

TCTAP 2019

Arterial Revascularization Trial (ART): 10-year Outcomes and Implications for Multiple Arterial Grafts

**David P Taggart MD (Hons), PhD, FRCS, FESC
Professor of Cardiovascular Surgery
University of Oxford, United Kingdom**

for the Arterial Revascularization Trial Investigators
(No conflicts declared)



NHS
*National Institute for
Health Research*

ORIGINAL ARTICLE

Bilateral versus Single Internal-Thoracic-Artery Grafts at 10 Years

David P. Taggart, M.D., Ph.D., Umberto Benedetto, M.D., Ph.D., Stephen Gerry, M.Sc., Douglas G. Altman, D.Sc.,* Alastair M. Gray, Ph.D., Belinda Lees, Ph.D., Mario Gaudino, M.D., Vipin Zamvar, M.S., F.R.C.S., Andrzej Bochenek, M.D., Brian Buxton, M.D., Cliff Choong, M.D., Stephen Clark, M.D., Marek Deja, M.D., Jatin Desai, M.D., Ragheb Hasan, M.D., Marek Jasinski, M.D., Peter O'Keefe, M.D., Fernando Moraes, M.D., John Pepper, M.D., Siven Seevanayagam, M.D., Catherine Sudarshan, M.D., Uday Trivedi, M.D., Stanislaw Wos, M.D., John Puskas, M.D., and Marcus Flather, M.B., B.S., for the Arterial Revascularization Trial Investigators†

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Number 1

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

FLOYD D. LOOP, M.D., BRUCE W. LYTLE, M.D., DELOS M. COSGROVE, M.D., ROBERT W. STEWART, M.D.,
MARLENE GOORMASTIC, 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.

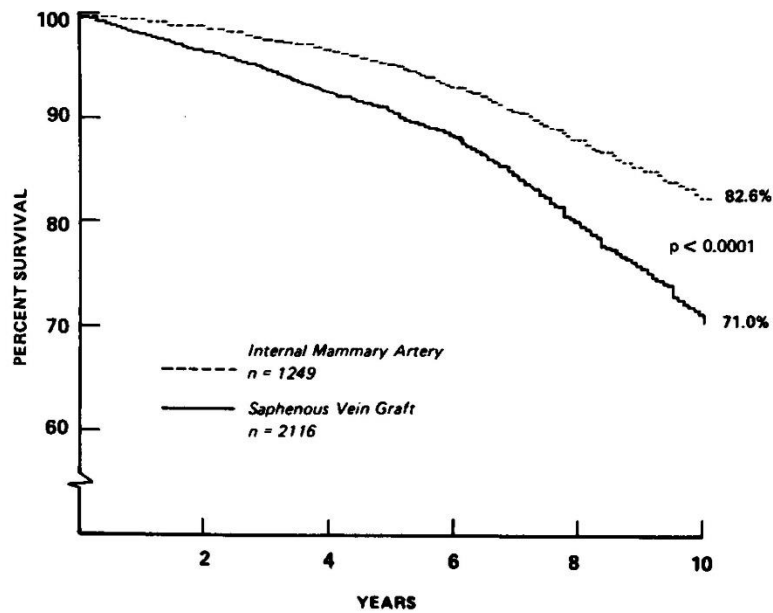


Figure 3. Ten-Year Survival of Patients with Three-Vessel Disease.

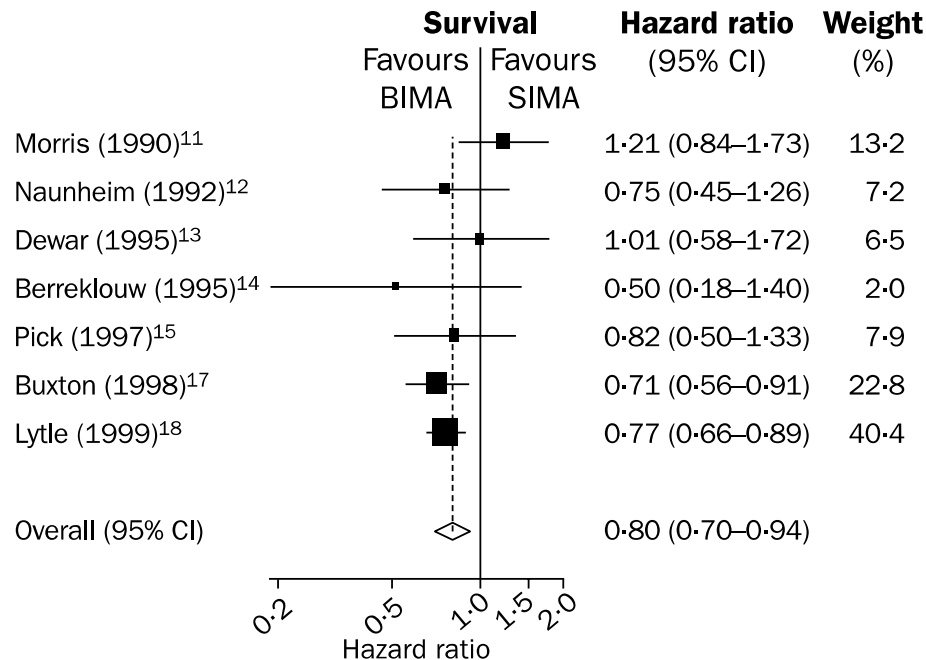
ITA to LAD Significantly Reduced The Risk Of

- ✓ Death
- ✓ Myocardial Infarction
- ✓ Recurrent Angina
- ✓ Repeat Revascularization
- ✗ (NB NOT an RCT !!)

Effect of arterial revascularisation on survival: a systematic review of studies comparing bilateral and single internal mammary arteries

David P Taggart, Roberto D'Amico, Douglas G Altman

[Lancet 2001]



15,692 patients
11,269 single IMA
4,693 bilateral IMA

Matched for

- Age
- Sex
- LV function
- Diabetes

Effects of bilateral IMA compared with single IMA

Random-effects meta-analysis of data from seven studies. Horizontal lines indicate 95% CI.

Background To ART: What We Already Know

- ① Coronary artery bypass grafting (CABG) is highly effective for symptoms and/or prognosis in multi-vessel and left main coronary artery disease (SYNTAX, FREEDOM, CORONARY, PRECOMBAT, BEST, EXCEL, NOBLE)
- ② Over 1 million CABG performed each year; standard operation in >90% is CABG x 3 (1 internal thoracic artery (**ITA**) and 2 vein grafts)
- ③ Strong **angiographic** evidence of progressive failure of vein grafts (due to atherosclerosis) that accelerates after 5 years and that increases **overall mortality and cardiac morbidity**
- ④ Strong **angiographic** evidence that **ITA** grafts have excellent long term patency rates (> 90% at 20 years)
- ⑤ Left **ITA** is established as the standard of care for grafting the left anterior descending (LAD) during CABG
- ⑥ Numerous observational studies have reported a 20% reduction in long-term mortality with **Bilateral ITA (BITA)** vs **Single ITA (SITA)** grafts
- ⑦ Low use of **BITA** (<10% in Europe, <5% in USA) due to 3 concerns
 - (i) increased technical complexity
 - (ii) potentially increased mortality and morbidity ?
 - (iii) lack of supportive evidence from RCTs

ART: Design and Outcome Measures



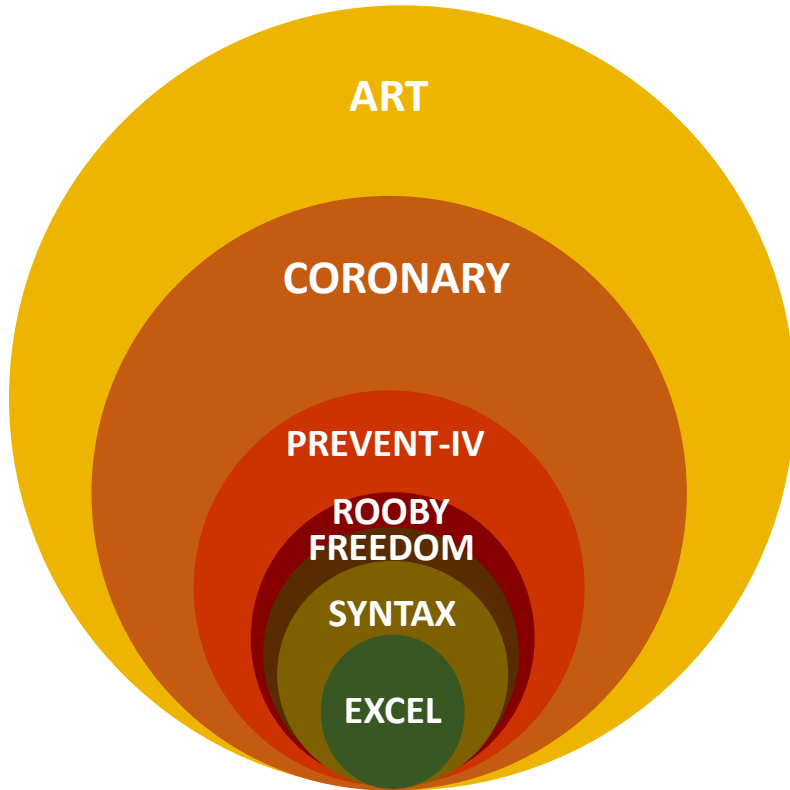
RCT of BITA (plus vein grafts) versus SITA (plus vein grafts)

SAMPLE SIZE

- **Estimate:** that at 10 years, BITA grafts will result in an absolute 5% reduction in mortality (i.e. from 25% to 20%) vs. SITA graft
- **Confirm:** with 90% power at $p < 0.05$ requires 2928 patients
- **Aim:** to enrol >3000 patients (1500 in each arm) over 3-years

OUTCOMES

- **PRIMARY:** All-cause Mortality at 10 years
- **SECONDARY:** COMPOSITE of All-cause Mortality, Myocardial infarction, Stroke



Largest coronary artery
interventional trial whether
by surgery or stents
(sample size is adjusted by
the length of the follow-up)

Eligibility

✓ INCLUSION:

- ✓ CABG patients with multi-vessel +/- left main coronary artery disease
- ✓ CABG for acute coronary syndrome (BUT not acute myocardial infarction)
- ✓ CABG could be performed “on-pump” or “off-pump”

✗ EXCLUSION:

- ✗ Patients requiring single graft
- ✗ Patients with evolving myocardial infarction
- ✗ Patients requiring concomitant valve surgery
- ✗ Patients requiring redo CABG

Results

- Enrolment from June 2004 to December 2007
- 28 centres in 7 countries (UK, Poland, Australia, Brazil, India, Italy, Austria)
- 3102 patients randomized (1554 [SITA](#) and 1548 [BITA](#))

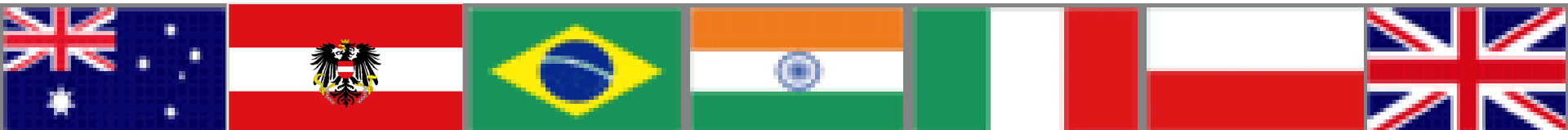
- **At 10 years exceptionally high Use of Guideline Directed Medical Therapy aspirin (81%), statins (89%), beta blockers (74%), ACE or ARB (73%)
HIGHEST OF ANY CONTEMPORARY TRIAL OF PCI OR CABG !!!!**

Compliance With Guideline-Directed Medical Therapy in Contemporary Coronary Revascularization Trials



[JACC 2018]

Ana-Catarina Pinho-Gomes, MSc(HONS),^a Luis Azevedo, MD, PhD,^b Jung-Min Ahn, MD,^c Seung-Jung Park, MD, PhD,^c Taye H. Hamza, PhD,^d Michael E. Farkouh, MD, MSc,^e Patrick W. Serruys, MD, PhD,^f Milan Milojevic, PhD,^f Arie Pieter Kappetein, MD, PhD,^g Gregg W. Stone, MD, PhD,^h Andre Lamy, MD, MHSc,ⁱ Valentin Fuster, MD, PhD,^{j,k} David P. Taggart, MD(HONS), PhD^a



17 Baseline Clinical Characteristics 'Near Identical'

	<u>BITA</u> (n=1548)	<u>SITA</u> (n=1554)
Male	85%	86%
Age mean (SD) years	64 (9)	64 (9)
Current smoker	15 %	14 %
Systolic BP mean (SD) [mmHg]	132 (18)	132 (19)
Body Mass index mean (SD)	28 (4)	28 (4)
Caucasian	92 %	92 %
South Asian	5 %	5 %
Insulin dependent diabetes	6 %	5 %
Non insulin dependent diabetes	18 %	18 %
Hypertension	77 %	78 %
Hyperlipidemia	94 %	93 %
Peripheral arterial disease	7 %	8 %
Prior stroke	3 %	3 %
Prior myocardial infarction	40 %	44 %
Prior PCI	16 %	16 %
NYHA class 1 and 2	78%	79%
CCS class 1-3	84%	84%

Surgical Details, Post-operative Care and Length of Stay

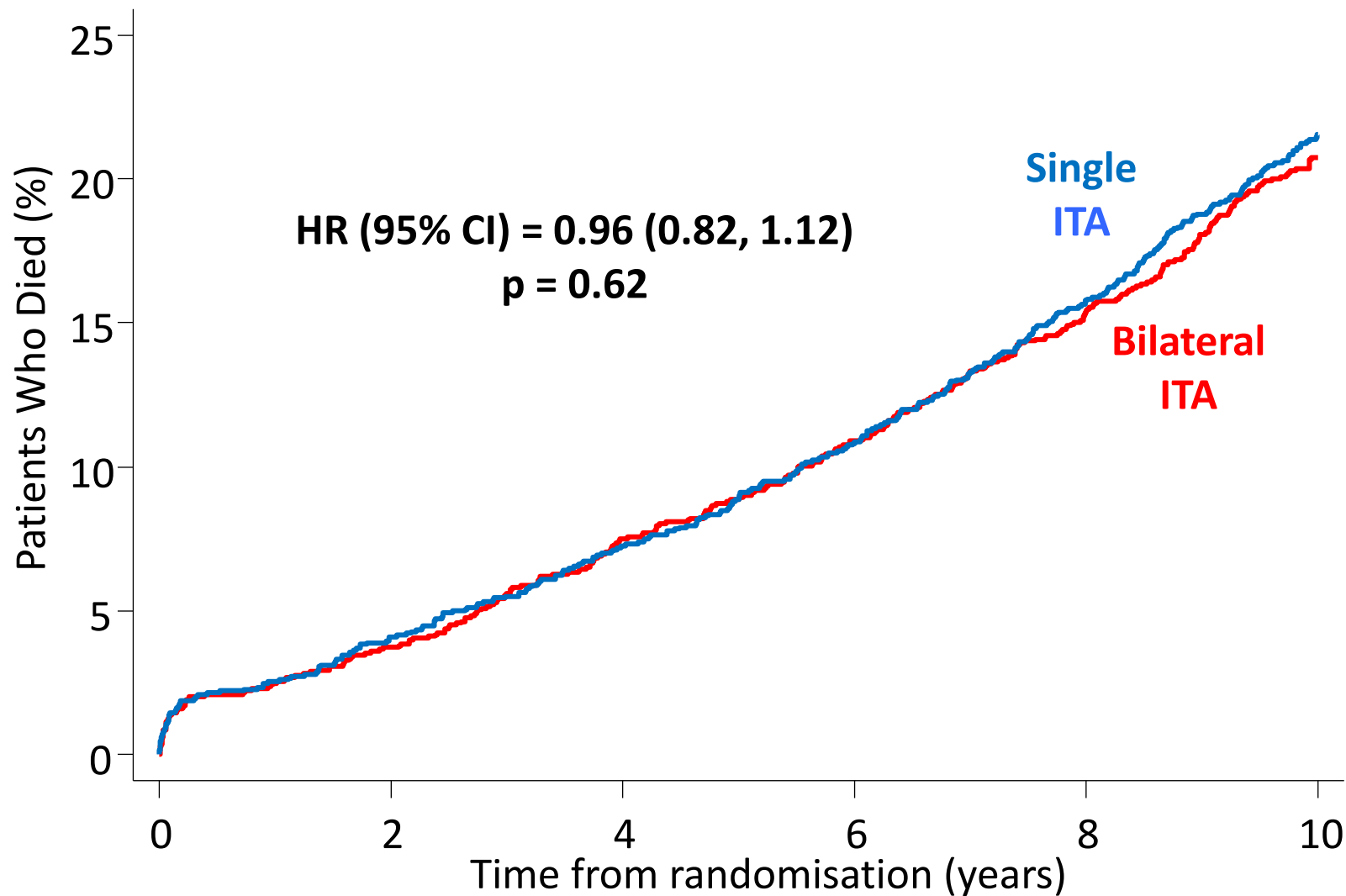
Procedures	<u>BITA</u>	<u>SITA</u>
Details of operation	(n=1531)	(n=1546)
On pump	58 %	60 %
<u>Off pump</u>	42 %	40 %
Conversion to bypass	2 %	2 %
<u>CABG duration minutes mean (SD)</u>	222 (61)	23 mins 199 (58)
Number of grafts		
2	18 %	18 %
3	50 %	49 %
4+	31 %	33 %
<u>Radial Artery Graft</u>	<u>19 %</u>	<u>22 %</u>
Cell saver	31 %	32 %
Aprotinin during surgery	24 %	24 %
Blood transfusion	12 %	12 %
Return to operating theatre	4 %	4 %
Intra-aortic balloon pump use	4 %	4 %
Renal support therapy	6 %	4 %
Hospital stay Mean days (SD)	8 (7)	8 (8)

Analysis of Results at 10 Years:

98.4% of Patients With Vital Status

1. Intention To Treat (ITT): Scientifically Most Robust
2. As Treated (AT): Non-Randomized
 - 40% of Patients Received A 'Different' Treatment Strategy
 - 14% of BITA crossed to SITA
 - 4% of SITA crossed to BITA
 - 22% of SITA had a 2nd Arterial Graft (Radial Artery)

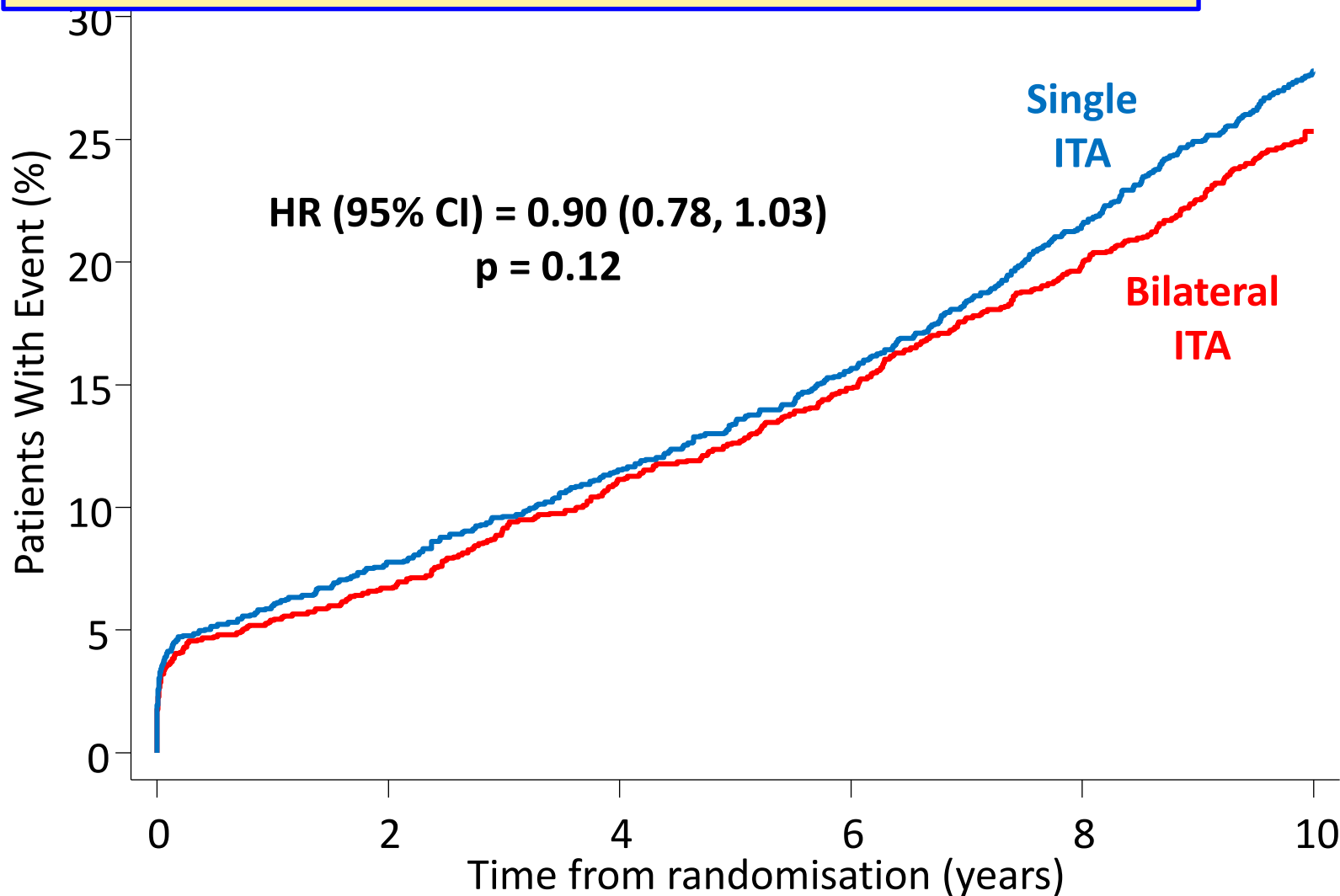
Primary Outcome: MORTALITY AT 10 YEARS (Intention To Treat)



No. at risk

Bilateral graft	1548	1481	1417	1359	1283	882
Single graft	1554	1484	1432	1370	1283	894

**Secondary Outcome AT 10 YEARS (Intention To Treat):
COMPOSITE DEATH, MI, STROKE**



No. at risk

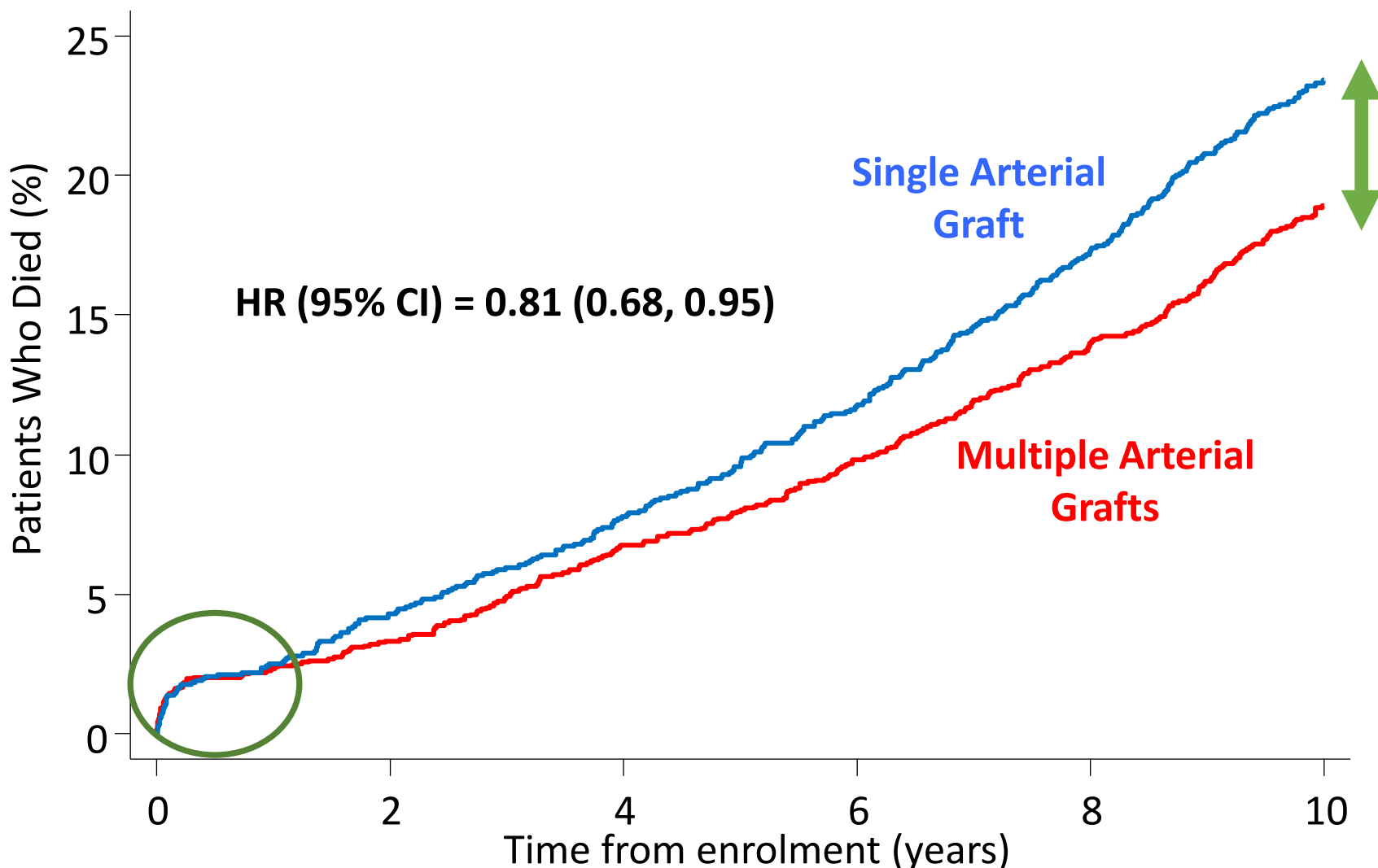
Bilateral graft	1548	1435	1362	1299	1214	830
Single graft	1554	1427	1366	1296	1194	821

As Treated (AT): Non-Randomized: **20 Baseline Characteristics ‘Near Identical’**

	<u>SITA</u> (1249)	<u>Multiple Arterial</u> (1668)	P-val
Age (mean/SD)	64 (9)	63 (9)	0.001
FEMALE n(%)	182 (14.6)	232 (13.7)	0.560
BMI (mean/SD)	28 (4)	28 (4)	0.045
Creatinine (mean/SD)	98 (22.7)	96 (21.7)	0.069
Unstable angina n(%)	95 (7.6)	132 (7.8)	0.885
Diabetes n(%)			0.183
No	951 (76)	1284 (76)	
IDDM	59 (5)	104 (6)	
NIDDM	239 (19)	300 (18)	
COPD n(%)	34 (2.7)	37 (2.2)	0.422
PVD n(%)	87 (7.0)	120 (7.1)	0.938
CVA n(%)	37 (3.0)	50 (3.0)	1.000
MI n(%)	557 (45)	672 (40)	0.011
MI to Surgery (days)	1358 (2263)	1360 (2271)	0.988
LVEF n(%)			0.758
>50%	914 (75.0)	1248 (76.1)	
30-49%	279 (22.9)	356 (21.7)	
<30%	26 (2.1)	35 (2.1)	
Vessel Diameter (mean/SD)	1.84 (0.43)	1.83 (0.37)	0.293
EuroSCORE (mean/SD)	2.7 (2.0)	2.5 (2.0)	0.003
Vessel Quality (1=good, 3=poor)	1.65 (0.57)	1.65 (0.56)	0.96

Important Baseline Clinical Characteristics of SITA and Multiple Arterial Grafts Very Similar

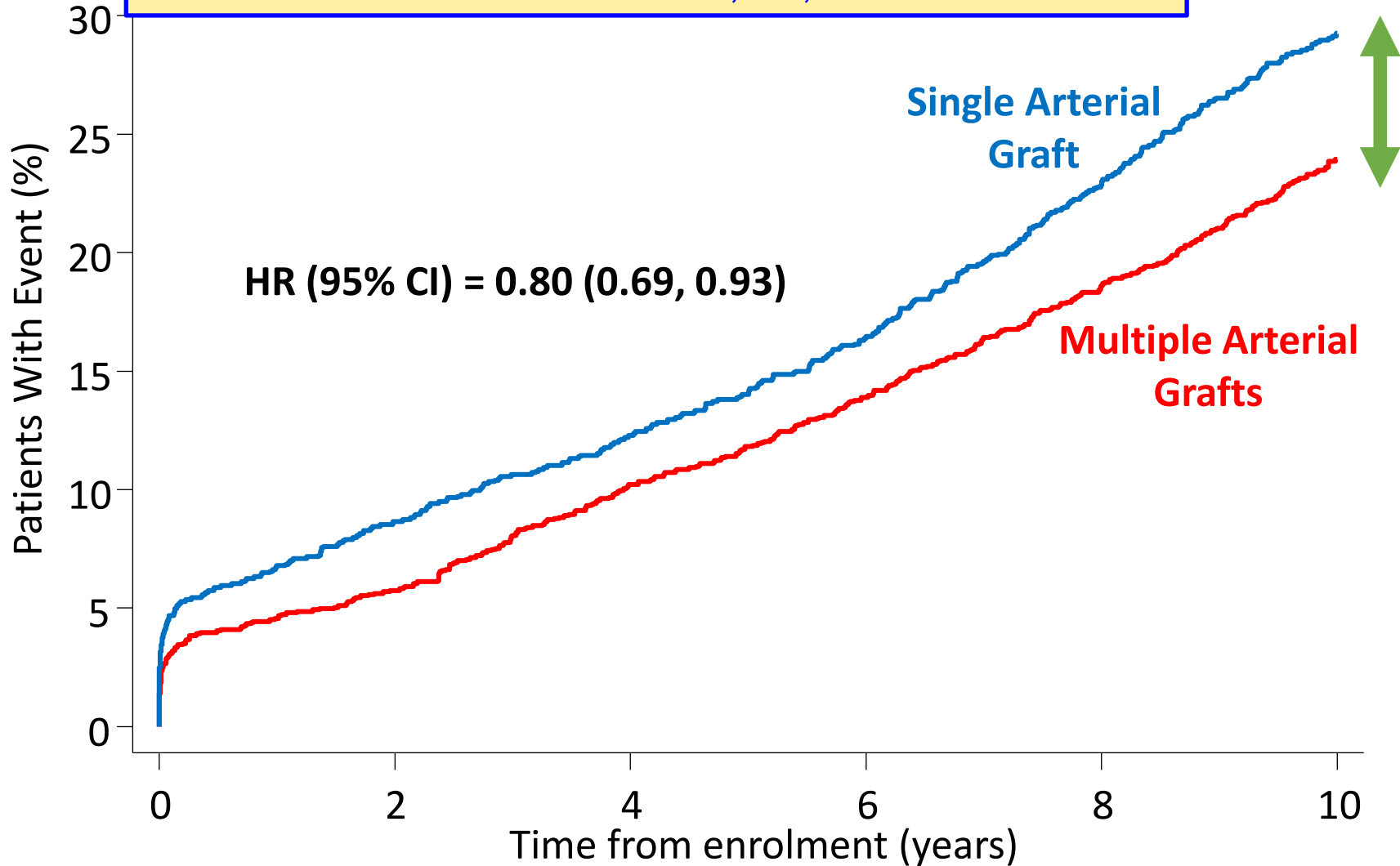
Primary Outcome: MORTALITY AT 10 YEARS (AS TREATED)



No. at risk

MAG	1690	1632	1567	1510	1430	998
SAG	1330	1270	1222	1163	1081	750

**Secondary Outcome AT 10 YEARS (AS TREATED):
COMPOSITE DEATH, MI, STROKE**



No. at risk

MAG	1690	1591	1510	1442	1353	934
SAG	1330	1212	1162	1101	1006	692

Why No Difference in BITA vs SITA @ 10 years (Intention To Treat) ?

1. Genuinely NO Difference

(Concept of Complete vs Incomplete Revascularization ?)

2. Radial Artery Use

22% of SITA: (superior 5yr patency and clinical outcomes)

3. High Use of Guideline Directed Medical Therapy

in > 80% (slows vein graft failure ?)

4. Surgeon Experience

Differential X-over: 14% of BITA → SITA; (4% SITA to BITA)

Individual Surgeon X-over from BITA to SITA: 0%-100%

ORIGINAL ARTICLE

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

Mario Gaudino, M.D., Umberto Benedetto, M.D., Stephen Femes, 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*

Table 3. Main Outcomes.* Radial Artery Database International Alliance (RADIAL)

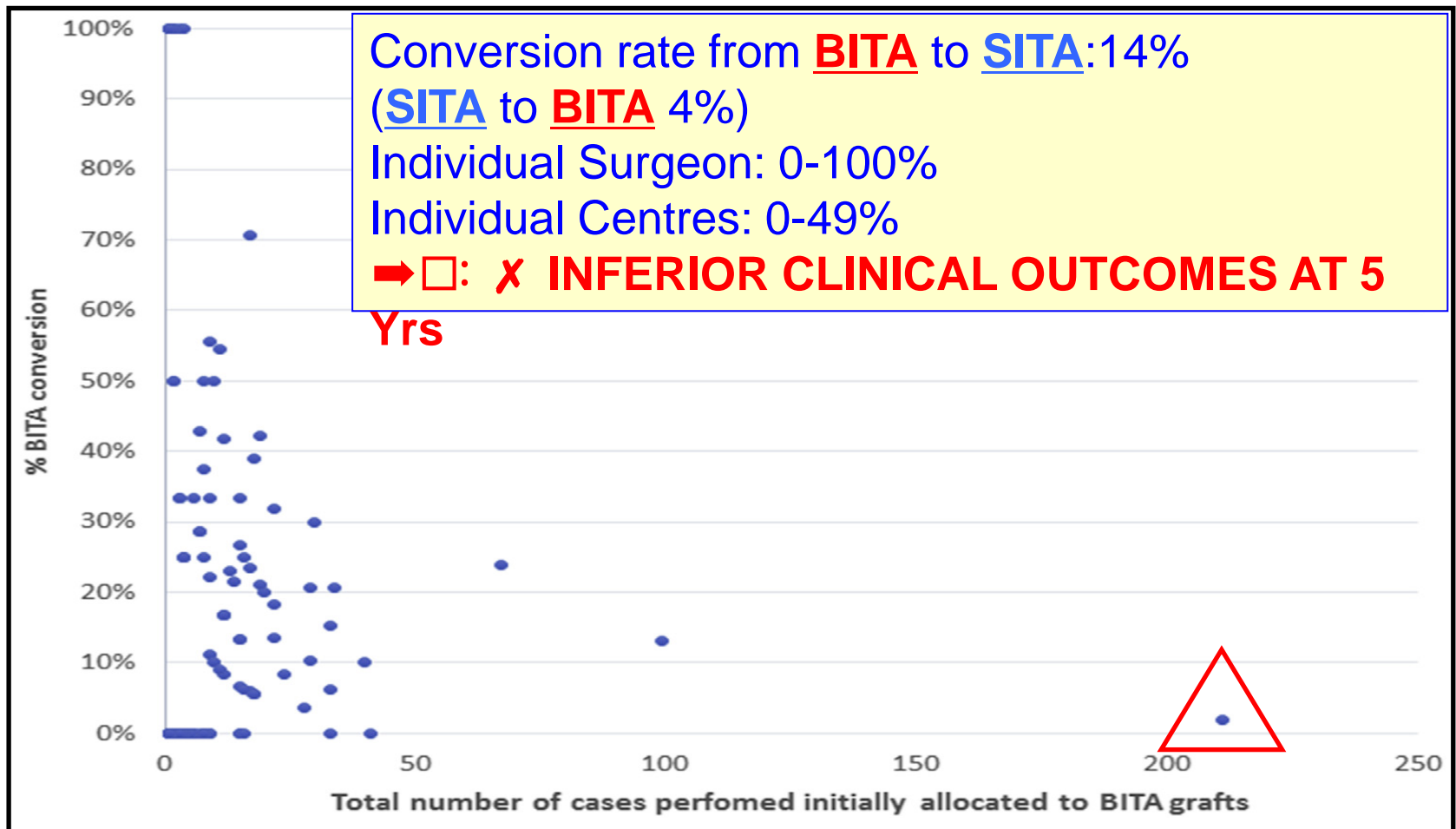
Outcome	Radial-Artery Group (N = 534)		Saphenous-Vein Group (N = 502)		Treatment Effect†	
	No. of Events (%)	Events per 1000 Patient-Yr‡	No. of Events (%)	Events per 1000 Patient-Yr‡	Hazard Ratio (95% CI)	P Value
Death, myocardial infarction, or repeat revascularization	67 (12.5)	25	94 (18.7)	39	0.67 (0.49–0.90)	0.01
Death	40 (7.5)	15	42 (8.4)	17	0.90 (0.59–1.41)	0.68
Myocardial infarction	16 (3.0)	6	21 (4.2)	9	0.72 (0.53–0.99)	0.04
Repeat revascularization	23 (4.3)	9	43 (8.6)	17	0.50 (0.40–0.63)	<0.001
Graft occlusion§	28/345 (8.1)	19	61/307 (19.9)	46	0.44 (0.28–0.70)	<0.001

RADIAL ARTERY: CARDIOLOGISTS TO THE RIGHT and SURGEONS TO THE LEFT !!

Incidence and clinical implications of intraoperative bilateral internal thoracic artery graft conversion: Insights from the Arterial Revascularization Trial

[JTCVS 2018]

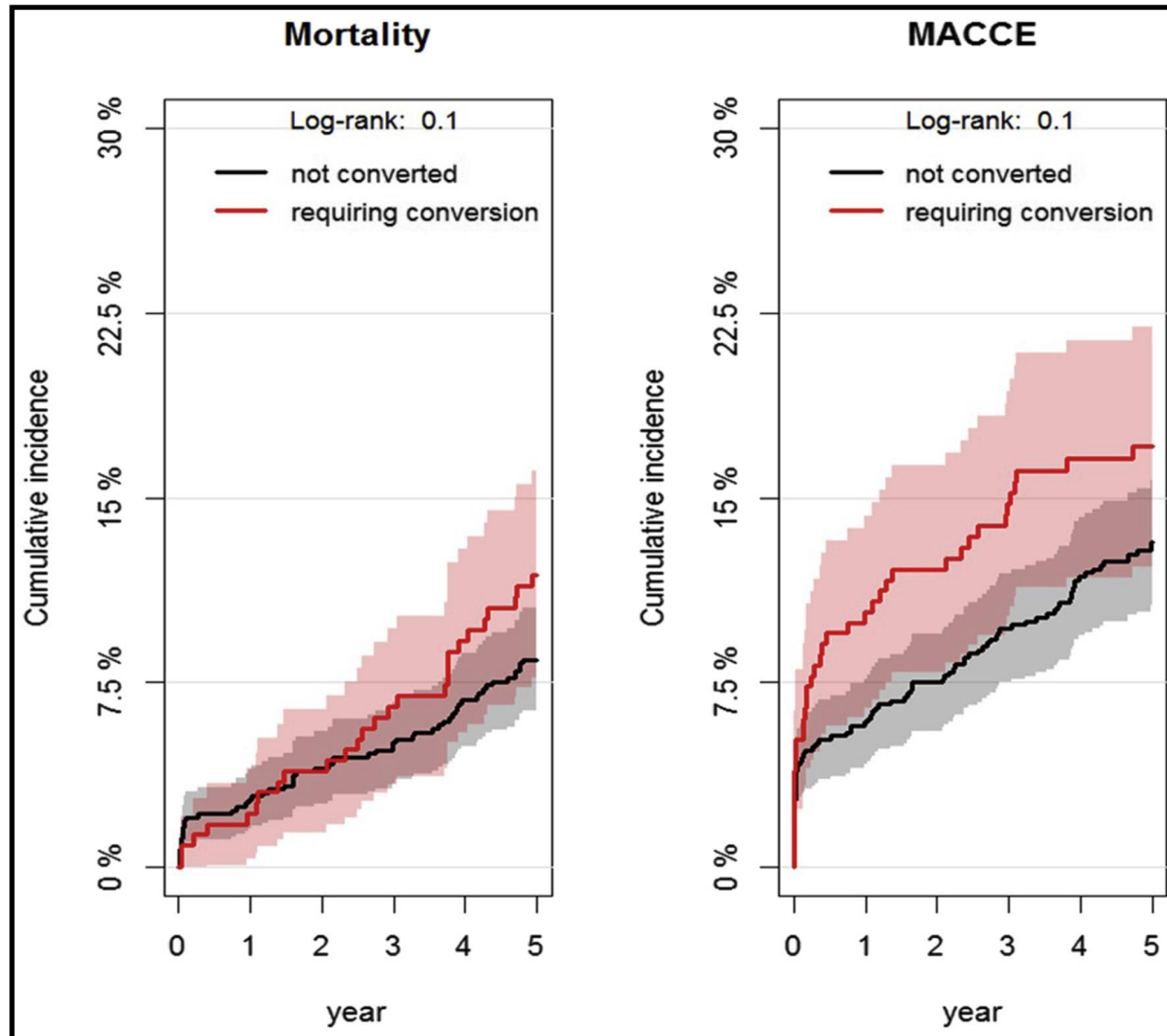
Umberto Benedetto, MD, PhD,^a Douglas G. Altman, DSc,^b Marcus Flather, MD,^c Stephen Gerry, MSc,^b Alastair Gray, PhD,^d Belinda Lees, BSc, PhD,^a and David P. Taggart, MD, PhD,^e on behalf of the Arterial Revascularization Trial Investigators



14% Conversion from BITA to SITA

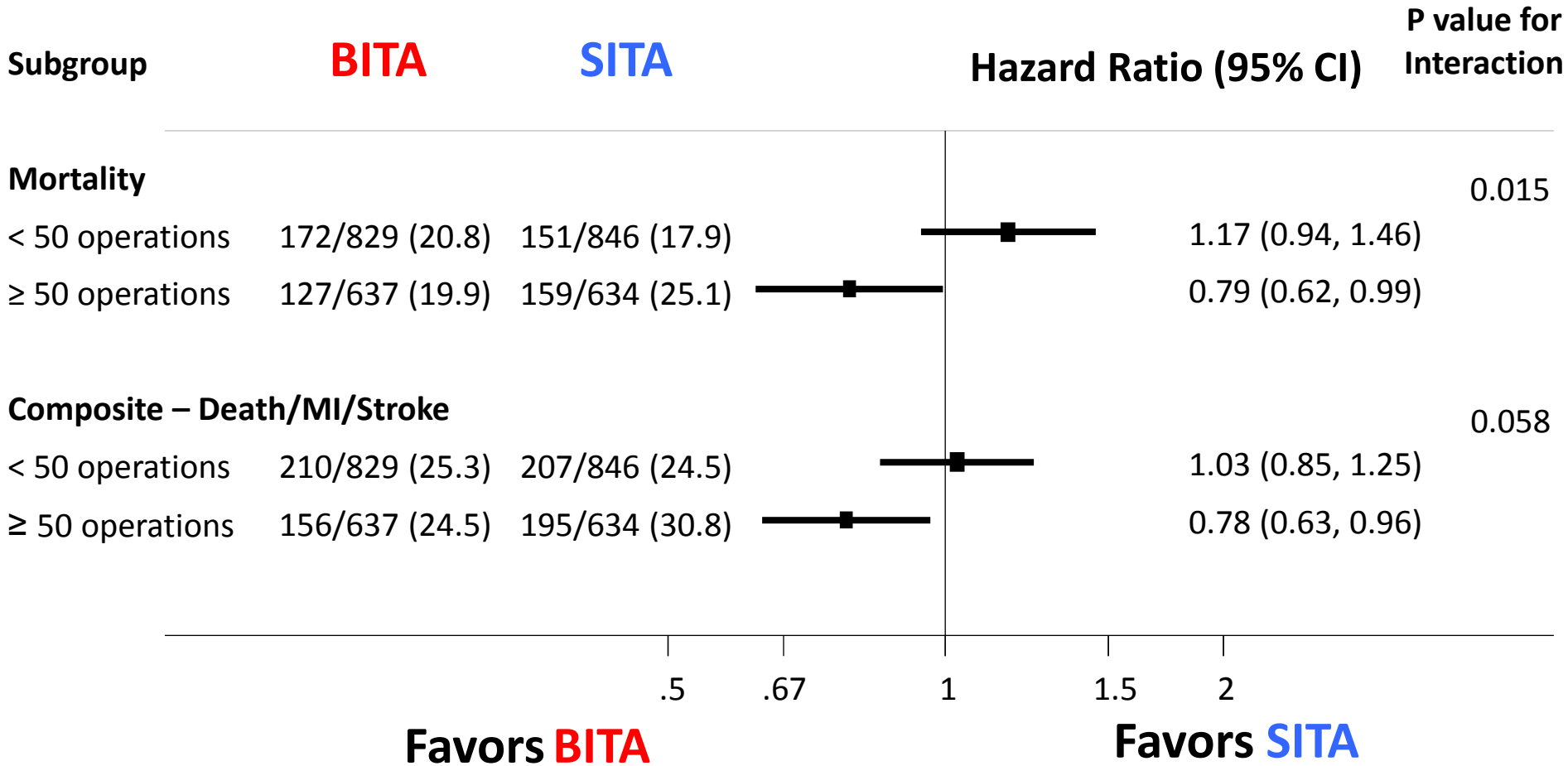
No Adverse Effect on Hospital Outcomes

Adverse Effect on 5 year Outcomes in Mortality and MACCE



Surgeon Experience

Intention To Treat Analysis at 10 YEARS

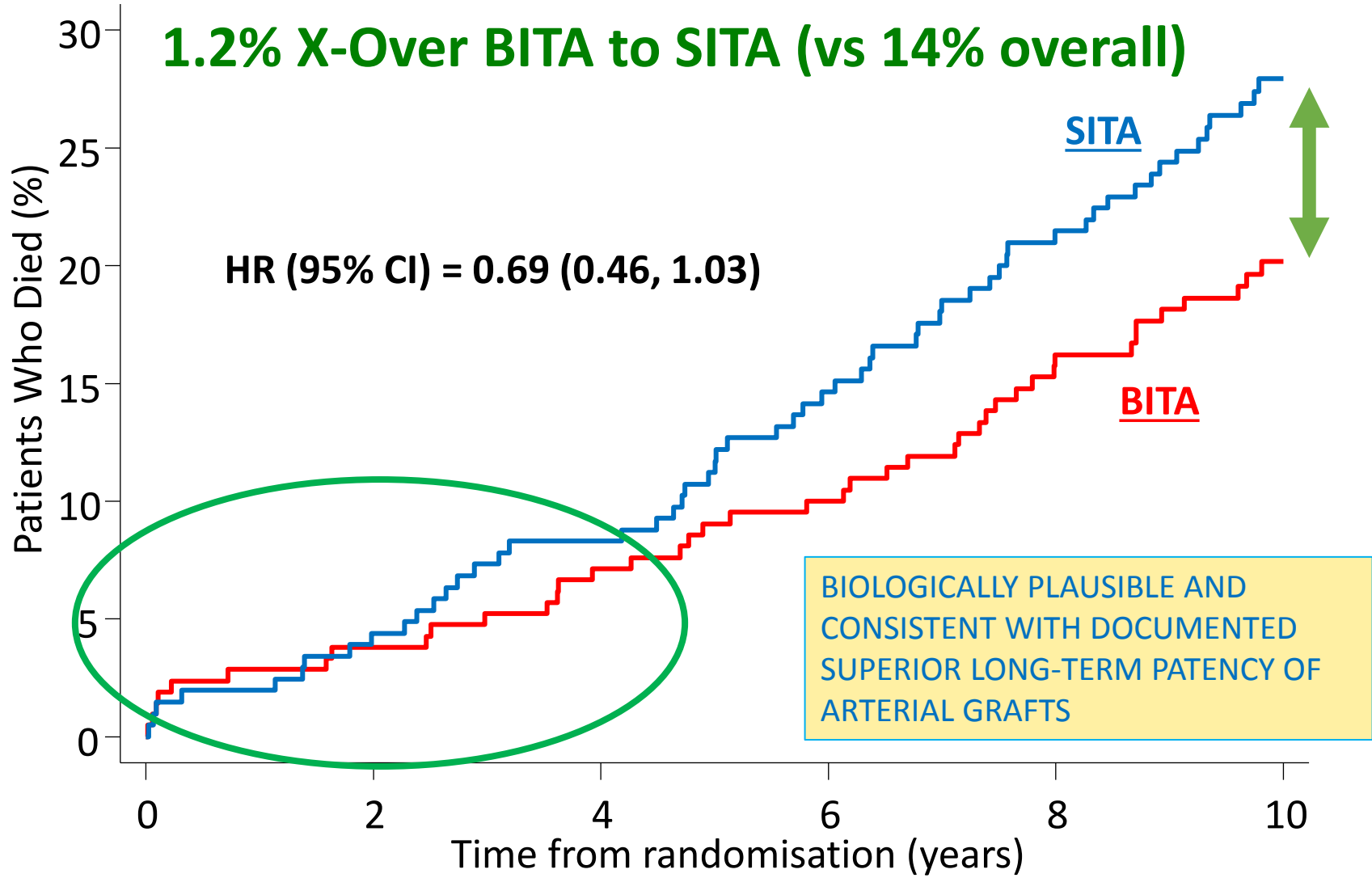


Both Mortality and Composite Outcome Better with BITA if Surgeon > 50 Operations

SURGEON EXPERIENCE: Intention to Treat

10-Year MORTALITY FOR HIGHEST VOLUME (n=416) ART SURGEON

1.2% X-Over BITA to SITA (vs 14% overall)



No. at risk

Bilateral graft	211	202	195	188	175	122
Single graft	205	196	188	175	161	114

Summary: Ten Year Analysis of the ART

- 1) ART Largest Coronary Intervention Trial with long term follow-up (>98% @ 10 yrs)
- 2) Excellent 10 year outcomes for CABG in both groups
- 3) 40 % of patients actually received different treatment from that originally intended
14% **BITA** to **SITA**, 4% **SITA** to **BITA** and 22% of **SITA** also received a radial artery
- 4) **Intention To Treat Analysis**: Confirms at 10 years
Safety of **BITA** grafts
No significant difference in all cause mortality or composite of mortality, MI or stroke
- 5) **As Treated (Non randomized) Analysis**: At 10 years multiple arterial grafts
Significant improvement in all cause mortality AND composite of mortality, MI, stroke
- 6) Surgeon experience crucial to **X-Over Rates** and **Outcomes** with **BITA** grafts
- 7) Need for further RCTs of Single vs Multiple arterial grafts by **experienced** surgeons
- 8) Respect the Radial Artery as a potentially very valuable conduit for both PCI/CABG

Cite this article as: Gaudino M, Alexander JH, Bakaeen FG, Ballman K, Barili F, Calafiore AM *et al.* Randomized comparison of the clinical outcome of single versus multiple arterial grafts: the ROMA trial—rationale and study protocol. *Eur J Cardiothorac Surg* 2017;52:1031–40.

Randomized comparison of the clinical outcome of single versus multiple arterial grafts: the ROMA trial—rationale and study protocol[†]

Mario Gaudino^{a,*}, John H. Alexander^b, Faisal G. Bakaeen^c, Karla Ballman^d, Fabio Barili^e, Antonio Maria Calafiore^f, Piroze Davierwala^g, Steven Goldman^h, Peter Kappeteinⁱ, Roberto Lorusso^j, Darren Mylotte^k, Domenico Pagano^l, Marc Ruel^m, Thomas Schwannⁿ, Hisayoshi Suma^o, David P. Taggart^p, Robert F. Tranbaugh^a and Stephen Fremes^q

REPORT

Randomized
comparison of the
clinical Outcome of
single versus Multiple
Arterial grafts: the
ROMA trial



Acknowledgements:

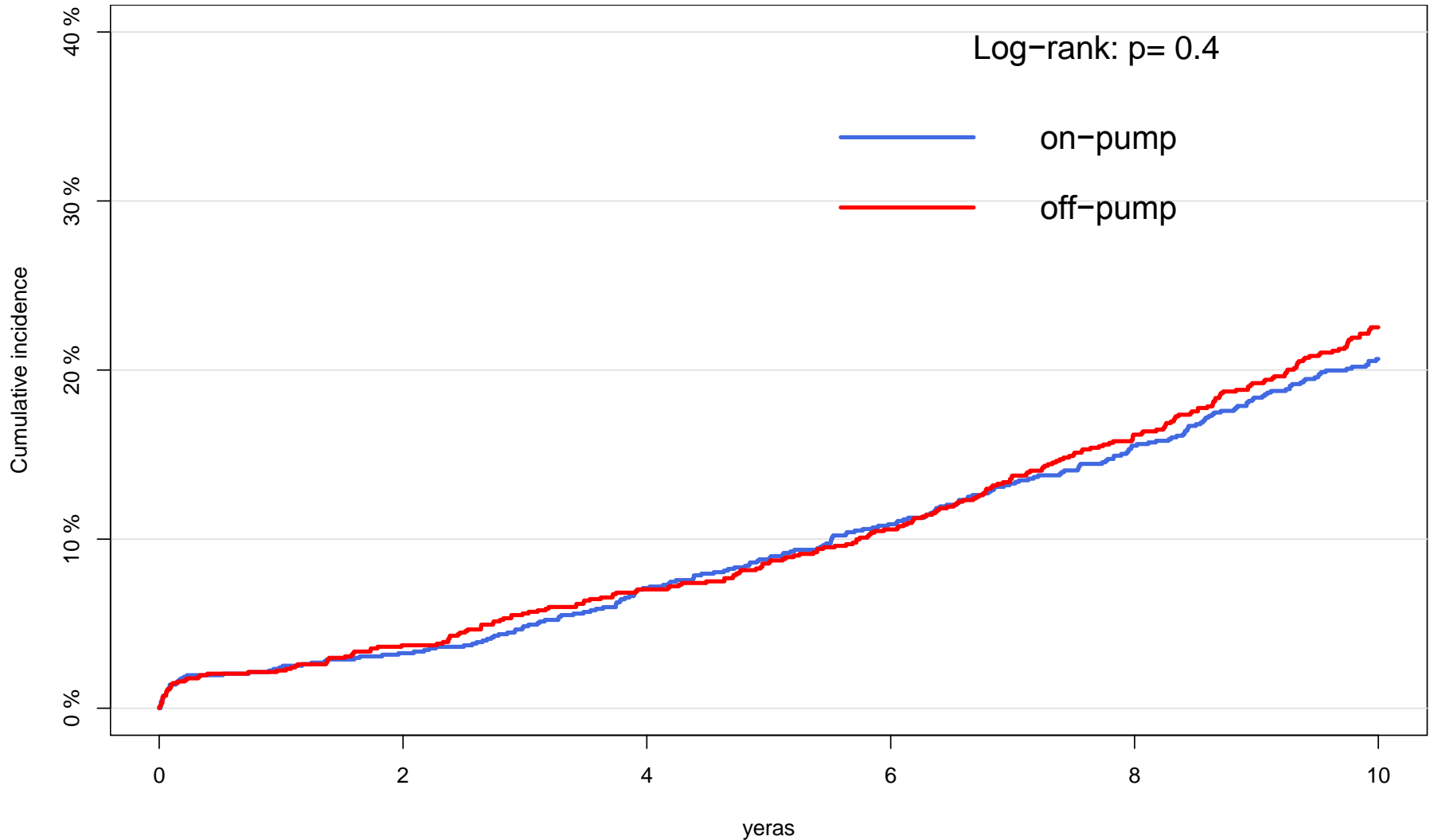
- **In Memoriam Prof Doug Altman: RIP June 2018**
- **Presented on behalf of all investigators and patients participating in ART**
- **Trial Steering Committee: Peter Sleight, Doug Altman, Keith Channon, John Dark, Barbara Farrell, Marcus Flather, Alastair Gray, John Pepper, Rod Stables, David Taggart, Geza Vermez, Jeremy Pearson, Mark Pitman, Belinda Lees, Umberto Benedetto**
- **Data Monitoring Committee: Salim Yusuf, Stuart Pocock, Desmond Julian, Tom Treasure**
- **Clinical Events Adjudicators, Luckasz Krzych (Poland)**
- **Trial Management: Belinda Lees, Carol Wallis, Jo Cook, Edmund Wyatt, Surjeet Singh (SITU), Stephen Gerry (Statistical Support)**
- **Funded by UK Medical Research Council, British Heart Foundation, National Institute of Health Research Efficacy and Mechanism Evaluation, sponsored by University of Oxford**
- **Design, conduct and analysis conducted independently of funding agencies and sponsor**



ART TRIAL: 10-year mortality on-pump vs off-pump



all-cause death



on-pump 1078
off-pump 1078

1037
1029

987
978

939
929

866
862

594
523

Compliance With Guideline-Directed Medical Therapy in Contemporary Coronary Revascularization Trials



[JACC 2018]

Ana-Catarina Pinho-Gomes, MSc(HONS),^a Luis Azevedo, MD, PhD,^b Jung-Min Ahn, MD,^c Seung-Jung Park, MD, PhD,^c Taye H. Hamza, PhD,^d Michael E. Farkouh, MD, MSc,^e Patrick W. Serruys, MD, PhD,^f Milan Milojevic, PhD,^f Arie Pieter Kappetein, MD, PhD,^g Gregg W. Stone, MD, PhD,^h Andre Lamy, MD, MHSc,ⁱ Valentin Fuster, MD, PhD,^{j,k} David P. Taggart, MD(HONS), PhD^a

RESULTS From a total of 439 references, 5 trials were included based on our inclusion and exclusion criteria. Overall, compliance with GDMT1 was low and decreased over time from 67% at 1 year to 53% at 5 years. Compliance with GDMT2 was even lower and decreased from 40% at 1 year to 38% at 5 years. Compliance with both GDMT1 and GDMT2 was higher in PCI than in CABG at all time points. Meta-regression suggested an association between lower use of GDMT1 and adverse clinical outcomes in PCI versus CABG at 5 years.

CONCLUSIONS Compliance with GDMT in contemporary clinical trials remains suboptimal and is significantly lower after CABG than after PCI, which may influence the comparison of clinical trial endpoints between those study groups.

(J Am Coll Cardiol 2018;71:591-602) © 2018 by the American College of Cardiology Foundation.

ART: GDMT 70-90% at 10 years !

Associations Between Adding a Radial Artery Graft to Single and Bilateral Internal Thoracic Artery Grafts and Outcomes

Insights From the Arterial Revascularization Trial

BACKGROUND: Whether the use of the radial artery (RA) can improve clinical outcomes in coronary artery bypass graft surgery remains unclear. The ART (Arterial Revascularization Trial) was designed to compare survival after bilateral internal thoracic artery (BITA) over single left internal thoracic artery (SITA). In the ART, a large proportion of patients ($\approx 20\%$) also received an RA graft instead of a saphenous vein graft (SVG). We aimed to investigate the associations between using the RA instead of an SVG to supplement SITA or BITA grafts and outcomes by performing a post hoc analysis of the ART.

METHODS: Patients enrolled in the ART ($n=3102$) were classified on the basis of conduits actually received (as treated). The analysis

David P. Taggart, MD,
PhD

Douglas G. Altman, DSc
Marcus Flather, MD
Stephen Gerry, MSc
Alastair Gray, PhD
Belinda Lees, BSc, PhD
Umberto Benedetto, MD,
PhD

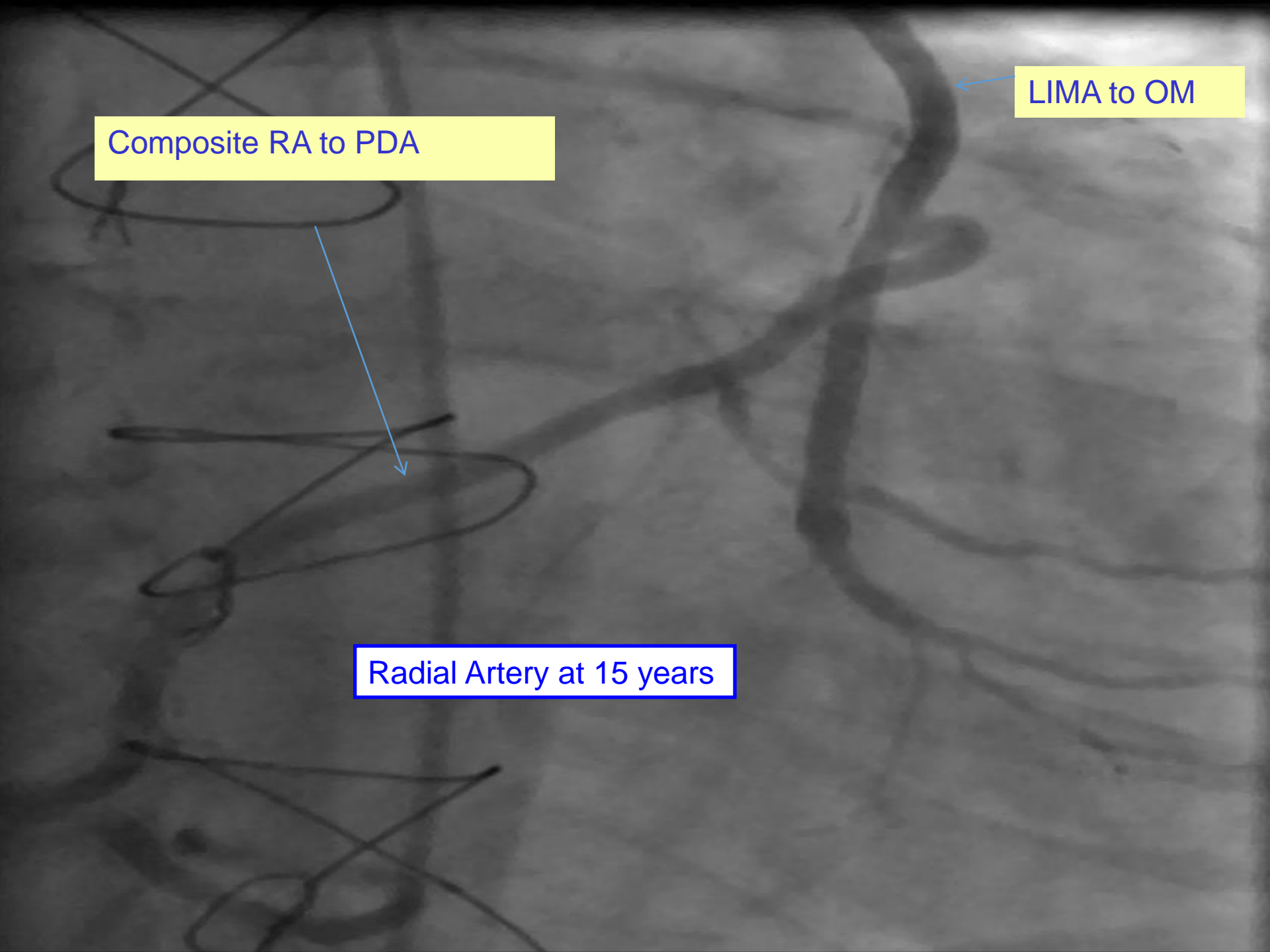
On Behalf of the ART (Arterial Revascularization Trial) Investigators

Radial Artery at 20 years

LIMA to OM

Composite RA to PDA

Radial Artery at 15 years

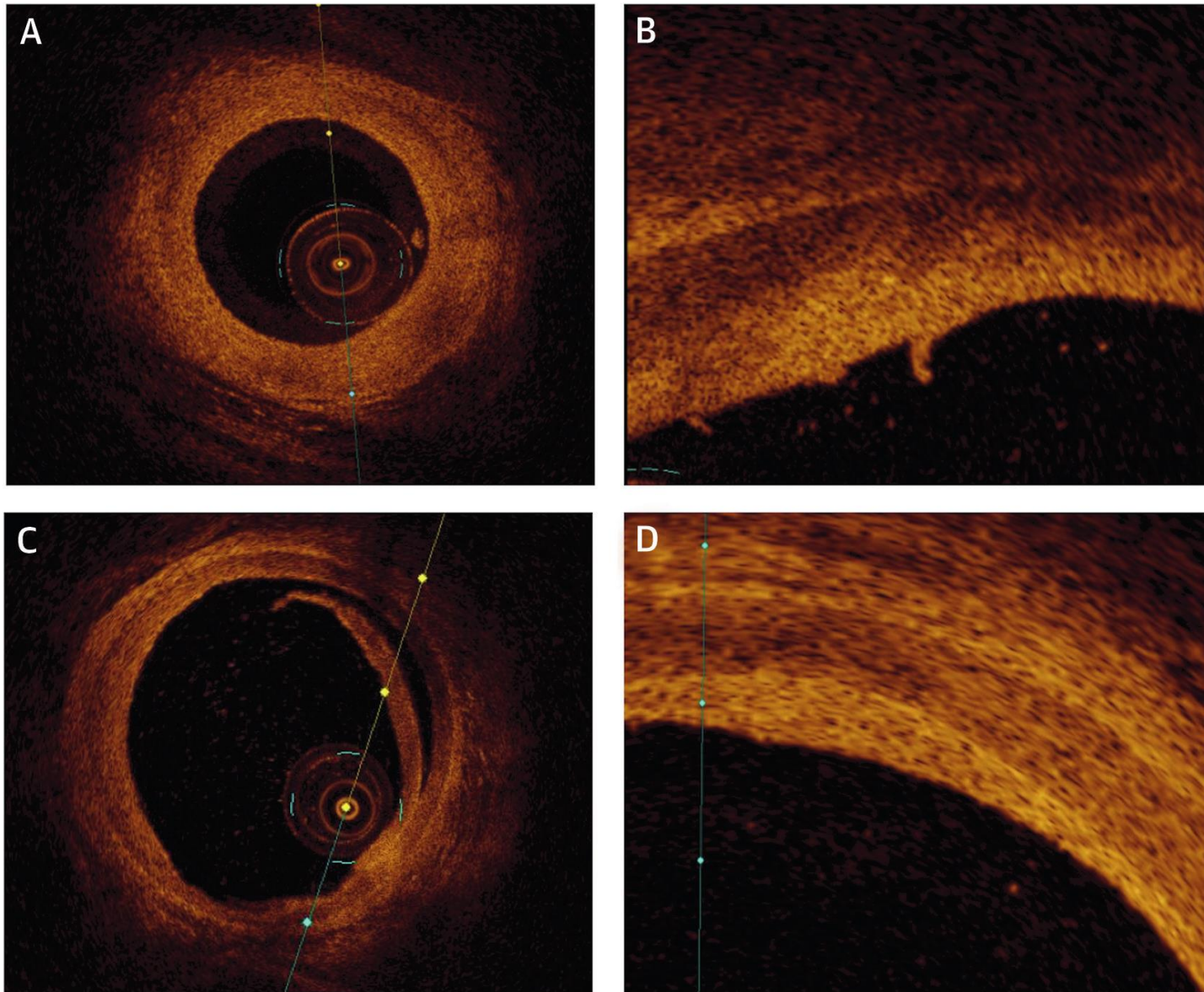


Does Previous Transradial Catheterization Preclude Use of the Radial Artery as a Conduit in Coronary Artery Bypass Surgery?

ABSTRACT: The radial artery (RA) is a commonly used conduit for coronary artery bypass grafting, and recent studies have demonstrated that it provides superior long-term patency rates to the saphenous vein in most situations. In addition, the RA is also being used with increasing

Craig A. Mounsey, BA
Jamie A. Mawhinney, BA
Raphael S. Werner, MB, BS
David P. Taggart, MD, PhD

Prior instrumentation leads to prolonged functional endothelial damage and reduced patency of RA for CABG



(A) Radial artery spasm documented at procedure's end. **(B)** Radial artery intimal tear documented at procedure's end. **(C)** Radial artery media dissection documented at procedure's end. **(D)** Radial artery intima thickening documented 6 months after a first transradial procedure.

The Radial Artery for Percutaneous Coronary Procedures or Surgery?



Mario Gaudino, MD,^a Francesco Burzotta, MD, PhD,^b Faisal Bakaeen, MD,^c Olivier Bertrand, MD,^d Filippo Crea, MD,^b Antonino Di Franco, MD,^a Stephen Femes, MD,^e Ferdinand Kiemeneij, MD, PhD,^f Yves Louvard, MD,^g Sunil V. Rao, MD,^h Thomas A. Schwann, MD,ⁱ James Tatoulis, MD,^j Robert F. Tranbaugh, MD,^a Carlo Trani, MD, PhD,^b Marco Valgimigli, MD, PhD,^k Pascal Vranckx, MD, PhD,^l David P. Taggart, MD, PhD,^m
for the Arterial Grafting International Consortium Alliance

ABSTRACT

This article summarizes the current research on the benefits of using the transradial approach for percutaneous procedures and the radial artery as a conduit for coronary artery bypass surgery. Based on the available evidence, the authors provide recommendations for the use of the radial artery in patients undergoing percutaneous or surgical coronary procedures.

(J Am Coll Cardiol 2018;71:1167–75) © 2018 by the American College of Cardiology Foundation.

Cardiologists to the Right, Surgeons to the Left !!!

ESC HOTLINE 2018

Arterial Revascularization Trial (ART): 10-year Outcomes

Randomized comparison of **single** versus **bilateral** internal thoracic artery grafts in 3102 CABG patients:

David P Taggart MD (Hons), PhD, FRCS, FESC
Professor of Cardiovascular Surgery
University of Oxford, United Kingdom

for the Arterial Revascularization Trial Investigators
(No conflicts declared)



50 Years Ago: First report of SYSTEMATIC use of SV grafts for CABG

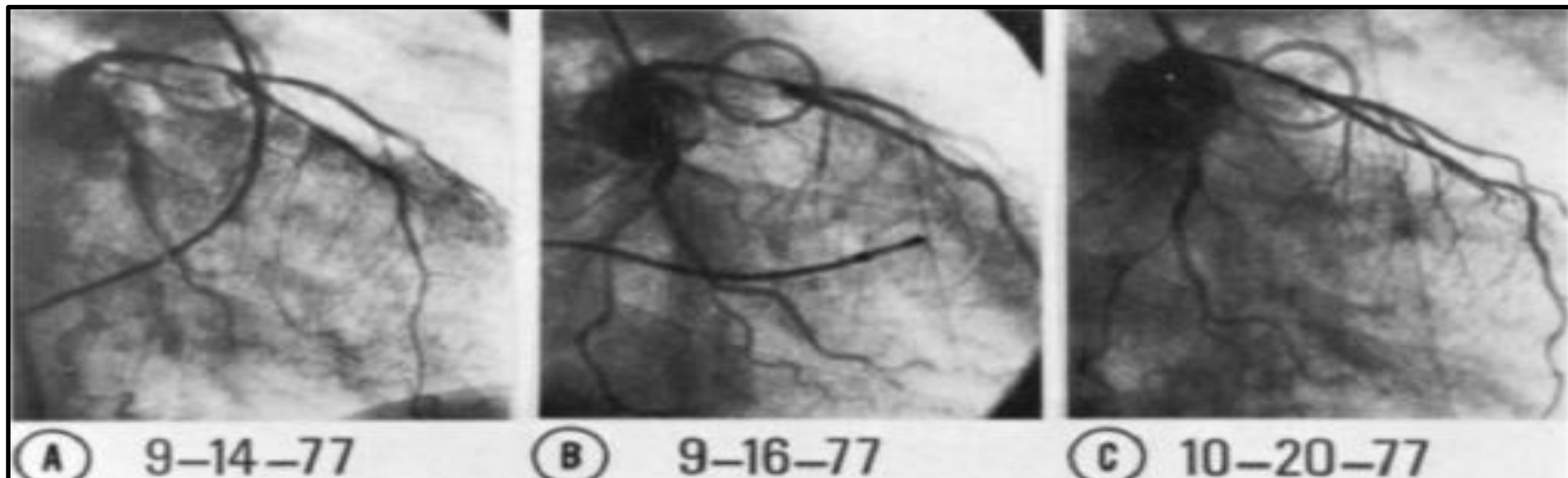
Saphenous Vein Autograft Replacement of Severe Segmental Coronary Artery Occlusion

Operative Technique

ATS [April 1968]

Rene G. Favaloro, M.D.

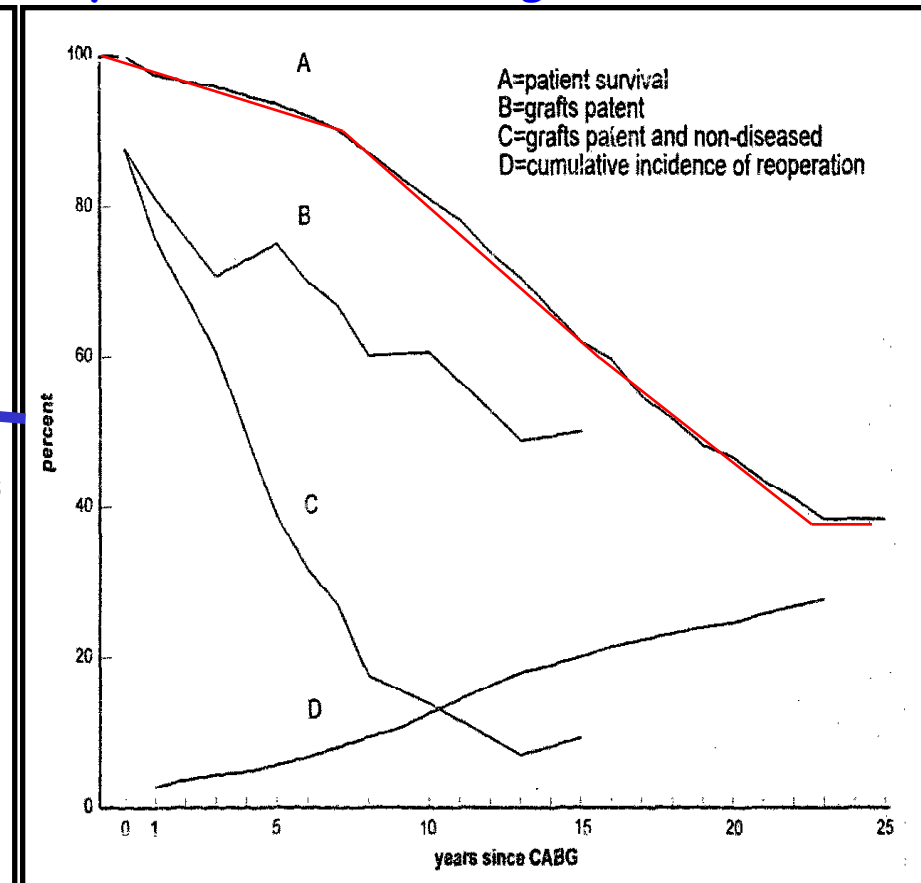
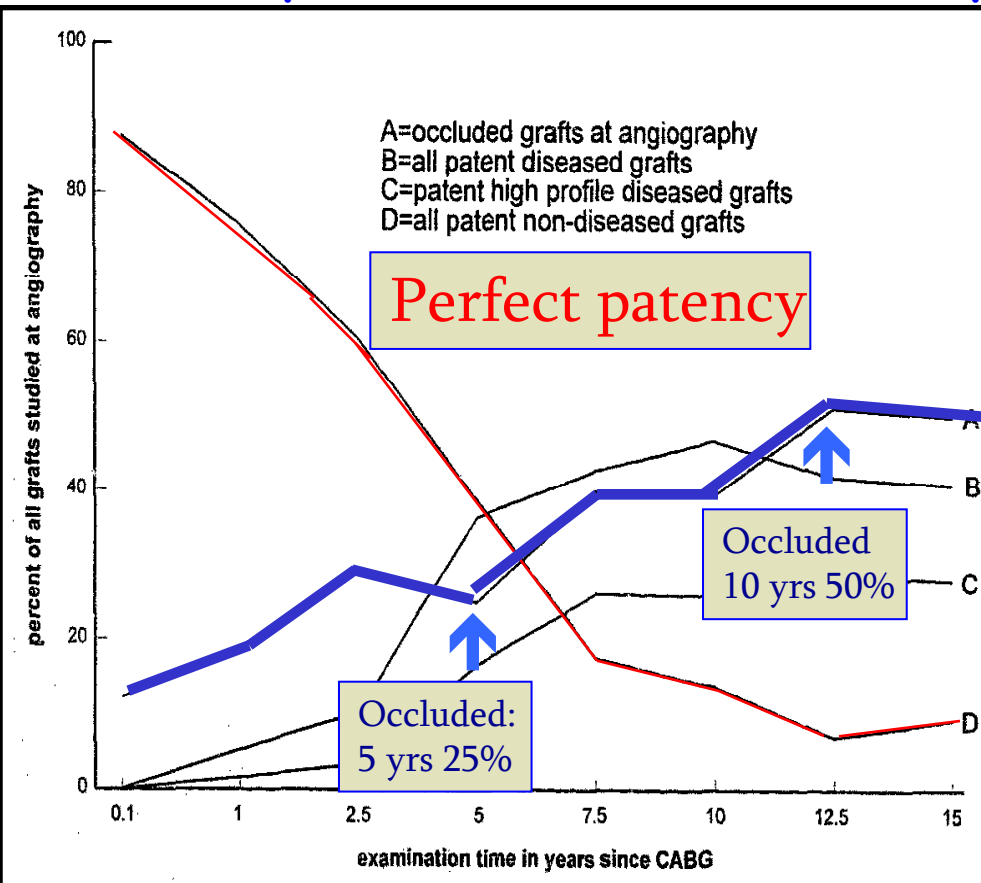
41 Years Ago: Gruentzig reports first PTCA (AHA 1977)



Coronary Bypass Graft Fate and Patient Outcome: Angiographic Follow-Up of 5,065 Grafts Related to Survival and Reoperation in 1,388 Patients During 25 Years [JACC 1996]

GERALD M. FITZGIBBON, LRCP&S(IRELAND), FACC, HENRYK P. KAFKA, MD, FACC, ALAN J. LEACH, MD, FRCPC, WILBERT J. KEON, MD, FACC, G. DAVID HOOPER, MD, FACC,† JEFFREY R. BURTON, MD, FACC

In current practice of > 1 million CABG per year > 80% of all grafts are SVG



While some contemporary studies show much superior vein graft patency the largest angiographic study (PREVENT IV) shows similar inferior patency

Improving SVG Patency

- ① Improved storage solutions (Somahlution),
- ② 'No Touch' harvest technique (Souza),
- ③ Composite graft from the ITA (KiBong Kim),
- ④ External stent (VEST)

European Journal of Cardio-Thoracic Surgery 53 (2018) 1127–1134
doi:10.1093/ejcts/ezx432 Advance Access publication 8 December 2017

REVIEW

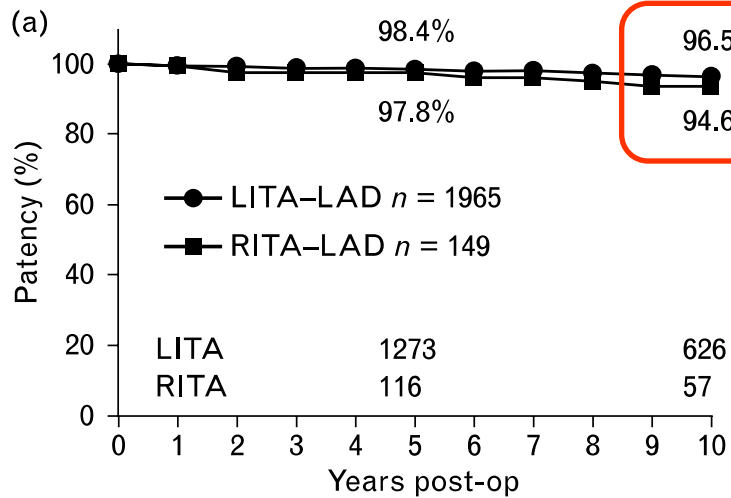
Cite this article as: Mawhinney JA, Mounsey CA, Taggart DP. The potential role of external venous supports in coronary artery bypass graft surgery. Eur J Cardiothorac Surg 2018;53:1127–34.

The potential role of external venous supports in coronary artery bypass graft surgery[†]

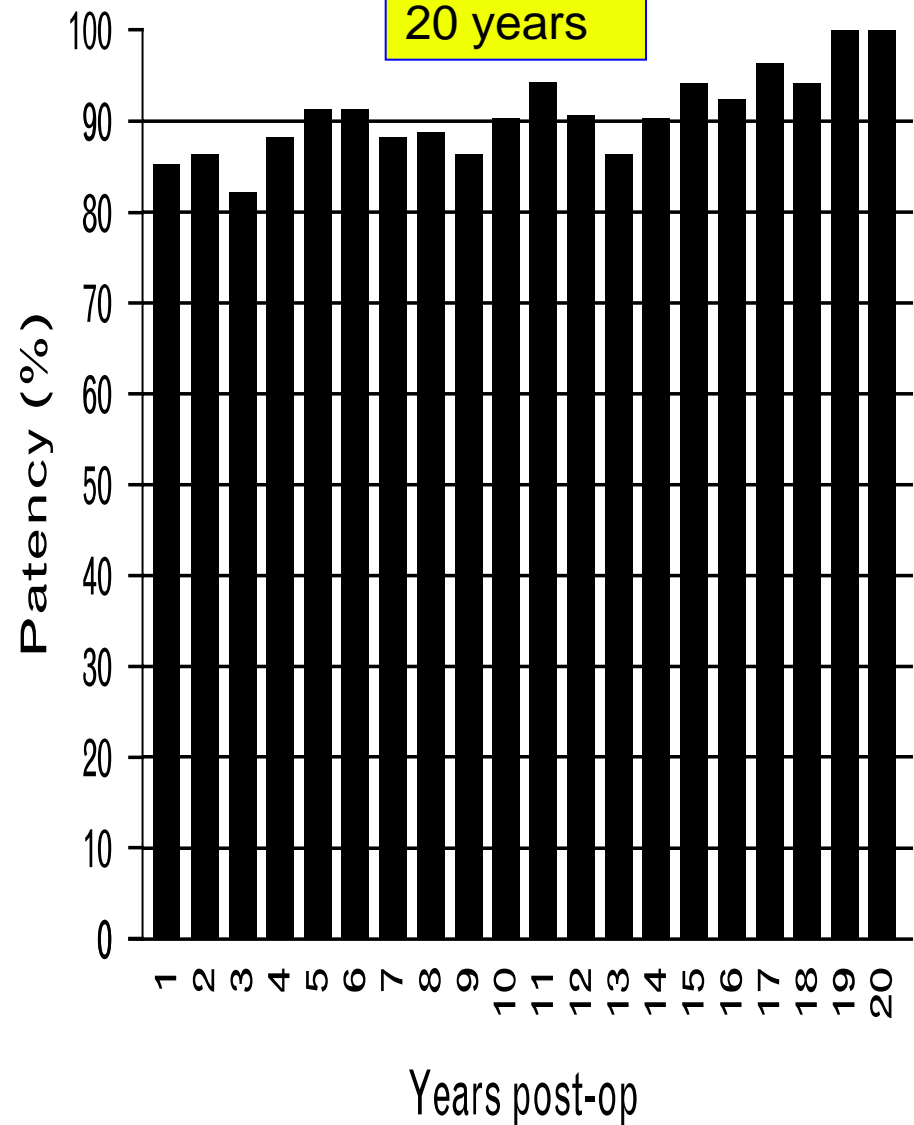
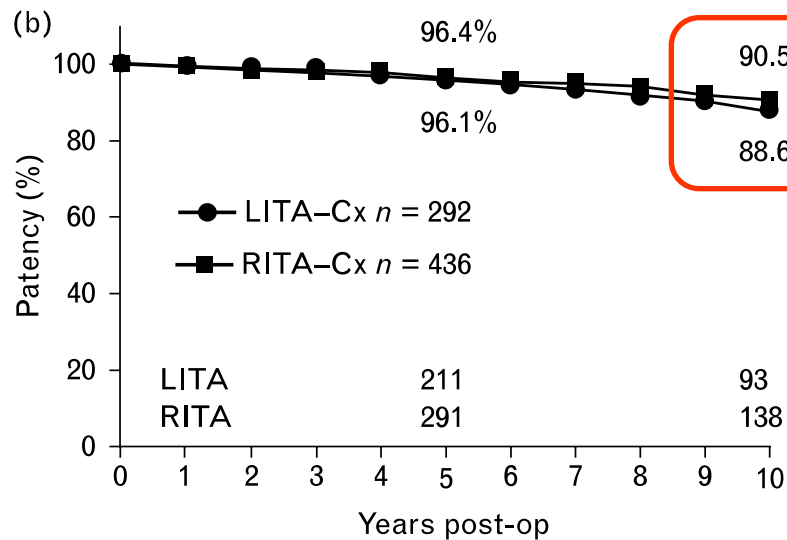
Jamie A. Mawhinney^{a,*}, Craig A. Mounsey^a and David P. Taggart^b

The right internal thoracic artery: is it underutilized?

James Tatoulis^{a,c}, Brian F. Buxton^{b,c} and John A. Fuller^b [2011]



10 years



Effect of Bilateral Internal Mammary Artery on Long-Term Survival

A Meta-Analysis Approach

[CIRC 2014]

Gijong Yi, PhD; Brian Shine, MD; Syed M. Rehman, MD; Douglas G. Altman, DSc; David P. Taggart, PhD

15,583 patients followed for a mean of >9 years

