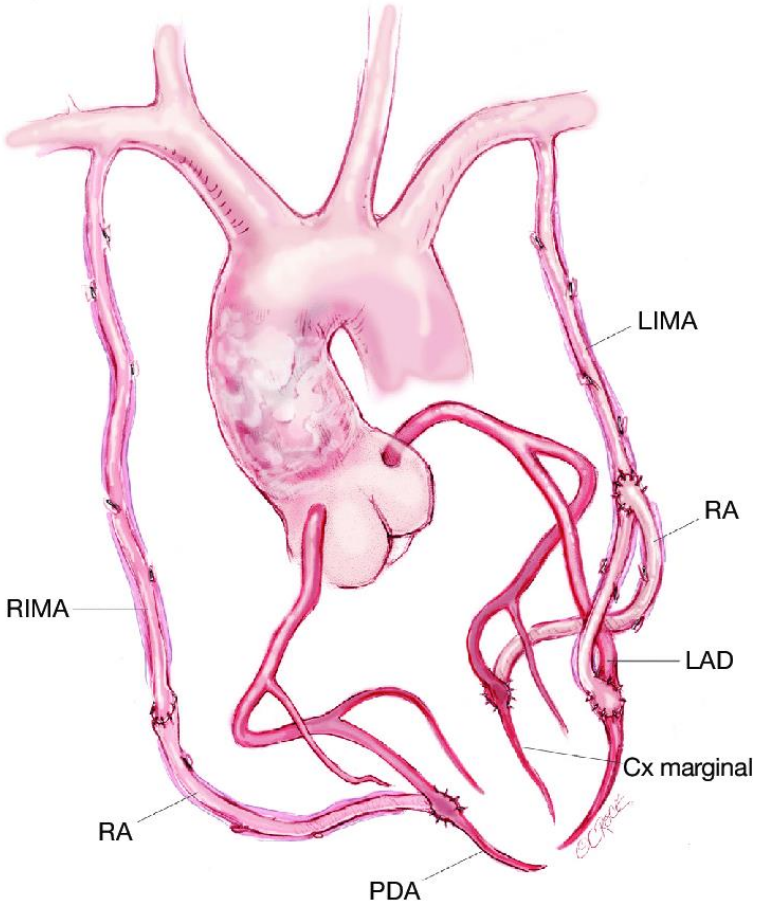
Arterial grafting in CABG



Yonsei University College of Medicine
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Gangnam Severance Hospital

Gijong Yi

Benefits of BITA use

- Guidelines / observational studies / meta-analyses

ART (Arterial Revascularization Trial)

- Large-volume RCT
- ‘Negative’ study?

Radial artery rebound

- RADIAL Investigators study
- RITA vs RA

Number of arterial grafts ; multi-arterial grafting

- Evidences from observational studies
- ROMA trial

Current guidelines on arterial grafting

; LITA > RITA ≒ RA

Recommendations on procedural aspects of coronary artery bypass grafting / 2018 ESC/EACTS guidelines

Conduit selection		
Arterial grafting with IMA to the LAD system is recommended.[453,454,546]	I	B
An additional arterial graft should be considered in appropriate patients.[467,482,547–551]	IIa	B
The use of the radial artery is recommended over the saphenous vein in patients with high-grade coronary artery stenosis.[d 482,549,550,552,553]	I	B
BIMA grafting should be considered in patients who do not have a high risk of sternal wound infection.[e 467,547,548,551]	IIa	B

Bilateral ITA use / 2016 STS guidelines

- The ITA should be used to bypass the LAD artery when bypass of the LAD is indicated (COR I, LOE B).
- As an adjunct to LITA, a second arterial graft (right internal thoracic artery or radial artery [RA]) should be considered in appropriate patients (COR IIa, LOE B).
- Use of BITAs should be considered in patients who do not have an excessive risk of sternal complications (COR IIa, LOE B).
- To reduce the risk of sternal infection with BITA consider the following:
  - Skeletonized grafts should be considered (COR IIa, LOE B).
  - Smoking cessation is recommended (COR I, LOE C).
  - Glycemic control should be considered (COR IIa, LOE B).
  - Enhanced sternal stabilization may be considered (COR IIb, LOE C).

2021 AHA/ACC guideline

Recommendations for Bypass Conduits in Patients Undergoing CABG
Referenced studies that support the recommendations are summarized in Online Data Supplement 37.

COR	LOE	RECOMMENDATIONS
1	B-R	1. In patients undergoing isolated CABG, the use of a radial artery is recommended in preference to a saphenous vein conduit to graft the second most important, significantly stenosed, non-LAD vessel to improve long-term cardiac outcomes (1-3).
1	B-NR	2. In patients undergoing CABG, an IMA, preferably the left, should be used to bypass the LAD when bypass of the LAD is indicated to improve survival and reduce recurrent ischemic events (4-9).
2a	B-NR	3. In patients undergoing CABG, bilateral IMA (BIMA) grafting by experienced operators can be beneficial in appropriate patients to improve long-term cardiac outcomes (3,10-12).

Benefits of BITA use – evidences from observational studies

; BITA use maybe better than SITA alone

Internal thoracic artery use – gold standard

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.

NEJM 1986

Bilateral ITA use – Two ITAs are better than one?

The Effect of Bilateral Internal Thoracic Artery Grafting on Survival During 20 Postoperative Years

Bruce W. Lytle, MD, Eugene H. Blackstone, MD, Joseph F. Sabik, MD,
Penny Houghtaling, MS, Floyd D. Loop, MD, and Delos M. Cosgrove, MD

Departments of Thoracic and Cardiovascular Surgery, and Biostatistics and Epidemiology, The Cleveland Clinic Foundation, Cleveland, Ohio

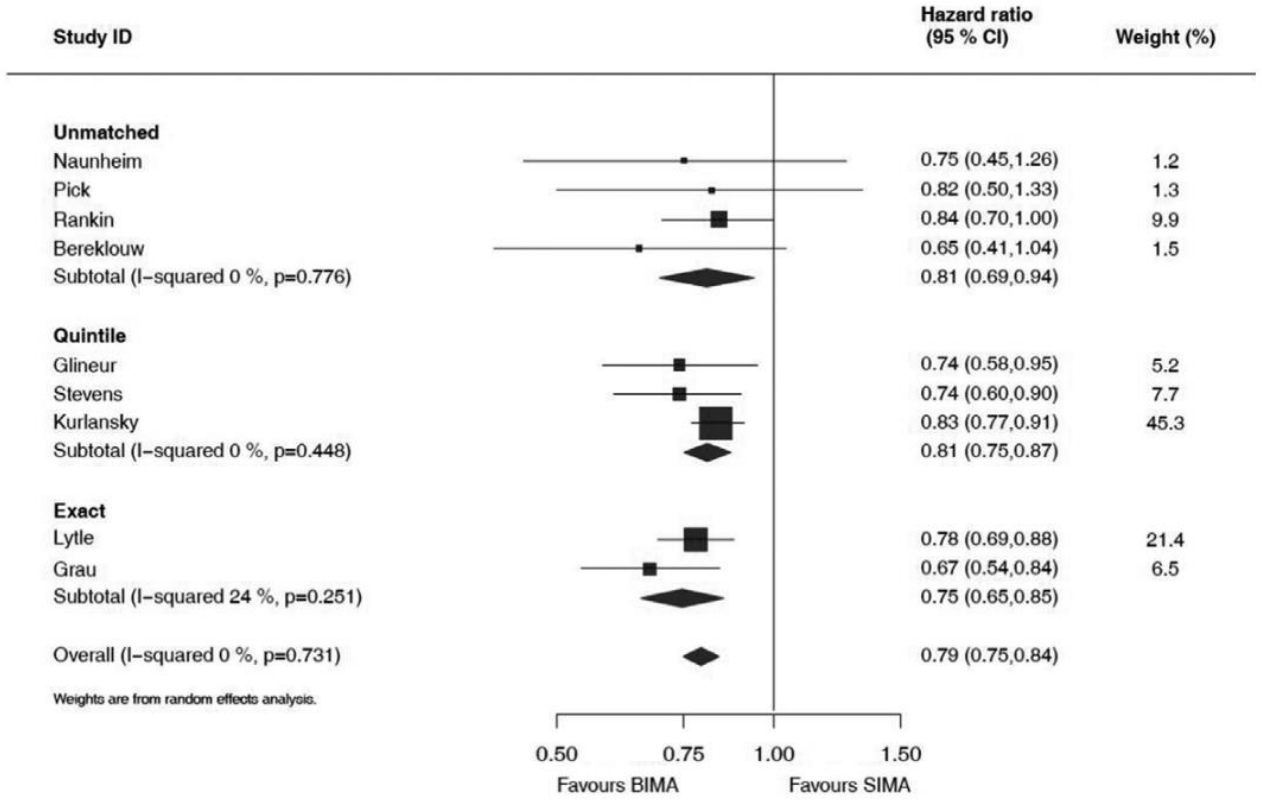
ATS 2004

Bilateral ITA better than single ITA / evidences from meta analysis

Effect of Bilateral Internal Mammary Artery Grafts on Long-Term Survival

A Meta-Analysis Approach

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



Circulation 2013

Benefits of BITA use – evidences from RCT (ART trial)

; a failed study?

; messages from ART

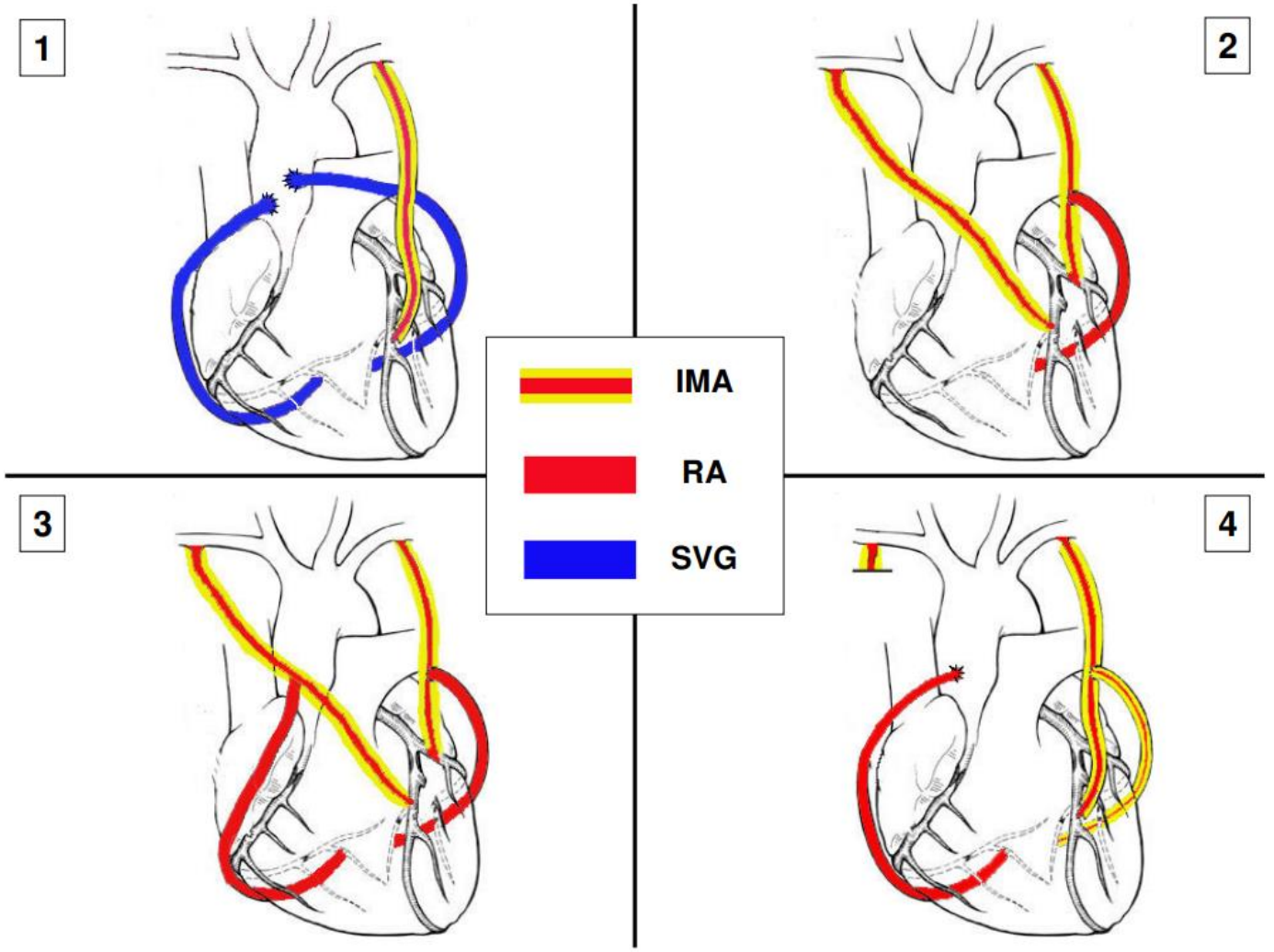
Randomized trial comparing BITA vs SITA / ART trial

Protocol for the Arterial Revascularisation Trial (ART). A randomised trial to compare survival following bilateral versus single internal mammary grafting in coronary revascularisation [ISRCTN46552265]

David P Taggart*[1], Belinda Lees[2], Alastair Gray[3], Douglas G Altman[4], Marcus Flather[2], Keith Channon[5] and the ART Investigators

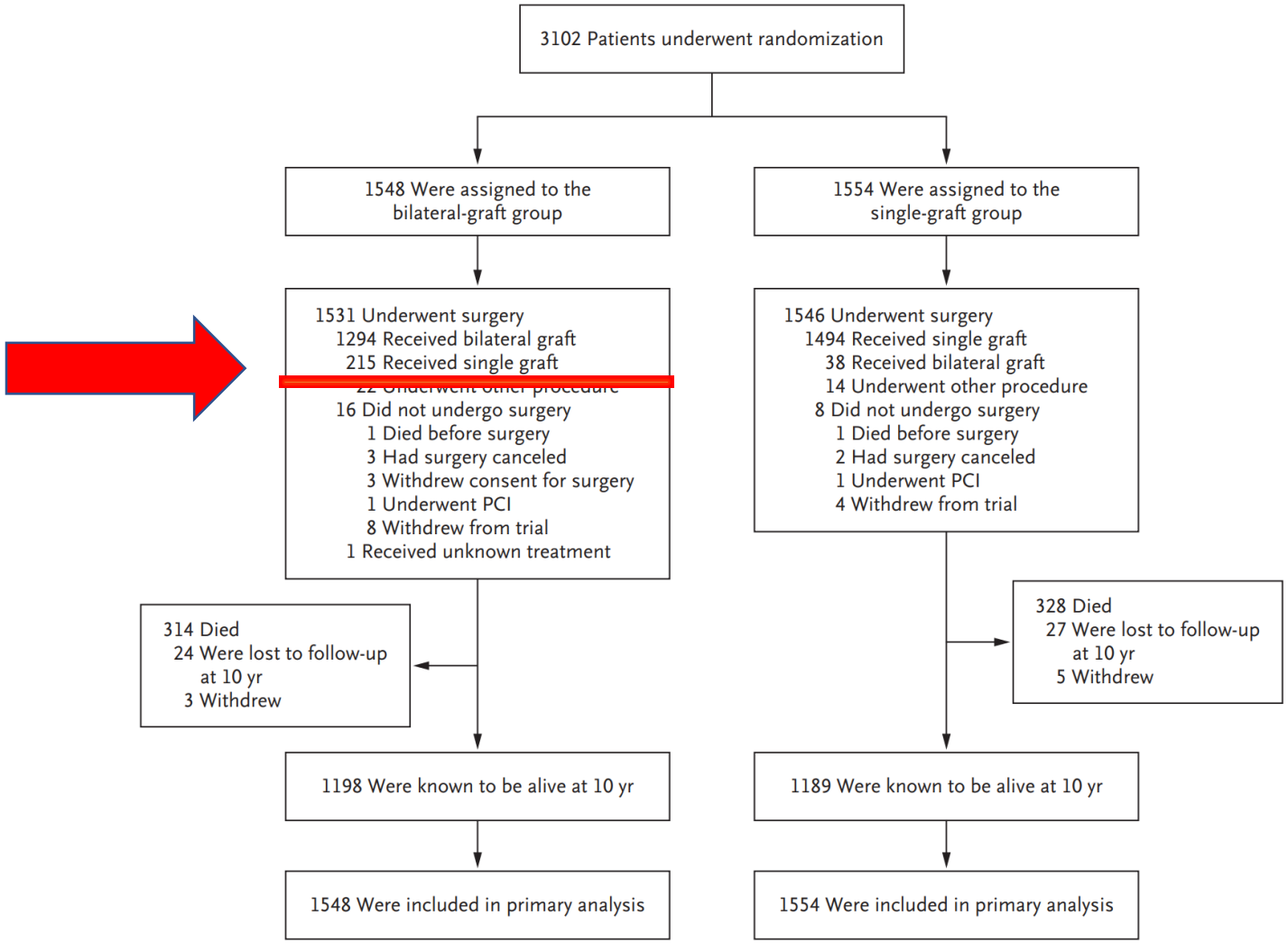
Trials 2006

Randomized trial comparing BITA vs SITA / ART trial



Trials 2006

ART trial – 10 years final report



NEJM 2019

ART trial – no differences in survival/ MACCE

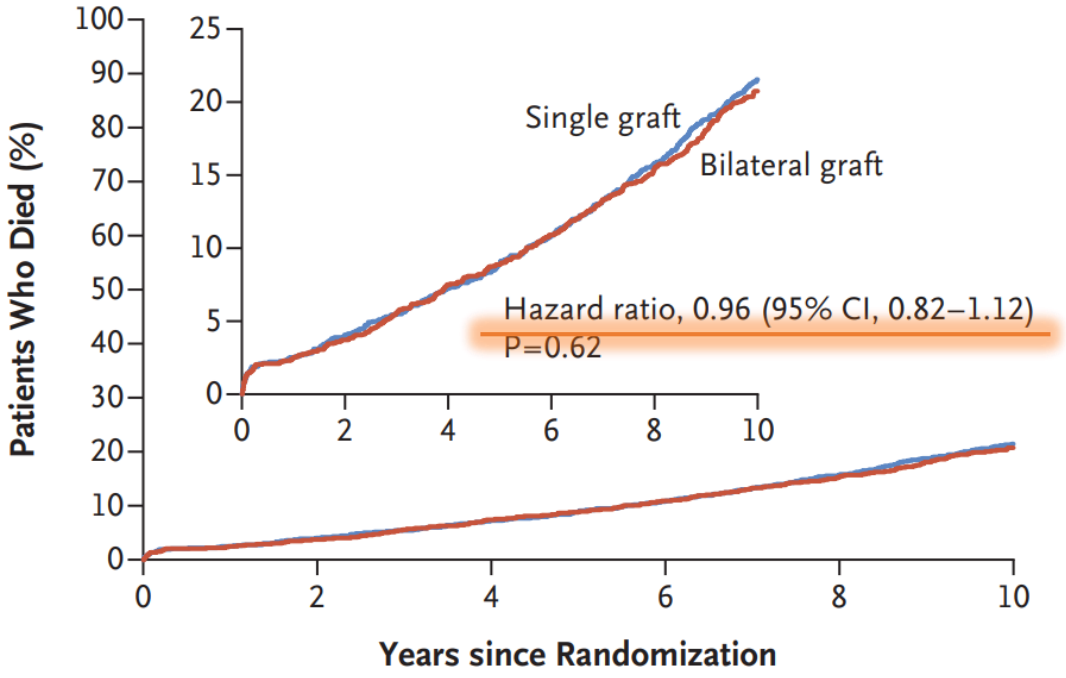
Table 2. Clinical Outcomes and Adverse Events at 10 Years (Intention-to-Treat Analysis).

Variable	Bilateral-Graft Group (N = 1548)	Single-Graft Group (N = 1554)	Hazard Ratio or Relative Risk (95% CI)*	P Value
	number (percent)			
Clinical outcome				
Primary outcome: death from any cause	315 (20.3)	329 (21.2)	0.96 (0.82–1.12)	0.62
Composite of death, myocardial infarction, or stroke	385 (24.9)	425 (27.3)	0.90 (0.79–1.03)	—
Myocardial infarction†	71 (4.6)	78 (5.0)	0.92 (0.66–1.26)	—
Stroke†	57 (3.7)	76 (4.9)	0.75 (0.53–1.06)	—
Adverse event				
Repeat revascularization	159 (10.3)	156 (10.0)	1.02 (0.83–1.26)	—
Major bleeding‡	52 (3.4)	48 (3.1)	1.09 (0.74–1.61)	—
Sternal wound complication‡	54 (3.5)	30 (1.9)	1.81 (1.16–2.81)	—
Sternal wound reconstruction‡	31 (2.0)	10 (0.6)	3.11 (1.53–6.32)	—

NEJM 2019

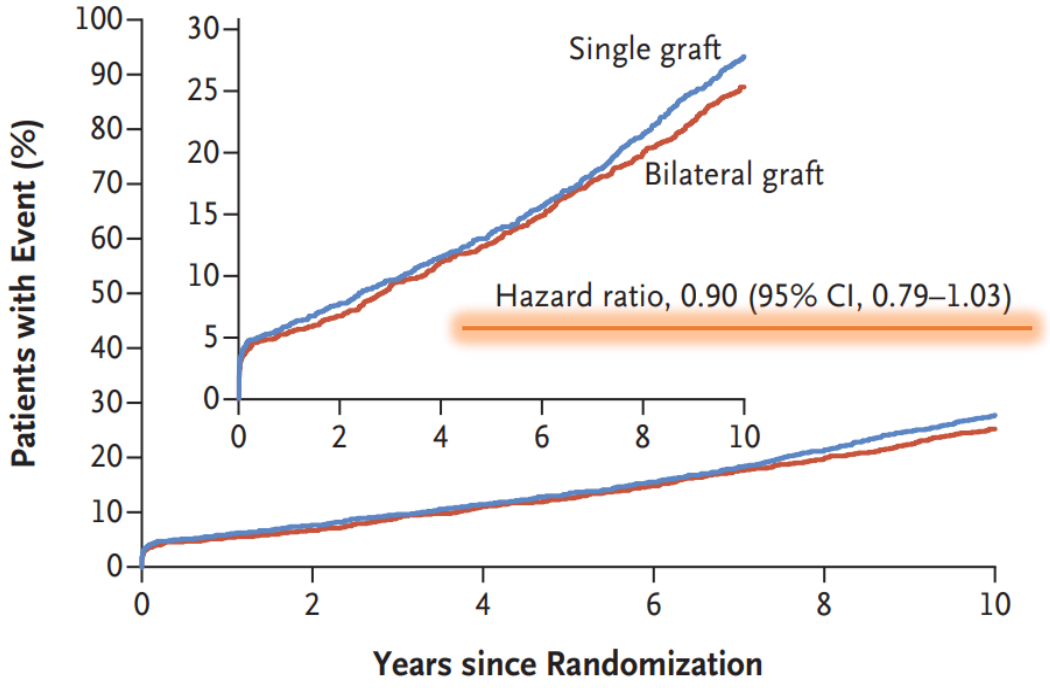
ART trial – no differences in survival/ MACCE

A **Death from Any Cause at 10 Yr**



No. at Risk						
Single graft	1554	1484	1432	1370	1283	894
Bilateral graft	1548	1481	1417	1359	1283	882

B **Composite of Death from Any Cause, Myocardial Infarction, or Stroke at 10 Yr**



No. at Risk						
Single graft	1554	1427	1366	1296	1195	820
Bilateral graft	1548	1435	1362	1299	1214	830

NEJM 2019

ART trial – conclusions

CONCLUSIONS

Among patients who were scheduled for CABG and had been randomly assigned to undergo bilateral or single internal-thoracic-artery grafting, there was no significant between-group difference in the rate of death from any cause at 10 years in the intention-to-treat analysis. Further studies are needed to determine whether multiple arterial grafts provide better outcomes than a single internal-thoracic-artery graft. (Funded by the British Heath Foundation and others; Current Controlled Trials number, ISRCTN46552265.)

NEJM 2019

ART trial – It is what it is.

Finally, although ART failed to show the superiority of BITA versus SITA grafting after 10 years, it should not be considered a "failed" study. In fact, it is a "landmark" trial. The real conclusion from ART is that when RA grafts and GDMT are performed in conjunction with SITA grafting, the overall results are equivalent to what can be obtained with BITA grafting, without the increased risk of sternal wound complications that contribute to increased morbidity and mortality. Furthermore, ART highlights the importance of GDMT to optimize the short- and long-term outcomes following CABG. Rather than attempting to explain the reasons for the shortcomings of ART, the authors should be encouraged to continue to analyze the ART data to determine which subgroups of patients will derive the greatest benefits from BITA grafting.

JAHA 2019

ART trial – Failed trial ??

- Vein graft failure – clinical effect on survival?

- 14% BITA group received single ITA (high cross-over rate)
  ; what if "as-treated analysis?"
  ; higher cross-over rate in less experienced surgeons

- 22% SITA group received additional radial artery graft

- Exceptionally high rate of guideline-directed medical therapy
  ; 70-90% for aspirin/ statins/ beta-blockers

NEJM 2019

ART trial – post hoc analysis

- Number of arterial grafts ; as-treated analysis
- Effect of radial artery graft
- Age effect
- Comparing with previous observational data

Effect of total arterial grafting in the Arterial Revascularization Trial

As-treated analysis

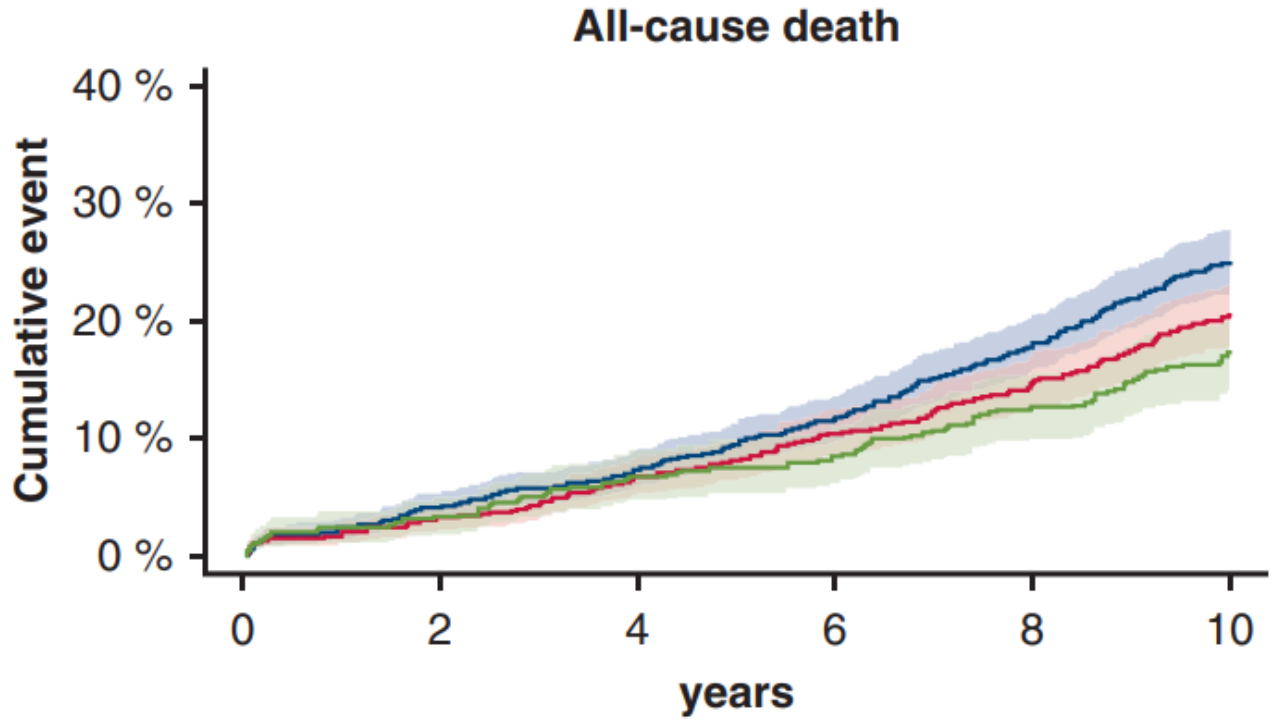
TABLE 3. Treatment effect estimation

	10-y cumulative incidence, %	Hazard ratio (95% CI)	*P* value
All-cause death (*P* trend = .02)			
SAG	24.6	Ref	
MAG	21.1	0.84 (0.69-1.03)	.09
TAG	18.4	0.68 (0.48-0.96)	.03
Death/MI/stroke/ revascularization (*P* trend = .01)			
SAG	37.0	Ref	
MAG	32.1	0.82 (0.69-0.96)	.02
TAG	31.4	0.71 (0.53-0.94)	.02

JTCVS 2022

Effect of total arterial grafting in the Arterial Revascularization Trial

As-treated analysis



TAG index						
<1/3:	1019	969	925	873	791	530
1/3->2/3:	936	898	855	817	762	499
>2/3:	529	507	483	468	439	300

B

The more arterial graft the better outcome

$$TAG\ index = \frac{Number\ of\ Arterial\ Grafts}{Number\ of\ Total\ Grafts}$$

JTCVS 2022

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

Insights From the Arterial Revascularization Trial

Additional RA graft

- SITA / BITA +radial artery (632) vs SITA / BITA + vein graft only (2105)

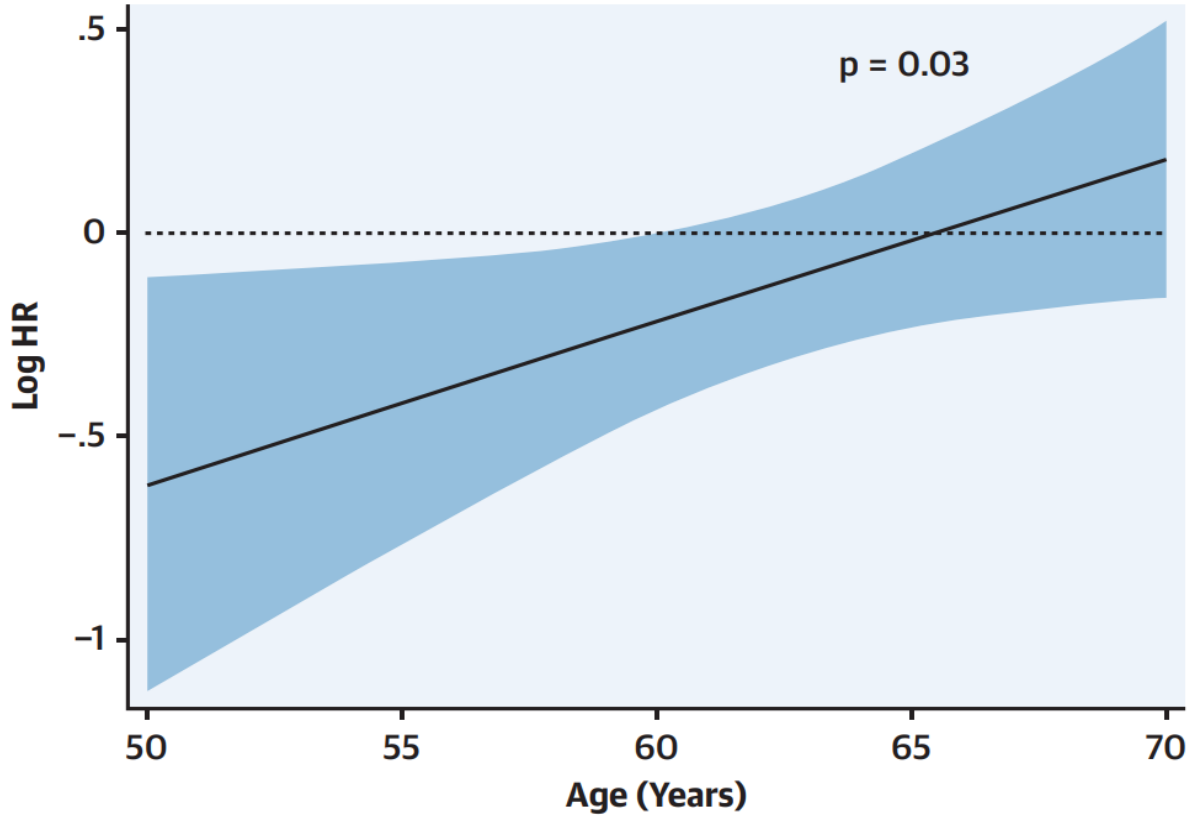
- Posthoc ART analysis , propensity score matching, stratified Cox regression model

CONCLUSIONS: This post hoc ART analysis showed that an additional RA was associated with lower risk for midterm major adverse cardiac events when used to supplement SITA or BITA grafts.

Circulation 2017

Association of Age With 10-Year Outcomes After Coronary Surgery in the Arterial Revascularization Trial

CENTRAL ILLUSTRATION **Treatment-Effect Plot for Interaction Between the 10-Year Composite Outcome of Bilateral Internal Thoracic Arteries Versus Single Internal Thoracic Artery With Age in Patients Between Age 50 and 70 Years**



Gaudino, M. et al. J Am Coll Cardiol. 2021;77(1):18-26.

BITA may improve long-term outcome in younger patients

JACC 2021

Radial artery rebound

- Better than vein graft?

- As good as RITA ?

Radial artery - better than SVG, as good as RITA?

JAMA | Original Investigation

Association of Radial Artery Graft vs Saphenous Vein Graft With Long-term Cardiovascular Outcomes Among Patients Undergoing Coronary Artery Bypass Grafting

A Systematic Review and Meta-analysis

JAMA 2020

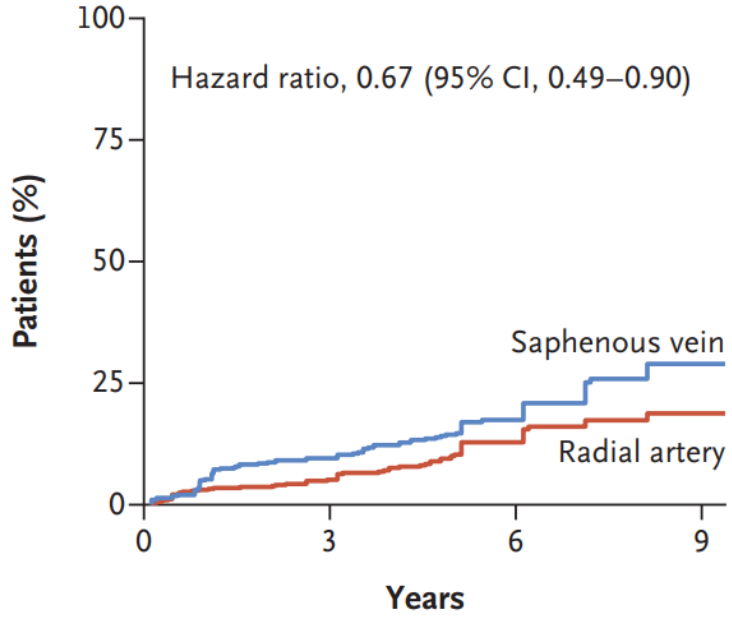
Radial-Artery or Saphenous-Vein Grafts in Coronary-Artery Bypass Surgery

NEJM 2018

Radial artery rebound
- RADIAL Investigators study

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

A Death, Myocardial Infarction, or Revascularization



No. at Risk				
Saphenous vein	502	375	168	10
Radial artery	534	408	163	14

Radial artery group
- Better cardiac related events
  (death, MI, repeat intervention)
- Better graft patency

NEJM 2018

2021 AHA/ACC guideline

RA similar to LITA ?

Recommendations for Bypass Conduits in Patients Undergoing CABG
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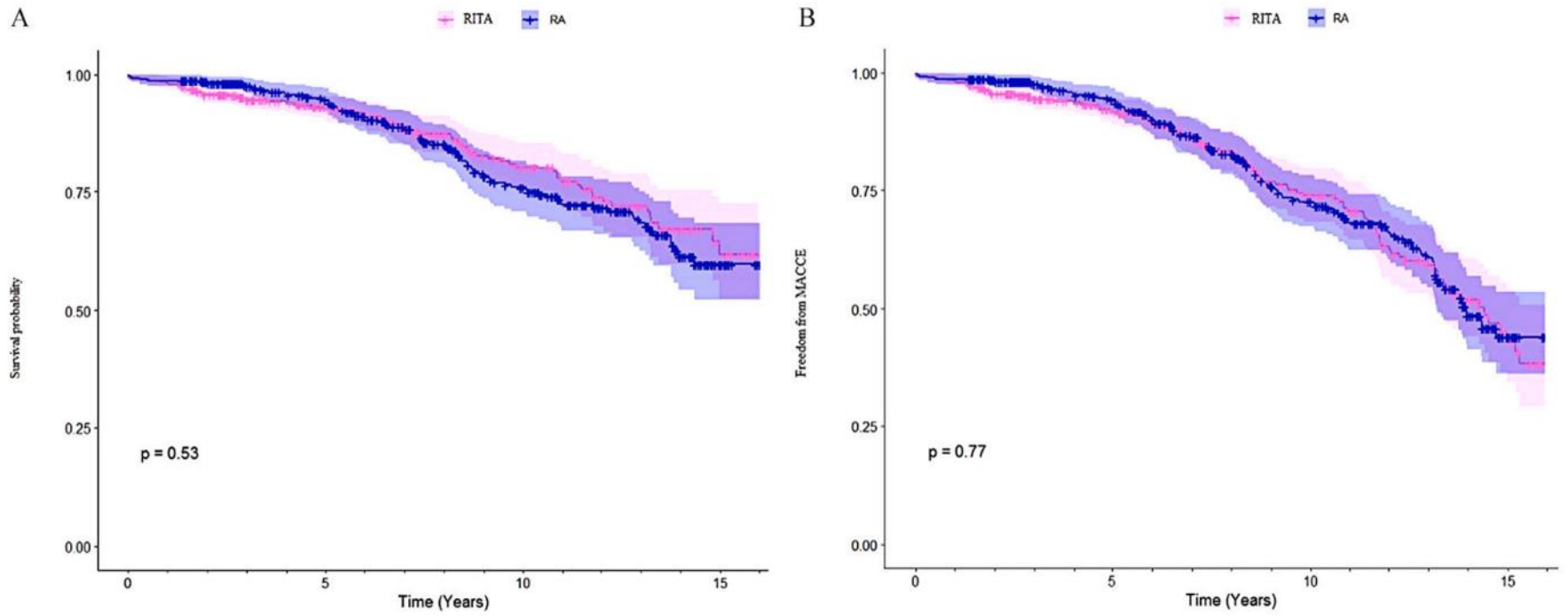
1	B-NR	2. In patients undergoing CABG, an IMA, preferably the left, should be used to bypass the LAD when bypass of the LAD is indicated to improve survival and reduce recurrent ischemic events (4-9).
2a	B-NR	3. In patients undergoing CABG, bilateral IMA (BIMA) grafting by experienced operators can be beneficial in appropriate patients to improve long-term cardiac outcomes (3,10-12).

Radial artery vs RITA

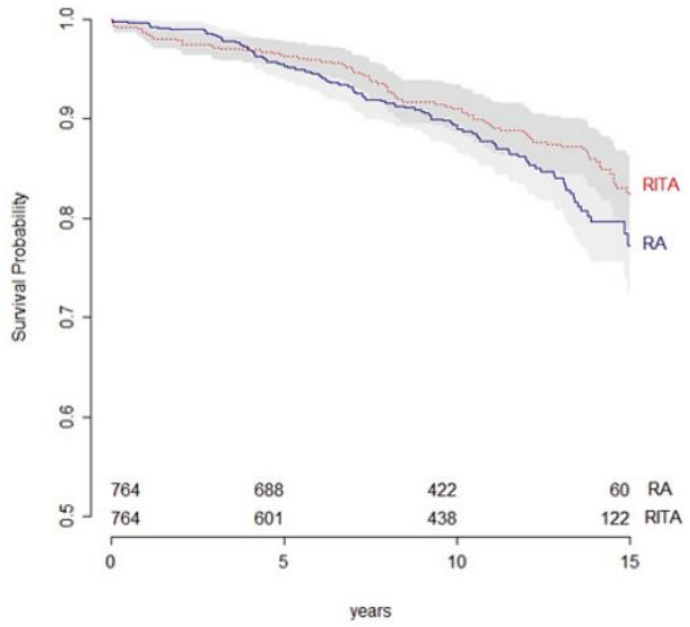
Long-term outcomes of patients receiving right internal thoracic artery or radial artery as a second arterial conduit. A propensity score matching study



Int J Cardiol 2023

Radial artery vs RITA

Right internal thoracic artery or radial artery? A propensity-matched comparison on the second-best arterial conduit



In a highly selected low-risk group of patients, the use of the RITA as second arterial conduit instead of the RA was associated with better survival when used to graft the left but not the right coronary artery.

J Thorac Cardiovasc Surg 2017

Radial artery vs RITA

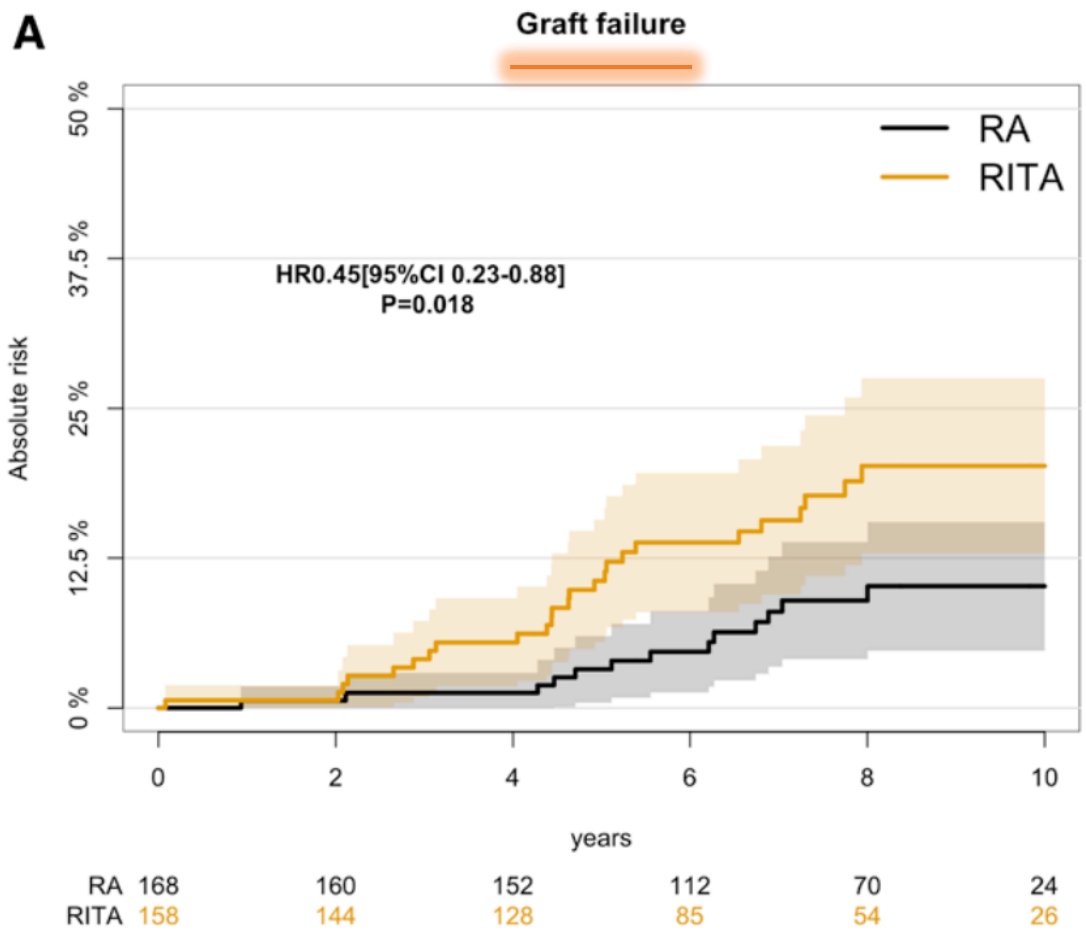
RCT comparing RA and RITA

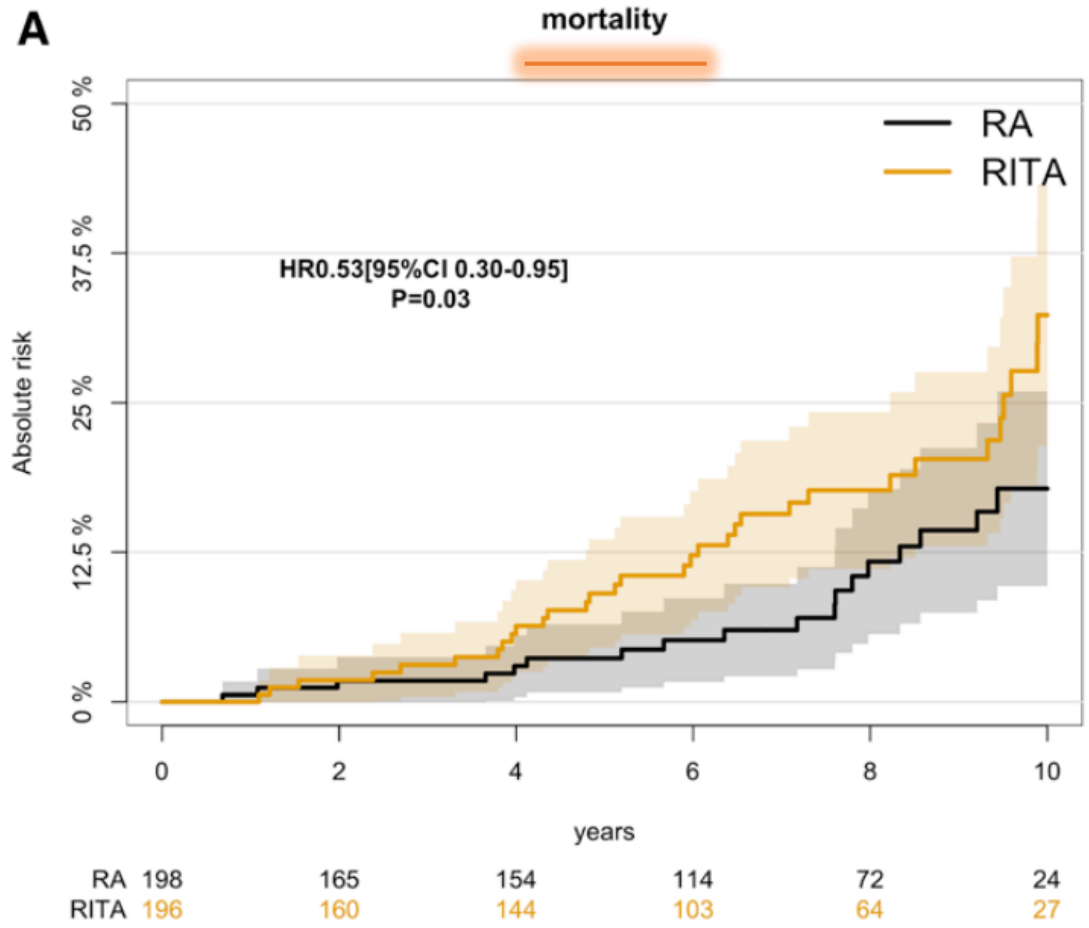
Long-Term Results of the RAPCO Trials

The RAPCO trial (Radial Artery Patency and Clinical Outcomes) was designed to compare the long-term patency of the radial artery with the most frequently used complementary grafts: the right internal thoracic artery and the saphenous vein.

Circulation 2020

Long-Term Results of the RAPCO Trials



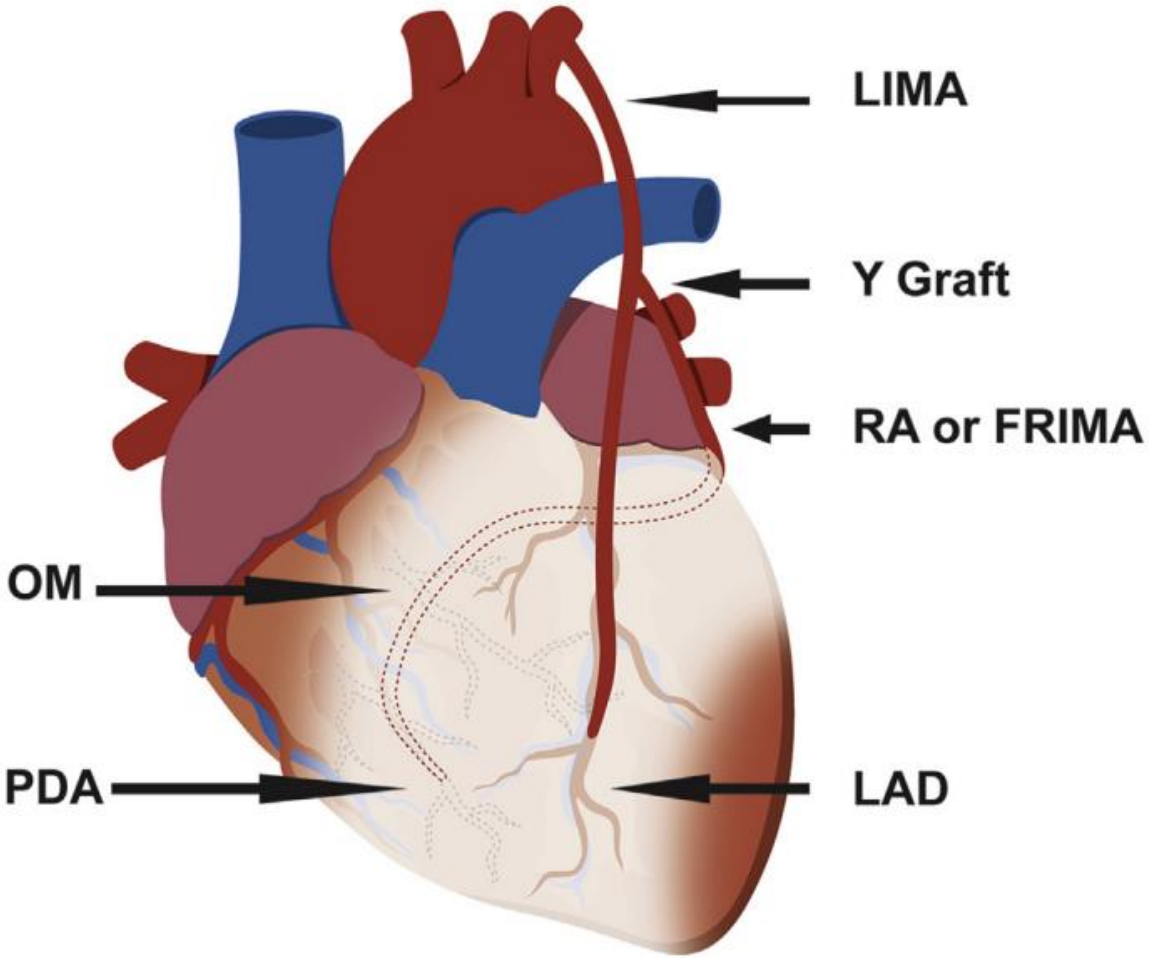


RA/RITA ; aortocoronary bypass

Circulation 2020

Radial artery vs RITA

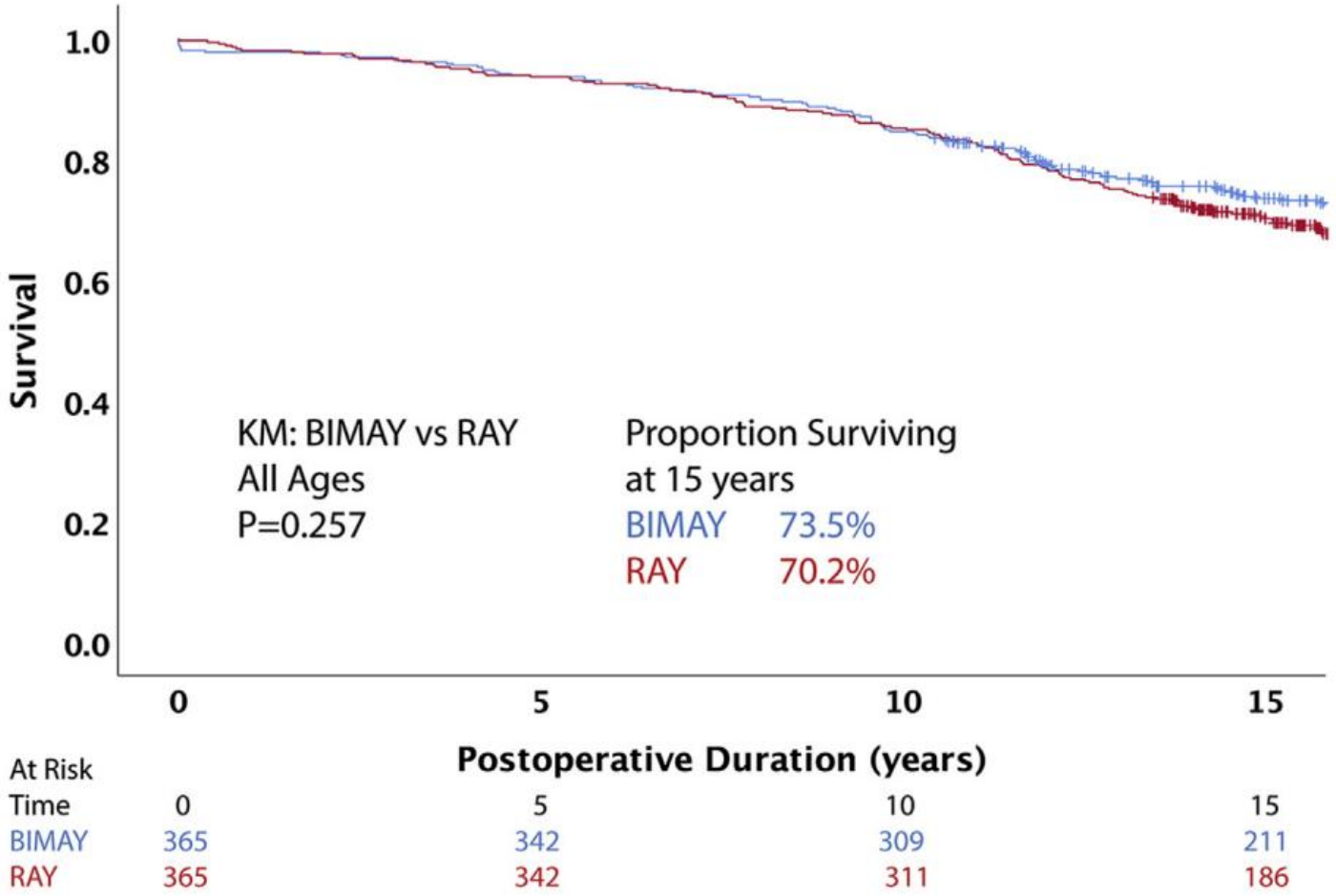
Radial Artery vs Bilateral Mammary Composite Y Coronary Artery Grafting: 15-Year Outcomes



Ann Thorac Surg 2021

Radial artery vs RITA

Radial Artery vs Bilateral Mammary Composite Y Coronary Artery Grafting: 15-Year Outcomes



Ann Thorac Surg 2021

Number of arterial grafts ; multi-arterial grafting

- Evidences from observational studies
- ROMA trial

Does “number of arterial graft” matters?

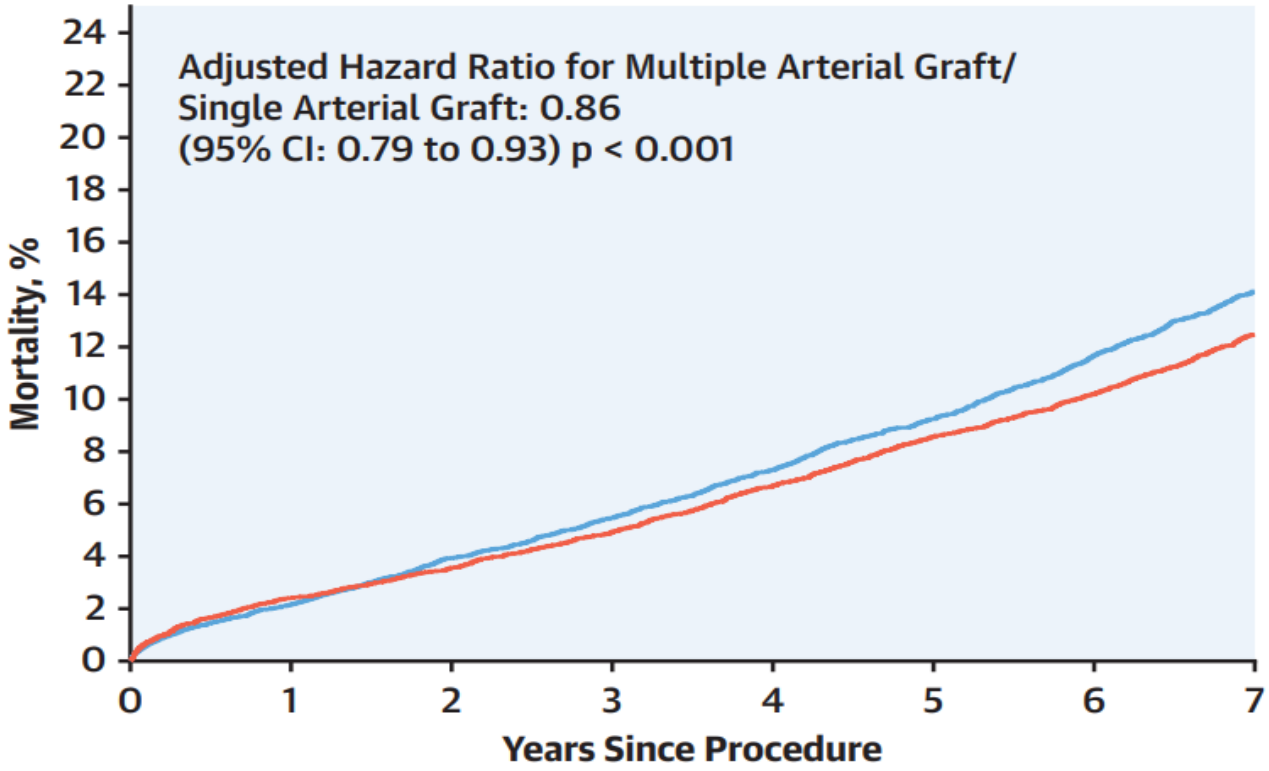
Multiple Versus Single Arterial Coronary Bypass Graft Surgery for Multivessel Disease

JACC 2019

Multiple Arterial Grafting Is Associated With Better Outcomes for Coronary Artery Bypass Grafting Patients

Circulation 2019

Multiple Versus Single Arterial Coronary Bypass Graft Surgery for Multivessel Disease



No. at Risk								
SAG	10,828	10,593	10,397	9,415	8,438	7,474	6,465	5,406
MAG	10,828	10,566	10,440	9,457	8,488	7,513	6,574	5,519

SAG MAG

- NY registry data
- 50,773 SAG vs 12,629 MAG
- 6.5 years FU

JACC 2019

Multiple Arterial Grafting Is Associated With Better Outcomes for Coronary Artery Bypass Grafting Patients

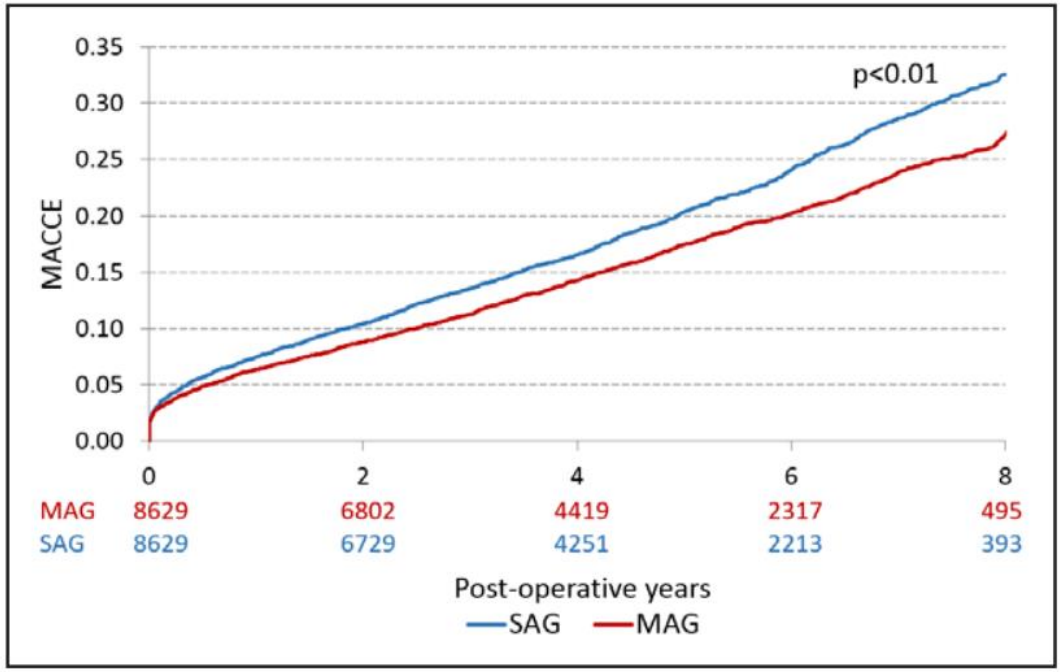


Figure 4. Cumulative incidence curves for the 8-year major adverse cardiac and cerebrovascular event (MACCE) for propensity-score matched (PSM) multiple arterial graft (MAG) vs single arterial group (SAG) groups.

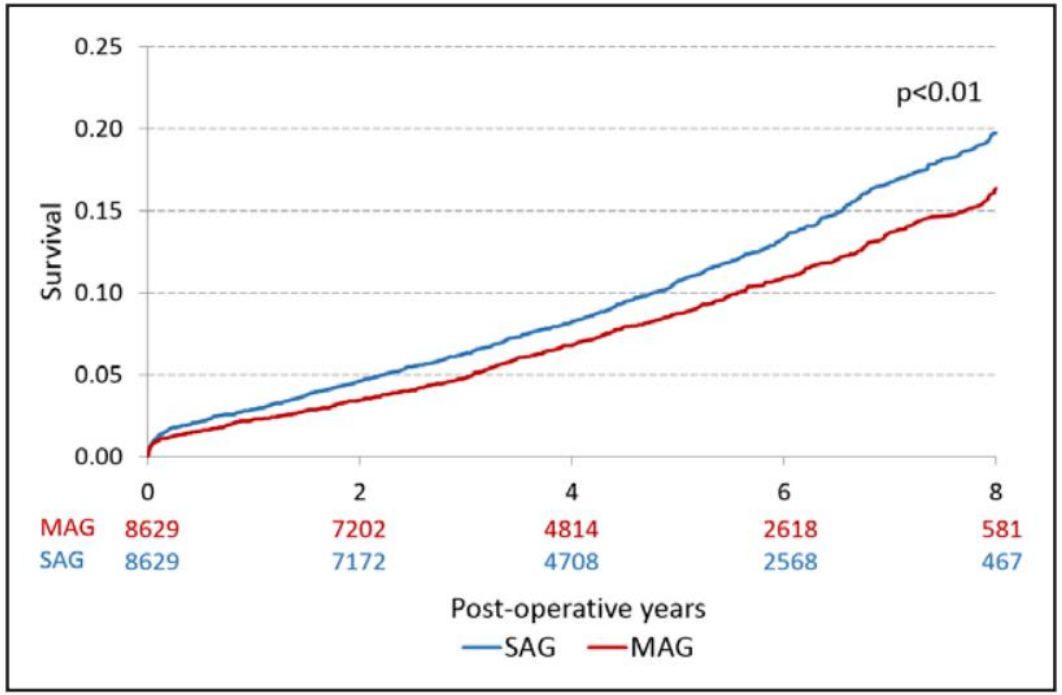


Figure 5. Cumulative incidence curves for the 8-year death for propensity-score matched (PSM) multiple arterial graft (MAG) vs single arterial group (SAG) groups.

Circulation 2019

Clinical Perspective

What Is New?

- The use of >1 arterial graft is increasing in the contemporary era, in Ontario, Canada.
- Multiple arterial graft coronary artery bypass graft (CABG) is associated with superior outcomes compared with single arterial graft.
- CABG with 3 arterial grafts is not associated with increased in-hospital death but is also not associated with better clinical outcomes up to 8 years, compared with CABG with 2 arterial grafts.

What Are the Clinical Implications?

- Multiple arterial graft CABG should be the procedure of choice for patients undergoing CABG using either 2 or 3 arterial grafts, in appropriate patients with reasonable life expectancy.

2 AG ≒ 3 AG

MAG better than SAG

Circulation 2019

Number of arterial grafts - multi-arterial grafting
- ROMA trial

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

RCT comparing single arterial group and multiple arterial group

More than 4300 patients (ART * 1.5)

More experienced surgeons

Primary endpoint ; composite of death, stroke, MI, repeat intervention

EJCTS 2017

Take-home messages

- Observational studies and multiple meta-analysis showed superior clinical outcomes favoring bilateral internal thoracic artery grafting.

- RCT comparing bilateral- and single ITA (ART) showed equivalent clinical outcomes after 10 years FU.

- When RA grafts and GDMT are performed in single ITA grafting, the results are equivalent with bilateral ITA grafting.

Take-home messages

- RA seems to have equivalent graft patency and clinical outcome compared with right ITA.
- Large-volume registry data showed superior clinical outcomes in multiple arterial grafting group compared with single arterial grafting group .
- Currently on-going RCT, comparing single vs multiple arterial grafting, will provide more evidences on this issue.

Thank you.