



THE MICHIGAN SOCIETY OF THORACIC & CARDIOVASCULAR SURGEONS

53RD ANNUAL SUMMER MEETING

August 9-12, 2018

The Ongoing Evolution of Surgical Coronary Revascularization

John D. Puskas, MD, FACS, FACC

*Chairman of Cardiovascular Surgery, Mount Sinai Saint Luke's & Mount Sinai Beth Israel
Director of Surgical Coronary Revascularization, Mount Sinai Health System
New York City - USA*



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Disclosure:

- National PI of the “Hybrid Coronary Revascularization Observational Trial”, ARRA #1-RC1HL100951
- International PI of the prospective randomized trial of “Hybrid Coronary Revascularization”, NHLBI #RO1- HL125488-01A1
- Royalties from coronary surgical instruments manufactured by Scanlan, Inc
- I make my living doing complex coronary surgery and believe that we must continuously advance the field
- I have an inherent bias towards collaboration rather than competition, including with cardiologists

Evolution of CABG in 2018:

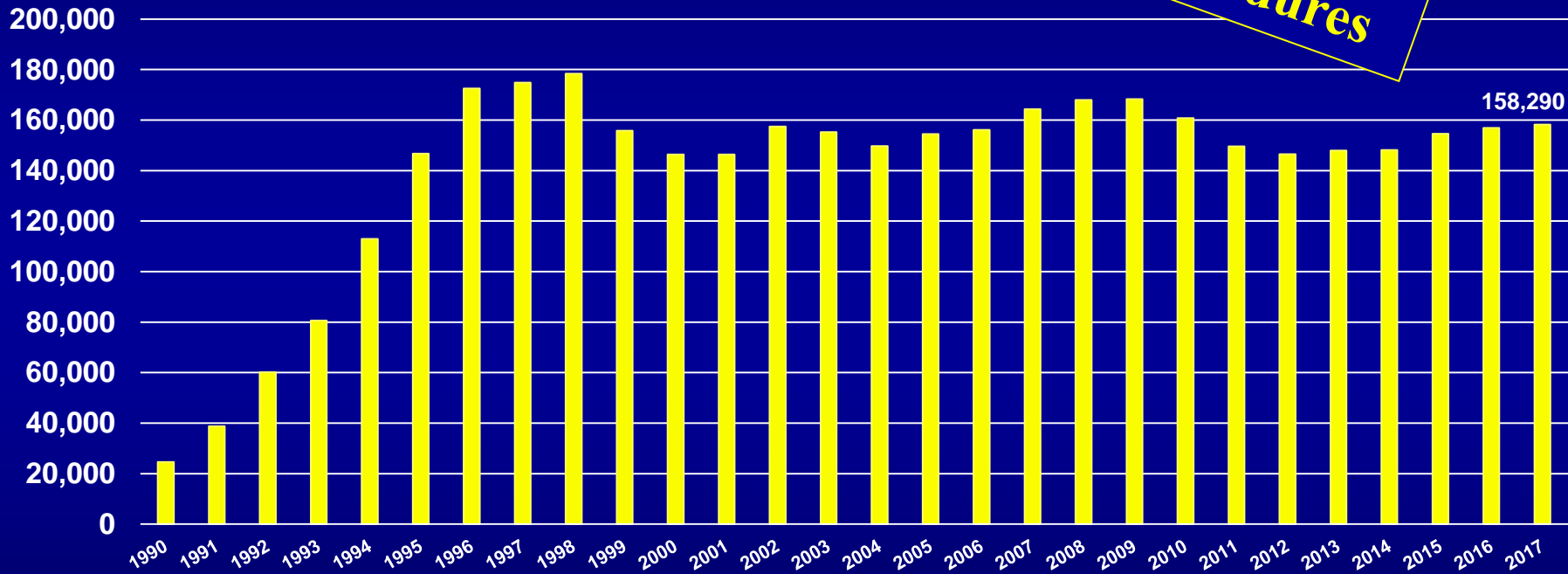
1. **CABG remains important—SYNTAX 5 yr data**
2. Brief History of CABG
3. Current State of CABG—STS Database
4. Ongoing Evolution of CABG with a Focus on Quality Improvement
 1. Improving On-Pump CABG:
 1. Epi-aortic U/S and single X-clamp
 2. Multiple arterial conduits
 3. Graft assessment and DAPT
 2. Improving Off-Pump CABG
 1. Patient and surgeon selection
 2. Epi-aortic U/S and Clampless OPCAB
 3. Evolution towards all-arterial no-aortic-touch OPCAB
 4. Graft assessment and DAPT
5. Robotic and hybrid robotic CABG
6. Optimal Medical Management of CABG Patients
7. The Coronary Heart Team



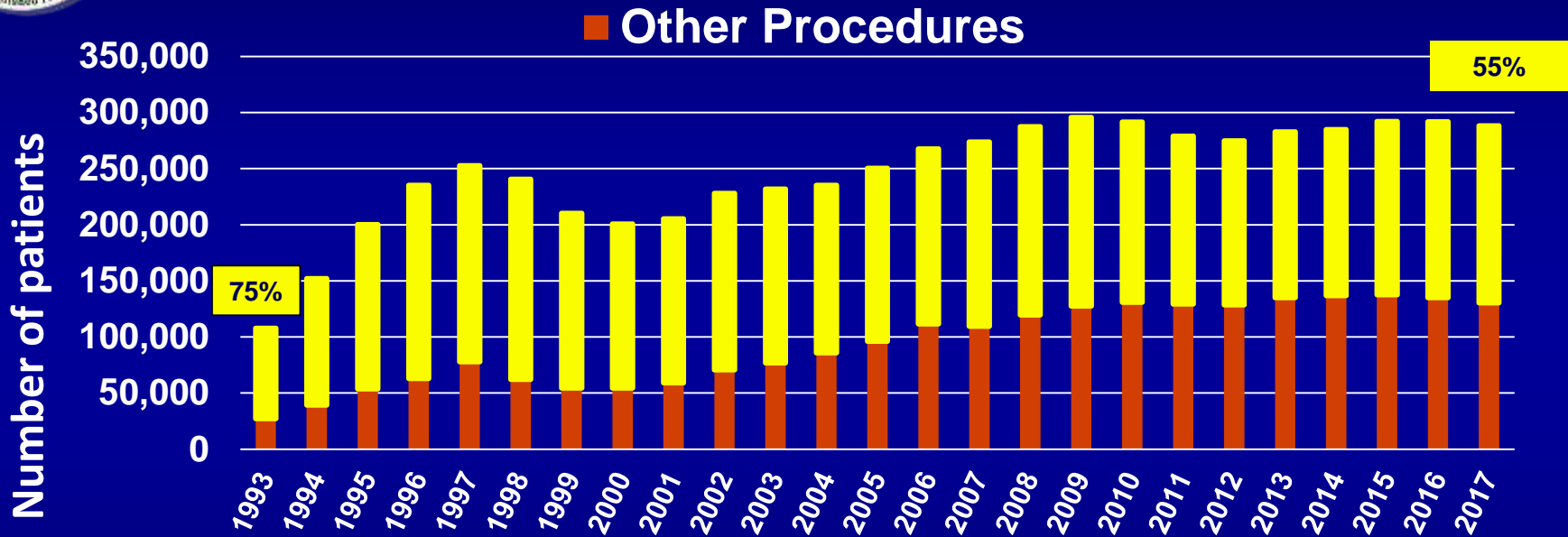


STS National Database CAB Procedures

**3,934,592 Isolated
CAB Procedures**



STS National Database: Procedure Volume 5,873,463 procedures since 1993



**Isolated CAB was 75% of overall procedure volume in 1993
and was 55% of overall procedure volume in 2017**

Coronary artery bypass grafting vs. percutaneous coronary intervention for patients with three-vessel disease: final five-year follow-up of the SYNTAX trial

Conclusion

Five-year results of patients with 3VD treated with CABG or PCI using the first-generation paclitaxel-eluting DES suggest that CABG should remain the standard of care as it resulted in significantly lower rates of death, MI, and repeat revascularization, while stroke rates were similar. For patients with low SYNTAX scores, PCI is an acceptable revascularization strategy, although at a price of significantly higher rates of repeat revascularization.

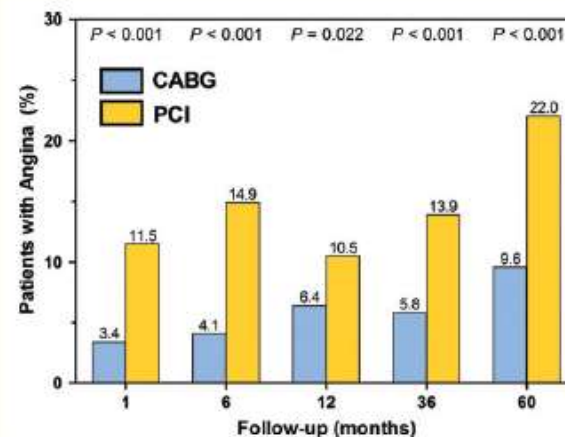


Figure 2 Presence of angina during follow-up. CABG, coronary artery bypass grafting; PCI, percutaneous coronary intervention.

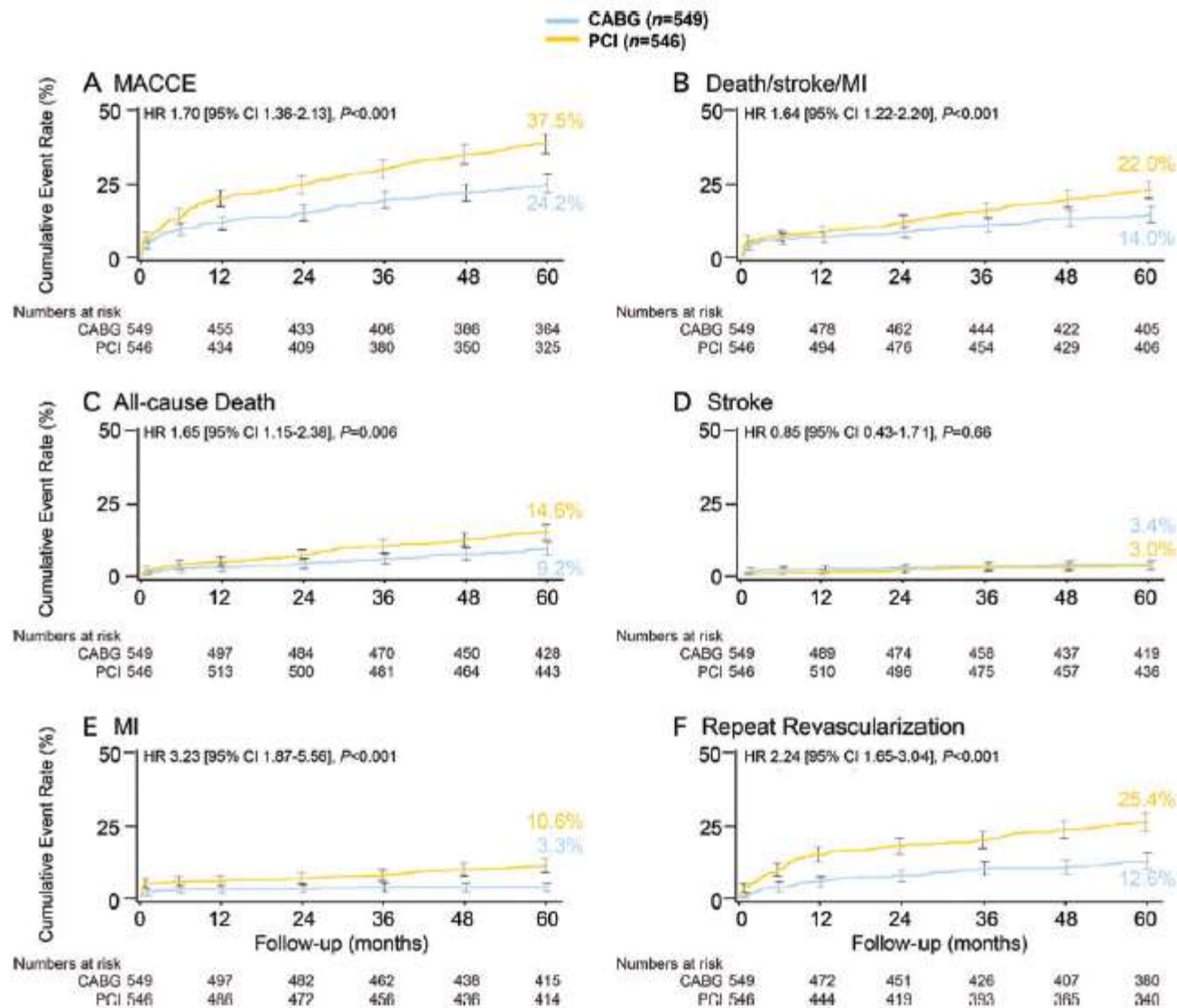


Figure 1 Five-year estimates of adverse events. Kaplan–Meier curves for (A) MACCE, (B) all-cause death/stroke/MI, (C) all-cause death, (D) stroke, (E) MI, and (F) repeat revascularization. Bars represent ± 1.5 standard error. P -values from log-rank test. CABG, coronary artery bypass grafting; CI, confidence interval; HR, hazard ratio; PCI, percutaneous coronary intervention; MACCE, major adverse cardiac and cerebrovascular events; MI, myocardial infarction.

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A Brief History of CABG: From Saphenous Vein to Total Arterial CABG

1. “Experimental” era
2. “Vein Graft” era
3. “Mixed ITA and vein” era
4. “Total arterial Revascularization” era



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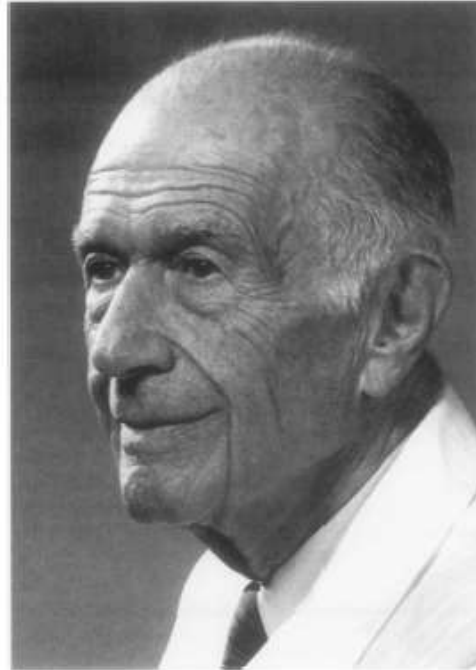


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1st ERA of CABG: “EXPERIMENTAL”



Alexis Carrel first described the concept of operating on the coronary circulation and did so in dogs



The LITA was used in humans as early as 1945 by Arthur Vineberg, who implanted it directly in the myocardium of the left ventricle



Vasilli I. Kolesov published first article reporting successful clinical CABG in 1959

1st ERA of CABG: “EXPERIMENTAL”

The Vineberg Legacy

Internal Mammary Artery Implantation
from Inception to Obsolescence

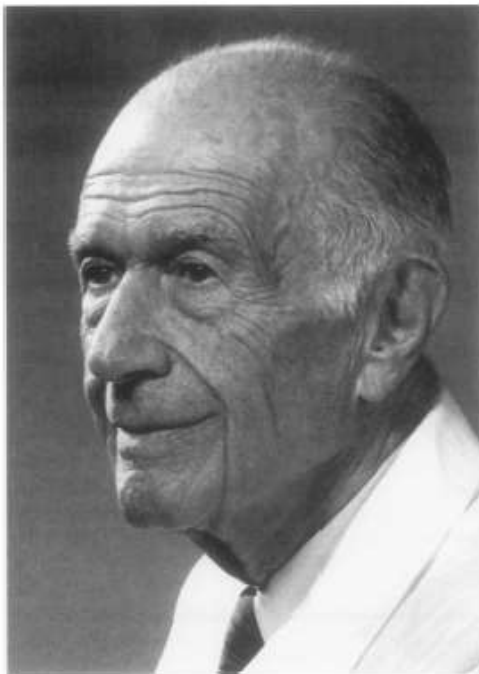


Fig. 1 Arthur M. Vineberg (1903-1988)

Early Experience with the Vineberg Operation

In April 1950, Vineberg performed the 1st IMA implantations in human beings—which he reported the following year.¹⁰ The left IMA was pulled into a myocardial tunnel parallel with the LAD (Fig. 2).¹¹ Although his 1st patient survived for only 62 hours after the procedure, postmortem examination revealed a patent IMA and no evidence of infarction, hemorrhage, or hematoma. The results of his 2nd attempt were more gratifying; the patient lived for 10 years after surgery.¹²

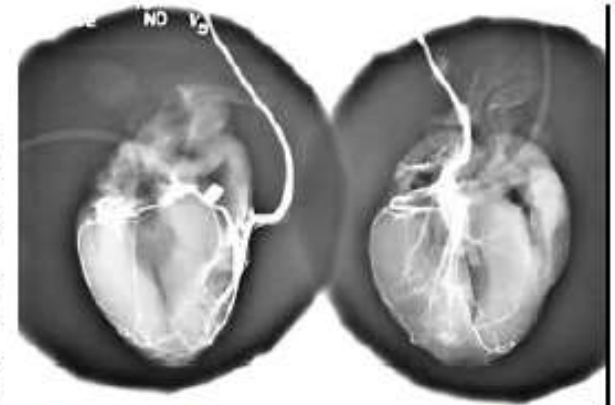


Fig. 4 Angiogram 2 months after insertion of a Vineberg internal mammary artery into the left ventricle of a dog. Note the open communications with branches of the coronary artery.

(From Wakabayashi A, Connolly JE.¹³ Reproduced with permission of the Journal of Thoracic and Cardiovascular Surgery.)

1st ERA of CABG: “EXPERIMENTAL”

First Selective Coronary Arteriogram

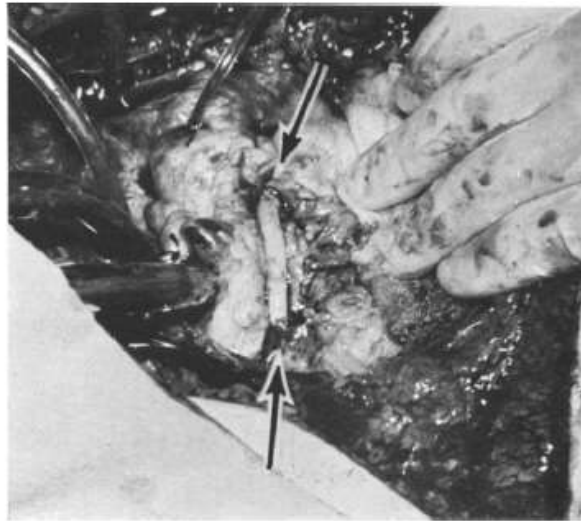


Cine frame from the first selective coronary arteriogram recorded by F. Mason Sones, Jr, on October 30, 1958.

Comment on the methodology:

Dr F. Mason Sones, Jr, of the Cleveland Clinic performed the first selective coronary arteriogram on October 30, 1958.² The selective right coronary arteriogram photographed by Sones on October 30, 1958, was inadvertently obtained during an aortic root injection in a 26-year-old patient with rheumatic heart disease,³ when the catheter whiplashed into the ostium of the right coronary artery. Although the performance of this selective coronary arteriogram was unintentional, it was the first direct injection of a contrast agent into a coronary artery (Figure).

2nd ERA of CABG: VEIN GRAFTS



Saphenous vein autograft at the end of the procedure.



FIG. 1. On the left, the coronary artery is shown dissected and clamped. On the right side, a longitudinal incision is made on top of the obstruction and is elongated until a patent lumen is found. Dotted lines show the place of transection in order to obtain an enlarged stump.

2nd ERA of CABG: VEIN GRAFTS

Saphenous Vein Autograft Replacement of Severe Segmental Coronary Artery Occlusion

Operative Technique

Rene G. Favaloro, M.D.

Direct operation on the coronary artery has been performed in 180 patients at the Cleveland Clinic up to October, 1967. Recently, a new operative technique has been applied in 15 patients with extensive and severe obstruction of the right dominant coronary artery, specifically to overcome some of the unfavorable results that occurred when pericardial patch reconstruction was performed.

FAVALORO

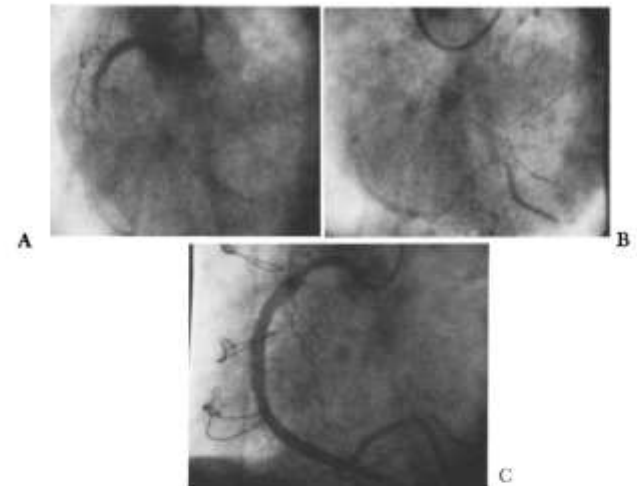


FIG. 5. Coronary angiogram of a 55-year-old Caucasian woman with total occlusion of the right coronary artery (A). Perfusion of distal right coronary artery by collateral branches from the left coronary artery (B). Total reconstruction of right coronary artery by a saphenous vein autograft (C).

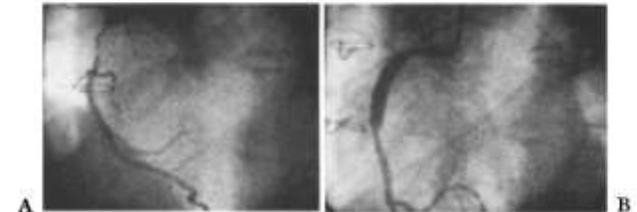


FIG. 6. Coronary arteriogram of a 42-year-old Caucasian man who underwent a right coronary endarterectomy with pericardial patch graft in April, 1967. Post-operative catheterization shows severe segmental occlusion (A). A saphenous autograft replacement was performed in Sept., 1967. Catheterization on tenth post-operative day shows the vessel to be patent (B).

true endarterectomy cannot be performed upon the coronary circulation. Placement of the pericardial patch graft on top of an irregular wall that usually has many crevices provides an ideal stratum for

Aorto-Coronary By-Pass with Autogenous Saphenous Vein Grafts: Histopathological Aspects

M.-C. MARTI, B. BOUCHARDY, and J. N. COX
Department of Pathology, University of Geneva

Received December 16, 1970

Summary. The histological modifications in 8 cases of autologous aorto-coronary saphenous vein grafts were studied. In the early stages, these showed intimal thickening and media hypertrophy, particularly affecting the middle circular layer. The intimal thickening progressed, and the media later became largely replaced by dense fibrous tissue. No aneurysmal dilatations were observed, but in 3 cases the grafts were thrombosed. The pathogenesis of these changes is discussed.

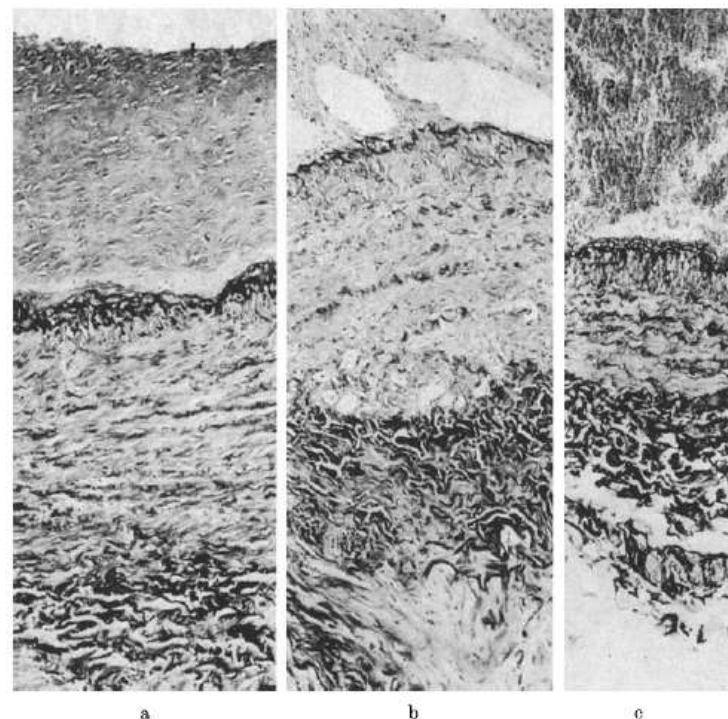
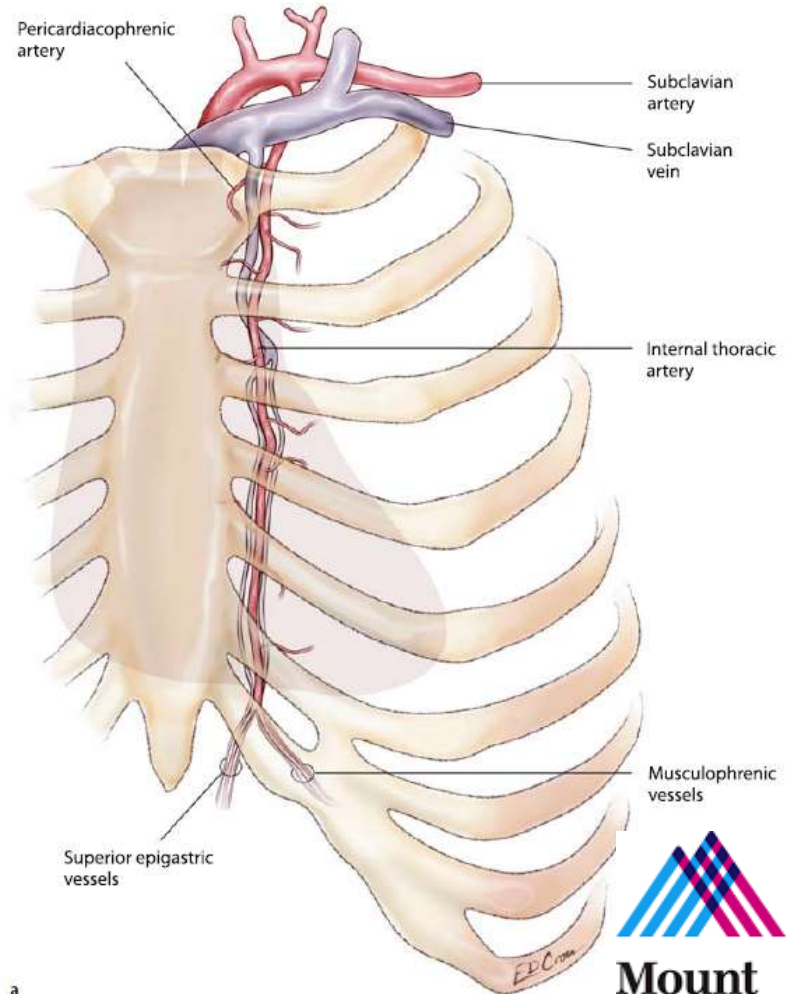


Fig. 9 a-c. Hypertrophy of the wall and intimal hyperplasia, more prominent near the aorto-venous junction (a) than towards the distal coronary-venous junction (b). Compared with contralateral saphenous vein control (c). Case No. 7 (42 days). Van Gieson. 90 ×

3rd ERA of CABG: “MIXED ITA AND VEIN”



In February 1968 Dr George Green performed the first LITA anastomosis to the LAD in the USA.



The New England Journal of Medicine

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Volume 314

JANUARY 2, 1986

Number 1

INFLUENCE OF THE INTERNAL-MAMMARY-ARTERY GRAFT ON 10-YEAR SURVIVAL AND OTHER CARDIAC EVENTS

FLOYD D. LOOP, M.D., BRUCE W. LITTLE, M.D., DELOS M. COSGROVE, M.D., ROBERT W. STEWART, M.D.,
MARLENE GOODMASTIC, M.P.H., GEORGE W. WILLIAMS, PH.D., LEONARD A.R. GOLDING, M.D.,
CARL C. GILL, M.D., PAUL C. TAYLOR, M.D., WILLIAM C. SHELDON, M.D.,
AND WILLIAM L. PROUDFIT, M.D.

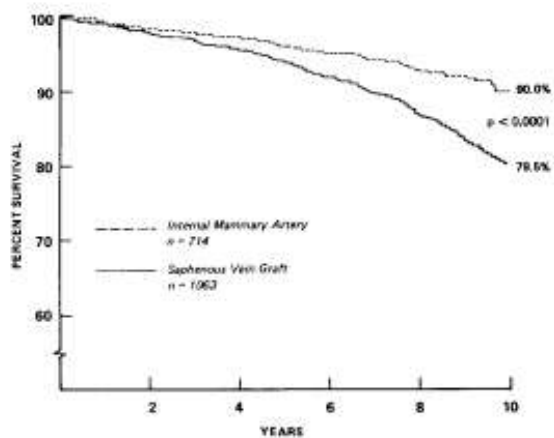


Figure 2. Ten-Year Survival of Patients with Two-Vessel Disease, Including Those with Lesions of the Proximal Anterior Descending Artery.

The difference in survival between the patients who received internal-mammary-artery grafts and those who received saphenous-vein grafts was significant by both univariate and multivariate analysis.

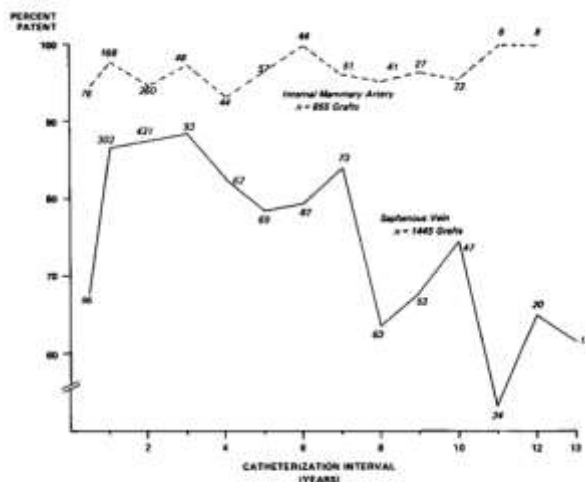


Figure 5. Patency of Internal-Mammary-Artery and Saphenous-Vein Grafts at One-Year Intervals.

The number of patients restudied at each interval is noted.

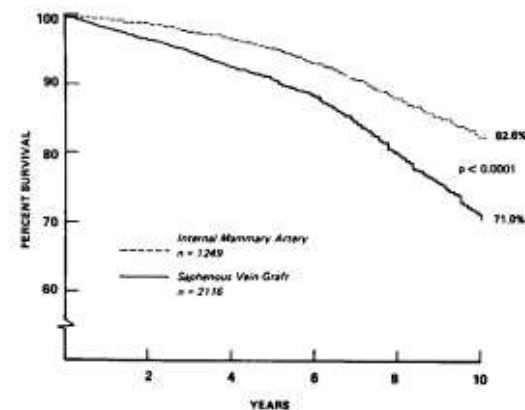


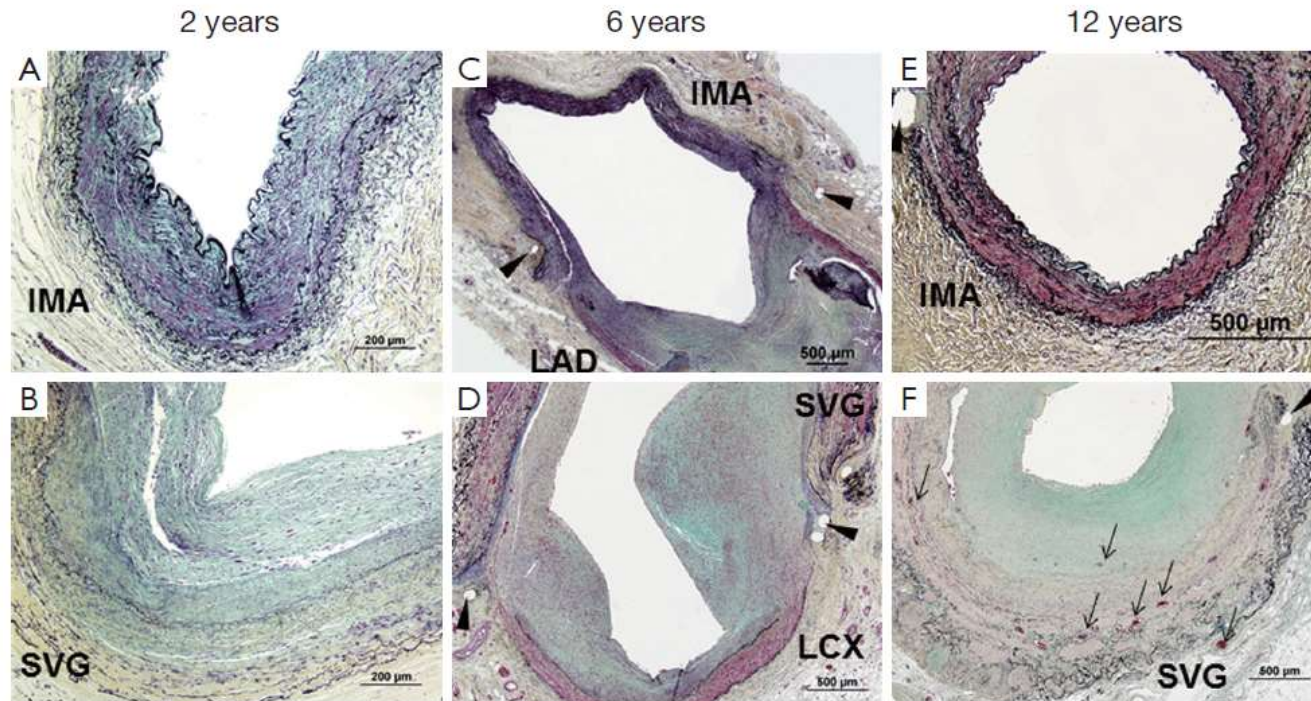
Figure 3. Ten-Year Survival of Patients with Three-Vessel Disease.

The internal-mammary-artery group contained those who had one internal-mammary-artery graft and one or more saphenous-vein grafts. The saphenous-vein-graft group had vein grafts only. The differences between the two groups were significant by both univariate and multivariate analysis.

Why is the mammary artery so special and what protects it from atherosclerosis?

Fumiyuki Otsuka, Kazuyuki Yahagi, Kenichi Sakakura, Renu Virmani

Ann Cardiothorac Surg 2013;2(4):519-526



Comparison of endothelial function of coronary artery bypass grafts in diabetic and nondiabetic patients: Which graft offers the best?

Demet Özkaramanlı Gür, Özcan Gür^d, Selami Gürkan¹, Selcem Cömez², Aylin Gönülltaş*, Murat Yılmaz³

J Cardiol 2015;

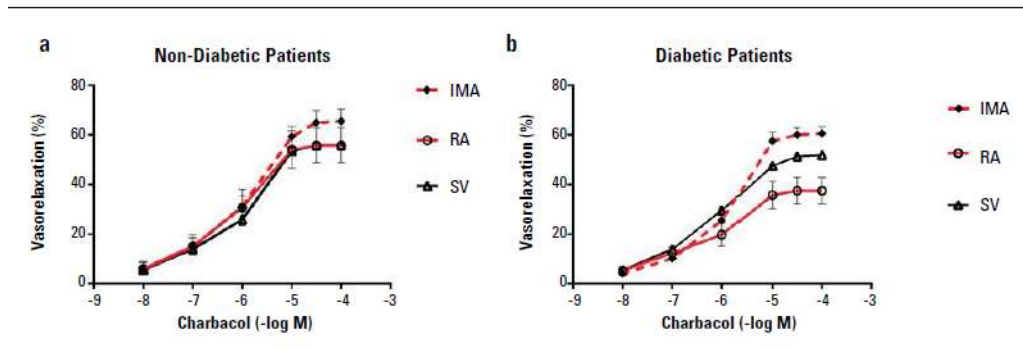


Figure 3. Comparison of vasodilatation responses of all three grafts in nondiabetic patients (3a) and diabetic patients (3b)
IMA - internal mammarian artery; RA - radial artery; SV - saphenous vein

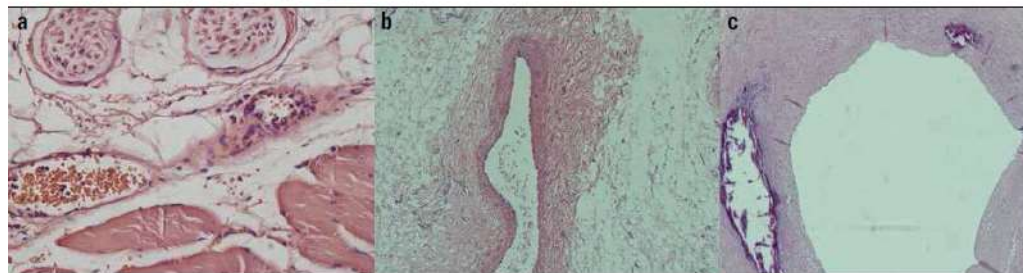


Figure 4. a-c. Sections from diabetic CABG grafts; 4a-SV shows no signs of atherosclerosis, 4b-IMA shows no signs of atherosclerosis, 4c-RA exhibiting intimal thickening and medial calcification

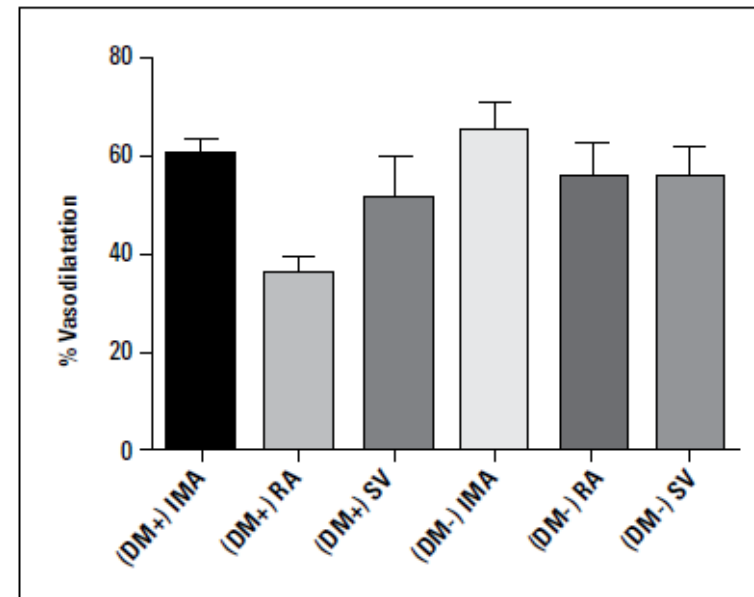
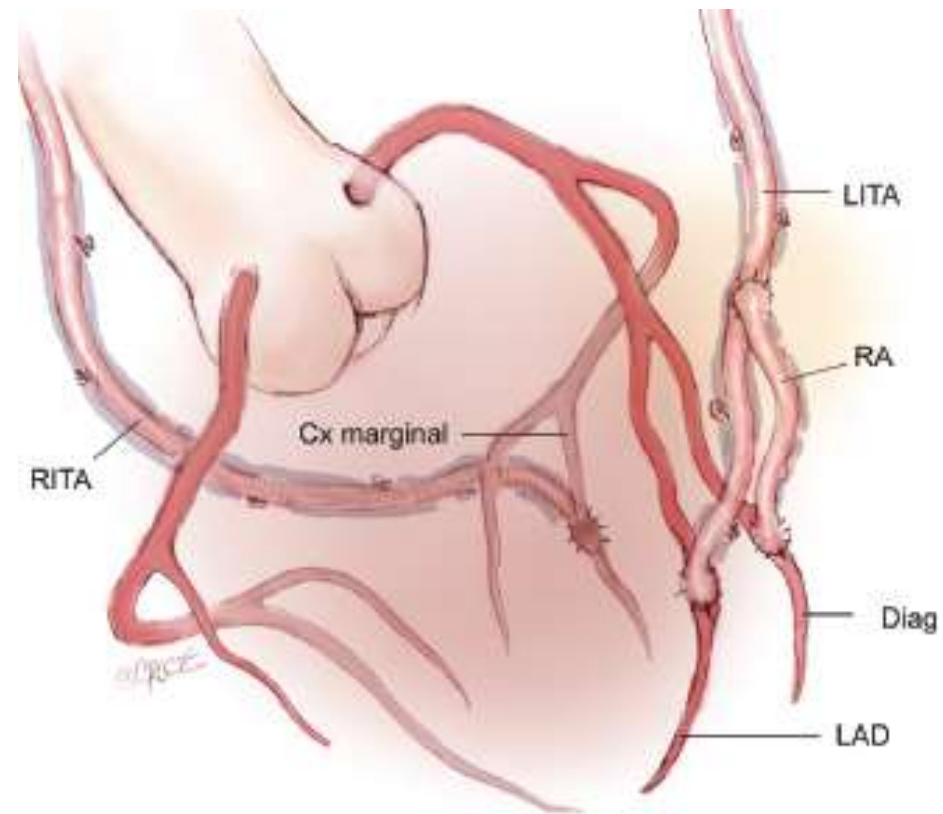
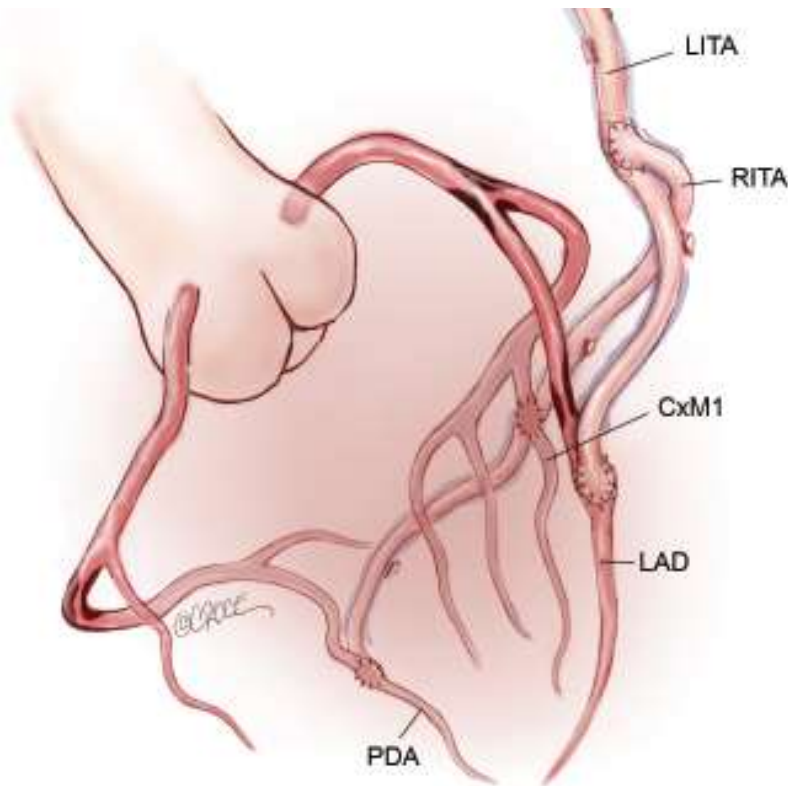


Figure 2. Maximal vasodilatation responses of all grafts
DM - diabetes mellitus; IMA - internal mammarian artery; RA - radial artery; SV - saphenous vein

What makes ITAs special is that they are NO pumps directed into the coronary system

4th ERA of CABG: TOTAL ARTERIAL REVASCULARIZATION

BILATERAL INTERNAL THORACIC ARTERY:



The Journal of THORACIC AND CARDIOVASCULAR SURGERY

SURGERY FOR ADULT CARDIOVASCULAR DISEASE

TWO INTERNAL THORACIC ARTERY GRAFTS ARE BETTER THAN ONE

Bruce W. Lytle, MD
Eugene H. Blackstone MD
Floyd D. Loop, MD
Penny L. Houghtaling, MS
John H. Arnold, MD
Rami Akhrass, MD
Patrick M. McCarthy, MD
Delos M. Cosgrove, MD

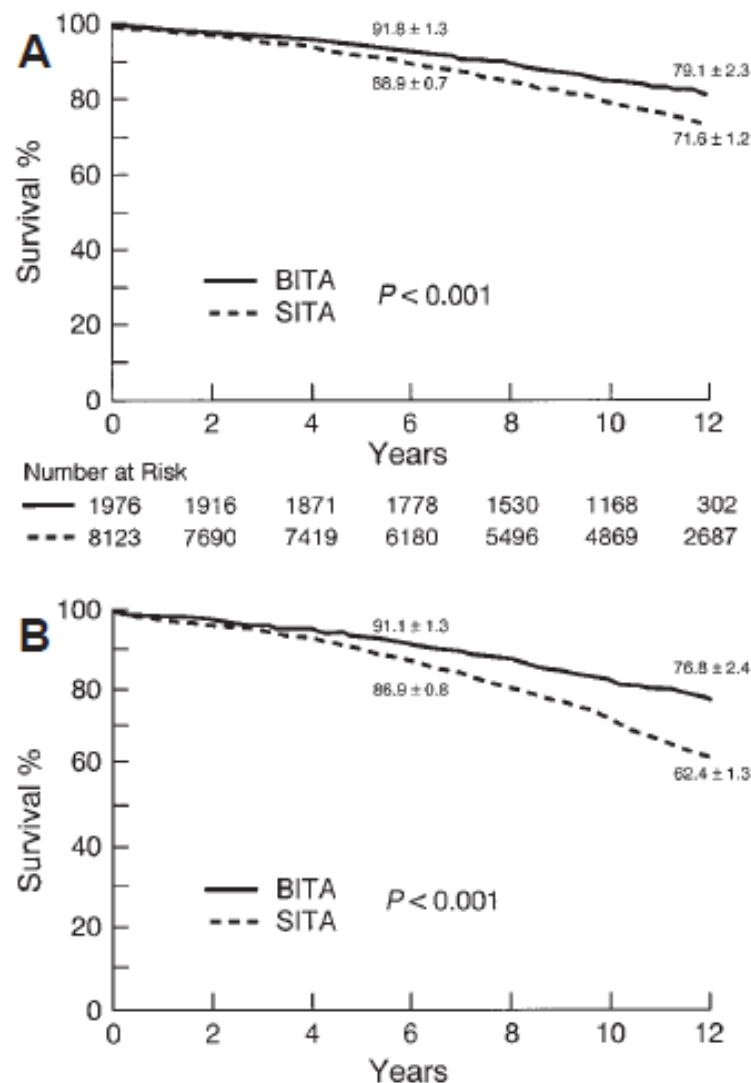
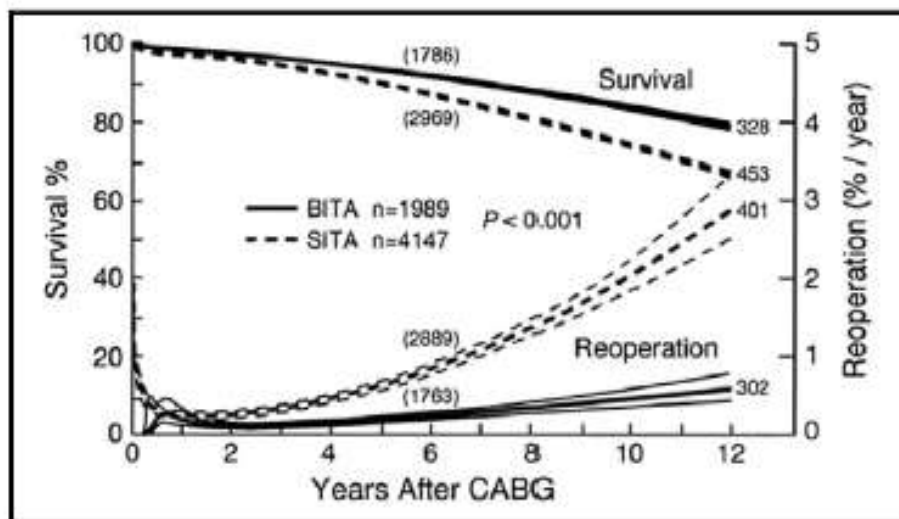


Fig 1. Comparison of the bilateral ITA (*BITA*) and single ITA (*SITA*) groups in terms of survival (**A**) and reoperation-free survival (**B**). Numbers of patients surviving at selected follow-up intervals are listed beneath **part A**.

Once more with emphasis: Two internal thoracic artery grafts are even better than one!

Timothy J. Gardner, MD

The Journal of Thoracic and Cardiovascular Surgery • September 2015



Despite this evidence in 1999, utilization of BITA grafts remains low.

Central Message

Two internal thoracic artery grafts are the best grafting option for patients with multivessel disease, regardless of age. Bilateral internal thoracic artery grafts are both safe and effective.



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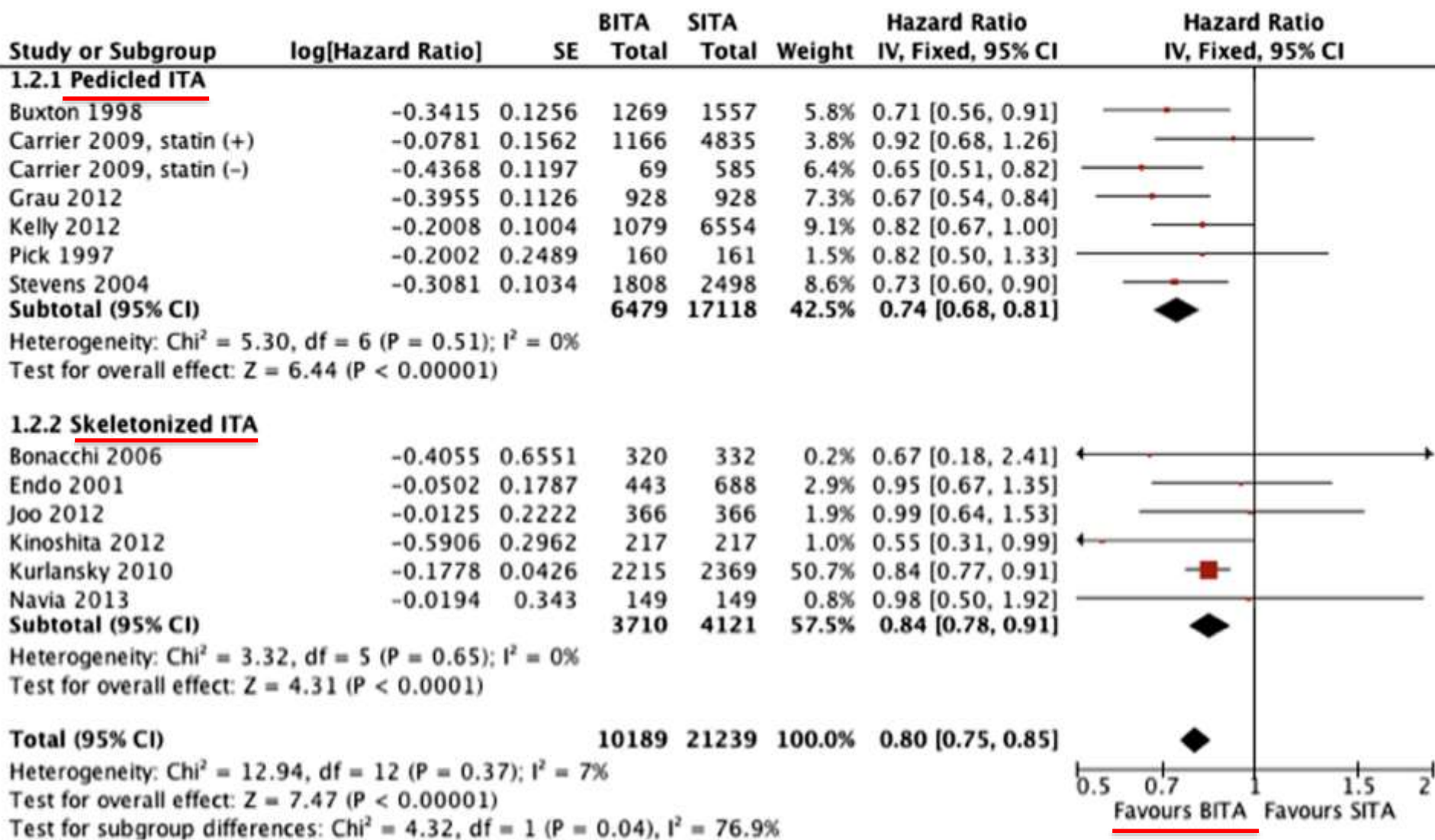
A Meta-analysis of Adjusted Hazard Ratios from 20 Observational Studies of Bilateral Versus Single Internal Thoracic Artery Coronary Artery Bypass Grafting

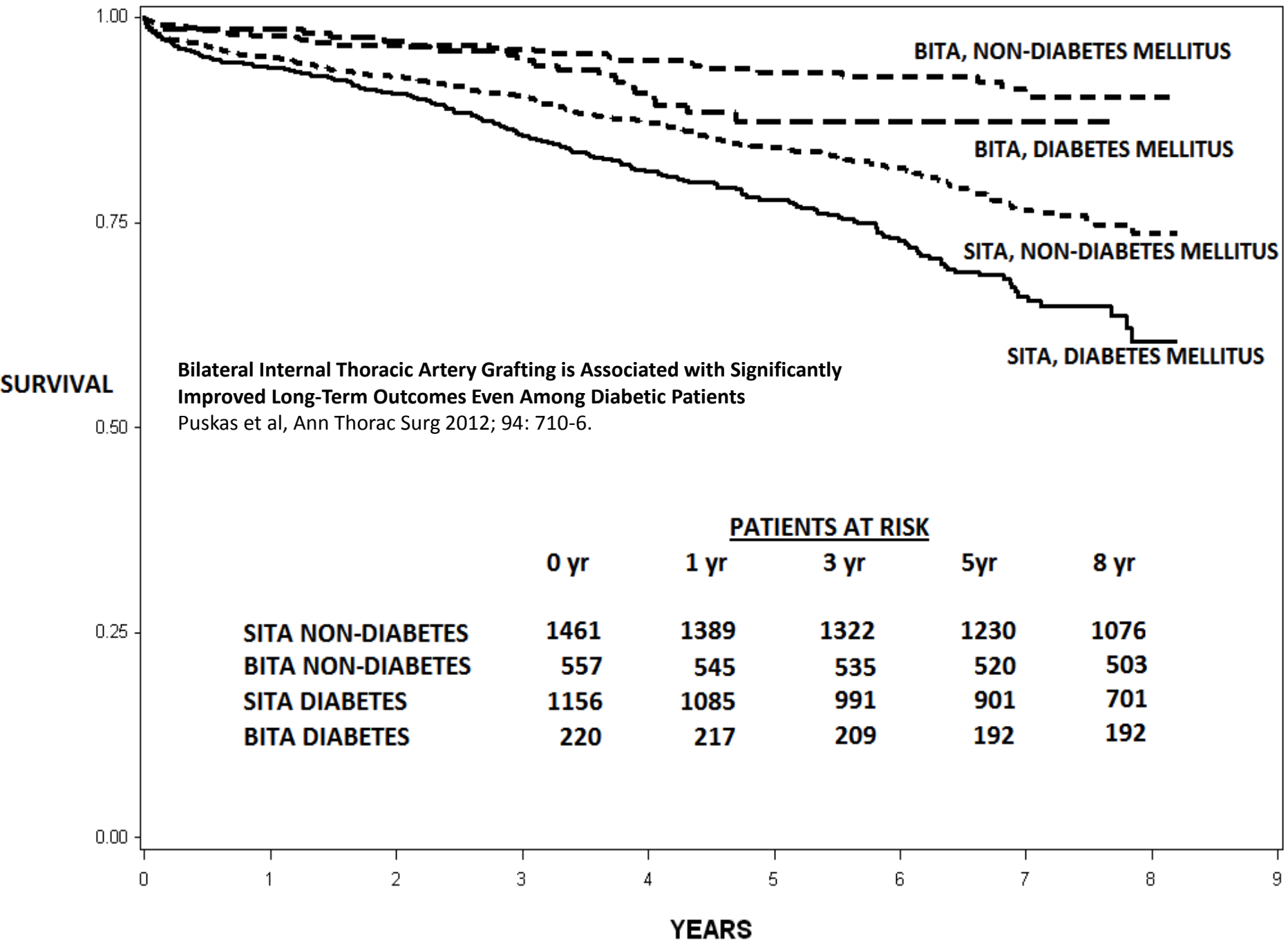
Takagi et al, JTCVS 2014;148:1282-90.

- 20 observational studies; 70,897 patients, pooled analysis
- BITA associated with significant reduction in long-term mortality relative to SITA (HR 0.80; 95% CI 0.77-0.84)
- Benefit of BITA increased in studies with higher proportions of males



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4th ERA of CABG: “TOTAL ARTERIAL REVASCULARIZATION”


RADIAL ARTERY :

The introduction and subsequent revival of the radial artery

The Aorta-to-Coronary Radial Artery Bypass Graft

A Technique Avoiding Pathological Changes in Grafts

Alain Carpentier, M.D., J. L. Guermontprez, M.D., A. Deloche, M.D.,
Claude Frechette, M.D., and Charles DuBost, M.D.

 DR. CARPENTIER: We have had some experience with the internal mammary artery, and I think the magnification techniques utilized by Dr. Green may explain why he is able to minimize the difficulties we have encountered because of the fragility of this artery. I don't think, though, that the discussion should be on the difference between the radial artery and the mammary artery; it should be between venous tissue and arterial tissue. The point would be to learn the true incidence of venous subendothelial proliferation and the comparative hemodynamic function of venous grafts and arterial grafts, and this will require further investigation.

In response to Dr. Kennedy's comments, I am not convinced that mathematics is more important than hemodynamics and biology in the understanding of such problems.

THE ANNALS OF THORACIC SURGERY
*Journal of The Society of Thoracic Surgeons and the
Southern Thoracic Surgical Association*

VOLUME 16 • NUMBER 2 • AUGUST 1973

Revival of the Radial Artery for Coronary Artery Bypass Grafting

Christophe Acar, MD, Victor A. Jebara, MD, Michele Portoghese, MD, Bernard Beyssen, MD, Jean Yves Pagny, MD, Philippe Grare, MD, Juan C. Chachques, MD, Jean-Noël Fabiani, MD, Alain Deloche, MD, Jean Leon Guermonprez, MD, and Alain F. Carpentier, MD, PhD

Department of Cardiovascular Surgery, Hôpital Broussais, Paris, France

(*Ann Thorac Surg* 1992;54:652-60)

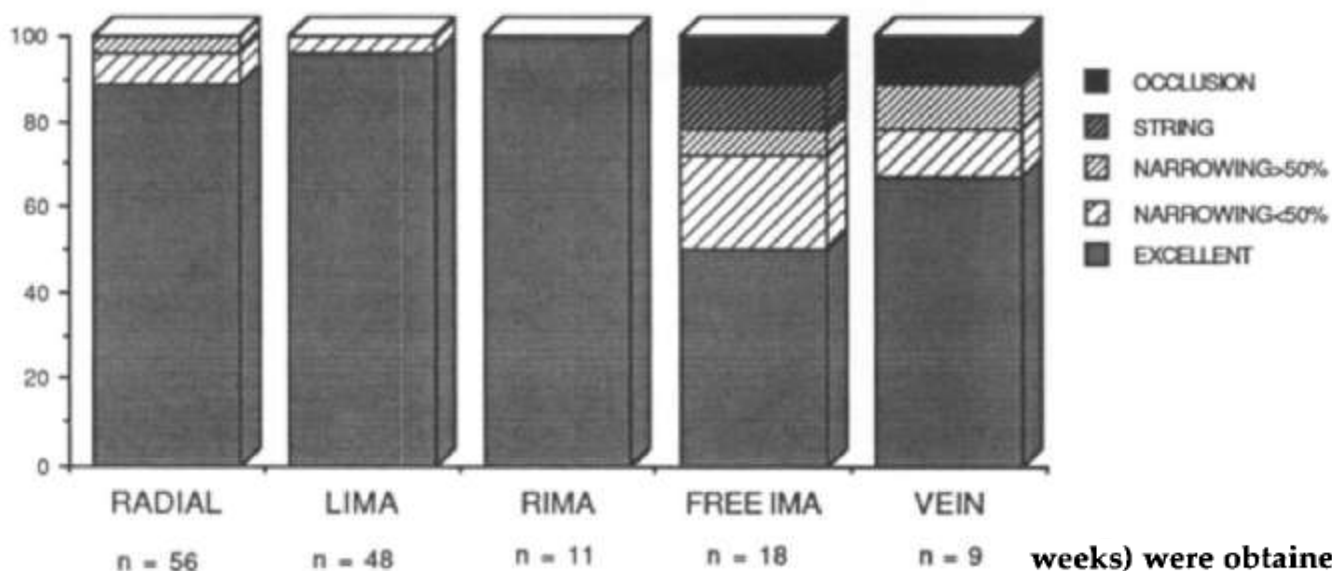


Fig 4. Early angiographic results. (IMA = internal mammary artery; LIMA = left IMA; RIMA = right IMA.)

Early angiographic controls (<2 weeks) were obtained in the first 50 consecutive patients and revealed 56 of 56 patent RA grafts, 48 of 48 patent left IMA grafts, 11 of 11 patent right IMA grafts, 14 of 18 patent free IMA grafts, and 8 of 9 patent vein grafts. Six

Radial Artery and Saphenous Vein Patency More Than 5 Years After Coronary Artery Bypass Surgery

Results From RAPS (Radial Artery Patency Study)

Radial arteries are associated with reduced rates of functional and complete graft occlusion compared with SVGs more than 5 years following surgery. (Multicentre Radial Artery Patency Study: 5 Year Results; NCT00187356) (J Am Coll Cardiol 2012;60:28–35) © 2012 by the American College of Cardiology Foundation

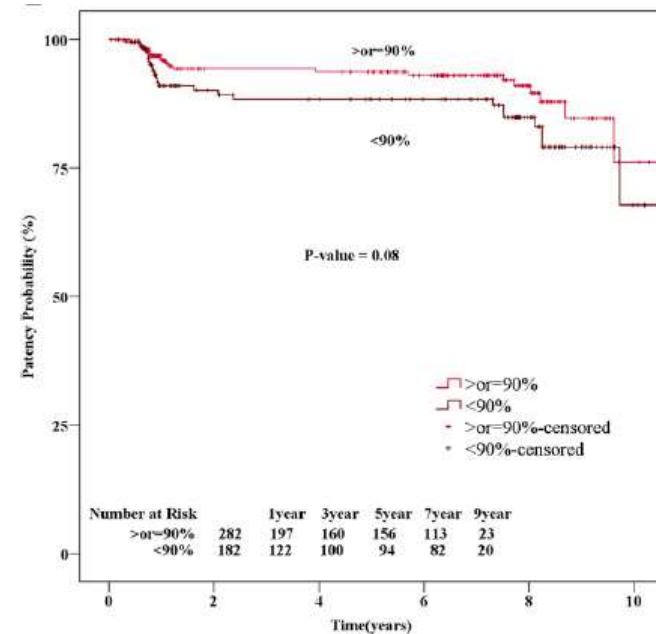
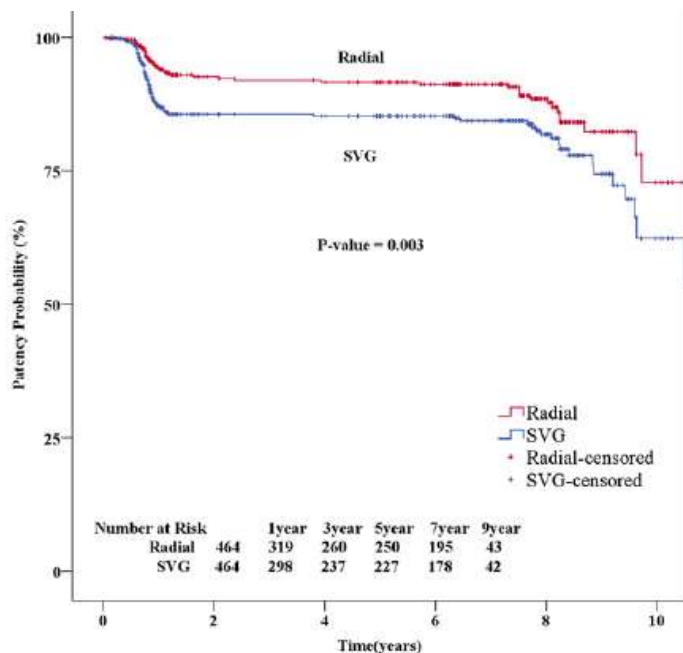


Figure 2

Freedom From Functional and Complete Graft Occlusion

Figure 3

Freedom From Functional and Complete Radial Graft Occlusion According to Target Vessel Stenosis Severity

Multiple arterial bypass grafting should be routine

Robert F. Tranbaugh, MD,^a David J. Lucido, PhD,^b Kamellia R. Dimitrova, MD,^a Darryl M. Hoffman, MD,^c Charles M. Geller, MD,^d Gabriela R. Dincheva, BS,^a and John D. Puskas, MD^a

The Journal of Thoracic and Cardiovascular Surgery • Volume 150, Number 6

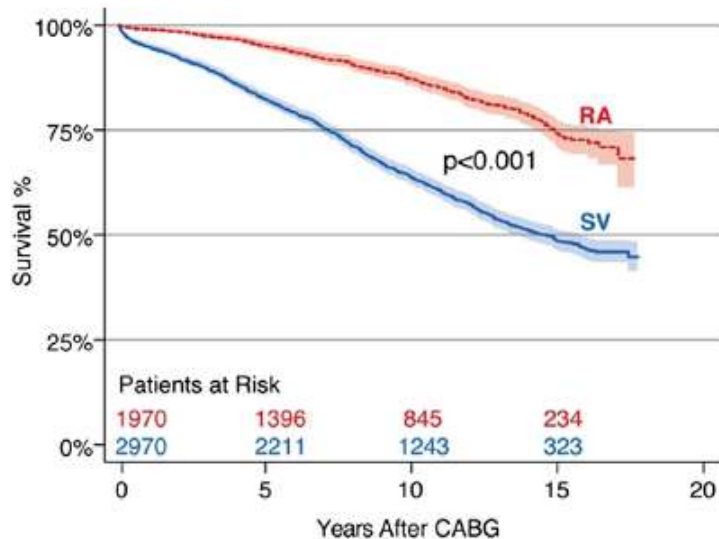


FIGURE 2. Comparison of Kaplan-Meier estimated survival for unmatched radial artery (RA) and saphenous vein (SV) patients (log rank test, $P < .001$). CABG, Coronary artery bypass grafting.

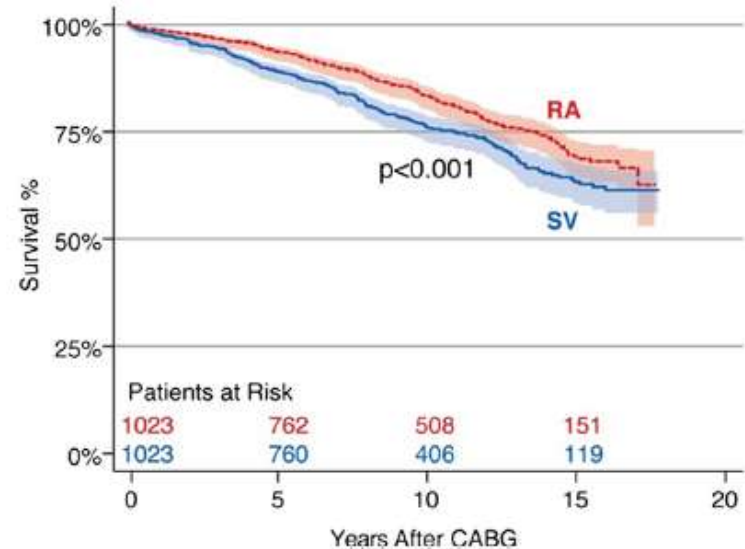


FIGURE 3. Comparison of Kaplan-Meier estimated survival for matched radial artery (RA) and saphenous vein (SV) patients (log rank test, $P < .001$). CABG, Coronary artery bypass grafting.

Conclusions: An 80% rate of MABG has the potential to prevent more than 10,000 deaths annually and add >64,000 person-years of life over the course of 10 years. The use of a second arterial graft during CABG should be routine in the majority of patients undergoing CABG. (J Thorac Cardiovasc Surg 2015;150:1537-45)



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Radial Artery Versus Saphenous Vein in Coronary Artery Bypass Surgery

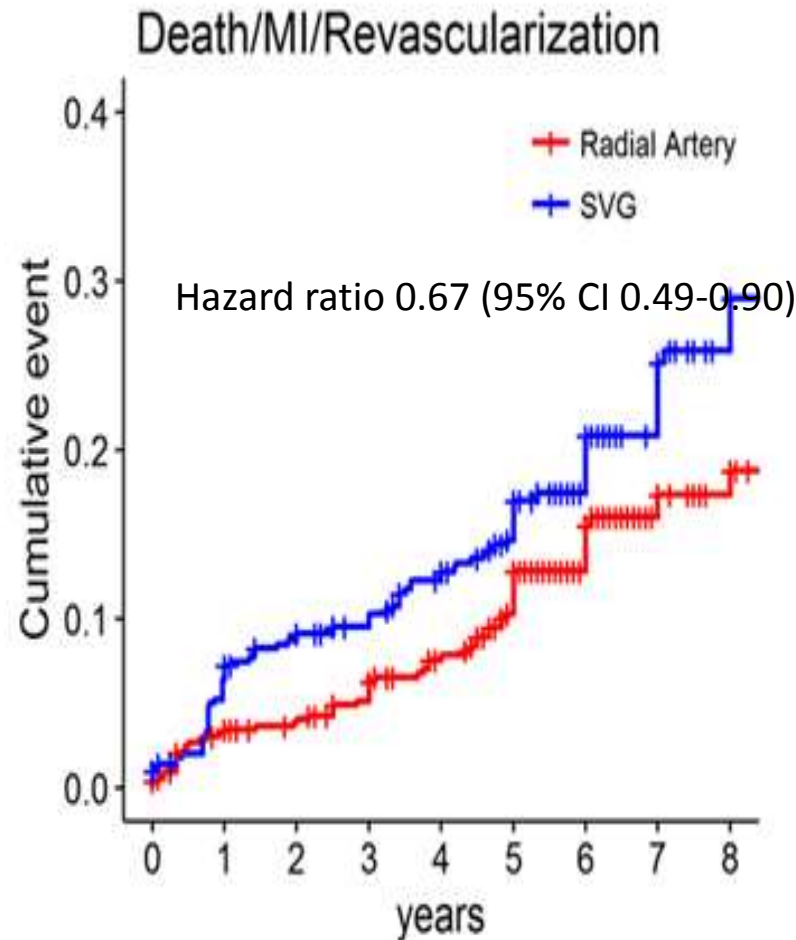
Presented at AATS 2018, San Diego, April 29,
2018 and Published Simultaneously in the New
England Journal of Medicine

Analysis

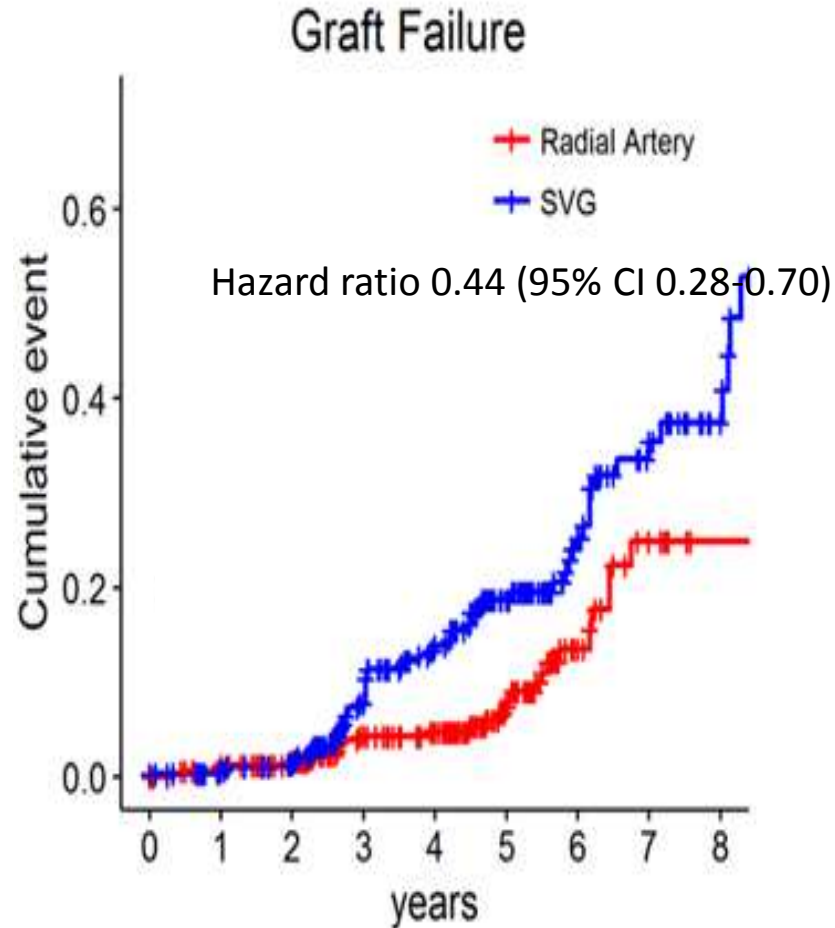


- The principal investigators of the six individual RCTs were contacted and **all agreed** to provide individual patient data and eventually to update the follow-up.
- Patient-level Metanalysis: Mixed-effect Cox regression models were used to estimate the treatment effect on outcomes.
- Pre-specified subgroup analyses for the primary outcome were performed by **age**, **gender**, presence of **diabetes**, prior **myocardial infarction**, left ventricular **ejection fraction** <35%, preoperative **renal insufficiency**, radial-artery graft **target vessel** and use of chronic **antispastic** therapy (angiographic outcome only).

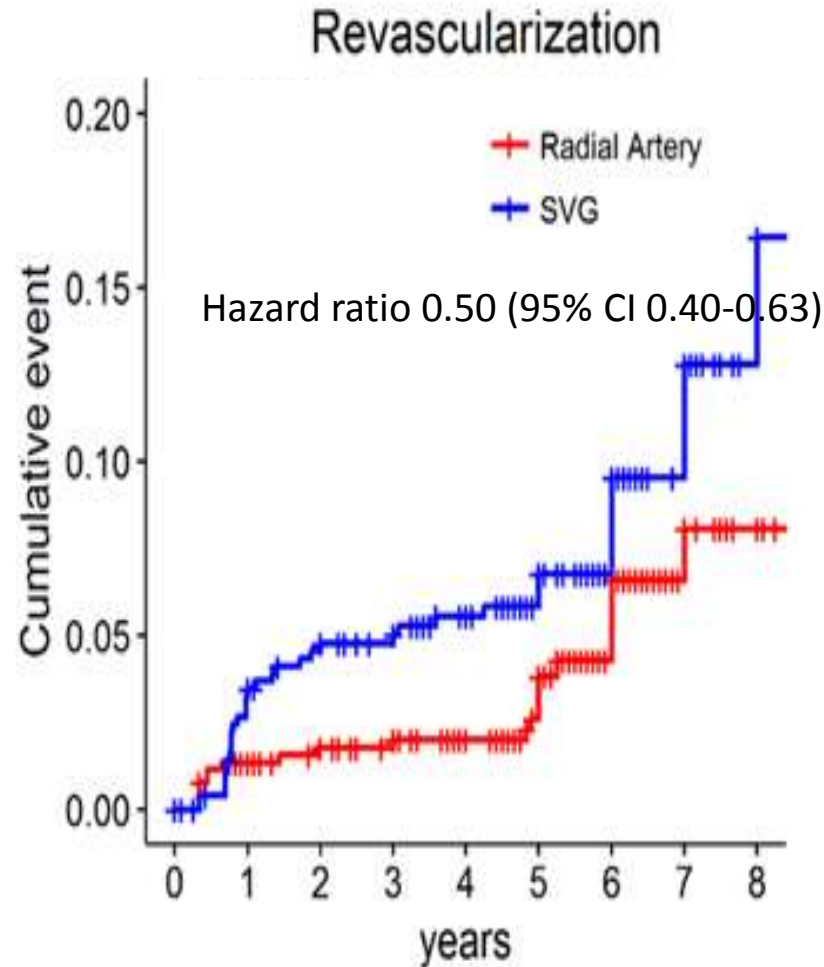
Adverse Cardiac Events at 5 Years



Angiographic Graft Failure



Follow-up: Repeat Revascularization





The NEW ENGLAND
JOURNAL of MEDICINE

ORIGINAL ARTICLE

Radial-Artery or Saphenous-Vein Grafts in Coronary-Artery Bypass Surgery

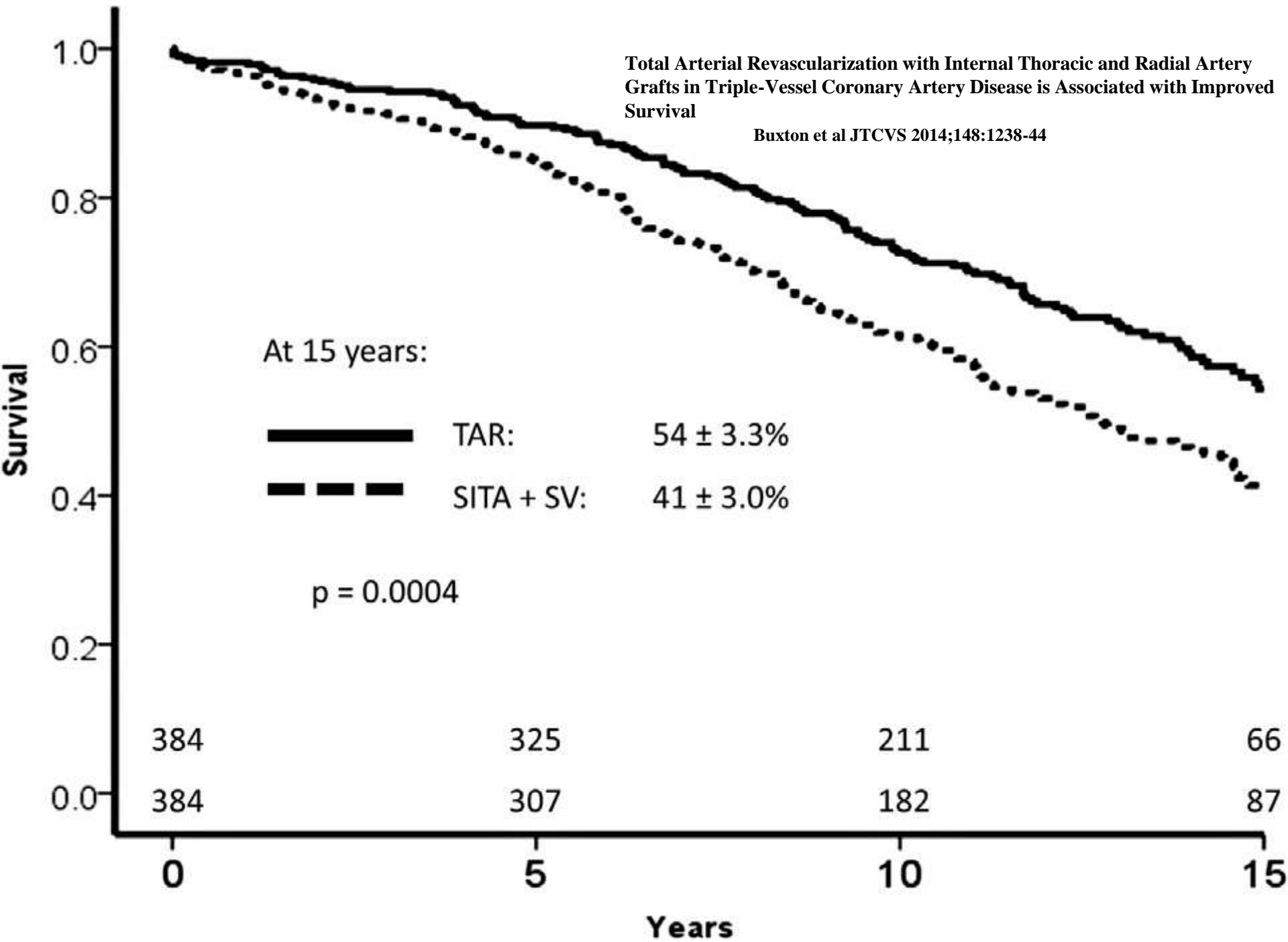
Mario Gaudino, M.D., Umberto Benedetto, M.D., Stephen Fries, M.D.,
Giuseppe Biondi-Zoccai, M.D., M.Stat., Art Sedrakyan, M.D., Ph.D.,
John D. Puskas, M.D., Gianni D. Angelini, M.D., Brian Buxton, M.D.,
Giacomo Frati, M.D., David L. Hare, M.D., Philip Hayward, M.D.,
Giuseppe Nasso, M.D., Neil Moat, M.D., Miodrag Peric, M.D.,
Kyung J. Yoo, M.D., Giuseppe Speziale, M.D., Leonard N. Girardi, M.D.,
and David P. Taggart, M.D., for the RADIAL Investigators*



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Total Arterial Revascularization with Internal Thoracic and Radial Artery Grafts in Triple-Vessel Coronary Artery Disease is Associated with Improved Survival

Buxton et al JTCVS 2014;148:1238-44



Total Arterial Revascularization: Achievable and Prognostically Effective—A Multicenter Analysis

James Tatoulis, MD, FRACS, Rochelle Wynne, PhD, Peter D. Skillington, FRACS, and Brian F. Buxton, MS, FRACS

(Ann Thorac Surg 2015;100:1268–75)

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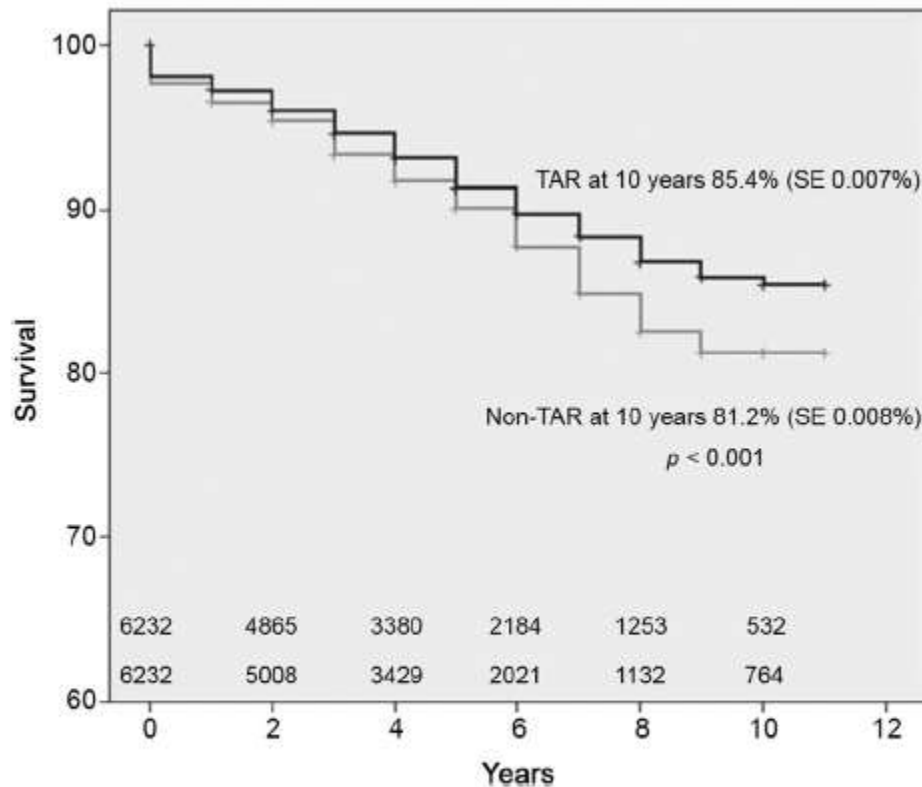


Fig 2. Survival in propensity-matched cohort. (Non-TAR = nontotal arterial revascularization; SE = standard equivalent; TAR = total arterial revascularization; $p < 0.001$.)

Methods. We reviewed 63,592 cases from an audited collaborative multicenter database. Of those, 34,181 consecutive patients undergoing first-time isolated coronary artery bypass (CABG) from 2001 to 2012 were studied. The data were linked to the National Death Index. We compared outcomes in patients who underwent TAR ($n = 12,271$) with outcomes in those who did not ($n = 21,910$). The influence of TAR on 10-year all-cause late mortality was assessed by propensity score analyses in 6,232 matched pairs.

Conclusion

Our study demonstrates long-term benefit for patients having total arterial revascularization for advanced coronary artery disease, yet with excellent perioperative results, and further contributes to the literature that multiple arterial bypass grafts are better in CABG. The challenge is to convince cardiac surgeons to use multiple arterial grafts for the long-term symptomatic and prognostic benefit of our patients.

AHA/ACC/AATS/STS CABG Guidelines 2011

Bypass Graft Conduits



When anatomically and clinically suitable, use of a second IMA to graft the left circumflex or right coronary artery (when critically stenosed and perfusing LV myocardium) is reasonable to improve the likelihood of survival and to decrease reintervention.



Complete arterial revascularization may be reasonable in patients ≤ 60 years of age with few or no comorbidities.

2014 ESC/EACTS Guidelines on Myocardial Revascularization

Procedural aspects of CABG

Recommendations	Class ^a	Level ^b	Ref. ^c
It is recommended to perform procedures in a hospital structure and by a team specialized in cardiac surgery, using written protocols.	I	B	635,636
Endoscopic vein harvesting should be considered to reduce the incidence of leg wound complications.	IIa	A	577,578,580–582, 637,638
Routine skeletonized IMA dissection should be considered.	IIa	B	586–589
Skeletonized IMA dissection is recommended in patients with diabetes or when bilateral IMAs are harvested.	I	B	586–589
Complete myocardial revascularization is recommended.	I	B	594,598,600
Arterial grafting with IMA to the LAD system is recommended.	I	B	602,603,639
Bilateral IMA grafting should be considered in patients <70 years of age.	IIa	B	165,606–610,640, 641
Use of the radial artery is recommended only for target vessels with high-degree stenosis.	I	B	618,642
Total arterial revascularization is recommended in patients with poor vein quality independently of age.	I	C	-
Total arterial revascularization should be considered in patients with reasonable life expectancy.	IIa	B	643
Minimization of aortic manipulation is recommended.	I	B	442,644
Off-pump CABG should be considered for subgroups of high-risk patients in high-volume off-pump centres.	IIa	B	626,627,629
Off-pump CABG and/or no-touch on-pump techniques on the ascending aorta are recommended in patients with significant atherosclerotic disease of the ascending aorta in order to prevent perioperative stroke.	I	B	443
Minimally invasive CABG should be considered in patients with isolated LAD lesions.	IIa	C	
Electrocardiogram-triggered CT scans or eptaortic scanning of the ascending aorta should be considered in patients over 70 years of age and/or with signs of extensive generalized atherosclerosis.	IIa	C	-
Routine intraoperative graft flow measurement should be considered.	IIa	C	-

Advancing the State of the Art in Surgical Coronary Revascularization

Puskas JD, Yanagawa B and Taggart DP *Ann Thorac Surg* 2016;101:419-21.

- Invited Editorial to accompany Aldea et al, the STS Workforce on Evidence Based Surgery Task Force's "Clinical Practice Guidelines on Arterial Conduits for Coronary Artery Bypass Grafting", based on a systematic review of the literature
- Nuanced changes:
 - Recommend bypassing LAD with ITA, not just LITA, in recognition that LITA and RITA have similar patency when grafted to LAD
 - Recommend use of "a second arterial conduit", recognizing that comparison of patency and clinical outcomes after radial artery versus RITA inconclusive (both shown superior to LITA plus SVG)
 - Recommend BITA grafting when risk of DSWI acceptable
 - Recommend skeletonized BITA harvest, smoking cessation, glycemic control, rigorously stable sternal closure to minimize risk of DSWI
 - Do not specify a minimum native stenosis for use of RA graft, but recommend its use for "severe stenosis", recognizing that patency is determined by complex interplay of factors
 - Does not include an age threshold for arterial revascularization



Advancing the State of the Art in Surgical Coronary Revascularization

Puskas JD, Yanagawa B and Taggart DP Ann Thorac Surg 2016;101:419-21.

- **Technical Details of Arterial Grafting:**
 - Risk of spasm of arterial conduits is directly related to the amount of trauma they experience during harvest and grafting. Atraumatic harvest technique may be more important than pharmacological prophylaxis in preventing spasm of ITA and RA conduits. Skeletonized ITA harvest with Harmonic Scalpel.
 - Beware native competitive flow patterns during complex multiarterial grafting. Composite arterial conduits should be designed to avoid unbalanced competitive flow.
 - Precise anastomotic technique is essential to effective use of multiple arterial conduits
 - Confirming patency with intraoperative transit-time doppler is useful.
- **Opinion:** All-arterial clampless OPCAB may offer the combined benefits of minimizing perioperative stroke risk and maximizing long-term graft patency
- **Advocacy:** Use of a second arterial conduit should be an STS Quality metric and should be rewarded with higher reimbursement by CMS.

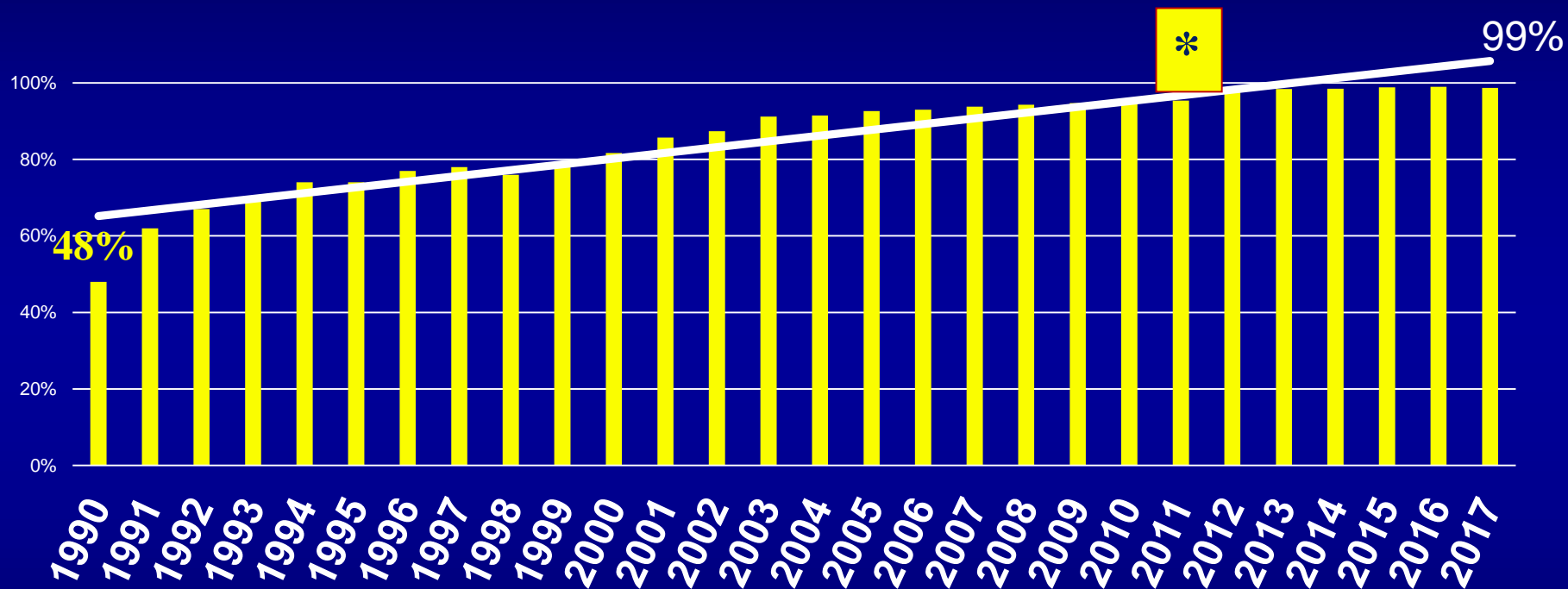


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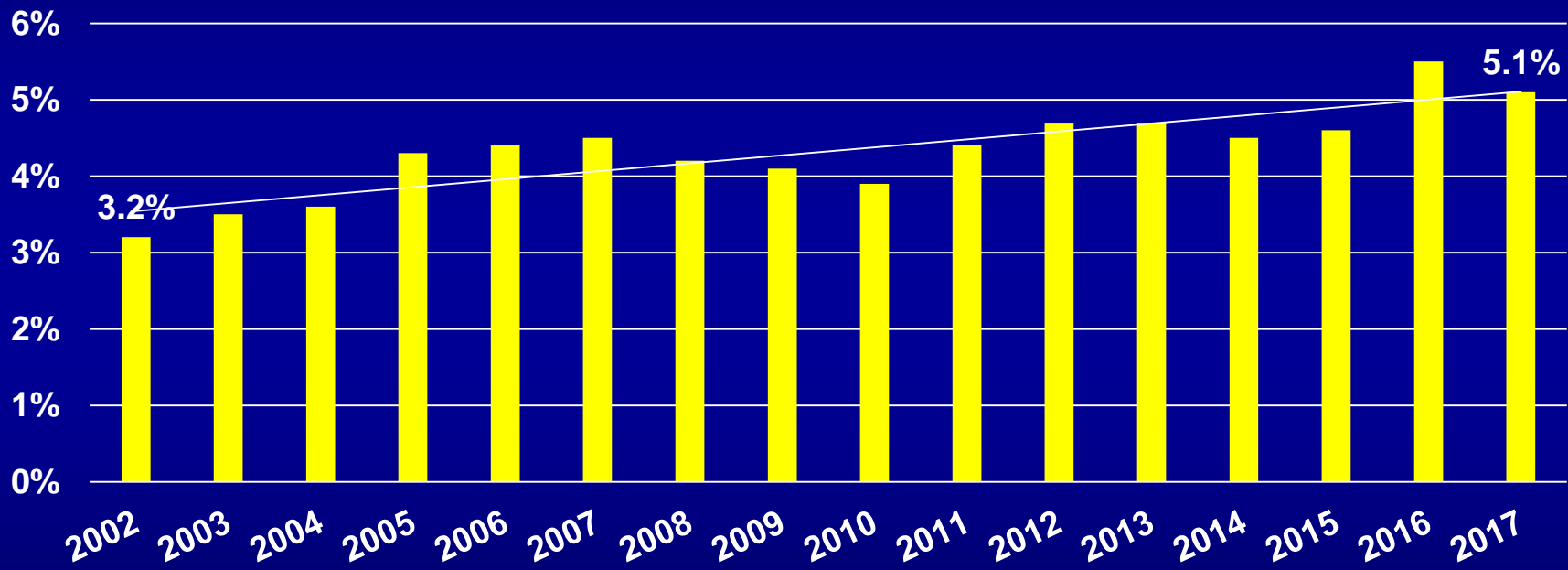
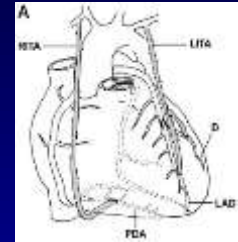
STS National Database: Isolated CAB IMA Use [excludes prior CAB]



* Exclusion criteria: Primary reason for not using added to STS NCSDb: IMA is not a suitable conduit due to size or flow, Subclavian stenosis, Previous cardiac or thoracic surgery, Previous mediastinal radiation, Emergent or salvage procedure, No LAD disease

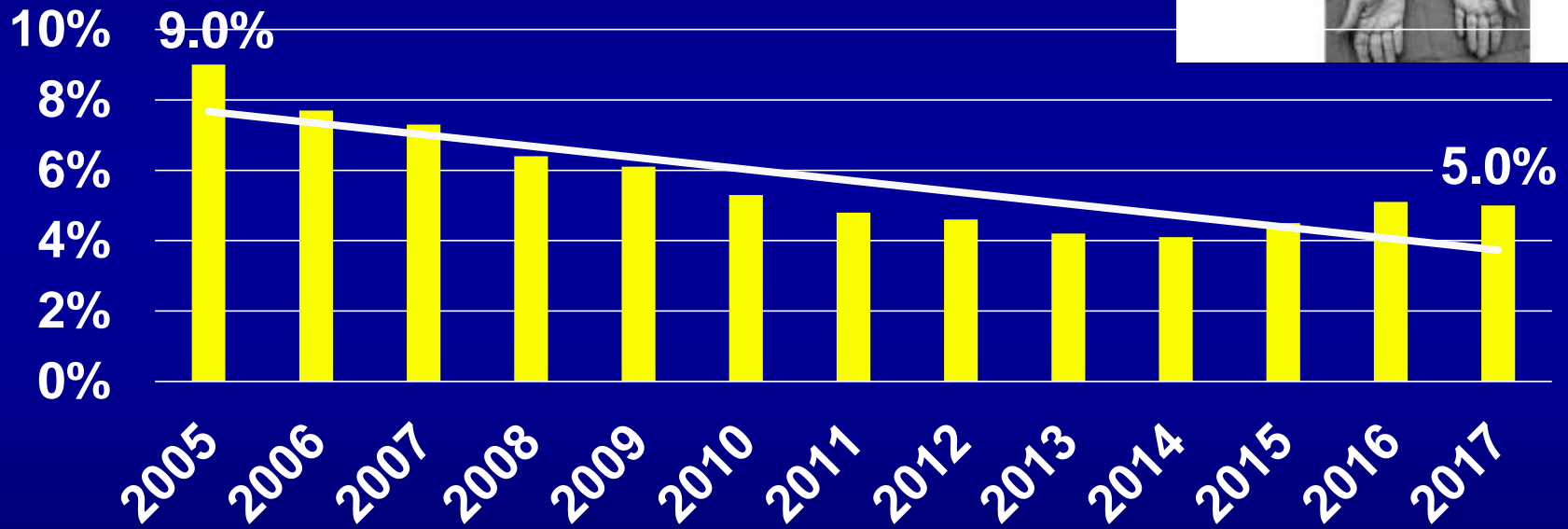


STS National Database: Isolated CAB Bilateral IMA Use [prior CAB excluded]





STS National Database: Isolated CAB Radial Artery Used



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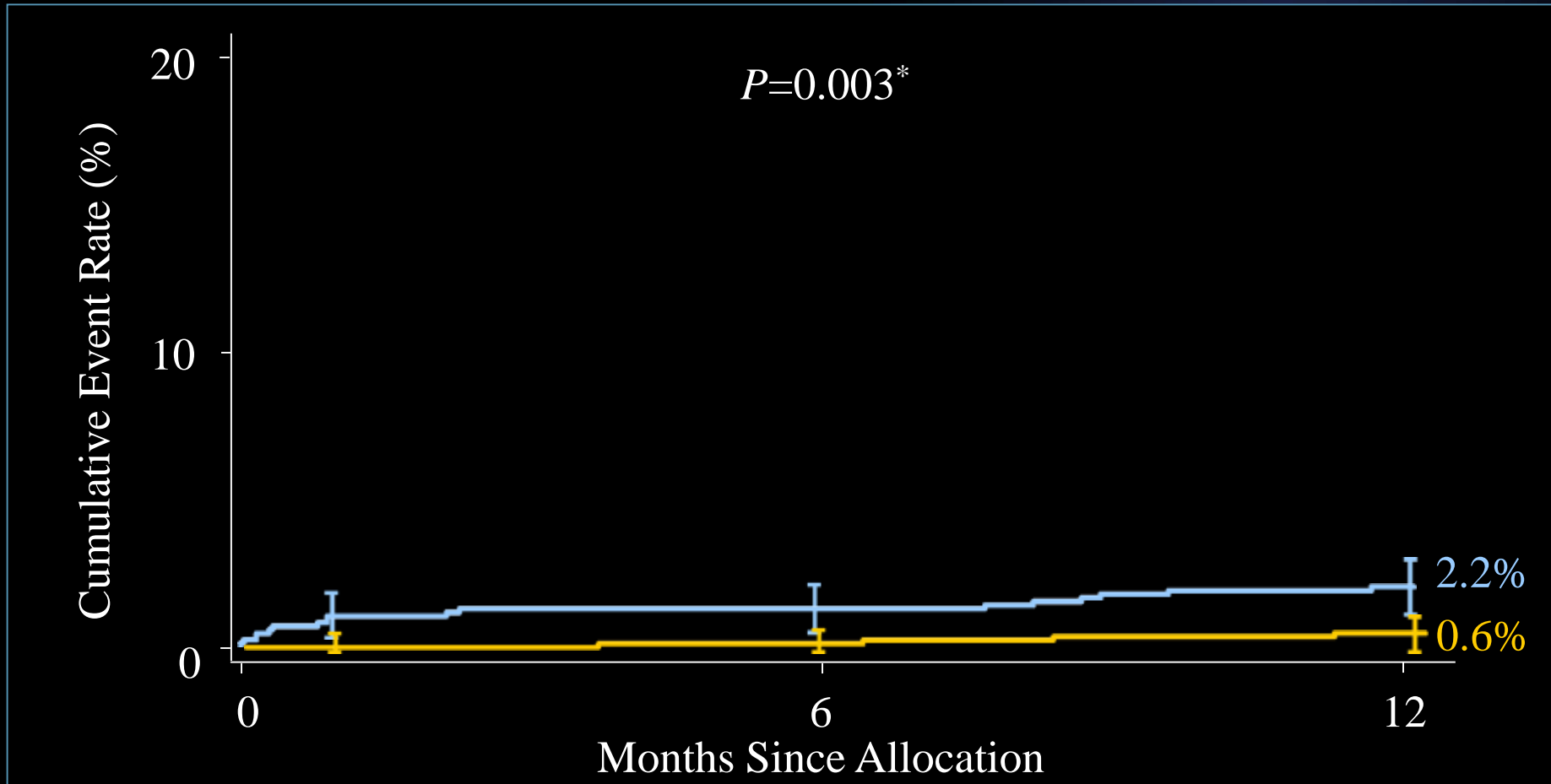


CVA to 12 Months



■ CABG (N=897)

■ TAXUS (N=903)

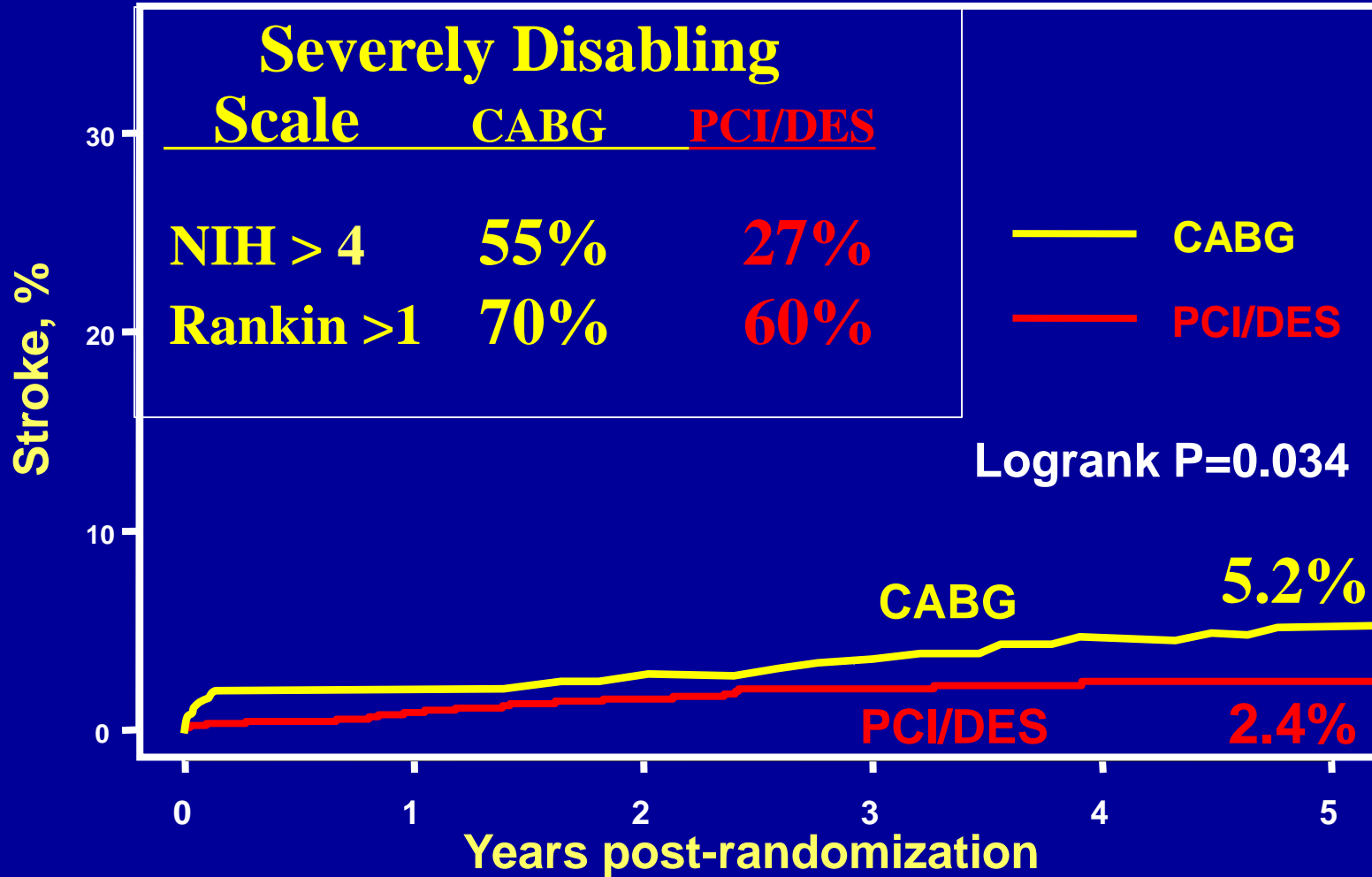


Event Rate \pm 1.5 SE. *Fisher's Exact Test

ITT population



STROKE

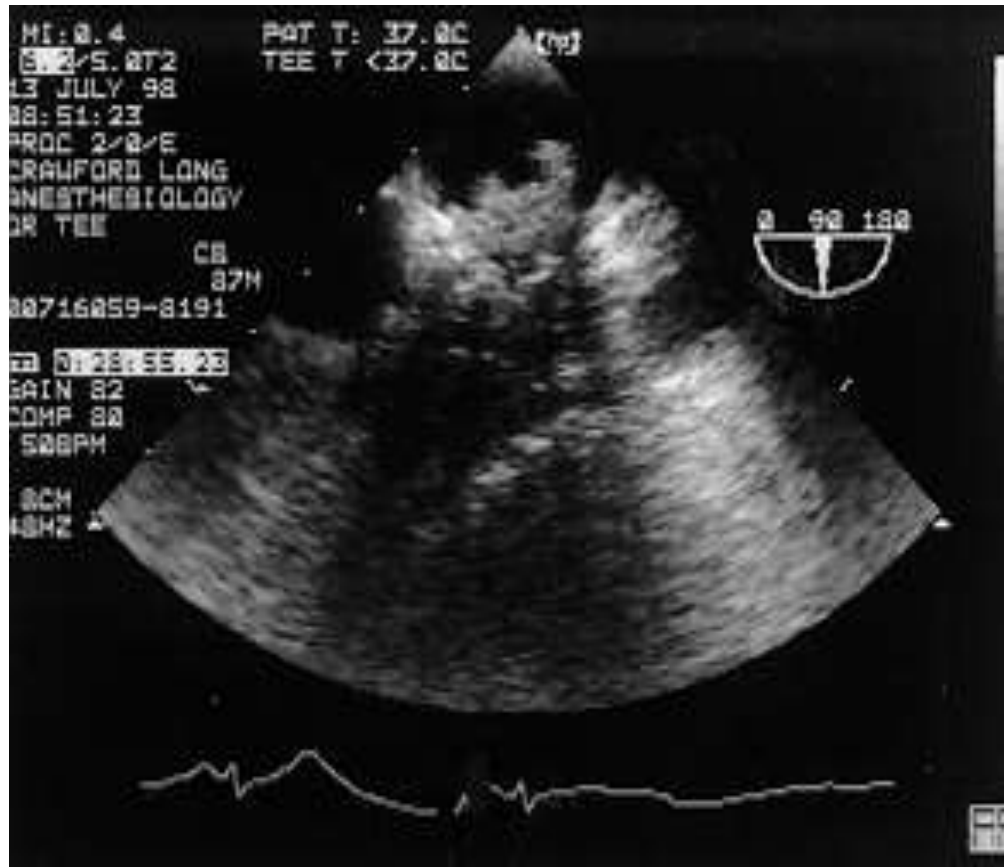


PCI/DES N	953	891	833	673	460	241
CABG N	947	844	791	640	439	230

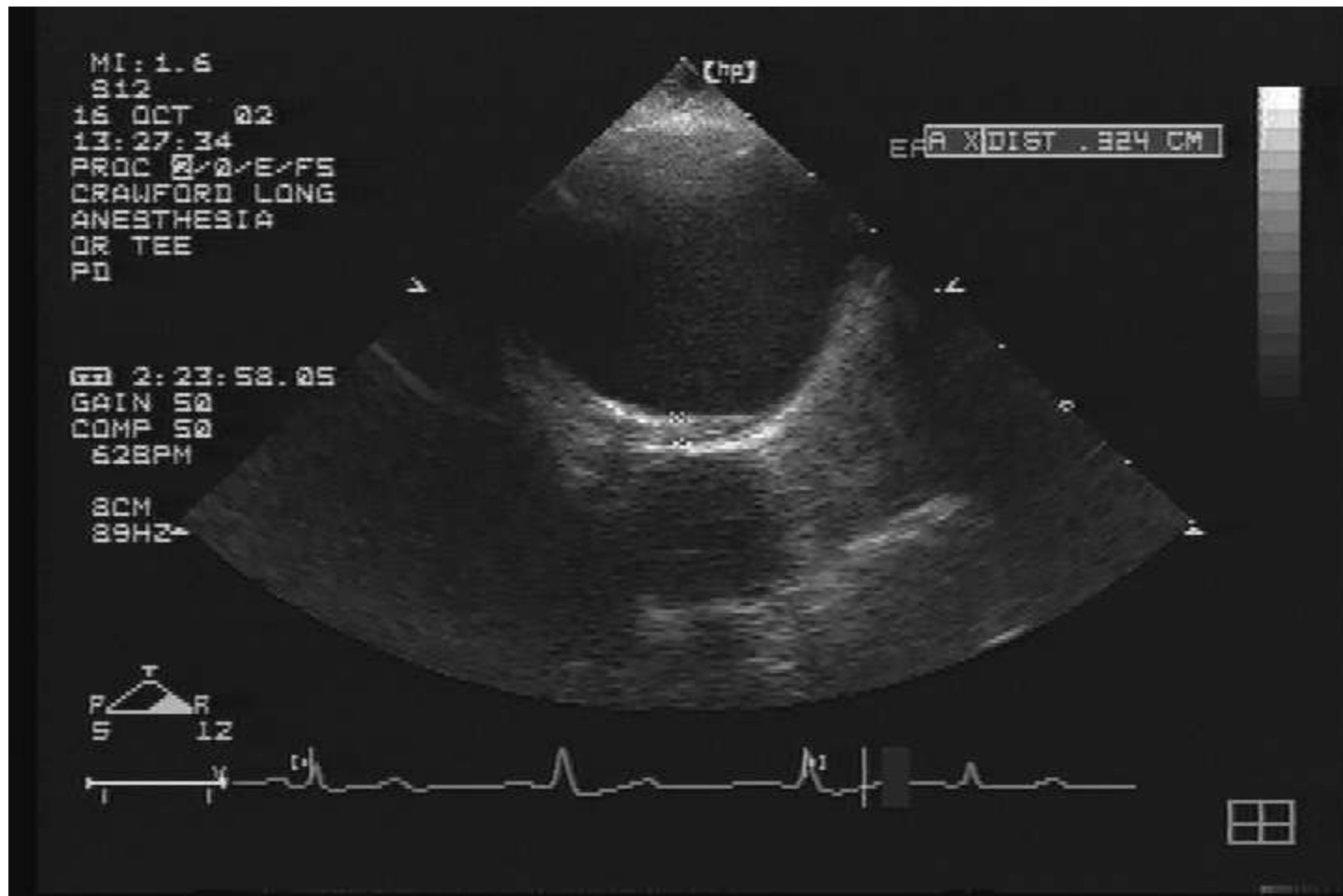
Epi-aortic Ultrasound Should Be Routine



Contraindication to CPB or Aortic Clamping



Posterior Atherosclerosis: Medial “Toothpaste” Debris



Usually NOT palpable!

Trends in aortic clamp use during coronary artery bypass surgery: Effect of aortic clamping strategies on neurologic outcomes

William T. Daniel III, BS, Patrick Kilgo, MS, John D. Puskas, MD, Vinod H. Thourani, MD,
Omar M. Lattouf, MD, PhD, Robert A. Guyton, MD, and Michael E. Halkos, MD, MSc

Objective: The purpose of the present study was to determine the effect of different clamping strategies during coronary artery bypass grafting on the incidence of postoperative stroke.

Methods: In the present case-control study, all patients at Emory hospitals from 2002 to 2009 with postoperative stroke after isolated coronary artery bypass grafting ($n = 141$) were matched 1:4 to a contemporaneous cohort of patients without postoperative stroke ($n = 565$). The patients were matched according to the Society of Thoracic Surgeons' predicted risk of postoperative stroke score, which is based on 26 variables. The patients who received on-pump and off-pump coronary artery bypass grafting were matched separately. Multiple logistic regression analysis with adjusted odds ratios was performed to identify the operative variables associated with postoperative stroke.

Results: Among the on-pump cohort, the single crossclamp technique was associated with a decreased risk of stroke compared with the double clamp (crossclamp plus partial clamp) technique (odds ratio, 0.385; $P = .044$). Within the on-pump cohort, no significant difference was seen in the incidence of stroke according to clamp use. Epiaortic ultrasound of the ascending aorta increased from 45.3% in 2002 to 89.4% in 2009. From 2002 to 2009, clamp use decreased from 97.7% of cases to 72.7%.

Conclusions: During on-pump coronary artery bypass grafting, the use of a single crossclamp compared with the double clamp technique decreased the risk of postoperative stroke. The use of any aortic clamp decreased and epiaortic ultrasound use increased from 2002 to 2009, indicating a change in the operative technique and surgeon awareness of the potential complications associated with manipulation of the aorta. (*J Thorac Cardiovasc Surg* 2014;147:652-7)



Effect of Aortic Clamping Strategies on Neurologic Outcomes

Daniel...Puskas...Halkos JTCVS 2014;147:652-7

- 10,054 consecutive isolated CABG cases
- 141 (1.4%) patients with stroke matched 1:4 to 565 patients without stroke

Analysis*	OR	95% CI
<u>On-pump double clamp (crossclamp plus partial clamp) vs single clamp</u>	2.60	1.03-6.67 ($P = .044$)
Off-pump partial clamp vs off-pump Heartstring	1.46	0.49-4.4
Off-pump partial clamp vs no clamp (Heartstring plus no touch)	1.21	0.48-3.03

OR, Odds ratio; CI, confidence interval. *Controlled for epiaortic grade.

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Utility of Intraoperative Doppler Graft Assessment

History and presentation

- 68 year old male
- c/o Exertional chest pain and shortness of breath
- Recent cardiac arrest (within 8 weeks from surgery) during STEMI due to occlusion of LAD requiring PTCA + STENT
- PM placement after the cardiac arrest

Comorbidities

- Ht 165 cm Wt 68 Kg BSA 1.8 BMI: 29
- PMH: history smoking for 15 years, DM with HbA1C 8.4, Sleep apnea, Creatinine baseline 1.7 mg/dl

Echocardiogram:

EF 55% with moderate hypokinesia of inferior wall.

Cath:

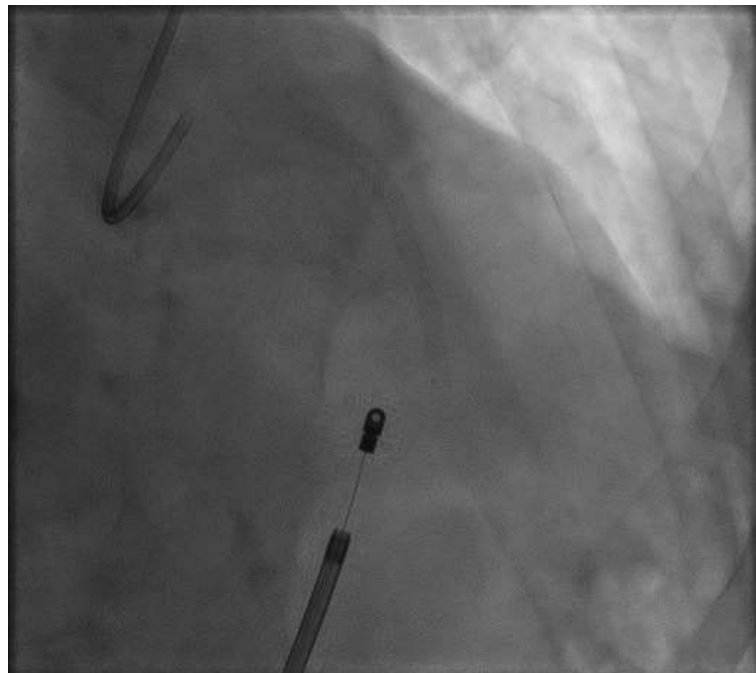
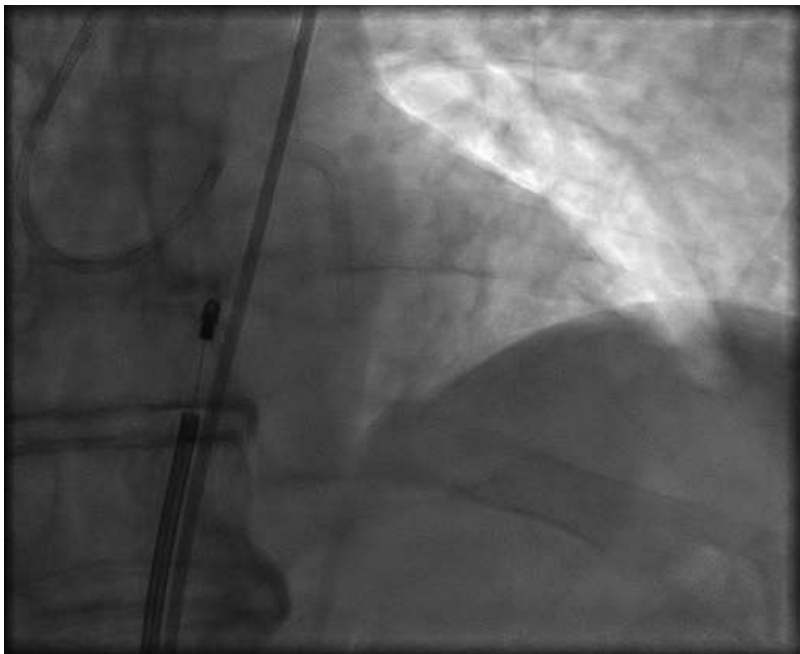
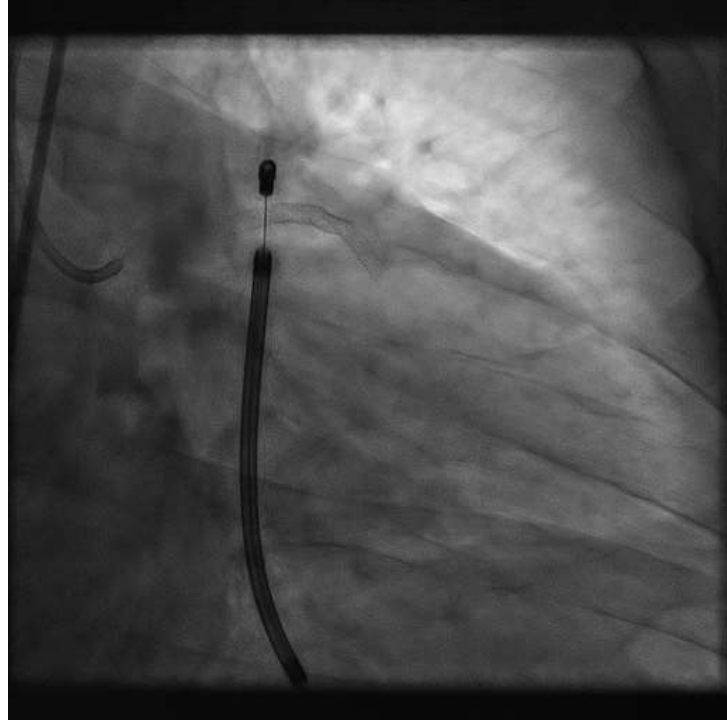
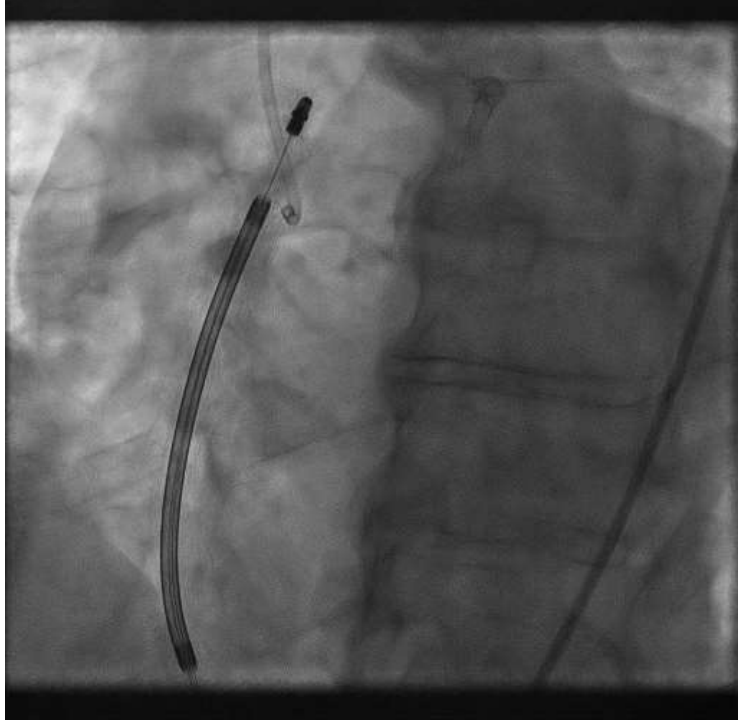
RCA: 70% distal stenosis at origin PDA

LM 60-70% distal lesion

LAD long lesion post stent with 70% origin of Diagonal 2

LCx 80% distal stenosis with 70% of origin of ALOM





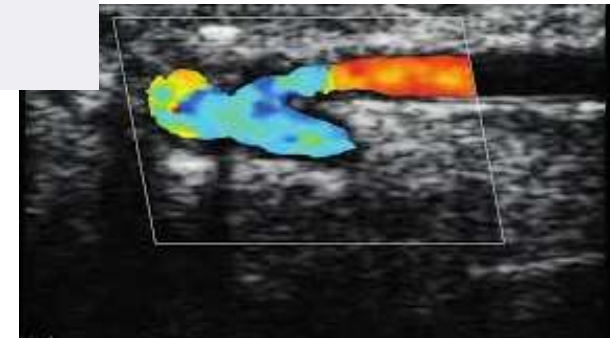
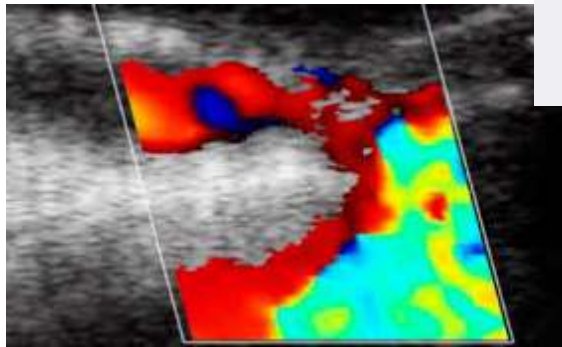
Surgery Performed:

Clampless OPCABG X 4 with 2 Arterial Conduits

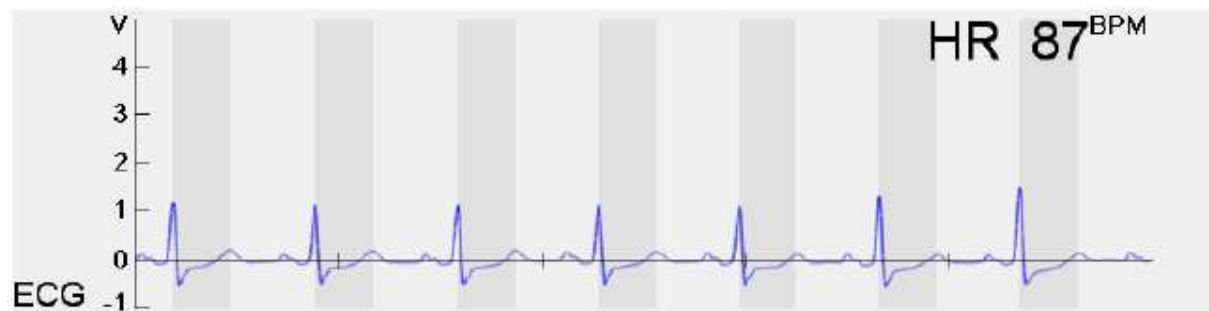
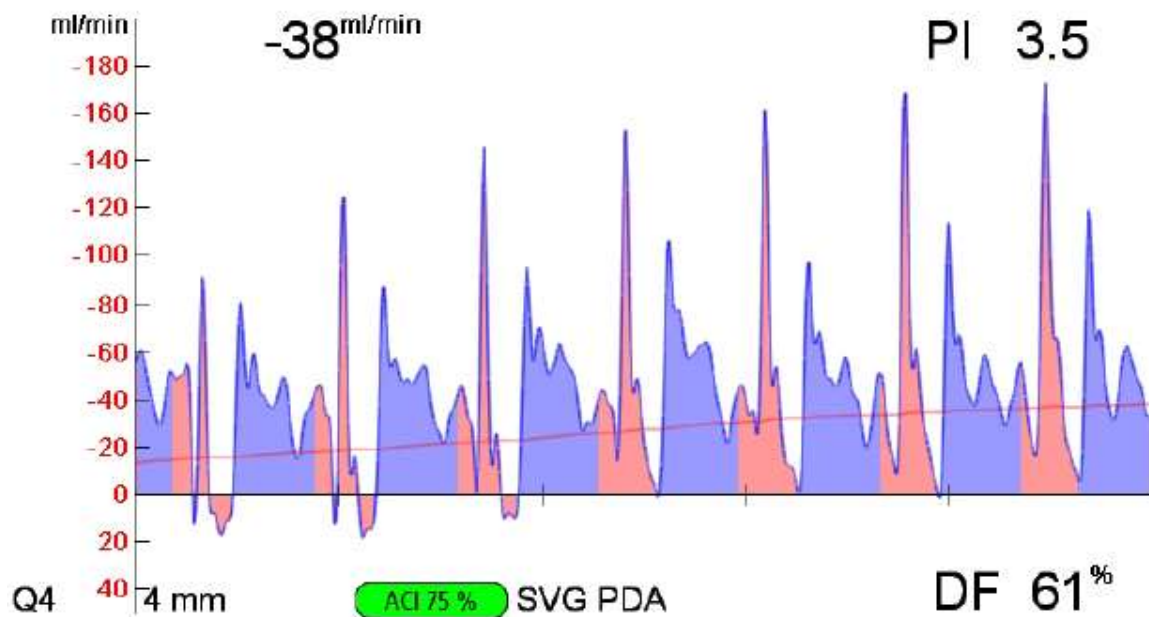
- LIMA to LAD
- SVG to Diagonal
- Left Radial to OM
- SVG to PDA



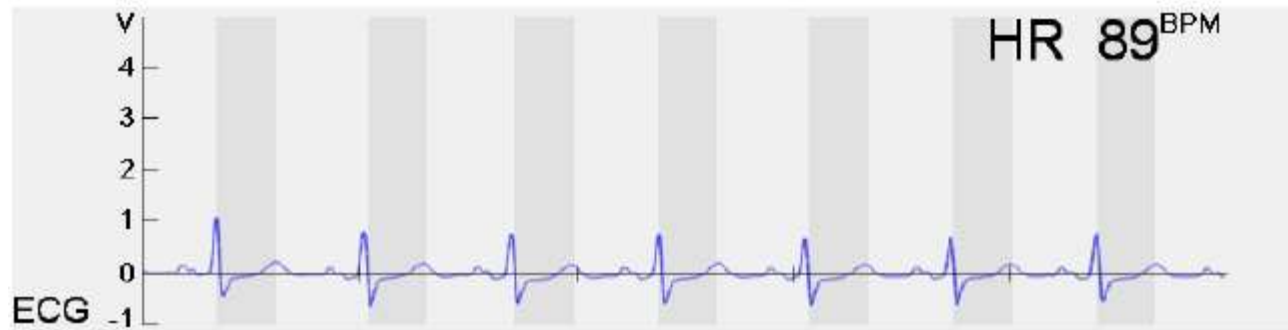
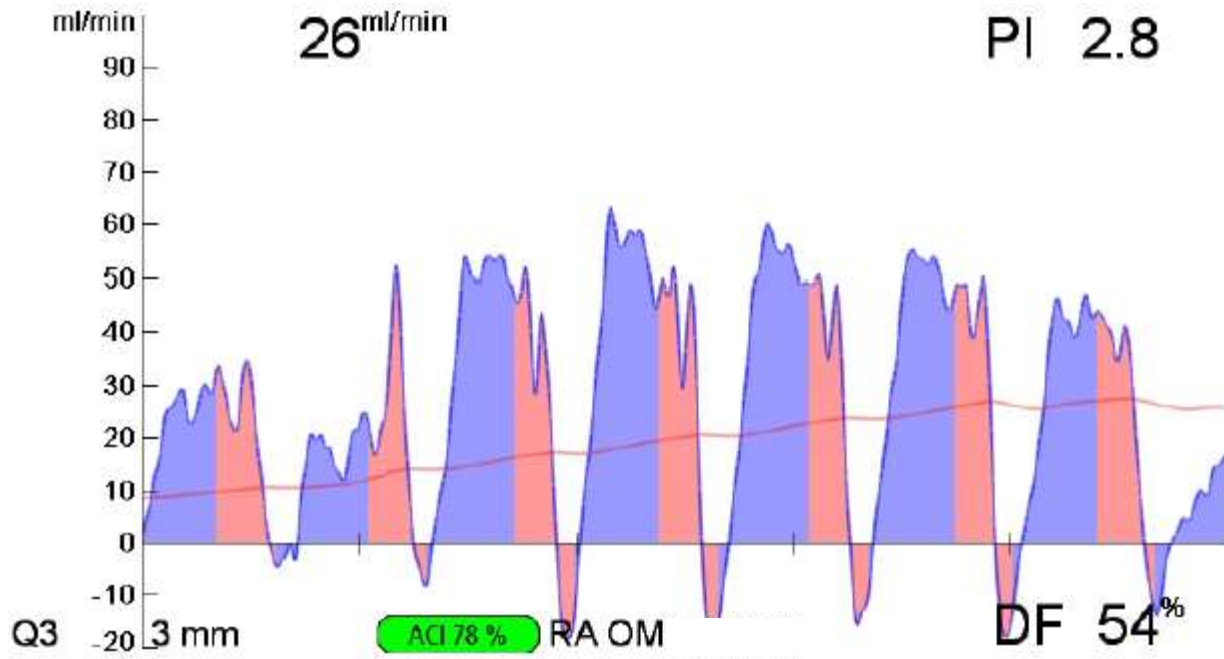
Medistim TTFM and Imaging Probe



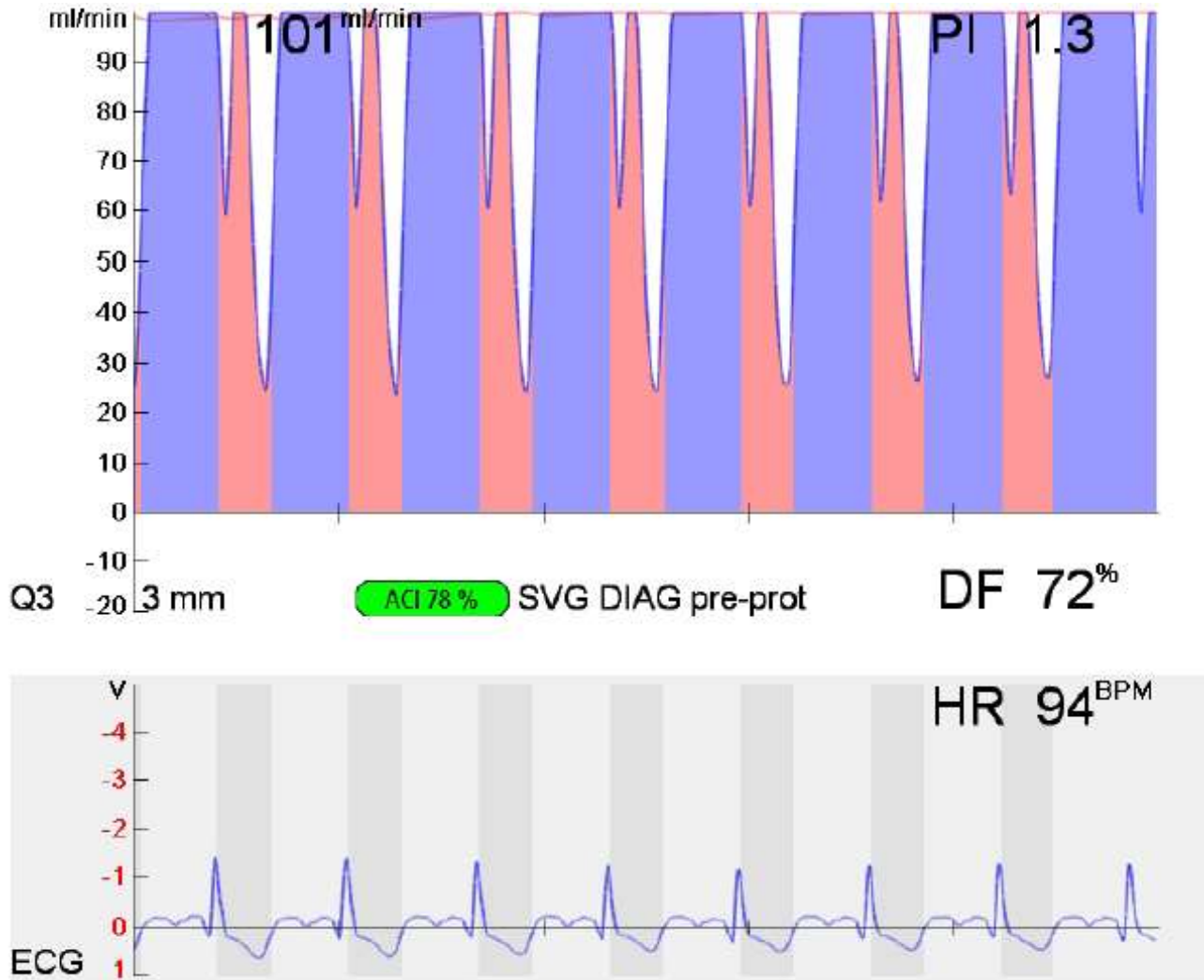
Medistim TTFM: *SVG to PDA*



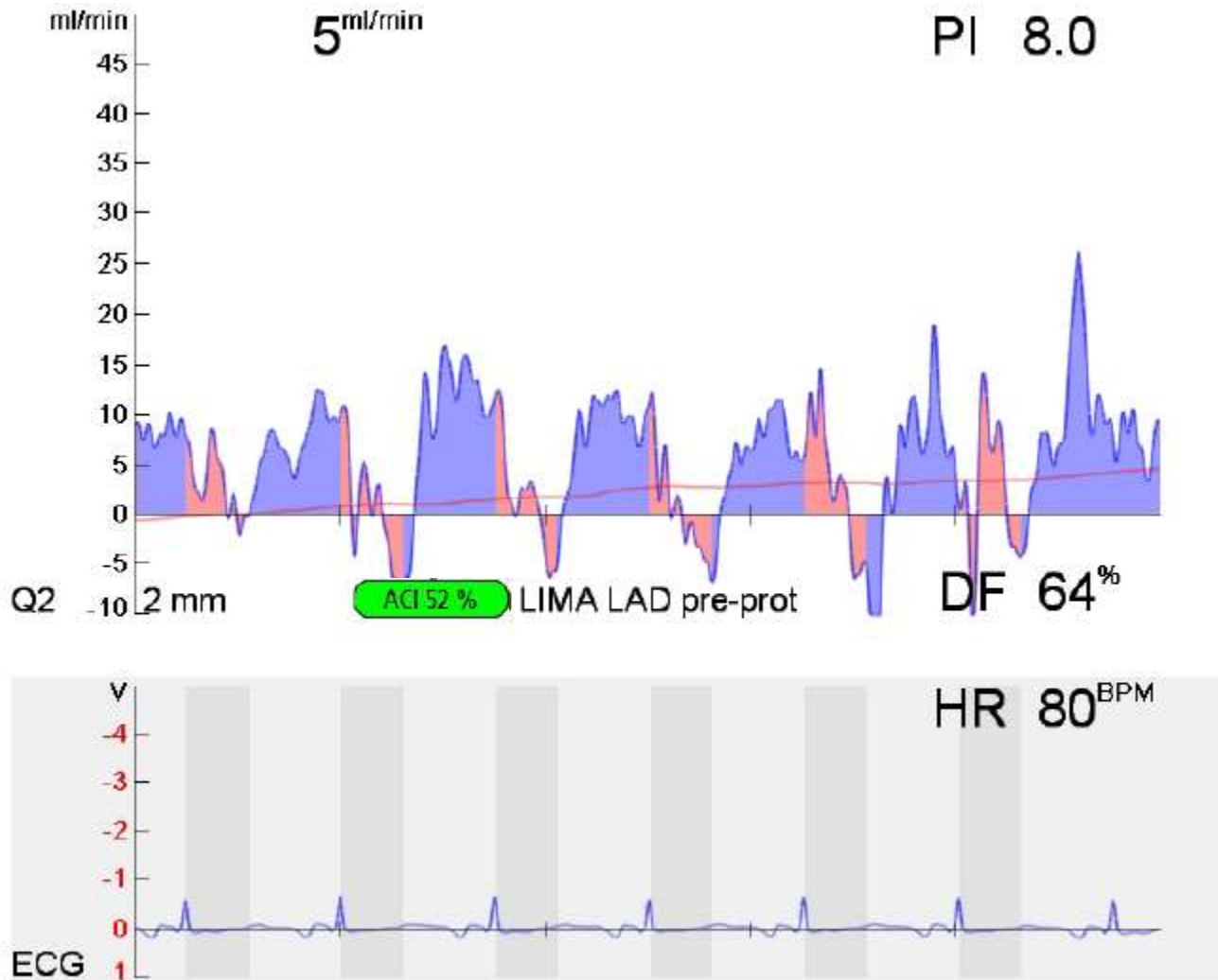
Medistim TTFM: *Left Radial to OM*



Medistim TTFM: *SVG Diagonal*



Medistim TTFM: *LIMA to LAD*

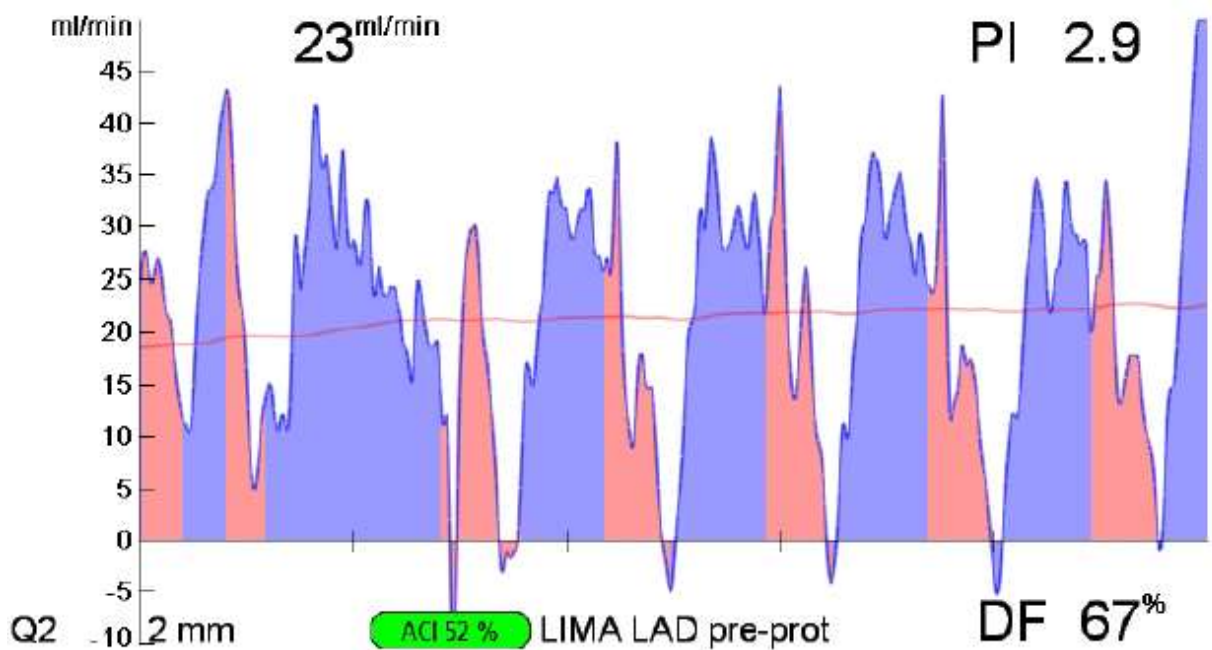


TTFM Case: What to do?

- Leave it alone
- Redo the LIMA to LAD
- Competitive flow from the Diagonal?



- We occluded the SVG to Diagonal and tested the flow in LIMA to LAD with no changes in the performance of the graft.
- Decision was made to redo LIMA to LAD. Repeated TTFM:



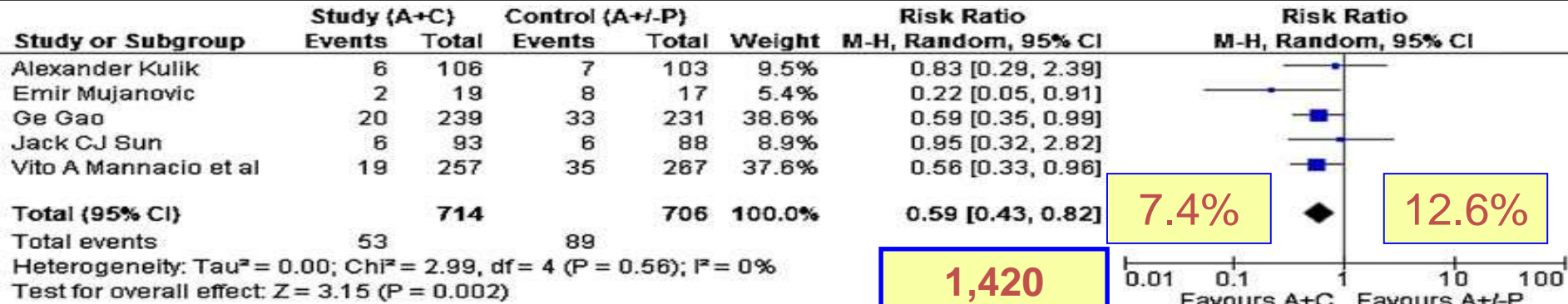
TTFM Case: Lessons Learned

- The Professor saw every stitch placed by the junior in each anastomosis and felt the operation was “perfect”.
- The LIMA-LAD TTFM was unacceptable and proved to NOT be due to competitive flow in large SVG-Diag graft
- When the LIMA-LAD anastomosis was taken down, there was no obvious problem, although the toe was perhaps slightly asymmetrical
- The LAD arteriotomy was extended distally 3mm and the LITA was trimmed and re-anastomosed by Professor
- Final LIMA-LAD TTFM was much improved.
- There were no clinical signs of a graft problem; only the TTFM alerted the surgical team
- TTFM should be a routine practice for every graft in every CABG case

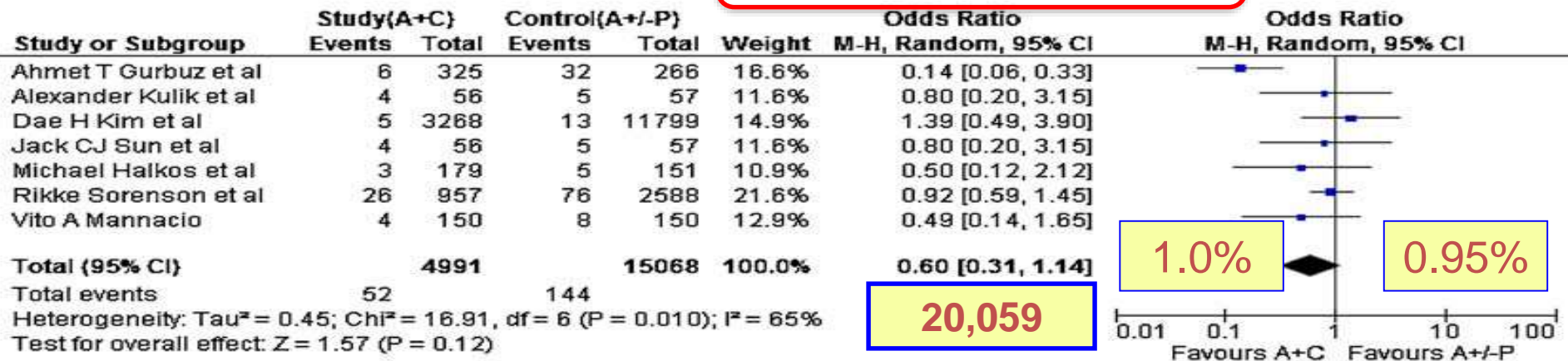


Dual Anti-platelet Therapy After Coronary Artery Bypass Grafting: Is There Any Benefit? A Systematic Review and Meta-Analysis

SV Deo, SM Dunlay, IK Shah et al [J Card Surg 2013]



A- Forest plot of saphenous graft patency

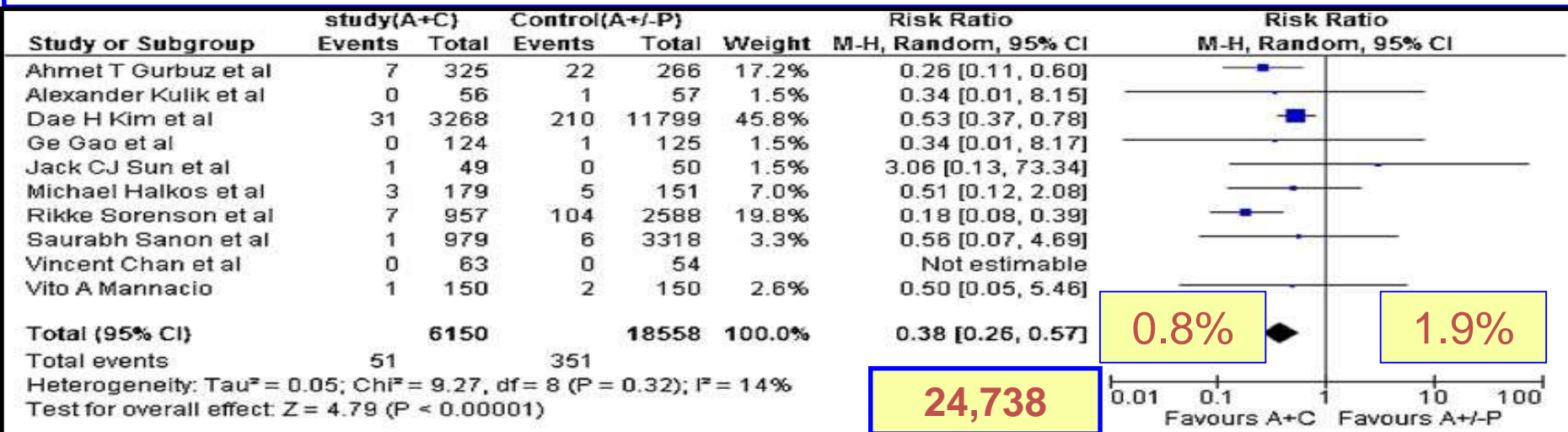


B- Forest plot depicting pooled estimate of adverse cardiac events

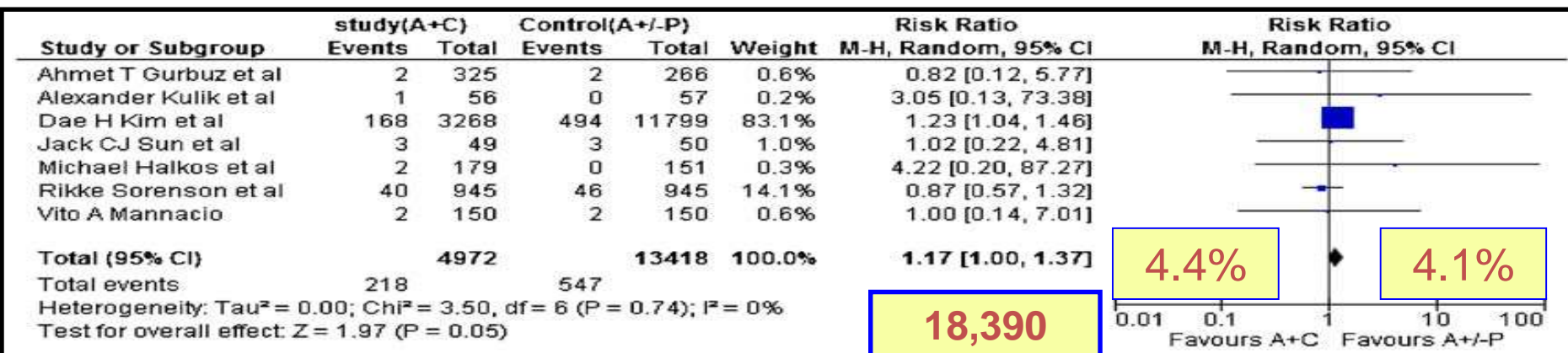
DAPT improves graft patency, reduces MACE and greatest in OPCARG

Dual Anti-platelet Therapy After Coronary Artery Bypass Grafting: Is There Any Benefit? A Systematic Review and Meta-Analysis

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Forest plot demonstrating pooled estimate of **early mortality**



Forest plot demonstrating pooled estimate of **major bleeding episodes**

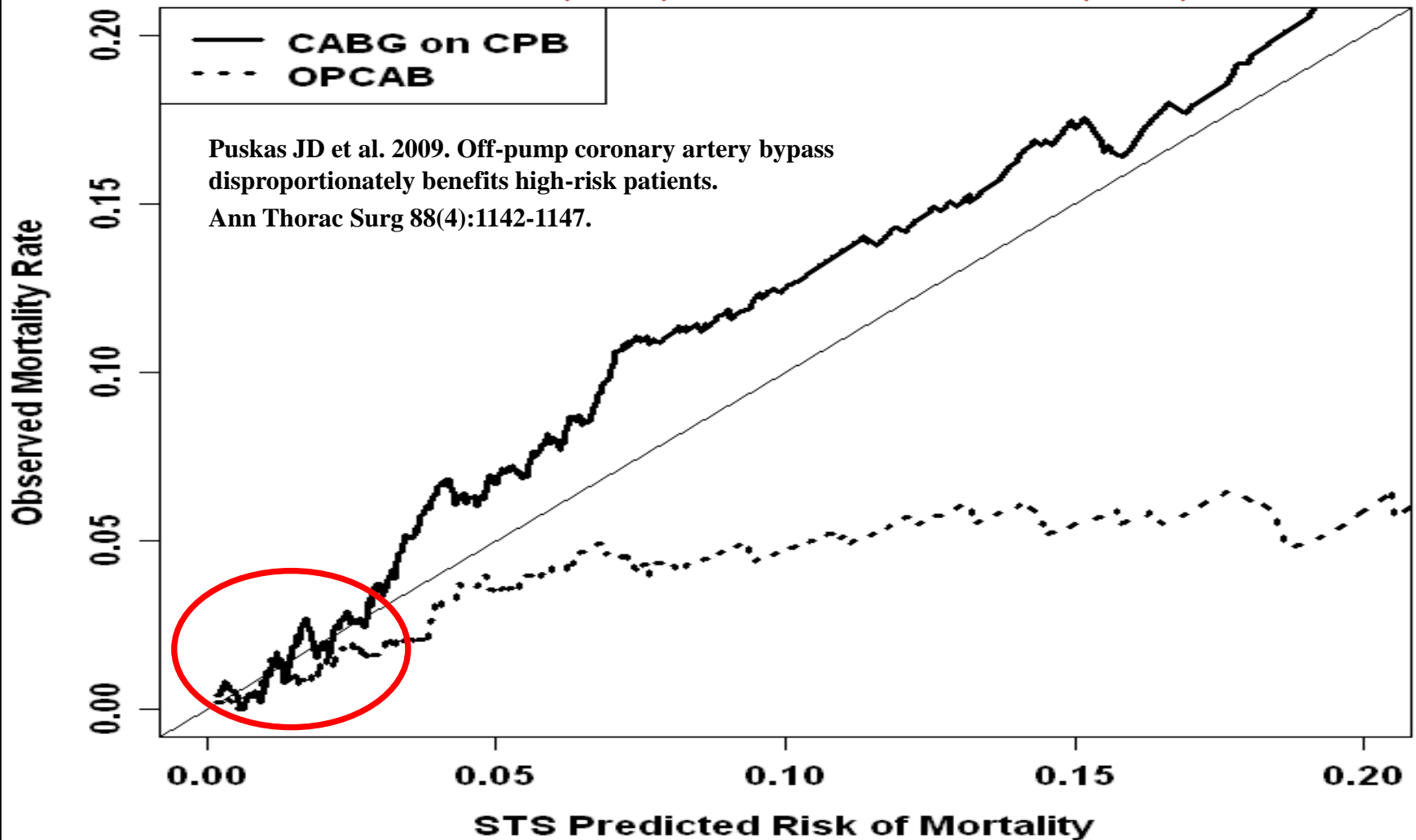
DAPT: reduces all CABG mortality (> OPCABG) and does NOT increase bleeding risk

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OPCABG Disproportionately Benefits High-Risk Patients

7083 OPCABG (48%) vs 7683 ONCABG (52%)



- The survival benefit of OPCABG appears when predicted mortality risk $>2.5\%$
- The survival benefit of OPCABG increases as predicted mortality increases

Off-Pump Techniques Benefit Men and Women and Narrow the Disparity in Mortality After Coronary Bypass Grafting

ATS 2009

John D. Puskas, MD, Fred H. Edwards, MD, Paul A. Pappas, MS, Sean O'Brien, PhD, Eric D. Peterson, MD, MPH, Patrick Kilgo, MS, and T. Bruce Ferguson, Jr, MD

Emory University, Atlanta, Georgia; University of Florida, Jacksonville, Florida; Duke Clinical Research Institute, Duke University School of Medicine, Durham, and Eastern Carolina University, Greenville, North Carolina

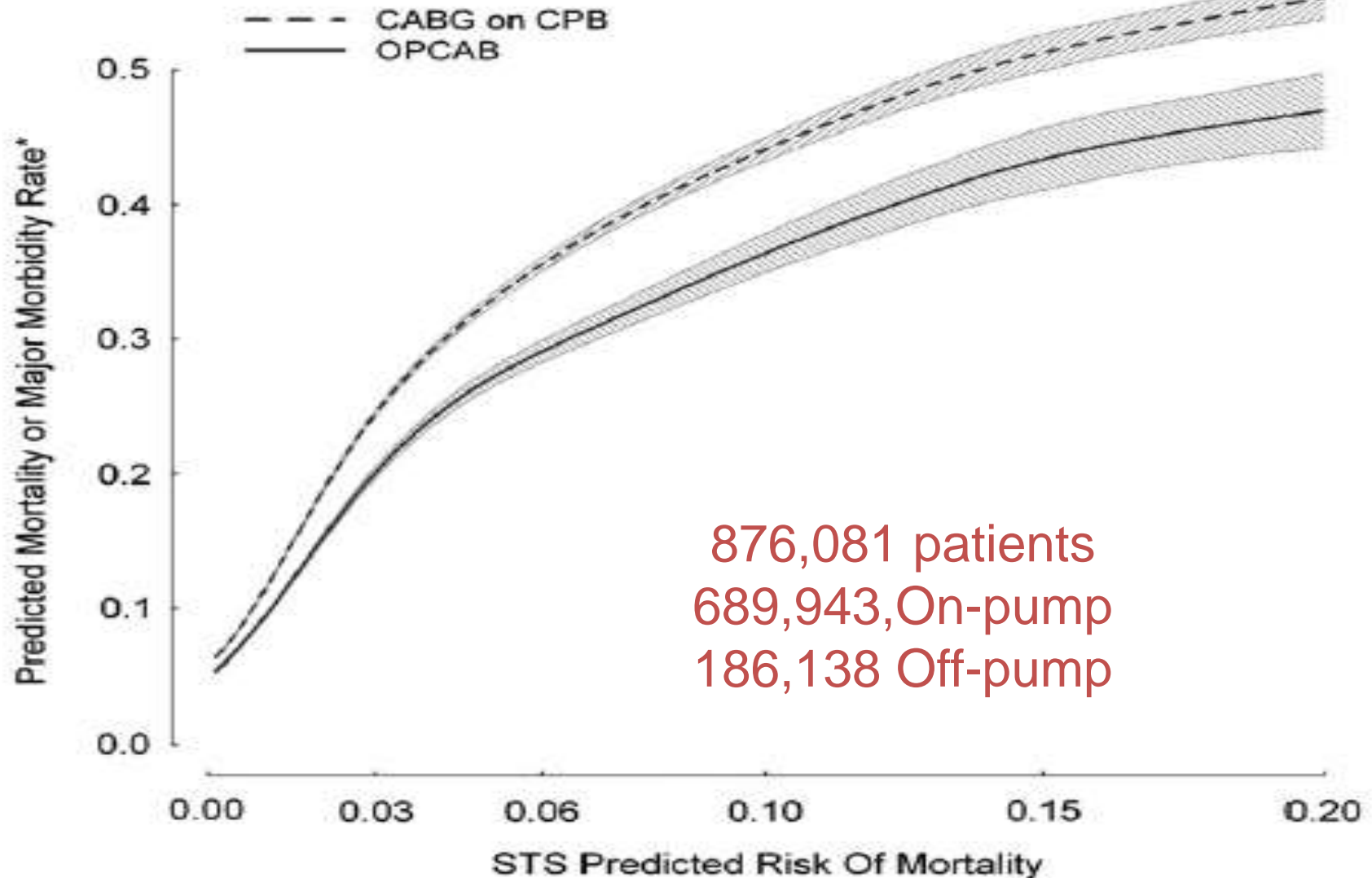
- 42,471 patients in STS database analysed by 32 clinical risk factors
- OPCABG benefits both genders but females > males

OUTCOME	Adjusted OR (95% CI) for OPCABG	p
DEATH	0.83 (0.69, 0.98)	0.03
Stroke	0.65 (0.52, 0.80)	<0.001
MI	0.67 (0.54, 0.84)	<0.001
MACE	0.71 (0.63, 0.81)	<0.001
LOS > 14 days	0.70 (0.63, 0.78)	<0.001

Outcomes of off-pump versus on-pump coronary artery bypass grafting: Impact of preoperative risk

JTCVS 2013

Marek Polomsky, MD,^a Xia He, MS,^b Sean M. O'Brien, PhD,^b and John D. Puskas, MD, MSc^a



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Intraoperative epiaortic scanning for preventing early stroke after off-pump coronary artery bypass

H.-C. Joo¹, Y.-N. Youn¹, Y.-L. Kwak², G.-J. Yi¹ and K.-J. Yoo^{1*}

¹ Division of Cardiovascular Surgery, Yonsei Cardiovascular Hospital, Yonsei University College of Medicine, Yonsei University Health System, 250 Seongsanno, Seodaemun-gu, Seoul 120-752, Korea

² Division of Cardiac Anaesthesiology, Yonsei Cardiovascular Hospital, Yonsei University College of Medicine, Yonsei University Health System, Seoul, Korea

* Corresponding author. E-mail: kjoy@yuhs.ac

Editor's key points

- Epiaortic scanning involves direct intraoperative ultrasound imaging of the aortic root and arch.
- It can inform decisions about the placement and positioning of aortic clamps.
- This observational cohort study involved patients undergoing off-pump coronary artery bypass surgery.
- Epiaortic ultrasound scanning (EAS) was associated with a lower incidence of stroke after partial clamping was performed.

Background. Numerous studies have demonstrated the accuracy of epiaortic ultrasound scanning (EAS) for assessing ascending aortic disease. It remains unclear whether EAS changes the incidence of perioperative stroke after off-pump coronary artery bypass (OPCAB).

Methods. We studied a retrospective cohort of 2292 patients who underwent isolated OPCAB from January 2001 to December 2011. Patients were retrospectively subdivided into two groups: the non-EAS group ($n=1019$) who underwent OPCAB under only intraoperative transoesophageal echocardiography and the EAS group ($n=1273$) who underwent OPCAB under EAS.

Results. In the non-EAS group, 317 (31.1%) patients underwent OPCAB with partial aortic clamping and 702 (68.9%) underwent OPCAB without partial aorta clamping. In the EAS group, 301 (23.7%) patients underwent OPCAB with partial aortic clamping and 972 (76.3%) underwent OPCAB without partial aortic clamping. The incidence of early stroke was not different statistically between the EAS and non-EAS groups [non-EAS 1.7% (17/1019) vs EAS 0.8% (10/1273); $P=0.052$]. However, in the subgroups of patients with partial aorta clamping, the incidence of the early stroke was significantly lower in the EAS group [2.8% (9/317) vs 0.7% (2/301) $P=0.041$].

Conclusions. EAS has a significant clinical benefit in reducing the incidence of early stroke in cases of partial aortic clamping in OPCAB. Therefore, EAS should be considered in patients who need partial aortic clamping in OPCAB.

Keywords: coronary artery bypass; early stroke; echocardiography; epiaortic scanning; monitoring; stroke

Accepted for publication: 6 February 2013



Clampless OPCAB: State of the Art CABG

Borgermann et al, Circulation 2012; 126:S176-182

- **395 consecutive clampless OPCAB (310 PAS-Port; 85 all-arterial without proximals)**
- **Propensity Score matching on 15 preop risk variables to compare outcomes among 394 pairs of clampless OPCAB vs cCABG:**

In-hospital death (OR 0.25; 95% CI 0.05-1.18; p=0.08)

Stroke (OR 0.36; 95% CI 0.13-0.99; p=0.048)

Death or Stroke (OR 0.27; 95% CI 0.11-0.67; p=0.005)

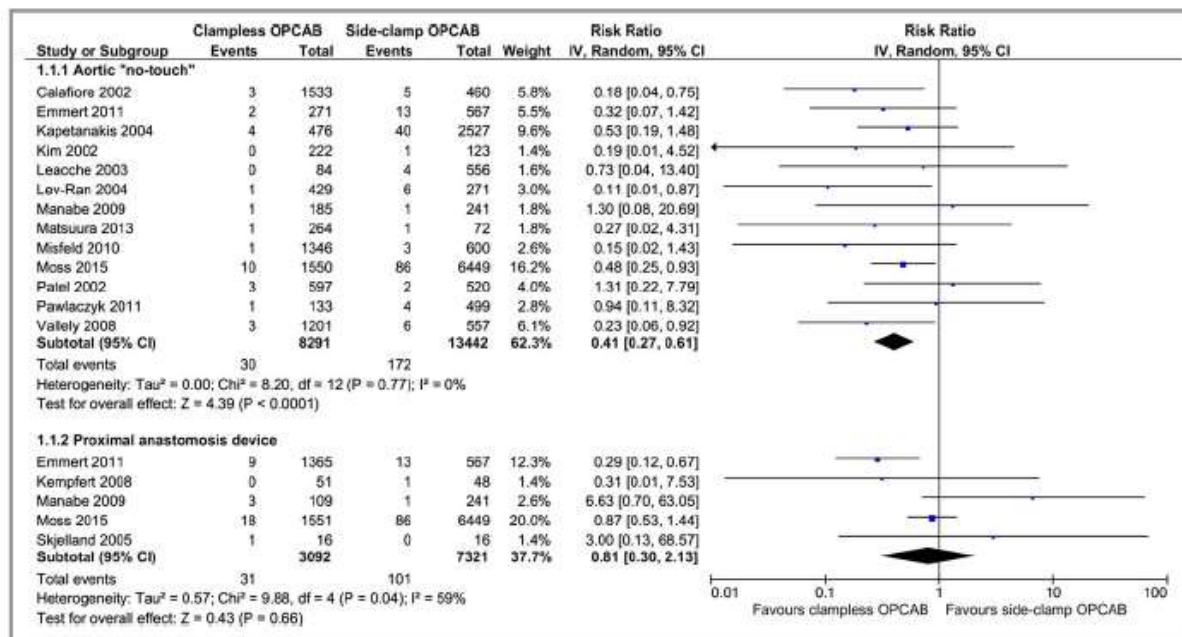
- **2 years F/U: Death (OR 0.39; 95% CI 0.19-0.80; p=0.01),
Death or Stroke (OR 0.58; 95% CI 0.34-1.00; p=0.05)**
- **MACCE (OR 0.62; 95% CI 0.37-1.02; p=0.06)**
- **Repeat revasc (OR 0.74; 95% CI 0.40-1.38; p=0.35)**

Cerebrovascular Events After No-Touch Off-Pump Coronary Artery Bypass Grafting, Conventional Side-Clamp Off-Pump Coronary Artery Bypass, and Proximal Anastomotic Devices: A Meta-Analysis

Wojciech Pawluszak, MD;* Mariusz Kowalewski, MD;* Giuseppe Maria Raffa, MD; Pietro Giorgio Malvindi, MD; Magdalena Ewa Kowalkowska, MD; Krzysztof Aleksander Szwed, MD; Alina Borkowska, MD, PhD; Janusz Kowalewski, MD, PhD; Lech Anisimowicz, MD, PhD

Background—Off-pump coronary artery bypass (OPCAB) has been shown to reduce the risk of neurologic complications as compared to coronary artery bypass grafting performed with cardiopulmonary bypass. Side-clamping of the aorta while constructing proximal anastomoses, however, still carries substantial risk of cerebral embolization. We aimed to perform a comprehensive meta-analysis of studies assessing 2 clampless techniques: aortic “no-touch” and proximal anastomosis devices (PAD) for OPCAB.

Conclusions—Aortic “no-touch” technique was associated with nearly 60% lower risk of postoperative cerebrovascular events as compared to conventional side-clamp OPCAB with effect consistent across patients at different risk. (*J Am Heart Assoc.* 2016;5:e002802 doi: 10.1161/JAHA.115.002802)



Single-Centre Experience of Off-Pump Multi-Vessel Coronary Artery Bypass Grafting Using Proximal Suture Device

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Background

To investigate the results of off-pump coronary artery grafting (OPCAB) with the proximal suture device (PSD) regarding postoperative stroke and graft patency.

Methods

The PSD was used in 376 patients (32.0%), aorta-no-touch OPCAB was performed in 523 patients (45.2%), on-pump beating CABG (on-beat group) in 125 patients (10.6%) including 51 conversions (conversion rate: 5.4%), and CABG with aortic clamp use (clamp group) in 152 patients. In the PSD group, Enclose II was used in 267 patients (71.0%).

Results

The hospital mortality rate was 1.95%. There was no early stroke in the OPCAB group, whereas the early-stroke rate was 0.8% in the on-beat group and 2.6% in the clamp group. The incidences of stroke at one month were: PSD group, 1.6%; no-touch group, 1.1%; on-beat group, 1.6%; and clamp group, 4.6% ($P=0.014$). The rates of complete revascularisation were higher in the PSD and clamp groups (94.7 and 94.0%, respectively) compared with the no-touch and on-beat groups (81.5 and 84.9%, respectively; $P<0.001$). The vein graft patency rates were comparable between the PSD and clamp groups. In multiple logistic regression analysis, OPCAB using the PSD did not increase the risk of stroke compared with the no-touch group (adjusted odds ratio [AOR]: 1.40; $P=0.594$) or on-beat group (AOR: 0.99; $P=0.206$), but reduced the risk of stroke compared with the clamp group (AOR: 0.19; $P=0.005$).

Conclusions

Off-pump coronary artery grafting using the PSD was a safe and effective procedure. It led to lower incidences of postoperative stroke and excellent rates of graft patency and complete revascularisation compared with conventional CABG.

Keywords

Stroke • CABG • Off-pump surgery • Graft patency



Clampless Anastomotic Devices Reduce Solid Cerebral Emboli

- TCD of MCA during 66 proximal anastomoses in 42 patients
 - 35 anastomoses with side-biting clamp
 - 20 anastomoses with Novare Enclose device
 - 11 anastomoses with Heartstring device
- Total microemboli: 11 clamp vs 11 Enclose vs 40 Heartstring ($p < 0.01$)
- Proportion of solid microemboli higher in clamp group: 23% clamp vs 6% Enclose vs 1% Heartstring ($p < 0.01$)

Commercially-Available Proximal Anastomosis Devices

Vitalitec
Enclose II



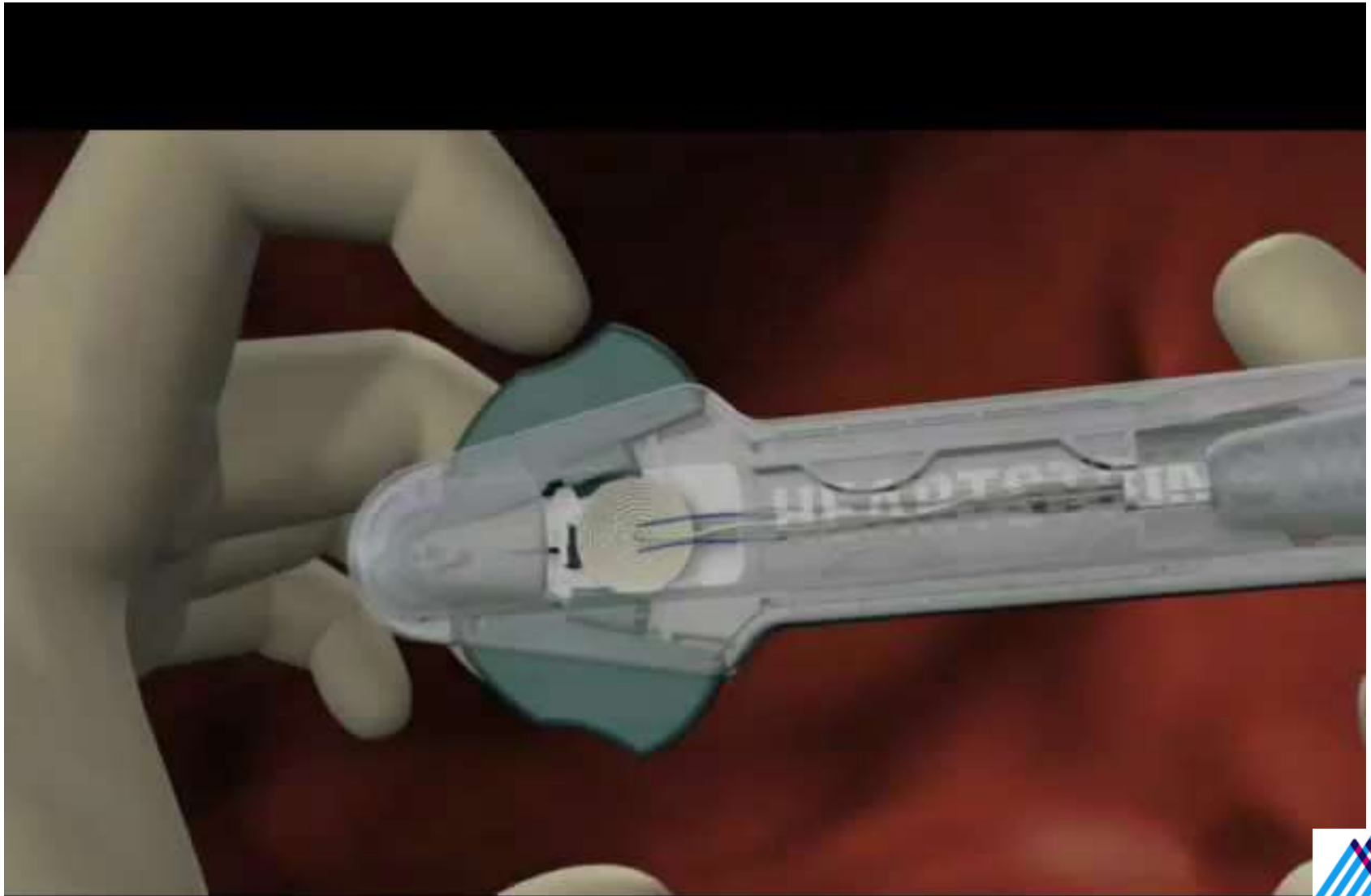
Cardia
PAS-Port



Maquet
Heartstring III



Maquet/Getinge Heartstring Deployment



An Interesting Technical Challenge: Heartstring III with Arterial Grafts

Heartstring III punch sizes:

4.3mm and 3.8mm

VS

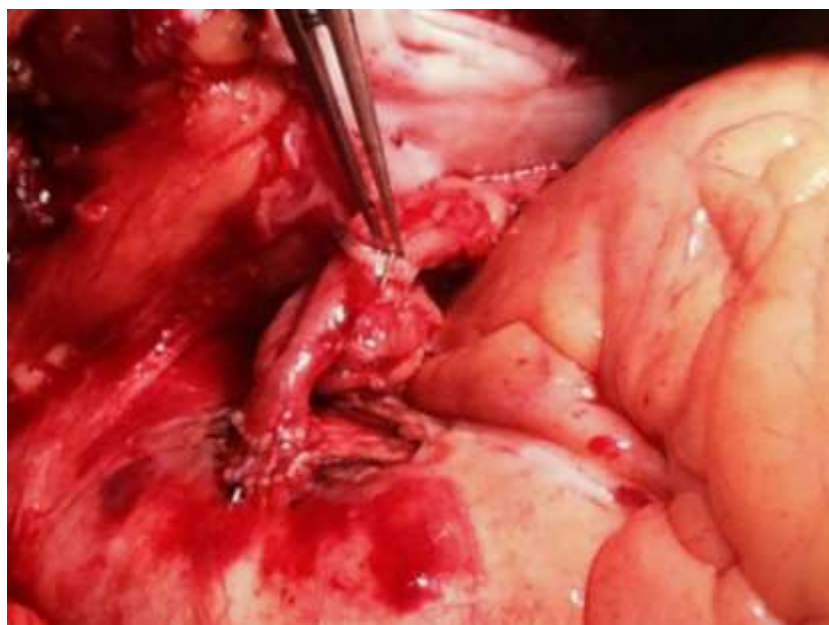
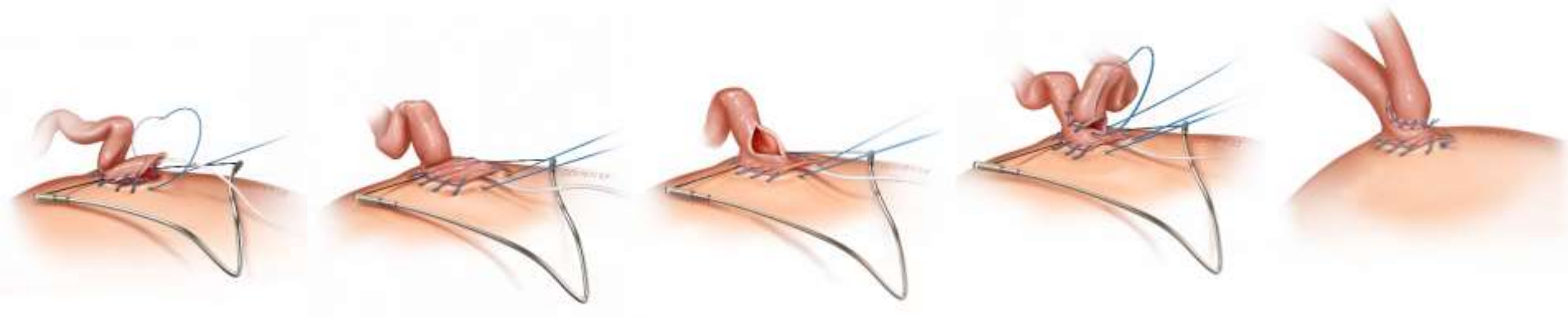
Average radial artery diameter

(in Texas): 2.2 ± 0.4 mm

Piggyback technique facilitates off-pump coronary artery bypass graft by using a proximal anastomostic device with arterial conduits

Bobby Yanagawa, MD, PhD, Vicente Orozco-Sevilla, MD, Amit Pawale, MD, and John D. Puskas, MD, MSc, FACS, FACC, New York, NY

J Thorac Cardiovasc Surg 2015; 150:725-7.



Mount
Sinai
St. Luke's

Evolution of CABG in 2018:

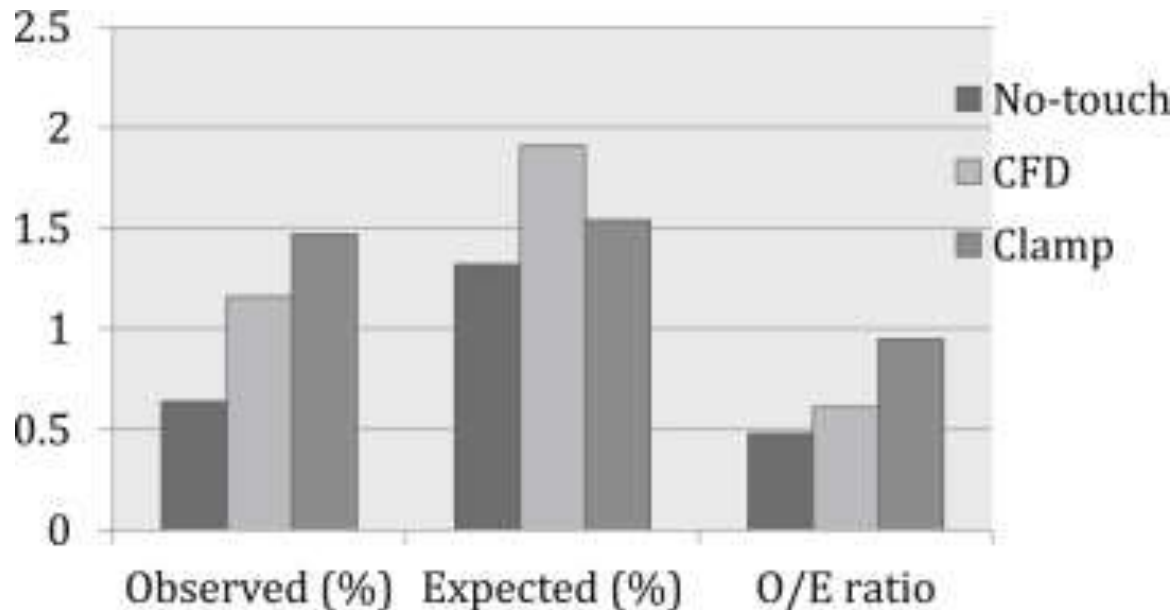
1. CABG remains important—SYNTAX 5 yr data
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 1. Improving On-Pump CABG:
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 3. Evolution towards all-arterial no-aortic-touch OPCAB
 4. Graft assessment and DAPT
5. Robotic and hybrid robotic CABG
6. Optimal Medical Management of CABG Patients
7. The Coronary Heart Team

Strategies to Reduce Stroke

No CPB

Routine use of epiaortic scanning

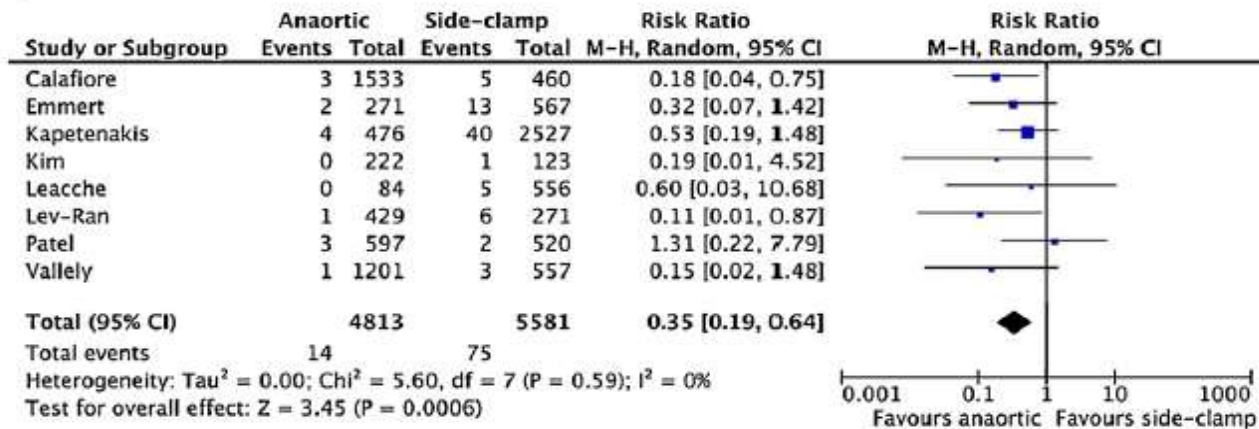
No or minimal aortic clamp



Meta-analysis of Stroke After Anaortic OPCAB vs Side-Clamp OPCAB and Anaortic OPCAB vs Conventional CABG

Edelman, et al Heart Lung and Circulation, 2012

a)



b)

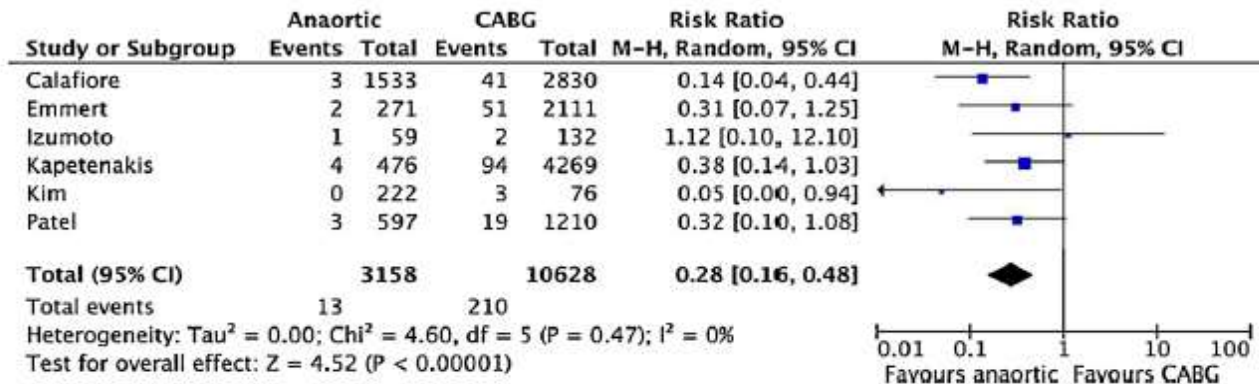


Figure 1. peri-operative stroke: (a) anaortic OPCAB vs. OPCAB using side-clamp and (b) anaortic vs. conventional CABG [12,19]. Reprinted with permission Journal of Thoracic and Cardiovascular Surgery.

Aortic No-Touch Technique Makes the Difference in OPCAB

Emmert et al JTCVS 2011; 142:1499-506.

- Two OPCAB groups: PC n=567 vs HS n=1365
- Propensity-adjusted regression, HS vs PC:

Stroke (0.7% vs 2.3%; OR 0.39; CI 95% 0.16-0.90; p=0.04)

MACCE (6.7% vs 10.8%; OR 0.55; CI 95% 0.38-0.79; p=0.001)

- Stroke rate similar between cCABG and PC OPCAB

Coronary Artery Bypass Grafting With and Without Manipulation of the Ascending Aorta



A Network Meta-Analysis

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Michael K. Wilson, MBBS,^{b,c,e} Michael J. Byrom, PhD,^{a,b,c,d,e} Vinod Thourani, MD,^f Andre Lamy, MD, MHSc,^g
David P. Taggart, PhD,^h John D. Puskas, MD,ⁱ Michael P. Vallety, PhD^{a,b,c,d,e}

- 13 studies with 37,720 patients, compared outcomes with 4 techniques:
 - (i) ONCABG,
 - (ii) OPCABG-PC,
 - (iii) OPCABG-HS,
 - (iv) ANOPCABG (NTAT)
- Effects on Death, Stroke, MI, Renal Failure, AF, Bleeding



A Stroke

anOPCABG			
0.48 (0.27 – 0.86)	OPCABG-HS		
0.34 (0.22 – 0.52)	0.71 (0.44 – 1.11)	OPCABG-PC	
0.22 (0.14 – 0.33)	0.45 (0.28 – 0.69)	0.64 (0.48 – 0.83)	CABG

B Mortality

anOPCABG			
0.80 (0.55 – 1.13)	OPCABG-PC		
0.60 (0.38 – 0.94)	0.75 (0.50 – 1.12)	OPCABG-HS	
0.50 (0.35 – 0.70)	0.63 (0.48 – 0.81)	0.84 (0.57 – 1.22)	CABG

C Myocardial infarction

OPCABG-HS			
0.97 (0.50 – 1.91)	anOPCABG		
0.82 (0.45 – 1.50)	0.84 (0.51 – 1.37)	OPCABG-PC	
0.71 (0.40 – 1.27)	0.73 (0.44 – 1.18)	0.86 (0.57 – 1.32)	CABG

D Renal failure

anOPCABG			
0.79 (0.53 – 1.13)	OPCABG-PC		
0.64 (0.39 – 1.05)	0.81 (0.52 – 1.28)	OPCABG-HS	
0.47 (0.31 – 0.68)	0.59 (0.41 – 0.84)	0.73 (0.45 – 1.14)	CABG

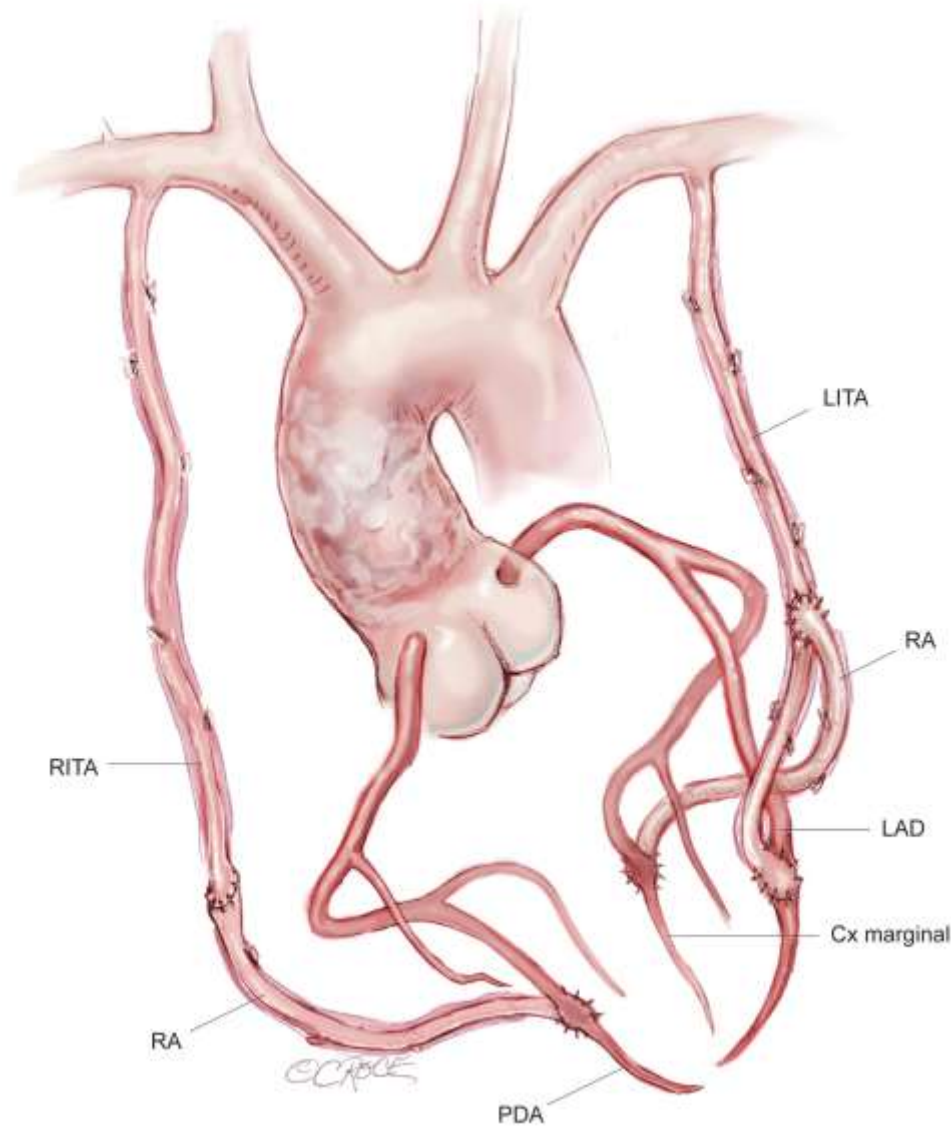
E Bleeding

anOPCABG			
0.78 (0.52 – 1.13)	OPCABG-PC		
0.64 (0.42 – 0.95)	0.82 (0.60 – 1.10)	CABG	
0.52 (0.31 – 0.87)	0.67 (0.44 – 1.04)	0.82 (0.52 – 1.30)	OPCABG-HS

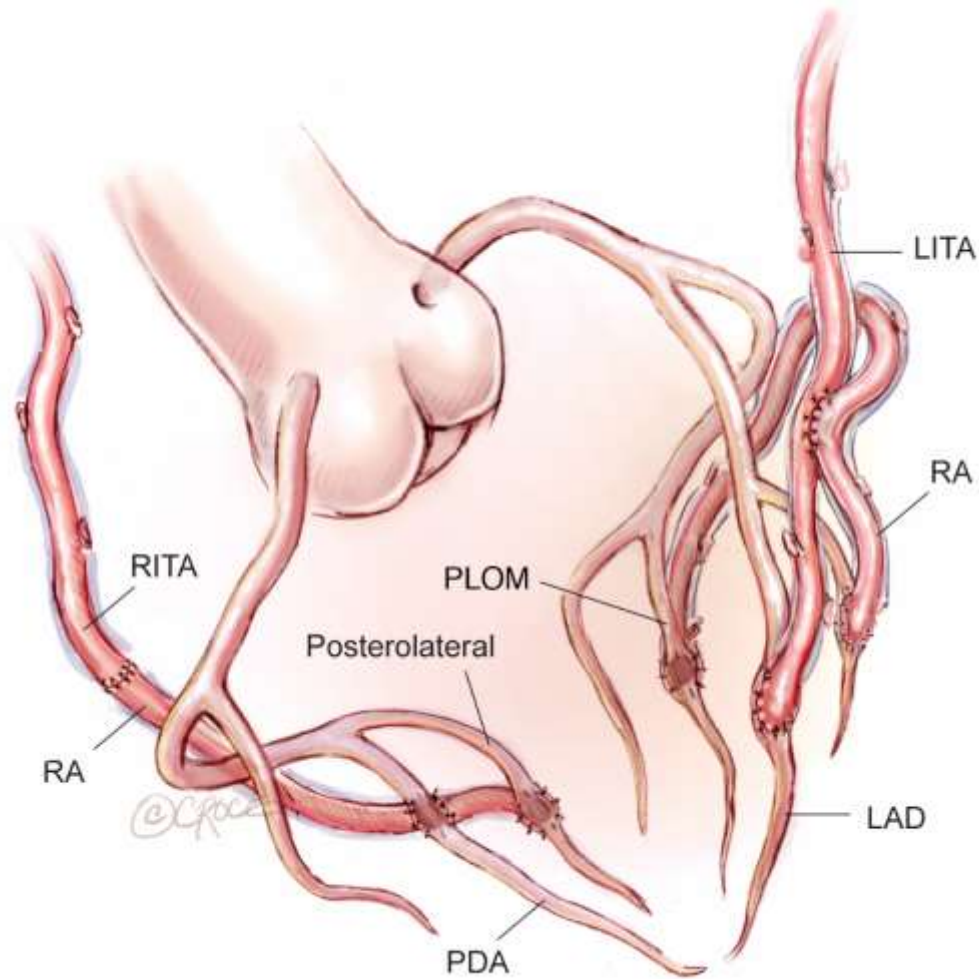
F Atrial fibrillation

anOPCABG			
0.80 (0.68 – 0.97)	OPCABG-PC		
0.71 (0.55 – 0.87)	0.88 (0.69 – 1.06)	CABG	
0.66 (0.49 – 0.89)	0.82 (0.60 – 1.09)	0.94 (0.70 – 1.29)	OPCABG-HS

Anaortic CABG: BITA plus RA



Anaortic BITA plus RA: "K" Graft



Implementation of the aortic no-touch technique to reduce stroke after off-pump coronary surgery

Alexander Albert, MD, PhD,^a Jürgen Ennker, MD, PhD,^{b,c} Yasser Hegazy, MD,^{d,e} Sebastian Ullrich,^f Georgi Petrov, MD,^a Payam Akhyari, MD, PhD,^a Stefan Bauer, MD, PhD,^d Eda Ürer,^a Ina Carolin Ennker, MD, PhD,^g Artur Lichtenberg, MD, PhD,^a Horst Priss, MD,^h and Alexander Assmann, MD, PhD^{a,i}

TABLE 2. Outcome of patients undergoing anOPCAB versus on-pump CABG

Variable	anOPCAB (n = 4485)	CPB (n = 8794)	OR (CI)	P value
Stroke	22 (0.49)	115 (1.3)	0.37 (0.24-0.59)	<.0001
Major stroke	13 (0.29)	93 (1.1)	0.27 (0.15-0.49)	<.0001
Early stroke	4 (0.09)	73 (0.83)	0.11 (0.04-0.29)	<.0001
Major early stroke	3 (0.07)	64 (0.73)	0.09 (0.03-0.29)	<.0001
Delayed stroke	18 (0.40)	42 (0.48)	0.83 (0.48-1.45)	.5181
Major delayed stroke	10 (0.22)	29 (0.33)	0.67 (0.33-1.38)	.312
ACS	111 (2.5)	173 (2.0)	1.27 (0.99-1.61)	.0558
CPR	52 (1.2)	162 (1.8)	0.63 (0.46-0.86)	.0031
Rethoracotomy	75 (1.7)	195 (2.2)	0.75 (0.57-0.98)	.0353
Reintubation	85 (1.9)	228 (2.6)	0.73 (0.56-0.93)	.0122
Creatinine, mg/dL	1.24 ± 0.02	1.20 ± 0.01	–	.0214
CVVHDF	161 (3.6)	328 (3.7)	0.96 (0.79-1.17)	.6852
30-d mortality	55 (1.2)	143 (1.6)	0.75 (0.55-1.03)	.0722

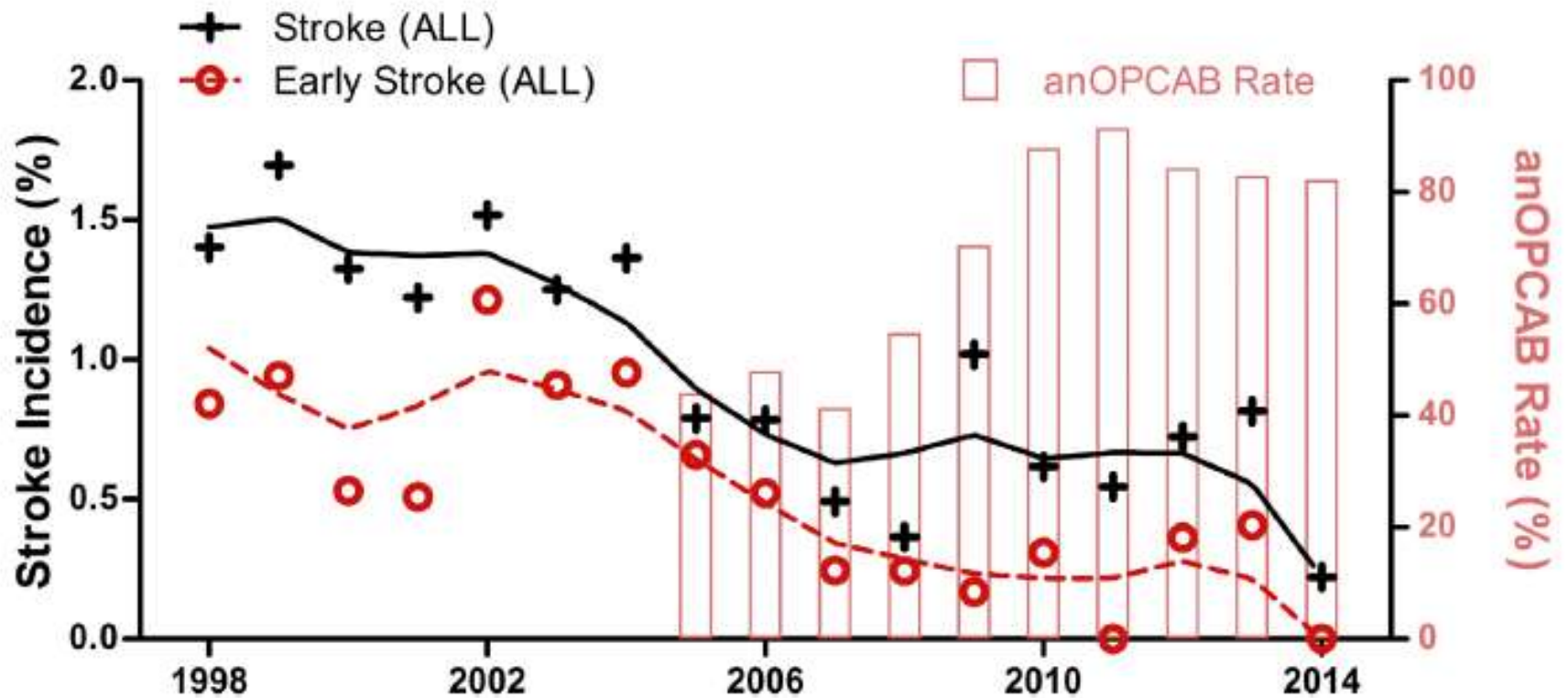
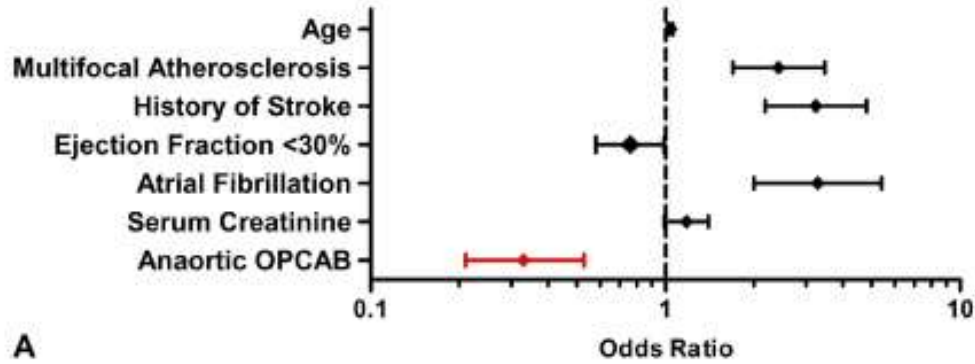


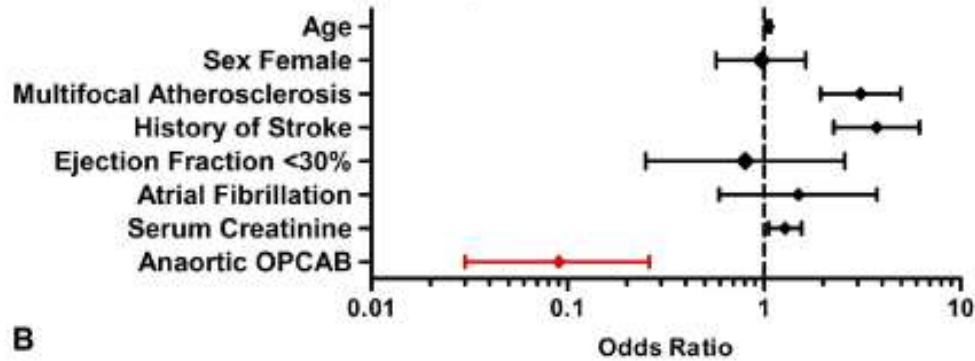
FIGURE 2. Annual stroke and early stroke rates. Reduction of the overall stroke rate (*black crosses*; $P < .0001$) and the early stroke rate (*red rings*) in all patients after the adoption of anOPCAB (*red bars, right y-axis*) starting in 2005. Curve fitting was performed according to the nonparametric Locally Weighted Scatterplot Smoothing method. *anOPCAB*, Anaortic off-pump coronary artery bypass grafting.

Stroke



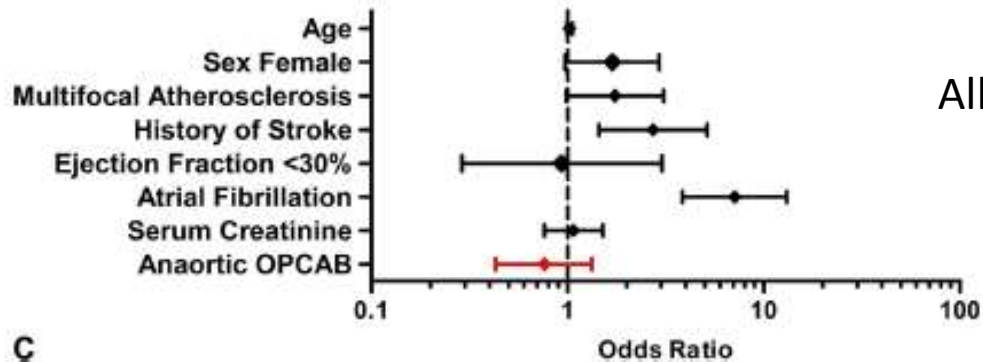
A

Early Stroke



B

Delayed Stroke



C

Albert et al JTCVS 2018

Off-pump, multiple arterial grafting with minimal aortic manipulation: Is it for everyone?

John D. Puskas, MD,^a Bobby Yanagawa, MD, PhD,^b and David P. Taggart, MD, PhD^c

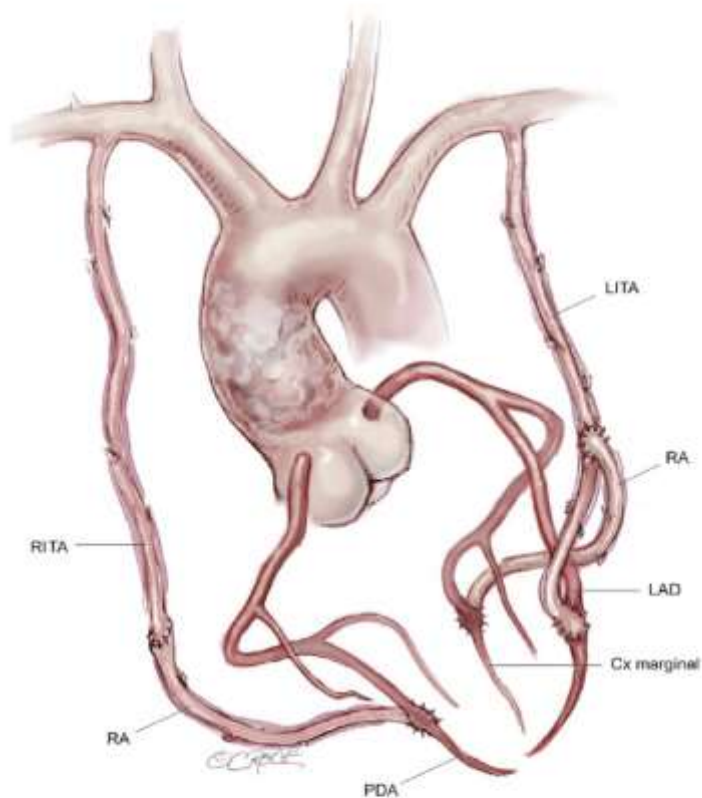


FIGURE 1. Anaortic total arterial grafting using in situ LITA with radial artery Y graft and right internal thoracic artery with radial artery extension. *RITA*, Right internal thoracic artery; *RA*, radial artery; *PDA*, patent ductus arteriosus; *LITA*, left internal thoracic artery; *LAD*, left anterior descending; *Cx*, circumflex.

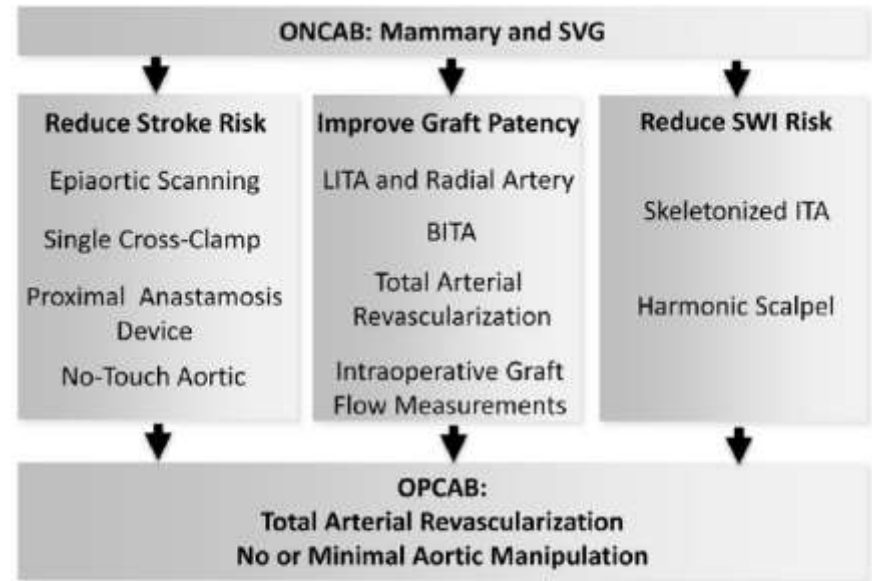


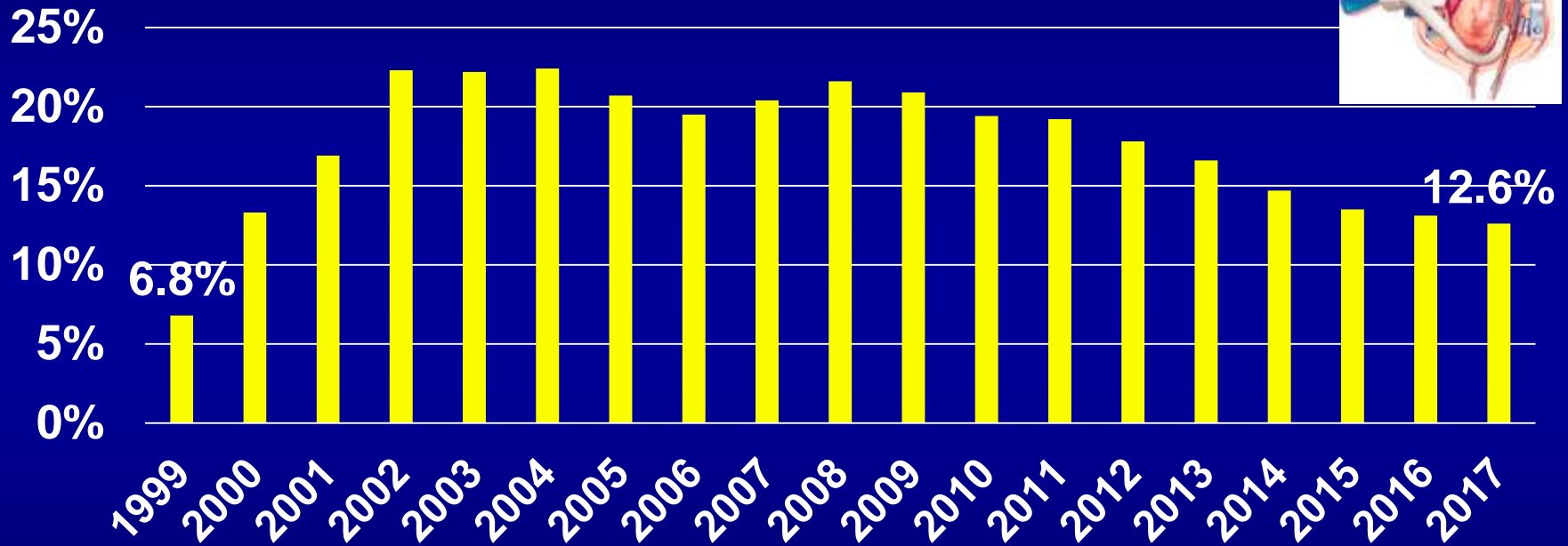
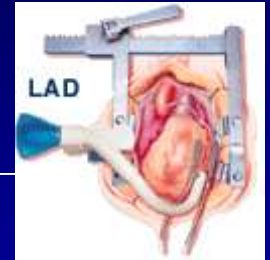
FIGURE 2. Strategies for transition from on-pump CABG to total arterial, minimal, or no aortic manipulation off-pump CABG. *ONCAB*, On-pump coronary artery bypass graft; *SVG*, saphenous vein graft; *LITA*, left internal thoracic artery; *BITA*, bilateral internal thoracic artery; *SWI*, sternal wound infection; *ITA*, internal thoracic artery; *OPCAB*, off-pump coronary artery bypass graft.

Summary: Current Status of OPCAB

- OPCAB can be better than ONCAB, but requires special expertise; we have not disseminated good ways to teach OPCAB
- Clampless/no-aortic touch OPCAB, by minimizing/avoiding manipulation of the ascending aorta, is associated with lower risk of stroke and especially benefits high risk patients
- BITA grafting prolongs life; Radial Arteries are (usually) better than veins; DAPT may improve OPCAB graft patency
- Clampless/no-aortic touch, all-arterial OPCAB is state-of-the-art CABG
- It may be best performed in a CABG Reference Center



STS National Database: Isolated CAB Off pump CAB

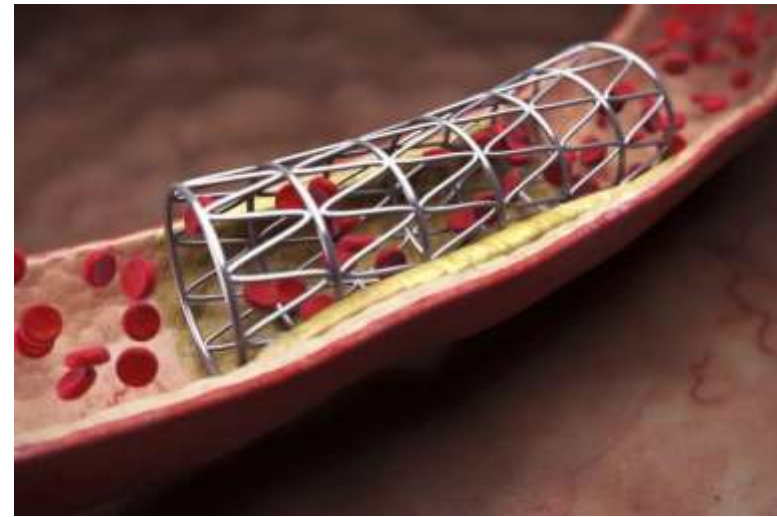
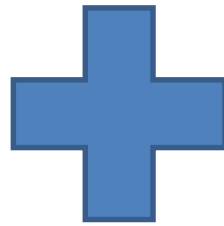


Evolution of CABG in 2018:

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5. **Robotic and hybrid robotic CABG**
6. Optimal Medical Management of CABG Patients
7. The Coronary Heart Team

Hybrid Coronary Revascularization:

Planned combination of surgical and percutaneous techniques in two different coronary territories, both scheduled and performed within a predefined time period in a patient with multi-vessel coronary artery disease

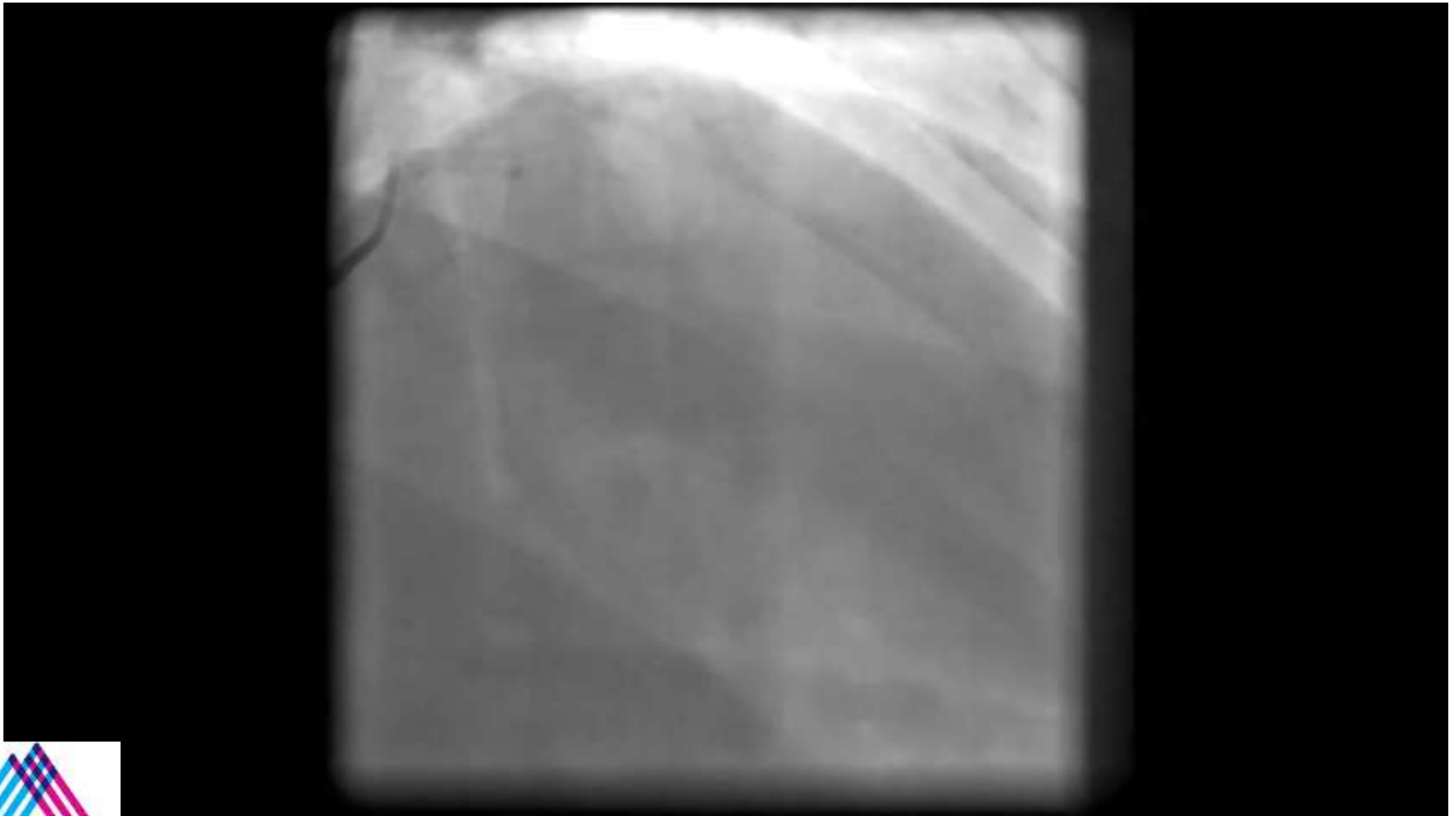


HCR Case:

2-Vessel CAD Including Proximal LAD Stenosis

- 58 yo male Jehovah's Witness
(refusing any blood transfusion)
- PMH:
 - testicular cancer s/p resection and chemoRx
 - HTN, HLD
- Presenting with unstable angina for 2 weeks

Preop Coronary Angiography: 2VD Including Proximal LAD Stenosis



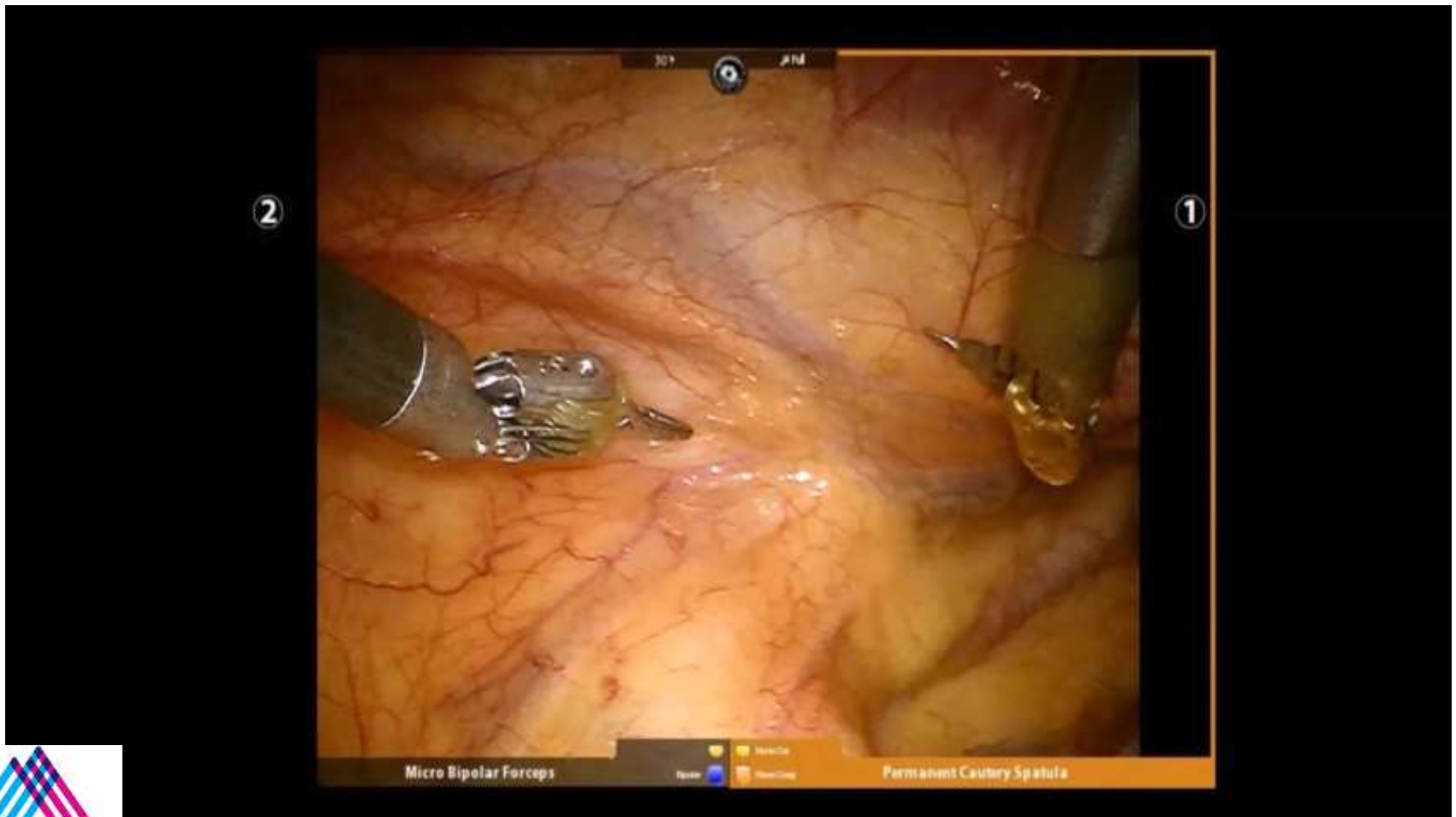
HCR OR Set Up



HCR: Robot Set Up



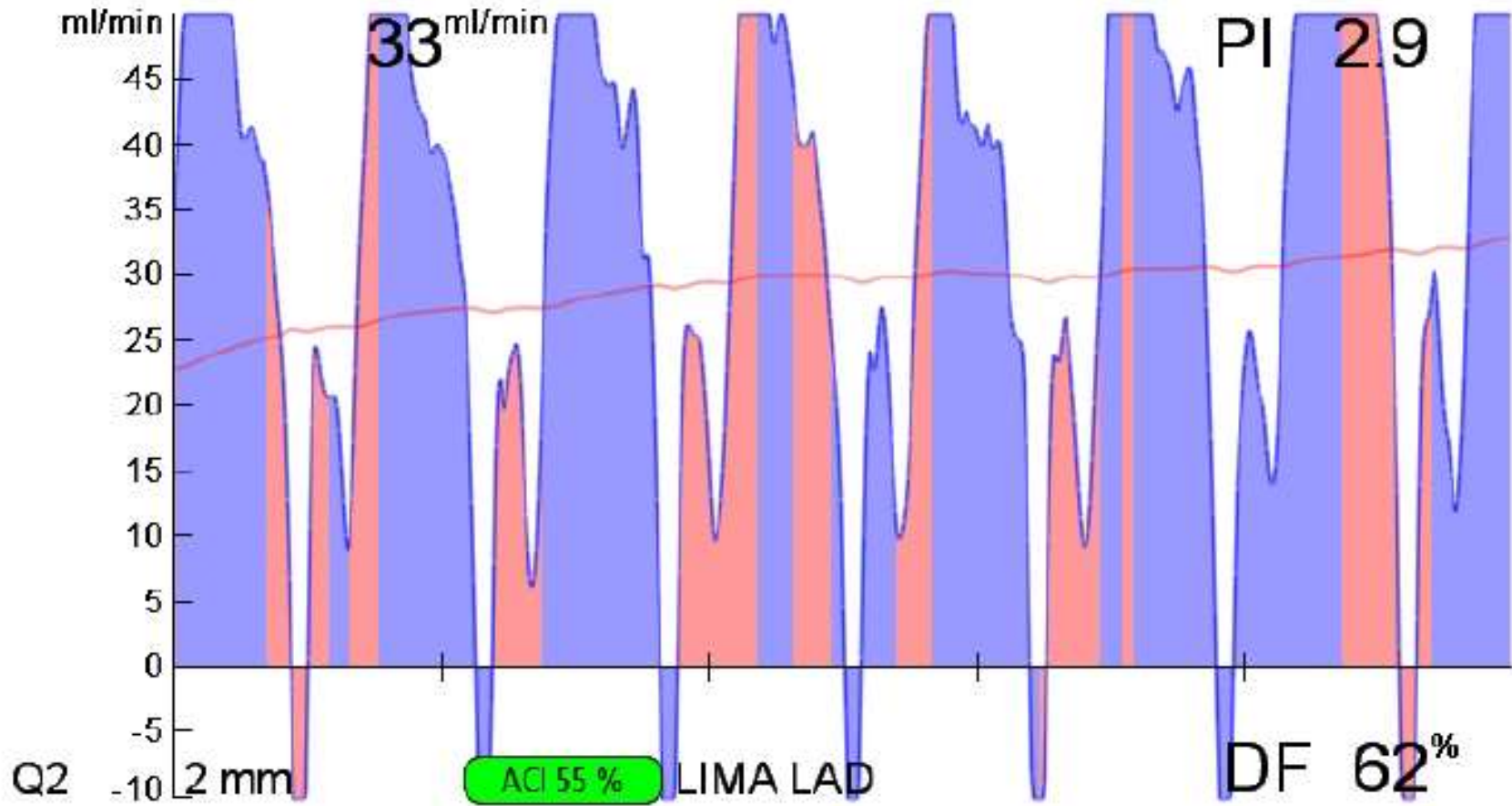
HCR: Robotic LIMA Harvest



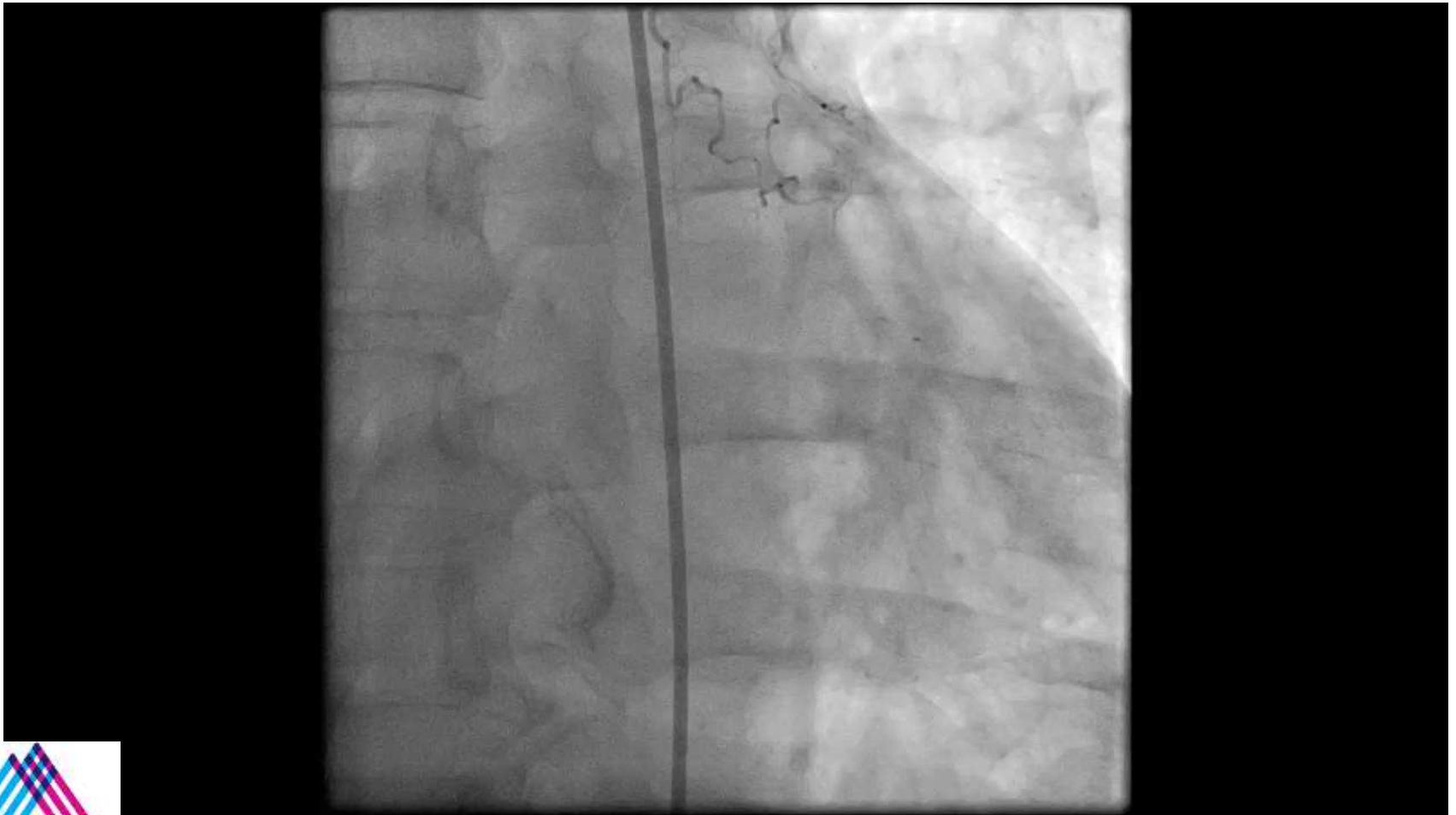
HCR (1st Stage): LIMA to LAD Anastomosis



HCR: LIMA to LAD Flow Measurement (Transit Time Doppler)



HCR (2nd Stage): LIMA Angiography and RCA stent



HCR Case: Left Main Disease

- 57 yo male with NSTEMI
- No significant past medical history
- Strong family history for CAD
- Distal LM disease and Proximal LAD
- RCA normal
- Laborer; refused sternotomy



Angiogram-LCA



Mount
Sinai
St. Luke's

Angiogram-LCA

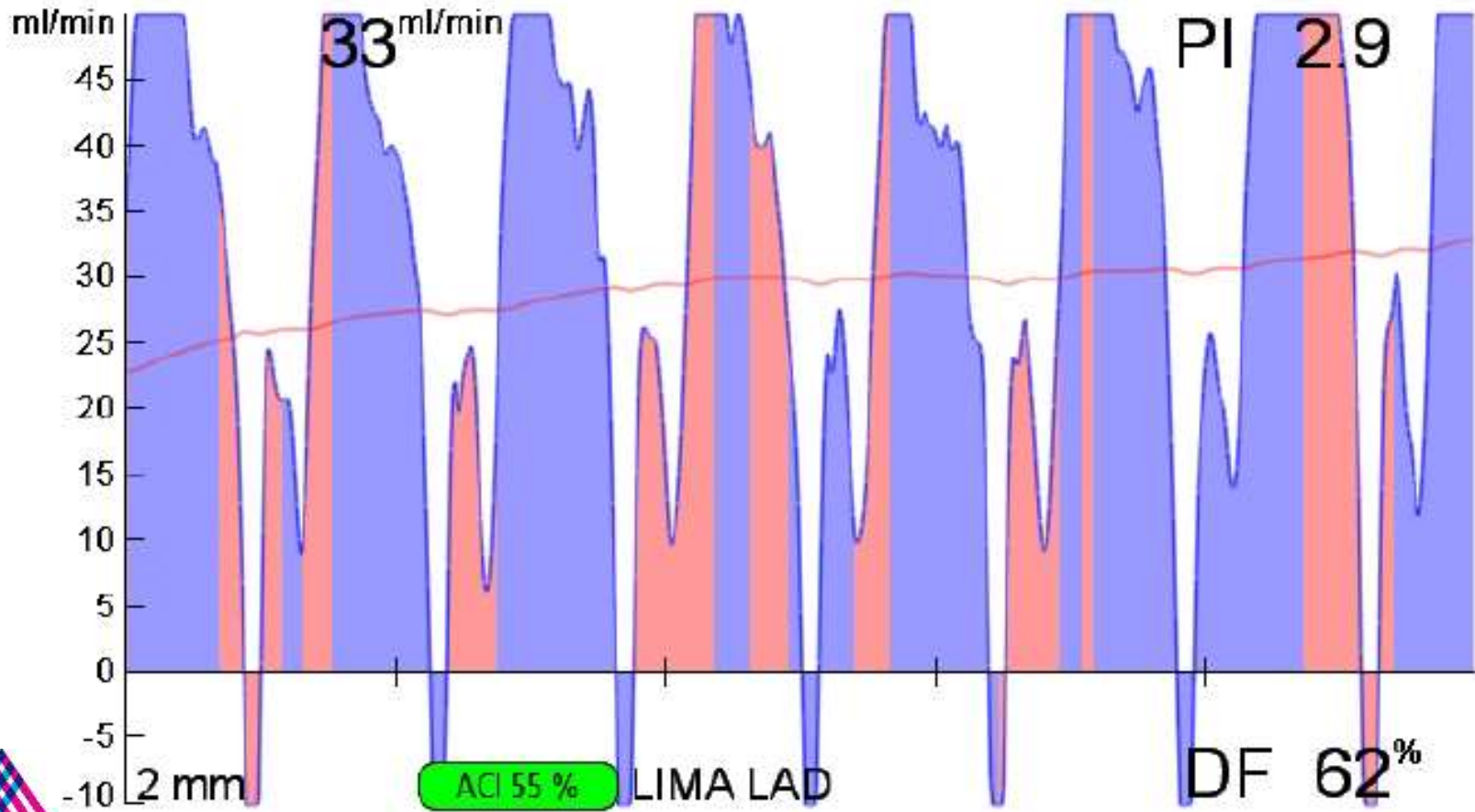


Mount
Sinai
St. Luke's

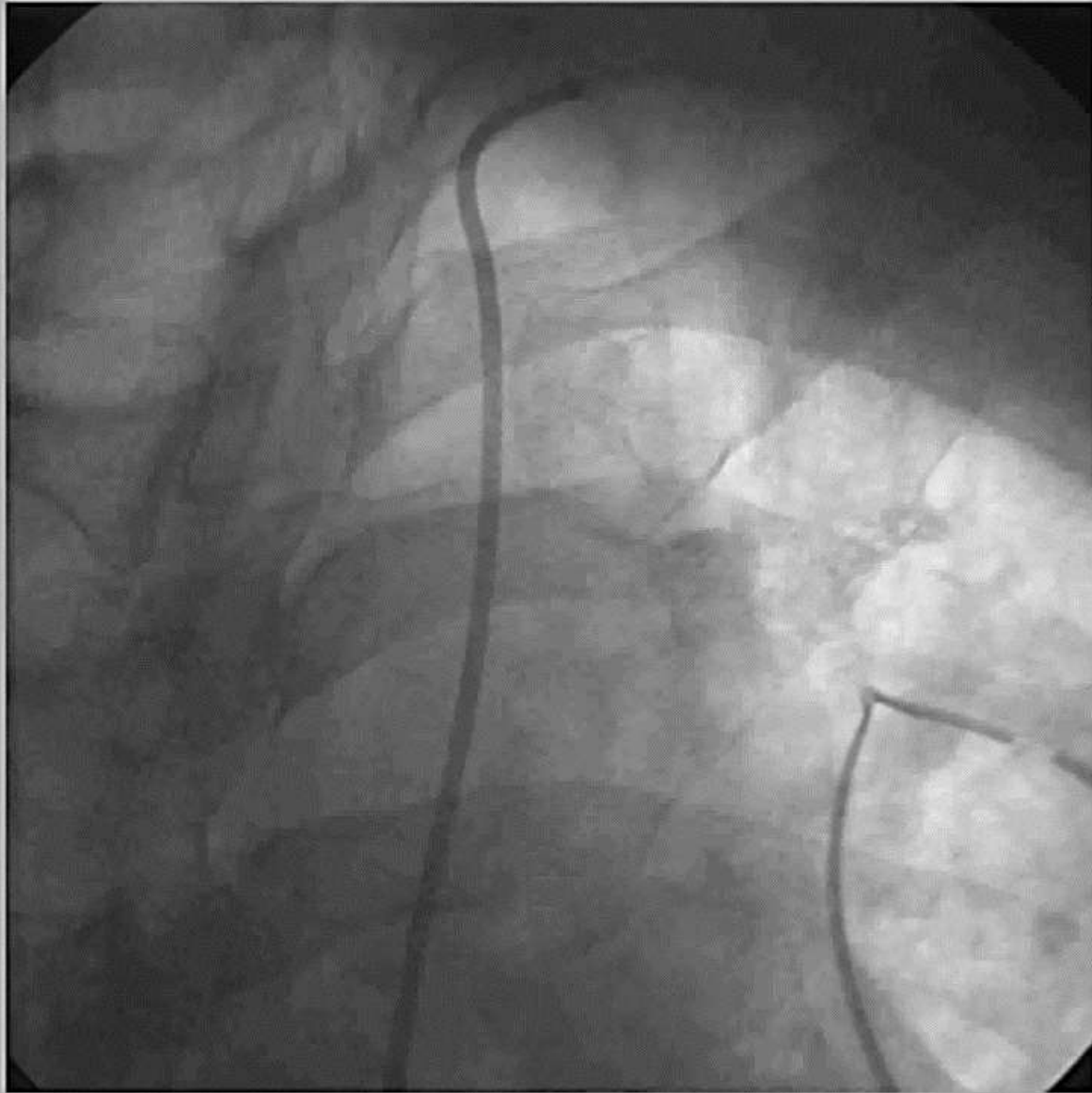
Plan

- Robotic assisted LIMA-LAD
- Subsequent PCI of LM into circumflex on POD #1

HCR: LIMA to LAD Flow Measurement (Transit Time Doppler)



LIMA Injection POD#1



Mount
Sinai
St. Luke's

PTCA of LM into LCx with DES



Mount
Sinai
St. Luke's

Completion Angio



Mount
Sinai
St. Luke's

Postoperative Course

- Taken to cath lab on POD#1
- Uncomplicated procedure
- Discharged home POD#3
- Back to work 2 weeks

4 Weeks after Robotic LIMA-LAD



Coronary Anatomic Indications for Hybrid Revascularization

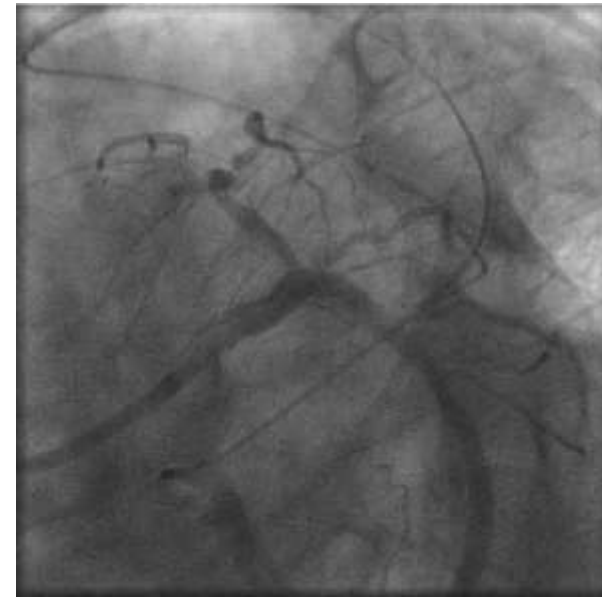
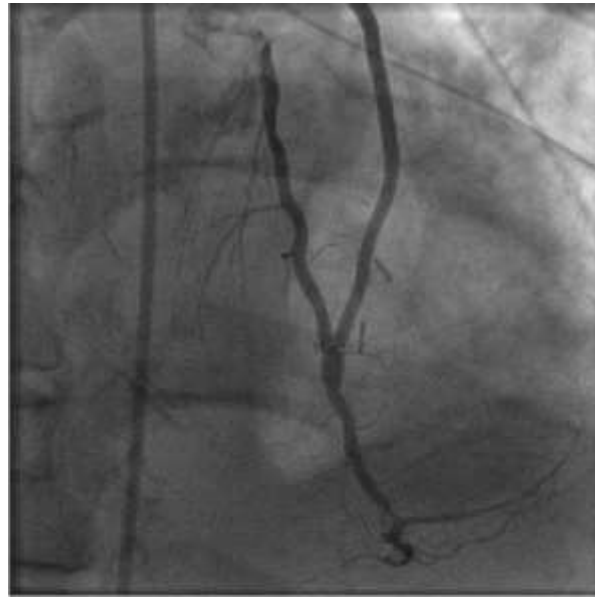
- Proximal LAD plus (typically) one other diseased vessel
 - Ostial LAD, restenosed proximal LAD stent, calcified long LAD lesions
 - Non-LAD lesion(s) amenable to PCI
- Isolated distal or bifurcation LM disease with/without proximal LAD disease
- “Why do an unprotected distal LM and/or complex prox LAD PCI when you can have a robotic LIMA-LAD for your patient and do a protected LM PCI procedure?”



Hybrid Coronary Revascularization Versus Off-Pump Coronary Artery Bypass for the Treatment of Left Main Coronary Stenosis

Michael E. Halkos, MD, S. Tanveer Rab, MD, Thomas A. Vassiliades, MD, MBA,
Douglas C. Morris, MD, John S. Douglas, MD, Patrick D. Kilgo, MS,
Henry A. Liberman, MD, Robert A. Guyton, MD, Vinod H. Thourani, MD, and
John D. Puskas, MD

(Ann Thorac Surg 2011;92:2155–60)



Hybrid Revascularization for Multivessel Coronary Artery Disease



Mariusz Gąsior, MD,* Michael Oscar Zembala, MD, PhD,† Mateusz Tajstra, MD, PhD,* Krzysztof Filipiak, MD, PhD,† Marek Gierlotka, MD,* Tomasz Hrapkiewicz, MD, PhD,† Michał Hawranek, MD, PhD,* Lech Poloński, MD,* Marian Zembala, MD,† on behalf of the POL-MIDES (HYBRID) Study Investigators

JACC: CARDIOVASCULAR INTERVENTIONS

VOL. 7, NO. 11, 2014

OBJECTIVES The aim of this study was to assess the feasibility of hybrid coronary revascularization (HCR) in patients with multivessel coronary artery disease (MVCAD) referred for standard coronary artery bypass grafting (CABG).

METHODS A total of 200 patients with MVCAD involving the left anterior descending artery (LAD) and a critical (>70%) lesion in at least 1 major epicardial vessel (except the LAD) amenable to both PCI and CABG and referred for conventional surgical revascularization were randomly assigned to undergo HCR or CABG (in a 1:1 ratio). The primary endpoint was the evaluation of the safety of HCR. The feasibility was defined by the percent of patients with a complete HCR procedure and the percent of patients with conversions to standard CABG. The occurrence of major adverse cardiac events such as death, myocardial infarction, stroke, repeated revascularization, and major bleeding within the 12-month period after randomization was also assessed.

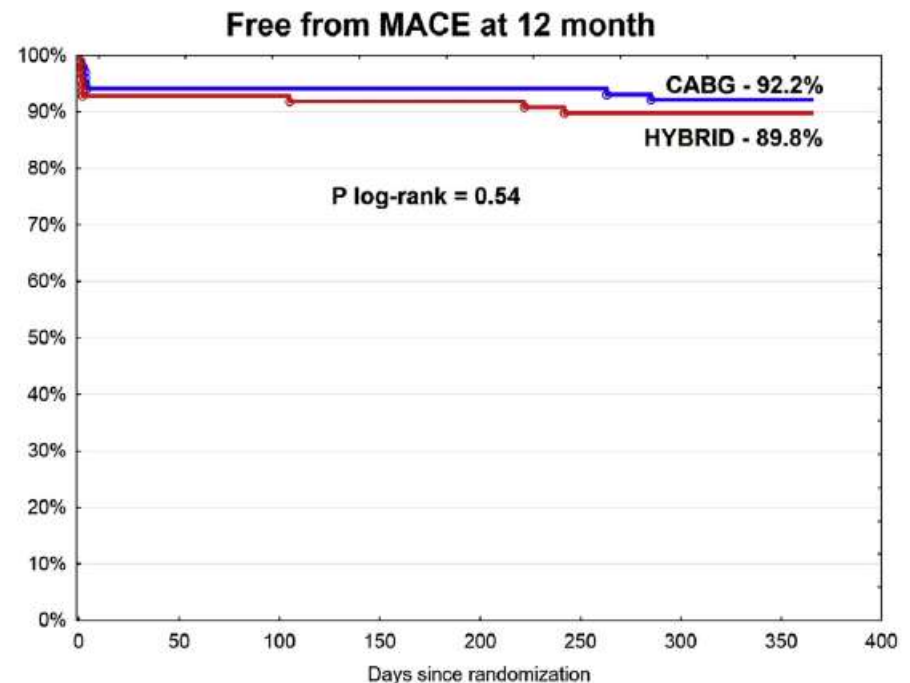
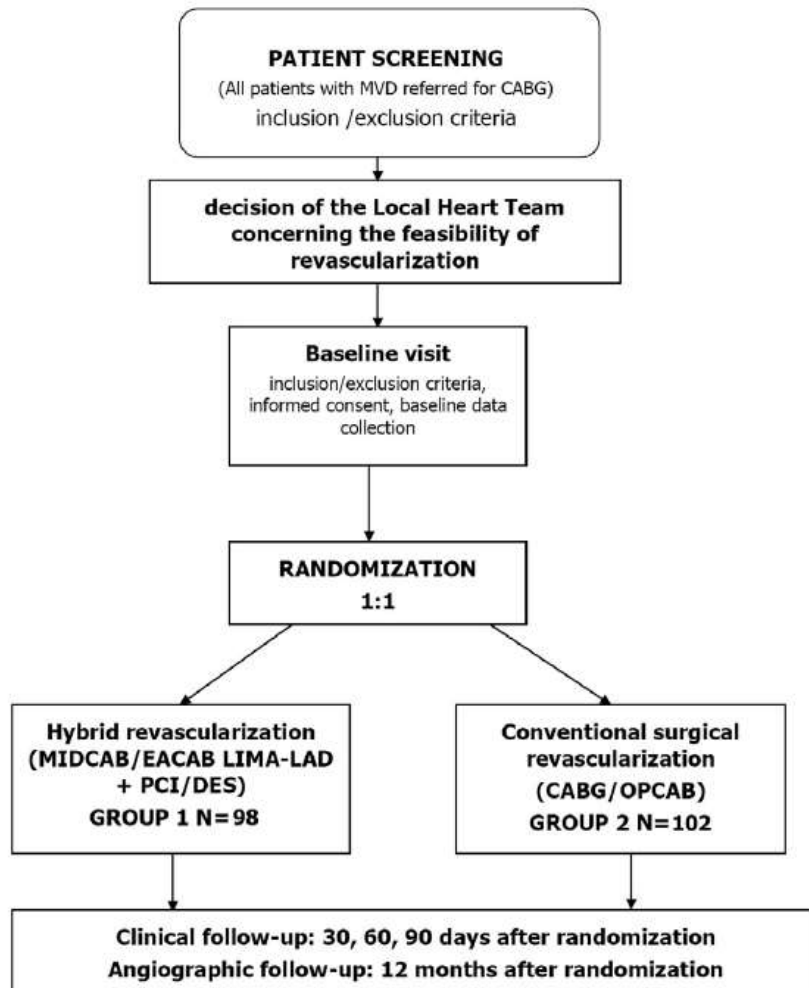
CONCLUSIONS HCR is feasible in select patients with MVCAD referred for conventional CABG. (Safety and Efficacy Study of Hybrid Revascularization in Multivessel Coronary Artery Disease [POL-MIDES]; [NCT01035567](#)) (J Am Coll Cardiol Intv 2014;7:1277-83) © 2014 by the American College of Cardiology Foundation.

Hybrid Revascularization for Multivessel Coronary Artery Disease

JACC: CARDIOVASCULAR INTERVENTIONS

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POL-MIDES (HYBRID) Study Investigators



EDITORIAL COMMENT

Hybrid Coronary Revascularization

A New Treatment Paradigm for Selected Patients With Multivessel Coronary Artery Disease*



John D. Puskas, MD, MSc, Amit Pawale, MD, Samin K. Sharma, MD

It may be more appropriate and impactful to study the safety and efficacy of HCR in patients with less extensive, hybrid-eligible coronary anatomy referred for either multivessel PCI or surgical coronary revascularization. Any patient with proximal LAD stenosis and significant lesion(s) in 1 or at most 2 other non-LAD vessels could be eligible for randomization to HCR versus multivessel PCI. Such

Hybrid Coronary Revascularization Versus Off-Pump Coronary Artery Bypass for the Treatment of Left Main Coronary Stenosis

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In-Hospital Outcomes	OPCAB (n = 81)	HCR (n = 27)	<i>p</i> Value
No. with blood transfusion (%)	50 (61.7)	9 (33.3)	0.01
Renal failure (%)	2 (2.5)	1 (3.7)	0.74
Hospital LOS (days, mean ± SD)	6.6 ± 5.6	5.6 ± 2.0	0.19
Postoperative atrial fibrillation (%)	19 (23.5)	5 (19.2)	0.65
Ventilator hours (mean ± SD)	32.8 ± 96.3	6.9 ± 7.9	0.022
ICU LOS (days, mean ± SD)	64.3 ± 120.3	36.4 ± 29.8	0.058

HCR = hybrid coronary revascularization; ICU = intensive care unit; LOS = length of stay; OPCAB = off-pump coronary artery bypass grafting; SD = standard deviation.

Repeat Revascularization	OPCAB (n = 81)	HCR (n = 27)	<i>p</i> Value
All repeat revascularization events (%)	1 (1.2)	2 (7.4)	0.09
Target vessel revascularization (%)	1 (1.2)	1 (3.7)	0.41
Progression of native disease (%)	0 (0.0)	1 (3.7)	0.08
Occlusion or stenosis of SVG (%)	1 (1.2)	0 (0.0)	0.56
In-stent restenosis (%)	0 (0.0)	1 (3.7)	0.08

HCR = hybrid coronary revascularization; OPCAB = off-pump coronary artery bypass; SVG = saphenous vein graft.





CrossMark

Hybrid Coronary Revascularization for the Treatment of Multivessel Coronary Artery Disease

A Multicenter Observational Study

John D. Puskas, MD,^{a,b} Michael E. Halkos, MD,^c Joseph J. DeRose, MD,^d Emilia Bagiella, PhD,^e
Marissa A. Miller, DMV, MPH,^f Jessica Overbey, MS,^e Johannes Bonatti, MD,^g V.S. Srinivas, MD,^d Mark Vesely, MD,^h
Francis Sutter, MD,ⁱ Janine Lynch, MPH,ⁱ Katherine Kirkwood, MS,^e Timothy A. Shapiro, MD,ⁱ
Konstantinos D. Boudoulas, MD,ⁱ Juan Crestanello, MD,ⁱ Thomas Gehrig, MD,^k Peter Smith, MD,^k
Michael Ragosta, MD,^l Steven J. Hoff, MD,^m David Zhao, MD,ⁿ Annetine C. Gelijns, PhD,^e Wilson Y. Szeto, MD,^o
Giora Weisz, MD,^p Michael Argenziano, MD,^p Thomas Vassiliades, MD,^{c,q} Henry Liberman, MD,^c
William Matthai, MD,^o Deborah D. Ascheim, MD^{a,e}



Mount
Sinai
Heart

Hybrid Observational Study

- Prospective cohort observational study
- 11 US clinical sites
- To inform design of an RCT of HCR vs. multivessel PCI (DES)
 - Feasibility of recruitment (# anatomically eligible pts)
 - More precise characterization of population undergoing HCR
 - Variability of treatment approaches
 - Event rates (MACCE)

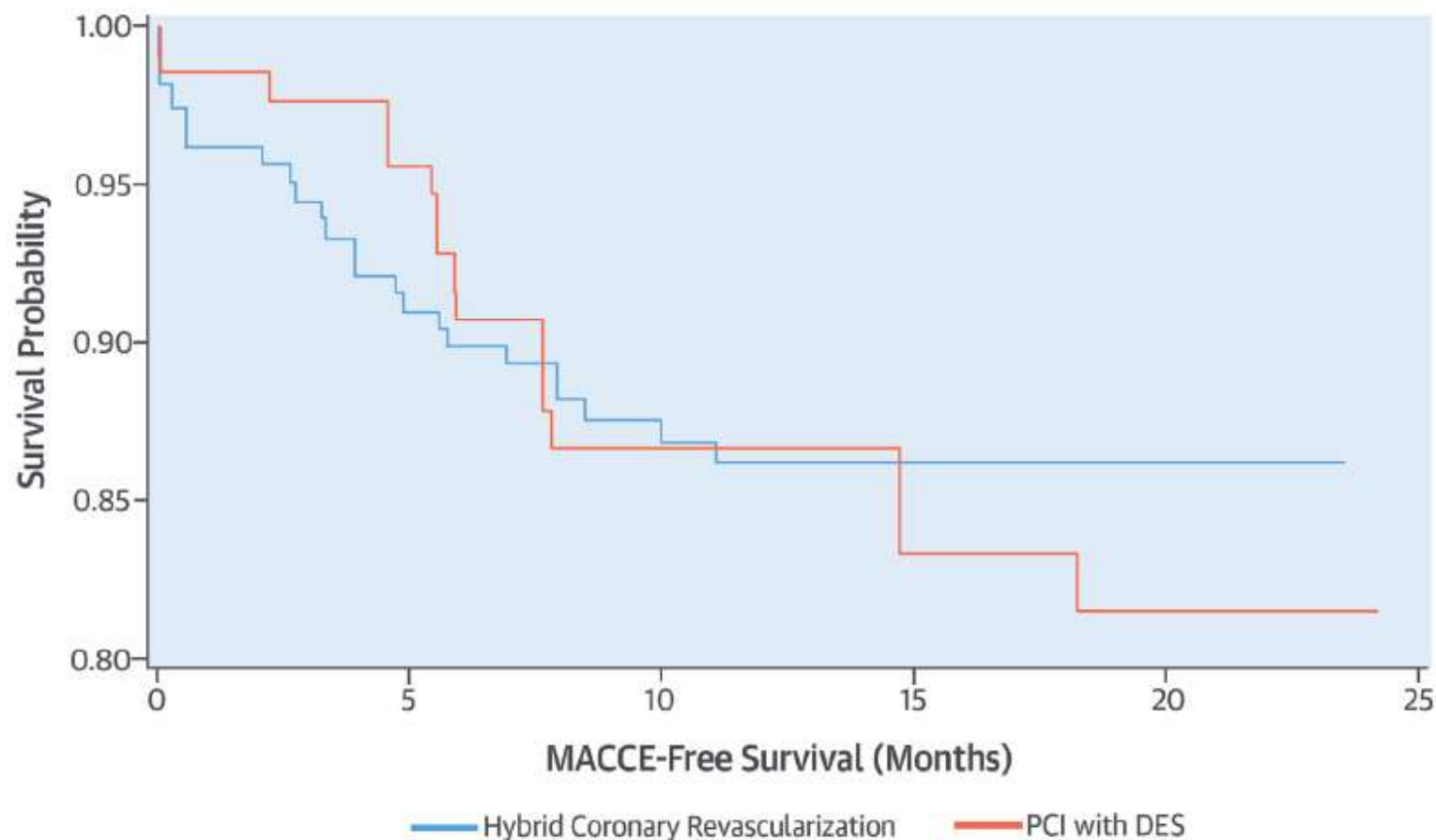
HCR Study Population

Clinical Site	HCR	PCI*
Brigham and Women's Hospital	0	1
Columbia University	3	23
Duke University Medical Center	3	5
Emory University	79	4
Lankenau Hospital	31	7
Montefiore Medical Center	26	14
Ohio State University	9	6
University of Maryland Medical Center	36	6
University of Pennsylvania	9	26
University of Virginia Health System	2	4
Vanderbilt University Medical Center	2	2
Total	200	98

- Median follow-up post-revasc 17.6 ± 6.5 months
- Analysis included 339.8 person-years at risk

*All anatomically & clinically eligible for HCR

MACCE-Free Survival at End of Study Follow-up



Puskas, J.D. et al. *J Am Coll Cardiol.* 2016;68(4):356-65.

In this first multicenter observational study of hybrid coronary revascularization (HCR) and multivessel percutaneous coronary intervention (PCI) for patients with hybrid-eligible coronary anatomy, risk-adjusted major adverse cardiovascular and cerebrovascular events (MACCE) rates were similar between groups through 12 months of follow-up. During longer follow-up, at 18 months, MACCE-free survival curves for HCR versus PCI began to diverge, with increasing MACCE in the multivessel PCI group. DES = drug-eluting stent(s).

NIH Hybrid Coronary Revascularization Randomized Trial

CCC: John Puskas (Mount Sinai) and Gregg Stone (CRF)

DCC: Emilia Bagiella, Alan Moskowitz (Mount Sinai)

Objectives



- To evaluate the safety and effectiveness of hybrid coronary revascularization (HCR) compared to multi-vessel percutaneous coronary intervention (PCI) with drug-eluting stents (DES) in patients with multi-vessel coronary artery disease (CAD) involving the Left Anterior Descending (LAD) and/or Left Main (LM) arteries.



Study Design



- Prospective, randomized, multi-center, comparative effectiveness trial
- Patients randomized with equal allocation (1:1).
- Registry-based Trial
 - Society of Thoracic Surgeons (STS) Data Registry will be used for peri-procedural and demographic data on patients randomized to HCR

Target Population & Interventions



- Patients with multi-vessel CAD involving the proximal or mid LAD distribution with a clinical indication for revascularization *and* eligible for both HCR and multi-vessel PCI with DES
- 2354 patients will be randomized:
 - HCR with Left Internal Mammary Artery (LIMA) to LAD + PCI of non-LAD vessels
 - Multi-vessel PCI with DES, including the LAD

Primary Endpoint



The occurrence of MACCE, defined as all-cause mortality, myocardial infarction (MI), stroke, and repeat revascularization over a minimum of 5 year follow-up after randomization

Secondary Endpoints



Cardiovascular Events

- MACCE at each data collection time point
- Individual components of MACCE
 - All-cause mortality
 - Repeat revascularization (all-cause)
 - Stroke
 - Myocardial infarction (MI)
- Ischemia-driven repeat revascularization
- Cardiovascular mortality

Hospitalizations

- Re-hospitalization (all-cause and cardiovascular)

Health Status

- Angina Score (Canadian Cardiovascular Society Classification [CCSC])
- Quality of Life (SF-12 and EuroQOL)

Cost and Cost Effectiveness

- Resource utilization: length of hospital stay for index procedure (as relevant), readmissions
- Days alive out of hospital
- Cost and cost-effectiveness (cost per quality-adjusted life year)



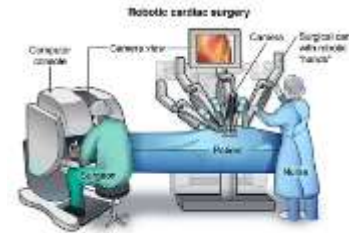
Hybrid Coronary Revascularization

- Evolving treatment paradigm for patients with proximal LAD disease and low SYNTAX score
- NIH HCR Observational Study suggests outcomes with PCI vs HCR are similar at 12 months.
- Just-funded NIH HCR Randomized Trial will explore whether HCR may offer longer-term advantages over multivessel PCI for hybrid-eligible patients.
- THIS IS A CARDIOLOGY TRIAL; all patients begin and end in the cath lab

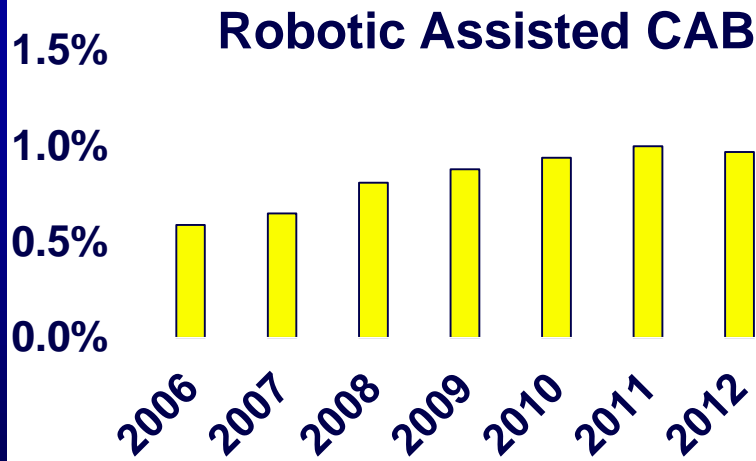


Trends in Robotic-Assisted Coronary Artery Bypass Grafts: A Study of The Society of Thoracic Surgeons Adult Cardiac Surgery Database, 2006 to 2012

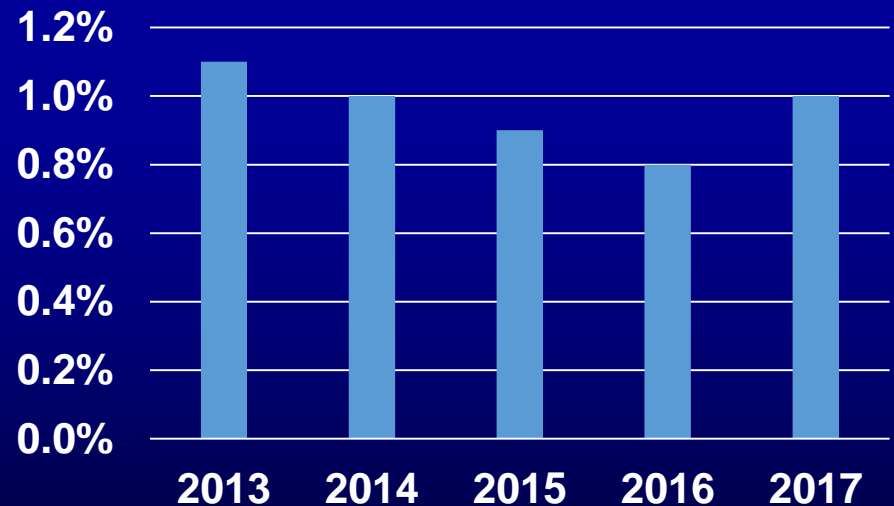
David J. Whellan, MD, MHS, Melissa M. McCarey, MPH, Bradley S. Taylor, MD, MPH, Todd K. Rosengart, MD, Amelia S. Wallace, MS, A. Laurie W. Shroyer, PhD, James S. Gammie, MD, and Eric D. Peterson, MD, MPH



(Ann Thorac Surg 2016;102:140-6)
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Robotic Assisted CAB Remains $\leq 1.1\%$



Evolution of CABG in 2018:

1. CABG remains important—SYNTAX 5 yr data
2. Brief History of CABG
3. Current State of CABG—STS Database
4. Ongoing Evolution of CABG with a Focus on Quality Improvement
 1. Improving On-Pump CABG:
 1. Epi-aortic U/S and single X-clamp
 2. Multiple arterial conduits
 3. Graft assessment and DAPT
 2. Improving Off-Pump CABG
 1. Patient and surgeon selection
 2. Epi-aortic U/S and Clampless OPCAB
 3. Evolution towards all-arterial no-aortic-touch OPCAB
 4. Graft assessment and DAPT
5. Robotic and hybrid robotic CABG
6. **Optimal Medical Management of CABG Patients**
7. The Coronary Heart Team

Circulation

Coronary Artery Bypass Graft Versus Percutaneous Coronary Intervention

Meds Matter: Impact of Adherence to Medical Therapy on Comparative Outcomes

BACKGROUND: Multiple studies have compared coronary artery bypass graft (CABG) with percutaneous coronary interventions (PCI) for coronary revascularization. There is considerable evidence that adherence to medical therapy can affect the outcomes of therapeutic interventions. However, the long-term influence of compliance with recommended medical therapy on the comparative outcomes of CABG versus PCI remains to be defined.

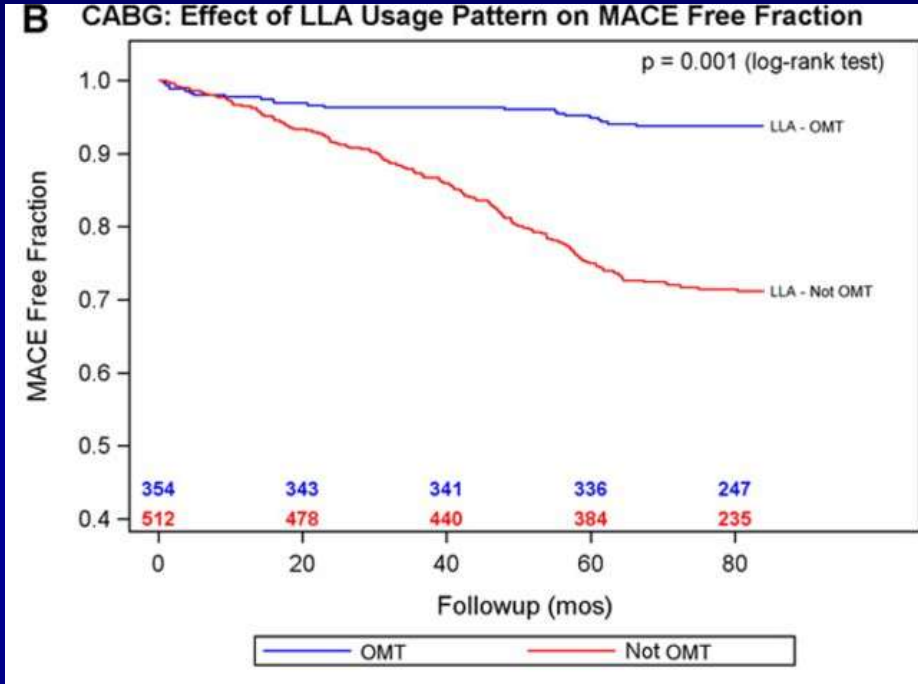
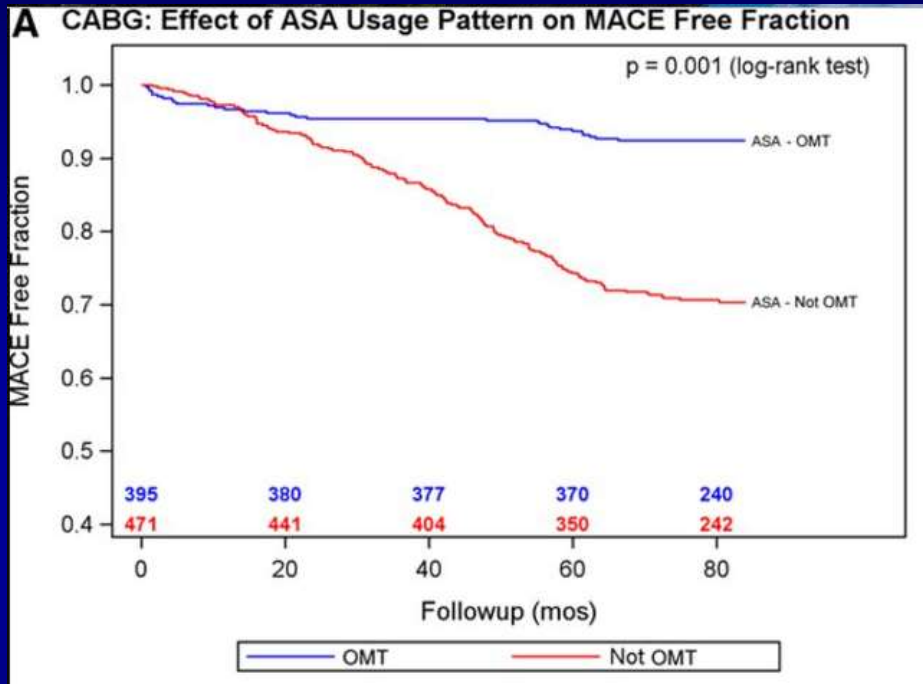
METHODS: All non-ST-segment-elevation myocardial infarction patients undergoing coronary revascularization in an 8-hospital network were followed for up to 8 years to determine medication history and major adverse cardiac events: all-cause mortality, nonfatal myocardial infarction, and reintervention. All mortalities were checked against the Social Security Death Index. Survival curves were derived with Kaplan-Meier methods; hazard ratios were calculated with the Cox proportional hazard model; and propensity score matching was used to account for differences in patient selection.

RESULTS: Among the 973 CABG and 2255 PCI patients, Kaplan-Meier major adverse cardiac event-free survival curves demonstrated a significant benefit for antiplatelet, lipid-lowering, and β -blocker therapy in both the CABG and PCI groups ($P=0.001$ for all 3 medications). Cox regression identified compliance with optimal medical therapy as a more powerful predictor of major adverse cardiac event-free survival than choice of therapy (hazard ratio for noncompliance=2.79; 95% confidence limits, 2.19–3.54; $P<0.001$; hazard ratio for PCI versus CABG=1.68, 95% confidence limits, 1.38–2.04; $P<0.001$). In propensity-matched patients CABG outcomes were superior to PCI outcomes in patients nonadherent to optimal medical therapy ($P=0.001$) but were not different in patients adherent to optimal medical therapy ($P=0.574$).

Paul Kurlansky, MD
Morley Herbert, PhD
Sarna Prince, RN
Michael Mack, MD

Kurlansky, P, *Circ.* 2016; 134: 1238-1246

- 8 Community Hospitals
 - 973 CABG Patients
 - 2255 PCI Patients
- Detailed Medication History
 - 18 months; 5-7 years
- Focus on:
 - ✓ Antiplatelet Therapy
 - ✓ Lipid Lowering agents
 - ✓ B-Blocker Treatment
 - ✓ End Point: Major Adverse Cardiac Event



Evolution of CABG in 2018:

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7. **The Coronary Heart Team**

Definition of Coronary Heart Team

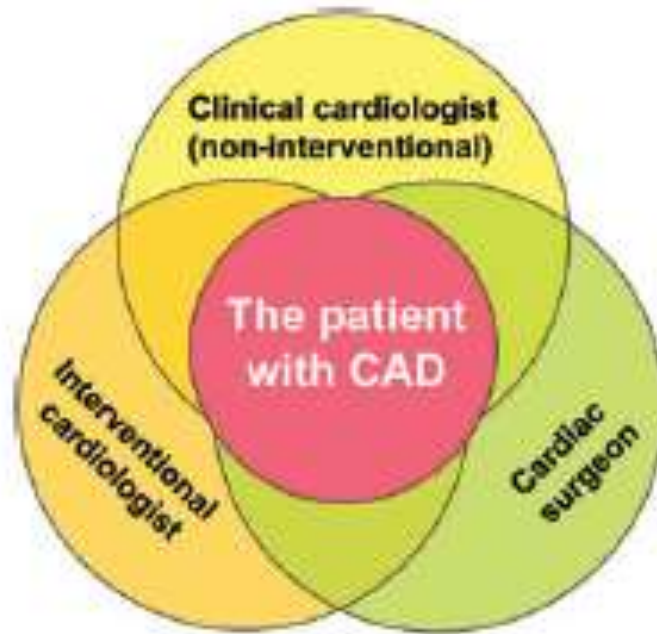


Figure 5 The basis for a Heart Team is involvement of necessary specialties and the patient to facilitate shared decision-making. Copied with permission from Wijns et al.⁸⁵ CAD = coronary artery disease.

History of the Coronary Heart Team

- Initiated in early randomized trials comparing CABG with medical therapy for stable CAD; used to select patients eligible for randomization
- Predates TAVR Heart Team by >20 years
- RCTs of CABG vs PCI followed.
- EAST and BARI trials included nested Registries along with the randomized cohorts to demonstrate if physician or patient-treatment preferences yielded different results than randomized patients

Clinical update

The rationale for Heart Team decision-making for patients with stable, complex coronary artery disease

**Stuart J. Head¹, Sanjay Kaul², Michael J. Mack³, Patrick W. Serruys¹,
David P. Taggart⁴, David R. Holmes Jr⁵, Martin B. Leon^{6,7}, Jean Marco⁸,
Ad J.J.C. Bogers¹, and A. Pieter Kappetein^{1*}**

¹Department of Cardiothoracic Surgery, Erasmus University Medical Centre, Rotterdam, The Netherlands; ²Cedars-Sinai Medical Center, University of California, Los Angeles, CA, USA; ³The Heart Hospital, Baylor Health Care Systems, Plano, TX, USA; ⁴John Radcliffe Hospital, Oxford University Hospitals NHS Trust, Oxford, UK; ⁵Mayo Clinic Rochester, Rochester, MN, USA; ⁶Columbia University Medical Center/New York-Presbyterian Hospital, New York, NY, USA; ⁷Cardiovascular Research Foundation, New York, NY, USA; and ⁸Clinique Pasteur, Toulouse, France

- Stable complex CAD can be treated with CABG, PCI or Med Rx
- Despite calls for Heart Team approach, there remains large variability in PCI-to-CABG ratios, due to physician-related factors, raising concern about overuse, underuse and inappropriate selection of revascularization
- Heart Team, consisting of clinical and interventional cardiologists and cardiac surgeon, can together better analyze and interpret the diagnostic evidence, consider the clinical condition and individual preferences of the patient and their own local expertise and through shared decision-making with the patient make the most appropriate recommendation for treatment strategy

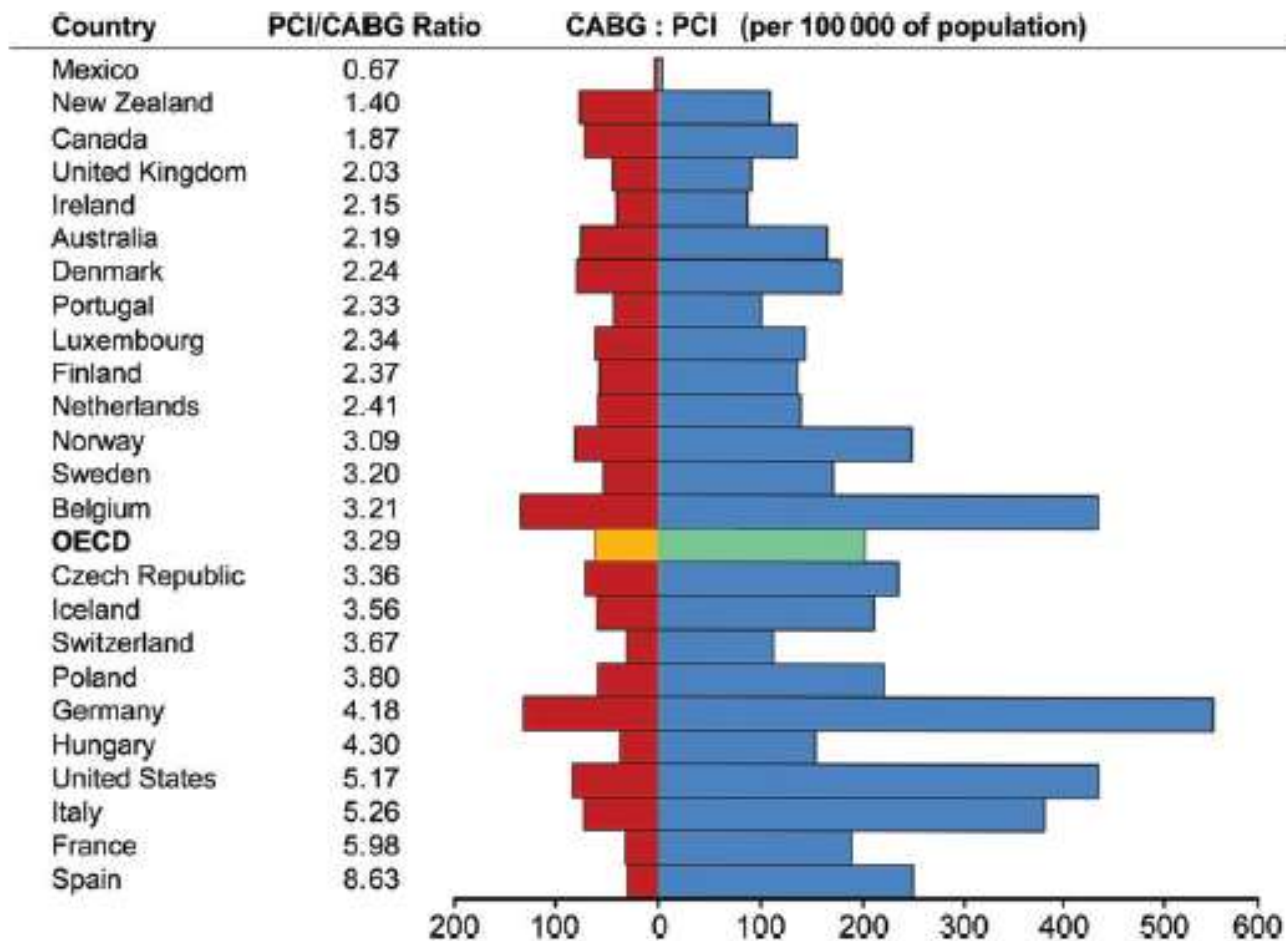


Figure 1 Revascularization procedures performed in countries throughout the Western world. Data from the Organisation for Economic Cooperation and Development (OECD) shows a great variety in the number of revascularization procedures per 100 000 inhabitants.¹³ CABG, coronary artery bypass grafting; PCI, percutaneous coronary intervention.

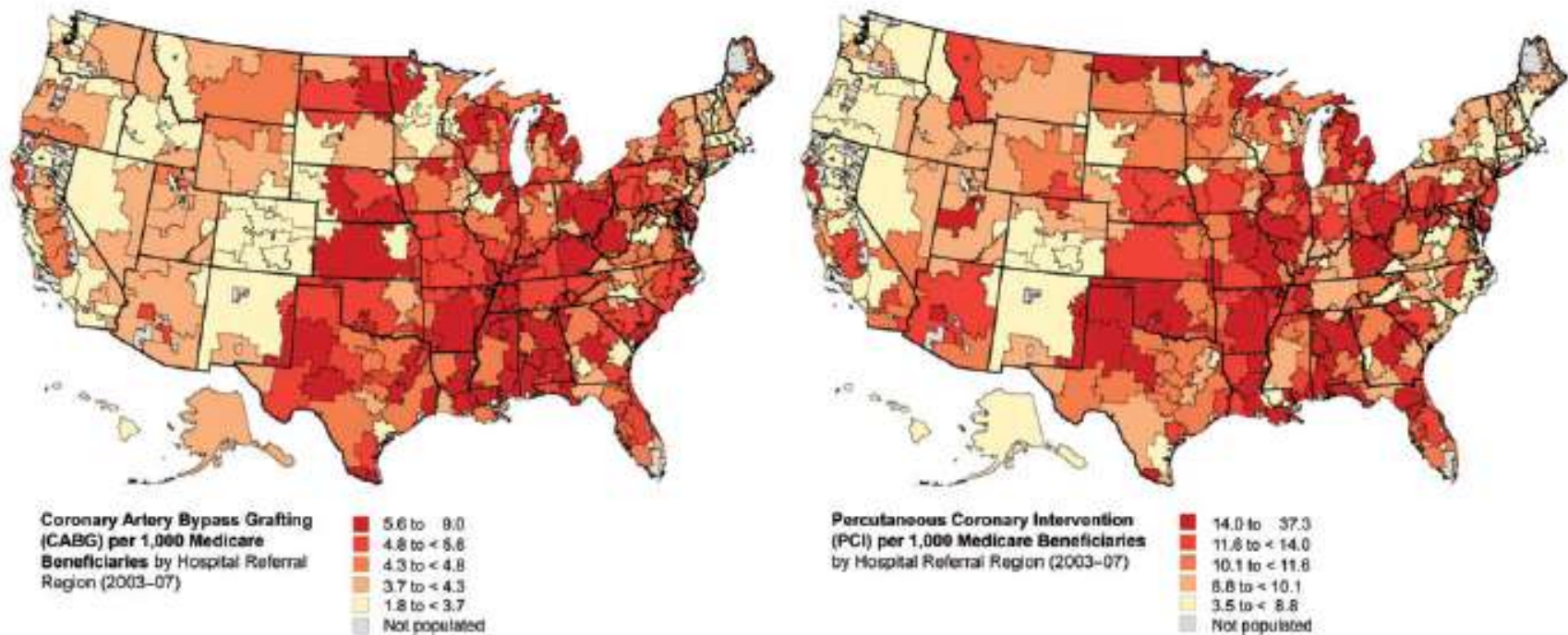


Figure 2 Rates of CABG and PCI in hospital referral regions within the United States. The mean rate of CABG was 5.2 per 1000 Medicare enrollees and 11.3 for PCI. Rates are adjusted for age, sex, and race. Copied from the Dartmouth Atlas of Health Care.⁸⁴ Abbreviations as previously.

Table 3 Inappropriateness of revascularization procedures

Author, year	Country	Inclusion	Number of procedures for stable angina	Rate of inappropriateness, %	Rate of uncertain appropriateness, %
PCI					
Hilborne, 1993 ⁵²	USA	1990	519	1%	42%
Bengtson, 1994 ⁴⁶	Sweden	1990	56	5%	9%
Meijler, 1997 ⁵⁵	The Netherlands	1992	891	33.4%	36.4%
Bernstein, 1999 ⁴⁷	Sweden	1994–1995	447	36.7%	37.8%
Hemingway, 1999 ⁵⁰	UK	1995	~328	43%	48%
Fitch, 2000 ⁴⁹	—	—	204	15%	44%
Aguilar, 2001 ⁴³	Spain	1997	467	15%	23%
Yim, 2004 ⁴⁴	Korea	1997	228	8.8%	67.1%
Chan, 2011 ⁴⁸	USA	2009–2010	144 737	11.6%	38.0%
Hannan, 2012 ⁵⁸	USA	2009–2010	24 545	14.3	49.6
CABG					
Winslow, 1988 ⁵⁷	USA	1979–1980, 1982	213	13	—
Gray, 1990 ⁴⁵	UK and USA	1987–1988	319	16	
Bengtson, 1994 ⁴⁶	Sweden	1990	307	1	8
McGlynn, 1994 ⁵⁴	Canada and USA	1989–1990	~980	~15	
Meijler, 1997 ⁵⁵	The Netherlands	1992	1054	4.5	13.4
Bernstein, 1999 ⁴⁷	Sweden	1994–1995	1038	8.5	13.2
Hemingway, 1999 ⁵⁰	UK	1995	~323	43	38
Fitch, 2000 ⁴⁹	—	—	204	19	40
O'Connor, 2008 ⁵⁶	USA	2004–2005	806	2.1	0
Hannan, 2012 ⁵⁸	USA	2009–2010	8168	1.1	8.6

~ indicates an approximate value that was calculated by combining the overall group and a percentage. For example, '34% of 287 patients had stable angina': $0.34 \times 287 = 97.6$ which would be listed here as ~98. Abbreviations as previously.

The True Coronary Heart Team Ethos

- Expanded and refocused by experience with TAVI
- Collaboration makes us better: from the era of PCI vs CABG to a era where PCI and CABG serve different patients or work together (Hybrid) for better patient outcomes
- Necessary to have a collaborative attitude from both parties of the heart team
- “1 + 1 \geq 2” “Together we are both better.”

The Coronary Heart Team: The Reality

- Expanded and refocused from experience with TAVI.
True, but.....
 - TAVI could not have started without the partnership of surgeons and cardiologists (ie transapical early devices)
 - In the USA, TAVI cannot be reimbursed unless both a primary cardiologist and primary surgeon are identified and scrubbed (neither can be paid without the other)
- In CAD, PCI is well developed and rarely “needs” a surgeon, either to perform a procedure or to ensure payment
- Even multivessel PCI that is not guidelines-directed is fully reimbursed if patient “refuses surgery”.

Coronary Heart Team: Part of Revascularization Guidelines

- Both European and American guidelines on myocardial revascularization are an ongoing joint effort of cardiology and surgical associations
- Both European and US updated guidelines advocate for Heart Team decision-making as a Class I(C) recommendation for patients with complex CAD

Heart Team Approach to Revascularization Decisions



A Heart Team approach to revascularization is recommended in patients with unprotected left main or complex CAD.



Calculation of the STS and SYNTAX scores is reasonable in patients with unprotected left main and complex CAD.



*Helping Cardiovascular Professionals
Learn. Advance. Heal.*



The Goals Of The Multidisciplinary Team

- To offer balanced and complementary approach to patient care by joint and shared decision making
- From a professional point: to improve and elevate the cognitive interchange that occurs among the specialties
- To give recommendation for therapy for a more informed and engaged patient

Holmes et al., Journal of the American College of Cardiology. Vol. 61 No. 9, 2013.

Coronary Heart Team Decision Making

Three step process:

1. Assessment of coronary lesions (SYNTAX score)
2. Assessment of patient's co-morbidities and operative risk (STS score)
3. Revascularization recommendation based on guidelines and patient preferences after education by Coronary Heart Team

Coronary Revascularization

- The application of PCI at the time of diagnostic angiography should be restricted in patients with complex or multi-vessel disease
- Pts will undergo diagnostic angiography and the procedure will be electively stopped to allow full discussion with members of the Heart Team and the patient and the family.

Limitations of the Heart Team

- Can cause delays in decision-making and treatment, inefficiency in care and increased expense by foregoing 'ad hoc' decisions.
- Heart Team meetings require an investment in time of surgeons, cardiologists and ancillary personnel, increasing direct costs
- Perhaps Heart Team should convene specifically for cases with question regarding revascularization strategy and not for single vessel disease or those with very low SYNTAX score, in whom 'ad hoc' stenting is appropriate to avoid two separate catheterizations

Limitations of the Heart Team

- Both the clinical (STS/Euroscore) and anatomical (SYNTAX) scores that are used for joint decision-making require some labor and entail significant inter- and intra-observer variability
- Uncollaborative or autocratic individuals can manipulate, dominate or derail the Heart Team
- Financial incentives motivate personal self-interest and specialty self-interest

Hybrid Coronary Revascularization: The Future of the Coronary Heart Team?

- The perfect combination of cardiologists' and surgeons' skills and energies in collaborative patient care
- Neither surgeon nor cardiologist “loses”
- Both surgeon and cardiologist “win”
- The Patient may be the biggest winner

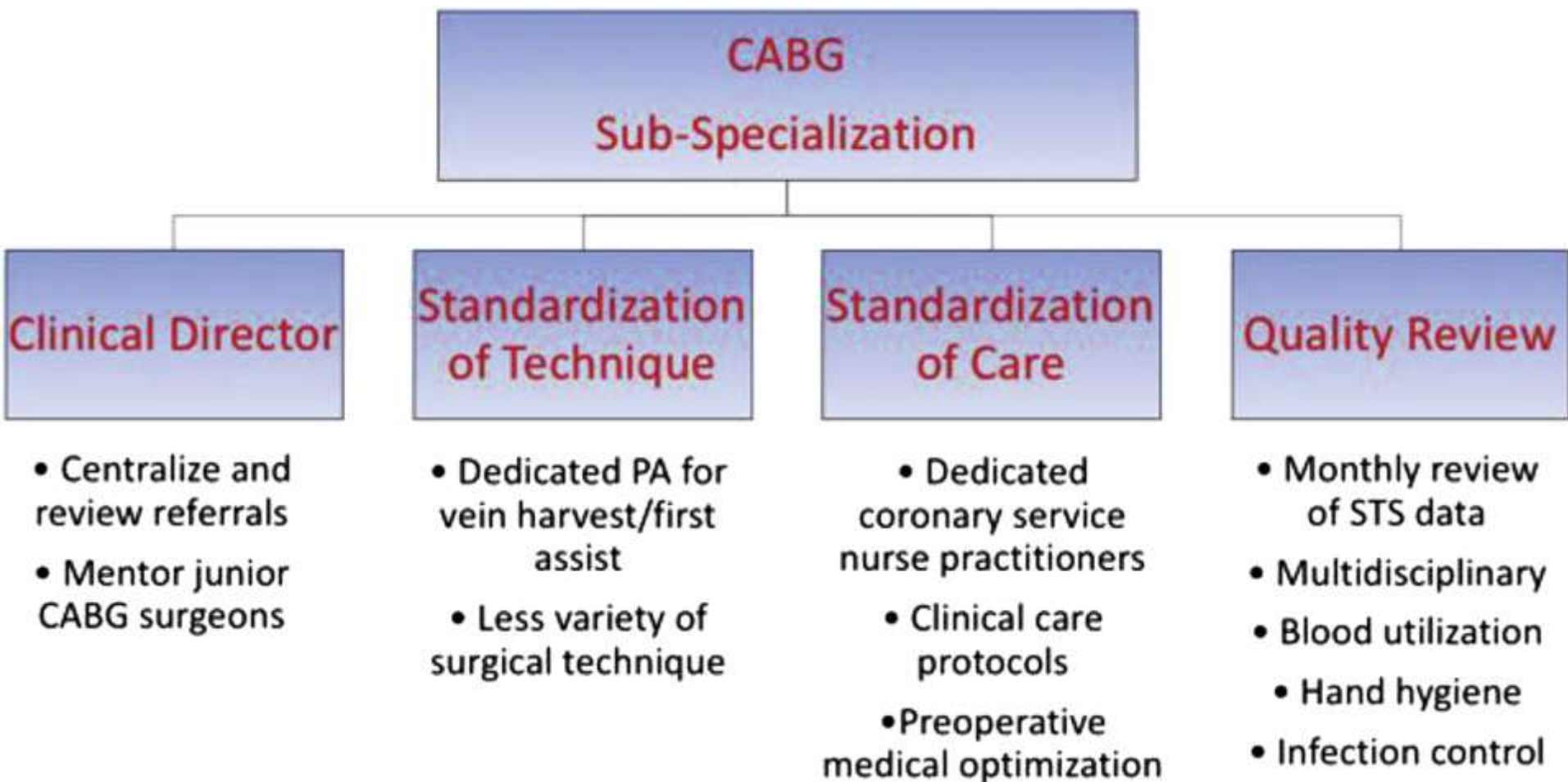
The Ongoing Evolution of Surgical Coronary Revascularization

- SYNTAX and FREEDOM 5-yr results demonstrate that CABG is superior to PCI for most patients (esp diabetics) with complex CAD, but stroke remains the Achilles Heal of CABG
- Epiaortic ultrasound scanning and doppler graft assessment should be routine in every case
- Numerous grafting techniques that minimize or avoid aortic clamping are available and should become routine (single clamp on-pump; clampless OPCAB)
- Arterial grafts last longer than venous grafts; they should be used routinely whenever appropriate; a second arterial graft should be an STS quality metric
- Medical management of the CABG patient is woefully suboptimal
- There is (much) room for improvement in both on-pump and off-pump CABG
- This will require genuine focus on CABG as the most technically demanding procedure we perform: International Coronary Congress, reference centers
- Goal: Zero mortality in elective CABG

Programmatic and Surgeon Specialization Improves Mortality in Isolated Coronary Bypass Grafting

A. Claire Watkins, MD, Mehrdad Ghoreishi, MD, Nathan L. Maassel, MD, Brody Wehman, MD, Filiz Demirdi, BS, CPHQ, Bartley P. Griffith, MD, James S. Gammie, MD, and Bradley S. Taylor, MD, MPH

Ann Thorac Surg 2018



Variable	General Era 2002–2012 (n = 3,256)	Specialized Era 2013–2016 (n = 1,283)	p Value
<u>Operative mortality</u> , No. (%)	87 (2.67)	19 (1.48)	0.02
Published STS benchmark, %	2.0	2.2	
Observed/expected mortality ratio	1.67	1.00	

Variable*	General Era 2002–2012 (n = 3,256)	Specialized Era 2013–2016 (n = 1,283)	p Value
Reoperation for bleeding	97 (3)	28 (2)	0.16
<u>Intra-op or post-op IABP</u>	148 (4.6)	34 (2.7)	0.004
<u>Permanent stroke</u>	51 (1.6)	9 (0.7)	<0.0001
Observed/expected ratio	0.9	0.53	
Published STS benchmark, %	1.3	1.3	
<u>Prolonged ventilation</u>	525 (16)	143 (11)	<0.0001
Observed/expected ratio	1.7	1	
Published STS benchmark, %	9.7	7.9	
Deep sternal wound infection	20 (0.6)	8 (0.6)	0.66
Observed/expected ratio	1	1.5	
Published STS benchmark, %	0.3	0.3	
Renal failure	40 (2)	23 (2)	0.15
Observed/expected ratio	0.3	0.49	
Published STS benchmark, %	2.4	2.1	
Cardiac arrest	72 (2)	30 (2)	0.14
Peri-op myocardial infarction	11 (0.34)	3 (0.23)	0.64
<u>Post-op transfusion</u>	1,589 (49)	461 (36)	<0.0001
<u>Length of stay, days</u>	8 ± 8	7 ± 5	0.7
Published STS benchmark, days	9.2	9.3	
<u>Readmission</u>	221 (7)	124 (10)	<0.0001