

SURGICAL MYOCARDIAL REVASCULARIZATION: ARTERIAL VS VENOUS GRAFTS, SINGLE VS MULTIPLE GRAFTS?

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Trends in mortality risks among 94,328 patients surviving 30 days after a first isolated coronary artery bypass graft procedure from 1987 to 2006: A population-based study

Susanne Nielsen

During 1987–2006, there was a significant improvement in survival after CABG for all categories, except in women aged less than 55 years. Men and women aged ≥ 55 years who survived the first 30 days after CABG

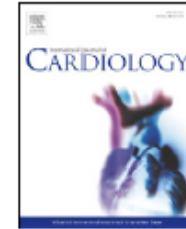
had a lower mortality risk than the general population



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Editorial

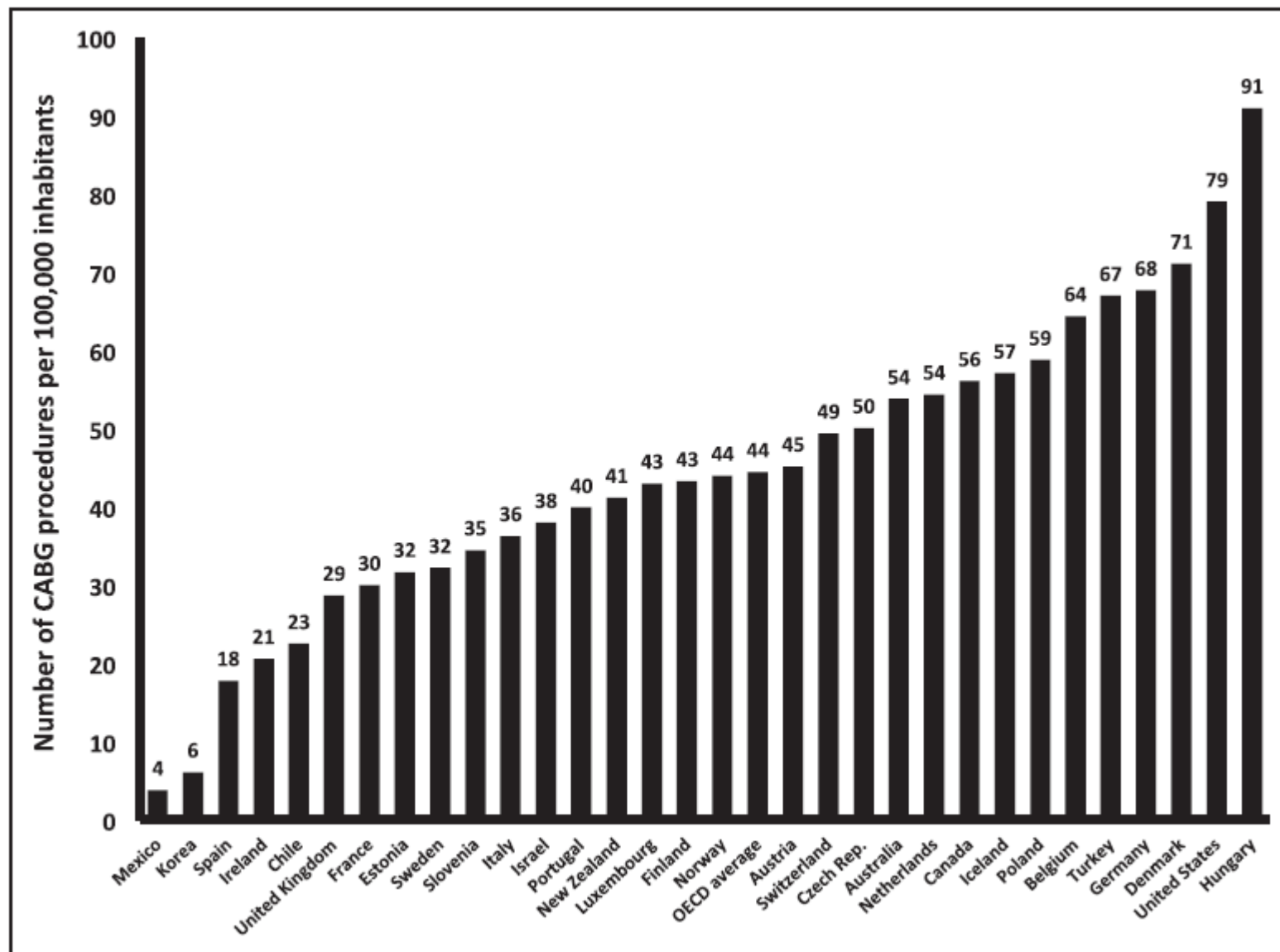
Coronary artery bypass graft: Is it still an elixir of life?

Luigi Martinelli

Cardiac Surgery Division, ICLAS - Istituto Clinico Ligure di Alta Specialità, Rapallo, Italy

As the authors point out, a comparison of the bypass to other methods of treatment of the myocardial ischemia was not among the aims of this study. However, given such important and stable results over time the clinician seems to be obliged to analyze thoroughly the benefits and disadvantages offered by the different possibilities of myocardial ischemia treatment in different clinical situations and patient categories, **not only considering the survival but also the quality of life.**

Number of coronary artery bypass graft (CABG) operations per 100 000 inhabitants.



Procedural characteristics of contemporary CABG

- CONDUITS
 - Saphenous veins, radial arteries, internal mammary arteries, (gastroepiploic artery)
- TECHNICAL SETTING
 - Use of ECC, hybrid procedure, minimally invasive approach
- QUALITY
 - Completeness of revascularization , intraoperative flow assessment

Peculiar aspects of contemporary cabg

CONDUITS

Guideline Recommendations for Conduit Use During Coronary Artery Bypass Grafting

| | 2011 ACCF/AHA ¹⁷ | 2016 STS ²⁰ | 2014 ESC/EACTS ¹⁶ |
|---------------|---|---|---|
| LAD territory | <p>"If possible, the LIMA should be used to bypass the LAD artery if indicated" (Class I, Level of Evidence B)</p> <p>"The RIMA is probably indicated to bypass the LAD artery when the LIMA is unavailable or unsuitable as a bypass conduit" (Class IIa, Level of Evidence C)</p> | <p>"The IMA should be used to bypass the LAD artery when bypass of the LAD is indicated" (Class I, Level of Evidence B)</p> | <p>"Arterial grafting with IMA to the LAD system is recommended" (Class I, Level of Evidence A)</p> |

- The use of LIMA on LAD territory is universally accepted
- The venous conduit is limited to emergency situations

Peculiar aspects of contemporary cabg

CONDUITS

Guideline Recommendations for Conduit Use During Coronary Artery Bypass Grafting

| | 2011 ACCF/AHA ¹⁷ | 2016 STS ²⁰ | 2014 ESC/EACTS ¹⁶ |
|-------------|---|---|---|
| BITA | “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” (Class IIa, Level of Evidence B) | “Use of BIMAs should be considered in patients who do not have an excessive risk of sternal complications” (Class IIa, Level of Evidence B) | “BIMA grafting should be considered in patients <70 yr of age” (Class IIa, Level of Evidence B) |

- Currently the use of BITA is still limited: 4% in USA, 10% in Europe
- The benefit of BITA is more noticeable in patients <70 years
- The use of BITA is associated to increased rate of sternal infections or dehiscence in obese, diabetic, COPD patients (not in skeletonized harvesting)

Randomized Trial of Bilateral versus Single Internal-Thoracic-Artery Grafts

David P. Taggart

BACKGROUND:

- Coronary artery bypass grafting (CABG) is highly effective for symptoms and prognosis in multi vessel and left main CAD (SYNTAX, CORONARY, PRECOMBAT, BEST, EXCEL, NOBLE 2013-2016)
- Over 1 million CABG performed worldwide each year; standard operation is CABGx3 (1 ITA + 2 veins)
- Strong angiographic evidence of **failure of vein grafts that accelerates after 5 years**
- Strong angiographic evidence that ITA grafts have long term patency rates (>90% at 20 years)

N Engl J Med 2016;375:2540-9.

Randomized Trial of Bilateral versus Single Internal-Thoracic-Artery Grafts

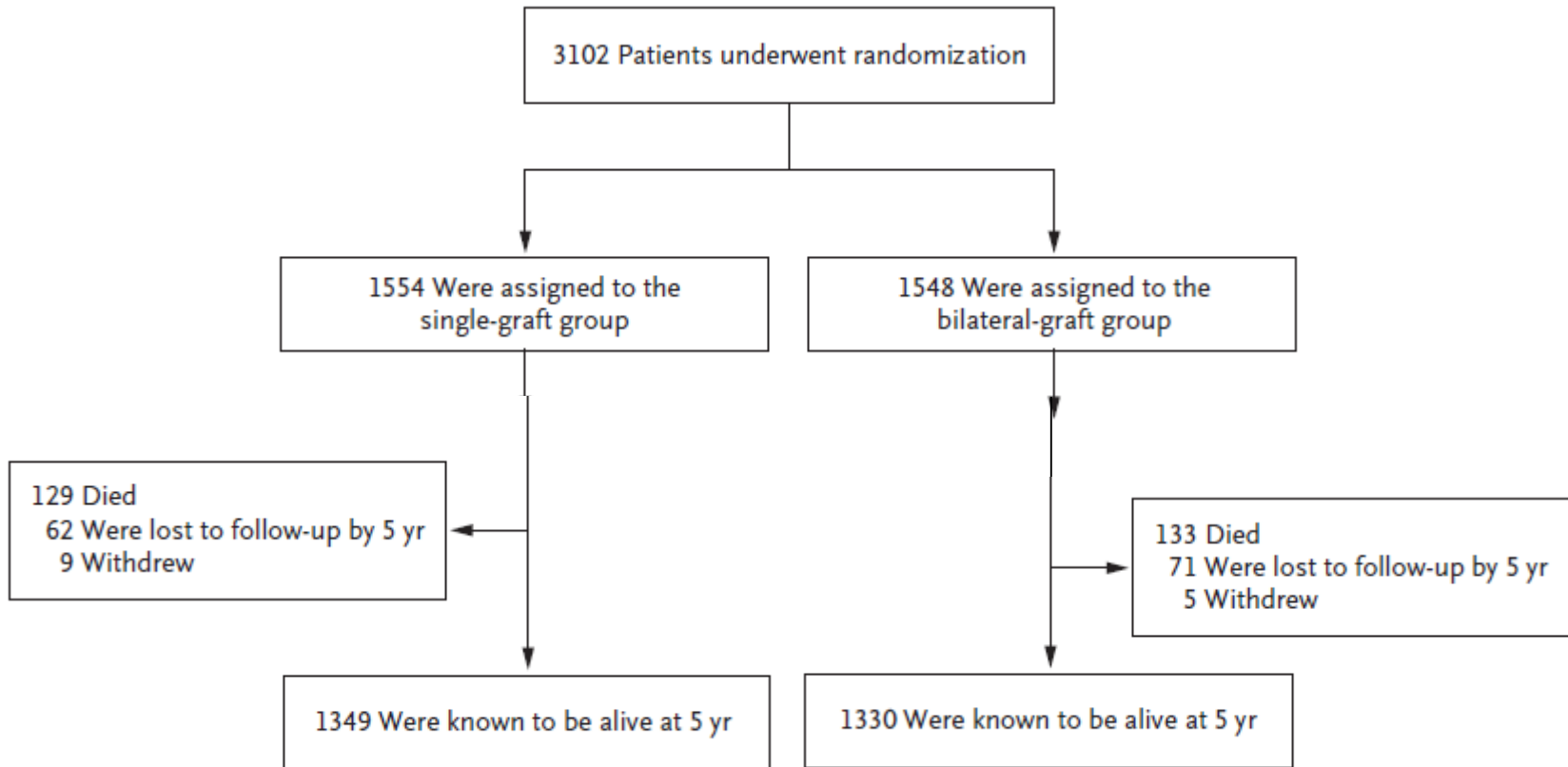
David P. Taggart

BACKGROUND:

- Left ITA is established standard of care for grafting the LAD
- Numerous **observational studies estimate a 20% reduction in mortality** with bilateral versus single ITA graft over long term
- Low use of bilateral ITA (< 10% Europe, < 5% USA) due to 3 concerns:
 - Increased technical complexity
 - Potential increased mortality & morbidity
 - Lack of evidence from CRT

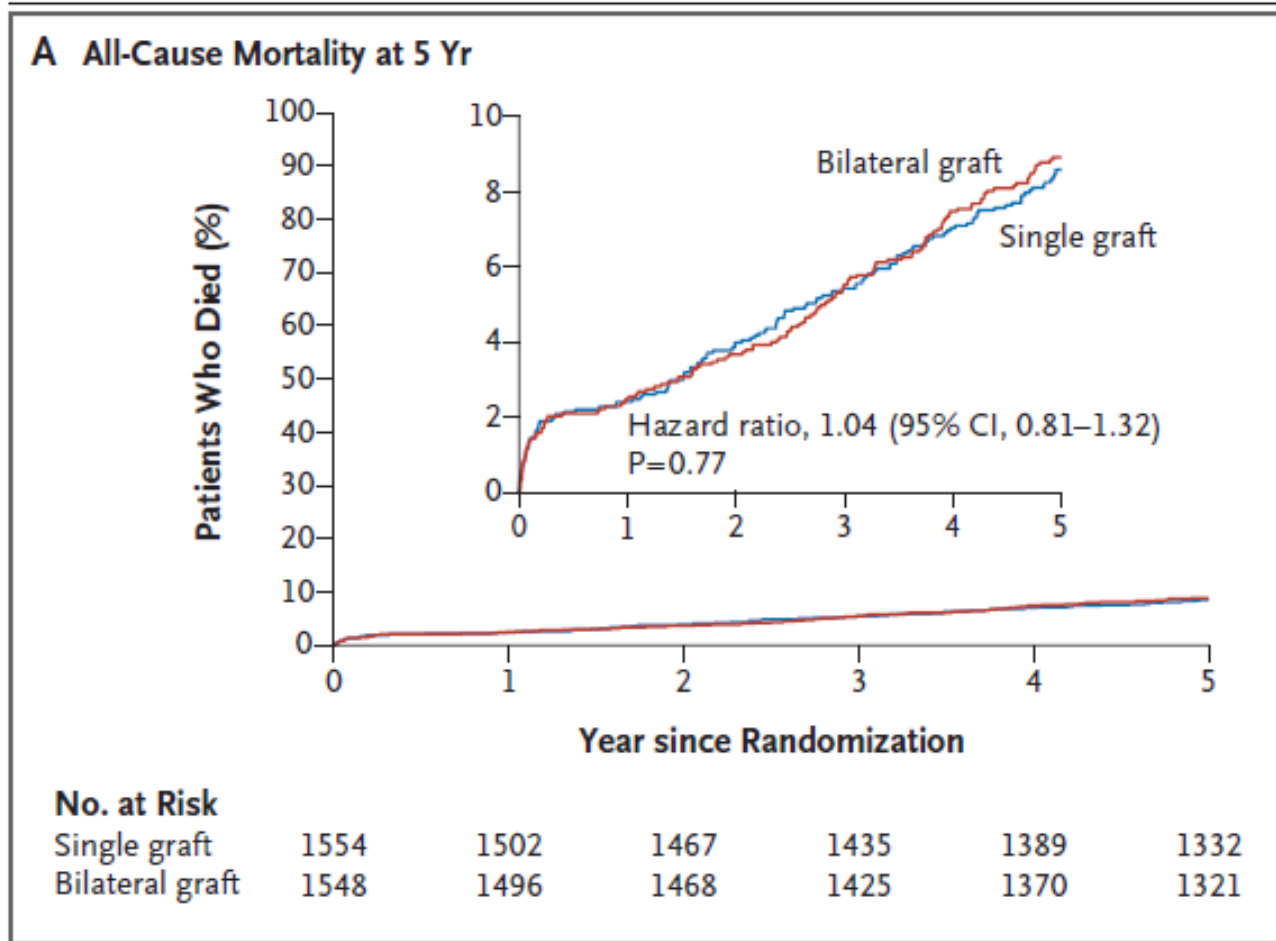
N Engl J Med 2016;375:2540-9.

ART TRIAL: 5 YEARS FOLLOW-UP



N Engl J Med 2016;375:2540-9.

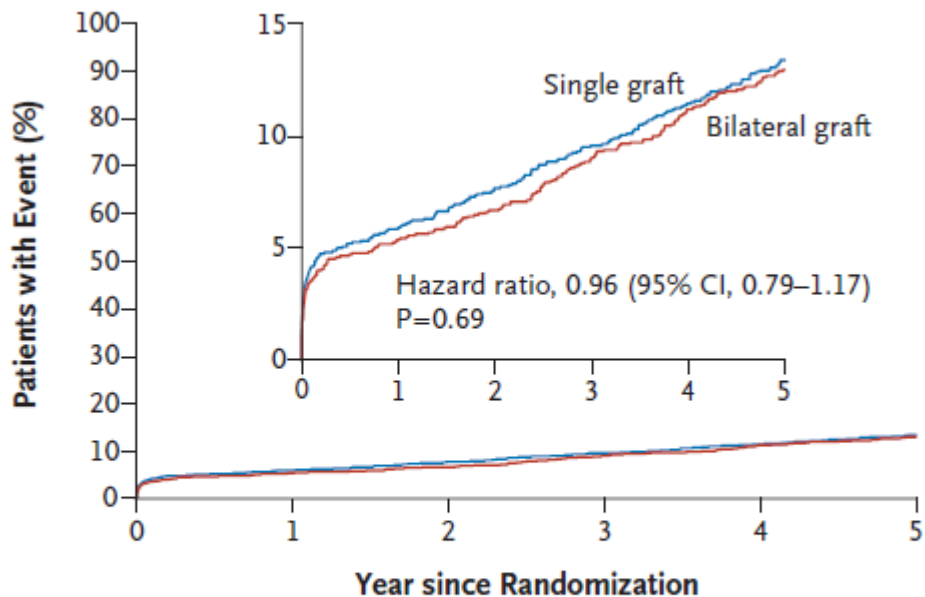
ART TRIAL: 5 YEARS FOLLOW-UP



N Engl J Med 2016;375:2540-9.

ART TRIAL: 5 YEARS FOLLOW-UP

B Composite of Death from Any Cause, Myocardial Infarction, or Stroke at 5 Yr



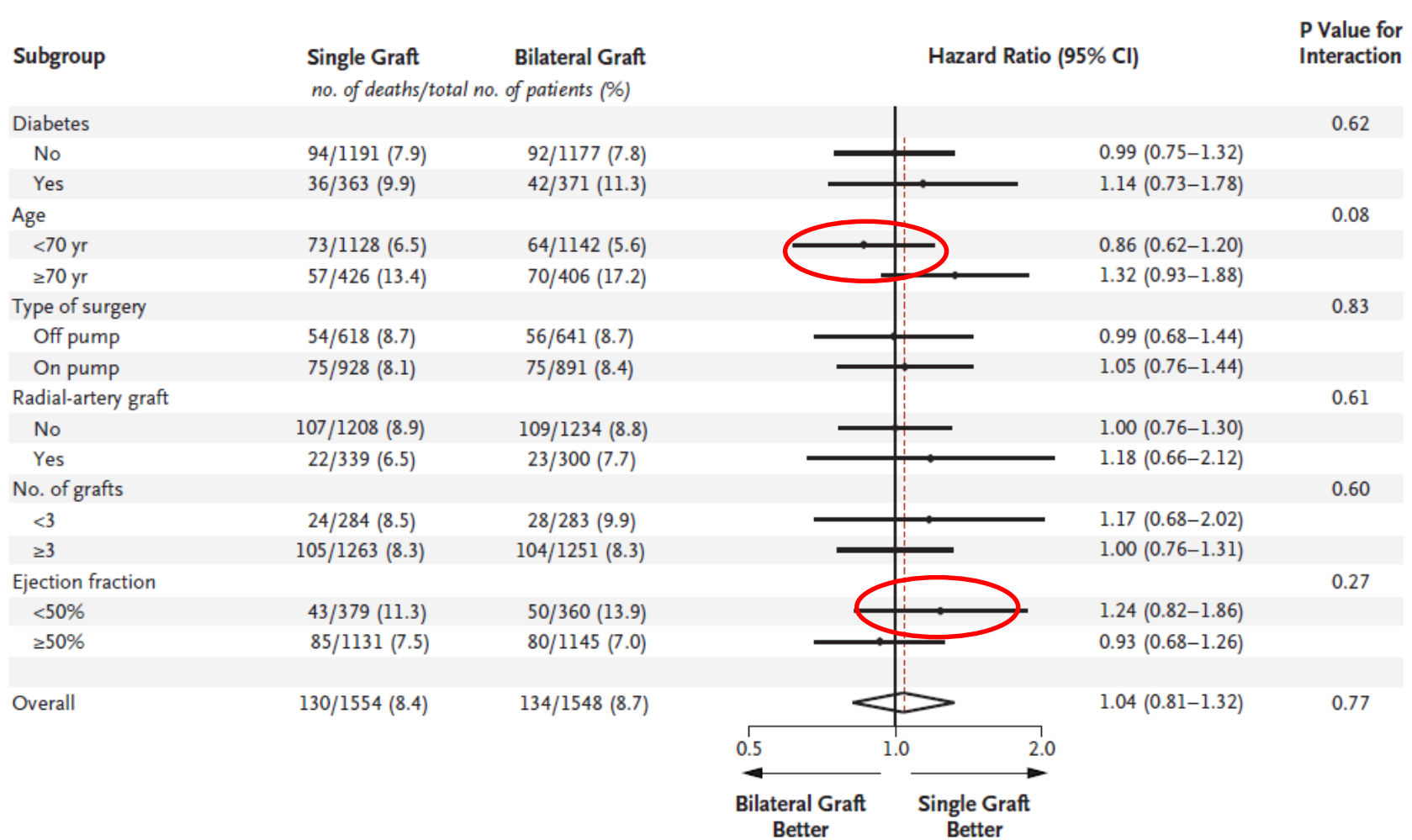
No. at Risk

| | | | | | | |
|-----------------|------|------|------|------|------|------|
| Single graft | 1554 | 1448 | 1410 | 1371 | 1322 | 1261 |
| Bilateral graft | 1548 | 1452 | 1422 | 1373 | 1317 | 1266 |

N Engl J Med 2016;375:2540-9.

ART TRIAL: 5 YEARS FOLLOW-UP

Subgroup Analysis of Death from Any Cause



N Engl J Med 2016;375:2540-9.

Randomized Trial of Bilateral versus Single Internal-Thoracic-Artery Grafts

David P. Taggart

POTENTIAL EXPLANATION FOR UNEXPECTED NEGATIVE RESULT:

- Too short time frame for intermediate analysis (the rate of vein failure at 5 years is not high enough)
- No necessary association with venous graft failure and clinical events
- Variation in surgical experience
- Higher rate (14%) of cross-over from BITA to SITA, use of radial artery as a second graft in SITA (20%)

EVIDENCE BASED PITFALLS OF BIMA GRAFTING:

- Increased risk of sternal wound complications
- More complex procedure with no advantage on mortality, MI, stroke, quality of life

NOT EVERYTHING IS LOST:

- Data at 10 years available in 2018
- New trial ongoing (ROMA trial)
- **The study confirms excellent results in both groups**

Peculiar aspects of contemporary cabg

CONDUITS

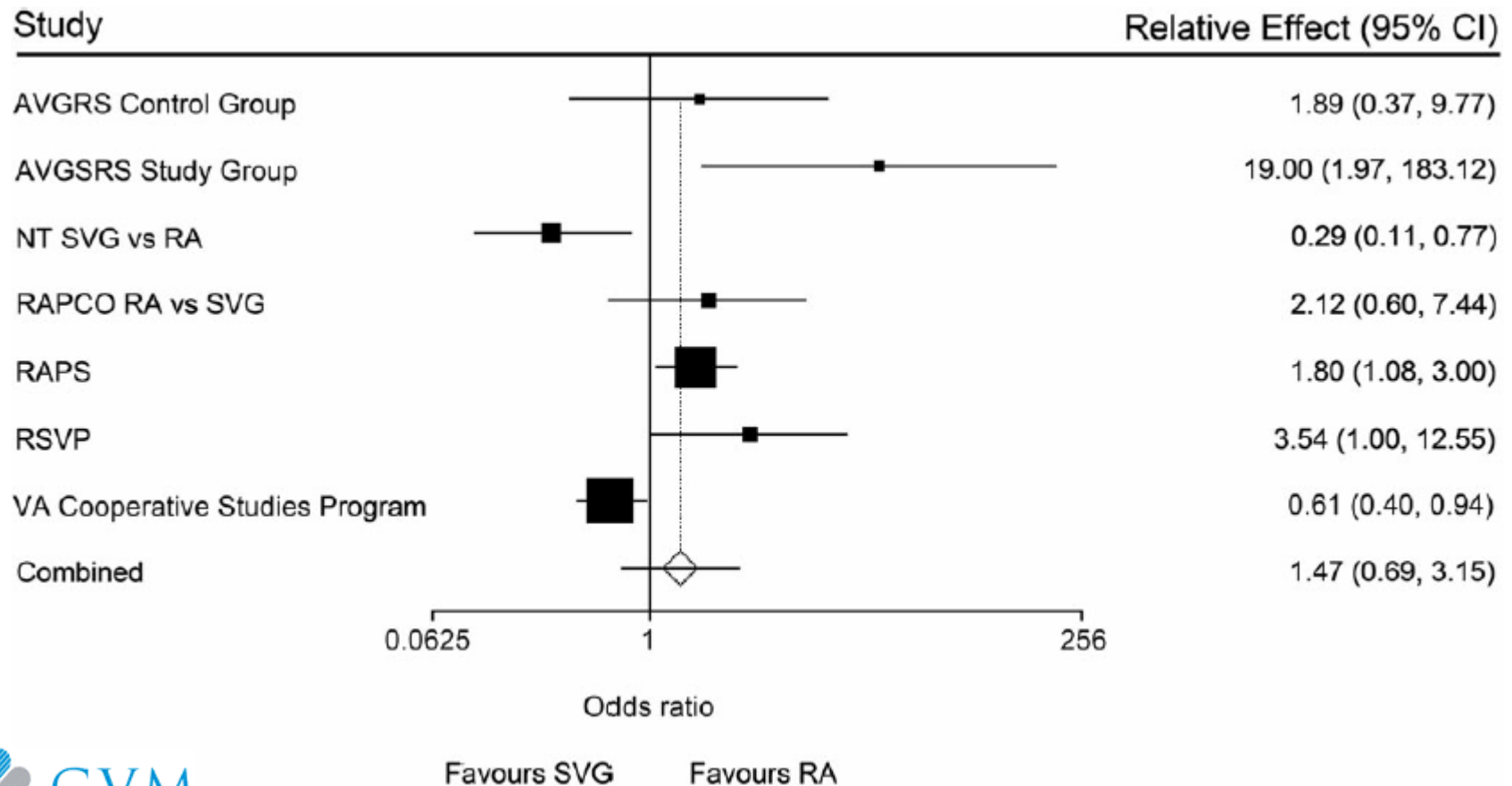
Guideline Recommendations for Conduit Use During Coronary Artery Bypass Grafting

| | 2011 ACCF/AHA ¹⁷ | 2016 STS ²⁰ | 2014 ESC/EACTS ¹⁶ |
|----------------------|---|---|---|
| Radial artery | "Use of a RA graft may be reasonable when grafting left-sided coronary arteries with severe stenosis (>70%) and right-sided arteries with critical stenosis (≥90%) that perfuse LV myocardium" (Class IIb, Level of Evidence B) | "As an adjunct to LIMA to LAD (or in patients with inadequate LIMA grafts), use of a RA graft is reasonable when grafting coronary targets with severe stenosis" (Class IIa, Level of Evidence B) | "Use of the RA is recommended only for target vessels with high-degree stenosis" (Class I, Level of Evidence B) |

- Is considered the best «second conduit» (after the mammaries) in programs of totally arterial revascularization
- Is the alternative to saphenous vein when necessary
- Must be used in > 90% stenosis

Searching for the second best graft for coronary artery bypass surgery: a network meta-analysis of randomized controlled trials[†]

Umberto Benedetto^{a,*}, Shahzad G. Raja^a, Alberto Albanese^a, Mohammed Amrani^a,
Giuseppe Biondi-Zoccai^b and Giacomo Frati^{b,c}



Saphenous Vein Graft Optimization

In current practice, almost 80% of all bypass conduits are saphenous veins

- ease of harvesting
- lesser technical challenge compared with multiple arterial grafting.

Pitfall:

- tendency for progressive failure during follow-up.

However, vein graft patency could be improved:

- no-touch technique during harvesting
- storage of vein grafts in a buffered solution
- use of an external stent which favours a lower oscillatory shear index that results in less turbulent flow.



Completeness of revascularization: is it still a dogma?

- **Definition:**

- 1 graft x district ? all graftable vessels ? all ischemic segments?

- **Procedural options:**

- Total arterial? Hybrid? Sequential venous?

- **Impact on survival:**

Positive: MASS II, BARI 2, Syntax 4yrs, etc...

No difference: MASS II 10yrs, Syntax 1 yr, ARTS II

Comparison of Stenting Versus Bypass Surgery According to the Completeness of Revascularization in Severe Coronary Artery Disease

Patient-Level Pooled Analysis of the SYNTAX, PRECOMBAT, and BEST Trials

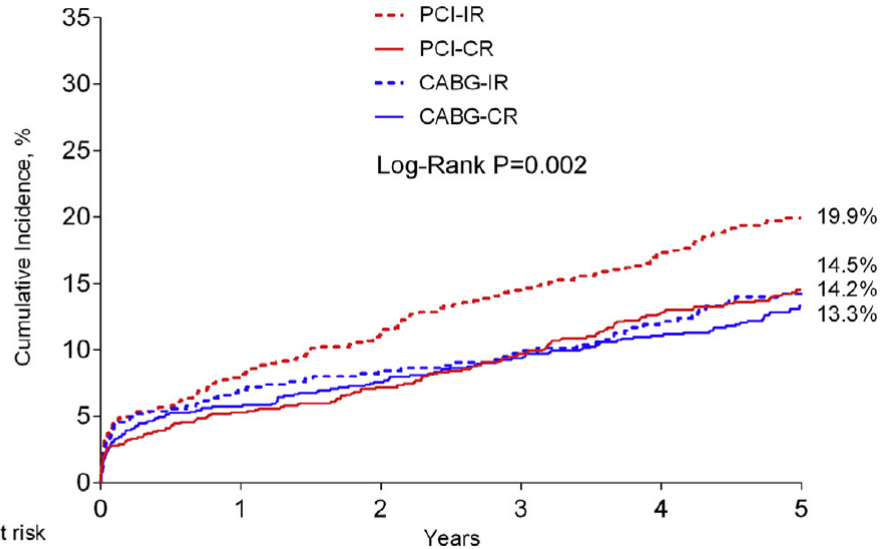
Jung-Min Ahn, MD

The aim of this study was to compare long-term survival between patients with severe coronary artery disease undergoing coronary artery bypass grafting (CABG) and those undergoing percutaneous coronary intervention (PCI) achieving complete revascularization (CR) or incomplete revascularization

JACC: CARDIOVASCULAR INTERVENTIONS
JULY 24, 2017: 1415–24

COMPLETENESS OF REVASCULARIZATION

B Death, Myocardial Infarction, or Stroke



| Patient at risk | 0 | 1 | 2 | 3 | 4 | 5 |
|-----------------|------|-----|-----|-----|-----|-----|
| PCI-IR | 724 | 665 | 619 | 564 | 509 | 260 |
| PCI-CR | 968 | 916 | 886 | 839 | 776 | 373 |
| CABG-IR | 505 | 458 | 443 | 418 | 394 | 210 |
| CABG-CR | 1015 | 939 | 891 | 834 | 765 | 350 |

JACC: CARDIOVASCULAR INTERVENTIONS
 JULY 24, 2017: 1415-24

Comparison of Stenting Versus Bypass Surgery According to the Completeness of Revascularization in Severe Coronary Artery Disease

The clinical benefit of CR was less prominent in patients undergoing CABG, as long as the left anterior descending coronary artery was successfully grafted, particularly by **using the internal mammary artery**

With respect to the risk for MI and any repeat revascularization, the PCI group showed a higher risk for events than the CABG group, regardless of achieving CR or IR, which is a well-known limitation of PCI and is considered a trade-off for its lesser invasiveness.

JACC: CARDIOVASCULAR INTERVENTIONS
JULY 24, 2017: 1415–24

Arterial grafts balance survival between incomplete and complete revascularization: A series of 1000 consecutive coronary artery bypass graft patients with 98% arterial grafts

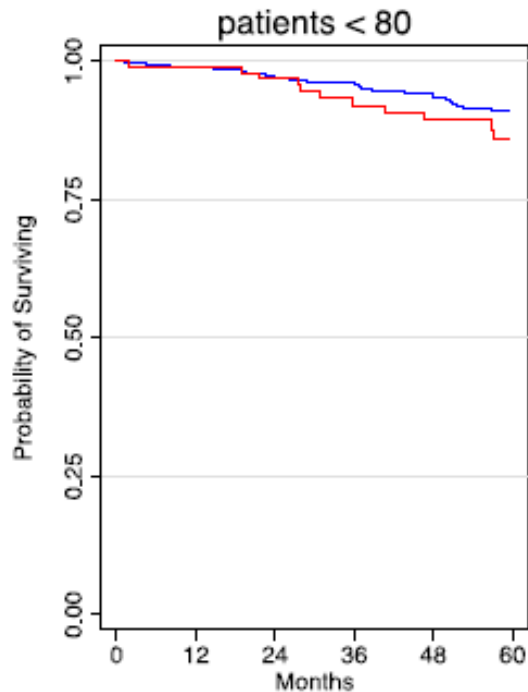
Teresa M. Kieser, MD,^a Helen J. Curran, MD,^b M. Sarah Rose, PhD,^a Colleen M. Norris, PhD,^c and Michelle M. Graham, MD^c

Coronary artery bypass grafting (CABG) with incomplete revascularization (ICR) is thought to decrease survival. We studied the survival of patients with ICR undergoing total arterial grafting.

In a consecutive series of all-comer 1000 patients with isolated CABG, operative and midterm survival were assessed for patients undergoing complete versus ICR, with odds ratios and hazard ratios, adjusted for EUROSCORE, CABG urgency, age, and comorbidities

J Thorac Cardiovasc Surg 2014;147:75-4

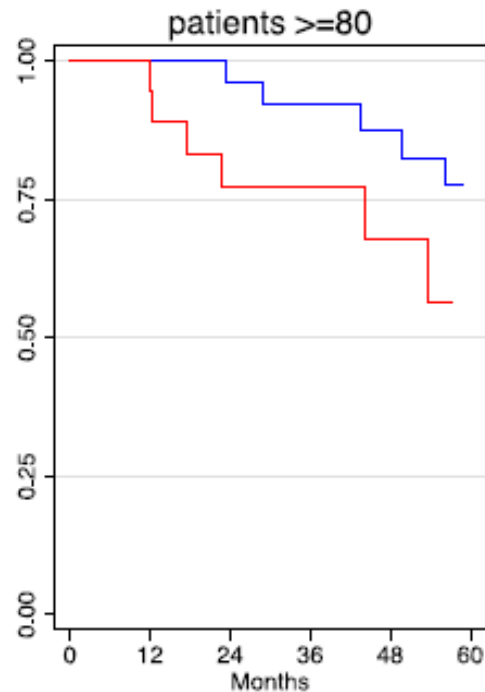
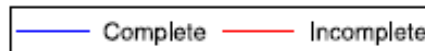
Unadjusted Kaplan-Meier survival curves stratified by age <80 years (n 788) and age ≥80 years (n 53).



Number at risk

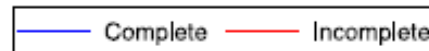
| | | | | | | |
|------------|-----|-----|-----|-----|-----|-----|
| Complete | 688 | 630 | 547 | 468 | 395 | 319 |
| Incomplete | 100 | 94 | 86 | 74 | 64 | 47 |

B



Number at risk

| | | | | | | |
|------------|----|----|----|----|----|----|
| Complete | 35 | 32 | 26 | 21 | 18 | 14 |
| Incomplete | 18 | 18 | 13 | 11 | 7 | 4 |



J Thorac Cardiovasc Surg 2014;147:75-4

Arterial grafts balance survival between incomplete and complete revascularization: A series of 1000 consecutive coronary artery bypass graft patients with 98% arterial grafts

Teresa M. Kieser, MD,^a Helen J. Curran, MD,^b M. Sarah Rose, PhD,^a Colleen M. Norris, PhD,^c and Michelle M. Graham, MD^c

Contrary to current beliefs regarding completeness of revascularization, we have demonstrated that ICR in this unique series of all-comer CABG with 98% arterial grafts is not associated with decreased survival perioperatively and at midterm in patients younger than age 80 years. However many factors affect survival and may act synergistically or independently. **Use of arterial grafts minimizes the adverse effects of not grafting the third region.**

J Thorac Cardiovasc Surg 2014;147:75-4

Long-term Outcomes of Multiple Arterial Coronary Artery Bypass Grafting

A Population-Based Study of Patients in British Columbia, Canada

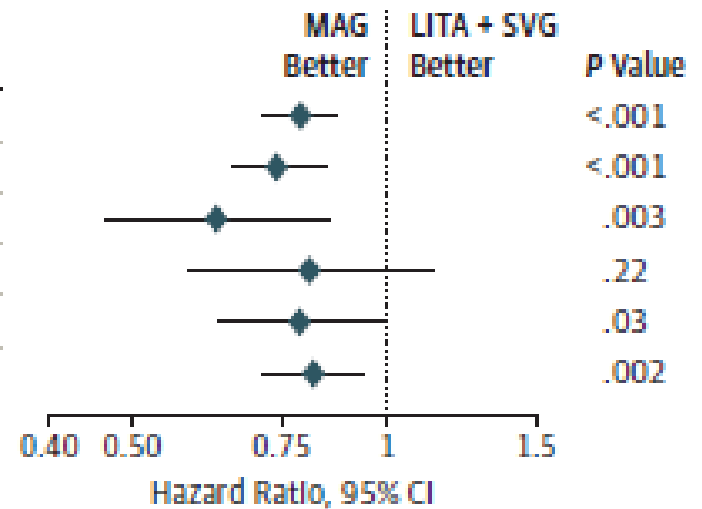
Aihua Pu, MSc; Lillian Ding, MSc; Jungwon Shin, MSc; Joel Price, MD, MPH; Peter Skarsgard, MD; Daniel R. Wong, MD, MPH; John Bozinovski, MD, MSc; Guy Fradet, MD, MSc; James G. Abel, MD, MSc

Although the long-term survival advantage of multiple arterial grafting (MAG) has been demonstrated, its safety and other long-term clinical benefits in a large, population-based cohort are unknown.

In this population-based observational study, we included **20 076 adult patients** with triple-vessel or left-main disease who underwent primary isolated coronary artery bypass grafting (**MAG, n = 5580; LITA+SVG, n = 14 496**) in the province of British Columbia, Canada, from January 2000 to December 2014

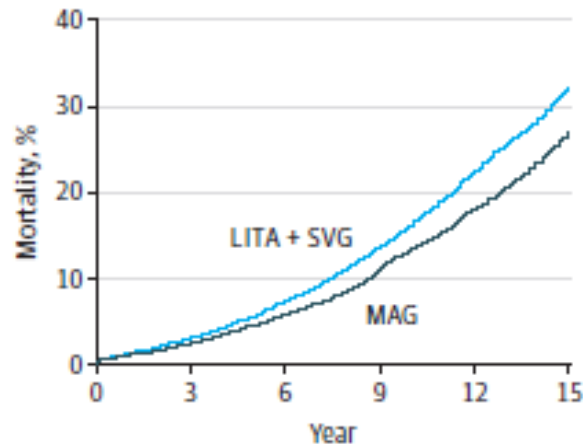
Cumulative Incidences of Long-term Outcomes for MAG vs ITA+SVG

| Long-term Outcome | Cumulative Incidence, (%) | | Hazard Ratio (95% CI) |
|----------------------------|---------------------------|------|-----------------------|
| | LITA + SVG | MAG | |
| Mortality | 32.1 | 27.0 | 0.79 (0.72-0.87) |
| Repeated revascularization | 19.6 | 14.7 | 0.74 (0.66-0.84) |
| Myocardial infarction | 5.9 | 4.2 | 0.63 (0.47-0.85) |
| Stroke | 3.2 | 3.0 | 0.82 (0.59-1.13) |
| Heart failure | 7.8 | 6.0 | 0.79 (0.64-0.98) |
| Composite end point | 23.6 | 20.0 | 0.82 (0.72-0.93) |



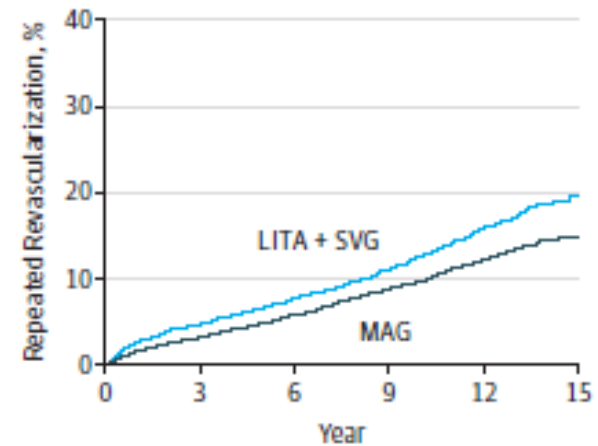
Cumulative Incidences of Long-term Outcomes for MAG vs ITA+SVG

B Mortality rates



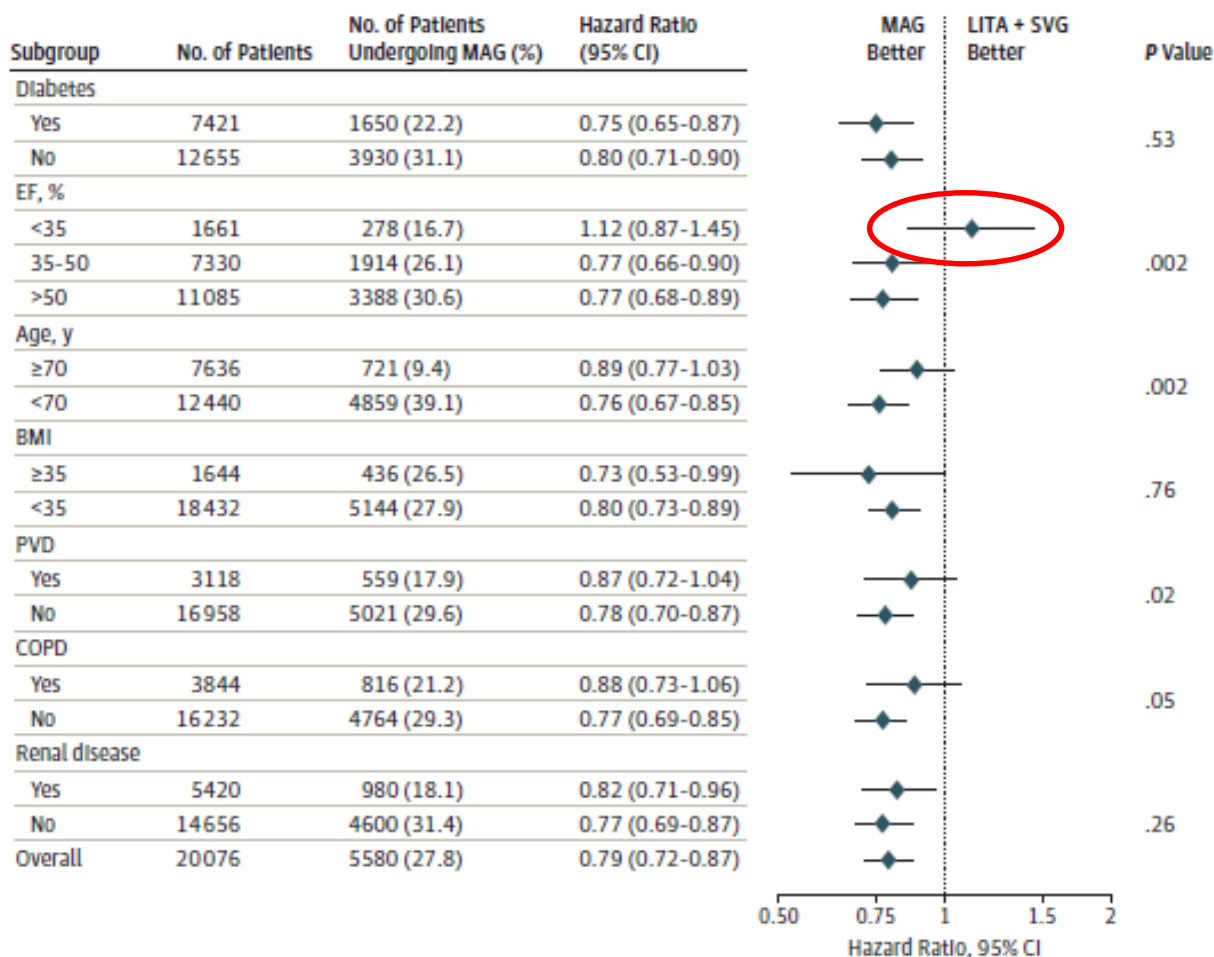
| No. at risk | | | | | | |
|-------------|------|------|------|------|------|-----|
| LITA + SVG | 5351 | 4495 | 3460 | 2341 | 1223 | 217 |
| MAG | 5580 | 4695 | 3635 | 2494 | 1360 | 250 |

C Repeated revascularization



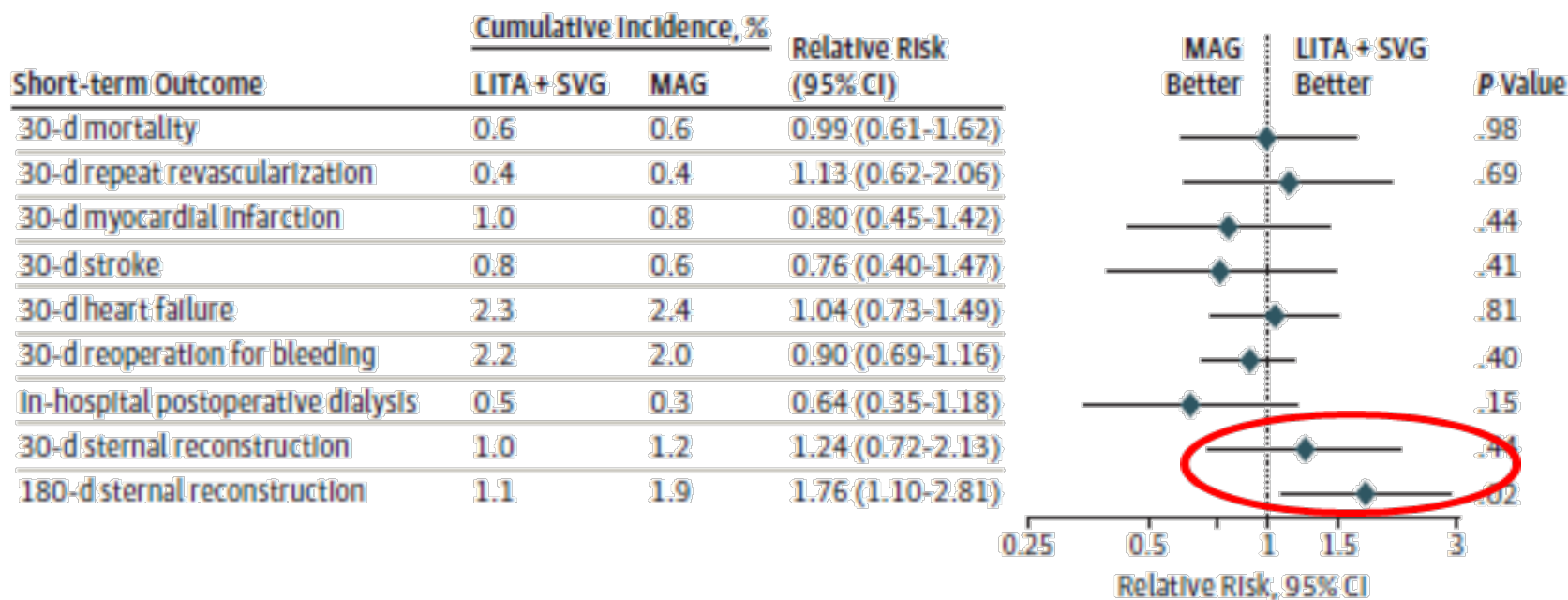
| No. at risk | | | | | | |
|-------------|------|------|------|------|------|-----|
| LITA + SVG | 5351 | 4274 | 3191 | 2073 | 1012 | 170 |
| MAG | 5580 | 4531 | 3419 | 2276 | 1177 | 208 |

Adjusted Hazard Ratios of Long-term Mortality for MAG vs LITA+SVG in Subgroups



JAMA Cardiol. doi:10.1001/jamacardio.2017.3705
Published online October 11, 2017.

Adjusted Relative Risks and Cumulative Incidences of Short-term Outcomes for MAG vs LITA+SVG



JAMA Cardiol. doi:10.1001/jamacardio.2017.3705
Published online October 11, 2017.

Arterial grafts balance survival between incomplete and complete revascularization: A series of 1000 consecutive coronary artery bypass graft patients with 98% arterial grafts

In this population-based study of 20 076 consecutive patients with triple-vessel or left-main disease, **multiple arterial grafting was associated with significant reductions in long-term mortality and repeated revascularization without increased perioperative risks.** Similar reductions in either mortality or repeated revascularization rates were observed among all subgroups of patients except for those with severely impaired ejection fraction.

Multiple arterial grafting can be safely extended to a broader spectrum of patients to maximize the long-term benefit of coronary artery bypass grafting among patients with multivessel disease.

JAMA Cardiol. doi:10.1001/jamacardio.2017.3705

Published online October 11, 2017.

Hybrid coronary revascularization versus coronary artery bypass surgery with bilateral or single internal mammary artery grafts

Joshua M. Rosenblum, MD, PhD,^a Ralf E. Harskamp, MD,^b Niels Hoedemaker, MD,^c Patrick Walker, MD,^a Henry A. Liberman, MD,^a Robert J. de Winter, MD, PhD,^c Thomas A. Vassiliades, MD,^d John D. Puskas, MD,^e and Michael E. Halkos, MD^a

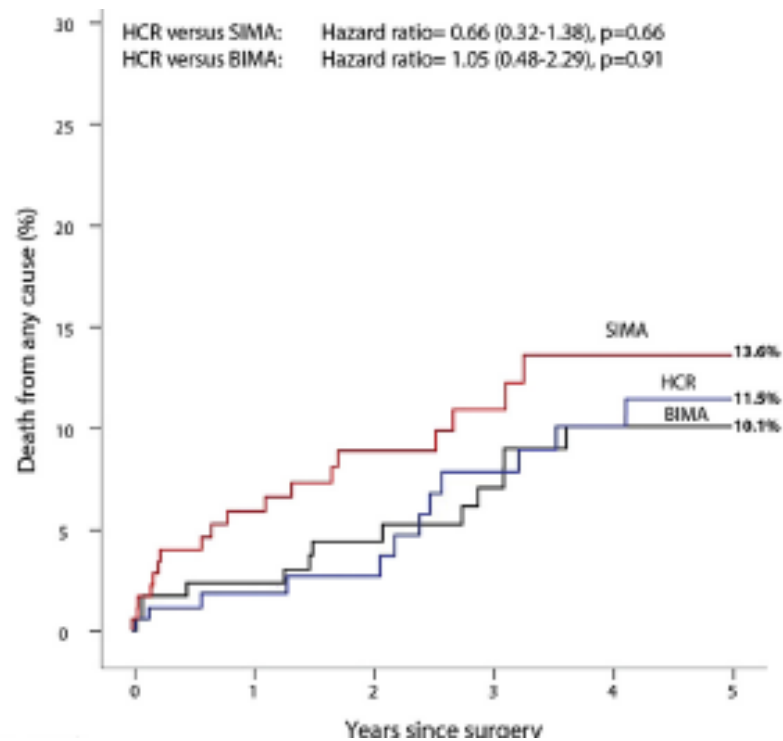
The purpose of this study was **to compare outcomes of HCR to conventional coronary artery bypass graft (CABG) surgery** with single internal mammary artery (SIMA) or bilateral internal mammary artery (BIMA) grafting.

Between October 2003 and September 2013, **306** consecutive patients who underwent HCR were compared with **8254** patients who underwent CABG with SIMA (7381; 89.4%) or BIMA (873; 10.6%)

In HCR a **minithoracotomic approach** was used

J Thorac Cardiovasc Surg 2016;151:1081-9

KAPLAN-MEIER CURVE FOR ALL-CAUSE MORTALITY



J Thorac Cardiovasc Surg 2016;151:1081-9

Hybrid coronary revascularization versus coronary artery bypass surgery with bilateral or single internal mammary artery grafts

Hybrid coronary revascularization is safe and durable compared with surgical revascularization with single or bilateral mammary grafts.

Perspective

In patients with multivessel CAD and favorable coronary anatomy, HCR may be an acceptable alternative to traditional CABG surgery.

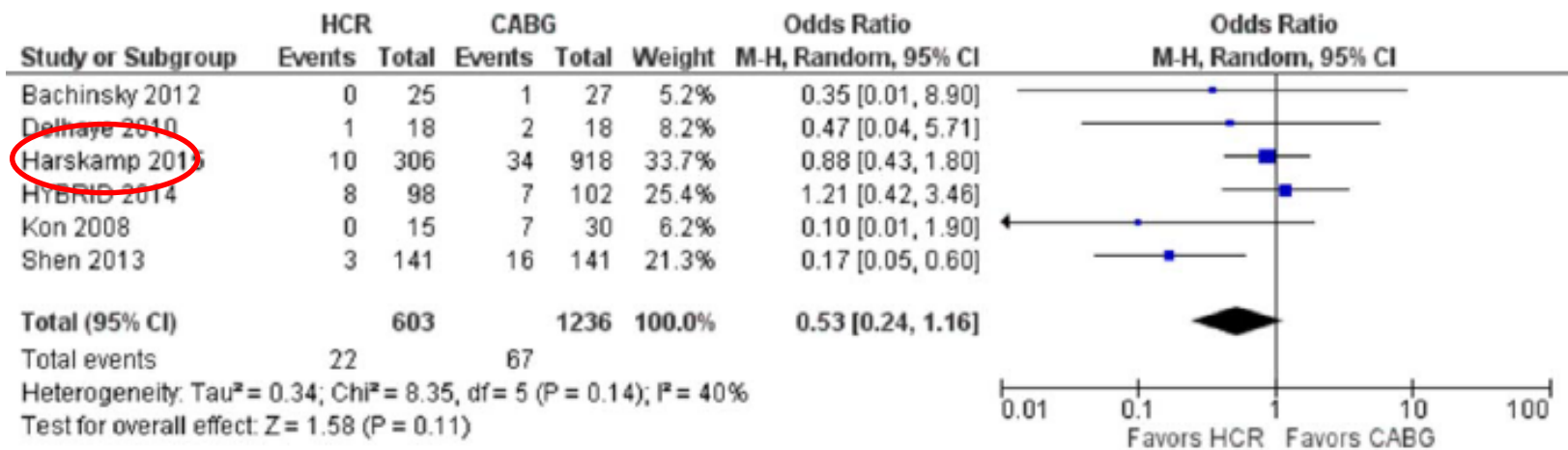
We show that short-term and mid-term outcomes are equivalent between the approaches in the appropriate patient populations

J Thorac Cardiovasc Surg 2016;151:1081-9

Hybrid Coronary Revascularization Versus Coronary Artery Bypass Grafting in Patients With Multivessel Coronary Artery Disease: A Meta-Analysis

Partha Sardar,^{1*} MD, Amartya Kundu,² MD, Michelle Bischoff,³ MD,

A: Major adverse cardiovascular events (a composite of all cause mortality, myocardial infarction and stroke) with HCR versus CABG



Catheterization and Cardiovascular Interventions 00:00–00 (2017)

Hybrid Coronary Revascularization Versus Coronary Artery Bypass Grafting in Patients With Multivessel Coronary Artery Disease: A Meta-Analysis

Our study demonstrates that HCR could be **a safe, feasible, and effective management strategy in select patients with MVCAD**. Compared to conventional CABG, HCR was associated with similar risk of MACCE, MI, stroke, repeat revascularizations, a lower need for blood transfusions, as well as a shorter hospitalization and intensive care unit stay. This warrants further validation in multi-centric, adequately powered randomized studies to definitively assess the absolute benefits and risks of HCR.

Catheterization and Cardiovascular Interventions 00:00–00 (2017)



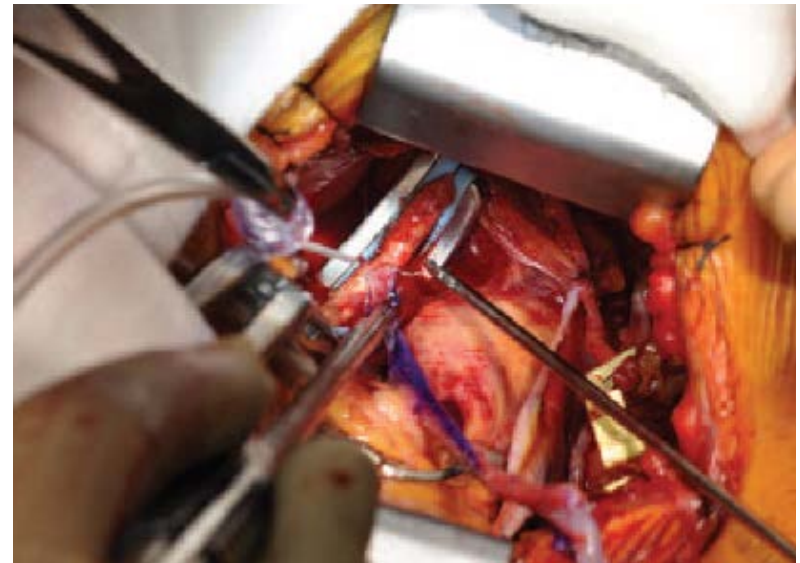
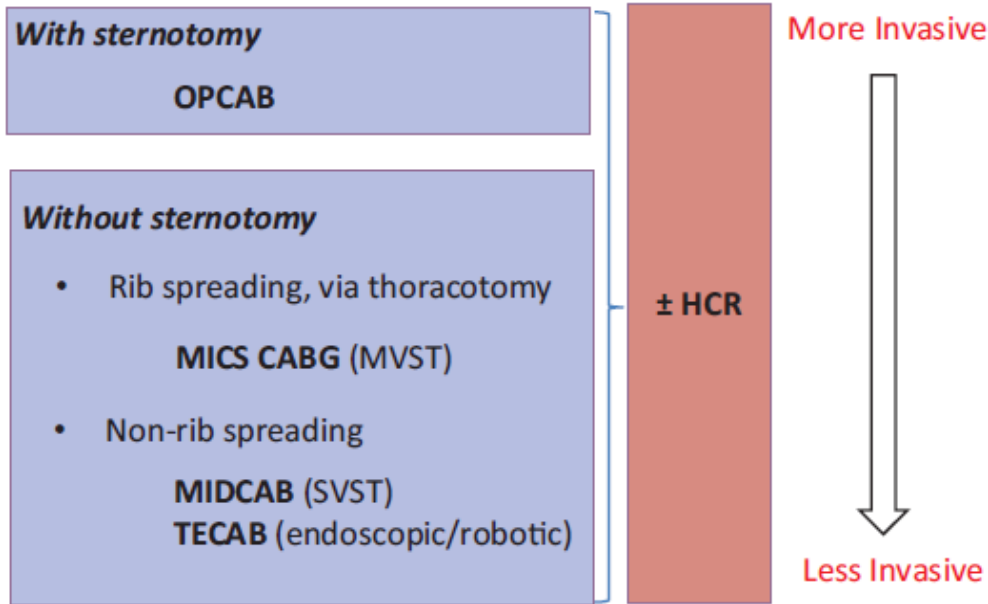
Less-invasive coronary artery bypass grafting international landscape and progress

Keita Kikuchi^a and Makoto Mori^b

| Indications | Contraindications |
|--|--|
| High risk for DSWI | Small and severe diffuse TVD |
| Patient desire for early recovery to normal activity | Emergent cases (AMI, hemodynamic instability) |
| Elderly patients | Severe chest wall deformity |
| Younger patients (with BITA) | Ischemic cardiomyopathy (poor EF, dilated heart) |
| Hybrid coronary revascularization | Severe COPD |
| Cosmetic | |

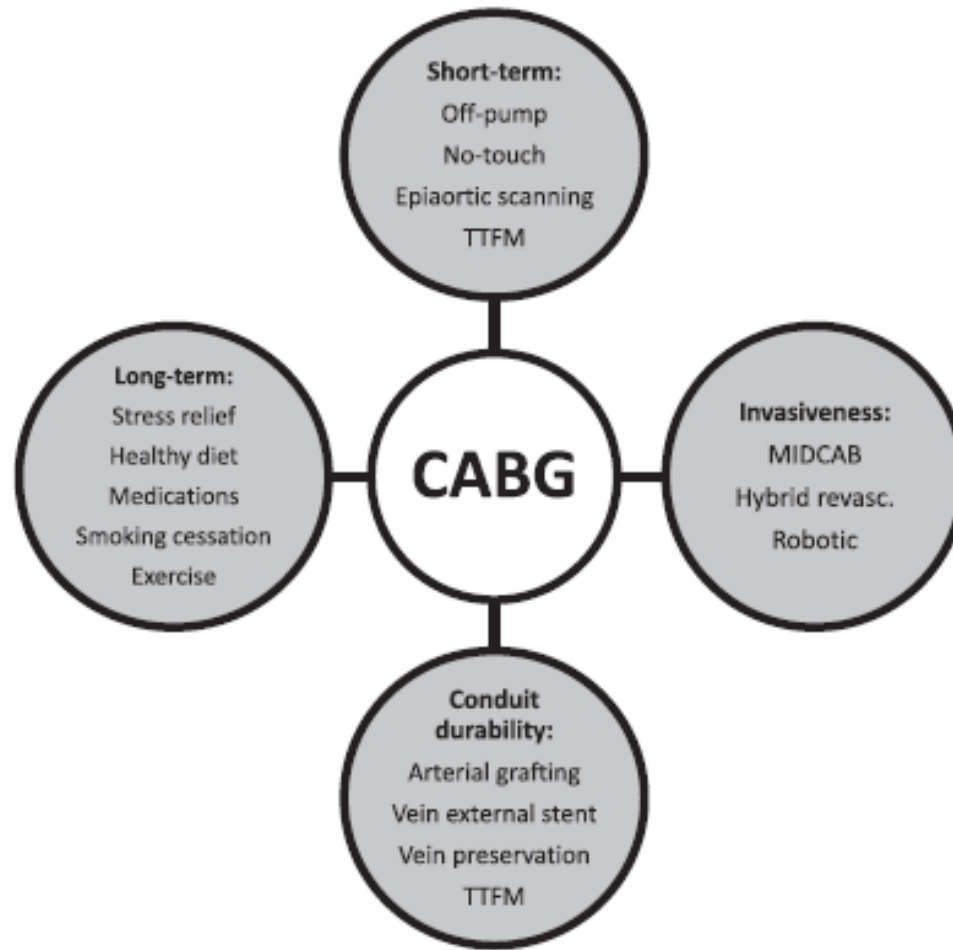
Curr Opin Cardiol 2017, 32:715–721

Classification of less-invasive coronary artery bypass grafting



Curr Opin Cardiol 2017, 32:715–721

Developments for state-of-the-art coronary artery bypass graft (CABG) according to procedural parameters



Current Practice of State-of-the-Art

Surgical Coronary Revascularization

Stuart J. Head, Milan Milojevic, David P.
Taggart, John D. Puskas

With the most recent randomized trials and large observational studies of PCI with drug-eluting stents versus CABG in multivessel disease showing improved outcomes with CABG, **surgeons will be reassured and confident that CABG is effective and offers increased longevity.**

Before HCR becomes a standard procedure at centers around the world, surgeons will have to commit to MIDCAB procedures

Circulation. October 3 2017;136:1331–1345

TAKE HOME MESSAGE

We can modify the natural history of coronary artery disease through surgical revascularization

- A stent doesn't just open a coronary artery. It changes the biology of that artery forever even if that vessel gets open
- We must move past the antiquated notion that bypass conduits are mere bridges that transfer blood from one place to another. Venous and arterial grafts have fundamentally different biological behaviours
- Arterial grafts are complex living metabolic units that prevent progression of CD while maintaining normal coronary endothelium and wall function.