Duct). A small endofacial opening is then created at the tip of the forceps which are projected under the mucosa. Once inserted, the surgeon first opens the forceps and clamps the balloon for the inflation cuff on the endotracheal tube which is passed submentally through the orifice that was made in the floor of the mouth. A guide is passed through the same pathway. Throughout this process, the patient is ventilated with 100% FuI. If a guide is used, the forceps are secondarily passed through the same route. After having disconnected the patient from the respirators and having removed the 'slip-joint' tube connector, one seals the end of the tube by clamping tightly to avoid entry of fluid or blood. The tube is then passed through the sub-mental opening[9].

The 'slip-joint' is immediately re-attached and the patient is again ventilated. Using pure oxygen, or replacing the alveolar nitrogen by oxygen (denitrogenation), results in an increase in oxygenated tissue reserves that allows for the doubling of the apnea time to 6 minutes[10]. This enables completion of the manoeuver without excessive urgency. The disconnection time for the ventilator is less than 2 minutes and there is no significant desaturation. Ventilation is verified by auscultation of both lungs and by the capnography curve. Finally, the endotracheal tube is secured in submental position with a suture. Definitive surgical intervention follows. The surgeon completes his operative inter-maxillary fixation, verifies his reductions and repairs and then withdraws. Three minutes before the completion of surgery, the FiO2 is re-established at 100%. The surgeon removes the sutures holding the tube. After having interrupted ventilation and detached the 'slip-joint', the anesthesiologist returns the tube to an endobuccal position while his finger firmly supports the tube held lengthwise along the medial surface of the angle of the mandible. The 'slip-joint' is then re-attached and the patient's ventilation is resumed. Next, the balloon is repositioned. Bilateral pulmonary ventilation is checked and the endotracheal tube is secured in the standard orotracheal position. The surgeon completes closure with 3 absorbable sutures in the mylohyoid muscle and subcutaneous tissue that will be removed 5 days later. As can be observed from our description, this technique requires close collaboration between the anesthesia and maxillofacial teams.

The indications for submental intubation in military trauma are essentially facial trauma requiring complete repairs during a single operation and for fractures in the floor anterior to the base of the skull associated with occlusal trauma. Certain constraints are to be considered with the procedure: the submental passage approach requires that a part of the tube has been reinforced, to avoid bending, to follow the curve around the tongue and in order to minimize inadvertent displacement of the tube from the larynx. One also needs a tube of sufficient length that allows for the separation of the 'slip-joint' from the rest of the tube. The only tube that fulfills these requirements is a Fastrach® tube.

Placement of the paramedian incision for passage of the tube is not arbitrarily chosen. It is preferable that it be placed on the side opposite fractures bordering the mandibular symphysis or infected wounds. It is likewise recommended to leave a guide in the submental neo-orifice between the time of the passage of the cuff balloon and that of the tube. This effectively prevents the creation of a false passage in the orifice and avoids trapping soft tissue between the endotracheal tube and its cuff balloon.

The risks and the adverse effects associated with submental intubation are the risks common to all healing wounds: an inflammatory scar due to infection or the formation of a cheloid. In addition, for patients ventilated during recovery, there is a risk of abscess and fistula in the mouth. However, the risk of fistula is observed only after 3 days of ventilation. In a series of 25 submental intubations completed by Meyer's team[12], 1 patient developed a cheloid scar and 2 developed an abscess in the floor of the mouth. These patients had been extubated late and the complications did not prolong their hospital stay. Gordon and Tostunov[13] report a case of submental intubation left in place for 3 days without complications, however there is risk of injury to the lingual nerve as well as to the sublingual salivary glands and to Wharton's duct.

Figure 2: Diagram illustrating the final position of the submental intubation tube.

Source: Cyprien Ricour, Thèse de chirurgie maxillo faciale, Université Lille nord de France 2013.

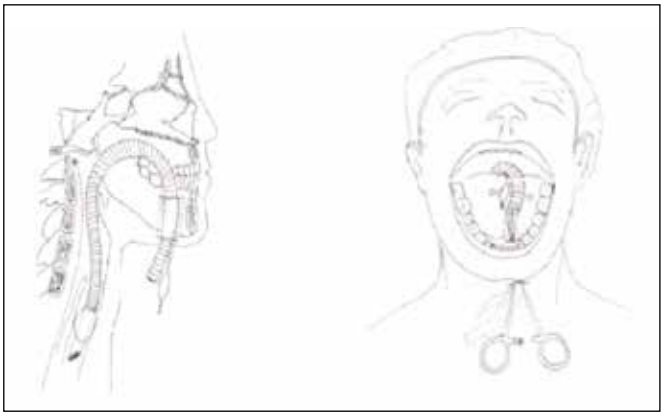


Figure 3: Fastrach® intubation tube.

Source: Cyprien Ricour, Thèse de chirurgie maxillo faciale, Université Lille nord de France 2013.

Figure 4: Subcutaneous dissection.

Source: Cyprien Ricour, Thèse de chirurgie maxillo faciale, Université Lille nord de France 2013.

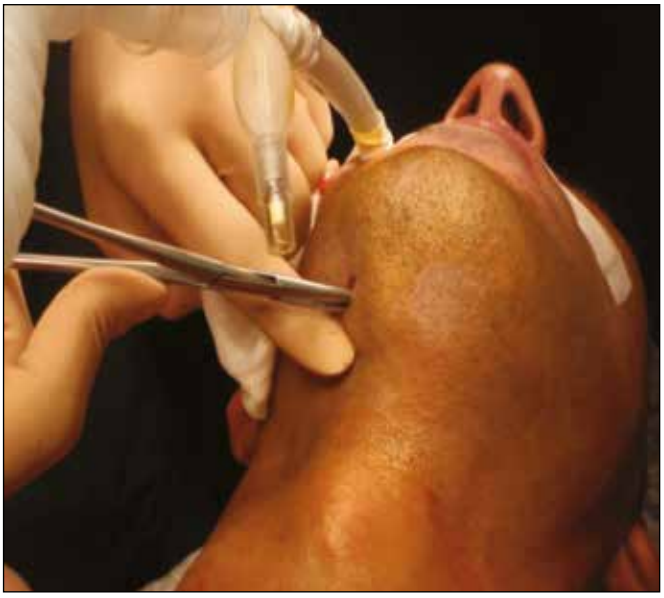
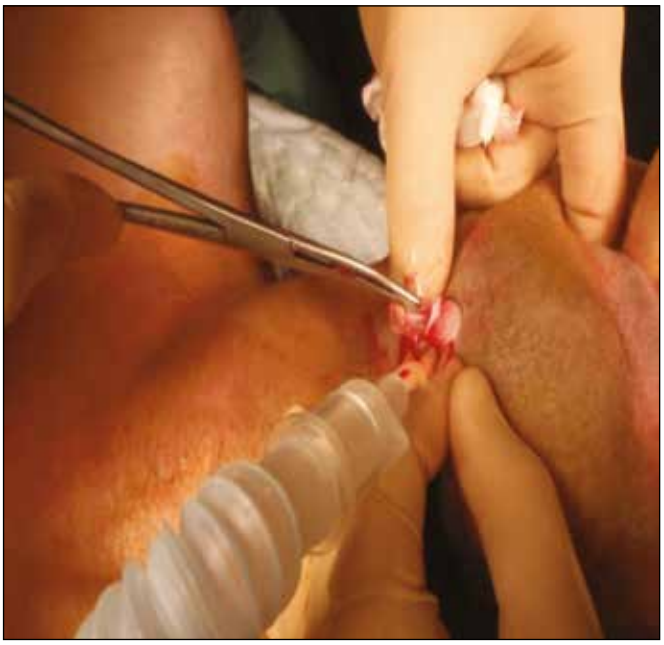


Figure 5: Passage of the intubation tube.

Source: Cyprien Ricour, Thèse de chirurgie maxillo faciale, Université Lille nord de France 2013.



MEDICAL EVACUATION OF SERIOUS WOUNDS

In their analysis of the types and mechanisms of wounds reported in recent conflicts in Iraq and Afghanistan, Owens *et. al.*[14] reported that among 6,609 wounds, 1,949 (29.4%) involved the head and the cephalic region. The accompanying analysis of wounds involving the head and cervical region revealed the following distribution: 635 facial wounds (33%), 509 head wounds (26%), 207 neck wounds (11%), 380 wounds to the eyes (19%), 175 ear wounds (9%) and 43 unspecified wounds (2%).

In comparison to previous conflicts (World War II, the Korean War and the Vietnam War), more wounds involving the head and cervical region; 30% versus 16-21%, and fewer wounds to the thoracic region; 6% versus 13% - $p < 0.0001$[13] are noticed.

Figure 6: Final position of the intubation tube following maxillary fixation.

Source: Cyprien Ricour, Thèse de chirurgie maxillo faciale, Université Lille nord de France 2013.

Facial trauma combat victims with dental articulation fractures (mandibular fractures or maxillary fractures requiring a bimaxillary fixation), at the base of the skull, or at the nasal pyramid cannot, theoretically, benefit from nasotreacheal or orotracheal intubation.

In a conflict zone's specified triage zone, the surgeon and the resuscitating anesthesiologist are responsible for facial traumas requiring mandibular fixation. This fixation is achieved with a Dautroy Arch or with intermaxillary fixation screws such as the IM Quick-Fix® (a model designated for the French army medical corps[①] in Afghanistan). For these patients, a tracheotomy is generally performed to facilitate transport to a tertiary level treatment center.

This technique is advantageous during evacuation because it allows for: simple access and direct connection of mechanical ventilation to the respiratory airways, aspiration of respiratory secretions and tube replacement if needed. However, tracheotomy has drawbacks associated with procedural time (20 to 40 minutes[15]), morbidity and mortality associated with its completion[4, 5], esthetic consequences and the psychological impact which is always an issue, especially in this patient population.

In this context, submental intubation seems to be a viable alternative to the tracheotomy. It should be achieved before mandibular fixation. The advantages are that this procedure is simple for all surgeons (general and orthopedic), it is of short duration (5 or 10 minutes[10]), and it involves a reduced risk of accidental extubation. Its risks are of two types: procedural trauma

[①] Service de Santé des Armées Français.

(injury of the facial nerve and of Wharton's duct) and infection if retained too long (more than 3 days). It requires close cooperation between the anesthesiologist and the surgeon as well as training (ej. CACHIRMEX course for French military surgeons). In extensive facial trauma, particularly that resulting from ballistic injuries, and in the massive post-traumatic facial hemorrhages requiring the use of facial compression dressings, submental intubation would be a useful surgical rescue measure for controlling maxillofacial damage[16].

This technique should be used only on patients with predicted assisted ventilation needs of less than 3 days, particularly those patients without associated severe neurological, abdominal or thoracic injuries. The time period required is compatible with the evacuation period of a French soldier from level 1 care in the conflict zone, until their return to a military hospital in France[②]. A retrospective study of 450 French soldiers wounded in Afghanistan showed that the average time between wound occurrence and arrival to level 4 care was 36 hours for Priority 1 wounds, according to NATO[17]. Medical evacuation is classified by Priority/Dependence/Classification and the patients described in our article would be classified P1/D1/C1 or seriously wounded. The transport plane should depart within 12 hours (P1) with patient intubated and ventilated (D1) and transported in a supine position (C2). Therefore, in terms of stabilization and disposition time, submental intubation is a technique well adapted to the evacuation of war wounds.

CONCLUSION

Submental intubation is a technique well-described in maxillofacial surgery, simply achieved and involving few complications. It presents an alternative technique to tracheotomy. This technique has never been utilized for military trauma in the battlefield; however it could be useful during the repatriation of facial trauma victims for which the predicted length of mechanical ventilation is short. In the same way that tracheotomy is a basic rescue method in war surgery; submental intubation should be approved and taught to resuscitating anesthesiologists and military surgeons. The goal of this article is not to argue in favor of one technique or the other, but to encourage discussion.

ABSTRACT

An increase in the number of wounds to the extremities and the head is observed in modern military conflicts. The management of upper airways and the requirement of an open operative site for the treatment of maxillofacial trauma constitute a challenge for the anesthesiologist and the surgeon. The problem is increased with facial trauma reaching the three stages because of the risk of intracranial penetration with naso-tracheal intubation. Orotracheal intubation prevents the operative correction of dental articulation. Tracheotomy is performed in facial trauma cases requiring an inter-maxillary fixation, in light of the impossibility of naso-tracheal intubation in treating central-facial trauma. The tracheotomy has an associated morbidity and mortality.

Submental intubation is not often used in maxillofacial surgery but represent an alternative to tracheotomy. Its advantages are that it is a simple procedure for all surgeons and it is completed quickly. There are two types of risks: procedure-related trauma and infection with prolonged ventilation. Submental intubation requires close cooperation between the anesthesiologist and surgeon. Though this technique has never been used in military trauma in the battlefield, it could be utilized in the case of facial trauma where the length of mechanical ventilation is expected to be brief.

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Seeking for Protective Agents Against Sulphur Mustard Gas: 14 Years of Researches Conducted in the Gulhane Military Medical Academy Using Nitrogen Mustard Model.*

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His research interests are melatonin, medical ozone and hyperbaric oxygen therapy. He conducted more than 44 national and 2 international projects during the 1999-2011 period. He looked for the healing mechanism of oxygen based bio-oxidative therapeutics (i.e., medical ozone and hyperbaric oxygen therapies) in a variety of experimental inflammatory and oxidative stress models. His laboratory is also focused on anti-oxidative and anti-nitrosative efficacy of melatonin in several experimental models. Recently, the lab has an emerging interest in the involvement of epigenetic mechanisms in human diseases and the mechanism of mustard toxicity as one of the most challenged issue in chemical warfare agents.

RESUME

A la recherche d'agents protecteurs contre les effets du gaz moutarde : Quatorze ans de recherches menées à l'académie militaire Guhlane en utilisaient le modèle des moutardes azotées.

Le gaz moutarde a été le gaz de combat le plus employé au cours du siècle passé et il a été responsable de milliers de morts et d'intoxiqués. Il continue à constituer une menace sérieuse tant pour le personnel militaire que pour les civils. Même si les recherches de long-terme menées ces dernières années ont atteint un certain degré de maturité, s'attaquant à ce qui n'avait pas été étudié jusqu'à présent, les mécanismes sous-tendant la toxicité ne sont toujours pas complètement compris.
Le groupe des moutardes est aussi connu sous le nom d'agents alkylants du fait qu'il y a addition de groupes alkyles dans les molécules d'ADN. Il a été démontré en outre que les mécanismes de la toxicité aiguë entraînent un stress oxydatif et nitrosatif. Pendant des années les travaux de différents laboratoires au sujet des dérivés du gaz moutarde reposaient sur le fait que la toxicité à long terme reposait sur des modifications épigénétiques. Cet article résume les recherches menées depuis 2001 dans le laboratoire des auteurs et leurs conclusions sur les mécanismes physiopathologiques.

Keywords: Nitrogen mustard, Sulphur mustard, Molecular mechanisms, Antidote.
Mots-clés : *Moutardes azotées, Moutardes soufrées, Mécanismes moléculaires, Antidotes.*

INTRODUCTION

Chemical weapons (CWs) were used for the first time on a large scale in World War I. The major class of chemical weapon is mustard gas. Although it is lethal in high doses and affects multiple organ systems, it is classified as a vesicant (blistering) agent. The use of vesicant sulfur mustard and the pulmonary agents, phosgene and chlorine, is known to have caused 1.3 million casualties. Since then, CWs have been utilized in numerous incidents, including terrorist attacks[1]. The last military deployment of

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* Presented at the 3rd ICMM Pan-European Congress on Military Medicine, Belgrade, Serbia, 2-6 June 2014.

sulphur mustard (SM) goes back to the Iraq – Iran war (1980–1988) where it was deployed against thousands of soldiers and civilians and was responsible for extensive casualties. Based on this continuous threat, CWs have been the subject of a considerable amount of toxicological research, the ultimate goal being to find defensive measures against these agents. What is remarkable is that these agents are as effective as they were designed - to harm people by any route of exposure and to be effective at low doses[2].

Mustard agents are divided into two groups, sulfur mustard and nitrogen mustard (NM). SM, also known colloquially as mustard gas, has been the most widely used chemical weapon, as mentioned earlier. Mustard gas, bis-(2-chloroethyl) sulfide, is also known as mustard, S-mustard, sulfur mustard, HS, HD, H, and Yperite. As a result of its devastating toxicity, its use during the World War I earned it the sobriquet "king of the battle gases". SM is a highly toxic CW and still remains as a threat to both civilians and military personnel. The other major compound, NM, was produced in the 1920s and 1930s during World War II as a potential chemical warfare weapon, but was found to be unsuitable as a munition. They are also known by their military designations - HN-1 [bis (2-chloroethyl) ethylamine], HN-2 [bis (2-chloroethyl) methylamine] and HN-3 [tris (2-chloroethyl) amine][3]. HN-2, which has a similar molecular structure to SM, became the first non-hormonal agent used in cancer chemotherapy. However, besides SM, other therapeutic mustards are themselves highly cytotoxic and induce several critical side effects[4].

Mustard gas causes injury via three major routes: 1) skin and eye damage after absorption through the integument and the ocular surface, respectively; 2) respiratory damage after inhalation; 3) systemic toxicity after ingestion or excessive exposure, manifesting as gastrointestinal, circulatory, renal, and bone marrow toxicity. Inhalation of mustards primarily affect the laryngeal and tracheobronchial mucosa causingtissue necrosis, airway inflammation, and lung edema. At low doses of exposure, these chemicals act as lung irritants rather than acute toxicants, bringing about long-term airway diseases, such as chronic bronchitis, lung fibrosis, and asthma[5]. Despite many years of research, the cytotoxic mechanisms induced by mustards and the events leading to cell death are still not fully known[6].

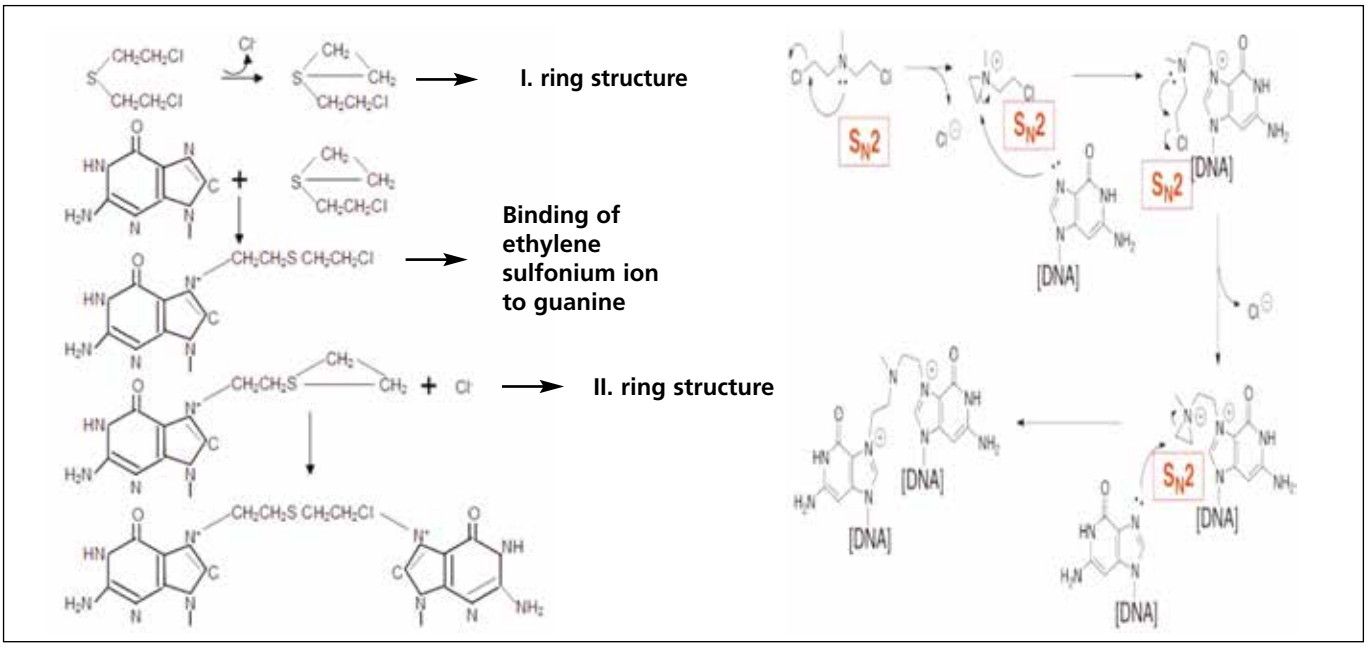
However, it is common knowledge that DNA is an important molecular target of mustards. Mustards damage DNA through alkylating and cross-linking purine bases[4]. Potent alkylating activity is not a result of mustards themselves, but is a consequence of their derivatives, including sulfonium and carbonium for SM, and aldophosphamide and acrolein for cyclophosphamide (CP) (Figure 1). The interstrand DNA cross-links produced by mustard compounds probably induces the lesion that is lethal at the lowest frequency of occurrence and at the lowest concentration of the agent. However, cell death from this lesion is delayed until the cell replicates its DNA or undergoes division. At higher cellular exposures, mechanisms other than DNA cross-linking may be attributable for the rapid cell death.

Besides the alkylation of DNA, considered to be the most significant injury to cells from mustards, oxidative stress is likely involved with alkylating agents - acute toxicity[7, 8]. Indeed, alkylating agents are known to encourage glutathione (GSH) depletion, probably contributing to lipid peroxidation and cell death[9]. Furthermore, there is an abundance of evidence that mustards cause nitric oxide (NO) production through nitric oxide synthase (NOS) induction that leads to peroxynitrite formation ($ONOO^-$) in target cells.

FREE OXYGEN RADICALS AND ANTIOXIDANT DEFENSE MECHANISM

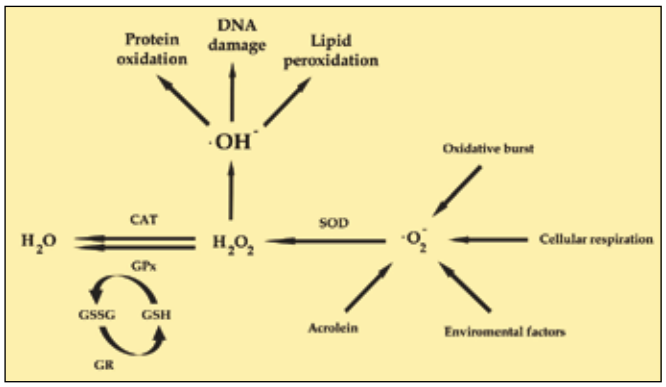
Reactive oxygen species (ROS) are constantly generated under physiologic conditions as a consequence of aerobic metabolism. ROS include free radicals, like superoxide

Figure 1: How mustard gas alkylation takes place ***a.*** *Sulfur mustard;* ***b.*** *Nitrogen mustard.*



anion ($\cdot O_2^-$), hydroxyl radicals ($\cdot OH^-$), and the non-radical molecule hydrogen peroxide (H_2O_2). They are particularly transient species because of their high chemical reactivity and can react with DNA, proteins, carbohydrates, and lipids in a destructive manner. The cell is endowed with an extensive antioxidant defense system to combat ROS, either directly by interception or indirectly through reversal of oxidative damage. When ROS overcome the defense systems of the cell and the innate redox homeostasis is altered, the outcome is oxidative stress (Figure 2)[10]. Oxidative stress is implicated in the pathogenesis of several diseases, such as inflammatory, ischemic, and neurodegenerative disorders, aging, diabetes, hypertension, and cancer[11].

Figure 2: Basic sources of ROS and the principal defense mechanisms. Major sources of ROS production include respiration of mitochondria, oxidative bursting of immune cells, and certain environmental factors, such as ultraviolet radiation, tobacco smoke, and exhaust gas. The generated superoxide is converted to H_2O_2 by superoxide dismutase (SOD). The two major defense systems against H_2O_2 are the GSH redox cycle and catalase (CAT)[68].



ANTIOXIDANT DEFENSE MECHANISMS AGAINST ROS

Components of the antioxidant defense system function to prevent oxidative damage by intercepting ROS before they can damage intracellular targets. The system itself consists mainly of three enzymes: superoxide dismutase (SOD), glutathione peroxidase (GPx), and catalase (CAT)[10, 12]. Three classes of SOD have been identified to date – the mitochondrial Mn-SOD, cytosolic and extracellular Cu, Zn-SOD, and Ni-SOD[13, 14]. All of these SOD isoforms destroy free radical superoxides by converting them to H_2O_2. The primary defense mechanisms against H_2O_2 are CAT and GPx. CAT is one of the most efficient enzymes known and cannot be saturated by H_2O_2 at any concentration. GSH-Px functions through the glutathione (GSH) redox cycle. The GSH complex is probably the most important cellular defense mechanism present in the cell[15].

NITRIC OXIDE AND NITRIC OXIDE SYNTHASE FAMILY

Nitric oxide (NO) is produced by the NOS family of enzymes through enzymatic oxidation of the guanidine group of arginine. This occurs in two sequential monooxygenase reactions utilizing NADPH as a co-substrate and involves molecular oxygen. Constitutive expression of two NOS isoforms is responsible for a low basal level of NO synthesis in neural cells (nNOS or NOS1) and in endothelial cells (eNOS or NOS3). Induction of either isoform (iNOS or NOS2 – both inducible) by cytokines (e.g. tumor necrosis factor , interleukins), bacterial products (endotoxin/LPS), and chemical agents has been observed in virtually all cell types, including macrophages, dendritic cells, fibroblasts, chondrocytes, osteoclasts, astrocytes, and epithelial cells, resulting in the production of large amounts of NO[16]. The controversy arises from observations reporting both cytotoxic and cytoprotective effects of NO. In cases where NO has been found cytotoxic, it was questioned whether NO directly or indirectly, through the formation of more reactive species, such as peroxynitrite ($ONOO^-$), exerted these effects[17].

THE ACTIVATED "DEVIL TRIANGLE" IN THE TARGET CELL

As both excess NO or excess $\cdot O_2^-$ decreases the bioavailability of $ONOO^-$, equimolar concentrations of the radicals are ideal for $ONOO^-$ formation. The $ONOO^-$ anion is in a pH-dependent protonation equilibrium with peroxynitrous acid (ONOOH). Hemolysis of ONOOH gives rise to the formation of the highly reactive hydroxyl radical ($\cdot OH^-$), mediating molecular and tissue damage associated with $ONOO^-$ production. $ONOO^-$ is formed when NO and $\cdot O_2^-$ react in a near diffusion-limited reaction[18]. The most powerful cellular antioxidant system protecting against the harmful effects of $\cdot O_2^-$ is embodied by SOD (especially cytosolic Cu, Zn-SOD and mitochondrial Mn-SOD). However, it was shown that NO efficiently, competes with SOD for superoxide (Figure 3)[19]. Beckman and Koppenol (1996) have therefore proposed that under conditions of increased NO production, NO can outcompete SOD for $\cdot O_2^-$, resulting in $ONOO^-$ formation.

$ONOO^-$ is not a radical, but is a stronger oxidant than its precursor radicals. It can directly react with target

Figure 3: Formation of the "devil triangle"; NO can be produced by nNOS, eNOS, and iNOS or in the mitochondria by mtNOS. Mustard can cause not only ROS production but also iNOS induction leading to NO overproduction. Under conditions of increased NO production, NO can outcompete SOD for superoxide anions resulting in peroxynitrite formation leading to PARP activation, lipid peroxidation, and protein oxidation[68].

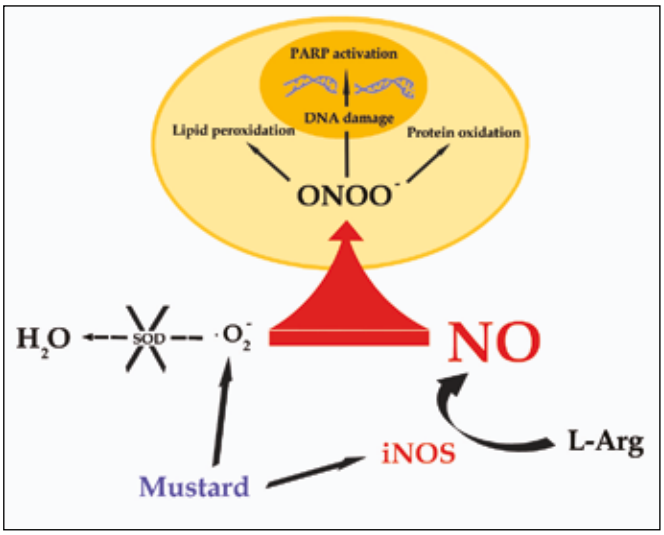
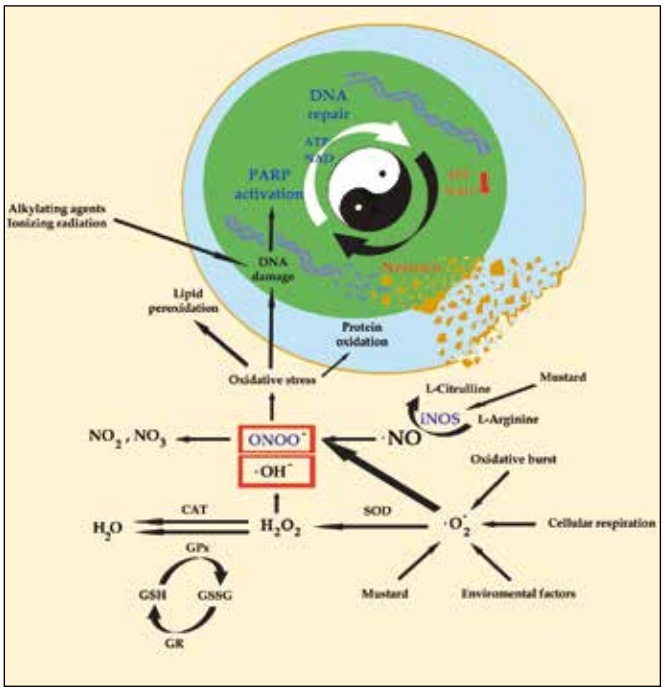


Figure 4: The overall mechanism of mustard-induced cell toxicity. Mustard can easily enter into the cell and cause both superoxide and nitric oxide overproduction. These two precursors may form peroxynitrite. Peroxynitrite is known as a strong nitrosative agent and causes lipid peroxidation, protein oxidation, and DNA damage. DNA damage leads to PARP activation and affects cellular energetic levels. If the damage is severe enough, PARP is overactivated and causes depletion of cellular NAD and ATP levels that ultimate wind up in cellular necrosis[68].



biomolecules via one or two electron oxidations. Higher concentrations and the uncontrolled generation of $ONOO^-$ may result in undesired oxidation and consecutive destruction of host cellular constituents. $ONOO^-$ may oxidize and covalently modify all major types of biomolecules. One of the most important mechanisms of cellular injury is $ONOO^{--}$ dependent increase in DNA strand breakage that triggers the activation of poly (adenosine diphosphate-ribose) polymerase (PARP), a DNA repair enzyme. DNA damage causes PARP overactivation, depleting oxidized nicotinamide – adenine dinucleotide (NAD +) and adenosine triphosphate (ATP), consequently bringing about necrotic cell death[20]. DNA single-strand breakage is an obligatory trigger for the activation of PARP. With that, $ONOO^-$ and $\cdot OH^-$ are the key pathophysiologically relevant triggers of DNA single-strand breakage[21]. Moreover, nitroxyl anion, a reactive molecule derived from nitric oxide, is a potent activator of DNA single-strand breakage and PARP activation *in vitro*[20, 21]. Subsequent studies have clarified that the actual trigger of DNA single-strand breakage is $ONOO^-$ rather than NO[17]. The identification of $ONOO^-$ as an important mediator of cellular damage in various forms of inflammation stimulated significant interest in the role of the PARP-related suicide pathway in numerous pathophysiological conditions. Endogenous production of $ONOO^-$ and other oxidants has been demonstrated to be associated with DNA single-strand breakage and PARP activation[22].

NF-κB AND CYTOKINES INVOLVED IN MUSTARD TOXICITY

NF-κB is a member of the Rel protein family and resides in the cytoplasm. This factor is normally bound to a member of the family of inhibitory proteins, inhibitor-κB (I-κB)[23]. The exposure of cells to NF-κB activators, including ROS and cytokines (e.g. TNF-α, IL-1), degrades I-κB. Activated NF-κB is then translocated to the nucleus where it is an important modulator of transcription events linked to a variety of stress conditions. The pro-inflammatory cytokine, TNF-α, plays an important role in diverse cellular events, including septic shock, obesity, diabetes, cardiovascular events, cancer, induction of other cytokines, cell proliferation, differentiation, necrosis, and apoptosis[24]. In response to TNF-α, transcription factors, like NF-κB, are activated in most types of cells and, in some cases, apoptosis or necrosis may also be induced.

Cells are often under genotoxic stress from both endogenous (e.g. ROS) and exogenous sources (e.g. ultraviolet radiation, ionizing radiation, DNA damaging chemicals, acrolein). The cellular response to genotoxic stress includes damage sensing, activation of different signaling pathways, and significant biological consequences that include cell cycle arrest and apoptosis. Transcription factors, including NF-κB, have been suggested to play critical roles in mediating cellular responses to genotoxic responses[25]. These transcription factors elicit various biological responses by promoting expression of their target genes. As activation of NF-κB can have anti-apoptotic or pro-apoptotic effects, the engagement of these two pathways may be key cellular responses that modulate the outcome of cells exposed to radiation and genotoxic chemicals. In most types of cells, inactive NF-κB is sequestered in the cytoplasm through its interaction with inhibitory proteins. As a reaction to various stimuli, like TNF-α and IL-1, inhibitory proteins of NF-κB release NF-κB and allow its translocation into the nucleus and the subsequent activation of its target genes. In the case of CP-induced gemorrhagic cystitis (HC), acrolein itself, cytokines, and ROS may cause NF-κB activation and intensification of the harmful effects of acrolein.

EXPERIMENTS FROM OUR LABORATORIES

In the experiments 1 to 3, we used cyclophosphamide, an analog of the nitrogen mustard which is similar to sulfur mustard structurally and functionally, to avoid harmfull effects of nitrogen mustard and to provide more safety study condition.

We began the studies with the prevention of further CP derivative nitrogen mustard-induced hemorrhagic cystitis (HC) in 2001. Cyclophosphamide is part of the nitrogen mustard group of alkylating antineoplastic chemotherapeutic agents. It is used alone or in combination with other chemotherapeutic agents to treat many neoplastic diseases[26].

HC is a major origin of potential toxicity and a dose-limiting side effect of CP and ifosfamide, a synthetic analog of CP[27]. The incidence of this side effect may be

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as high as 75% in patients receiving high intravenous doses[28]. The urological side effects vary from transient irritative voiding symptoms, including urinary frequency, dysuria, urgency, suprapubic discomfort, and strangury with microhematuria, to life threatening HC[29]. The urotoxicity of these nitrogen mustard group cytostatics is not based on direct alkylating activity within the urinary system, but on the formation of renally- excreted 4-hydroxy metabolites, particularly acrolein that is formed from hepatic microsomal enzymatic hydroxylation (Figure 5)[30].

Experiment 1. Hyperbaric oxygen (HBO) and mesna was used in guinea pigs. Mesna contains a sulfhydryl compound that binds acrolein within the urinary collecting system and detoxifies it, resulting in inert thioether that is passed innocuously in the urine and does not cause any damage to the uroepithelium[31]. The biological effect of HBO derives from hypersaturating circulating plasma with dissolved oxygen during and shortly after treatment, resulting in a transiently increasing diffusion gradient between the circulation and surrounding tissues that drive the transport of oxygen into the interstitium and tissues[32]. HBO facilitates the healing of tissue damage, decreases edema, and promotes capillary angiogenesis by raising tissue oxygen levels 10- to 15-fold[33]. The protective effects of the HBO/mesna combination were examined in the guinea pig bladder epithelium after further intraperitoneal administration of non-lethal urotoxic doses of CP.

In this particular study, it was evaluated whether combining HBO with mesna would provide better results for the prophylaxis and treatment of further CP-induced HC. Additional CP doses brought about statistically significant changes in all forms of histological damage, including inflammation, ulceration, edema, bladder weight, the ratio of bladder-to-body weight, and hematuria. Although mesna and HBO alone provided significant but not complete protection against further CP damage in guinea pig bladders, the protective effect of mesna appeared more promising than that of HBO on its own. Furthermore, while mesna or HBO alone provided noteworthy, but not complete, protection against additional CP damage in guinea pig bladders, the combination employed in this specific study bolstered bladder healing that a pathologist was unable to differentiate from control bladders. The protection provided by this combination was likely from the contribution of the protective effects of mesna, which limits the toxic effects of acrolein on the urothelium, and HBO, which strengthens defense mechanisms by increasing capillary angiogenesis, fibroblast replication, collagen formation, and reducing edema in guinea pig bladder tissue[34]. An additional advantage of HBO is the absence of significant adverse effects on bladder structure or function, potentially seen with other therapies.

Experiment 2. In 2003, studies demonstrated that endogenous inflammatory mediators, like platelet activated factor, TNF-α, and interleukin-1β (IL-1β), are involved in cystitis[35]. It was shown that, in particular, cytokines TNF-α and IL-1β mediate the production of NO in ifosfamide-induced cystitis. NO is a free radical gas that regulates a number of important physiological and pathophysiological processes, including vascular tone, polymorph nuclear leukocyte (PMNL) adhesion, and inflammation. There is evidence suggesting that NO-produced iNOS is toxic as in animal models, selective iNOS inhibition improved the outcome and decreased inflammatory events. It is well known that iNOS synthesis is strongly induced by IL-1β and TNF-α, and inhibition of these inflammatory mediators decreases iNOS expression[17]. The NOS enzyme catalyzes the reaction of L-arginine to citrulline and NO, and the NO produced is oxidized to nitrate and nitrite. NOS inhibition decreases the production of nitrite-nitrate[36]. In this discrete study, the changes in NO in CYP-induced bladder damage and the benefit of HBO as a HC treatment was investigated. The NO substrate, L-arginine, the nonselective NOS inhibitor L-NG-nitroarginine methyl ester (L-NAME), and the selective iNOS inhibitor, S-methylisothiourea (SMT), were evaluated.

In the work being described, HBO did not exhibit anti-inflammatory properties. Histological findings of the CP group treated with HBO were similar to those of the group treated with CP alone except that HBO decreased necrosis. HBO could probably not prevent CP-induced cystitis, though it accelerated tissue repair. This in agreement with a previous study showing HBO on its own could not completely protect the bladder against acrolein insult. L-NAME was seen to decrease nitrite-nitrate levels but no significant effect on bladder damage was observed from L-NAME or L-arginine administration. Yet, SMT diminished each ratio significantly. CP caused an approximately 2,5-fold increase in bladder-to-body weight (BLW/BW) ratios and a 3,5-fold increase in nitrite-nitrate levels. HBO affected neither the BLW/BW nor the nitrite-nitrate ratios caused by CP. In this experiment, HBO did not show a beneficial effect alone or together with L-arginine and L-NAME. Moreover, HBO did not improve the SMT group outcome.

Experiment 3. The objective of this 2005 study was to evaluate the protective effects of melatonin as an antioxidant, iNOS inhibitor, and peroxynitrite scavenger against CP-induced urinary bladder damage. Thwarting the damage inflicted by free radicals and reactive species is the function of, as mentioned earlier, a complex antioxidative defense system. This system includes enzymes such as superoxide dismutase, catalase, and glutathione peroxidase along with many of the most commonly used and experimentally studied non-enzymatic antioxidants, including melatonin[37, 38]. Melatonin is further known to be a potent iNOS inhibitor and peroxynitrite scavenger[39, 40]. Regarding this work, whether melatonin would diminish CP-induced bladder damage via several mechanisms, i.e. as an antioxidant, iNOS inhibitor and peroxynitrite scavenger, was assessed.

Melatonin was used at two different dosages, 5 and 10mg. CP presented severe histological changes, and macroscopic hematuria was present until the end of the study. Melatonin, at both doses, exhibited significant protection against bladder damage versus CP.

Reduced hematuria was also apparent in the melatonin-treated rats, while macroscopic hematuria was essentially absent at the end of the study. Histologically, the two melatonin-treated groups could not be distinguished from each other based on their morphology. CP injection caused HC increased MDA levels, indicating oxidative stress, while melatonin ameliorated MDA levels in the bladder versus CP. Moreover, CP also elevated NOx levels in urine and iNOS activity in the bladder. Melatonin injection decreased both NOx levels and iNOS activity.

In the light of the current data, it was speculated that oxidative stress, iNOS induction leading to NO overproduction, and peroxynitrite formation are responsible, at least in part, for CP-induced bladder damage. Melatonin may ameliorate bladder damage through scavenging of ROS and RNS and inhibiting iNOS activity in bladder tissue.

POSSIBLE MECHANISMS OF CP-INDUCED BLADDER DAMAGE

Starting in 2001, the author's attempted to shed light on the pathophysiology of CP-induced HC. In 2006, they published a review on the mechanism of CP-induced HC.

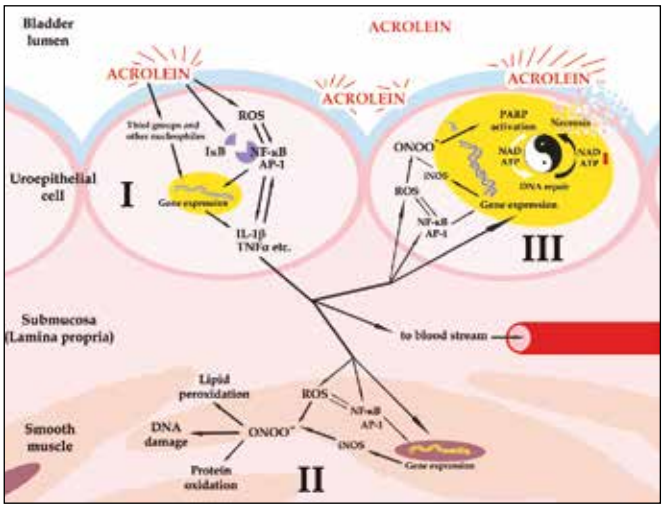
The first step in the pathogenesis of CP-induced bladder damage is the entry of acrolein into the uroepithelium. Then, the cascade is activated as follows; first, acrolein rapidly enters into the uroepithelial cells. Next, it activates intracellular ROS and NO production (directly or through NF-κB and AP-1), leading to $ONOO^-$ production. Third, the increased $ONOO^-$ levels damage lipids (through lipid peroxidation), proteins (protein oxidation), and DNA (strand breaks), leading to PARP activation. Figure 5 demonstrates the proposed mechanism of acrolein-induced HC in detail.

It has been seen that when evaluating the data on the mechanism of sulfur mustard toxicity through HC caused by CP, the pathophysiological mechanisms of HC caused by CP and mustard gas are almost the same.

Experiment 4. It was decided to use melatonin in important studies conducted against nitrogen mustard toxicity. Based on the observed cytotoxic mechanisms above, this study was performed to test the potent antioxidant molecule, melatonin, in terms of its capability in protecting the lungs, a major main target of mustards. using the prototype nitrogen mustard (mechlorethamine/HN_2) as a model.

Melatonin reportedly scavenges toxic reactive species, including hydroxyl radicals, superoxide radicals, peroxynitrite anions, peroxyl radicals, nitric oxide, and singlets of oxygen. Moreover, being highly lipophilic as well as hydrophilic, melatonin readily penetrates all known physiological barriers and accumulates in all tissues and subcellular compartments. A number of *in vitro* and *in vivo* reports claim that melatonin effectively protects membrane lipids, intracellular proteins, and DNA from oxidative damage that comes about from a variety of

Figure 5: The overall mechanism regarding acrolein-induced HC pathogenesis. (I) Acrolein enters the uroepithelium and causes ROS production, iNOS induction, and activation of transcription factors (e.g. NF-κB and AP-1). Activated NF-κB and AP-1 cause cytokine (TNF-α, IL-1β) gene expression, iNOS induction, and, again, ROS production. (II – III) The cytokines produced spread out into other uroepithelial cells, the bloodstream, and detrusor smooth muscle. ROS and NO form peroxynitrite in both the uroepithelium and detrusor, leading to lipid peroxidation, protein oxidation, and DNA damage. DNA damage gives rise to PARP activation and energy crisis and, ultimately, cellular necrosis. (IV) During necrotic cell death, the cellular content is released into the tissue, exposing neighboring cells to potentially harmful attack by intracellular proteases and other released factors[41].



free radical-generating agents and processes in a variety of tissues[42]. The discovery of protective molecules that combat HN_2 toxicity and the understanding of the toxic mechanisms in the lungs are crucial for the development of specific therapies and may prove valuable in further mechanistic investigations of SM toxicity.

A total of 40 male albino Wistar rats, with body weights of 220–250 g, were divided into four groups using the 'simple random sampling method'and they were given food and waterad libitum. The animal models for this study were given a toxic dose of 0.5mg/kg HN_2 dissolved in saline intratracheally, while control animals were injected with only saline. Doses of melatonin [20mg/(kg equiv.) or 40mg/(kg equiv.)] were administered intraperitoneally for 1 h before HN_2 application; additional melatonin was given every 12 h for a total of six doses. Thereafter, the animals were allowed to survive for an additional 48 h (for a total experiment duration of 120 h).

Cu, Zn-SOD activity was found to be physiologically reduced, but GPx activity was higher in the control group. Administration of HN_2 caused no change in Cu, Zn-SOD activity, however GPx activity significantly decreased after HN_2 administration. The 20mg/kg dose of melatonin had inconsistent effects on SOD, though 40mg/kg doses of melatonin significantly enhanced Cu, Zn-SOD activity. Additionally, melatonin protected against the loss of GPx in a dose-dependent manner.

MDA was increased after HN_2 administration and both doses of melatonin diminished MDA levels in rat lung tissue.

HN_2 injection caused significant iNOS induction in the lung. Urinary NOx excretion increased almost four-fold in HN_2-treated rats. These outcomes provide evidence that nitrosative stress took place with HN_2 administration in addition to oxidative stress. Melatonin reduced NOx levels and iNOS activity at both doses in a dose-dependent manner. iNOS inhibition by 20mg/kg melatonin was statistically insignificant, but the decrement in NOx was clear. Melatonin (40mg/kg) caused marked iNOS inhibition to near control values.

Control animals presented normal lung tissue; neither edema nor alveolar hemorrhage was encountered in these lungs. Histopathological evaluation of rat lungs following HN_2 administration revealed the development of lesions predominantly in the parenchymal region. There was severe inflammatory cell infiltration and many of the alveoli were obstructed. Inflammatory cells were also apparent around the small airways and mucosal epithelium. Interestingly, many airways were dilated while some were even collapsed. In addition, significant edema and alveolar hemorrhage were also observed following HN_2 treatment. Lung parenchyma showed inflammation, including neutrophil infiltration, into the airways and alveoli. The noteworthy lung lesions included congestion, hemorrhage, and accumulation of hemorrhagic exudate, parenchymal debris, and pulmonary edema. Both melatonin doses improved lung morphology in a dose-dependent manner. In the melatonin-treated rats, significantly less edema, alveolar hemorrhage, inflammatory cell infiltration, and airway pathology was observed.

Based on the described toxicity mechanisms, it would appear that melatonin is able to counter the numerous consequences of mustard toxicity. A recent review clearly demonstrates that melatonin, as well as its many derivatives, have the capacity to neutralize ROS and RNS in an almost endless fashion[42]. Melatonin, as a potent antioxidant, directly scavenges ROS produced and it supports enhancing cellular GSH levels in the case of mustard toxicity[43]. In the current experiment, melatonin reduced lung MDA levels and promoted intercellular antioxidant enzyme levels. The dramatic decrease in GPx concentrations seen in HN_2-treated rats was successfully prevented by melatonin. This beneficial effect is not achieved with the use of either iNOS inhibitors or a peroxynitrite scavenger, or even several other antioxidants.

Melatonin is also a well-known selective iNOS inhibitor[44]. Lung issue iNOS measurements and urinary NOx levels indicate that melatonin, or a metabolite, blocked iNOS induced by HN_2 in a dose-dependent manner[45]. Melatonin was also shown to block iNOS in the case of CP-induced bladder toxicity[67]. Thus, melatonin can successfully block the coupling of the two precursors, i.e. NO and $O_2^{\bullet-}$, from forming peroxynitrite. Further, melatonin is also capable of directly scavenging peroxynitrite if it is produced[40, 44, 46]. As a consequence of these actions of melatonin, mustard toxicity in lung tissue was diminished significantly at both the biochemical and morphological levels. Histologically, there was less alveolar hemorrhage, less edema, and reduced inflammatory cell infiltration in the melatonin-treated rats. This is the first experimental study to provide evidence that melatonin may significantly reduce mustard-induced toxicity in the lungs.

In the authors' clinic as well as the international environment, significant results have been achieved with respect to melatonin. At this stage, in the fight against mustard toxicity, the authors published an article specifically focusing on melatonin.

DISCUSSION

To date, a number of studies have been performed in order to find novel therapeutic approaches against mustard toxicity in different tissues. Most of these therapeutic agents consist of molecules that possess anti-inflammatory, antioxidant, proteases and surfactant properties[47].

As an antiinflammatory agent, pentoxifylline is considered because its a TNF-α inhibitor property, and pentoxifylline has been shown to reduce pathological alterations in the elastic properties of the lung through anti-inflammatory and antioxidant activities in rats[48]. Silibinin, another novel therapeutic agent, has been demonstrated to attenuate skin injury due to mustard toxicity by exerting as an anti-inflammatory and antioxidant agent[49]. Also it has been shown that silibinin has potential therapeutic effects on ocular injuries due to both sulphur and nitrogen mustard[50]. Another

Table 1: Models, agents and analyses used in the experiments.

Experiment	Model	Protective Agent	Analyse Type
1	Guinea pig, bladder	HBO_2, Mesna	Histopathology
2	Sprague-Dawley, bladder	HBO_2, L-arginine, L-NAME, SMT	Histopathology
3	Sprague-Dawley, bladder	Melatonin	Histopathology, Biochemical analyses
4	Wistar-Albino, lung	Melatonin	Histopathology, Biochemical analyses

potential therapeutic approach for mustard injuries is antibodies against inflammatory cytokines such as TNF-α. It has been shown that anti-TNF-α antibody attenuate nitrogen mustard induced pulmonary fibrosis and injury[51].

Moreover, specific agents such as N-acetyl cystein and melatonin have been also studied as other considerable molecules against mustard toxicity[52 ,53].

In a review article, it has been suggested that melatonin, a hormone secreted from pineal gland, might be a therapeutic molecule against mustard toxicity through its antioxidant, anti-inflammatory and gene regulating properties[54]. Following this review, other melatonin researches had performed to evaluate the efficacy of melatonin against mustard toxicity[55, 56]. At present, there is no enough scientific study performed with melatonin in order to discuss its efficacy against mustard toxicity completely. Given the results of the other melatonin studies about all other research area, it may be concluded that melatonin has ameliorative effects on almost all pathological conditions prominently[57, 58]. Another interesting and promising issue is that melatonin is a molecule produced in body endogenously and its overdose was not defined in previous scientific studies yet[59]. It is more likely that this properties of melatonin will provide an advantage to threat tissue injuries due to mustard toxicity in human. In addition, currently, melatonin is not only used for experimental studies in order to ameliorate various pathologies as a safety agent, but also is used as antioxidant and sleep supporter in human[60]. Thus, the transposition of utilization of melatonin against the mustard toxicity to humankind will be so easy. Because some of agents studied experimentally on mustard toxicity are used in humandkind clinically, same impressions are able to be applied to these agents studied on mustard toxicity previously including N-acetyl cystein and pentoxifylline.

SM causes not only genotoxicity but also alters epigenetic processes, this could explain, partially, the delayed effects of this warfare agent. It is proposed that epigenetic regulation of DNA may be the underlying mechanism of the delayed effects of SM[61]. A genetic change is thought of as a permanent, inheritable change affecting every cell if it is passed along through the germline. However, these assumptions are not totally accurate. In addition to the DNA inheritance system underlying classical genetics, it is now recognized that variations can be transmitted between generations in other ways; the epigenetic inheritance system (EIS). The traditional view that the interactions between genes and the environment control disease susceptibility can now be expanded to include epigenetic reprogramming as a key determinant of the origins of human sickness[62]. After putting forward the hypothesis that epigenetic mechanisms may cause sulfur mustard complications in the chronic phase, the authors are continuing molecular studies on nitrogen mustard.

CONCLUSION

Currently, it seems that the limitation of use of chemical weapons including mustard gas especially is almost impossible at both war or peacetime. Because, mustard gas has been used in Syria in despite of international prohibition about these weapons. Therefore, scientific studies towards development of novel therapeutic agents against chemical weapons would maintain its importance in future, rather than the limitation of chemical weapons. When considered from this point of view, it is more likely that some molecules such as melatonin which is secreted endogeneously and possess a wide spectrum about various pathologies will be ideal therapeutic agents against the chemical weapons. This situation show promising for challenge to chemical weapons.

Overall, the scientific endeavors of the authors' research laboratory, starting with nitrogen mustard, continues to elucidate the damaging mechanism of sulfur mustard and to demonstrate potential antidotes. Attempting to find a cure for this chemical warfare agent, one that has cost many, many people their lives and health, is still exciting. However, the urgent necessity for an antidote against sulfur mustard, capable of causing serious mortality and morbidity, is increasing day by day considering the conjectural situation of the authors' geographical region. It is therefore quite apparent that all sensible states and statesmen have the important duty of increase support for research related to sulfur mustard and to ensure accepting as a political health and defence objective the development of an antidote against sulfur mustard.

SUMMARY

Mustard gas was the most commonly employed chemical weapon during the past century and led to hundreds of thousands of people being injured and killed. Mustard gas continues to be a very serious threat to both military personnel and civilians. Even though long-term studies conducted over recent years have reached a stage of maturity in terms of what has been uncovered, the mechanisms that lead to toxicity as a consequence of mustard gas are not fully understood. The mustard group of agents are also known as alkylating agents based on the addition of alkyl groups to DNA chains. Furthermore, it has been demonstrated that the means by which acute toxicity is brought about also causes oxidative and nitrosative stress.

For years, studies related to mustard gas derivatives in various laboratories have resulted in the hypothesis that the toxicity of the chronic period may be from epigenetic changes. This article summarizes the research on and conclusions from all these pathophysiological mechanisms from the authors' laboratories from 2001 to the present.

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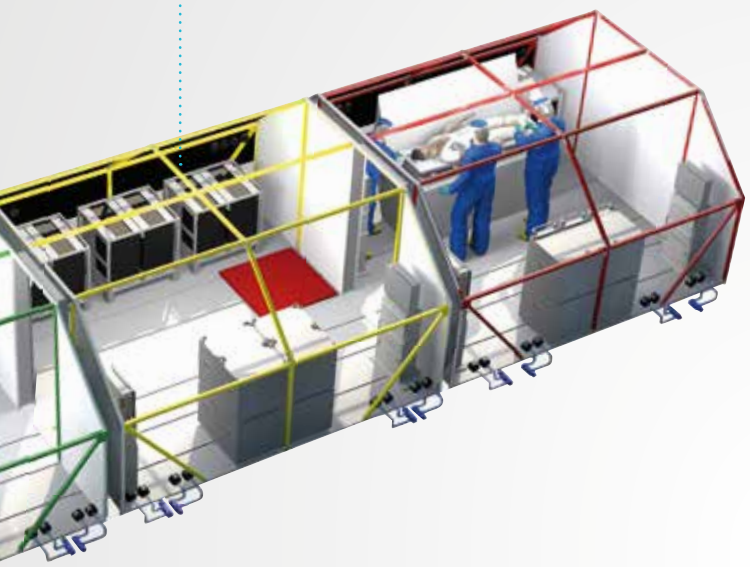

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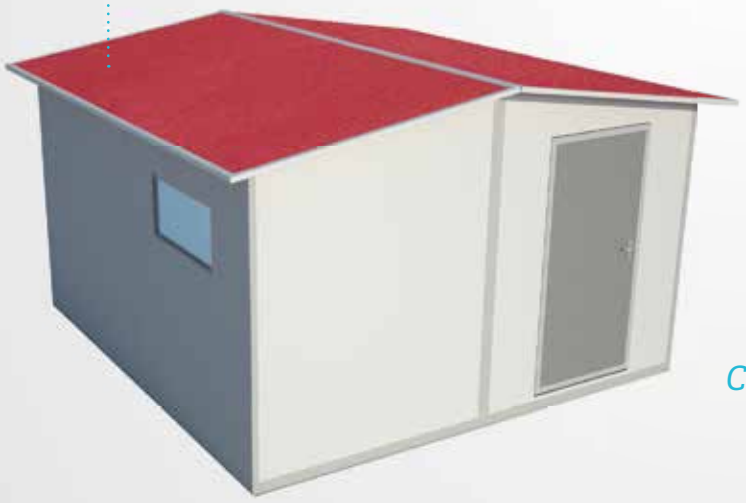

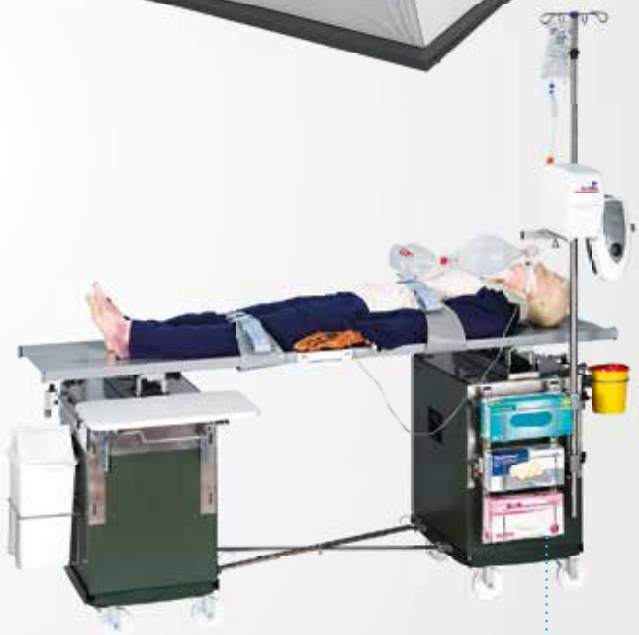

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The Role of an Effective Malaria Vaccine in the Management of Malaria in Military Personnel.*

By E.F. VILLASANTE[1] and K.A. EDGEL[2]. U.S.A.

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RESUME

La place d'un vaccin efficace dans la prise en charge du paludisme chez les militaires.

Le personnel militaire est déployé à travers le monde dans le cadre d'opérations de combat et de sécurité pour assurer une stabilité régionale.

Les militaires sont également engagés dans des missions humanitaires et participe aux opérations de maintien de la paix. Certaines de ces régions sont endémiques pour le paludisme. La plupart des contingents militaires venant de pays développés ne sont pas immunisés contre le paludisme et peuvent être touchés par des taux élevés de morbidité et de mortalité lorsqu'ils sont infectés. Actuellement, la prévention du paludisme en milieu militaire repose sur l'utilisation de médicaments préventifs ainsi que l'usage de moustiquaires imprégnées en insecticides et de répulsifs contre les moustiques. Néanmoins ces mesures ne sont pas efficaces à 100 % en raison de la résistance des parasites aux traitements médicamenteux, de la résistance des moustiques aux insecticides ainsi que des niveaux variables de non-observance des mesures de protection. Pour ces raisons, il est très urgent de développer un vaccin hautement efficace contre le paludisme pour la prévention des infections chez le personnel militaire.

KEYWORDS: Malaria vaccine, Plasmodium falciparum, RTS,S vaccine, PfSPZ Vaccine.

MOTS-CLÉS : *Vaccin contre le paludisme, Plasmodium falciparum, Vaccin RTS,S, Vaccin PfSPZ.*

In 2015, nearly half (47%) of the countries in the world, had on-going malaria transmission[1]. Malaria remains a significant disease threat to deployed military personnel with the risk varying year to year depending on the location of combat, humanitarian, and peacekeeping missions. Most military personnel from developed countries are non-immune to malaria and thus suffer high rates of morbidity and mortality when infected. Symptoms, which include intermittent fever, chills, and sweats, can progress, depending on the malaria species, to renal and liver failure, pulmonary and cerebral edema, coma, and death without appropriate treatment. The mission can be severely impacted if a large number of personnel in a military unit become infected. Military personnel suffering from malaria may lose 7 to 10 days of duty per event. There is no licensed malaria

vaccine; therefore, military personnel must rely on the use of chemoprophylaxis to prevent malaria infection and personal protective measures to prevent mosquito bites by wearing insecticide-impregnated uniforms, keeping sleeves and pant legs down, sleeping under bed nets, and applying insect repellant. Several factors negatively affect the utility of these measures and drive the need for a highly effective malaria vaccine, including poor compliance, drug resistance, pharmacogenomic profiles, and drug-drug interactions.

MALARIA AND THE MILITARY

From a historical perspective, malaria has had a significant impact on military operations, often causing greater manpower loss than combat injuries during deployments to endemic areas[2-4, 5, 6]. In World War II, the United States (U.S.) military recorded 695,550 hospital admissions due to malaria infections resulting in 11-12 million sick-days and 389 deaths[4]. Similarly, in the Vietnam War, the U.S. military recorded 65,053 admissions due to malaria infections resulting in 1.2 million sick-days and 124 deaths[4].

Many of the recent cases and outbreaks of malaria in U.S. military have been due to the lack of compliance with use of personal protective measures[7-9]. In 2003, there were approximately 80 confirmed or presumed cases of *Plasmodium falciparum* infection among 225 U.S. Marines deployed to Liberia[10]. This high rate of infection was suspected to be due to a combination of poor compliance with prescribed prophylactic drugs (mefloquine), and low to no use of insect repellents, permethrin-treated uniforms, and bed nets. Six years later, a member of the U.S. Naval Mobile Construction Battalion 3, became infected with *P. falciparum* during a deployment to Liberia, and developed cerebral malaria, dying shortly after being medically evacuated to Landstuhl Regional Medical Center in Germany[11]. A lack of enforcement by the battalion leadership of use of malaria preventive measures was noted during an investigation of this case.

In 2014, the U.S. Africa Command, which lead Operation United Assistance, the U.S. military's humanitarian response to the Ebola outbreak in West Africa, reported that the risk of malaria infection was a greater threat to U.S. military personnel than the risk of becoming infected with Ebola virus[12]. The number of malaria cases during Operation United Assistance was low due to the extremely high emphasis placed by leadership on enforcing compliance with the daily malaria chemoprophylaxis regimen and other personal protective measures. In addition, deployed personnel were given Malarone (atovaquone/proguanil) despite its higher cost in comparison to other antimalarial drugs such as doxycycline because of its longer half-life; a missed dose of Malarone poses less of a health risk than a missed dose of doxycycline.

THE MALARIA LIFE CYCLE AND VACCINE TARGETS

Plasmodium has a complex life cycle with several stages in the mosquito vector and vertebrate host that could serve as potential vaccine targets. Infected female *Anopheles* mosquitos deposit *Plasmodium* sporozoites in the dermis of a human host while probing for a blood source. Sporozoites exit dermal tissue and enter the bloodstream within a couple of hours. Sporozoites then invade hepatocytes and develop over the course of the next few days. From the infection of one sporozoite, tens of thousands of merozoites burst from an infected hepatocyte to infect erythrocytes. The parasites develop and multiply within the erythrocytes from which many more new merozoites emerge. Soon after, clinical symptoms present. Some merozoites develop into gametocytes, the sexual stage of the *Plasmodium* life cycle. An uninfected female *Anopheles* mosquito can become infected if it bites a human host with circulating gametocytes, which then continue their development inside their mosquito host: gamete, zygote, ookinete, oocyst, then sporozoite. The mosquito, now with sporozoites in its salivary glands, bites another human, thereby spreading malaria.

There are three main stages within the *Plasmodium* life cycle that could be targeted by vaccines. First is the prevention of infection at the pre-erythrocytic stage: neutralization of sporozoites by antibodies and killing of infected hepatocytes by T cells and cytokines. The pre-erythrocytic vaccine approach is being pursued by the U.S. Military Malaria Vaccine Program (USMMVP), because this type of vaccine is designed to kill parasites when they are at their lowest numbers and before they cause clinical disease. The second approach is an erythrocytic stage vaccine that blocks parasite invasion of and development in erythrocytes. Third are transmission-blocking vaccines that target sexual erythrocytic or early mosquito-stage antigens and reduce the proportion of infected mosquitoes. This type of vaccine depends on herd immunity to reduce the incidence of infections in a community.

The U.S. military through its medical research laboratories, headquartered at the Naval Medical Research Center (NMRC) and the Walter Reed Army Institute of Research (WRAIR), with laboratories in Southeast Asia, Africa, and South America, has had a long history of research in malaria drug development and vaccines[3, 13], as well as on entomology and vector control[14-16]. The USMMVP's mission is to develop *P. falciparum* and *P. vivax* malaria vaccines to prevent malaria morbidity and mortality in

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* Presented at the 41st ICMM World Congress on Military Medicine,
Bali, Indonesia, 17-22 May 2015.

military personnel and in vulnerable populations for the benefit of global public health, with the objective to completely prevent infection and progression of disease before clinical illness. The focus of the USMMVP has been on the pre-erythrocytic vaccine approach – to induce strong antibody and/or cellular responses targeting sporozoites and/or liver stage parasites at the pre-erythrocytic stage of the *Plasmodium* life cycle.

PERFORMANCE ATTRIBUTES OF A MALARIA VACCINE FOR THE MILITARY

The performance attributes of a malaria vaccine for military personnel must take into account training, operational and mission requirements. Ideally, a military malaria vaccine would meet the following requirements: (1) Efficacy of at least 80% and preferably greater than 90% against all strains of *P. falciparum*, the most prevalent and deadliest of the *Plasmodium* species that infect man. A vaccine that prevents infection with other species of *Plasmodium*, such as *P. vivax*, is also needed and must be considered by vaccine developers. Ideally, a single vaccine would protect against both falciparum and vivax malaria. Vaccine protective efficacy of greater than 90% would maintain mission effectiveness and reduce medical and logistics burdens. A vaccine that provides protection against multiple strains of *P. falciparum* is important due to the genetic diversity of the parasite worldwide[17, 18]. (2) Target efficacy should ideally be achieved within 14 to 21 days after completion of the immunization regimen. Rapid achievement of target vaccine efficacy is important as shown by the U.S. military experience in Somalia, where most malaria cases were seen in the first 5 weeks of arrival in country, and in Liberia where troops that became infected were only on-site for 10 days[10, 19]. (3) The dosing regimen should include the fewest number of doses to limit the time, cost, and medical resources required to prepare personnel for deployment. An initial immunization regimen could consist two or three doses during training followed by a boost prior to deployment. (4) Duration of protection ideally should last at least twelve months after completion of the immunization regimen. Protective immunity for one year fits with the duration of most military deployments and missions. The average U.S. military deployment length to Afghanistan and Iraq during Operation Enduring Freedom and Operation Iraqi Freedom between 2001 and 2010 was 7.7 months[20]. Many non-combat missions are of shorter duration, such as the recent deployments to West Africa for Operation United Assistance, which were four to five months. A vaccine that provides at least six-months protection would be beneficial for short-term deployments; however, an extended period of protection would lessen the logistics support requirements and reduce costs for immunizing troops. (5) A malaria vaccine must be safe, well-tolerated, and compatible with the other measures used to prevent malaria. It is likely that a first generation malaria vaccine against *P. falciparum* would be used in combination with prophylactic drugs and personal protective measures to provide protection against the other malaria species. (6) All vaccines used by the U.S. military must be licensed by the U.S. Food and Drug Administration (FDA).

LEADING MALARIA VACCINE CANDIDATES TARGETING THE PRE-ERYTHROCYTIC STAGE

The two leading malaria vaccine candidates targeting the pre-erythrocytic stage that have shown the highest levels of protection in clinical trials are the RTS,S vaccine (GlaxoSmithKline; GSK), a recombinant protein vaccine, and PfSPZ Vaccine (Sanaria, Inc.), a whole sporozoite-based vaccine. The RTS,S vaccine is the most advanced malaria vaccine in development globally and is the first malaria vaccine to advance to phase 3 clinical trials. RTS,S is a hybrid virus-like particle made up of the *P. falciparum* circumsporozoite protein (CSP) containing the repeat region B-cell epitopes (**R**) and T-cell epitopes (**T**) fused to the hepatitis B surface antigen (**S**) and free **S** antigen combined with an adjuvant. The phase 3 clinical trial in approximately 16,000 infants and children in Africa was completed recently. In infants six to 12 weeks old, RTS,S had 27% efficacy against clinical malaria and 15% against severe malaria. In children five to 17 months old, RTS,S had 46% efficacy against clinical malaria and 36% against severe malaria. RTS,S is being developed by GSK/PATH-Malaria Vaccine Initiative for infants and young children in malaria endemic areas in sub-Saharan Africa. After receiving a positive recommendation from the European Medicines Agency in July 2015, the World Health Organization (WHO) Strategic Advisory Group of Experts on Immunization and the Malaria Policy Advisory Committee (SAGE/MPAC) recommended pilot implementation of RTS,S in children 5 to 17 months of age in sub-Saharan Africa prior to considering a wider scale-up. The pilot implementation would provide an assessment of the vaccine's protective efficacy when administered outside of a trial, as well as data on feasibility of administering four doses in routine vaccination programs and the impact on child mortality and safety of the vaccine. This vaccine as currently formulated, would not meet the military requirements for efficacy. However, very promising results have been recently reported on a phase 1 clinical trial with controlled human malaria infection (CHMI) that was conducted at WRAIR in 2013-14, which replicated the study design and efficacy of a prior WRAIR study conducted in 1997, in which 6 of 7 research subjects were protected after CHMI[21, 22]. This study design, designated delayed fractional dose (DFD), utilized a standard dose of RTS,S/AS01$_B$ administered at 0- and 1-month followed by a one-fifth dose (fractional) administered at month 7. Future clinical trials are being planned to further test and optimize DFD regimen.

The Sanaria ® PfSPZ Vaccine is the first malaria vaccine to provide 100% protection against CHMI. The vaccine is based on studies done in the 1970s to 1990s, which demonstrated greater than 90% protection lasting for at least 10 months in human subjects immunized by the bite of mosquitoes containing radiation-attenuated sporozoites[23-25]. The PfSPZ Vaccine is comprised of live, aseptic, purified, cryopreserved, radiation-attenuated

sporozoites from the salivary glands of mosquitoes. The PfSPZ Vaccine administered by direct venous inoculation (DVI) is safe and well-tolerated and protected six of six subjects who received five doses of 135,000 PfSPZ[26].

Clinical trials are underway or are being planned to optimize the vaccine regimens of RTS,S and PfSPZ Vaccine and determine durability of protection and cross-strain protection in semi-immune and non-immune research subjects. These data will be critical to support the licensure of a highly effective malaria vaccine for future military use.

SUMMARY

Malaria continues to be a major challenge to readiness and the fitness of the military. It is a significant disease threat to deployed military personnel with the risk varying year to year depending on the location of combat, humanitarian, and peacekeeping missions. Most military personnel from developed countries are non-immune to malaria and thus suffer high rates of morbidity and mortality when infected. While there are available personal protective measures to protect against malaria infection by preventing mosquito bites (skin repellents, long sleeves, long pants, and insecticide-treated uniforms and bed nets) as well as prophylactic drugs, several factors negatively affect their utility. Non-compliance, along with drug resistance, pharmacogenomics profiles, and drug-drug interactions, are driving the need for an effective malaria vaccine. The performance attributes of a malaria vaccine for military personnel must take into account training, operational and mission requirements. The desired characteristics for a malaria vaccine for military use are protective efficacy of at least 80%, but preferably greater than 90%, with greater than six months durability, acceptable safety and tolerability profile, and compatibility with existing malaria personal protective measures.

Disclaimer

The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, nor the U.S. Government. Kimberly Edgel is a military service member and this work was prepared as part of her official duties. Eileen Villasante is a civilian government employee and this work was prepared as part of her official duties. Title 17 U.S.C § 105 provides that "Copyright protection under this title is not available for any work of the U.S. Government." Title 17 U.S.C § 101 defines a Government work as a work prepared by a military service member as part of that person's official duties.

Conflict of Interest Statement

Kimberly Edgel and Eileen Villasante declare no conflict of interest. Funding: A portion of the work described in this manuscript was supported and funded by the Military Infectious Diseases Research Program (Work Unit Number A1217), the Joint Warfighter Medical Research Program (Work Unit Number A1413), and Navy Medicine Advanced Medical Development (Work Unit Number A1008).

ABSTRACT

Military personnel deploy worldwide to execute combat and security operations to promote regional stability, engage in humanitarian missions, and participate in peacekeeping operations. Some of the regions to which military deploy are endemic for malaria. Most military personnel from developed countries are non-immune to malaria and suffer high rates of morbidity and mortality when infected. Currently, malaria prevention in the military includes prophylaxis with drugs, and use of insecticide-treated bed nets and mosquito repellants; however, these interventions are not 100% effective due to parasite resistance to the drugs, mosquito resistance to insecticides, and varying degrees of non-compliance with personal protective measures. A highly effective malaria vaccine designed to prevent infection in military personnel is urgently needed.

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Piezogenic Pedal Nodules in Polish Soldiers (National Reserve Forces) - Assessment of the Prevalence and the Effect on Physical Activity.

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RESUME

Les papules piezogéniques des pieds chez les soldats polonais (Force de réserve nationale) - Evaluation de la prévalence et de l'effet sur l'activité physique.

La peau des pieds de soldats est en permanence soumise à l'agression de facteurs externes, pouvant contribuer au développement de maladies diverses. Un trouble fréquent chez les personnes actives est les papules piezogéniques des pieds (PN). Elles consistent en une hernie de graisse sous-cutanée à travers la matrice de collagène du derme réticulaire. Les PN peuvent affecter jusqu'à 10-20 % de la population générale, se manifestant par des papules ou des nodules douloureux ou asymptomatiques. La forme douloureuse des PN est plus fréquente chez les femmes. Un traumatisme peut déclencher la formation de lésions caractéristiques de la plante du pied. Ils se manifestent au niveau du talon lorsque le patient est debout et disparaissent en position couchée. La localisation peut être unie ou bilatérale et les lésions sont généralement multiples. Assez fréquemment le patient se plaint de douleurs en station debout ou en marchant. Dans le cas de lésions douloureuses, aucun traitement efficace n'est disponible.

Objectif : *Le but de cet article est d'étudier la fréquence des PN chez les soldats.*

Matériels et méthodes : *La recherche a concerné 450 soldats de la force de réserve nationale (hommes et femmes) d'un âge moyen de 28,5 ans, et deux groupes contrôle : Un premier (I) – constitué de 100 patients en centres de réadaptation et un deuxième (II) constitué de 100 jeunes personnes n'ayant pas une pratique sportive régulière.*

Résultats : *Les PN ont été observées chez 20,33 % (122) des soldats, dont 39,34 % étaient des hommes et 60,66 % des femmes. Dans le groupe contrôle I les PN ont été observées chez 13 % (13 personnes), dont 69,20 % étaient des hommes et 30,80 % étaient des femmes et 17 % dans le groupe contrôle II (17 personnes), dont 52,94 % étaient des hommes et 47,06 % étaient des femmes. Dans le groupe des soldats, 100 % concernaient des atteintes siégeaient sur les talons et pour 54,10 % des cas les deux pieds étaient concernés. Les PN ont été observées chez les soldats qui jouaient activement au football (14,75 %). Un caractère douloureux a été rapporté par 3 soldats et 2 personnes appartenant aux groupes contrôles. Il n'y avait pas d'antécédents familiaux de maladie du tissu conjonctif dans le groupe des soldats.*

Conclusions : *Les modifications cutanées conduisant aux papules piezogéniques sont liées à l'activité physique. L'entraînement. pourrait diminuer le risque de PN chez ceux qui ont une prédisposition génétique.*

Keywords: Soldiers, Feet, Piezogenic nodules, Training.

Mots-clés : *Soldats, Pieds, Papules piezogéniques, Entraînement.*

INTRODUCTION

Soldiers, same as athletes, are significantly more frequently exposed to injuries than other occupational groups. In most parts of sport disciplines, healthy feet play an important role, as the skin of the foot is prone to all possible microinjuries.

In human anatomy, the feet are the most peripheral parts of the lower extremities. Both feet and hands are homologous structures. As for their constitution, however, they

are differently shaped due to their different functions. The main function of the foot is its contribution to body movement (supportive – weight bearing and locomotive function). Its construction is unique to humans due to their vertical posture. Foot skin injuries often occur in physically active individuals[1].

Therefore, some nosological units are more frequent in soldiers than in other occupational groups.

These include tinea, talon noir, pitted keratolysis, mechanical intertrigo of the feet, ingrown toenails or foot skin phlegmon[2, 3, 4].

Among athletes and soldiers, piezogenic pedal papules or fat hernia are quite frequently observed. This dermatological condition was first described in 1968 by Sheley and Rawnsley[5]. The changes occur in a form of papules or nodules located along the plantar foot surface. More rarely, they occur in the carpal or thenar area[6]. They appear in skin colour or in white. Their sizes range from 0.5 to 1.5 cm[7]. The papules become apparent with the increased load (when a patient stands) and disappear in a horizontal position[8]. Quite often, the patients feel pain while standing or walking[2]. The changes, as a rule, are multiple and may appear on one or, more frequently, on both feet[9]. Singh *et al.*[10] noted as many as 22 papules and nodules on one foot and 17 on the other one in a 20 year old male subject.

The papular appearance is caused by herniation of subcutaneous fat tissue into the dermis of the peripheral parts of the feet at the moment when an excessive load is placed on them[9, 11]. This herniation of fat is connected with the genetic decrease in the number or resistance of fat tissue fibrous septa. A differential diagnosis usually considers: adipose tumours, connective tissue nevi or ganglion neurofibromas. The changes may occur at any age, in adults and children[6].

Piezogenic pedal nodules are relatively frequent observed. There are two forms of this disease: the symptomatic form, affecting 10-20% of the general population[2, 12] and the painful form, observed mainly in athletes or individuals with connective tissue diseases [mainly Ehlers-Danlos Syndrome (EOD)][13]. The typical painful nodules occur with individuals who have sustained injuries in the area of feet. The disease usually affects athletes, most often track- and- field athletes[14] and also soldiers[15].

The goal of the paper was to discuss the prevalence of piezogenic pedal nodules in soldiers.

MATERIAL AND METHODS

The sample comprised 450 Polish soldiers (National Reserve Forces), male (421) and female (179), aged 19-38 years (the mean age = 28.5 years) including males aged 19-30 years (the mean age = 24.5 years), and females aged 19-28 years (the mean age = 28,5 years), and two control groups. The first (I) control group consisted of 100 patients of rehabilitation centres (male and female) aged 19-77 years (the mean age = 48 years) included males aged 19-77 (the mean age = 48 years) and females aged 31-76 years (the mean age = 53.5 years). The second (II) group comprised 100 young people (not practicing an active sport, male and female) aged 16-35 years (the mean age = 25,5 years) included males aged 16-35 (the mean age = 25,5 years) and females aged 20-30 years (the mean age = 25 years) was a check-up group.

The diagnosis was based on the history-taking and the characteristic clinical symptoms. Additionally, the anamnesis was oriented towards the history (personal or genetic) of connective tissue diseases and of foot ailments.

RESULTS

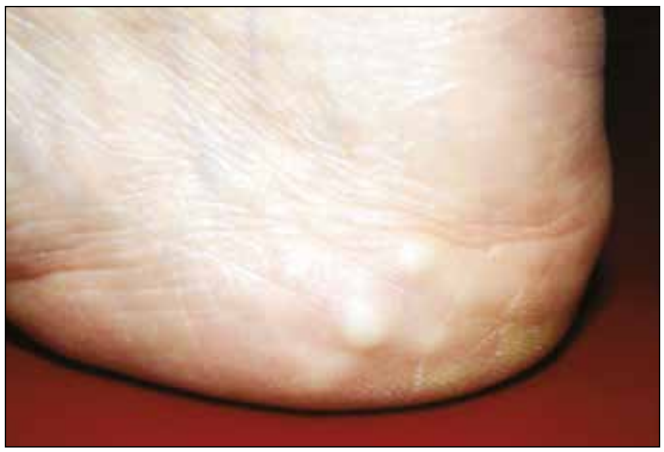
Piezogenic pedal nodules (Fig. 1) occurred in 122 subjects (20,33%) from the soldiers' group. It regarded 39,34% males (48 subjects) and 60,66% females (74 subjects).

In the (I) control group, piezogenic pedal papules were reported in 13 subjects (13%). In this group 69,20% males (9 subjects) and 30,80% females (4 subjects) were affected. In the (II) control group, piezogenic pedal papules were reported in 17 subjects (17%) of which 52,94% males (9 subjects) and 47,06% females (8 subjects).

Among the soldiers with piezogenic pedal papules, there was no history of connective tissue diseases. In the (I) control group, among the subjects with piezogenic pedal papules, there were three women (23,07%) treated for rheumatoid arthritis. In the soldiers' group, 3 subjects reported pain (2,45%) due to piezogenic pedal papules. In the control groups (I) and (II) two subjects reported pain (individuals with rheumatoid arthritis), which makes a total of 8,65% of individuals with piezogenic pedal papules.

In the group of affected soldiers there were 56 subjects (45,90%) with piezogenic pedal papules on one foot

Figure 1: Piezogenic pedal nodules on the heel in soldier.



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and 66 subjects (54,10%) on both feet. However, 100% of the changes appeared in the heel area. Conversely, in the control group (I) the dermatological changes were located only on the heels in 5 subjects (38,46%) and in 8 subjects (61,54%) they also affected lateral surfaces of the feet. In all 13 subjects (100%) they affected both feet. In the control group (II) the dermatological changes were located on the heels in 100% of the subjects. In 15 cases (88,23%) they affected one foot and in 2 cases (11,77%) both feet.

DISCUSSION

Piezogenic pedal papules occur in 10-20% of the general population[2]. They are reported in people of any age.

Greenberg and Krafchik noted piezogenic pedal papules in 5.9% of the studied newborns and 39.45% of those infants from Canada[16]. Lorralde de Luna *et al.* in turn, reported 4 cases of piezogenic pedal papules among the studied newborns from Argentina[17].

In the studied groups (800 subjects), 19% (152 subjects) presented piezogenic pedal papules. The prevalence of these changes significantly correlates with participation in strenuous activity.

It seems notable to mention track-and-field athletes as a group with a relatively high prevalence of piezogenic pedal papules when compared to athletes practicing other sports[14].

Training may evoke such skin changes in genetically predisposed individuals (reduction in the number or resistance of fat tissue fibrous septa)[18]. The painfulness of the papules seems also differently intensified.

In his study Laing[19] also noted 86% hernias with pain symptoms and Brzezinski only 5,88%[18].

In the presented study, pain was reported by 2,45% and 8,65% of the athletes and the control groups respectively.

The patients felt a moderately intensified pain during training sessions and some of them while walking.

Painful papules may restrict the active participation in team games, which later affect the athletic performance.

So far, no study has confirmed when the papules become painful and what percentage of the population experiences painful changes.

In the analyzed control groups there were cases of piezogenic pedal papules which already occurred at school age (in physically active individuals) and were present until old age without causing any symptoms.

Pain is more often associated with piezogenic pedal papules in connective tissue diseases of experienced foot injuries.

Doukas assumed that injuries or genetic connective tissue diseases were the main factors responsible for painful papules[20]. Poppe *et al.* reported piezogenic pedal papules in 34,5% of their EOD patients[13]. There was also one case reported of a family history of piezogenic pedal papules[21].

Among the studied group there was one woman with rheumatoid arthritis. In most of the studied soldiers (54,10%) the changes were present on both feet. Conversely, in the control group, most of the changes (88,23%) were noted at one foot.

A study of 50 children, girls and boys between 1-10 years old and their parents was conducted in Poland. The authors described PN in 16% of the children and in 22,06% of their parents[12]. Brzezinski *et al.* inform that there is a possibility of the incidence of PN among families, especially if one of the parents was physically active and trained a lot in the past.

Usually asymptomatic changes do not require treatment. If necessary painful papules and nodules may be surgically removed[8]. Moreover, it is advised to reduce body mass (for overweight individuals) and to avoid long periods of standing upright[2].

Doukas *et al.* presented a non-surgical approach towards the condition. They injected betamethasone and bupivacaine in 3 equal doses (1-2ml per injection) over a period of 1, 3 and 5 months. The last and final injection resulted in pain relief[20]. Electro-acupuncture was tried out as well[22]. Pantious *et al.* applied special orthopaedic protective heel pads in cases of intensified pain[23].

CONCLUSIONS

The discussed and analyzed nosological unit quite often affects humans, both adults and children. The patients rarely report this problem to physicians as they regard it as a cosmetic defect. They seek medical advice when the changes become painful once the hernias are formed.

Piezogenic pedal papules are significantly correlated with intensive activity and training may induce such changes in genetically predisposed individuals.

Painful papules or nodules may restrict active participation in training, which later affects soldiers.

Surgical removal of the dermal changes is a confirmed method of treatment, although recurrence is expected due to a genetic predisposal.

ABSTRACT

The skin on the feet of soldiers is continuously subjected to an unfavourable influence of deleterious external factors, which may contribute to the development of various diseases in this area. A frequent disorder seen among active people are piezogenic foot nodules (PN). They consist of the herniation of subcutaneous fat

through a collagen matrix of reticular dermis. PN affects even 10-20% of the general population, manifesting as painful or asymptomatic papules or nodules. The painful form of PN is more frequently observed in the female population. Trauma may initiate the formation of these characteristic pedal lesions, which usually take the form of papules or nodules, located on the sole of the foot. They manifest at the heel, when the patient is standing upright, and resolve in a recumbent position. The condition may be uni- or bilateral and there are usually multiple lesions. Frequently, the patient complains of pain whilst standing or walking. In the case of painful lesions, no effective treatment is yet available.

Aim of paper: The aim of this paper is to study the frequence of PN in the group of soldiers.

Materials and methods: This research involved 450 soldiers-National Reserve Forces (men and women) with a mean age of 28,5 years. There were also two control groups. The First (I) group concerned 100 patients of rehabilitation centres and the Second (II) group of 100 young persons (not practicing active sport) being a check-up group.

Results: PN was observed in 20,33% of the soldiers (122) of which 39,34% were men and 60,66% were women. In the check-up group (I) PN was observed in 13% (13 persons), of which 69,20% were men and 30,80% were women. In the control group (II) PN was observed in 17% (17 persons), of which 52,94% were men and 47,06% were women. In the soldiers' group 100% concerned changes on the heels and in 54,10% of these cases it concerned both feet. The most prevalent incidence of PN was observed in soldiers who actively play football (14,75%). Pain ailments were reported by 3 soldiers and 2 people from both check-up groups. There was no family history of connective tissue disease in the soldiers' group nor in the control groups.

Conclusions: Changes of skin appearance during piezogenic nodules illness is connected with increased activity. Training is the cause which could release changes of genetic predisposition to PN.

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The Effect of Hyperbaric Oxygen on the Healing of Rat's Flexor Muscle Injury.*

By R. DWIPAYANA. Indonesia

Rady DWIPAYANA

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RESUME

Effet de l'oxygénothérapie hyperbare sur la guérison des blessures du muscle fléchisseur chez le rat.

Le déficit fonctionnel et la déformation apparaissent lorsque la réparation de la blessure d'un muscle n'est pas optimale. L'oxygénothérapie hyperbare (OH) fait partie des méthodes thérapeutiques alternatives mais qui font toujours l'objet de discussions aujourd'hui.
Une étude expérimentale a été menée pour évaluer l'effet de l'OH sur la réparation du muscle et utilisant deux marqueurs : l'index de granulation et l'épaisseur de la prolifération des fibroblastes.
Quarante-huit rats ont subi une blessure chirurgicale qui a été suturée sur le muscle fléchisseur du postérieur droit. Les quarante-huit rats ont été répartis en quatre groupes.
Le premier et le troisième groupe étaient des groupes contrôles qui n'ont pas reçu d'oxygène. Les groupes 2 et 4 ont respectivement reçu de l'oxygène pendant une et deux semaines. Chaque groupe a ensuite bénéficié d'une étude histologique déterminant l'index de granulation et l'épaisseur de la prolifération fibroblastique dans la zone de guérison.
L'index de granulation moyen était de 24,525 ± 11,208 pour le 1er groupe et de 42,991 ± 20.261 pour le second. L'épaisseur de la prolifération fibroblastique était de 22,483 ± 11.626 pour le 3ème groupe et de 73.775 ± 18.692 pour le 4ème La différence entre le second groupe et le premier était significative ainsi que celle du 4ème groupe par rapport au 3ème.
Cette étude a montré que l'OH peut stimuler la granulation et la prolifération fibroblastique dans le processus de réparation musculaire.

KEYWORDS: Hyperbaric oxygen, Muscle healing, Fibroblast proliferation.
MOTS-CLÉS : *Oxygène hyperbare, Réparation musculaire, Prolifération des fibroblastes.*

RESEARCH BACKGROUND

Muscle tissue is the dominant tissue in the human body. It covers 40% - 60% of the body weight. This tissue consist of muscles with nervous tissues, blood vessels and connective tissues around it. Muscles have the ability to contract, therefore they move the joints and the body. When muscles injuries occur, muscles should be immobilized for a certain period of time and it may cause muscles stiffness because of the lack of elasticity and the reduction of muscle mass which may cause disablement in the future. As one of adjuvant therapy, Hyperbaric Oxygen (HBO) has been commonly used especially in soft tissue injuries which experience ischemia and infection. Ebberhard, et al in 1993, Wright J in 1994 and Hunt T K in 1995 reported that the giving of hyperbaric oxygen may increase the healing on a specimen but Hamarlund and Sundberg pointed in 1994 out that hyperbaric oxygen didn't give significant results in the injuries' healing[1,2,3.4]. Until today, the use of this method for muscle injuries treatment is still under debate.

When muscle injuries occur, there is also damage in the capillaries and the soft tissues around them. So, three processes of healing might occur, those are angiogenesis, fibroblast proliferation and muscles proliferation itself. However, the use of Hyperbaric Oxygen will increase the partial oxygen pressure (PO_2) in the tissues and the Oxygen (O_2) content which is dissolved in plasma[5]. This process may counteract the effect of hypoxia in the scar tissue and improve the quality of the newly formed muscle tissue, but the continuous application of hyperbaric O_2 without any intervals will result in forming free radical compounds such as reactive oxygen species (ROS) which may damage the tissue and cause tissue necrosis. Physiologically, free radical compounds in the human body are not harmful, since our body cells have a certain mechanism to neutralize them by forming scavenger. O_2 has an important role in the muscle wound healing[6].

However, until today, the use of hyperbaric oxygen to restore the tissue perfusion in the rate and quality of muscle injuries' healing is still under debate. Due to this fact, we undertook experimental research on Rattus Norvegicus concerning the effect of hyperbaric oxygen to the muscle injuries' healing.

RESEARCH ISSUES

- The cases of muscle injuries are very frequent, while therapies to ameliorate healing processes are still unsatisfying and time consuming.
- The effect of applying hyperbaric oxygen therapy for muscle injuries' healing is still under debate.

RESEARCH BENEFITS

1. To enrich the knowledge about the effect of applying hyperbaric oxygen to the healing of muscle injuries.

2. To provide an additional theory concerning the effect of applying hyperbaric oxygen on the healing of muscles injuries (see graphe 1).

RESEARCH METHODS

- RESEARCH TYPE

Actual Laboratory Experimental Study, because the three principles: randomization, replication and treatment and control group are fulfilled.

- RESEARCH DESIGN

We made an experiment in four groups of white rats (Rattus Norvegicus) treated with and without Hyperbaric Oxygen, that schematically can be described as follows (see graphe 2):

- POPULATION, SAMPLE, NUMBER OF SAMPLE

POPULATION

Population of the research sample is the white rat from the breeding place of Veterinary Faculty of Airlangga University, Surabaya with requirements:

1. Wistar furrow Rattus Norvegicus
2. Approximately 2 months of age
3. Weight approximately 200 grams
4. Male sex
5. Good health

- SAMPLE

Research sample determined with random sampling. Number of sample calculated based formula[7]

$$n = \frac{(Z_\alpha + Z_\beta)^2 \times \sigma D^2}{\delta^2}$$

Which $\delta/\sigma = 1$, so $(\sigma D)^2/\delta^2 = 1$, and $Z\alpha = Z_{0,05} = 1,65$
With $Z\beta = Z_{0,20} = 1,25$ then obtained number of sample ~10.

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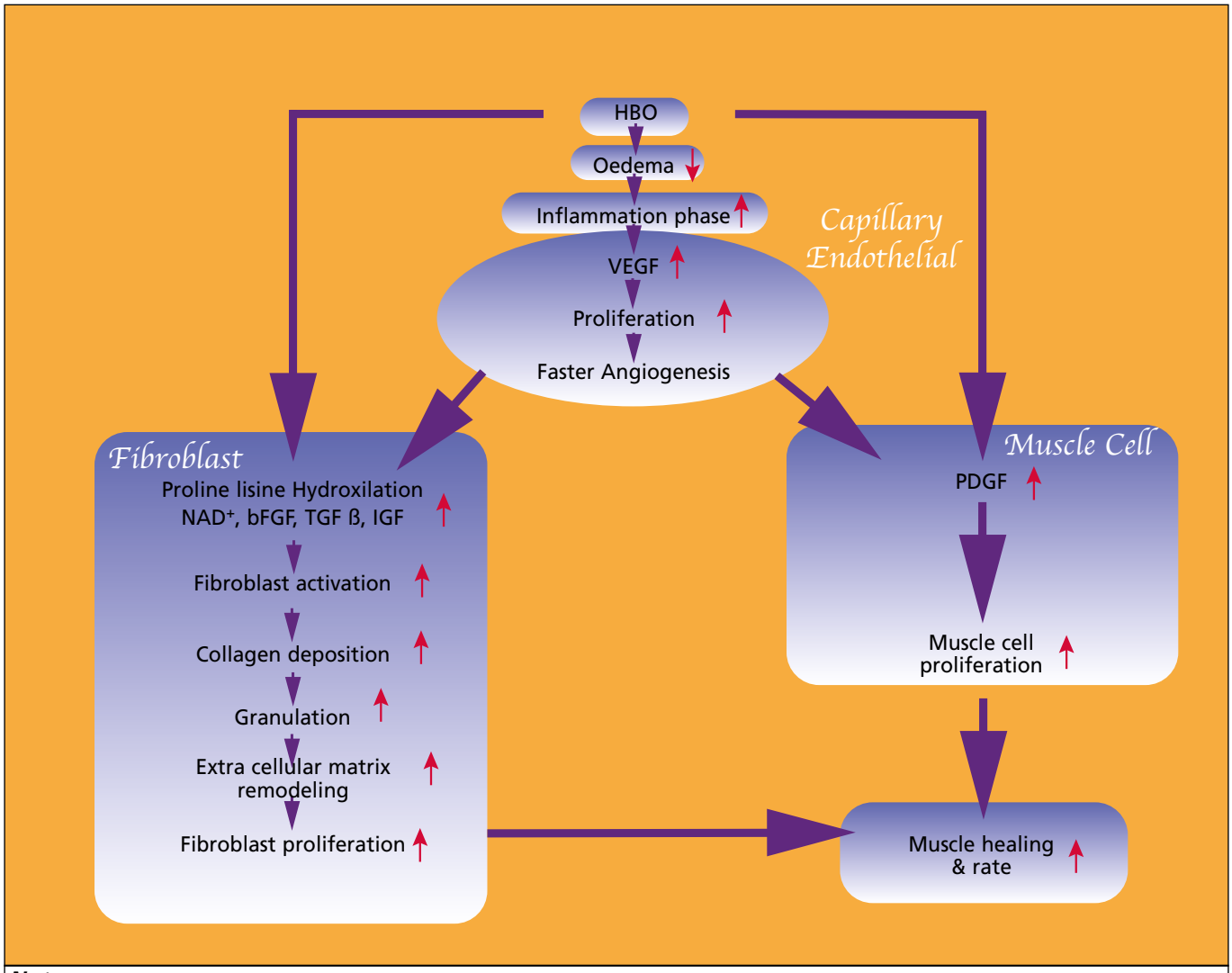
Graphe 1.



Note:

When HBO was given in the early phase of the muscle injury, it will cause the decrease of Nitrous Oxide (NO) production and vasoconstriction will occur in the inflammation phase. In this condition, oedema will be decreased since the phase of inflammation is shorter than usual and as the result the angiogenesis in the injury area starts earlier.

The acceleration of angiogenesis will increase the phase of muscles proliferation and also the forming of collagen by fibroblasts, since the supply of basic proliferation materials such as proteoglican, elastin and some other more growth factors, is sufficient. HBO also increases the differentiation of mesenchymal cells and the proliferation of muscle tissue or fibroblasts. Some growth factors from platelets in the form of PDGF, active in the muscle cells, proliferation pathways are produced.

Meanwhile, HBO will increase hydroxylation of proline and lysine, NAD + (Nicotinamide adenin dinucleotide) and also some growth factors such as bFGF (basic fibroblast growth factor), TGF (Transforming growth factor) ß, and IGF (Insulin growth factor) which will directly stimulate the fibroblasts' activities in forming an extracellular matrix of the wounds, and more and faster granulation tissues as a consequence. In parallel with the collagen matrix production by fibroblasts, in hyperbaric condition, production of metalloproteinase, may result in faster remodeling of extra cellular matrix. In this condition, extra cellular matrix is expected to be replaced by muscle tissue proliferation with a faster and better quality recovery of muscles.

In this study a number of the sample was taken in account: 12 for each group to anticipate the death of animals during research time.

Research Variable

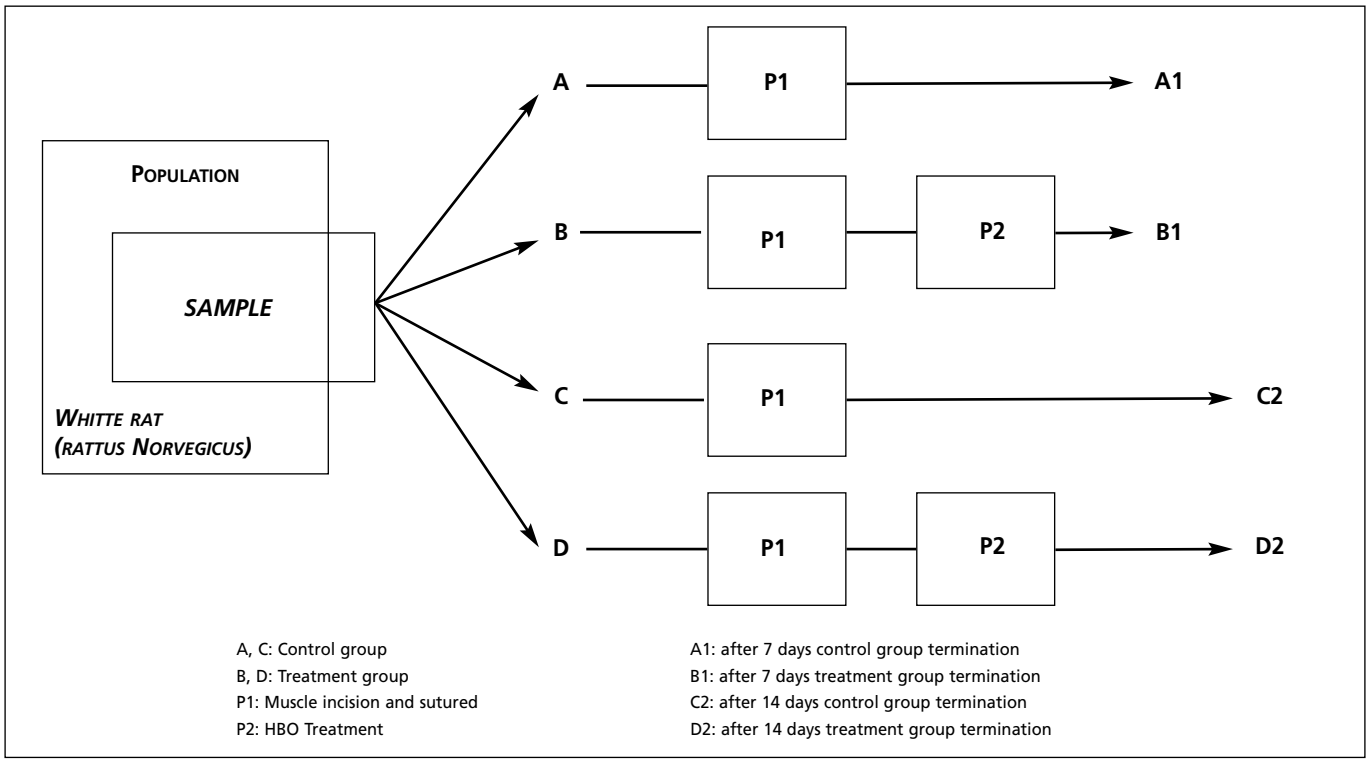
- **Independent Variable**: Hyperbaric Oxygen treatment (P2)
- **Dependent Variables**:
  - Granulation Tissue Ratio
  - Fibroblast Proliferation Thickness
- **Control Variables:**
  1. Type of Experimental animal
  2. Experimental animal sex
  3. Physical Health of experimental animal
  4. Treatment time
  5. Experimental animal age
- **Moderator Variable:** Experimental animal weight

Operational Variable definition:

a. Hyperbaric Oxygen (P2)

Hyperbaric Oxygen is the administration of oxygen in a pressurized air chamber 2.4 ATA (Atmosphere Absolute). In this experiment for Group B during 7 days

Graphe 2.



and for Group D for 14 days based on Guritno modification Kindwall Table, given by way of air pressurized of 2.4 ATA for 10 minutes breathing normal air, then 90 minutes of breathing 100% oxygen. The administration was divided into 3 phases each for 30 minutes with 5 minutes breathing interspersed with normal air.

b. Granulation Tissue Ratio

Granulation Tissue ratio is comparation between the area of granulation tissue and the entire cross-sectional area of muscle tissue. Three sectional slices have been taken within 0.5mm of the wound.

c. Fibroblast Proliferation Thickness

Fibroblast proliferation thickness is the average cross-sectional thickness of muscle tissue undergoing fibroblast proliferation as measured microscopycally with graticule. Two slices were taken within 0.5mm of the widest place and examined with a magnification of 100 times.

Place and time of study

Place

Experimental animals were kept in the same shape cages and placed around Hyperbaric Chamber in The Naval Medical Institution, Surabaya Indonesia, given 15-20 grams of feed pellets and drink everyday.

Time

Research time needed until the completion of the reporting of the results is 6 months.

Data Analysis

Research data were tabulated and analyzed by:

1. Descriptive test
2. Distribution normality test
3. Homogeneity test preliminary data on the weight variable
4. Anakova test to prove the difference in the control and treatment group and to test the effect of moderator variables

EXPERIMENT RESULTS AND DISCUSSION

Until this research was done, none of the samples were dropped out or died. So, the samples in this research fulfilled the criteria of minimal samples. From the result of weight homogeneity test, it has been found out that the samples were from the same population ($p > 0.05$). The result of normality distribution test, all the dependent variable and moderator were normally distributed with $p > 0.05$ (Table 1, Table 2, Table 3, Figure 1).

From the point of observation of granulation tissue ratio in muscle tissue healing, a significant difference was found between groups with hyperbaric Oxygen therapy compared to the groups without hyperbaric Oxygen therapy; ($p > 0.05$) (Table 4, Figure 2).

In the variable of fibroblast proliferation thickness, a significant difference between the groups with Oxygen Hyperbaric therapy and the groups without Oxygen hyperbaric therapy, ($p > 0.05$) was found. This observation was consistent with a theory which is stated that Oxygen hyperbaric therapy can promote the fibroblast proliferation in flexor tendons and other soft tissues[9].

Fibroblast Proliferation in this process, clearly will increase the rate of wound healing. Nevertheless, it can't be concluded directly that it always give better quality of wound healing. Since the maturation phase of muscle healing process usually take seven days until one year. And it is a dynamic and a continue process. So, an intense and continuous observation is needed until it has changed into a permanent healing in good quality and quantity.

Table 1: Basic data weight (grams) and granulation tissue ratio (%) on the termination day 7.

Group	Weight	Granulation tissue ratio			
		C1	C2	C3	Mean
(A) NO HYPERBARIC	205	20	20	17	19
	206	35	37	40	37,3
	199	11	12	11	11,3
	197	26	21	23	23,3
	207	41	47	51	46,3
	205	19	23	27	23
	200	32	36	28	32
	200	11	17	19	15,6
	204	33	35	29	32,3
	205	09	07	07	7,6
	198	18	16	21	18,3
	206	27	33	25	28,3
(B) HYPERBARIC	201	28	32	31	30,3
	208	24	30	27	27
	207	59	62	64	61,6
	204	47	58	51	52
	199	27	28	31	28,6
	203	20	21	23	21,3
	205	46	41	38	41,6
	206	50	56	53	53
	201	89	92	91	90,6
	204	23	21	20	21,3
	199	41	33	33	35,6
	200	59	49	51	53

Table 2: Basic data Weight (grams) and Fibroblast Proliferation Thickness (micron) on the termination day 14.

Group	Weight	Fibroblast Proliferation Thickness (micron)			
		C1	C2	C3	Mean
(C) NO HYPERBARIC	200	23	24	24	23,6
	203	34	26	29	29,6
	199	09	06	07	7,3
	198	27	34	36	32,3
	201	52	39	43	44,6
	205	17	13	19	16,3
	200	11	12	09	10,6
	200	13	10	16	13
	203	09	07	10	8,6
	200	37	33	33	34,3
	198	23	21	25	23
	200	25	32	23	26,6

Table 2: Basic data Weight (grams) and Fibroblast Proliferation Thickness (micron) on the termination day 14 (continuation).

(D) HYPERBARIC	204	85	82	80	82,3
	205	84	64	67	71,6
	207	100	97	89	95,3
	204	73	66	68	69
	198	53	47	44	48
	200	54	32	42	42,6
	203	63	58	57	59,3
	200	80	68	74	74
	201	112	105	100	105,6
	204	80	68	63	70,3
	199	77	75	68	73,3
	200	106	89	87	94

Note:
(C1,C2,C3): C = Results of Calculation by 3 different Pathologic Anatomy consultants to maintain the validity of the Interobservational results

Table 3: The results mean and standard deviation of the weight and granulation tissue of the groups A and B on the termination day 7.

GROUP	STATISTIC	BODY WEIGHT	GRANULATION
CONTROL (GROUP A)	MEAN	202,666	24,525
	STANDARD DEVIATION	3,576	11,208
TREATMENT (GROUP B)	MEAN	203,083	42,991
	STANDARD DEVIATION	3,088	20,261

Table 4: The results mean and standard deviation of the weight and fibroblast proliferation thickness of the groups C and D on the termination day 14.

GROUP	STATISTIC	BODY WEIGHT	FIBROBLAST PROLIFERATION
CONTROL (GROUP C)	MEAN	200,583	22,483
	STANDARD DEVIATION	2,108	11,626
TREATMENT (GROUP D)	MEAN	202,083	73,775
	STANDARD DEVIATION	2,778	18,692

Figure 1: Charts of the average granulation tissue ratio for each group on the termination day 7.

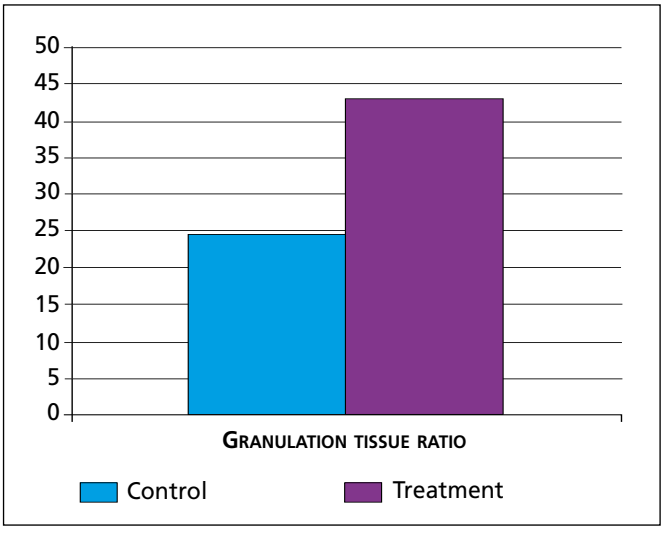
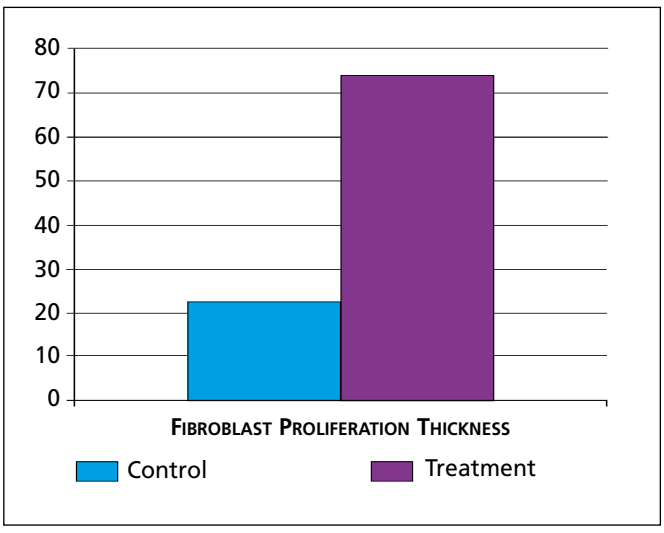
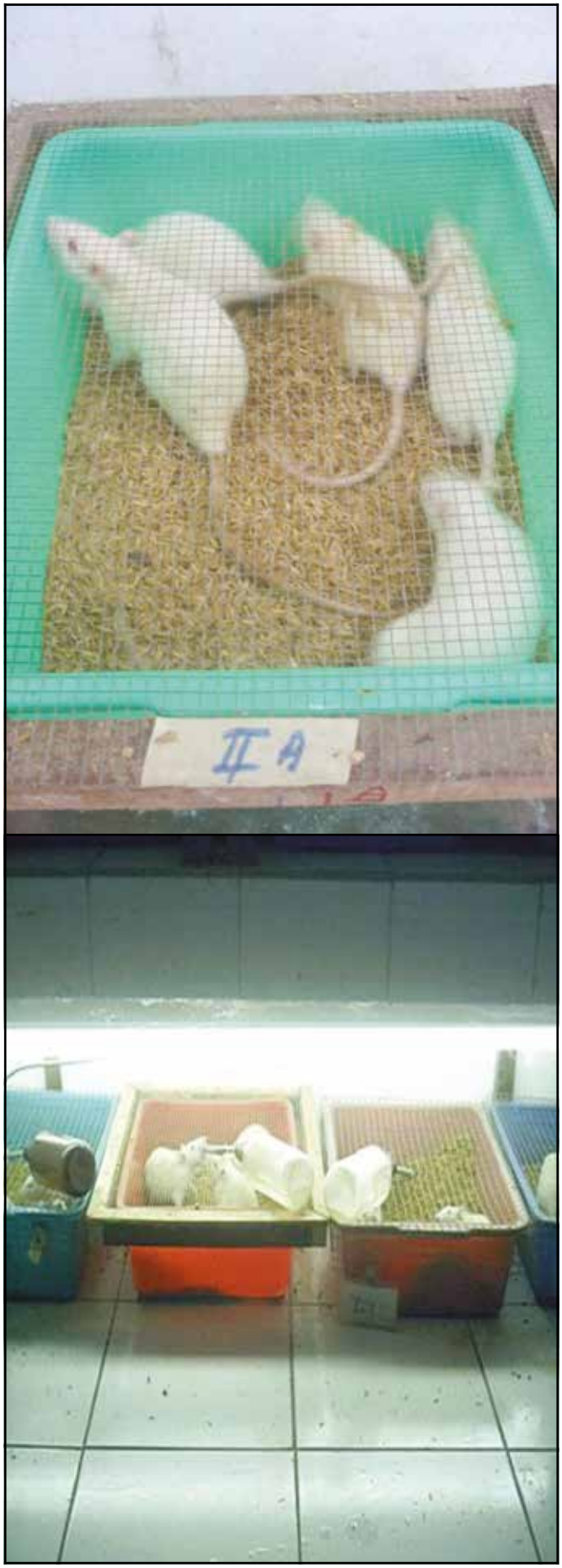


Figure 2: Charts the average for each group on fibroblast proliferation tissue on termination day 14.



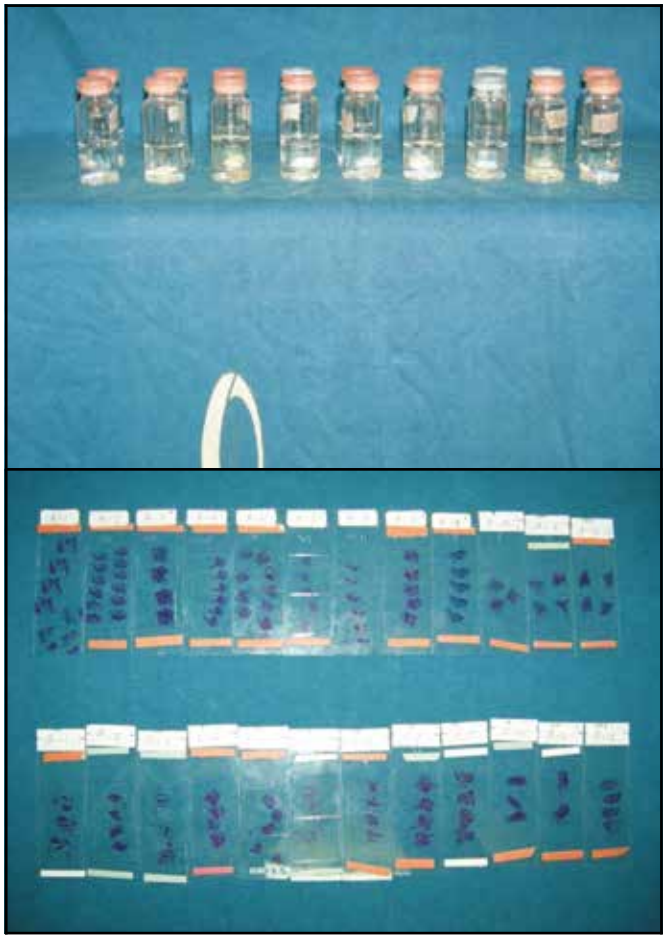
Figures 3, 4: Rats were placed in plastic cages measuring 30x40x15 cm each containing 5 rats and covered with woven wire and chaff repose.



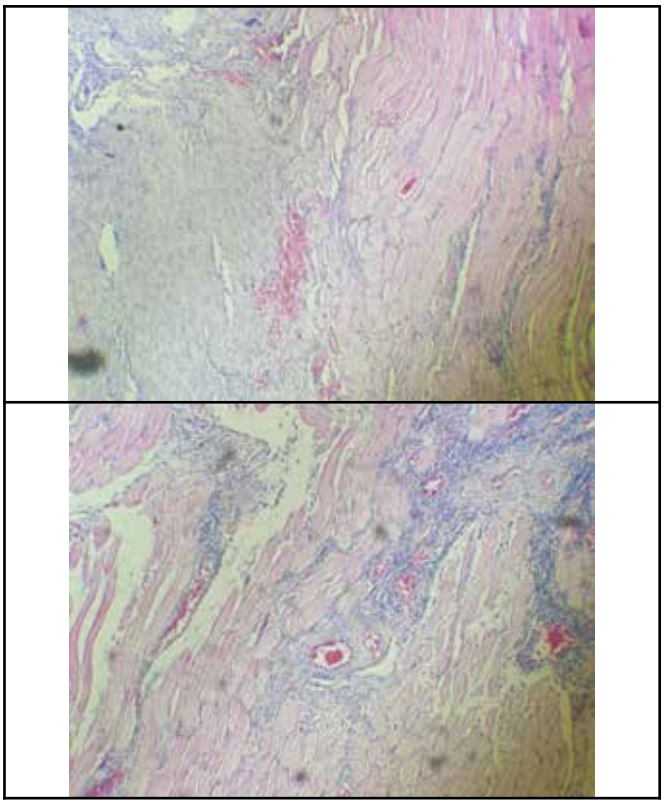
Figures 5, 6, 7: The process of cutting and suturing flexor muscles and fixed with plaster cast of Paris thereafter.

Figures 8, 9: Rats put in a glass box that furnished pure oxygen and was placed in a monoplace hyperbaric chamber.

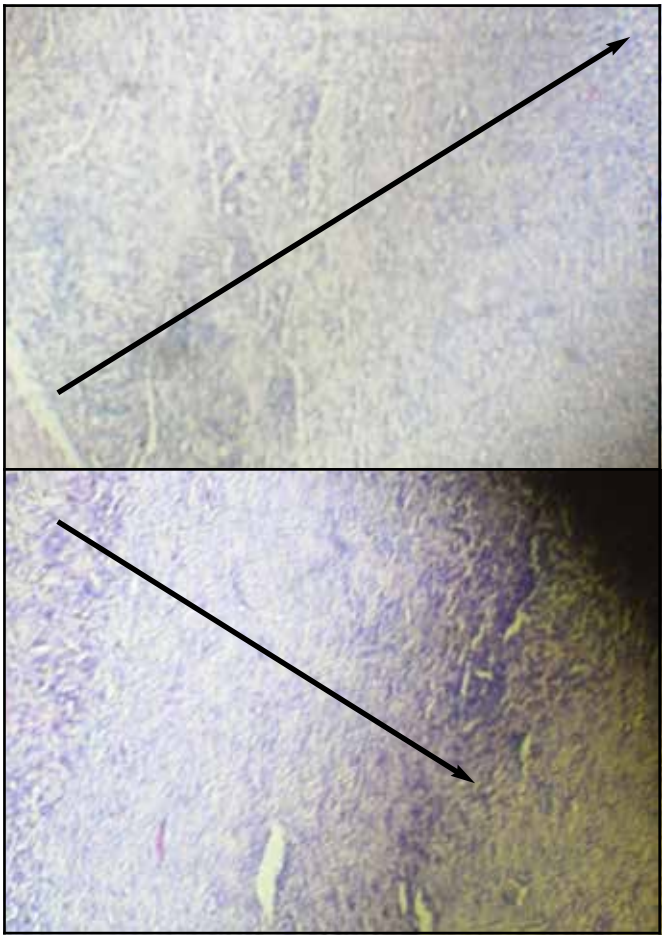
Figures 10, 11: Flexor muscle in 10% formalin fixation and rat muscle preparations that have been given special staining.



Figures 12, 13: Cross section photograph in the rat's muscle tissue on termination 7th day, the control group (above), the treatment group (below) with 100x magnification seemed marked presence of granulation tissue with blood vessels in fibrous tissue in both groups.



Figures 14, 15: Counting on termination 14th day: Photographs of fibroblast proliferation thickness with 100x magnification, treatment group (above), control group (below).



CONCLUSION

Oxygen hyperbaric promotes the forming of granulation cells and fibroblast proliferation in flexor muscle healing wounds in Rattus Norvegicus.

SUMMARY

Disability and deformity will occur when the healing of muscle injury is not optimal. Many adjuvant therapies were used to achieve an optimal healing process. Hyperbaric Oxygen (HBO) was one of the alternative therapies to improve muscle healing but until now remained debated.

This Experimental Study was performed to know the effect of HBO in muscle healing with two indicators: the Granulation ratio and the Fibroblast proliferation thickness.

Forty-eight *Rattus norvergicus* underwent "clean cut" injury and suture on the flexor muscle of right lower leg. The forty-eight rats were then divided in four groups. The first and third Group were control groups which did not receive any HBO therapy. The second group received HBO for a week and the fourth group for two weeks. Every group then underwent histopathological analysis for the Granulation ratio and the Fibroblast proliferation thickness in the healing muscle area.

The Granulation ratio was 24,525 ± 11,208 for the 1st group and 42,991 ± 20.261 for the 2nd group and the fibroblast proliferation thickness was 22,483 ± 11.626 for the 3rd group and 73.775 ± 18.692 for the 4th group. The 2nd group had a significantly higher granulation ratio than the 1st one and the fibroblast proliferation thickness in 4th group was significantly higher than in the 3rd group. This experimental study shows that HBO can promote granulation tissue and the fibroblast proliferation thickness in muscle healing.

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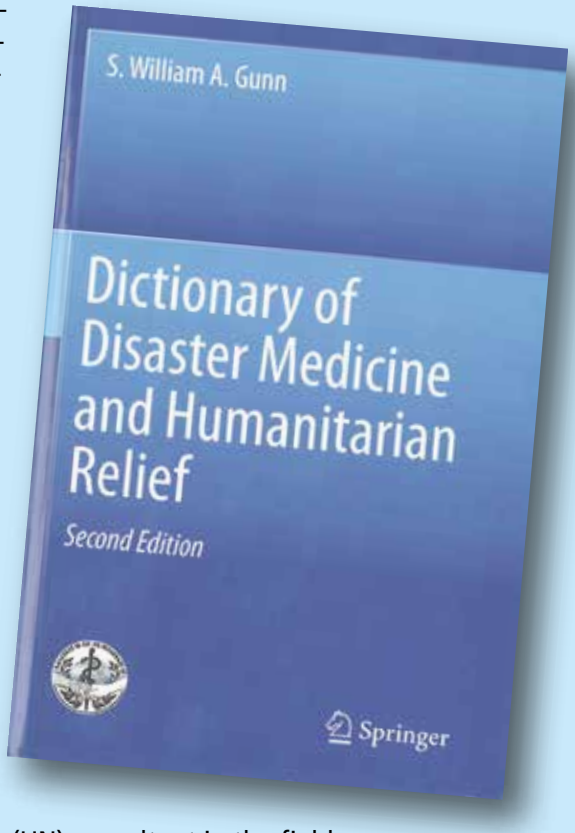
Dictionary of Disaster Medicine and Humanitarian Relief

(Second Edition)

S. William A. Gunn

Springer Science + Business Media New York, Heidelberg, Dordrecht, London; 2013, 208 pp.
ISBN 978-1-4614-4444-2; ISBN 978-1-4614-4445-9 (eBook)



Mass disasters, whether caused by natural, industrial or man-made events, require rapid mitigation of the resultant consequences, for which equally rapid, simple and proper communication is an essential prerequisite for multidisciplinary rescue teams from various fields. Such communication is the only means by which lives can be saved and further damages prevented. In today's globalized world, wherein international cooperation in cases of mass disaster has become quite typical and necessary, the issue of intercommunication and understanding among teams has become all the more urgent.

Dr. Gunn's *Dictionary of Disaster Medicine and Humanitarian Relief* is an invaluable tool for all those involved in mitigating the effects of mass disasters, including rescue workers, paramedics, law enforcement, technicians, engineers and meteorologists, as well as organizers of national and international authorities, politicians and functionaries of governmental and non-governmental organizations. This is the second, revised and expanded edition of this dictionary, originally published by the same author in 1990[1]; it has also been translated into French, Japanese and German languages. The author is highly regarded as one of the most competent, renowned experts in the field of disaster medicine, having served as longtime Director of the World Health Organization's (WHO) Emergency Humanitarian Operations; a United Nations (UN) consultant in the field of disaster medicine; former President of the World Association for Disaster and Emergency Medicine (WADEM); and former President of the International Federation of Surgical Colleges (IFSC).

In the 1990s, Dr. Gunn was associated with (the there) League of Red Cross and Red Crescent Societies, and he currently serves as President of the International Association for Humanitarian Medicine (IAHM). In addition to his contributions to medical science, organizational work and international engagements, the author dedicated a considerable amount time to defining and compiling lexical terminology for disaster medicine, which stemmed from his tremendous amount of experience and understanding of the field. These efforts during his tenure with the WHO resulted in a lexicon for use in the creation of documents, tools, and dictionaries such as this, which not only facilitate communication among domestic or international teams on the ground, but also among those participating in consultations and planning at organizational centers. Until publication of this new edition, the first edition of this dictionary had been the definitive work for this particular field.

It is certainly worthwhile to peruse the beautifully written preface by Dr. Halfdan Mahler, a former director of the WHO in Geneva, Switzerland. The dictionary is divided into two parts. Part one comprises a custom dictionary with alphabetically sorted entries, which are followed by a definition and simultaneous cross references pertaining to similar, or semantically, related complementary information with entries and synonyms. For example, among its vast coverage it contains an extensive array of definitions concerning military medicine, law of war, nuclear conflict terms war gases, civil defense genocide, torture, etc. Twenty-five years ago the Revue[2] had already welcomed the initial Dictionary, and the present enlarged edition deals even more extensively with Red Cross related terminology.

Part two contains a rich representation of the most frequently used acronyms and abbreviations used in the field of disaster medicine and humanitarian relief. Overall, this new edition contains more than 3,000 entries with up-to-date supplementation of terms related to climate change and bioterrorism. It is highly readable, well-organized, and easy to understand, which facilitates quick orientation to pertinent issues. Every employee involved in disciplines dealing with natural or industrial mass disasters, whether in domestic or international environments, should have this invaluable tool close at hand. It can also serve as an excellent teaching tool and it is, therefore, not surprising that it has been recommended as the official teaching aid in numerous courses organized by the UN. Numerous authorities and institutions dealing with (for example) issues related to refugees, migration or terrorism could benefit from having this tool available when dealing with current global challenges.

The book and its author have also received international awards: In 2014, Dr. Gunn received the A. Meneghetti Award for his life-long contributions to science and humanism[3]. *The Dictionary of Disaster Medicine and Humanitarian Relief* is heartily recommended; not only for use among employees of integrated rescue systems, but also other professionals from various disciplines worldwide.

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WORLD CBRN & MEDICAL CONGRESS
19 – 21 OCTOBER 2016
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WORLD CBRN AND MEDICAL CONGRESS

PRAGUE, CZECH REPUBLIC

19-21 OCTOBER, 2016

Health consequences of using weapons of mass destruction have usually an impact both on individuals and teams. It is not only about the armed forces, but also civilians. Hence, the importance of active prevention and protection intensifies due to the possibility of its abuse, especially in the field of international terrorism. Last year we also had to face the problem of a highly contagious disease Ebola and thus solve its spreading and endangering people on several continents. All such situations are forcing us to look into possible countermeasures in the field of antidotes, modern pharmaceuticals, or improve the first aid methods on the battlefield.

The aim of the World CBRN & Medical Congress is to contribute prevention against State and non-State actors by taking part in development and the harmonizing of protection & defence capabilities.

This congress will also foster the development of specific capabilities to support impeding the trafficking of WMD, related materials and means of delivery and will support the CBRN Defence interdependence with other sectors such as logistics, healthcare, ... and especially necessity to apply civil - military cooperation.

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7ème Cours International du CIMM
pour le Soutien Sanitaire en Milieu Saharien
Tozeur (Sud de la Tunisie)
7-11 novembre 2016

Chers confrères et amis,

J'ai l'honneur et le plaisir de vous annoncer que la Direction Générale de la Santé Militaire de Tunisie organise, sous l'égide du CIMM, le 7ème Cours International sur le Soutien Sanitaire en Milieu Saharien et ce du 7 au 11 novembre 2016 à Tozeur.

Le milieu désertique est un environnement hostile à l'homme et au médecin qui y exerce sa profession. Il est connu pour ses conditions climatiques extrêmes, son terrain particulier, sa faune et sa flore spécifiques. Des difficultés sont souvent rencontrées lors de la gestion de l'eau et la prise en charge de ses multiples pathologies.

Ce cours, fortement sollicité par la communauté scientifique nationale et internationale, est devenu un véritable enseignement spécialisé de la pathologie saharienne. Il est enrichissant pour les participants qui viennent approfondir leurs connaissances et échanger leurs expériences dans le domaine du soutien sanitaire en conditions extrêmes. Pour permettre aux participants une meilleure immersion dans le milieu saharien, des ateliers pratiques sur la survie en milieu saharien sont prévus.

Cet événement gagne également en intérêt, suite aux nombreuses crises humanitaires constatées ces dernières années dans les régions sahariennes. Ces crises ont engendré un afflux de réfugiés, nécessitant le déploiement et l'assistance des services de santé des armées.

Ce cours rassemblera d'éminents conférenciers nationaux et internationaux relevant d'institutions partenaires civiles et militaires. Il s'agit également d'une occasion plaisante pour découvrir les merveilleux sites naturels du sud tunisien.

Nous vous invitons à participer nombreux à ce cours et nous serons très heureux de vous accueillir à Tozeur, aux portes du désert tunisien.

Médecin Général de Brigade Mondher YEDEAS
Directeur Général de la Santé Militaire Tunisienne

Le comité d'organisation du cours a choisi cette année de continuer à faire évoluer le contenu scientifique du cours et à consacrer davantage d'espace et de temps aux activités pratiques et de terrain. Le programme scientifique comporte deux volets :

I. Une formation théorique comprenant des modules spécialisés
- Un module lié à la gestion de l'eau en milieu désertique et à certaines pathologies émergentes ou liées à l'environnement tel que les maladies à transmission hydrique ou à transmission vectorielle ainsi que les pathologies pulmonaires dues au milieu désertique.
- Un module lié à l'acclimatation et à l'adaptation à la chaleur.
- Un module sera consacré aux envenimations scorpioniques et ophidiennes.

II. Une formation pratique sur terrain incluant
- Le soutien sanitaire en opération dans un environnement saharien, avec programmation d'activités d'instruction opérationnelle.
- Un atelier permettra aux participants une meilleure immersion dans le milieu saharien, et intégrera des gestes pratiques sur la survie en milieu saharien.

Les conférences seront présentées en langue française ou anglaise avec une traduction simultanée.

Plus d'information sur : www.cimm-icmm.org

Traumatismes de guerre chez les militaires lors du conflit du nord du Mali.

Par S. KEITA[1], M.S. CISSE[2], A. TRAORE[3], M DIOP, H. SAMAKE[4], F. KEITA[5], B. DOUMBIA[6], C. FAU[2] G. DIALLO[3] et D. SANGARE[1]. Mali

Soumaïla KEITA

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- 2006 : Diplôme d'études spéciales en chirurgie générale à la FMOS de Bamako;
- 2007 : Attestation de formation spécialisée en cœliochirurgie à la FMOS de Bamako;
- 2011 : Attestation de formation spécialisée en chirurgie cancérologique à la faculté de médecine Jacques LISFRAN de Saint Etienne (France);
- 2013 : Inscription au Diplôme d'études spéciales en médecine légale l'université Cheick Anta DIOP de Dakar.

SUMMARY

Military Injuries During the Northern Malian Conflict.

The war in northern Mali started in 2012 and required the mobilization of the international community for political and military management.
Objectives: *The aim of this study was to describe the epidemiological, clinical and therapeutic war trauma in the military during the conflict in northern Mali.*
Methodology: *This was a retrospective descriptive study, from January 09, 2013 to May 12, 2015 focused on the records of 112 soldiers treated for war trauma. All medically supported military war trauma victims during the period were included.*
Results: *Head Trauma, neck and limb trauma each accounted for 28.6%. Blunt trauma were found in 68% of the injured. Accidents of military vehicles caused 42.8% of these injuries. The surgery was performed in 51 patients (45.5%). Two patients died postoperatively.*
Conclusion: *The management of war injuries during the conflict in northern Mali allowed to identify the limits of the casualties support system. Efforts are still needed to acquire a Military Teaching Hospital and medicalized aircrafts for evacuations.*

Mots-clés: Traumatismes, Guerre, Chirurgie, Mali.
Keywords: *Trauma, War, Surgery, Mali.*

INTRODUCTION

Le nord du Mali a connu depuis la période des Grands Empires (particulièrement le Songhay avec Sonni Ali Ber) plusieurs rébellions touarègues dont la nature et les objectifs variaient en fonction des contextes politiques. Parmi les cinq révoltes recensées de 1916 à 2012, celle de 2012 se caractérise par les velléités sécessionnistes du mouvement national de libération de l'Azaouad (MNLA) renforcé par des groupuscules islamistes et narcotraficants (MUJAO, Ansar Eddine, AQMI)[1]. Un certain nombre de facteurs ont contribué à la résurgence de cette dernière rébellion touarègue :
- la dégradation des conditions socio-économiques et environnementales;
- l'émergence des groupes djihadistes et narcotrafiquants;
- le Sahara, plus vaste désert du monde, considéré

comme un itinéraire incontournable du narcotrafic;
- le laxisme dans l'administration des territoires concernés;
- les conséquences de la guerre civile de Libye qui voit l'arrivée massive de combattants lourdement armés.

Le conflit asymétrique qui a commencé en janvier 2012 se caractérise par l'utilisation d'armes de guerre et de techniques de combat non conventionnelles[2]. Il a nécessité dans un premier temps, une mobilisation importante des forces armées et de défense du Mali pour arrêter l'offensive et dans un second temps, l'appui de la communauté internationale tant sur le plan militaire que politique.

Les combats qui ont opposé l'armée malienne aux différents groupes armés ci-dessus cités se particularisent par leur atrocité entraînant du coup des blessures accompagnées de traumatismes variés.

C'est dans ce contexte que des antennes médico-chirurgicales furent déployées afin d'assurer la prise en charge rapide des malades et blessés de guerre en portant l'accent sur la médicalisation de l'avant. Les objectifs visés étaient de:
- diminuer le taux de mortalité liée aux traumatismes de guerre;
- prévenir la survenue d'infirmités;
- raccourcir les délais d'incapacité opérationnelle.

Au combat, 20 à 30 % des décès dus à des lésions potentiellement curables sont évitables, ces lésions sont à 80 % constituées d'hémorragies au tronc et aux membres[3]. Leur prise en charge nécessite l'intervention d'un chirurgien expérimenté en traumatologie viscérale, thoracique et vasculaire.

Le but de cette étude était de décrire les aspects épidémiologiques, cliniques et thérapeutiques des traumatismes de guerre chez les militaires lors du conflit du nord du mali.

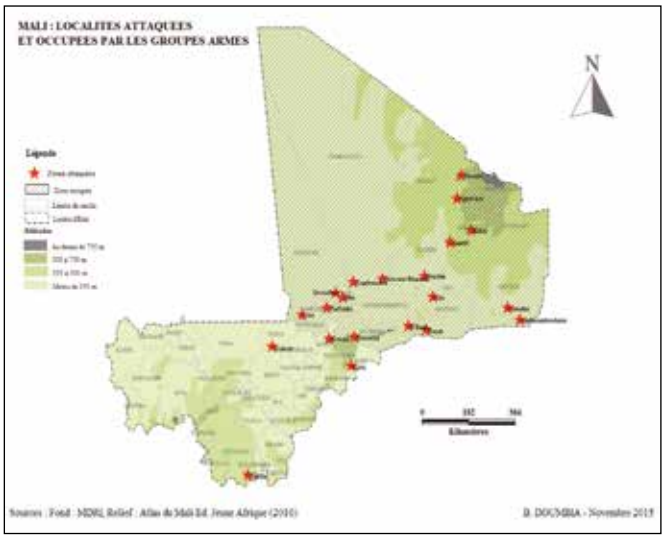
METHODOLOGIE

Le nord du Mali

Le nord du Mali couvre les trois régions de Tombouctou, Gao et Kidal (carte n° 1). Il couvre une superficie estimée à 826000 km² soit 66,5 % du territoire national. En y ajoutant le nord de la région de Mopti, les zones occupées par les groupes armés couvrent 858000 km² soit 69,1 % de la superficie du Mali. L'immensité des espaces et les conditions naturelles difficiles constituent des contraintes majeures pour les forces armées Maliennes qui doivent contenir des ennemis ayant une parfaite maîtrise du terroir convoité.

Le relief est dominé par les bas-plateaux de l'Adrar des Ifoghas (qui culmine à 890 m) recouverts par de nombreux ergs. Le climat sahélo-saharien, qui se caractérise par la brièveté de la saison des pluies (3 mois au maximum) et la faiblesse de pluviométrie (500 mm de pluies par an au maximum), est un facteur limitant des productions agricoles et surtout du développement de l'élevage qui constitue la principale activité économique de cette zone.

Carte n° 1 : Localisation des zones attaquées et occupées par les groupes armés au Mali.



Ces conditions naturelles sont aussi très déterminantes dans le peuplement de ce territoire qui abrite seulement 1284836 habitants soit 8,8 % des 14528662 maliens recensés en 2009 (INSTAT, 2009). Les densités y sont très faibles, 1,5 hab./km² en moyenne largement inférieures à la moyenne nationale (11,7 hab./km²).

C'est dans cette zone « hostile » à la présence humaine que se sont déroulés les nombreux combats (carte n° 1) ayant opposé les forces armées maliennes aux groupes armés du Nord aux. La dureté des combats a entraîné de nombreuses pertes en vies humaines mais aussi de nombreuses blessures particulièrement dans les rangs de l'armée.

Les attaques perpétrées par les groupes armés concernent essentiellement la partie Nord du pays. Cependant il faut

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noter quelques attaques au centre et au sud du pays qui ont aussi fait des victimes militaires. Celles-ci ont contribué à attirer l'attention des autorités politiques et militaires sur la situation sécuritaire du pays. Ainsi, les militaires ont été mis en alerte pour éviter une expansion des groupes terroristes (d'obédience islamiste) sur le territoire national et en même temps diminuer les coûts d'intervention particulièrement en matière de prise en charge des traumatismes.

Les équipes et la prise en charge

Chaque antenne chirurgicale était composée de chirurgiens généralistes, d'infirmiers anesthésistes, d'instrumentistes, de panseurs (brancardiers) et de chauffeurs d'ambulance.

La logistique était assurée par la Direction Centrale des Services de Santé des Armées (DCSSA) à partir de Bamako en coordination avec le PCG et les directeurs régionaux de santé militaire. La relève des équipes était en théorie pour tous les 6 mois.

La coordination des antennes chirurgicales, pré-positionnées à Kidal, Ménaka et Tombouctou, se faisait au niveau du poste de commandement de Gao (PCG). En l'absence d'hôpital militaire de campagne, les blessés étaient pris en charge au niveau des hôpitaux civils des régions militaires de Tombouctou, Kidal et de Gao et au centre de santé de référence de Ménaka.

Les évacuations sanitaires utilisaient essentiellement les moyens terrestres et dans quelques rares cas des avions de la Mission Intégrée des Nations Unis pour la Stabilisation du Mali (MINUSMA) et de l'Opération Serval devenue Barkhane. Des agents médicaux assistaient les blessés et malades lors des évacuations.

Type de l'étude

Il s'agit d'une étude rétrospective et descriptive sur une période allant du 9 janvier 2013 au 12 mai 2015. Elle a porté sur les dossiers de 112 militaires prises en charge pour traumatismes de guerre.

Critères d'inclusion

Tous les militaires victimes de traumatisme de guerre et pris en charge pendant la période, ont été inclus.

Les cas de pathologies médicales, les pathologies chirurgicales non traumatiques, les traumatismes de guerre chez les civils et les décès immédiats sur le front n'ont pas été retenus.

RESULTATS

Un total de 112 dossiers de militaires pris en charge au niveau rôle 3 pour traumatisme de guerre a été colligé. Les blessés provenaient de Gao dans 51,8 % des cas (Figure 1). Les militaires de rang ont constitué 69,6 %. La proportion d'officiers dans l'étude était de 5,4 %. La tranche d'âge de 20 à 30 ans a représenté 70,5 % des patients. L'armée de terre a enregistré le plus de blessés soit 51,7 % suivi de la garde nationale avec 30,3 %.

La voie terrestre a été utilisée dans 89 % des cas pour l'évacuation des blessés contre 11 % de transport aérien. Les traumatisés ont été pris en charge dans les structures jouant le niveau rôle 3 de l'Organisation du Traité de l'Atlantique Nord (Figure 2).

Les lésions retrouvées ont été majoritairement les traumatismes de la tête et du cou dans 28,6 %, les traumatismes des membres dans 28,6 % et ceux du rachis dans 25 %. Les traumatismes fermés ont été retrouvés dans 68 % des cas.

Les traumatismes de la tête et du cou et ceux du rachis ont représenté 27,8 % chacun dans la tranche d'âge de 20-30 ans. Les traumatismes multifocaux ont représenté 10,7 % de l'échantillon (n=12) parmi lesquels 23,5 % (n=5) appartenaient à la tranche d'âge de 31-40 ans (Tableau 1).

Figure 1 : Provenance des blessés.

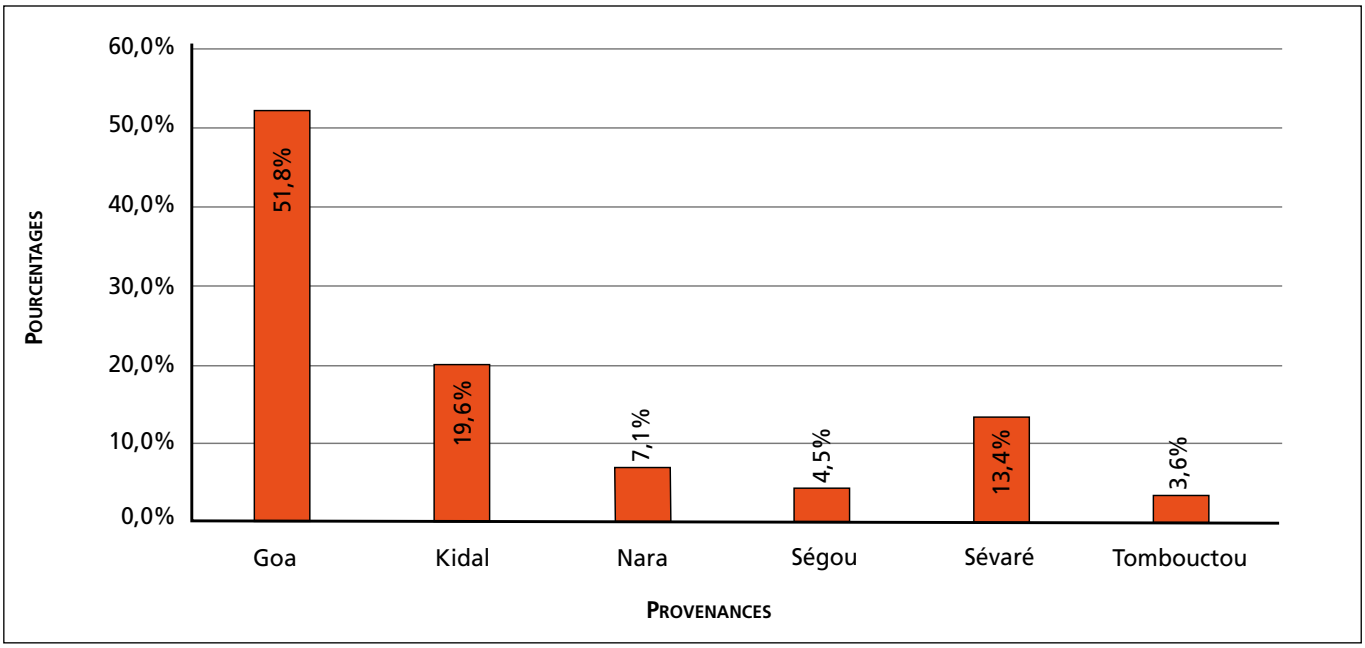

Figure 2 : Structures de prise en charge de rôle 3.

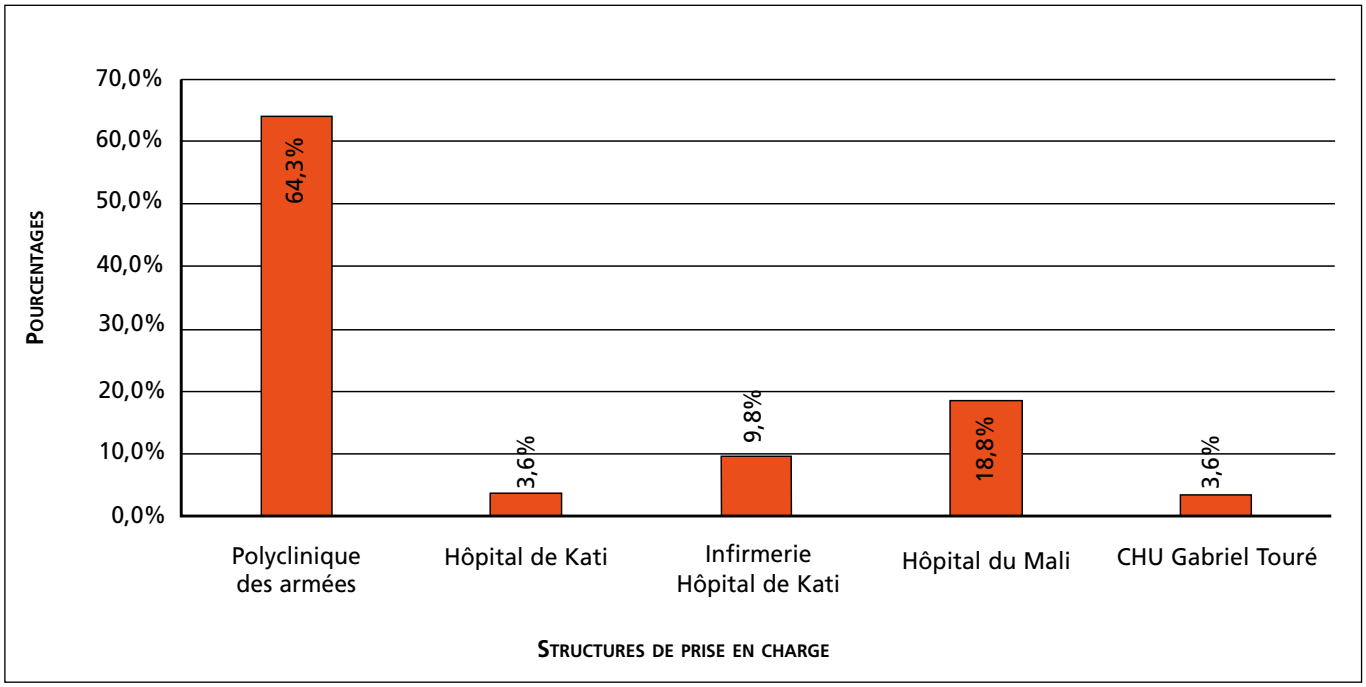

Tableau 1 : Traumatismes et tranches d'âge.

Types de traumatisme	Tranches d'âges										Total général	
	20 à 30 ans		31 à 40 ans		41 à 50 ans		50 ans et plus		ND			
	Eff.	%	Eff.	%	Eff.	%	Eff.	%	Eff.	%	Eff.	%
Tr. tête et cou	22	27,8 %	3	17,6 %	1	14,3 %	1	100 %	5	62,5%	**32**	**28,6%**
Tr. de l'abdomen	0	0,0 %	2	11,8 %	0	0,0 %	0	0,0 %	0	0,0 %	**2**	**1,8 %**
Tr. membres inférieurs	14	17,7 %	3	17,6 %	1	14,3 %	0	0,0 %	1	12,5 %	**19**	**17,0 %**
Tr. membres supérieurs	10	12,7 %	1	5,9 %	2	28,6 %	0	0,0 %	0	0,0 %	**13**	**11,6 %**
Traumatisme du rachis	22	27,8 %	4	23,5 %	2	28,6 %	0	0,0 %	0	0,0 %	**28**	**25,0 %**
Traumatisme du thorax	6	7,6 %	0	0,0 %	0	0,0 %	0	0,0 %	0	0,0 %	**6**	**5,4 %**
Traumatisme multifocal	5	6,3 %	4	23,5 %	1	14,3 %	0	0,0 %	2	25,0 %	**12**	**10,7 %**
Total général	**79**	**100 %**	**17**	**100 %**	**7**	**100 %**	**1**	**100 %**	**8**	**100 %**	**112**	**100 %**

Les étiologies de ces traumatismes ont été les accidents de véhicules militaires dans 42,8 %, les mines dans 31,3 %, les balles dans 12,5 % et 5,4 % étaient liées à des automutilations et aux coups et blessures entre combattants (n=6).

La proportion de patients ayant séjourné moins de 30 jours dans les structures de rôle 3 a été de 38,4 % contre 12,5 % de ceux ayant été hospitalisé pendant plus de 120 jours. Le séjour hospitalier était variable selon la nature des traumatismes (Tableau II).

La chirurgie a été pratiquée chez 51 patients soit 45,5 % parmi lesquels 51 % de chirurgie en ortho-traumatologie (n=26/51), 29,4% d'interventions neurochirurgicales (n=15/51) et 15,7 % de chirurgie multidisciplinaire (n=8/51). Parmi les patients pris en charge en chirurgie orthopédique et traumatologique, 18 ont bénéficié d'une ostéosynthèse et 04 ont été amputés.

Les suites opératoires ont été simples dans 97,3 % des cas. La guérison avec séquelles a été obtenue dans 25,92 % des cas. Deux malades sont décédés en post opératoire dont un en neurochirurgie et un pour défaillance multi viscérale. Deux malades ont été évacués en dehors du Mali pour la suite des soins (Tableau III).

COMMENTAIRES ET DISCUSSION

Au cours de l'étude 112 dossiers de blessés de guerre ont été retenus selon les critères d'inclusion. Ces chiffres sont une sous-évaluation du fait l'absence de registre de blessés de guerre. L'armée de terre a enregistré le plus de blessés soit 51,7 % et la garde nationale avec 30,3 %, il s'agit essentiellement des deux unités les plus engagées sur le terrain.

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Tableau II : Traumatismes et séjour hospitalier.

Types de traumatisme	Moins de 30 jours		De 30 à 59 jours		De 60 à 89 jours		De 90 à 119 jours		120 jours et plus		ND		Total général	
	Eff.	%	Eff.	%	Eff.	%	Eff.	%	Eff.	%	Eff.	%	Eff.	%
Tr. tête et du cou	9	20,9 %	4	40,0 %	3	33,3 %	1	33,3 %	4	28,6 %	11	33,3 %	32	28,6%
Tr. de l'abdomen	0	0,0 %	0	0,0 %	1	11,1 %	0	0,0 %	0	0,0 %	1	3,0 %	2	1,8 %
Tr. membres inférieurs	6	14,0 %	0	0,0 %	3	33,3 %	1	33,3 %	3	21,4 %	6	18,2 %	19	17,0 %
Tr. Membres sup.	5	11,6 %	0	0,0%	1	11,1 %	0	0,0 %	3	21,4%	4	12,1%	13	11,6%
Traumatisme du rachis	18	41,9 %	4	40,0 %	0	0,0 %	1	33,3 %	2	14,3 %	3	9,1 %	28	25,0 %
Traumatisme du thorax	4	9,3 %	0	0,0 %	1	11,1 %	0	0,0 %	0	0,0 %	1	3,0 %	6	5,4 %
Traumatisme multifocal	1	2,3 %	2	20,0 %	0	0,0 %	0	0,0 %	2	14,3 %	7	21,2 %	12	10,7 %
Total général	**43**	**100 %**	**10**	**100 %**	**9**	**100 %**	**3**	**100 %**	**14**	**100 %**	**33**	**100 %**	**112**	**100 %**

Tableau III : Traumatisme et devenir des patients.

Types de traumatisme	Devenir des patients						Total général	
	Guéri		Décédé		Evacué			
	Eff.	%	Eff.	%	Eff.	%	Eff.	%
Tr. tête et cou	31	28,7 %	1	50,0 %	0	0 %	32	28,6 %
Traumatisme de l'abdomen	2	1,9 %	0	0 %	0	0 %	2	1,8 %
Tr. des membres inférieurs	18	16,7 %	0	0 %	1	50,0 %	19	17,0 %
Tr. membres supérieurs	13	12,0 %	0	0 %	0	0 %	13	11,6 %
Traumatisme du rachis	27	25,0 %	0	0 %	1	50,0 %	28	25,0 %
Traumatisme du thorax	6	5,6 %	0	0 %	0	0 %	6	5,4 %
Traumatisme multifocal	11	10,2 %	1	50,0 %	0	0 %	12	10,7 %
Total général	**108**	**100,0 %**	**2**	**100,0 %**	**2**	**100,0 %**	**112**	**100,0 %**

La proportion élevée de blessés en provenance de la région de Gao s'explique par sa position stratégique (aéroport, PC et présence de l'hôpital de campagne de la force Serval).

La région de Tombouctou du fait de son enclavement et en l'absence de moyen aérien disponible a été la moins active dans les transferts de blessés.

Les militaires de rang ont représenté 69,6 % des traumatisés ceci du fait de leur nombre élevé dans le dispositif, leur présence au premier rang de la ligne de front mais aussi par leur manque d'expérience. La tranche d'âge de 20 à 30 ans est également en rapport avec le nombre des militaires de rang n'ayant pas 10 ans de service actif. R. Haus–Cheymola *et al.*[6] avaient retrouvé un âge moyen de 29 ans avec des extrêmes de 18 et 55 ans.

En l'absence d'hôpital d'instruction des armées, les blessés ont été répartis entre la polyclinique des armées (64,3 %) et les hôpitaux civils.

Un blessé de guerre est un traumatisé grave avec des lésions multiples. Ces blessures réalisent un tableau de poly traumatisme dont la prise en charge est poly disciplinaire et au cours de laquelle le facteur temps est essentiel.

La non-disponibilité des moyens aériens pour le transfert des blessés a conduit à l'usage de la voie terrestre dans des conditions de précarité compromettant ainsi le pronostic des patients.

Le mécanisme lésionnel dominant dans cette étude était les accidents de véhicules militaires dans 42,8 %, les mines dans 31,3 %. Ces accidents se traduisent par des renversements de véhicules favorisés par la morphologie du terrain caractérisée par un relief de sable formant des « dunes coupées » avec une pente abrupte, ou lors de projections en cas d'explosion de mine mais aussi suite à de mauvaises manœuvres dans un contexte de panique.

Il ressort de la littérature que les éclats sont les principaux agents vulnérants dans 78 à 80 % des conflits modernes.

Ils proviennent d'un engin explosif (bombe, obus, roquette, grenade, engin explosif improvisé). Le port de protection individuelle (casque et ou gilet pare-balles) n'a pas été évalué au cours de l'étude. Une prédominance des atteintes de la tête et du cou et de la face dans l'échantillon contrairement à la littérature ne sont pas le fait d'un manque de protection mais la conséquence de ces chutes. L'atteinte abdominale de 1,8 % dans notre série est inférieure aux 11 % de Owens BD *et all*[7] p=0,001.
La chirurgie a été pratiquée dans 45,5 % des cas parmi lesquels 51 % de chirurgie en ortho-traumatologie (n=26/51), 04 patients ont été amputés pour atteinte vasculaire et ou infectieuse. La durée moyenne d'hospitalisation a été de 120 jours et plus chez 14 patients.

L'incapacité partielle permanente a été déterminée chez 33 patients après consolidation définitive. La létalité a été de 1,8 %.

CONCLUSION

La gestion des blessés de guerre dans le cas du conflit du nord du Mali a permis de déterminer d'une part les limites du système et d'autre part un retour d'expérience dans ce domaine.

Des efforts restent à faire pour l'acquisition d'un hôpital d'instruction des armées et des aéronefs médicalisés pour les évacuations.

RESUME

La guerre dans la partie Nord du Mali débutée en 2012 a nécessité la mobilisation de la communauté internationale dans le cadre la gestion politique et militaire.

Objectifs : Le but de cette étude était de décrire les aspects épidémiologiques, cliniques et thérapeutiques des traumatismes de guerre chez les militaires lors du conflit du nord du Mali.

Méthodologie : Etude rétrospective et prospective descriptive, du 9 janvier 2013 au 12 mai 2015. Elle a porté sur les dossiers de 112 militaires prises en charge pour traumatismes de guerre.

Tous les militaires victimes de traumatisme de guerre et pris en charge pendant la période, ont été inclus.

Résultats : Les traumatismes de la tête et du cou et les traumatismes des membres ont représenté chacun 28,6%. Les traumatismes fermés ont été retrouvés dans 68% des cas. Les étiologies de ces traumatismes ont été les accidents de véhicules militaires dans 42,8%. La chirurgie a été pratiquée chez 51 patients soit 45,5%. Deux malades sont décédés en post opératoire.

Conclusion : La gestion des blessés de guerre dans le cas du conflit du nord du Mali a permis de déterminer les limites du système dans la prise en charge. Des efforts restent à faire pour l'acquisition d'un hôpital d'instruction des armées et des aéronefs médicalisés pour les évacuations.

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Observance of the Anti-Malaria Prophylaxis in the Spanish Armed Forces During ASPFOR XXXIII.*

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RESUME

Observance de la prophylaxie antipaludique dans les forces armées espagnoles au cours de la mission ASPOR XXXIII.

Le Paludisme est une maladie endémique en Afghanistan dans toutes les régions situées au-dessous de 2000 mètres d'altitude. Il reste une menace pour toutes les forces combattantes en dépit de la disponibilité de médicaments préventifs et de procédés permettant de se protéger des insectes. Notre évaluation montre qu'un effort est nécessaire pour obtenir une meilleure observance notamment de la chimioprophylaxie.

KEYWORDS: Malaria, Prophylaxis, Afghanistan.

MOTS-CLÉS : *Paludisme, Chimioprophylaxie, Afghanistan.*

INTRODUCTION

Malaria is an infectious disease caused by protozoa gender *Plasmodium sp.* and transmitted by the bite of the infected anopheles female mosquito. Malaria keeps on being the infectious disease with the higher fatality rates all over the world.

Malaria is an important public health problem in more than 90 countries. That means more than 2400 million people are in risk of infection.

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* With courtesy of the Editor of *Sanidad Militar*. Already published in 2015 - Volume 71/2.

Considering there's no vaccine available for this disease, the most important thing is prevention. The methods used to prevent malaria include medications, mosquito elimination and bite-avoidance means. The secondary prevention is based on the anti-malaria prophylaxis or intake of antimalarial medications in a preventive dose before, during and after staying in an endemic area.

The different drugs and their doses are based on the WHO recommendations. The WHO distinguishes between areas with *P. falciparum* sensitive to the effects of the Chloroquine and areas with resistance to the drug.

The prevention recommended for each country is decided on the basis of following factors: the risk of infection, the prevalent species, the drug resistances, and the possibility of serious side effects.

Even with all the recommendations, of all the cases of imported Malaria, over the 75%, appear in travellers who didn't do the prophylaxis. And this percentage grows into an 85-97% if we consider those who didn't do it in a proper way. Those are very important data that coincides with what we have found in this study. In the Table number 1 are shown the main drugs used in malaria prevention.

Afghanistan is one of the countries included in the malaria-endemic areas. The WHO determines that there is a real risk of infection between May and November, below an altitude of 2000 meters (Figure 1). That means that over 12 millions of Afghans live in a risk area. Also it affects the international troops deployed in the country. For example, the cities of Herat and Kabul are situated at an altitude of 964 and 1795 meters of he ight respectively, so there is risk of infection.

In 2003 there were 591.441 cases of confirmed malaria in the whole Afghan population, so the incidence rate is 197/10000. The *P. vivax* species accounts for the 93% of the cases and the *P. falciparum* for the remaining 7%. We can find the *P. falciparum* in a 0.002% of the cases in Wardak and up to the 31% in Takhar.

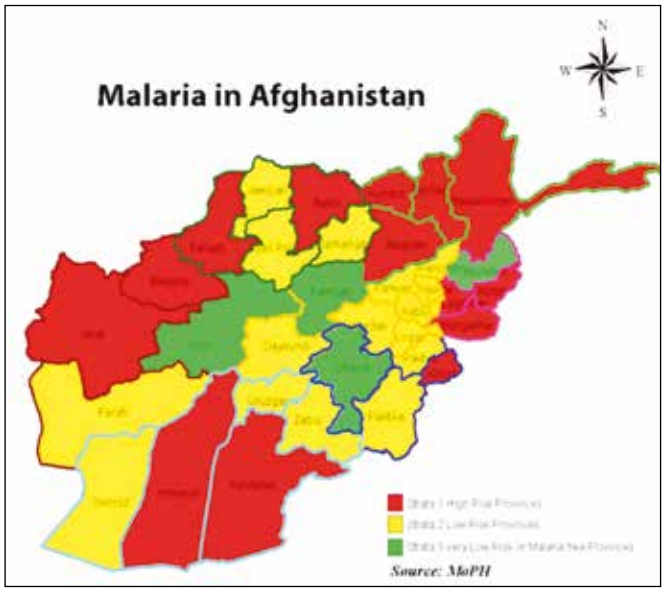
There has been reported cases of malaria in the NATO Armies of all the countries taking part in the deployment, 15 cases in 2001 among the British, 7 cases between 2002 and 2004 among the Spanish, 38 cases between June and September 2011 among the Americans, and there were also 21 cases in French Role 2 of Camp Warehouse in December 2008.

There are four groups related with the kind of prophylaxis recommended, these four Classes are in Table number 2. In Afghanistan *P. falciparum* has started to develop widespread resistance to Chloroquine, so the prophylaxis recommended is Class IV. Class IV includes Mefloquine or Atovaquone + Proguanil, or Doxycycline. It is also important to consider that for pilots or other personnel who needs

Table 1 : Main antimalarial medicines.
Source : Boletín Epidemiológico de las Fuerzas Armadas.

DRUG	DOSE	INDICATIONS	SIDE EFFECTS	CONTRAINDICATIONS
Chloroquine 150 mg.	2 pills once a week 1 week before leaving And four weeks after arriving	Areas without resistence	Stomachache, dizziness, vomiting Convulsions Psychosis	G6PD deficit, retinopathy,epilepsy miastenia gravis
ChloroquineProguanil 200mg proguanil 100mg chloroquine	1 pill once a day 1day before leaving And four weeks after arriving.	Areas without Chloroquine resistence Not recommended for Sub-saharian Africa.	As Chloroquine	Renal and liver failure
Mefloquine. 250mg.	1 pill once a week 1 week before leaving And four weeks after arriving	Areas with Chloroquine resistence	Neurologic and psychiatric side effects Stomachache,dizziness, vomiting	Psiquiátrics diseases Epilepsy Pilots and personnel with high concentration needed.
Doxycicline. 100mg.	1 pill once a day four weeks after arriving.	Areas with Chloroquine resistence	Stomachache,dizziness, vomiting Candidiasis	Children under 8 years. Pregnants Precaution in liver failure
Atovaquone +Proguanil... 100mg proguanil 250mg atovaquone	1 pill once a day 1day before leaving And 1 week after arriving.	Areas with Chloroquine resistence	Stomachache,dizziness, Vomiting fever	Children under 5 years. Pregnants Precaution in renal failure
Primaquine 15mg.	2 pills a day	Areas with Chloroquine resistence	Leucopenia Digestive effects.	Pregnants G6PD deficit

Figure 1: Risk areas in Afghanistan.
Source: http://www.afghan-web.com/health/malaria_afghanistan.jpg



special concentration Mefloquine is not recommended, they should use Atovaquone + Proguanil or Doxycycline.

In 2013 began the withdrawal of the Spanish troops in Bagdhis, with the handover of the base of Ludina to the Afghan National Army (ANA). It was followed with the transfer of the bases of Moqur and Sanga Tesh, and finally the withdrawal finished with the transfer of the base of Qala-i-Naw, the main Spanish base in Bagdhis.

Afghanistan Spanish Force, ASPFOR, number XXXIII was the last rotation of Spanish contingent in the base of "Ruy González de Clavijo" in Qala-i-Naw. The withdrawal and the special logistics of this mission had an important influence in the medical matters. It is to consider that throughout this period both human and material medical resources were decreasing each day.

Another matter of fact is that before the redeployment all the military personnel had meetings about all the main points of the mission. In these meetings the medical information and the sanitary measures must be clearly explained for avoiding health risks and for their own safety.

METHODS AND MEASUREMENTS

The purpose of this paper was to carry out an observational transversal study based on the data obtained from the health questionnaire that all the Spanish Military personnel must complete before leaving Afghanistan, once they finish the deployment.

The variable considered is the degree of observance of the anti-malaria prophylaxis, in the total amount and also distributed among different groups based on rank, sex and age.

In the health survey there are two different parts, the first one consist of a few questions the military personnel must complete, and the second one of some questions made by the medical officer in order to obtain the most of the information about the anti-malaria prophylaxis.

In the part that the person must complete by his own there are a few questions about contact with insects and the observance of the primary prevention measures. Also about prophylaxis: the way of observance, if it was done suitably, and if not, the reasons why.

RESULTS

Data have been collected from the health surveys and an interview with all the personnel just before getting back home. There are different groups in rank, sex, and we made four age groups in order to classify them.

With our data in ASPFOR XXXIII in the base "Ruy González de Clavijo" in Qala-i-Naw, up to 78% of the personnel didn't observe the prophylaxis in a proper way. A 61% did not even start it because they considered that the risk of taking the antimalarial medication was higher than the benefit. There were a 17% of

Table 2 : Endemic areas for Malaria and recommended prophylaxis.
Source : Boletín Epidemiológico de las Fuerzas Armadas.

RISK OF MALARIA	PROPHYLAXIS
CLASS I Low risk.	Only mosquito elimination and bite-avoidance means.
CLASS II Risk of Malaria caused by *P. vivax* or *P. falciparum* without Chloroquine resistence.	Mosquito elimination and bite-avoidance means and prophylaxis with Chloroquine.
CLASS III Risk of Malaria caused by *P. vivax* or *P. falciparum* with spreading Chloroquine resistence.	Mosquito elimination and bite-avoidance means and prophylaxis with Chloroquine + Proguanil.
CLASS IV High risk of Malaria caused by *P. falciparum* with antimalarial drugs resistence or low risk of Malaria caused by *P. falciparum* with high risk of drug resistence.	Mosquito elimination and bite-avoidance means and prophylaxis with Mefloquine or Doxycicline or Atovaquone + Proguanil. Considering the resistenceces in the area.

withdrawals, of those only 22% were attributable to real side effects.

Divided in ranks, the right observance of the prophylaxis was higher among the officers, up to the 42%, than among the non-commissioned officers and the troop.

By gender the observance in women was higher: 38% versus 22% among men.

We made four groups of age: < 25 years old, 25-35, 35-45 and > 45. The observance of the prophylaxis was higher in the two last groups of age. The percentage of unfulfillment was higher in the first group and in the second one, 86% and 82% respectively, and in third and last ones were 70% and 74% respectively.

Apart from all this another key problem was the mistakes in starting and finishing the prophylaxis. Up to the 40% didn't start it before leaving Spain, and the 57% didn't know to complete they should carry on the prophylaxis for four weeks once they were back home. And, as we mentioned before, the main target of the deployment of ASPFOR XXXIII was the transfer of the Spanish base in Qala-i-Now "Ruy González de Clavijo" to the Afghan National Army (ANA), so there was some personnel that thought that when they left Qala-i-Now they shouldn't complete it in Herat. The problem probably was that this concrete point wasn't explained well enough.

DISCUSSION

The first data we consider is a problem with the way of formulating the questions in the health questionnaire, due to the excessively medical contents that made that not everyone could answer de questions in the right way, because an ignorance of the medical terms used in the survey. This problem, in the most of the cases, was solved by the help of the medical officer. For example, the word prophylaxis has to be explained to almost the 80% of the personnel. That makes us think that maybe this not an appropriated term for personnel without medical training. And when the people answered no, the most of them were meaning that they hadn't done the prophylaxis properly, no that they hadn't done it.

Among the most common causes for not even beginning the prophylaxis in spite of the recommendations of doing it, the argue for not doing it were mainly the personal reasons and the fear of the side effects, that means that there is a wrong perception of the risk-benefit balance.

In the group that discontinued the treatment we could find that one main point was that they hadn't seen mosquitoes at all and the other one was because of having suffered side effects. The most common side effects referred were headache, dizziness, and gastrointestinal problems. Another group was composed by those ones who, having experimented side effects with the prophylaxis in the past, decide not to do it again. There was no reference of suffering psychiatric side effects.

Our study showed that correct administration of prophylaxis is very important. In many cases prophylaxis administration wasn't sufficient due to a lack of easy access to the antimalarial medication and administration schedule.

In many cases military personnel had the possibility of having personally anti-malaria prophylaxis and a correct administration schedule, in other cases they had to ask for the medication and administration schedule to the medical services.

Some personnel decided to leave the prophylaxis because of their frequent omissions and oversights. Perceiving they weren't administrating the prophylaxis in a correct way they concluded it was useless to continue the prophylaxis.

CONCLUSIONS

In spite of the wide experience of the different Armies in the international deployments in malaria-endemic areas, there are no reliable publications of data about the observance of anti-malaria prophylaxis in the international deployments. What we do have found in our research for references is that there have been cases of malaria reported by almost all the Armies that have taken part in these operations.

So we think that, by now, there are no data comparable to those that we have found in this study. Again we have to mention that obtained data are from a very concrete sample in the last Spanish ASPFOR rotation, and with all the special features caused by the retreat.

We haven't obtained a sufficient observance of the anti-malaria prophylaxis. In spite of the efforts made in health training, these have been inadequate in this rotation.

If the data we have found were comparable to those obtained in other rotations and in another international deployments, it is obvious that we have to improve our ways of consciousness-raising in the risk of getting the disease in endemic areas, and real possibility of suffering side effects caused by the prophylaxis. It will be also important to deliver measures for monitoring the real observance of the anti-malaria prophylaxis.

SUMMARY

Malaria in Afghanistan is an endemic disease in low altitude areas, less than 2000 meters. In the XXI century it remains a threat to troops in combat zone, despite the availability of preventive drugs and mosquito bite-avoidance means, as the most effective prevention measures. It is necessary a bigger effort to get a higher and better observance of the anti-malaria prophylaxis.

ANEXO 3

MINISTERIO DE DEFENSA

SANIDAD MILITAR

CUESTIONARIO DE SALUD AL REGRESO DE LA MISIÓN

Este cuestionario es sólo para empleo en el ámbito sanitario.

Apellido 1º ..... Empleo ..... Ejército/CC .....
Apellido 2º ..... Destino (Unidad de origen) ..... Ciudad .....
Nombre ..... DNI/TIM ..... Sexo ..... Fecha de nacimiento ...../ ...../ .....

Misión/Operación ..... Unidad ..... Localidad .....
País ..... Otros lugares frecuentados .....
Fecha de incorporación: .../.../.... Fecha de regreso: .../.../.....

LAS PREGUNTAS FORMULADAS A CONTINUACIÓN SE REFIEREN SOLO A LA MISIÓN ACTUAL

1.- ¿Ha tenido algún problema médico o dental?
a ☐ Si médico
b ☐ Si dental
c ☐ No he tenido problemas ni médicos ni dentales
¿En caso afirmativo, por qué motivo? .....

2.- ¿ Necesitó asistencia médica o dental?,
a ☐ Si
b ☐ No
¿En caso afirmativo, por qué motivo? .....

3.- ¿ En cuántas ocasiones? (responder solo si la anterior es afirmativa)
a ☐ Una
b ☐ Dos
c ☐ Tres
d ☐ Mas de tres

4.- ¿Estuvo rebajado para el servicio más de tres días en alguna ocasión?
a ☐ Si
b ☐ No
¿En caso afirmativo, por qué motivo? .....

5.- ¿Ha necesitado apoyo psicológico o atención médica para su salud mental?
a ☐ Si
b ☐ No
¿En caso afirmativo, por qué motivo? .....

6.- ¿Considera que ha estado sometido a algún factor tóxico o de riesgo?
a ☐ Si
b ☐ No
(En caso afirmativo, explíquelo)..... .....

7.- ¿Fue mordido o arañado por algún animal doméstico o salvaje?
a ☐ Si
b ☐ No
(En caso afirmativo, explíquelo)..... .....

8.- ¿Estuvo en contacto con animales domésticos o ganado?

a ☐ Si
b ☐ No
(En caso afirmativo, explíquelo)..... .....

9.- ¿Sufrió picaduras frecuentes de mosquitos, de otros insectos u otro tipo de animales (serpientes, arañas, escorpiones, garrapatas, tábanos, etc.)?
a ☐ Si
b ☐ No
(En caso afirmativo, explíquelo).....

10.- ¿ Con que combatía la presencia de moscas, mosquitos, etc ?
a ☐ Repelentes de contacto
b ☐ Mosquiteros
c ☐ Métodos caseros
d ☐ No hacía nada

11.- ¿Mantuvo contacto frecuente o estrecho con la población civil?
a ☐ Si
b ☐ No
(En caso afirmativo, explíquelo).....

12.- ¿Mantuvo relación sexual con personal civil local? (Si no desea contestar déjela en blanco, pero no falte a la verdad)
a ☐ Si
b ☐ No
(En caso afirmativo, explíquelo).....

13.- ¿Alguno de sus compañeros de dormitorio tuvo que ser evacuado por enfermedad a Territorio Nacional?
a ☐ Si
b ☐ No
(En caso afirmativo, explíquelo).....

14.- Indique el tipo o tipos de dormitorio que utilizó:
a ☐ Hotel
b ☐ Contenedor para mi solo
c ☐ Contenedor compartido
d ☐ Tienda de campaña
e ☐ Otros
(Especificar tipo y duración).....

15.- ¿Entró en contacto con edificaciones o instalaciones destruidas por acciones de guerra?
a ☐ Si
b ☐ No
(En caso afirmativo, explíquelo).....

16.- ¿Entró en contacto con material de guerra, como carros de combate, cañones... destruidos o abandonados?
a ☐ Si
b ☐ No
(En caso afirmativo, explíquelo).....

17.- ¿Han cambiado sus hábitos de sueño o su resistencia al cansancio durante la misión?
a ☐ Sí, dormía peor que antes de la misión y me cansaba con mas frecuencia
b ☐ No, dormía igual que antes de la misión y tenía la misma resistencia al cansancio que antes.

18.- ¿Ha modificado sus hábitos de consumo de tabaco, alcohol u otros productos durante la misión?
a ☐ Si, fumaba mas
b ☐ Sí, fumaba menos
c ☐ Si, bebía mas
d ☐ Si, bebía menos
e ☐ No he modificado mis hábitos de consumo

19.- ¿Le recomendaron realizar quimioprofilaxis durante la misión?
a ☐ Si
b ☐ No
(En caso afirmativo, explíquelo).....

20.- ¿Lo hizo como le indicaron?
a ☐ Si
b ☐ No
(En caso negativo, explique los motivos).....

21.- ¿Está Vd. preocupado por su salud o quiere hacer alguna pregunta sobre posibles exposiciones o circunstancias que le hayan sobrevenido durante la misión? .....
.....
.....
.....
.....
.....

22.- Describa brevemente el trabajo desempeñado durante la misión:.....
.....
.....
.....
.....

Valoración sobre el estado de salud. *(a rellenar por el Servicio de Sanidad)*

a. *Valoración actual del estado de salud:* .....
.....

b. *Posibles riesgos a los que pueda haber estado expuesto el interesado:* .....
.....

c. *¿Cree conveniente alguna consulta de especialista o alguna exploración complementaria en Territorio Nacional?* ....
.....

d. *¿Estaban previstos los riesgos encontrados en la zona de operaciones?:* .....

e. *¿En su caso, pruebas médicas practicadas en zona y resultados:* .....
.....

f. *¿Se tuvo que completar el calendario de vacunación en zona de operaciones?* .....
.....

g. *¿Se añadió alguna vacuna no prevista en Zona de Operaciones?:* .....

h. *¿Tuvo que hacer quimioprofilaxis? (en caso afirmativo decir el medicamento que toma)* .....

i. *¿Tiene noticias de que el interesado haya tenido contacto con algún caso de enfermedad transmisible?* .....
.....

Comentarios:
(Justificar los análisis, consultas o pruebas complementarias indicadas).....
.....
.....

Datos del oficial médico encuestador:

Apellidos: .....*Nombre:* ..... *Empleo* .....
Unidad de destino en España: ..... *Teléf:* ..... *Fax* .....

En ....., *a* ..... *de* ..... *de 200* ....
Firma:

Apellidos: *Nombre:* *Empleo:*
Unidad de destino en España:

En QALA I NAW, a de de 201 .

Fdo:

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2016
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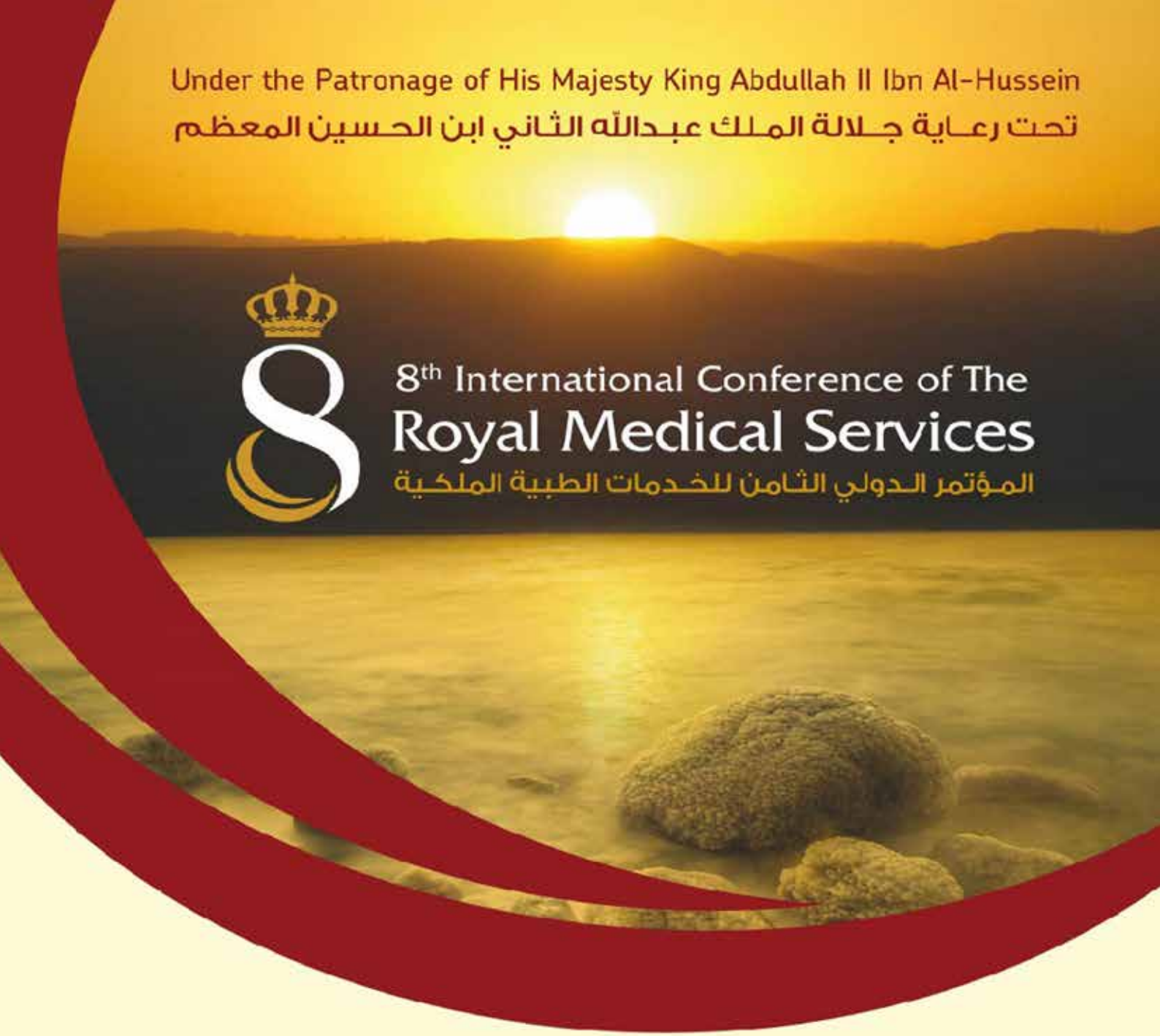

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Lignes directrices pour l'élaboration d'une politique de l'eau en contexte opérationnel.

Par G. BORNERT[1], M. BONI[2] et F. CALVET[3]. France

Gilles BORNERT

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- Responsable pédagogique et co-directeur du Cours du CIMM de « gestion de la sécurité sanitaire des eaux en contexte opérationnel ».

SUMMARY

Guidelines for the elaboration of a policy for water supplies during military operations.

During military operations, water supplies for troops must be carried out in accordance with objectives of efficiency and health security. From this perspective, it appears essential to develop a global strategy considering practical, sanitary, technological and economical imperatives. Elaborating a water doctrine for the battlefield should involve a definition of guiding principles, from a technical and organizational point of view, with reference to predefined objectives, and should take into account the specificities of military operations.

MOTS-CLÉS : Eau, Opérations militaires, Doctrine, Réglementation, Sécurité sanitaire.

KEYWORDS: *Water, Military operations, Doctrine, Regulation, Health safety.*

INTRODUCTION

L'approvisionnement en eau d'un dispositif militaire déployé sur un théâtre opérationnel représente une préoccupation majeure pour le commandement. Les contraintes à prendre en considération sont très fortes, d'ordre sanitaire, mais aussi logistique, pratique, écologique et économique. Cette question de l'eau en situation opérationnelle prend une dimension particulière lorsque les opérations militaires se déroulent dans des régions du monde où l'eau est rare dans le milieu naturel, de sorte

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que l'approvisionnement en eau peut devenir un facteur limitant le bon déroulement des activités de la force militaire. Les hasards de la géopolitique ont fait du Sahel et du Moyen-Orient des régions particulièrement concernées par les déploiements militaires, de sorte que la question de l'approvisionnement en eau revêt actuellement un intérêt particulier.

Face à un tel challenge, l'expérience montre que l'improvisation est une source possible de déboires pour les forces armées, avec un impact majeur sur la santé et la disponibilité opérationnelle des personnels. L'élaboration et la mise en application d'une doctrine de l'eau adaptée aux contraintes du terrain apparaissent indispensables pour répondre à ce défi, en favorisant la mise en place des moyens et de l'organisation adaptés. Nous présentons ici les questions essentielles auxquelles une telle doctrine doit répondre.

CONTRAINTES À PRENDRE EN COMPTE

La construction ou la révision d'une doctrine opérationnelle en matière d'eau doit prendre en compte des éléments dont certains relèvent de spécificités nationales, en lien notamment avec la politique d'engagement opérationnel des forces, et d'autres sont sous-tendus par des considérations scientifiques. Un bilan initial doit amener à identifier les contraintes liées aux spécificités des opérations militaires.

A. CONTRAINTES GENERALES LIEES AUX OPERATIONS MILITAIRES

Sur le plan sanitaire, il importe de tenir compte de l'extrême diversité des contextes épidémiologiques auxquels une force de projection peut être confrontée. D'une manière générale, le risque naturel varie en fonction de la région du monde où se déroulent les opérations, de sorte que l'on peut se trouver confronté à des dangers totalement ignorés en métropole. L'amibiase à *Entamœba histolytica* est un exemple de maladie inconnue en Europe, qui prend une importance critique pour les troupes déployées en zone intertropicale. À ces spécificités s'ajoutent des facteurs qui majorent le risque naturel ou provoqué, en lien avec la désorganisation des structures sanitaires des pays en guerre, aux destructions voire aux actes délibérés de sabotage.

Une autre contrainte à prendre en compte est que la projection de forces armées peut se faire à très grande distance de la base arrière, ce qui va rendre les approvisionnements plus compliqués et très coûteux, notamment en matière d'eau. Un approvisionnement local est alors généralement indispensable. La projection pose aussi problème dans la mesure où il peut y avoir urgence à se déployer, de sorte que la mise en place de moyens optimisés n'est pas toujours immédiatement possible. Parfois les effectifs déployés sont très importants et la priorité sera toujours donnée aux aspects militaires, surtout en contexte hostile. Enfin, la mobilité de certains dispositifs complique encore l'organisation du soutien.

Lorsque les ressources naturelles en eau sont rares, le risque de surexploitation par la force militaire est important, ce qui peut spolier la population locale d'une denrée vitale. Il importe donc de tenir compte de cette contrainte supplémentaire.

B. ASPECTS REGLEMENTAIRES

Les éléments de doctrine opérationnelle ne peuvent être en infraction avec la réglementation applicable aux activités militaires. En ce qui concerne les textes de droit commun, la situation observée varie selon les pays. Pour certaines nations, les opérations extérieures ne font pas exception au droit commun, de sorte que la doctrine de l'eau devra se conformer strictement aux exigences de la réglementation en vigueur en métropole. Pour d'autres nations, à l'image de la France, les opérations militaires échappent au cadre réglementaire national et européen. Il y a ainsi un vide législatif, que la doctrine doit venir combler.

Il est parfois aussi nécessaire de ne pas occulter les contraintes liées à la réglementation du pays hôte, particulièrement lors d'exercices effectués en pays ami ou durant des stationnements de forces prépositionnées. Les principaux aspects sont alors en lien avec la protection de l'environnement, la préservation des ressources naturelles et la limitation des pollutions. Cette question d'ordre juridique doit être tranchée avant tout déploiement ou toute signature d'accords de défense.

Certaines contraintes spécifiques peuvent aussi être rencontrées. Par exemple, les pays ayant ratifié des accords internationaux se doivent de les mettre en application. C'est ainsi que les pays membres de l'Organisation du traité de l'Atlantique Nord (OTAN) ont pour la plupart ratifié des accords de standardisation[1, 2] relatifs à l'eau en contexte opérationnel, dont les exigences doivent être intégrées dans la doctrine nationale. Dans le cas des interventions à caractère humanitaire, il est d'usage de se référer aux standards[3] définis par le Haut-Commissariat des Nations unies aux réfugiés (UNHCR).

DEFINITION DES OBJECTIFS A ATTEINDRE

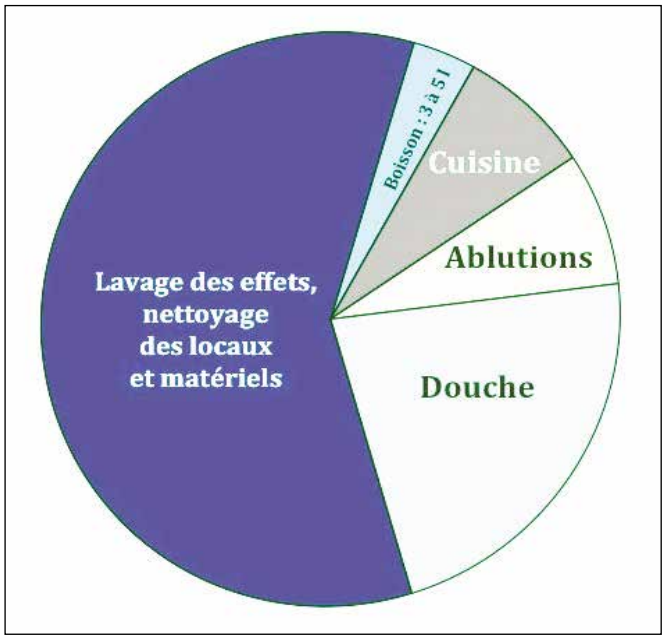
Les éléments généraux étant identifiés, il importe de définir les objectifs à atteindre. Dans le domaine de l'eau, ces objectifs concernent les aspects quantitatifs, d'une part, et qualitatifs, d'autre part.

A. OBJECTIFS QUANTITATIFS

Il est tout particulièrement important de ne pas occulter la réflexion relative à la quantification des besoins en eau d'un dispositif militaire, car il s'agit d'un aspect dimensionnant pour la logistique opérationnelle. Dans des conditions réputées normales de confort, un européen utilise de l'ordre de 100 à 200 litres d'eau par jour (figure 1) pour les activités de la vie courante : boisson, préparation des aliments, hygiène corporelle et vestimentaire, entretien des locaux de vie, etc. Si la boisson ne représente qu'une partie minime de cette consommation

d'eau, de l'ordre de moins de 10 %, il est vital, en toutes circonstances, de garantir au minimum des apports en eau suffisants pour répondre aux besoins physiologiques des individus. Il semble alors difficile de fournir moins de 7 à 10 litres d'eau de boisson par personne et par jour[3], voire plus si le climat est très chaud et si une activité physique intense est exigée des soldats, par exemple en situation de combat. L'idéal serait aussi de prévoir, dans ce volume minimal, de l'eau pour la préparation des aliments ainsi que pour permettre de garantir un semblant d'hygiène individuelle (lavage des mains). C'est pourquoi, les standards minimaux se situent souvent à des niveaux supérieurs, soit de l'ordre de trente litres par homme et par jour sous les climats chauds[2]. Si de tels niveaux d'apports *a minima* peuvent se concevoir pour des troupes en situation extrême, par exemple des forces spéciales engagées dans des missions de combat de courte durée, il est rapidement nécessaire de prendre en compte le confort du soldat et l'hygiène individuelle et collective, lorsque le dispositif militaire se stabilise. Il devient alors inévitable de tendre vers des apports quotidiens en eau de 80 à 150 litres par homme[2]. L'impact logistique de l'approvisionnement en eau devient alors considérable. Le passage d'apports a minima à des conditions de confort relatif peut se faire bien évidemment progressivement en lien avec le calendrier de déploiement des structures de soutien logistique.

Figure 1 : Répartition de la consommation d'eau en fonction des différents usages domestiques. Le volume total consommé varie, en Europe, de 100 à 200 litres par jour.



Les acteurs de la santé au sein des armées doivent demeurer très vigilants en ce qui concerne les choix du commandement dans la définition de standards quantitatifs pour l'eau : au-delà de la seule prise en compte des besoins physiologiques des combattants, c'est toute l'hygiène en campagne qui est conditionnée par la quantité d'eau disponible. Restreindre les apports en eau est toujours préjudiciable au respect des règles de base de l'hygiène corporelle ou vestimentaire. Il ne s'agit donc pas seulement d'assurer un certain niveau de confort aux combattants, mais bien de lutter contre le risque de diffusion d'agents infectieux au sein de l'effectif déployé sur le terrain. On peut enfin retenir que dans ce domaine la doctrine devrait toujours affirmer la volonté du commandement de favoriser les économies d'eau, par un recours à des dispositifs adaptés (pommeaux de douche et robinets spécifiquement conçus, etc.) et par une sensibilisation permanente des personnels aux bons réflexes en la matière (douches courtes, robinets fermés, etc.).

B. OBJECTIFS QUALITATIFS

Si la question des objectifs quantitatifs est d'importance, le débat sur les exigences qualitatives applicables aux eaux en conditions opérationnelles est particulièrement critique et délicat. La transposition *in extenso* de critères qualitatifs prévus pour la population tout-venant en temps de paix appelle différents commentaires.

Ces critères sont conçus pour garantir une protection optimale de l'ensemble de la population, sur le long terme. En particulier, pour les polluants chimiques, l'objectif est de permettre de maîtriser l'ensemble des effets toxiques chroniques, y compris sur le très long terme, soit une consommation d'eau sur une vie entière. Cette vision, adaptée à des expositions de très longue durée, ne correspond clairement pas à la réalité des contextes opérationnels. De plus, la réglementation de temps de paix est conçue pour la totalité de la population, comprenant aussi des femmes enceintes, des nourrissons ou des vieillards, c'est-à-dire des personnes fragilisées ou malades. La population militaire, au contraire, est essentiellement composée d'adultes jeunes en bonne santé. On en vient donc à s'interroger sur l'opportunité de transposer aux opérations extérieures des critères ainsi conçus.

Un autre constat important est que les exigences réglementaires se fondent sur des considérations très diverses, selon les polluants. Ces derniers ont en effet un impact très variable en termes de santé publique, et l'on en vient ainsi à fixer des critères réglementaires pour des agents très toxiques, tels que l'arsenic ou les cyanures, mais aussi pour des composés peu toxiques (sulfates par exemple, responsables de désordres digestifs à très hautes doses) et même pour des composés qualifiés d'indésirables tels que les chlorures, totalement dépourvus de toxicité. L'importance, en termes de santé publique, des différents paramètres réglementés est donc particulièrement variable. Dans la perspective de la création d'exigences spécifiques des contextes opérationnels, l'intérêt de prendre en compte des composés dépourvus de toxicité peut être discuté.

Pour de nombreux paramètres, la valeur cible définie par la réglementation métropolitaine n'est pas fixée sur des bases de toxicologie. C'est le cas par exemple pour de nombreux pesticides. Pour ces composés, la valeur maximale acceptable est fixée le plus souvent à 0,1 microgramme par litre d'eau, en Europe[4]. En revanche, la valeur toxicologique, donc la limite acceptable pour ces composés au plan de la toxicité, peut

être bien supérieure. À titre d'exemple[5], elle est de 255 µg/L pour la propyzamide, 60 µg/L pour le glufosinate et 300 µg/L pour le dimétachlore. Cela signifie qu'un dépassement modéré de la valeur limite réglementaire définie pour la métropole n'aura aucun impact sur la santé des consommateurs, même sur le très long terme.

Un dernier débat d'importance suscite la controverse. Les réglementations applicables dans de nombreux pays, notamment au sein de l'Union européenne[4], traitent de ce qu'il est convenu d'appeler les « eaux destinées à la consommation humaine » : il s'agit non seulement des eaux destinées à la boisson mais aussi celles utilisées pour la cuisine et pour l'hygiène individuelle ou collective. En pratique, la même qualité d'eau est attendue pour l'ensemble de ces usages. La question qui se pose alors est de savoir si, quand l'eau est chère et rare, il est réellement nécessaire d'exiger de l'eau « potable » pour les douches ou le lavage du linge, activités qui représentent jusqu'à 80 % de la consommation totale d'eau. Une option pourrait être d'opter pour des garanties minimales applicables à ces eaux qui ne sont pas destinées à être ingérées, mais la réflexion sur ce sujet demeure difficile faute de données scientifiques suffisantes. Certains contaminants des eaux peuvent en effet exercer un effet néfaste par simple contact avec la peau, par effet local ou du fait d'une résorption transcutanée; d'autres sont dangereux par inhalation. De ce fait, la définition de critères spécifiques des eaux de douche, pourtant souhaitée par le commandement, reste inachevée.

Au bilan, dans la conception d'une doctrine de l'eau, il apparaît particulièrement difficile de fixer, de manière rigoureuse, des critères de qualité *a minima*, pourtant souhaités pour pallier les difficultés de la production d'eau sur les théâtres opérationnels. La bonne approche est vraisemblablement de s'en tenir à des exigences rigoureuses au plan scientifique et de s'efforcer de gérer intelligemment les situations extrêmes, plutôt que de figer une doctrine plus tolérante, pour ne pas dire laxiste. Cette vision est d'autant plus importante que la doctrine dimensionne les moyens, c'est-à-dire que les forces vont se préparer au vu de la doctrine, acquérir les matériels nécessaires et autant que possible les emmener avec elles. Si au contraire la doctrine se fonde sur une vision minimaliste, les moyens matériels ne seront pas acquis, donc *de facto* jamais disponibles sur les théâtres.

Dans une telle approche, la possibilité de déroger aux exigences strictes fixées par la doctrine doit être prévue, sur la base d'une évaluation scientifique au cas par cas, confiée à des experts reconnus et indépendants. Une cellule de crise spécialisée est donc à prévoir pour faire face à des telles situations.

DEFINITION DES PRINCIPES D'ORGANISATION DES RESPONSABILITES

Un dispositif opérationnel en campagne peut être très complexe dans sa structure et le risque en matière d'eau est de répartir les charges entre différents intervenants mal coordonnés, avec une « dilution » des responsabilités pouvant mettre à mal le fonctionnement du processus technique de production et de distribution de l'eau. Cette complexité est particulièrement évidente en contexte multinational ou onusien, et en cas d'externalisation d'une partie de l'activité. Pour garantir la cohérence technique, la doctrine doit absolument poser le problème des responsabilités et répondre à la question de la répartition des missions élémentaires en matière d'eau. Dans ce domaine, l'idéal est de ne jamais perdre de vue qu'un système de captage-production et distribution d'eau est indissociable au plan technique, dans la mesure où le résultat final au robinet dépend de la cohérence de l'ensemble des étapes de la ressource au robinet. C'est la raison pour laquelle, un manager technique unique pour l'ensemble du processus est indispensable. Ce responsable opérationnel, placé sous l'autorité du commandant de la force, doit être le « chef d'orchestre » de la fonction eau, en mesure de superviser et d'organiser l'activité de tous les intervenants techniques, de toutes natures. Il a pour responsabilités d'attribuer les missions à chacun, de vérifier la bonne exécution de ces missions et il doit mettre en place un tableau de bord qui lui permette de disposer à tout moment d'indicateurs. Il rend compte au commandant de la force. Fondamentalement, tout doit reposer sur l'établissement d'un organigramme fonctionnel et sur la définition des circuits selon lesquels les données vont circuler afin que les bonnes personnes aient accès aux bonnes informations. Enfin, il importe d'établir un ensemble de plans d'action permettant la gestion des dysfonctionnements et crises.

Lorsque certaines fonctions sont confiées à des sociétés sous-traitantes, il importe de conserver la maîtrise de la situation en mettant en place une supervision des activités externalisées, en ce qui concerne notamment leur cohérence, la qualité des matériels mis en œuvre, la compétence des opérateurs, etc.

Un dernier aspect à organiser est le contrôle de l'ensemble par un acteur indépendant : ce « contrôle sanitaire » est dans de nombreuses armées confié au service de santé, qui doit disposer d'experts de haut niveau pour exercer cette mission.

ASPECTS TECHNIQUES

Le but d'un document de doctrine n'est pas de détailler les modalités de la gestion technique de la question traitée, mais de définir les concepts essentiels afin de donner une orientation générale aux activités techniques. Dans le domaine des approvisionnements en eau, les concepts de base sont les suivants.

A. CARACTERISER LA RESSOURCE EN EAU

Lorsque le dispositif militaire se propose d'exploiter une ressource naturelle en eau en vue de son alimentation, la filière de traitement à mettre en place ne peut être définie qu'à l'issue d'une étape de caractérisation de la ressource. Il s'agit d'une démarche reposant sur une double expertise d'analyse des dangers.

Le premier volet consiste à apprécier la pollution avérée des eaux brutes, c'est-à-dire la nature et la concentration des polluants en présence. Cette approche repose sur des examens de laboratoire aussi exhaustifs que possible. Le canevas analytique peut être utilement adapté au vu de l'historique du site au plan des activités industrielles et agricoles notamment. Par exemple, la liste des pesticides à rechercher dans l'eau doit tenir compte des molécules effectivement utilisées par l'agriculture locale, plutôt que de se calquer sur les listes qui font référence en métropole. Il est donc important de nouer des contacts avec les autorités locales, en charge de l'agriculture et de la santé, mais aussi de procéder à des reconnaissances de terrain afin d'observer les pratiques agricoles.

En tout état de cause, une analyse de laboratoire n'apporte cependant qu'une image de la situation à un instant donné, sans éléments de prospective. Il est donc essentiel de disposer, en outre, de données permettant de prévoir les risques de variations de la qualité de l'eau au cours du temps, mais aussi les variations de débit.

La sensibilité de la ressource aux variations qualitatives liées aux conditions spécifiques est qualifiée de vulnérabilité. Son évaluation repose sur la prise en compte des caractéristiques du site au plan de la géologie, de l'hydrologie et de l'hydrogéologie. À cela s'ajoute la prise en compte des sources de pollution identifiées dans l'environnement immédiat.

La synthèse de l'ensemble de ces données permet d'établir une liste des polluants avérés ou vraisemblables dans la ressource. Cette approche d'analyse des dangers conditionne la conception de la filière technologique.

B. METTRE EN PLACE UNE FILIERE DE TRAITEMENT EN COHERENCE AVEC LES CARACTERISTIQUES DE LA RESSOURCE

La filière de traitement doit être conçue pour éliminer les polluants dont la présence est avérée. Lorsque la ressource est vulnérable, la filière devrait aussi avoir la capacité de traiter les pollutions dont la survenue est vraisemblable. Faute de quoi, la filière de traitement se trouverait dépassée en cas d'évolution de la qualité de la ressource, mettant en péril l'approvisionnement en eau.

La prise en compte de la vulnérabilité de la ressource conduit donc inévitablement à mettre en place des filières de traitement plus complètes, ce qui constitue une approche cohérente dans une perspective de sécurité sanitaire et de pérennité de l'approvisionnement en eau, mais génère des surcoûts. Cette vision se heurte inévitablement à une conception a minima du traitement d'eau, par souci d'économie, qui consiste à ne prendre en considération que les pollutions effectives. Dans la mesure où il est difficile d'assurer un monitorage exhaustif et continu de la ressource, faute de laboratoire de proximité et de techniques suffisamment rapides, l'arrivée de nouveaux polluants dans la ressource en eau peut n'être découverte qu'après des délais importants. On comprend ainsi la nécessité d'une approche fondée sur une réelle analyse des dangers, afin que la filière technologique ne puisse être prise en défaut.

C. ASSURER LA PROTECTION DE L'ENVIRONNEMENT

Une politique de l'eau bien conçue comprend toujours une exigence de protection de l'environnement par la force militaire. Cela passe essentiellement par la mise en place de périmètres de protection au niveau du point de captage, zones où les activités polluantes seront interdites ou limitées. L'objectif est de pérenniser la production d'eau en limitant les risques de pollution des eaux brutes. À proximité immédiate du point de captage, une zone de protection immédiate est à créer, totalement clôturée et où aucune activité n'est autorisée (figure 2). On entoure cette première zone par un second périmètre, plus vaste, où les activités polluantes sont interdites. Enfin, une troisième zone plus vaste peut être définie où les activités polluantes sont aussi réduites que possible.

Figure 2 : Périmètre de protection immédiate d'un captage d'eau. La zone fait l'objet d'une protection physique vis-à-vis des intrusions et n'héberge aucune installation pouvant constituer une source de pollution des eaux. Le bâtiment abrite la tête de forage et les matériels de traitement de l'eau.

La protection de la ressource concerne aussi le volet quantitatif. Il est important de suivre le niveau de la nappe qui est exploitée, afin d'éviter de l'assécher par une surexploitation. Cela permet non seulement de pérenniser la production d'eau pour la force, mais aussi de ne pas spolier la population locale qui exploite peut-être aussi cette même ressource.

D. ASSURER LA MAITRISE DU PROCESSUS TECHNOLOGIQUE

Un aspect technique capital que la doctrine de l'eau doit mettre en avant est la maîtrise du processus technologique de production et de distribution d'eau, selon les principes de la méthode HACCP*, largement utilisée par ailleurs en agroalimentaire. Il s'agit probablement de l'aspect non seulement le plus important mais aussi le plus difficile à faire prendre en compte.

* HACCP : « Hazard Analysis Critical Control Point » soit « analyse des dangers; points critiques pour leur maîtrise ». Méthodologie utilisée en agroalimentaire pour développer une approche de maîtrise des procédés sur la base d'une analyse des dangers.

L'analyse des dangers dans le domaine des eaux n'est pas très originale car elle repose sur un bilan de la qualité et de la vulnérabilité de la ressource, aspects que nous avons déjà évoqués, puis sur un inventaire des éventuelles pollutions ajoutées lors des étapes de traitement et de distribution. On applique ensuite la méthodologie de type HACCP en identifiant les points critiques au niveau du processus et en mettant en place des moyens techniques et une organisation adaptée pour assurer la surveillance et la maîtrise de ces étapes considérées comme critiques. Finalement, les opérateurs disposent des modes opératoires nécessaires mais aussi d'un ensemble de moyens de surveillance du processus, qui complètent la simple application des règles de bonnes pratiques d'hygiène.

La surveillance doit concerner l'ensemble de la filière, ressource, traitement et distribution, avec pour objectif de détecter en temps réel les éventuels dysfonctionnements, avant qu'ils ne puissent avoir de conséquences pour les consommateurs. Cette activité doit exploiter toutes les options pertinentes, suivi de données technologiques, observations de terrain et analyses rapides. Ces dernières ne constituent donc pas les seuls outils et elles ne sont jamais exhaustives, donc ne permettent pas de prouver la potabilité de l'eau. La surveillance doit être conçue comme une activité de tous les jours, pour ne pas dire de tous les instants, faisant l'objet d'enregistrements, avec une attention particulière du responsable technique et une volonté d'agir en cas d'anomalie.

E. ENTRETENIR LA COMPETENCE TECHNIQUE DES OPERATEURS

Il apparaît essentiel de fixer des exigences formelles de compétence des acteurs de la filière « eau ». Cet aspect est essentiel au regard des spécificités des contextes opérationnels, où des matériels souvent sophistiqués sont confiés à des personnels qui sont relevés par périodes de quatre à six mois. L'existence d'un effectif suffisant de personnels formés apparaît donc comme une contrainte absolue, que la doctrine doit réaffirmer.

À des exigences de formation initiale des opérateurs, doit s'ajouter une démarche formalisée d'entretien et d'actualisation des compétences. Cela repose sur l'organisation d'une veille réglementaire et scientifique, l'organisation d'exercices mettant en jeu l'ensemble des structures concernées, y compris dans une perspective multinationale, et la prise en compte des retours d'expérience.

F. GARANTIR LA SECURITE DES INSTALLATIONS

Une approche de ce type doit intégrer une réflexion sur la question de la prévention vis-à-vis des actes malveillants. Par extension avec ce qui existe dans le domaine alimentaire, on parle de « *water defense* ». Ce type d'approche relève pour l'essentiel des services en charge du renseignement et de la sécurité militaire, en lien avec les experts de la technologie des eaux. Il s'agit d'un domaine où la veille technologique revêt aussi une importance majeure, en particulier en ce qui concerne les développements en matière de surveillance en continu de la qualité des eaux et les techniques rapides de détection des polluants.

G. ENCOURAGER LES ECONOMIES D'EAU

Il est enfin essentiel de ne jamais concevoir une politique de l'eau sans affirmer une volonté claire de favoriser les économies d'eau à tous les niveaux. Cette orientation, indispensable pour limiter les volumes consommés et alléger les contraintes logistiques, doit amener à rechercher en permanence des solutions techniques adaptées : robinetteries à débit réduit, systèmes de recyclage des eaux, approches alternatives de production d'eau, etc.

H. FIXER UNE STRATEGIE EN MATIERE D'ANALYSES D'EAU

Quel que soit le mode d'approvisionnement retenu et les options techniques en place, la réalisation d'analyses périodiques est indispensable pour s'assurer que l'eau respecte les exigences qualitatives définies. Il est donc difficile de concevoir une doctrine de l'eau sans poser le problème des canevas analytiques et des plans d'échantillonnage, ce qui doit amener aussi à s'interroger sur les moyens nécessaires pour la réalisation des analyses. Concernant ce dernier aspect, les choix techniques peuvent varier, le déploiement de laboratoires complets sur le terrain n'étant pas la seule option. L'expérience montre que les choix d'organisation en matière de laboratoire doivent correspondre au meilleur compromis entre des arguments purement techniques et des contraintes d'ordre logistique. En pratique, certaines méthodes d'analyse ne sont pas facilement transposables au terrain, surtout lorsque les conditions d'installation du dispositif militaire sont précaires. De plus, le transport de laboratoires complets vers des sites éloignés peut apparaître trop contraignant. Cependant, certaines analyses ne peuvent être réalisées que dans des délais contraints, en particulier les analyses microbiologiques. Sans moyens de transport aériens dédiés, il est de ce fait impossible de s'en remettre intégralement à un laboratoire de l'arrière. La bonne approche sera donc le plus souvent un partage des charges entre des laboratoires de terrain (figure 3) et des laboratoires de l'arrière.

Figure 3 : Laboratoire d'analyses d'eau de l'armée française au Liban. Le principe retenu est de disposer sur le terrain de matériels de base pour réaliser des analyses de routine, portant principalement sur des paramètres bactériologiques et physico-chimiques. Ce type de laboratoire est doté d'étuves pour bactériologie, d'un turbidimètre, d'un chloromètre, d'un conductimètre-pHmètre, et d'un spectrophotomètre.

CONCLUSION

Aussi indispensable soit-elle, une doctrine de l'eau en situation opérationnelle s'avère toujours complexe à mettre au point, en trouvant le meilleur compromis entre des exigences sanitaires à caractère obligatoire et les réalités du terrain et de la logistique. Les règles ainsi définies par le commandement au plus haut niveau déterminent l'ensemble des politiques de formation spécialisée, d'acquisition de matériels et d'organisation, pour les unités et services impliqués dans la logistique de l'eau. Il s'agit donc d'un challenge majeur pour les forces.

Loin de figer la situation, la doctrine de l'eau doit aussi avoir vocation à évoluer afin d'intégrer notamment les évolutions en matière de réglementation, de connaissances scientifiques et de technologie, mais aussi pour s'adapter en permanence à la doctrine d'emploi des forces.

RÉSUMÉ

La gestion des approvisionnements en eau sur un théâtre opérationnel doit répondre à des objectifs d'efficience et de respect de la sécurité sanitaire des personnels. Dans cette perspective, il importe de définir une stratégie globale prenant en compte des impératifs pratiques, sanitaires, technologiques et économiques. L'élaboration d'une doctrine de l'eau doit permettre de fixer les principes clés à respecter en fonction des objectifs prédéfinis, tout en prenant en compte les spécificités des opérations militaires.

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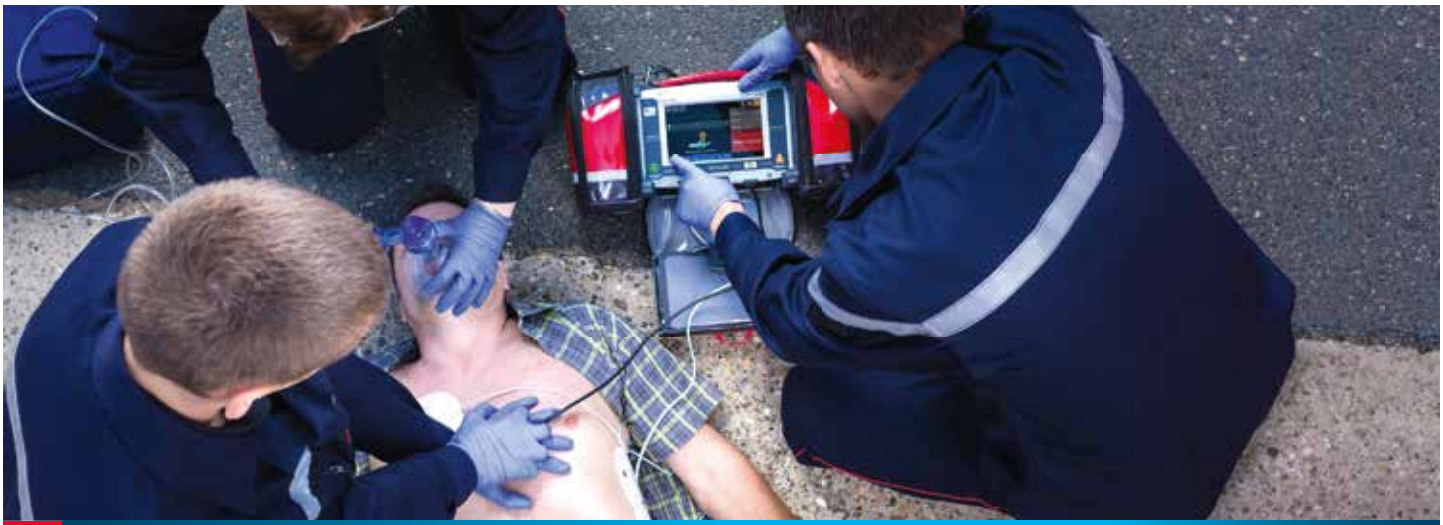

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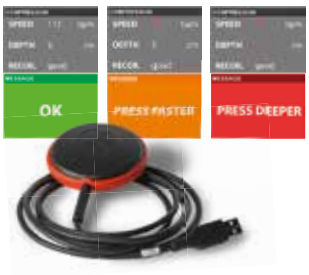

* except in France, Germany, UK and USA

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The Art of Diagnostics

Disease Surveillance by Using Short Message Service (SMS) Among Royal Cambodian Armed Forces (RCAF).*

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Satharath PROM

Major General PROM Satharath was born in 1962. He spent three years studying in Russia as a special technical worker. He joined the military in 1984, and in 1994, he graduated from the Faculty of Medical Sciences in Phnom Penh as a Doctor of Medicine. As a Major, he served as the Deputy Chief of the Technical Office of the Department of Health within the Ministry of National Defense (MoND), and was responsible for the hygiene, prevention, care and treatment training units. As a Colonel, he was promoted to Chief of Technical Office. Since this appointment, he has worked closely with CNM (Cambodia National Malaria Center) on initiatives such as train-the-trainer prevention programs for malaria for the Royal Cambodia Armed Forces. He has extensive inter-agency collaborative experience, having worked with the Cambodian CDC within the Ministry of Health, National Committee for Disaster Management (NCDM), Naval Medical Research Unit-2, Phnom Penh (NAMRU-2), and Armed Forces Research Institutes of Medical Sciences (AFRIMS), as well as the 2010 ASEAN Expert Working Group (EWG) for Military Medicine. In 2011, he was promoted to the rank of Major General, and became a Deputy Director of Department of Health, General Department Logistic and Finance, MoND, where he continues to be actively engaged with national and international efforts to control and eliminate malaria.

RESUME

Surveillance épidémiologique utilisant les SMS (Short Message Services) au sein des forces armées royales Cambodgiennes.

Le manque d'information sur la répartition des maladies et l'absence de système intégré de collection des données au sein du Ministère de la défense du Cambodge constituent une préoccupation prioritaire du Département militaire de la santé (DoH). Depuis août 2011, en collaboration avec l'Unité de recherche médicale de la Marine des Etats-Unis n°2 de Phnom Penh, le DoH a entrepris un projet de surveillance utilisant les SMS. Les bases militaires désignées comme sites de surveillance ont envoyé des messages SMS concernant 16 maladies sous déclaration à une station de collecte située dans chacune des régions militaires. Les résultats sont collationnés par la station régionale et un rapport est envoyé au DoH. Avant la mise en route de ce projet, différentes sessions d'entraînement ont été faites sur l'utilisation des procédures, la définition des cas, l'analyse sommaire des données et l'épidémiologie. En octobre 2015, 48 278 SMS avaient été reçus en provenance de 33 sites localisés dans 7 provinces et concernant 31 247 cas de maladies. Les syndromes grippaux (41,8 %), sont les plus souvent rapportés, suivis par les diarrhées aiguës (33,1 %), les fièvres avec éruption (11,2 %), les blessures (7,2 %), les brûlures et les plaies (2,5 %) et divers (4,2 %). Une extension de la surveillance est envisagée afin de couvrir 15 des provinces du Cambodge.

KEYWORDS: Epidemiological survey, SMS, Armed forces, Cambodia.

MOTS-CLÉS : *Surveillance épidémiologique, SMS, Forces armées, Cambodge.*

BACKGROUND

Surveillance for diseases is essential for health system for early detection of outbreaks, measuring disease burden, change in morbidity and mortality patterns, and timely implementation of control and preventive measures. Disease outbreaks have the potential to give rise to significant public health emergencies because of their capacity to cause illness, death, fear and economic loss on a large scale. Identifying infectious disease outbreaks in their early stages makes the job of management and control of the disease easier and reduces their impact[3, 5].

In low- and middle-income countries, an integrated and continuous disease surveillance system has not been a

priority due to monetary and human resource constraints, including for military personnel, despite their serving as the frontline of defense and security of a country.

In April 2010, the Johns Hopkins University Applied Physics Laboratory (JHU/APL) and the Armed Forces Health Surveillance Center (AFHSC), Division of Global Emerging Infections Surveillance (GEIS) Operations, visited various locations in Southeast Asia, including Phnom Penh, Cambodia, for the purpose of initiating the discussion of electronic disease surveillance systems. At that time, the team made presentations to US Naval Medical Research Unit No. 2, Phnom Penh (NAMRU-2) staff and the Royal Cambodian Armed Forces (RCAF), as well as the Cambodian Ministry of Health (MoH).

As a result of these discussions, the Department of Health, Cambodia Ministry of National Defense (DoH, MoND) in collaboration with the NAMRU-2 and JHU/APL, developed a SMS-based disease surveillance system using *Rapid Android* application. With this surveillance system, it is hoped to optimize disease surveillance at military bases throughout Cambodia.

The disease surveillance within RCAF officially started in August 2011, with ten reporting units under direct command of RCAF Regional 3 in Kampong Speu sending the data by SMS to the main station. In December 2012, additional reporting sites were expanded to include military bases under the command of the Royal Cambodian Navy (RCN), encompassing 23 reporting sites with 3 main stations (Ream Naval Base Sihanoukville, Kampong Speu Royal Cambodian Navy Command Office, and the Royal Cambodian Navy Headquarter). Of the 23 reporting units, 16 reporting units are ground military bases and 7 island bases.

METHODS

Disease surveillance data is transmitted from each reporting unit to the officer in the main station appointed by MoND. Reports are sent daily, including null reports from stations for which there are no reportable cases by using simple SMS messages that contain the date, main station and reporting unit codes, disease codes, and number of cases from a cell phone. All the SMS messages are received by a smart phone with *Rapid Android* application. SMS reports are directly incorporated into an Excel spreadsheet, thereby eliminating the potential for typographical error due to repeated human entry[4]. The officers in the main stations compile and transmit all the SMS data by email attachment (.XLS or .CSV) in a weekly report to MoND in Phnom Penh. The main stations also can generate their own internal reports based on the data that they received from the unit reporting sites under their command using the ESSENCE (Electronic Surveillance System for the Early Notification of Community-based Epidemics) Desktop Edition (EDE), developed by JHU-APL, which can provide numerical and graphical data results. These data are then aggregated monthly and annually into reports generated by MoND and disseminated to all the main stations and stakeholders.

Figure 1 illustrates the flow of the disease surveillance data.

Definition of each disease is syndromic in nature. Seventeen syndromes must be reported by each reporting unit, including disease outbreaks of unknown etiology. Each reporting unit is also required to report the baseline numbers of outpatient consultations and patients classified as "sick in quarters", or too ill to present for duty. Table 1 shows the disease list and their respective reporting codes.

Ongoing support for this program includes initial and refresher trainings in the disease definitions and reporting format. Additionally, training is provided in the use of technology and basics of epidemiology, and site visits are conducted annually at a minimum to facilitate any necessary troubleshooting at the sites. (Figure 2).

Figure 1: System Architecture of RCAF disease surveillance.

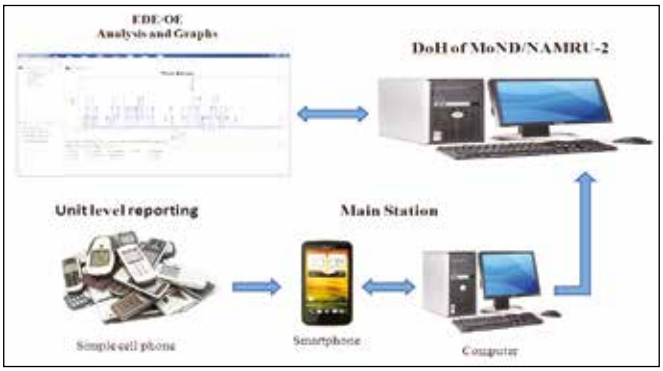


Figure 2: Tabletop Exercices.

❶ Department of Health, General Department of Logistics and Finance, Ministry of National Defense, Cambodia.

❷ US Naval Medical Research Unit-2, Detachment Phnom Penh, Cambodia.

❸ Royal Cambodian Navy Headquarters.

❹ Royal Cambodian Armed Forces, Regional 3.

* Presented at the 41st ICMM World Congress on Military Medicine, Bali, Indonesia, 17-22 May 2015.

Table 1: List of Reportable Diseases and Syndromes under the RCAF Disease Surveillance.

Disease Code	Disease Name
D1	Acute diarrhea
D2	Acute Fever with Rash
D3	Acute Flaccid Paralysis
D4	Influenza like illness (ILI)
D5	Dengue Fever or Dengue Hemorrhagic Fever
D6	Meningitis or Encephalitis
D7	Acute jaundice
D8	Diphtheria
D9	Rabies
D10	Neonatal tetanus
D11	Body injuries
D12	Burns and corrosions
D13	Poisoning by drugs medicaments and biological substances
D14	Suspected radiation
D15	Acute lower respiratory tract inflammatory (pneumonia)
D16	Suspected malaria
D17	Unknown disease outbreak
C1	Consultation
S1	Sick in Quarters

RESULTS

As of October 2015, 48,278 SMS reports have been received from 33 reporting sites, which cover 7 provinces (Kampong Speu, Kampot, Kep, Koh Kong, Phnom Penh, Sihanoukville, and Phnom Penh). 18,879 of these have been generated by RCAF Regional 3 and 29,399 by RCN. These reports include 31,247 cases of infectious diseases, with Influenza-Like Illness (ILI) as the most frequently reported syndrome (41.8%), followed by acute diarrhea (33.1%), acute fever with rash (11.2%), body injuries (7.2%), burns and corrosions (2.5%), and others (4.2%). Figure 3 shows the time series distribution of influenza-like illness syndrome by branch of service.

Figure 4 shows the five most commonly reported diseases between mainland and island military bases. ILIs and suspected malaria cases were reported more frequently from the island military bases (47.8% and 2.6% versus 39.2% and 0.4%, $p < 0.05$), whereas acute febrile rash syndromes were reported more frequently from land stations (12.5% v. 8.2%, $p < 0.05$).

LESSONS LEARNED AND DISCUSSION

The limited number of military personnel with medical or epidemiology training presents challenges to implementing the surveillance system. During the initial years of utilization, problems of inconsistency, incompleteness and reporting delays were recognized. Misunderstanding and misapplication of the disease definitions were also observed to be common[6]. As a result, and as a continuous process improvement intervention, ongoing training has subsequently been provided to involved personnel.

Maintaining motivation for continuous and consistent reporting of disease incidence from each site has also proven difficult in the resource-limited and often isolated settings of military bases. Ongoing financial support from the external stakeholders has been necessary to maintain a functioning system. Further, frequent rotation of military personnel trained in the reporting system remains an additional barrier to sustainability of the disease surveillance project. In addition to the regular training of project staff, it is therefore important to provide education to military personnel and their families about the importance of early presentation to care, reporting, and the potential impact of infectious diseases on military readiness.

Other logistical challenges have included poor cell signal infrastructure in remote areas, sometimes worsened by local conditions, such as inclement weather affecting the island bases in particular. Additionally, technological challenges such as electrical outages and surges have been encountered. To overcome these problems, hard copy log books are maintained as a contingency at all sites, and data is sent to the main stations as soon as conditions permit. Record books are provided to the officers in each reporting unit to record all disease cases in their working areas, which also facilitates data validation and preservation in case of technologic misadventure.

CONCLUSION AND FUTURE PLANS

Disease surveillance via mobile phone mechanisms have been recognized as important public health tools, especially with their low cost and universal applicability[2]. Our experience with such a monitoring system in a resource-limited military setting demonstrates that despite barriers, implementation of a functional system is possible. Further, the data collected can be used as a reference for disease eradication and prevention program in every military base.

Future directions for this project include expanding the surveillance area from 7 provinces into 15 provinces with total 55 reporting units, along with the establishment of the rapid response team at both the regional and headquarter that can provide direct response when an outbreak disease occur. As this system matures, it is hoped that the surveillance network can be expanded through military bases nationwide.

With the timely information generated by this surveillance system, it is hoped that it may also enhance collaboration among health ministry services, which would enable real-time management and monitoring

Figure 3: Influenza-like illness daily distribution.

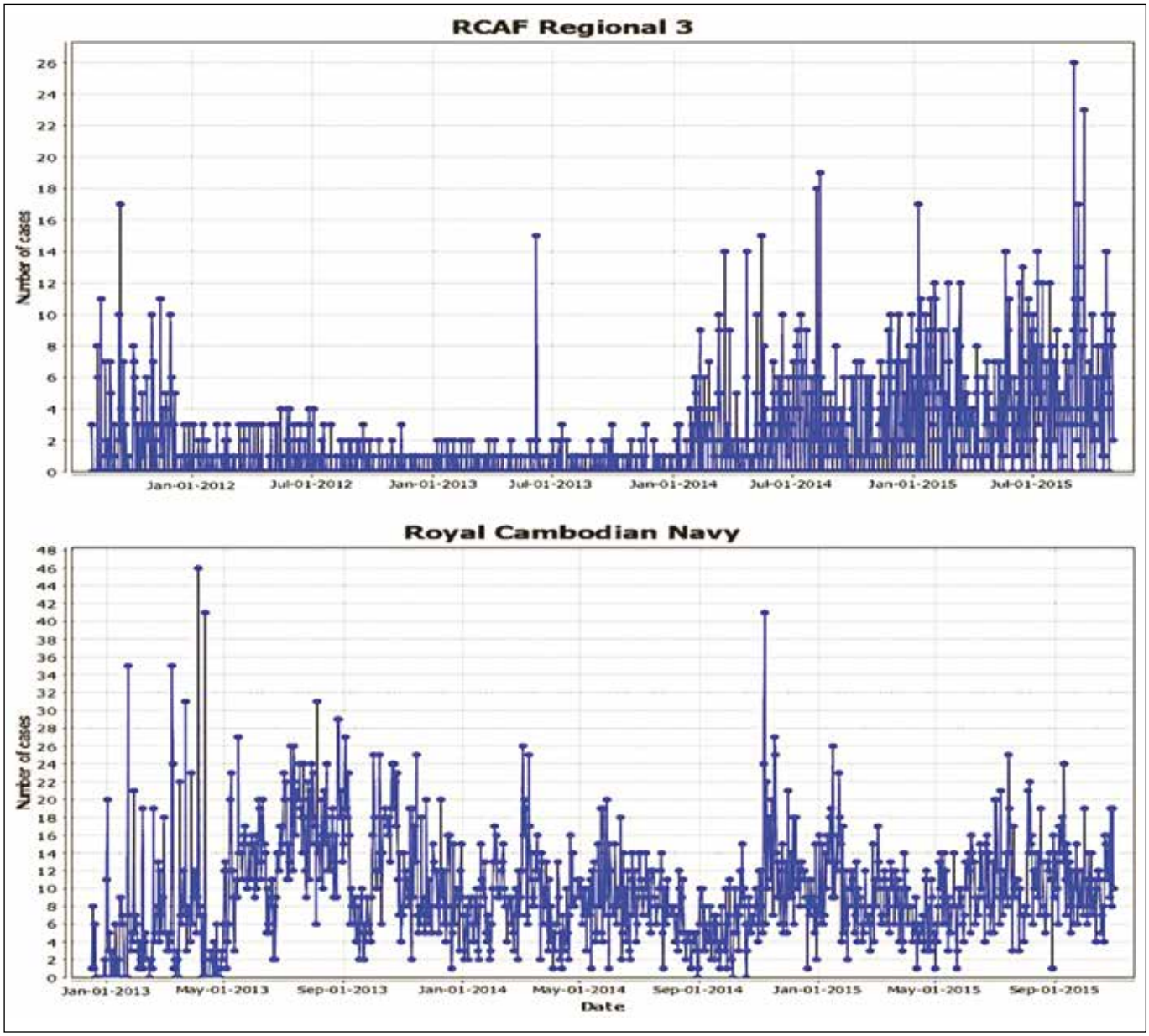
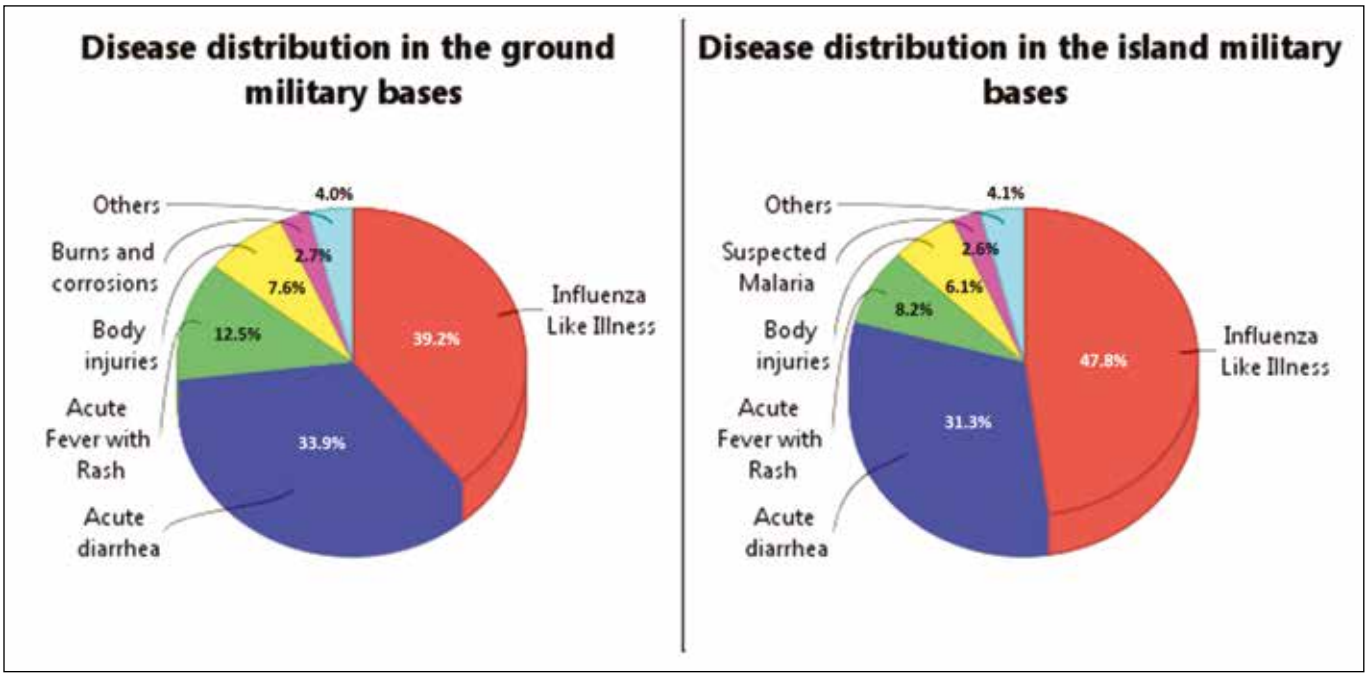


Figure 4: Disease distribution in the ground and island military bases.



of outbreak investigation and control measures. It is also hoped that this process and its outcomes can help to generate support for further public health advances within the military, such as the creation of a basic rapid response team led by the DoH MoND in partnership with external stakeholders. As internal capacity develops, this team could be expanded to an inter-agency collaborative effort within the health-related civilian ministries to meet guidelines established by the International Health Regulations as stipulated by the WHO.

SUMMARY

The lack of adequate information on disease distribution and the absence of an integrated reporting system on military bases within the Cambodian Ministry of National Defense system are of primary concern for the Military Department of Health (DoH). Since August 2011, in collaboration with the U.S. Naval Medical Research Unit-2, Detachment Phnom Penh (NAMRU-2), the DoH has implemented a project to conduct disease surveillance using SMS. Military bases designated as reporting sites send daily SMS text messages, covering 16 reportable diseases, to a main station which is located in each military region. Results are aggregated by the regional station and a report is sent to the Department of Health, Ministry of National Defense. To facilitate this project, various trainings have been conducted on SMS procedures, case definition, basic data analysis, and epidemiology. Recent data reported as of October 2015, 48,278 SMSs have been received from 33 reporting sites, which encompassing 7 provinces, detailing 31,247 cases of disease. Influenza-like illness has been the most frequently reported syndrome (41.8%), followed by acute diarrhea (33.1%), acute fever with rash (11.2%), body injuries (7.2%), burns and corrosions (2.5%), and others (4.2%). Expansion is planned to increase coverage from 7 to 15 provinces in Cambodia.

CONFLICTS OF INTEREST: None

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FINANCIAL SUPPORT: DTRA

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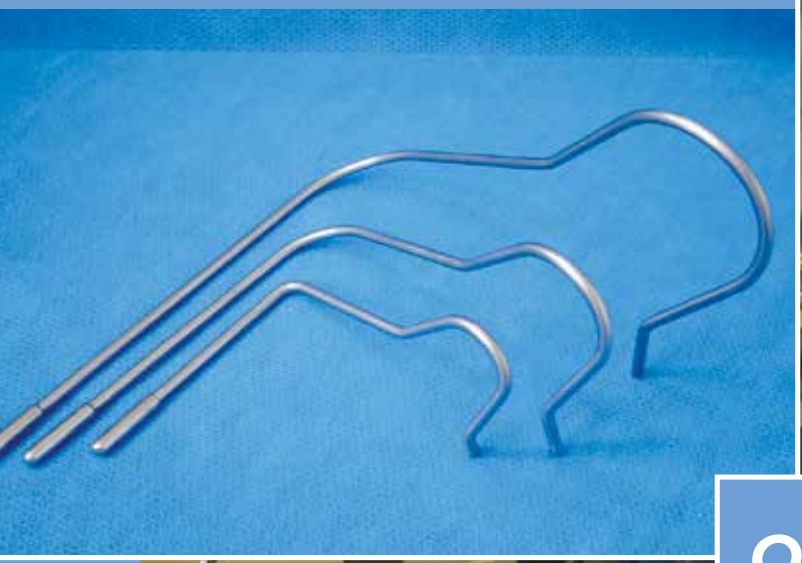

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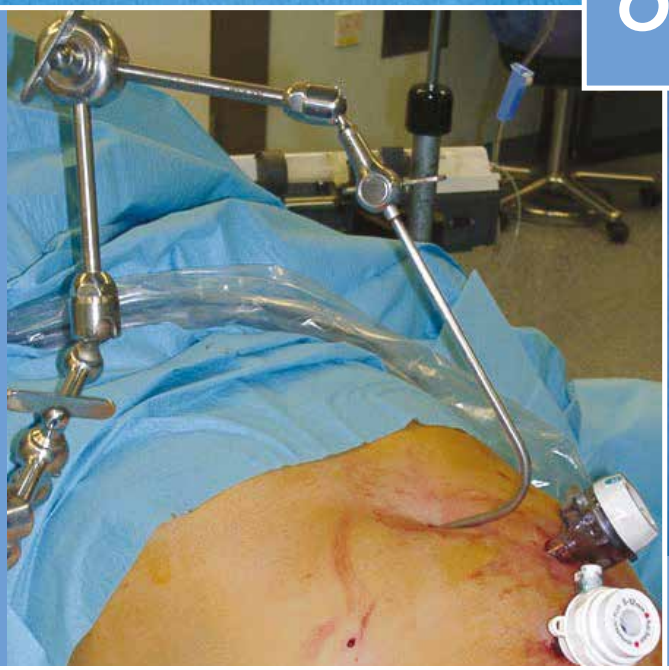

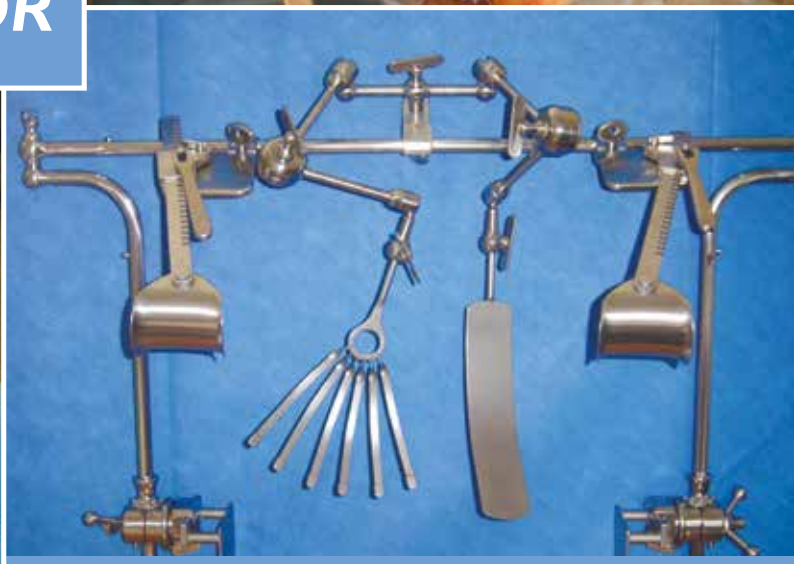

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