Amjad Bani Hani

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CABG

INTRODUCTION

- HISTORY OF CARDIAC SURGERY
- CORONARY ARTERY ANATOMY
- MANAGEMENT
- SURGICAL TECHNIQUES

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Adult Cardiac Surgery: Ischemic Heart Disease

- **Alexis Carrel**-

"In certain cases of angina pectoris, when the mouth of the coronary is calcified, it would be useful to establish a complementary circulation for the lower part of the arteries. I attempted to perform an…anastomosis between the descending aorta and the left coronary. It was, for many reasons, a difficult operation."

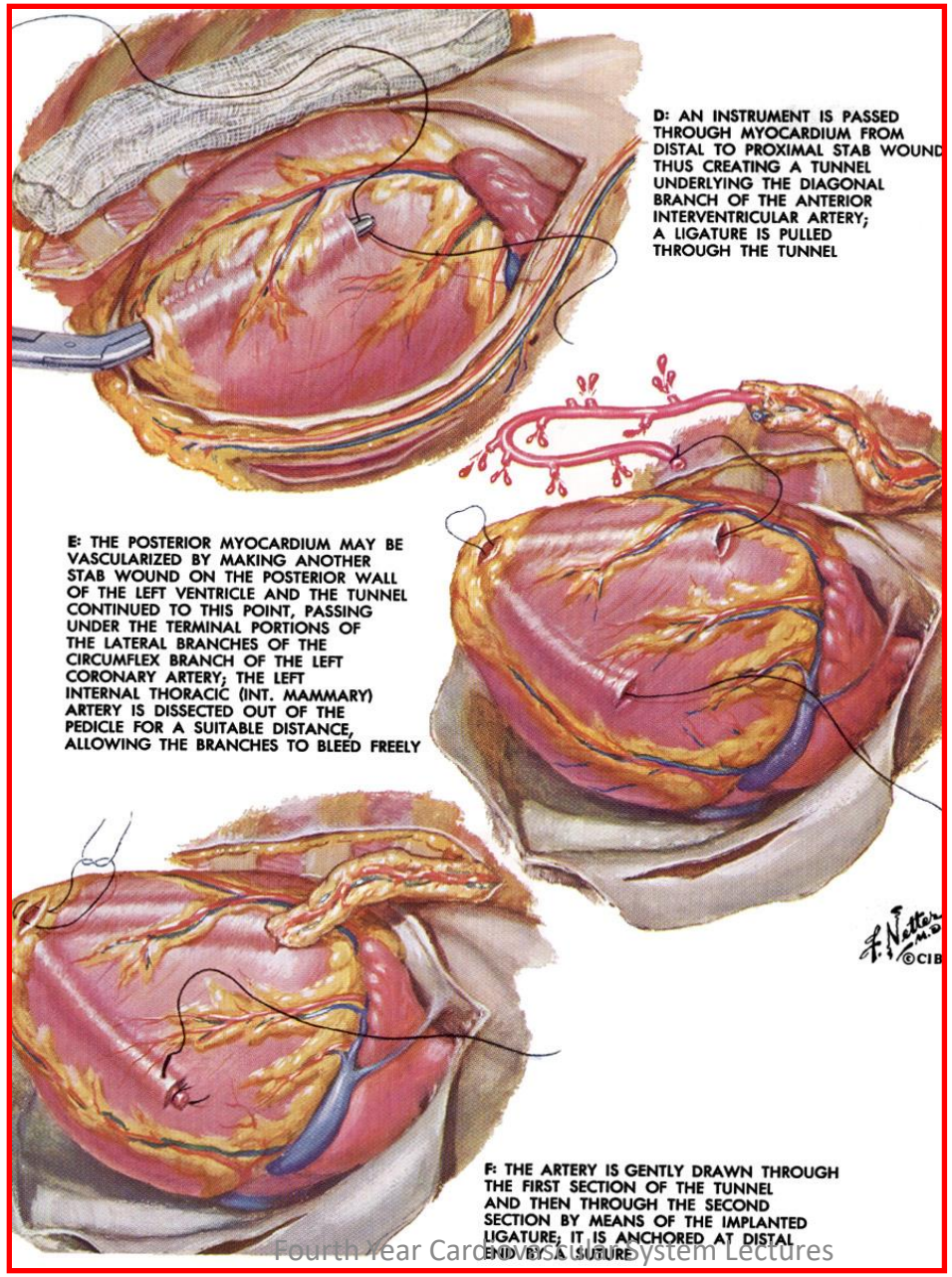
American Surgical Association, 1910

Adult Cardiac Surgery: Ischemic Heart Disease (History)

- **Claude Beck**
  - **1930's-** sought to increase myocardial blood flow indirectly with pericardial fat and omentum.
- **Arthur Vineberg**
  - **1940's-** Mobilization of left internal mammary artery with implantation of bleeding end into the left ventricle.
  - **1964-** follow-up study on 140 patients

    33% mortality

    85% relief from angina


D: AN INSTRUMENT IS PASSED THROUGH MYOCARDIUM FROM DISTAL TO PROXIMAL STAB WOUND THUS CREATING A TUNNEL UNDERLYING THE DIAGONAL BRANCH OF THE ANTERIOR INTERVENTRICULAR ARTERY; A LIGATURE IS PULLED THROUGH THE TUNNEL
E: THE POSTERIOR MYOCARDIUM MAY BE VASCULARIZED BY MAKING ANOTHER STAB WOUND ON THE POSTERIOR WALL OF THE LEFT VENTRICLE AND THE TUNNEL CONTINUED TO THIS POINT, PASSING UNDER THE TERMINAL PORTIONS OF THE LATERAL BRANCHES OF THE CIRCUMFLEX BRANCH OF THE LEFT CORONARY ARTERY; THE LEFT INTERNAL THORACIC (INT. MAMMARY) ARTERY IS DISSECTED OUT OF THE PEDICLE FOR A SUITABLE DISTANCE, ALLOWING THE BRANCHES TO BLEED FREELY
F. Netter M.D.
©CIB
F: THE ARTERY IS GENTLY DRAWN THROUGH THE FIRST SECTION OF THE TUNNEL AND THEN THROUGH THE SECOND SECTION BY MEANS OF THE IMPLANTED LIGATURE; IT IS ANCHORED AT DISTAL END BY A SUTURE

Adult Cardiac Surgery: Ischemic Heart Disease (History)

- **Mason Sones,**

  1950's- cine coronary arteriography.

  1962- direct and reproducible catheterization of the coronary arteries.

  "Collectively, all of the cardiological advances in this century pale in comparison with this priceless achievement."

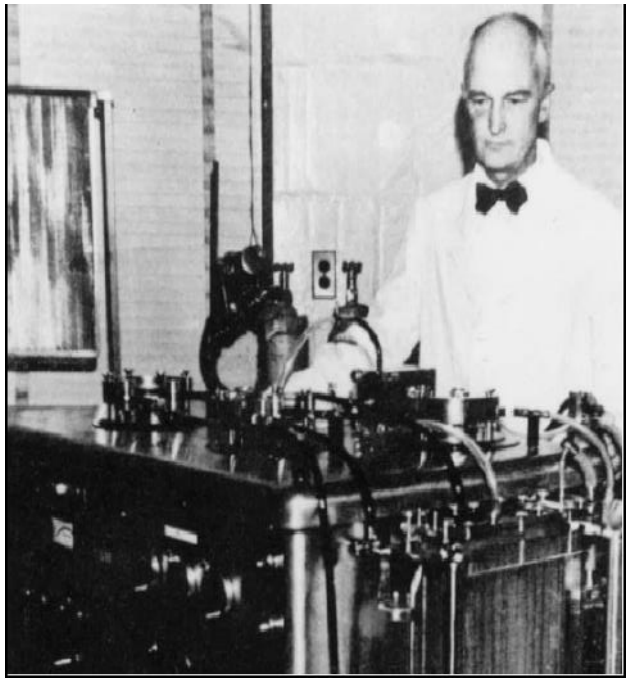
  Floyd Loop, MD

Adult Cardiac Surgery: Ischemic Heart Disease (History)

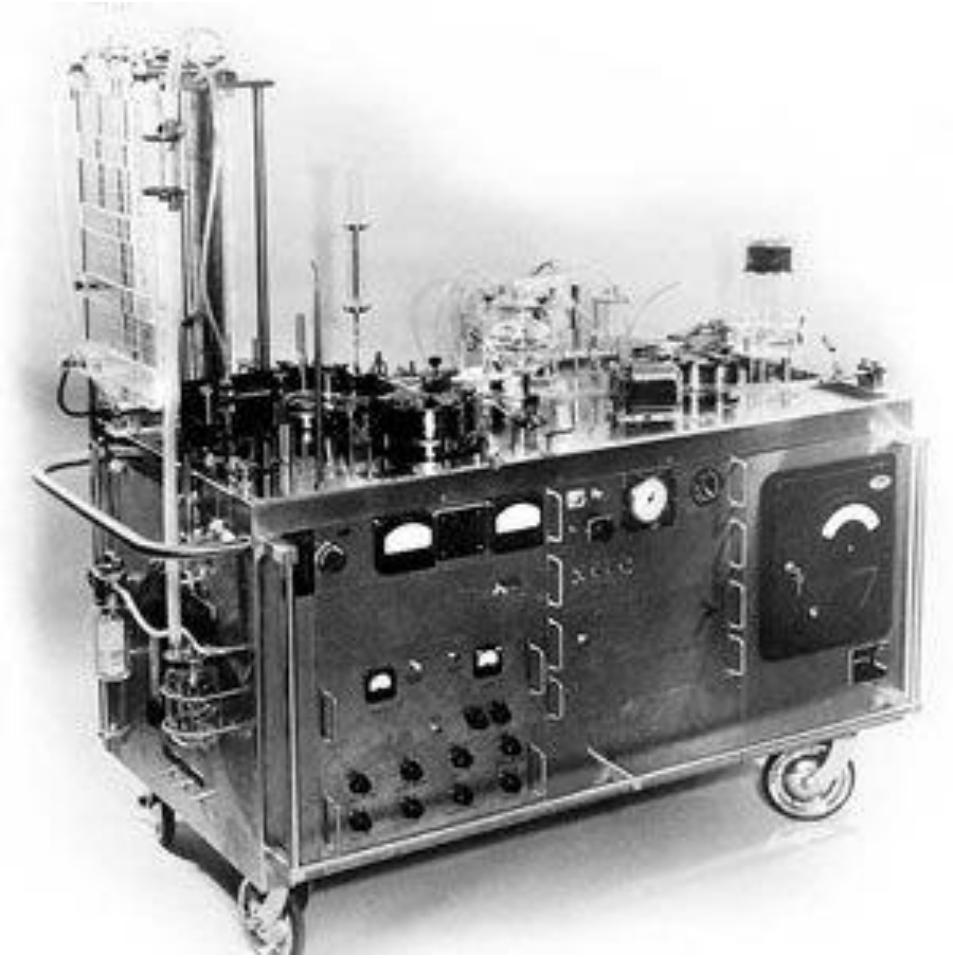
John H. Gibbon, Jr.

"During the long night, helplessly watching the patient struggle for life as her blood became darker and her veins more distended, the idea naturally occurred to me that if it were possible to remove some of the blue blood…put oxygen into that blood and allow carbon dioxide to escape from it, and then to inject continuously the now-red blood back into the patient's arteries, we might have saved her life."

- Heart-lung machine
- May 6, 1953- ASD closure



Heart Lung Machine



Adult Cardiac Surgery: Ischemic Heart Disease (History)

- 1962- **David C. Sabiston, Jr.-**
  - Aortocoronary saphenous vein bypass
- 1964-**KOLOSOV** LIMA -LAD IN Russia

Adult Cardiac Surgery: Ischemic Heart Disease (CABG)

- Early and widespread acceptance of coronary bypass was delayed.

- Best known cooperative studies (1970-80's) were the;

  VA

  Coronary **A**rtery **S**urgery **S**tudy

  European Coronary Surgery Study

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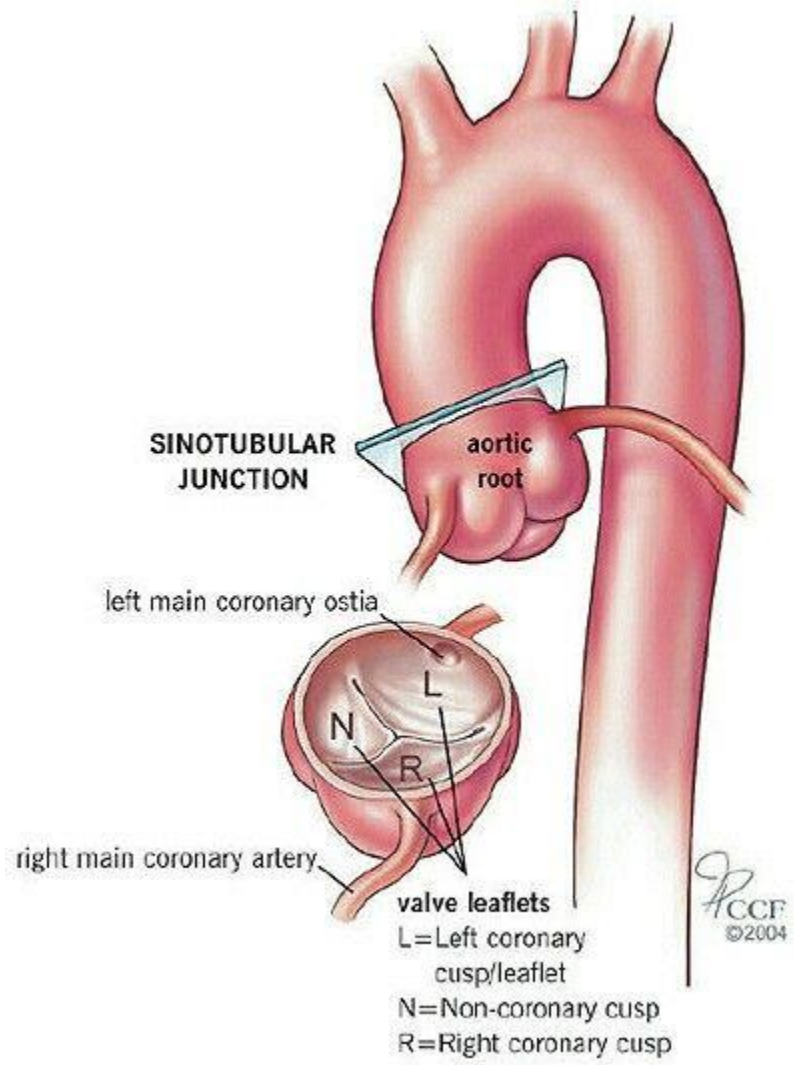
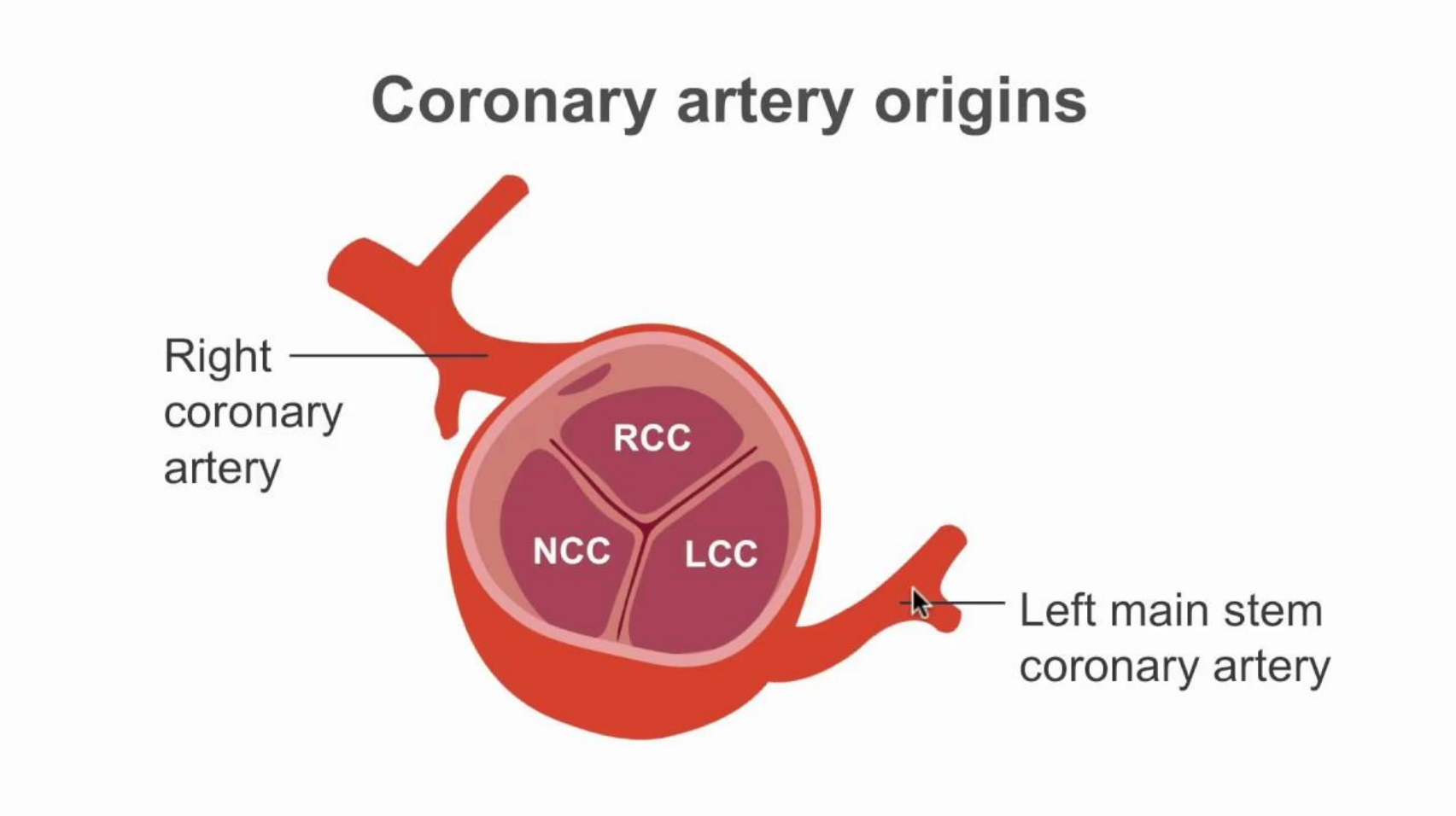
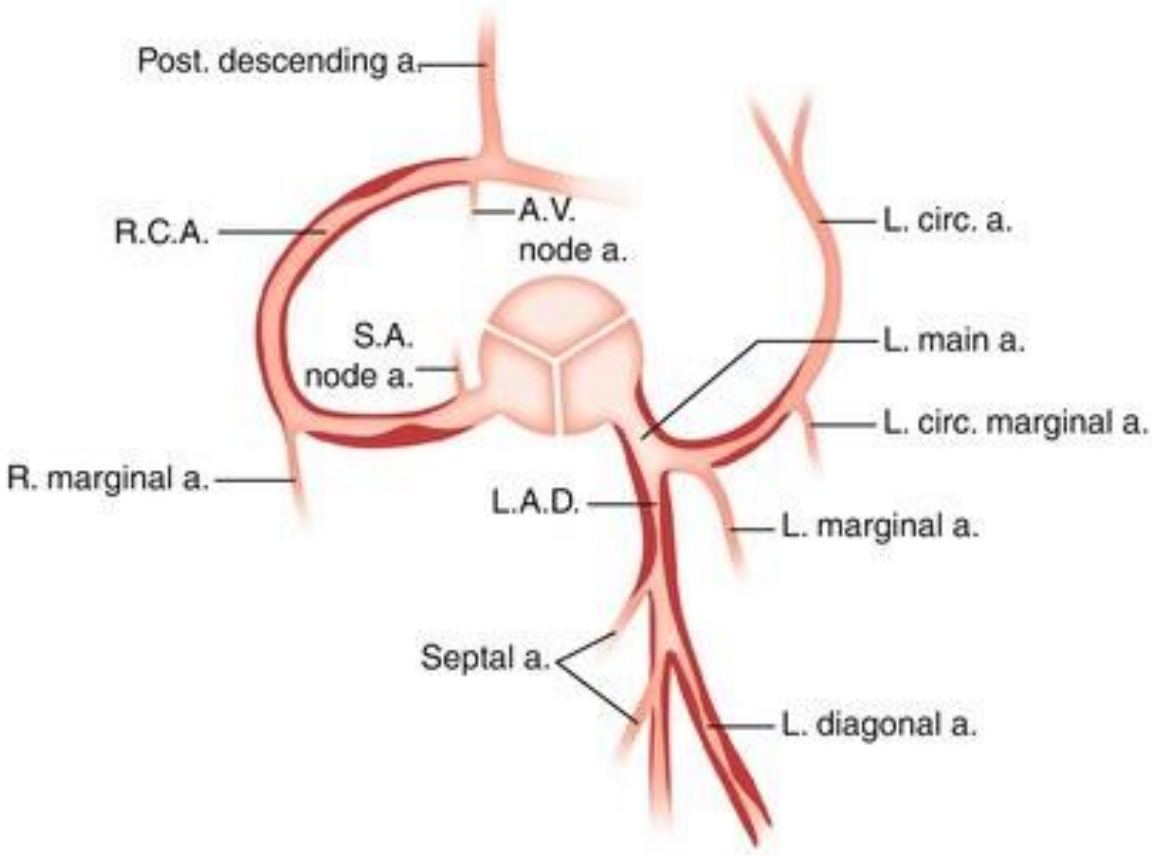
Coronary Anatomy



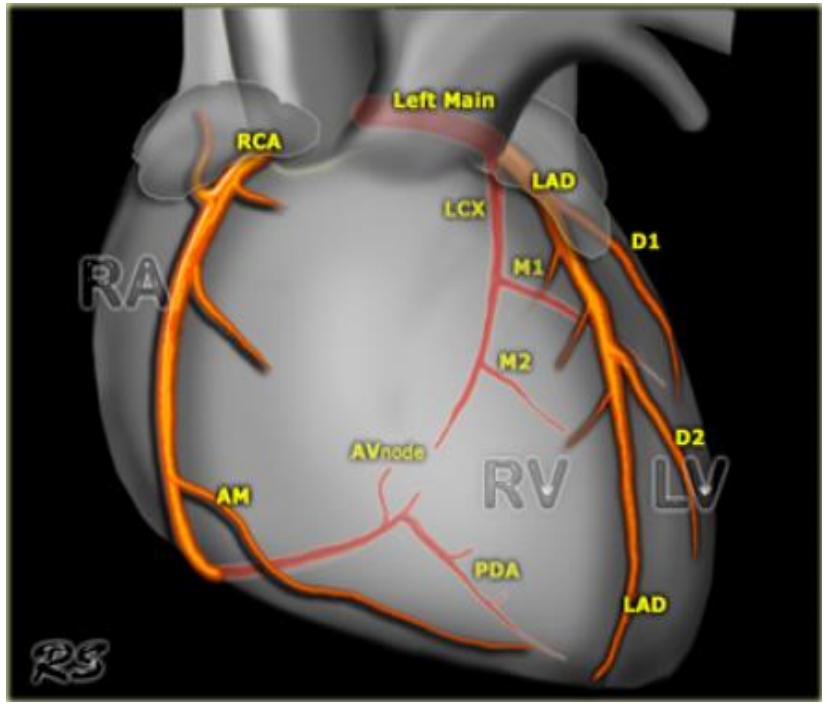
Coronary Anatomy

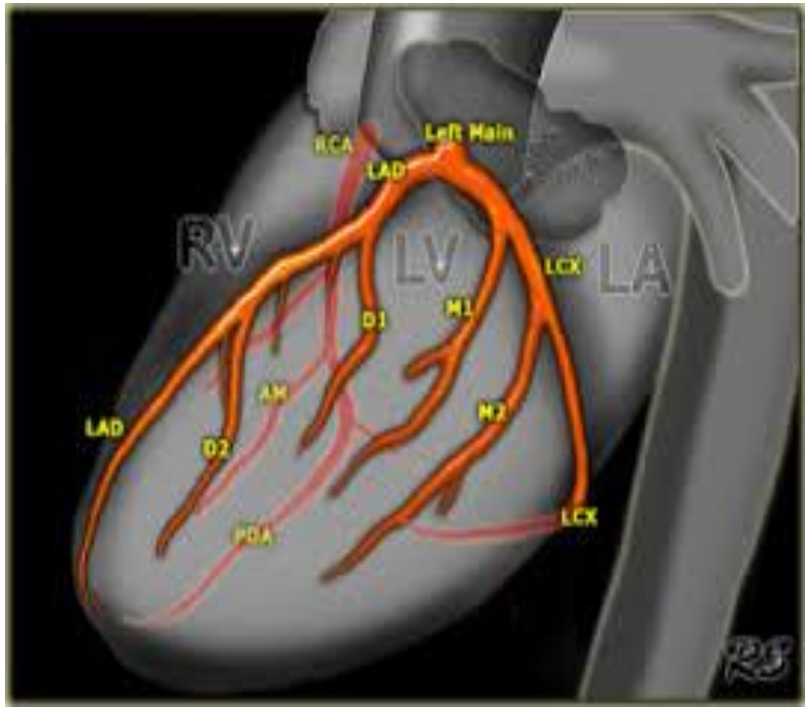


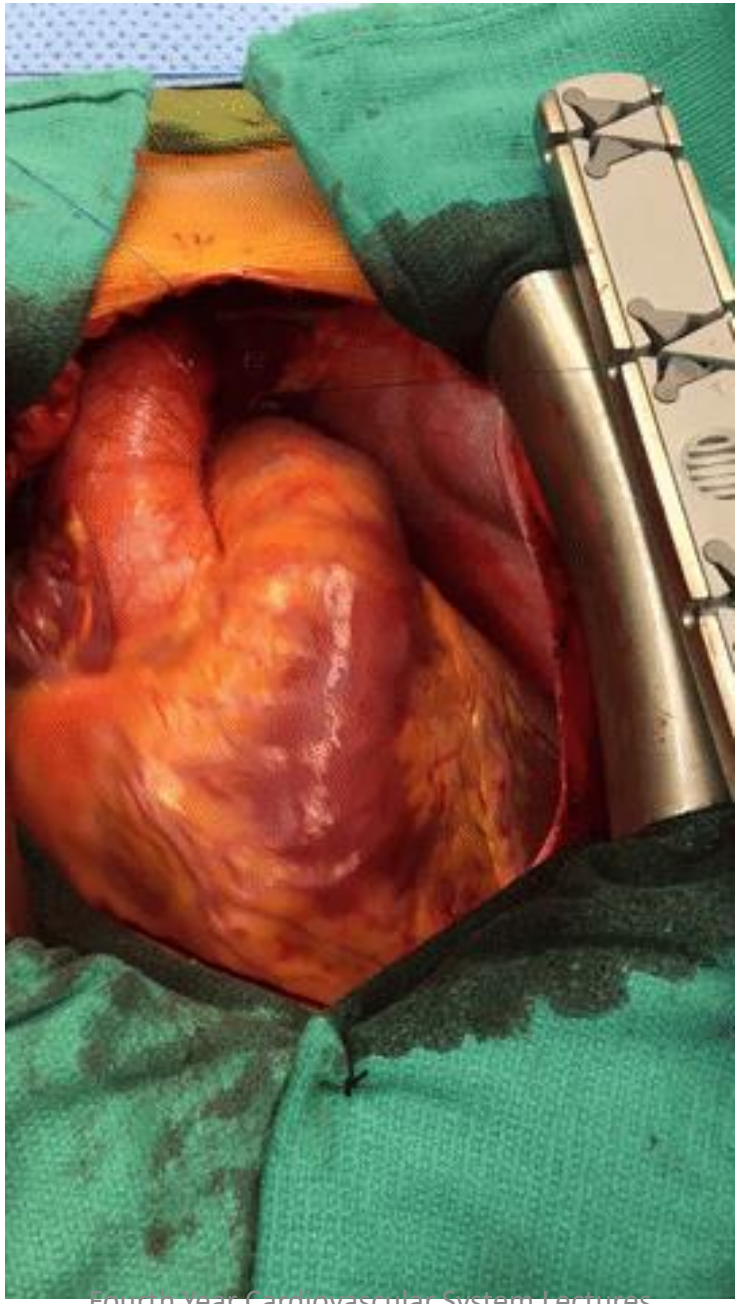
Coronary Anatomy

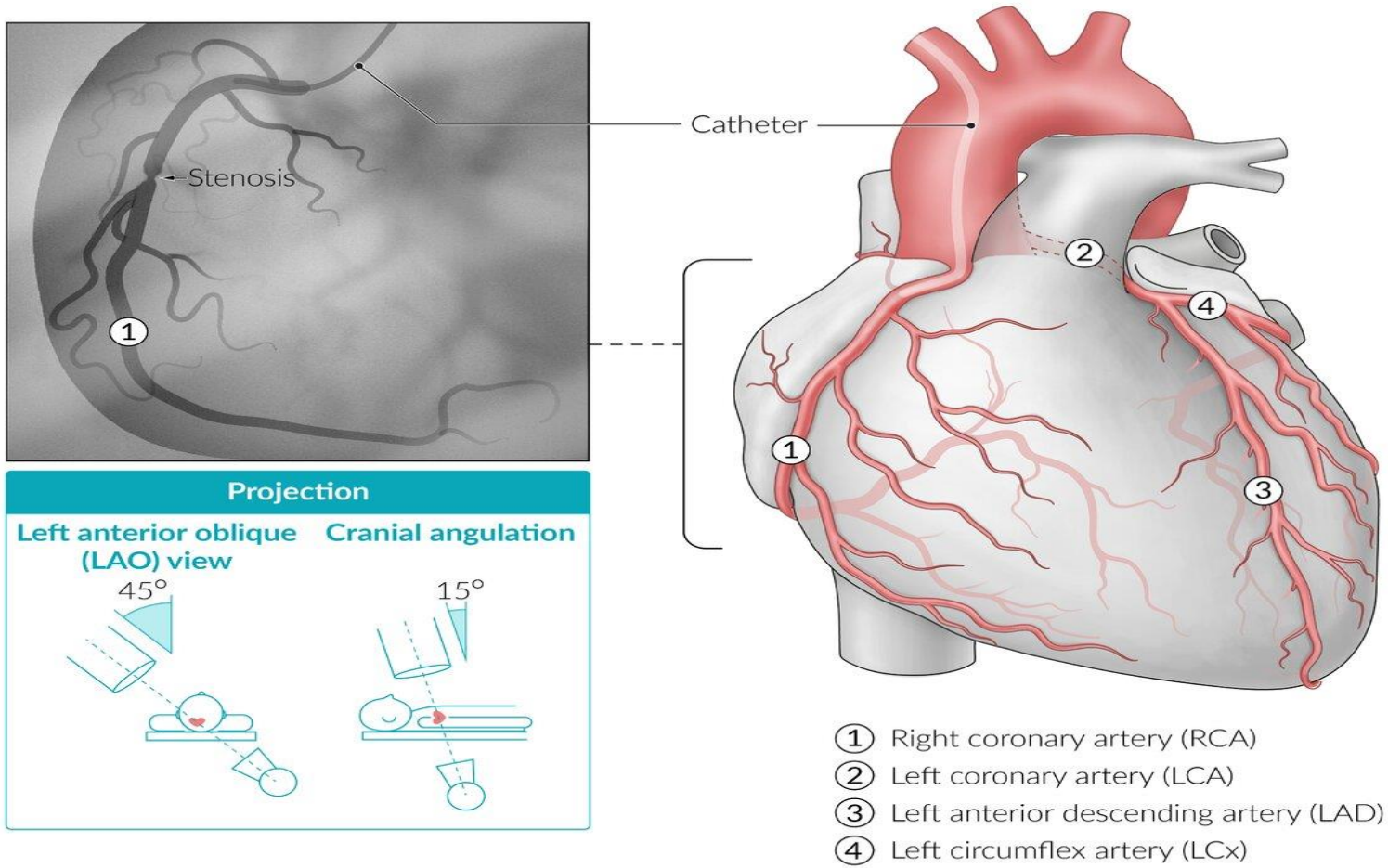


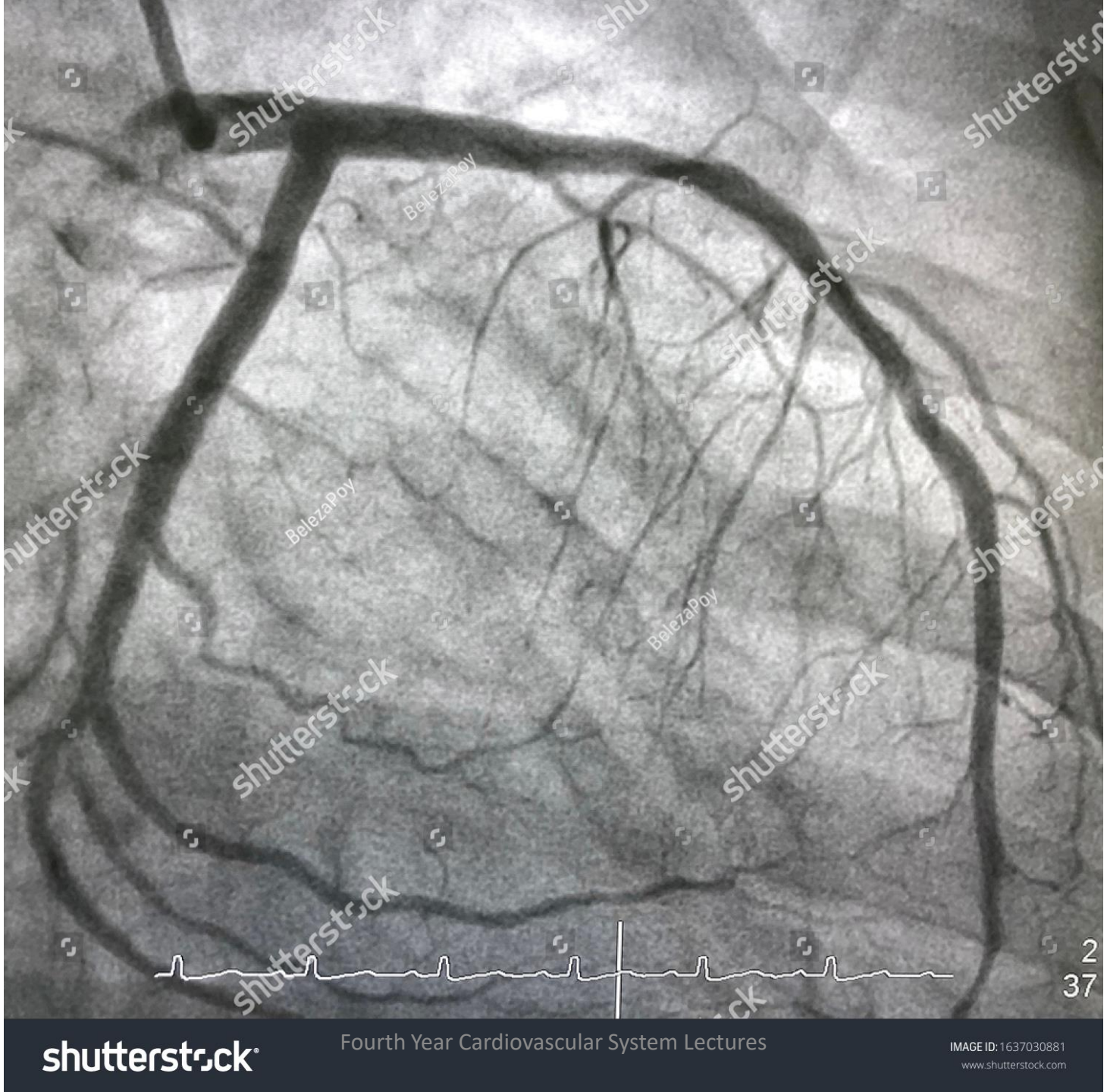
The Normal Heart - Coronary Artery Anatomy








Stenosis
1
Catheter
2
4
1
3
Projection
Left anterior oblique (LAO) view
45°
Cranial angulation
15°
1 Right coronary artery (RCA)
2 Left coronary artery (LCA)
3 Left anterior descending artery (LAD)
4 Left circumflex artery (LCx)

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RAO 1.8°

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Management

- Indication For Surgery
- Preoperative Evaluation
- Conduits decision
- Operation Decision
- ERAS

Indications for Coronary Artery Bypass Grafting: (CABG)

- Triple vessel disease with DM and decreased EF
- Lf main coronary artery disease (Distal)
- Hi risk PCI or not Suitable for PCI
- Complications of PTCA
- Mechanical complications of MI
- Anomalies of Coronary arteries.

Table 2. Applying Class of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care (Updated May 2019)

AMERICAN COLLEGE of CARDIOLOGY FOUNDATION

CLASS (STRENGTH) OF RECOMMENDATION	
CLASS 1 (STRONG)	**Benefit >>> Risk**
Suggested phrases for writing recommendations: • Is recommended • Is indicated/useful/effective/beneficial • Should be performed/administered/other • Comparative-Effectiveness Phrases†: – Treatment/strategy A is recommended/indicated in preference to treatment B – Treatment A should be chosen over treatment B	
CLASS 2a (MODERATE)	**Benefit >> Risk**
Suggested phrases for writing recommendations: • Is reasonable • Can be useful/effective/beneficial • Comparative-Effectiveness Phrases†: – Treatment/strategy A is probably recommended/indicated in preference to treatment B – It is reasonable to choose treatment A over treatment B	
CLASS 2b (WEAK)	**Benefit ≥ Risk**
Suggested phrases for writing recommendations: • May/might be reasonable • May/might be considered • Usefulness/effectiveness is unknown/unclear/uncertain or not well-established	
CLASS 3: No Benefit (MODERATE) **(Generally, LOE A or B use only)**	**Benefit = Risk**
Suggested phrases for writing recommendations: • Is not recommended • Is not indicated/useful/effective/beneficial • Should not be performed/administered/other	
Class 3: Harm (STRONG)	**Risk > Benefit**
Suggested phrases for writing recommendations: • Potentially harmful • Causes harm • Associated with excess morbidity/mortality • Should not be performed/administered/other	

LEVEL (QUALITY) OF EVIDENCE‡	
LEVEL A	
• High-quality evidence‡ from more than 1 RCT • Meta-analyses of high-quality RCTs • One or more RCTs corroborated by high-quality registry studies	
LEVEL B-R	**(Randomized)**
• Moderate-quality evidence‡ from 1 or more RCTs • Meta-analyses of moderate-quality RCTs	
LEVEL B-NR	**(Nonrandomized)**
• Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies • Meta-analyses of such studies	
LEVEL C-LD	**(Limited Data)**
• Randomized or nonrandomized observational or registry studies with limitations of design or execution • Meta-analyses of such studies • Physiological or mechanistic studies in human subjects	
LEVEL C-EO	**(Expert Opinion)**
• Consensus of expert opinion based on clinical experience	

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† For comparative-effectiveness recommendations (COR 1 and 2a; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡ The method of assessing quality is evolving, including the application of standardized, widely-used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.

Revascularization in SIHD

Revascularization to Improve Survival in SIHD Compared With Medical Therapy

Recommendations for Revascularization to Improve Survival in SIHD Compared With Medical Therapy Referenced studies that support the recommendations are summarized in Online Data Supplement 10.		
COR	**LOE**	**Recommendations**
Left ventricular dysfunction and multivessel CAD		
1	**B-R**	**1. In patients with SIHD and multivessel CAD appropriate for CABG with severe left ventricular systolic dysfunction (left ventricular ejection fraction <35%), CABG is recommended to improve survival.**
2a	**B-NR**	**2. In selected patients with SIHD and multivessel CAD appropriate for CABG and mild-to-moderate left ventricular systolic dysfunction (ejection fraction 35%–50%), CABG (to include a left internal mammary artery [LIMA] graft to the LAD) is reasonable to improve survival.**

Revascularization to Improve Survival in SIHD Compared With Medical Therapy (con't.)

Left main CAD		
1	B-R	3. In patients with SIHD and significant left main stenosis, CABG is recommended to improve survival.
2a	B-NR	4. In selected patients with SIHD and significant left main stenosis for whom PCI can provide equivalent revascularization to that possible with CABG, PCI is reasonable to improve survival.

Revascularization to Improve Survival in SIHD Compared With Medical Therapy (con't.)

Multivessel CAD		
2b	B-R	5. In patients with SIHD, normal ejection fraction, significant stenosis in 3 major coronary arteries (with or without proximal LAD), and anatomy suitable for CABG, CABG may be reasonable to improve survival.
2b	B-R	6. In patients with SIHD, normal ejection fraction, significant stenosis in 3 major coronary arteries (with or without proximal LAD), and anatomy suitable for PCI, the usefulness of PCI to improve survival is uncertain.

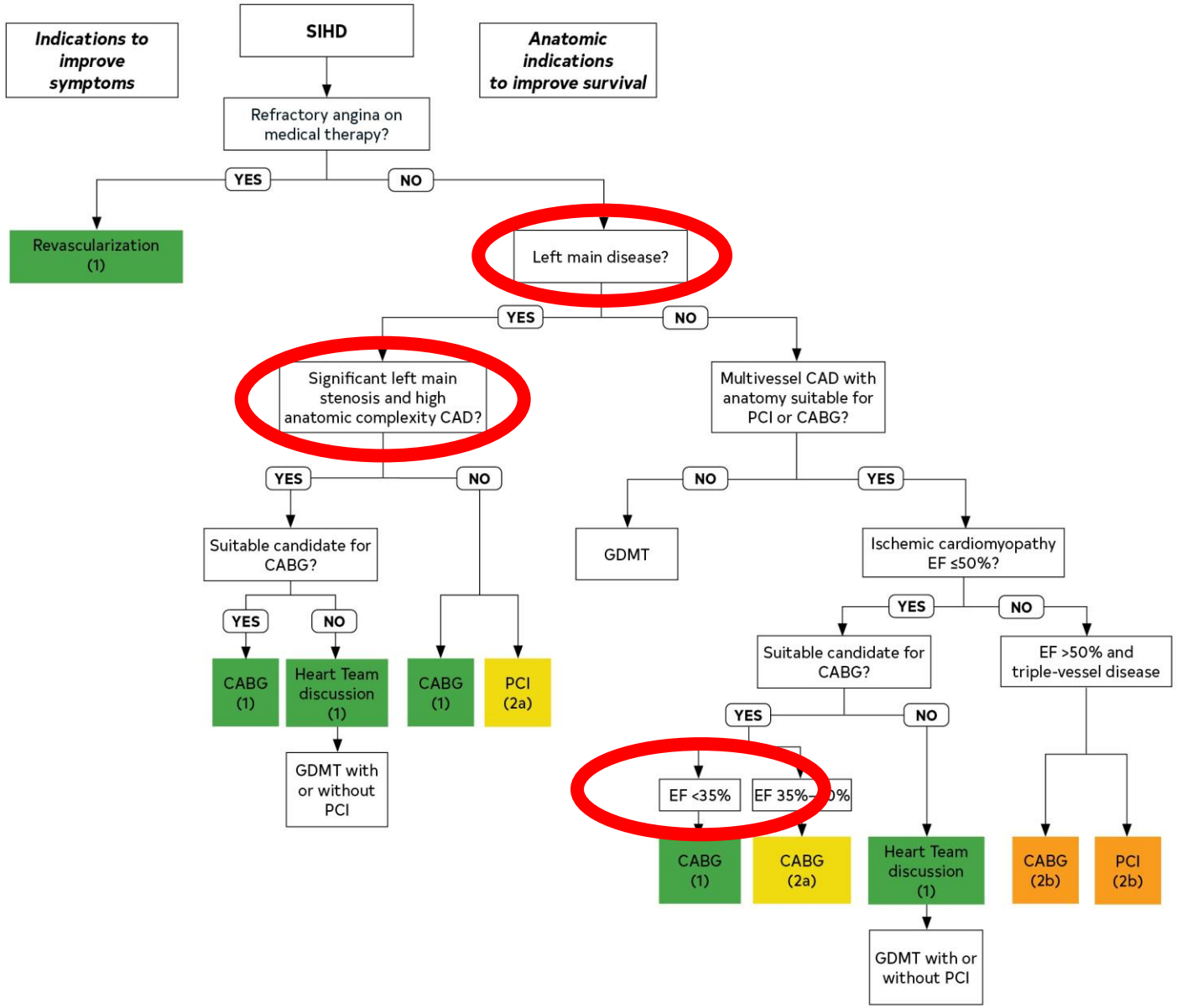
Revascularization to Improve Survival in SIHD Compared With Medical Therapy (con't.)

Stenosis in the proximal LAD artery		
2b	**B-R**	**7. In patients with SIHD, normal left ventricular ejection fraction, and significant stenosis in the proximal LAD, the usefulness of coronary revascularization to improve survival is uncertain.**
Single- or double-vessel disease not involving the proximal LAD		
3: No Benefit	**B-R**	**8. In patients with SIHD, normal left ventricular ejection fraction, and 1- or 2-vessel CAD not involving the proximal LAD, coronary revascularization is not recommended to improve survival.**

Figure 6. Revascularization in patients with SIHD.

Colors correspond to Table 2.

CABG indicates coronary artery bypass graft; CAD, coronary artery disease; EF, ejection fraction; PCI, percutaneous coronary intervention; SIHD, stable ischemic heart disease; and GDMT, guideline-directed medical therapy.



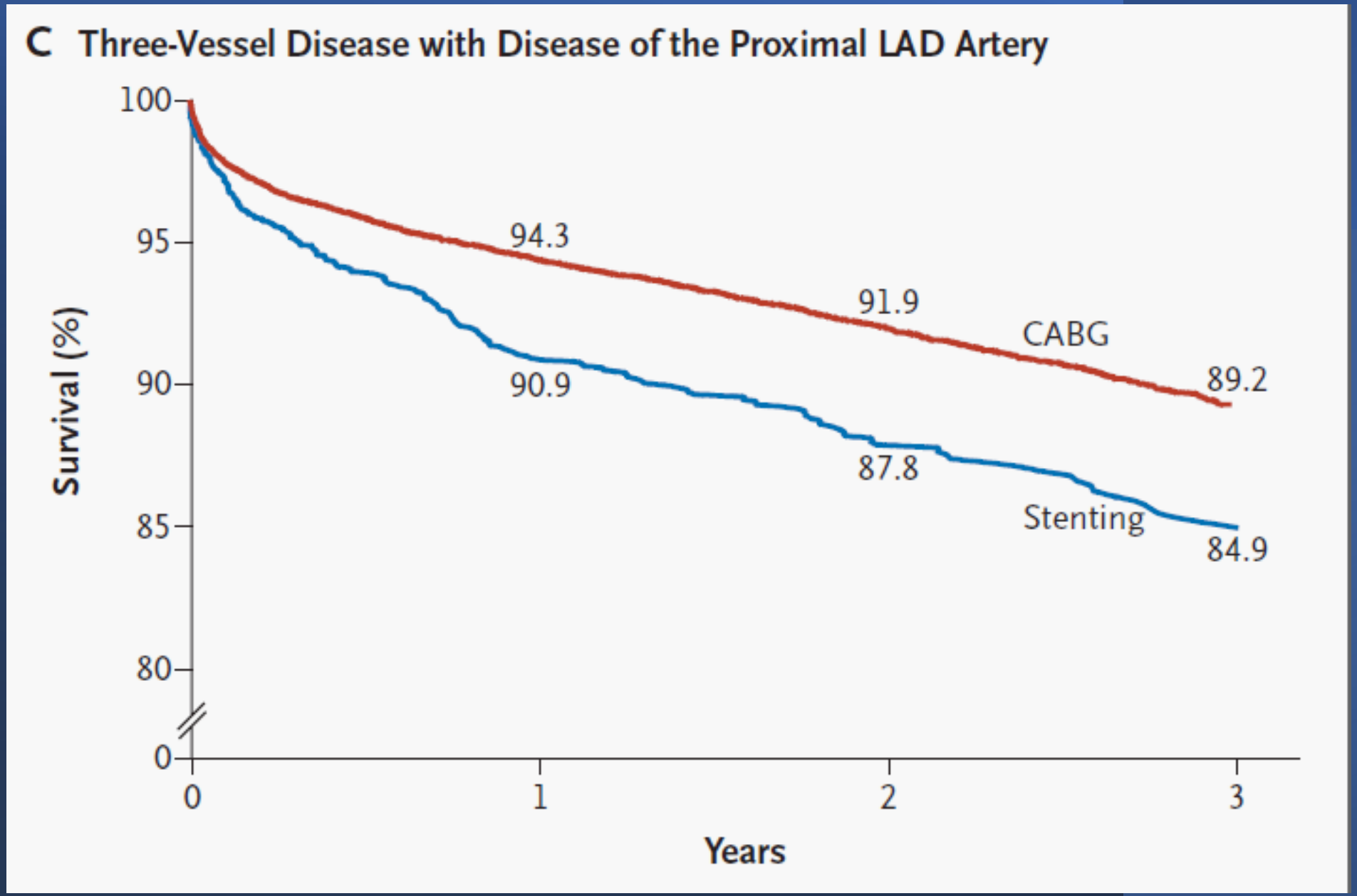
Situations in Which CABG Would Be Preferred

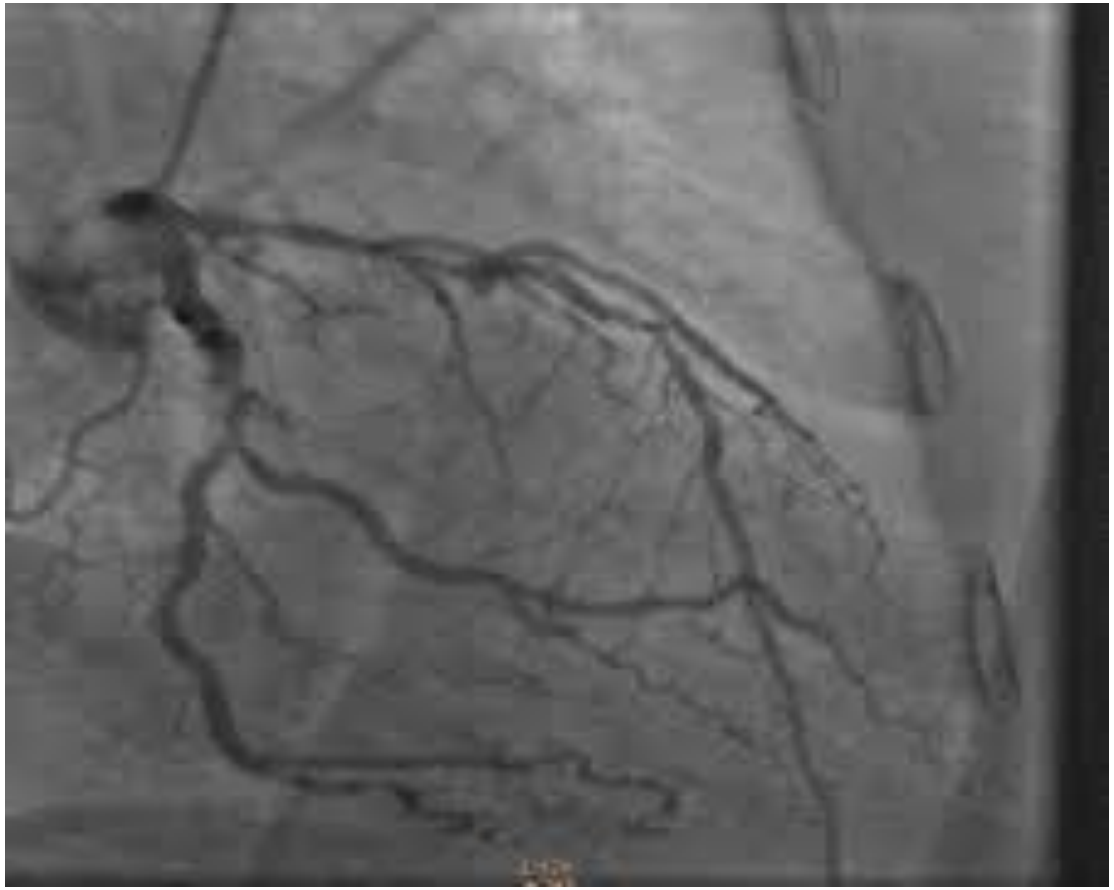
Patients With Complex Disease

Recommendations for Patients With Complex Disease Referenced studies that support the recommendations are summarized in Online Data Supplement 13.		
COR	**LOE**	**Recommendations**
1	**B-R**	**1. In patients who require revascularization for significant left main CAD with high-complexity CAD, it is recommended to choose CABG over PCI to improve survival.**
2a	**B-R**	**2. In patients who require revascularization for multivessel CAD with complex or diffuse CAD (e.g., SYNTAX score >33), it is reasonable to choose CABG over PCI to confer a survival advantage.**

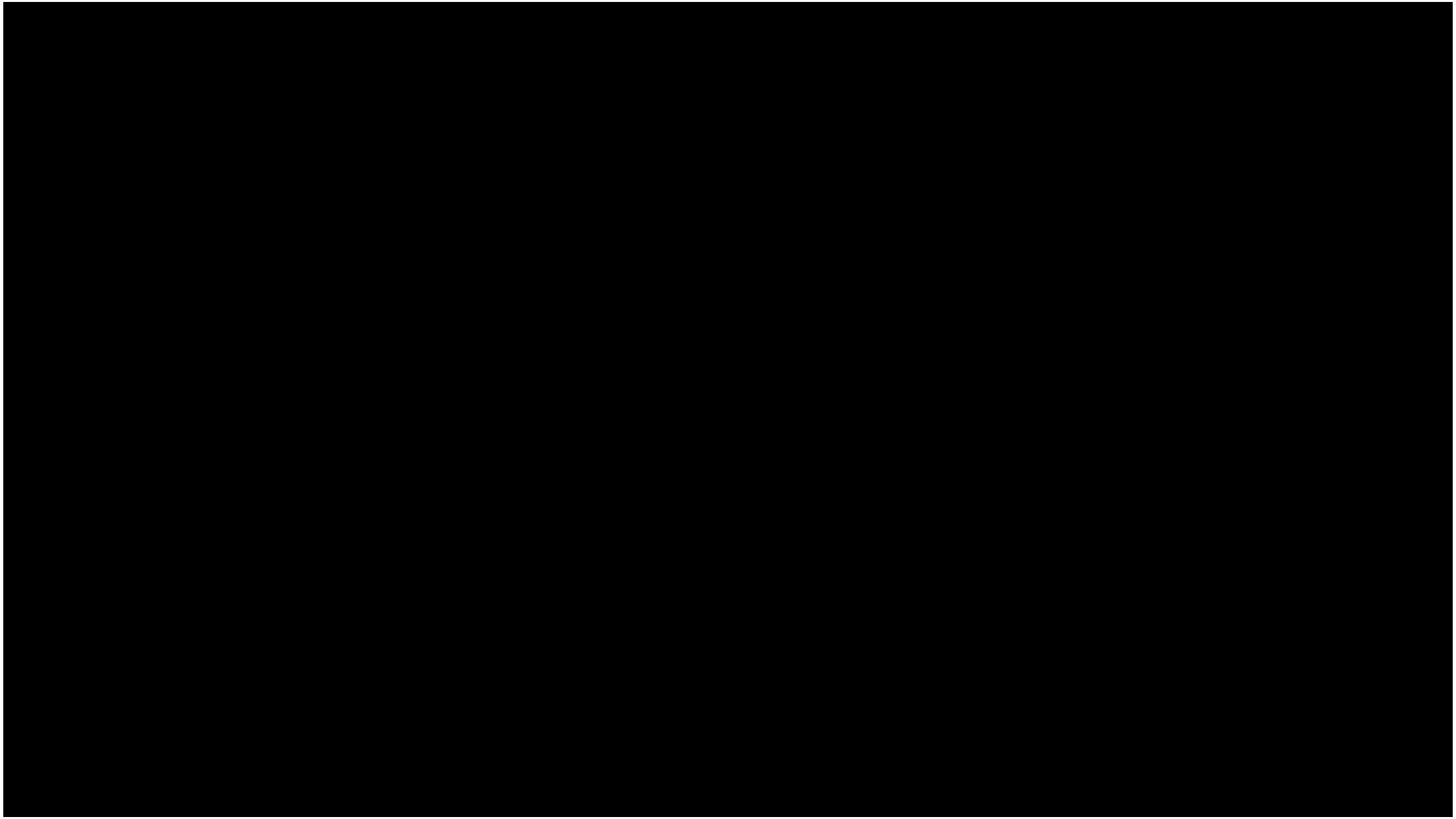
Patients With Diabetes

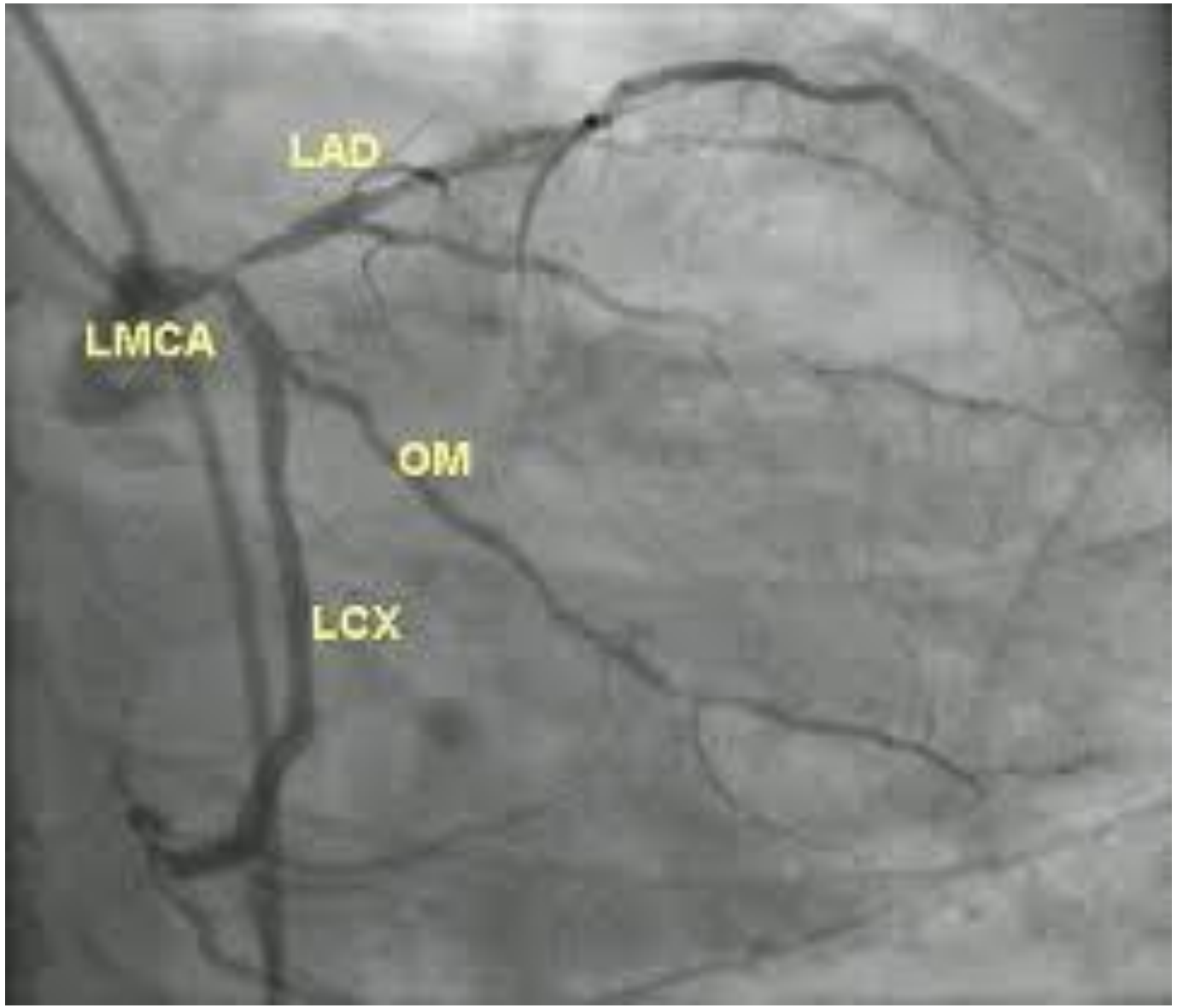
Recommendations for Patients With Diabetes Referenced studies that support the recommendations are summarized in Online Data Supplement 14.		
COR	**LOE**	**Recommendations**
1	**A**	**1. In patients with diabetes and multivessel CAD with the involvement of the LAD, who are appropriate candidates for CABG, CABG (with a LIMA to the LAD) is recommended in preference to PCI to reduce mortality and repeat revascularizations.**
2a	**B-NR**	**2. In patients with diabetes who have multivessel CAD amenable to PCI and an indication for revascularization and are poor candidates for surgery, PCI can be useful to reduce long-term ischemic outcomes.**
2b	**B-R**	**3. In patients with diabetes who have left main stenosis and low- or intermediate-complexity CAD in the rest of the coronary anatomy, PCI may be considered an alternative to CABG to reduce major adverse cardiovascular outcomes.**


C Three-Vessel Disease with Disease of the Proximal LAD Artery
Survival (%)
100
95
90
85
80
0
0
1
2
3
Years
94.3
91.9
89.2
CABG
90.9
87.8
84.9
Stenting



- A 50-year-old male patient
- Diabetic on OHA (Metformin)
- Hypertensive on BB and CCB
- Dyslipidemia on Statin and aspirin
- Presented to the ER with ACS (Unstable Angina)
- He was started on Clopidogrel and admitted for further evaluation




LAD
LMCA
OM
LCX

- Cath showed
  - Distal Left Main Stenosis
  - RCA stenosis

Factors for Consideration by the Heart Team

Coronary Anatomy

- Left main disease
- Multivessel disease
- High anatomic complexity (i.e., bifurcation disease, high SYNTAX score)

Comorbidities

- Diabetes
- Systolic dysfunction
- Coagulopathy
- Valvular heart disease
- Frailty
- Malignancy
- ESRD
- COPD
- Immunosuppression
- Debilitating neurological disorders
- Liver disease/ cirrhosis
- Prior CVA
- Calcified aorta
- Aortic aneurysm

Procedural Factors

- Local and regional outcomes
- Access site for PCI
- Surgical risk
- PCI risk

Patient Factors

- Unstable presentation or shock
- Patient preferences
- Inability or unwillingness to adhere to DAPT
- Religious beliefs
- Patient education, knowledge, and understanding

Guiding Principle: Ideal situations for Heart Team consideration include patients with complex coronary disease, comorbid conditions that could impact the success of the revascularization strategy, and other clinical or social situations that may impact outcomes.

American Heart Association.

Abbreviations: COPD indicates chronic obstructive pulmonary disease; CVA, cerebral vascular accident; DAPT, dual antiplatelet therapy; ESRD, end-stage renal disease; PCI, percutaneous coronary intervention; and SYNTAX, Synergy Between PCI With TAXUS and Cardiac Surgery.

Lawton, J. S. et al. 2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization. *Circulation.*

Improving Equity of Care in Revascularization

Health disparities by sex and race are evident across the spectrum of CVD in the United States.

Women and non-White patients are less likely to receive guideline-based therapies.

Women and non-White patients derive comparable benefit from revascularization after controlling for other factors.

In patients who require coronary revascularization, treatment decisions should be based on clinical indication, regardless of sex or race or ethnicity, and efforts to reduce disparities of care are warranted (Class 1).

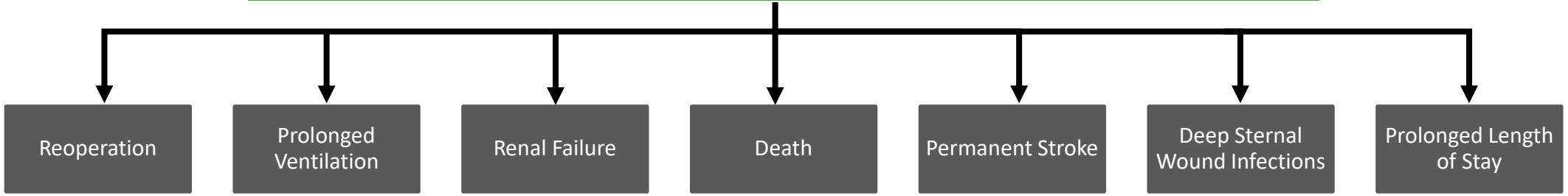
Abbreviations: CVD indicates cardiovascular disease.

Lawton, J. S. et al. 2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization. *Circulation.*

American Heart Association.

Assessing Risk for Patients Undergoing CABG

In patients who are being considered for CABG, calculation of the Society of Thoracic Surgeons (STS) and EURO II risk score is recommended to help stratify patient risk (Class 1).*



Risk Factors Not Quantified in the STS Score	
Cirrhosis	Meld
Frailty	Gait Speed
Malnutrition	MUST

Guiding Principle: In patients who are being considered for CABG, calculation of the STS \ Euro II risk score is recommended to help stratify patient risk. The MELD score, gait speed, and the MUST score may help in patients with cirrhosis, frailty, and malnutrition respectively.

Abbreviations: CABG indicates coronary artery bypass grafting; MELD, Model for End-Stage Liver Disease; MUST, Malnutrition Universal Screening Tool; and STS, Society of Thoracic Surgeons.

*** See:** https://www.sts.org/resources/risk-calculator

American Heart Association.

Lawton, J. S. et al. 2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization. *Circulation.*

INDICATION??

Revascularization to Improve Survival in SIHD Compared With Medical Therapy (con't.)

Left main CAD		
1	B-R	3. In patients with SIHD and significant left main stenosis, CABG is recommended to improve survival.
2a	B-NR	4. In selected patients with SIHD and significant left main stenosis for whom PCI can provide equivalent revascularization to that possible with CABG, PCI is reasonable to improve survival.

Patients With Diabetes

Recommendations for Patients With Diabetes Referenced studies that support the recommendations are summarized in Online Data Supplement 14.		
COR	**LOE**	**Recommendations**
1	**A**	**1. In patients with diabetes and multivessel CAD with the involvement of the LAD, who are appropriate candidates for CABG, CABG (with a LIMA to the LAD) is recommended in preference to PCI to reduce mortality and repeat revascularizations.**
2a	**B-NR**	**2. In patients with diabetes who have multivessel CAD amenable to PCI and an indication for revascularization and are poor candidates for surgery, PCI can be useful to reduce long-term ischemic outcomes.**
2b	**B-R**	**3. In patients with diabetes who have left main stenosis and low- or intermediate-complexity CAD in the rest of the coronary anatomy, PCI may be considered an alternative to CABG to reduce major adverse cardiovascular outcomes.**

- Indication For Surgery
- Preoperative Evaluation
- Conduits decision
- Operation Decision
- ERAS

- Respiratory Evaluation
- Renal Evaluation
- Infection Evaluation
- Carotids
- Frailty
- Risk Assessment
- Liver
- Thyroid
- Medications
- Coagulopathy

Perioperative Pharmacotherapy

Pre-op Anti-platelet

PRE-OP ANTI-PLATELET	PLAN TO DECREASE RISK OF BLEEDING
ASA, daily	CONTINUE, if already taking (Class 1)
Clopidogrel & Ticagrelor	STOP At least 24 hrs, if URGENT (Class 1)
	STOP Ticagrelor at least 3d, if elective (Class 2a) Clopidogrel at least 5d, if elective (Class 2a) Prasugrel at least 7d, if elective (Class 2a)
Eptifibatide & Tirofiban	STOP At least 4 hrs (Class 1)
Abciximab	STOP At least 12 hrs (Class 1)

Anti-Arrhythmics* Preop

BB and Amiodarone can reduce the incidence of post-op afib (Class 2a)

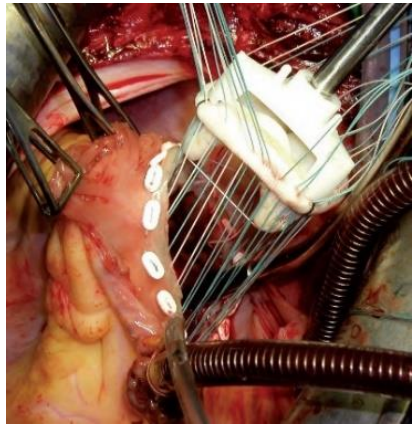
BB may reduce mortality or postop complications (Class 2b)

* In patients with no contraindications to usage

Abbreviations: AFIB indicates atrial fibrillation; ASA, aspirin; BB, beta blockers; D, days; and HRS, hours.

Lawton, J. S. et al. 2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization. *Circulation.*

Patients Undergoing Other Cardiac Surgery and Operative Approach



Valve, aortic, OR other cardiac surgery

↓

Significant CAD

↓

Concomitant CABG (Class 1)

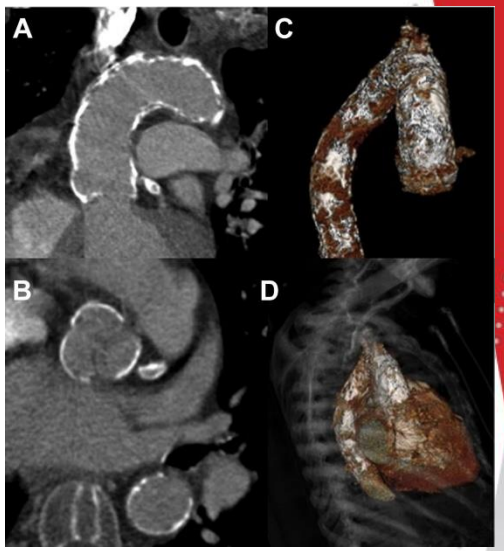
Significant Aortic Calcification OR Significant Pulmonary disease

↓

Decrease stroke risk

↓

Off-pump or beating heart approach may be reasonable (Class 2a)



Abbreviations: CABG indicates coronary artery bypass grafting; and CAD, coronary artery disease.

Lawton, J. S. et al. 2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization. *Circulation.*

American Heart Association.

Shared Decision-Making and Informed Consent

Informed Consent

Clinician provides the best available evidence for treatment options, including the risks & benefits of each option

Patient-Centered Care

Treatment & care options take into consideration individual values & preferences

Shared Decision-Making

A collaborative decision about treatment or care is documented and shared with relevant stakeholders

COR	RECOMMENDATIONS
1	In patients undergoing revascularization, decisions should be patient centered—that is, considerate of the patient's preferences and goals, cultural beliefs, health literacy, and social determinants of health—and made in collaboration with the patient's support system.
1	In patients undergoing coronary angiography or revascularization, adequate information about benefits, risks, therapeutic consequences, and potential alternatives in the performance of percutaneous and surgical myocardial revascularization should be given, when feasible, with sufficient time for informed decision-making to improve clinical outcomes.

American Heart Association.

Lawton, J. S. et al. 2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization. *Circulation.*

Table 8. Patient Clinical Status Definitions to Guide Revascularization

Elective	**Cardiac function has been stable in the days-weeks before intervention.** The intervention could be deferred without increased risk of compromise to cardiac outcome.
Urgent	**Intervention is required during the same hospitalization to minimize chance of further clinical deterioration.** Examples include worsening sudden chest pain, heart failure, acute myocardial infarction, anatomy, intra-aortic balloon pump, unstable angina, with intravenous nitroglycerin, or rest angina.
Emergency	**Patients requiring emergency intervention will have ongoing, refractory, unrelenting cardiac compromise, with or without hemodynamic instability, and not responsive to any form of therapy except cardiac intervention.** There should be no delay in providing operative intervention.
Emergency/salvage	**Patients requiring emergency/salvage intervention are those who require cardiopulmonary resuscitation in route to intervention**, before induction of anesthesia or who require extracorporeal membrane oxygenation to maintain life.

American Heart Association.

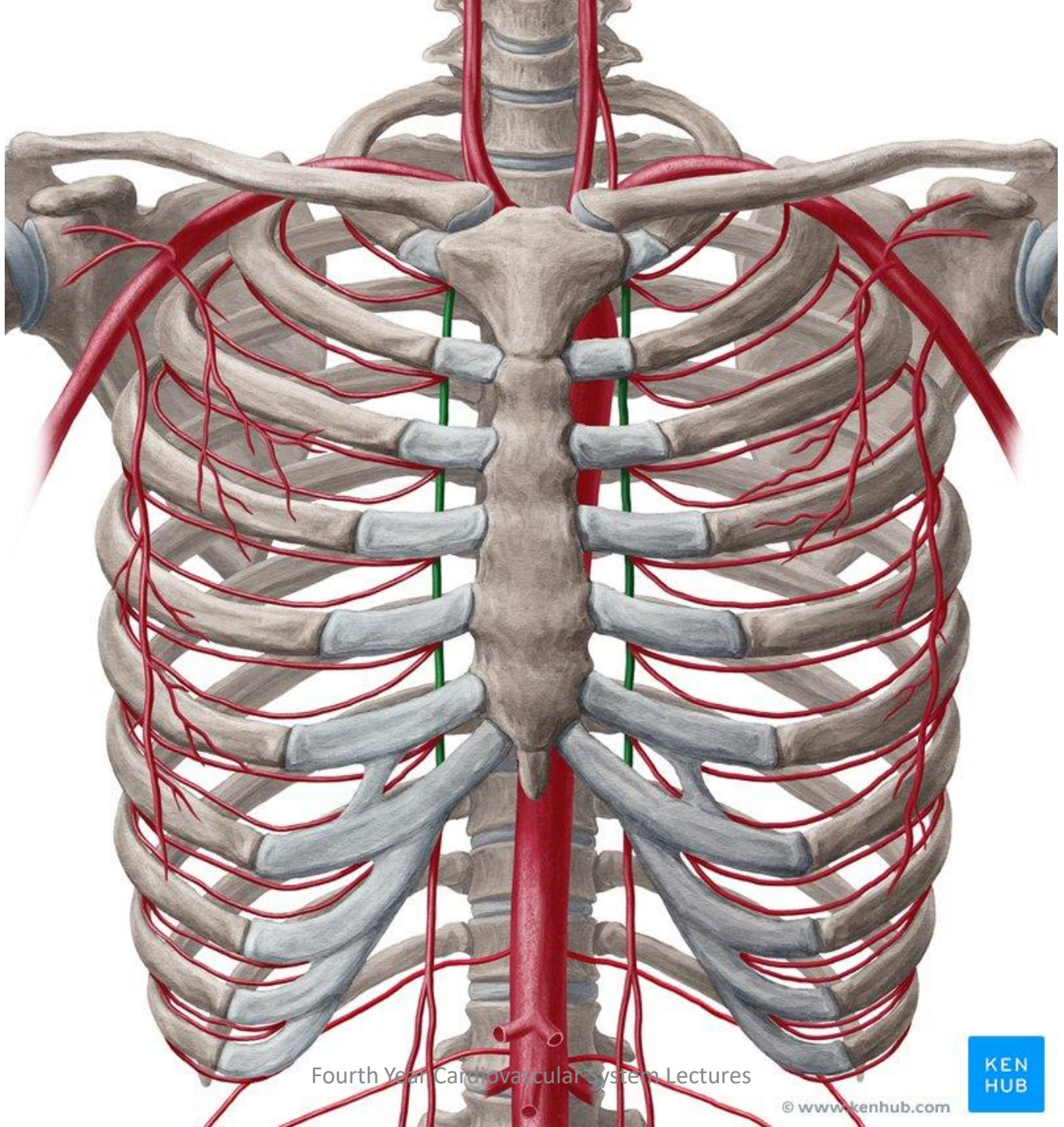
Lawton, J. S. et al. 2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization. *Circulation.*

General Procedural Issues for CABG

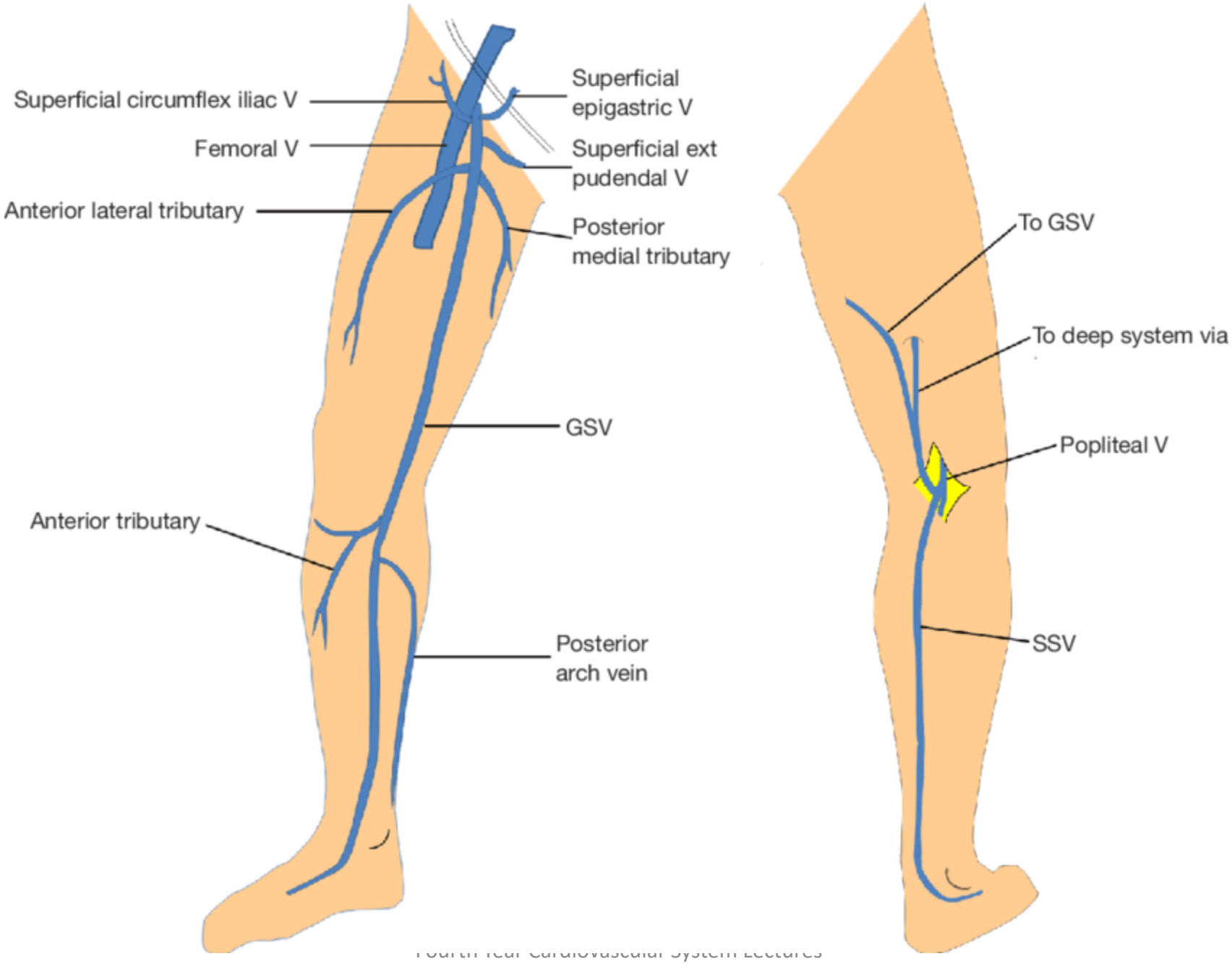
- Indication For Surgery
- Preoperative Evaluation
- Conduits decision
- Operation Decision
- ERAS

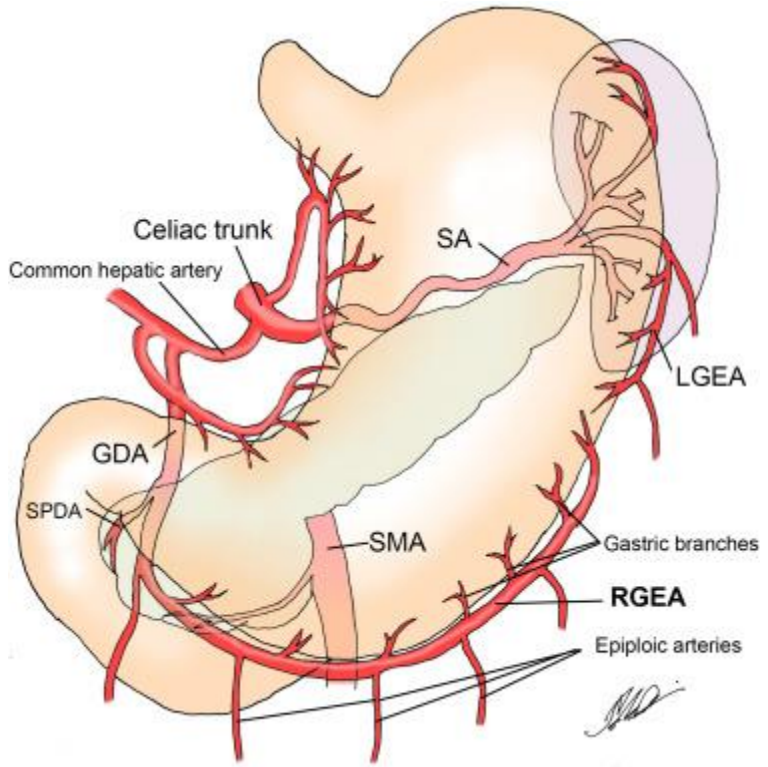
Conduites

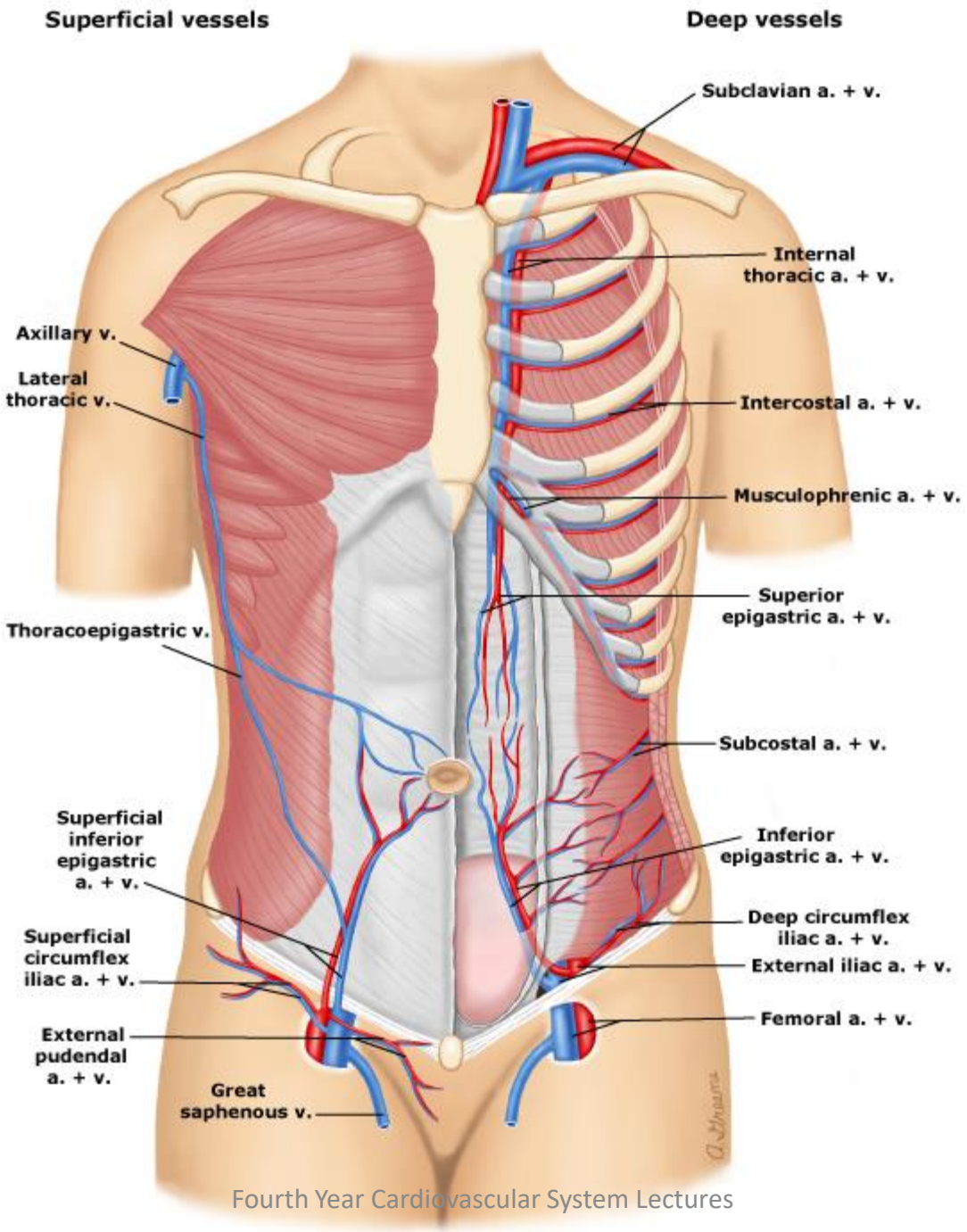
- Arterial
  - LIMA
  - RIMA
  - RA
  - GEA
  - IEA
- Venous
  - GSV
  - SSV
  - Arm Veins


© www.kenhub.com
KEN HUB

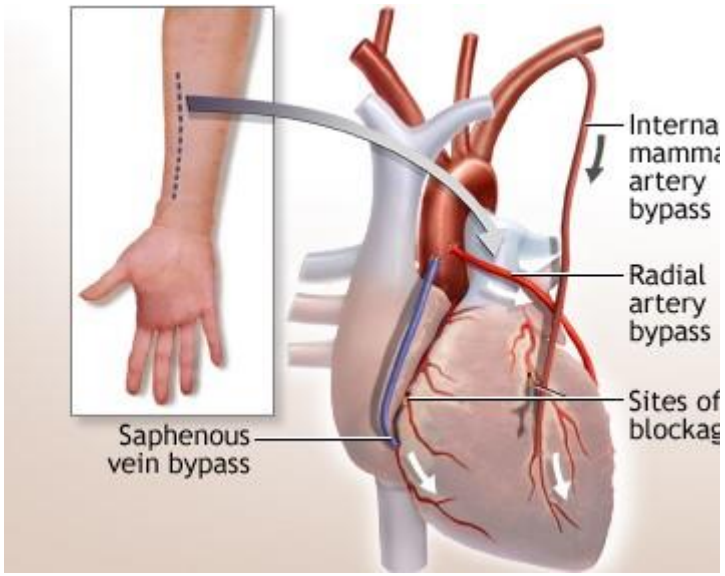
(a)

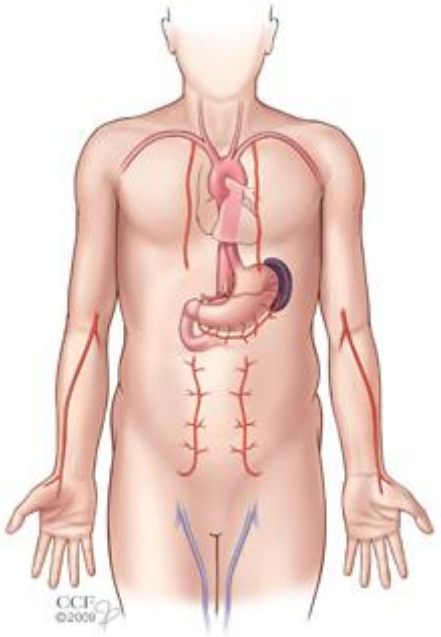

Superficial circumflex iliac V
Femoral V
Anterior lateral tributary
Anterior tributary
Superficial epigastric V
Superficial ext pudendal V
Posterior medial tributary
GSV
Posterior arch vein
To GSV
To deep system via
Popliteal V
SSV


Celiac trunk
Common hepatic artery
SA
LGEA
GDA
SPDA
SMA
Gastric branches
RGEA
Epiploic arteries


Superficial vessels
Deep vessels
Subclavian a. + v.
Internal thoracic a. + v.
Axillary v.
Lateral thoracic v.
Intercostal a. + v.
Musculophrenic a. + v.
Superior epigastric a. + v.
Thoracoepigastric v.
Subcostal a. + v.
Superficial inferior epigastric a. + v.
Inferior epigastric a. + v.
Deep circumflex iliac a. + v.
Superficial circumflex iliac a. + v.
External iliac a. + v.
Femoral a. + v.
External pudendal a. + v.
Great saphenous v.

Arterial vs Venous conduits

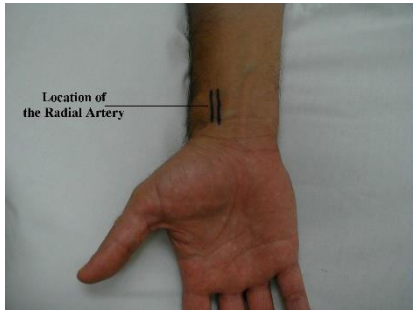




Bypass Conduits in Patients Undergoing CABG

Radial artery

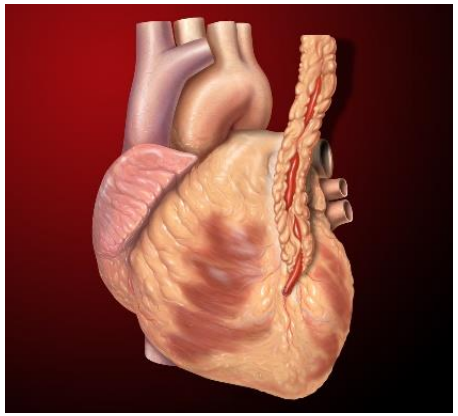
Recommended in preference to a saphenous vein conduit to graft the second most important, significantly stenosed, non–LAD vessel (Class 1)



Source: This Photo by Unknown Author is licensed under CC BY-SA

IMA (prefer left)

To LAD (Class 1)



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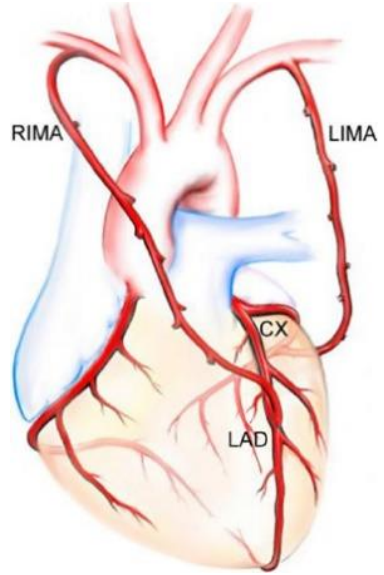
BIMA



Source: https://vpjournal.net/article/view/3141

Improves long-term outcomes when procedure is done by experienced operators (Class 2a)

Click here for more best practices

Abbreviations: BIMA indicates bilateral internal mammary artery; IMA, internal mammary artery; LAD, left anterior descending; and SVG, saphenous vein graft..

Lawton, J. S. et al. 2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization. *Circulation.*

The New England Journal of Medicine

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. 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.

Abstract We compared patients who received an internal-mammary-artery graft to the anterior descending coronary artery alone or combined with one or more saphenous-vein grafts (n = 2306) with patients who had only saphenous-vein bypass grafts (n = 3625). The 10-year actuarial survival rate among the group receiving the internal-mammary-artery graft, as compared with the group who received the vein grafts (exclusive of hospital deaths), was 93.4 percent versus 88.0 percent (P = 0.05) for those with one-vessel disease; 90.0 percent versus 79.5 percent (P<0.0001) for those with two-vessel disease; and 82.6 percent versus 71.0 percent (P<0.0001) for those with three-vessel disease. After an adjustment for demographic and clinical differences by Cox multivariate analysis, we found that patients who had only vein grafts had a 1.61 times greater risk of death throughout the 10 years, as compared with those who received an internal-mammary-artery graft. In addition, patients who received only vein grafts had 1.41 times the risk of late myocardial infarction (P<0.0001), 1.25 times the risk of hospitalization for cardiac events (P<0.0001), 2.00 times the risk of cardiac reoperation (P<0.0001), and 1.27 times the risk of all late cardiac events (P<0.0001), as compared with patients who received internal-mammary-artery grafts. Internal-mammary-artery grafting for lesions of the anterior descending coronary artery is preferable whenever indicated and technically feasible. (N Engl J Med 1986; 314:1-6.)

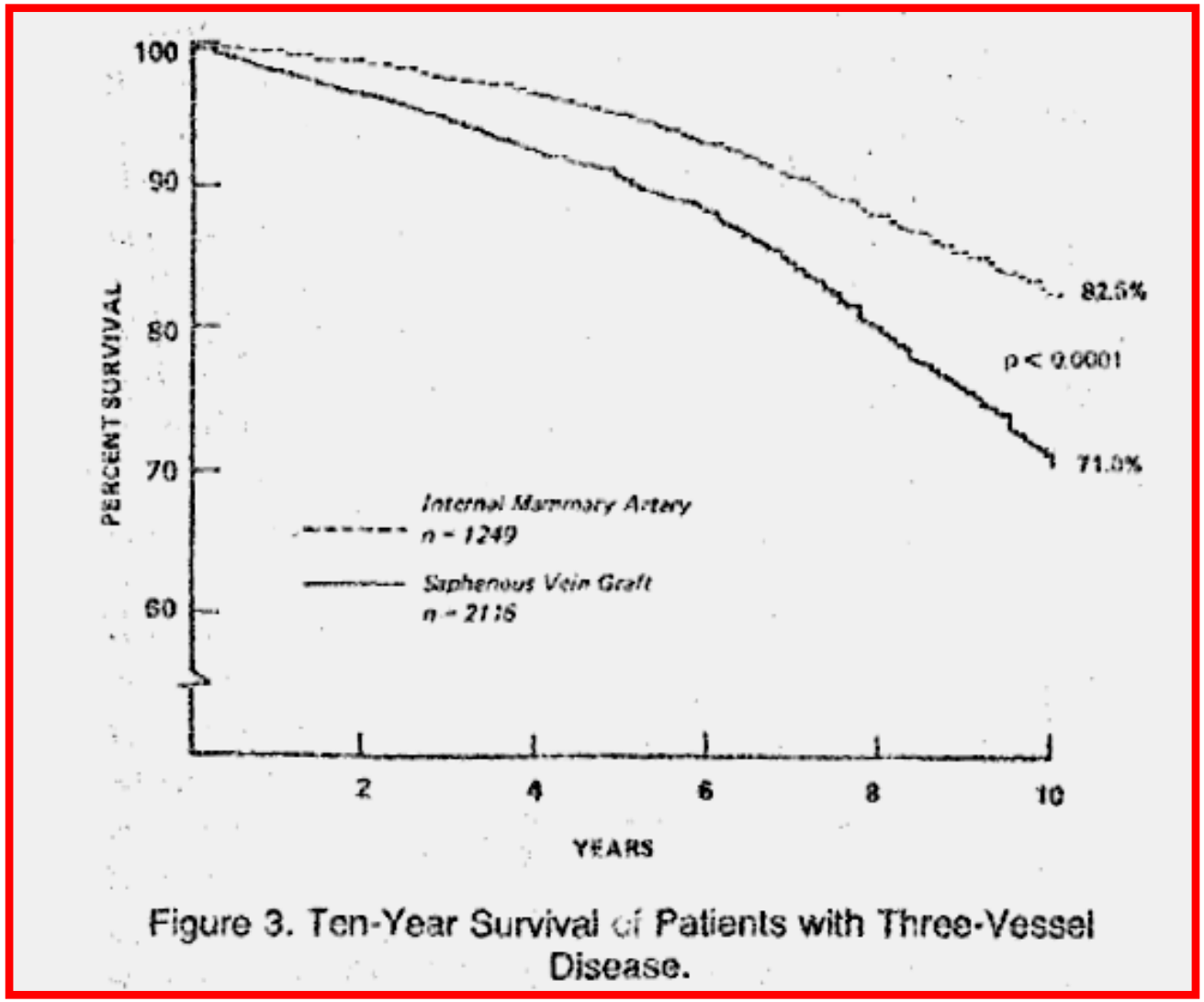


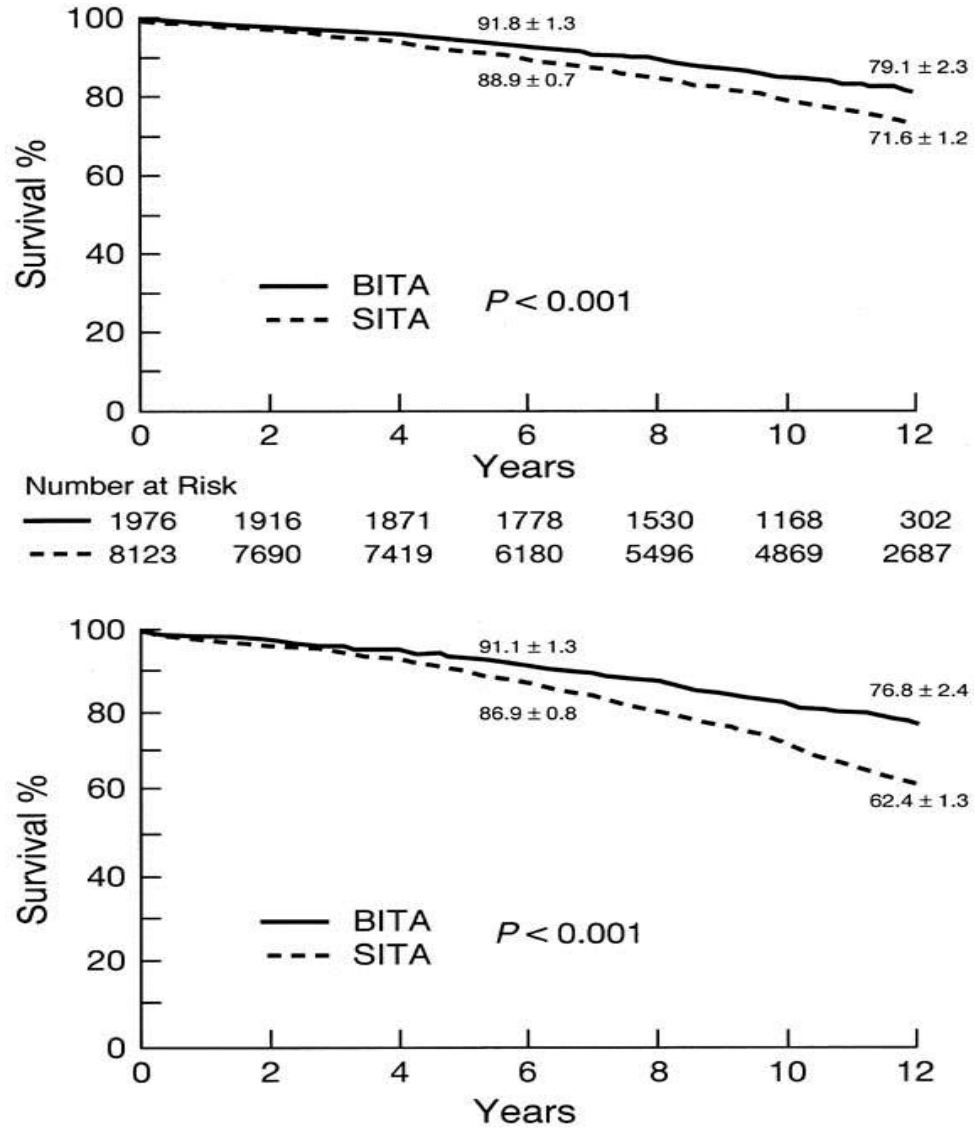
Figure 3. Ten-Year Survival of Patients with Three-Vessel Disease.

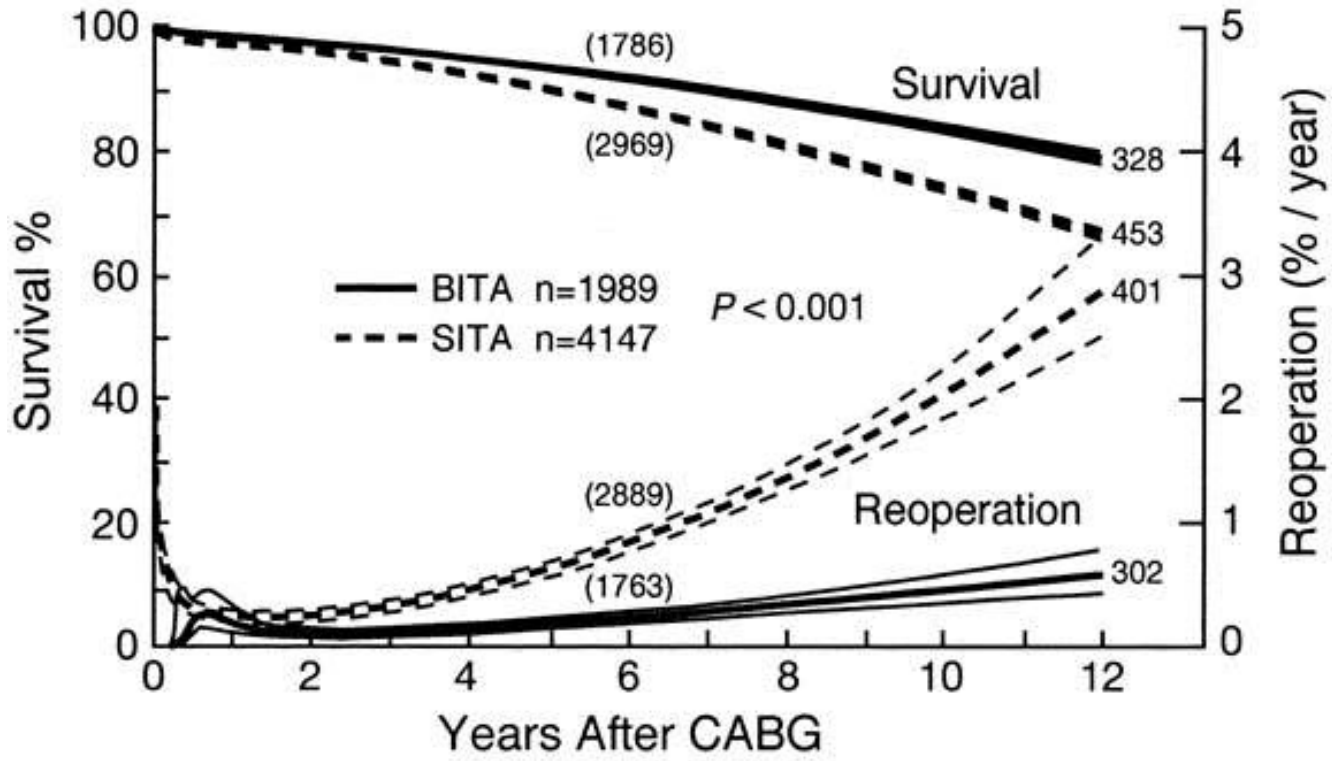
Loop FD et al NEJM 1986

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

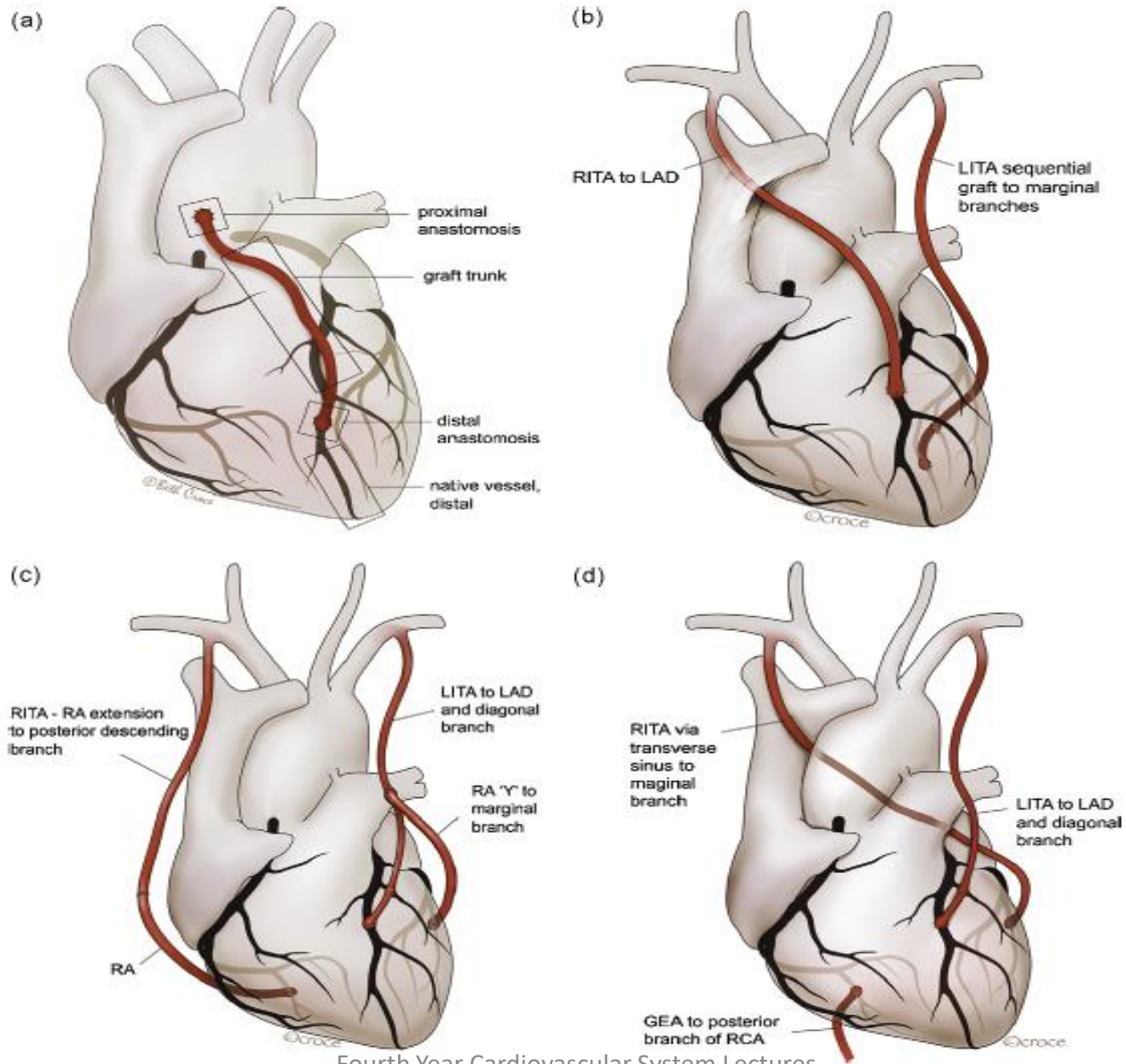
The Journal of Thoracic and Cardiovascular Surgery
Volume 117 Issue 5 Pages 855-872 (May 1999)
DOI: 10.1016/S0022-5223(99)70365-X


100
80
60
40
20
0
Survival %
91.8 ± 1.3
88.9 ± 0.7
79.1 ± 2.3
71.6 ± 1.2
BITA
SITA
P < 0.001
0
2
4
6
8
10
12
Years
Number at Risk
1976 1916 1871 1778 1530 1168 302
8123 7690 7419 6180 5496 4869 2687
100
80
60
40
20
0
Survival %
91.1 ± 1.3
86.9 ± 0.8
76.8 ± 2.4
62.4 ± 1.3
BITA
SITA
P < 0.001
0
2
4
6
8
10
12
Years


100
80
60
40
20
0
Survival %
0
2
4
6
8
10
12
Years After CABG
5
4
3
2
1
0
Reoperation (% / year)
(1786)
Survival
(2969)
328
453
BITA n=1989
SITA n=4147
P < 0.001
401
(2889)
Reoperation
(1763)
302

Arterial conduits used for coronary artery bypass grafting

- Internal Thoracic Artery
- Radial Artery
- Right Gastroepiploic Artery
- Inferior Epigastric Artery
- Others


(a)
proximal anastomosis
graft trunk
distal anastomosis
native vessel, distal
(b)
RITA to LAD
LITA sequential graft to marginal branches
(c)
RITA - RA extension to posterior descending branch
LITA to LAD and diagonal branch
RA 'Y' to marginal branch
RA
(d)
RITA via transverse sinus to maginal branch
LITA to LAD and diagonal branch
GEA to posterior branch of RCA

A meta-analysis comparing bilateral internal mammary artery with left internal mammary artery for coronary artery bypass grafting

Aaron J. Weiss[1,2], Shan Zhao[3], David H. Tian[2], David P. Taggart[4], Tristan D. Yan[2,5]

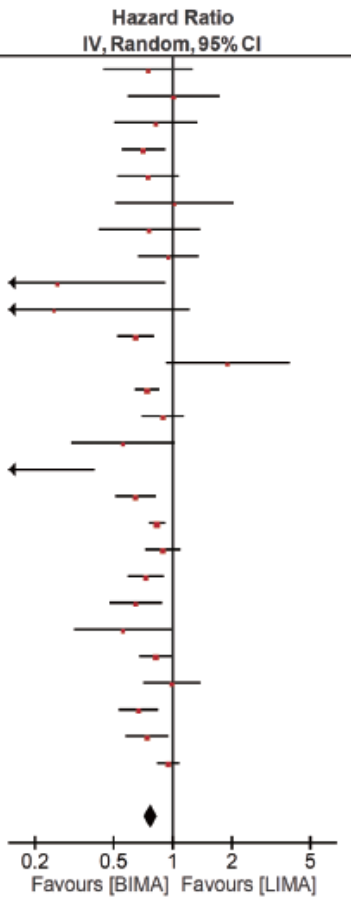
[1]Department of Cardiothoracic Surgery, Mount Sinai School of Medicine, New York City, New York, USA; [2]The Collaborative Research (CORE) Group, Sydney, Australia; [3]Department of Pharmacology and Systems Therapeutics, Mount Sinai School of Medicine, New York City, New York, USA; [4]Department of Cardiac Surgery, John Radcliffe Hospital, Oxford University Hospitals NHS Trust, Oxford, UK; [5]Department of Cardiothoracic Surgery, Royal Prince Alfred Hospital, University of Sydney, Sydney, Australia

Corresponding to: Aaron J. Weiss, M.D. Department of Cardiothoracic Surgery, Mount Sinai Medical Center, 1190 Fifth Avenue Box 1029, New York, NY 10029, USA. Email: aaron.weiss@mountsinai.org.

Study or Subgroup	log[Hazard Ratio]	SE	BIMA Total	LIMA Total	Weight	Hazard Ratio IV, Random, 95% CI	Year
Naunheim	-0.288	0.265	100	100	1.7%	0.75 [0.45, 1.26]	1992
Dewar	0.01	0.272	377	765	1.6%	1.01 [0.59, 1.72]	1995
Pick	-0.198	0.247	160	161	1.9%	0.82 [0.51, 1.33]	1997
Buxton	-0.342	0.127	1269	1557	4.9%	0.71 [0.55, 0.91]	1998
Jones	-0.288	0.181	172	338	3.1%	0.75 [0.53, 1.07]	2000
Tarelli	0.02	0.349	150	150	1.0%	1.02 [0.51, 2.02]	2001
Berreklouw	-0.274	0.301	249	233	1.4%	0.76 [0.42, 1.37]	2001
Endo	-0.051	0.179	443	688	3.1%	0.95 [0.67, 1.35]	2001
Danzer	-1.347	0.639	382	139	0.3%	0.26 [0.07, 0.91]	2001
Hirotani	-1.386	0.805	179	124	0.2%	0.25 [0.05, 1.21]	2003
Stevens	-0.431	0.106	1808	2498	5.8%	0.65 [0.53, 0.80]	2004
Calafiore	0.642	0.367	570	570	1.0%	1.90 [0.93, 3.90]	2004
Lytle	-0.301	0.071	1152	1152	7.9%	0.74 [0.64, 0.85]	2004
Toumpoulis	-0.117	0.126	490	490	4.9%	0.89 [0.69, 1.14]	2006
Bonacchi	-0.58	0.306	320	332	1.3%	0.56 [0.31, 1.02]	2006
Mohammadi	-3.912	1.528	1388	9566	0.1%	0.02 [0.00, 0.40]	2008
Carrier	-0.431	0.119	1235	5420	5.2%	0.65 [0.51, 0.82]	2009
Kurlansky	-0.186	0.047	2215	2369	9.3%	0.83 [0.76, 0.91]	2010
Kieser	-0.117	0.103	1038	4029	6.0%	0.89 [0.73, 1.09]	2011
Locker	-0.315	0.107	1153	1153	5.8%	0.73 [0.59, 0.90]	2012
Puskas	-0.431	0.155	812	2715	3.8%	0.65 [0.48, 0.88]	2012
Kinoshita	-0.58	0.291	217	217	1.4%	0.56 [0.32, 0.99]	2012
Kelly	-0.198	0.096	1079	6554	6.4%	0.82 [0.68, 0.99]	2012
Joo	-0.01	0.169	366	366	3.4%	0.99 [0.71, 1.38]	2012
Grau	-0.4	0.115	928	928	5.4%	0.67 [0.54, 0.84]	2012
Glineur	-0.301	0.127	297	291	4.9%	0.74 [0.58, 0.95]	2012
Parsa	-0.051	0.065	728	16881	8.2%	0.95 [0.84, 1.08]	2013
Total (95% CI)			**19277**	**59786**	**100.0%**	**0.78 [0.72, 0.84]**	

Heterogeneity: Tau² = 0.01; Chi² = 47.10, df = 26 (P = 0.007); I² = 45%

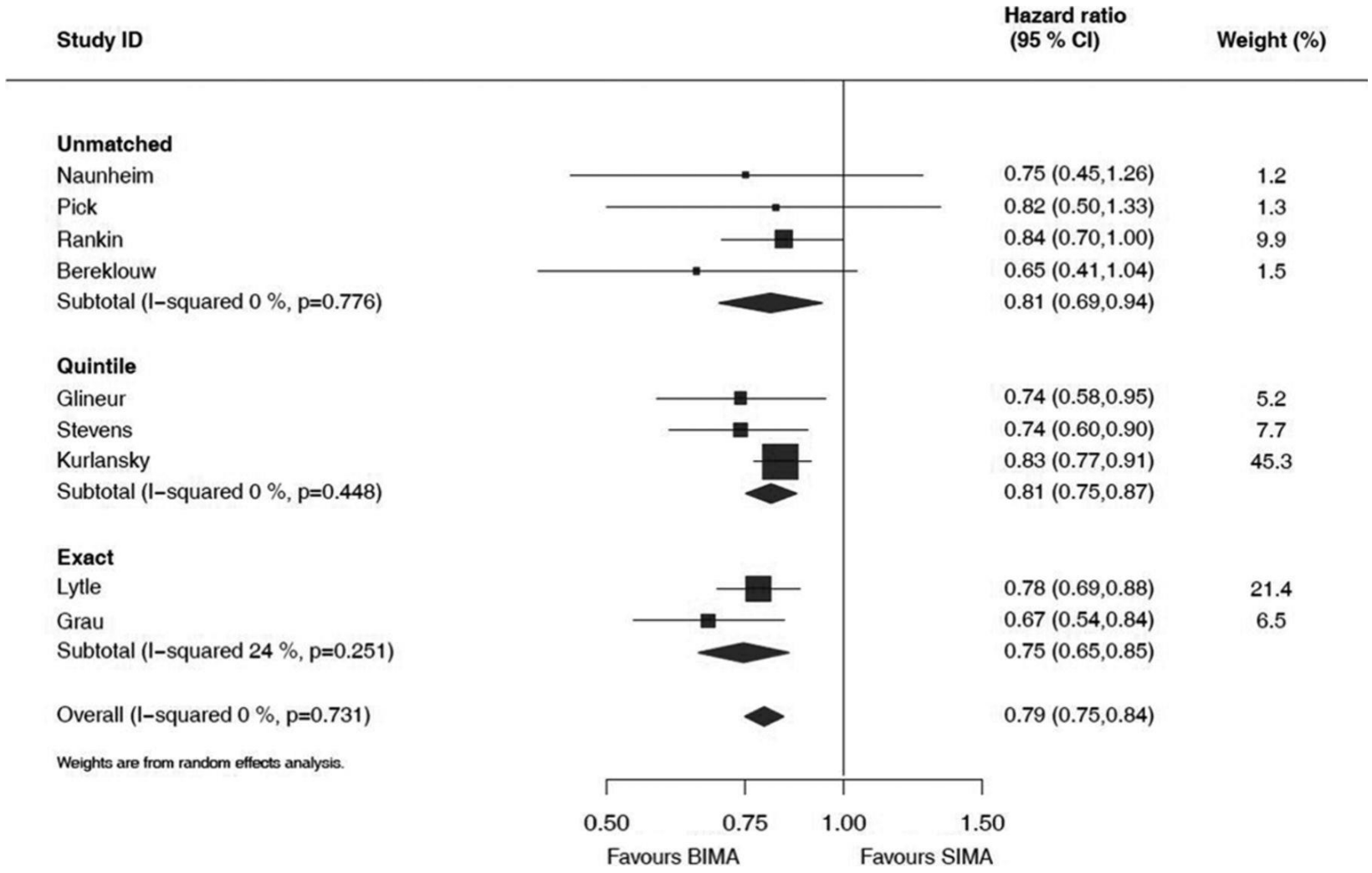
Test for overall effect: Z = 6.61 (P < 0.00001)



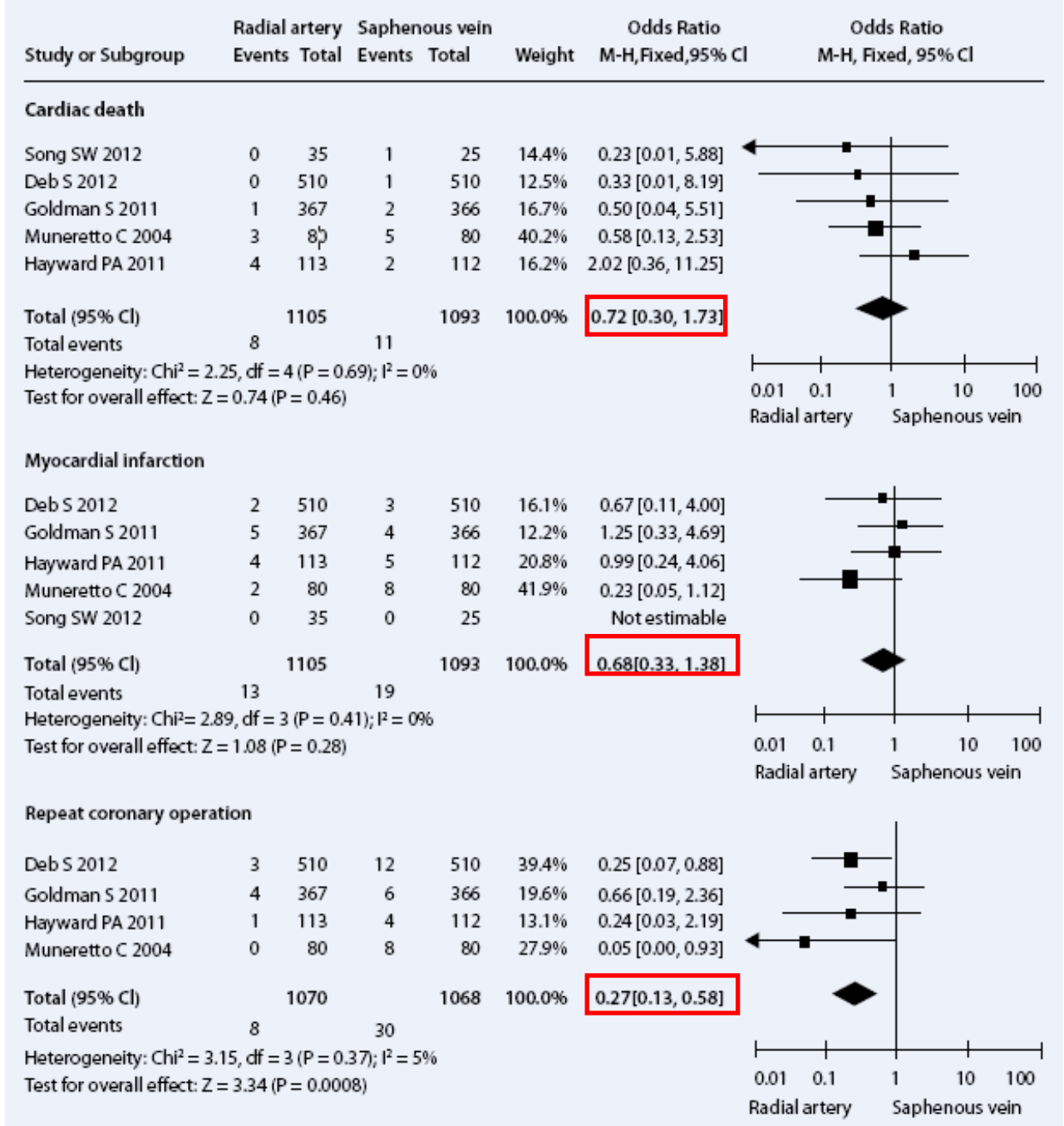
Fourth Year Cardiac Clerkship Presentation

Ann Cardiothorac Surg 2013

Effects of bilateral internal mammary artery grafting on long-term survival.



Gijong Yi et al. Circulation. 2014;130:539-545



Comparison of radial artery versus saphenous vein for clinical outcomes

Zhang H. *Herz* 2013

Saphenous Vein Graft Failure After Coronary Artery Bypass Surgery
Insights From PREVENT IV

Connie N. Hess, MD, MHS; Renato D. Lopes, MD, PhD; C. Michael Gibson, MD; Rebecca Hager, MR; Daniel M. Wojdyla, MSc; Brian R. Englum, MD; Michael J. Mack, MD; Robert M. Califf, MD; Nicholas T. Kouchoukos, MD; Eric D. Peterson, MD, MPH; John H. Alexander, MD, MHS

Background—Coronary artery bypass grafting success is limited by vein graft failure (VGF). Understanding the factors associated with VGF may improve patient outcomes.

Methods and Results—We examined 1828 participants in the Project of Ex Vivo Vein Graft Engineering via Transfection IV (PREVENT IV) trial undergoing protocol-mandated follow-up angiography 12 to 18 months post–coronary artery bypass grafting or earlier clinically driven angiography. Outcomes included patient- and graft-level angiographic VGF (≥75% stenosis or occlusion). Variables were selected by using Fast False Selection Rate methodology. We examined relationships between variables and VGF in patient- and graft-level models by using logistic regression without and with generalized estimating equations. At 12 to 18 months post–coronary artery bypass grafting, 782 of 1828 (42.8%) patients had VGF, and 1096 of 4343 (25.2%) vein grafts had failed. Demographic and clinical characteristics were similar between patients with and without VGF, although VGF patients had longer surgical times, worse target artery quality, longer graft length, and they more frequently underwent endoscopic vein harvesting. After multivariable adjustment, longer surgical duration (odds ratio per 10-minute increase, 1.05; 95% confidence interval, 1.03–1.07), endoscopic vein harvesting (odds ratio, 1.41; 95% confidence interval, 1.16–1.71), poor target artery quality (odds ratio, 1.43; 95% confidence interval, 1.11–1.84), and postoperative use of clopidogrel or ticlopidine (odds ratio, 1.35; 95% confidence interval, 1.07–1.69) were associated with patient-level VGF. The predicted likelihood of VGF in the graft-level model ranged from 12.1% to 63.6%.

Conclusions—VGF is common and associated with patient and surgical factors. These findings may help identify patients with risk factors for VGF and inform the development of interventions to reduce VGF.

Clinical Trial Registration—URL: http://www.clinicaltrials.gov. Unique identifier: NCT00042081.

(*Circulation*. 2014;130:1445-1451.)

Prevalence and Variability of Internal Mammary Artery Graft Use in Contemporary Multivessel Coronary Artery Bypass Graft Surgery

Analysis of the Society of Thoracic Surgeons National Cardiac Database

Minoru Tabata, MD, MPH; Joshua D. Grab, MS; Zain Khalpey,
Sean M. O'Brien, PhD; Lawrence H. Cohn, MD; R.

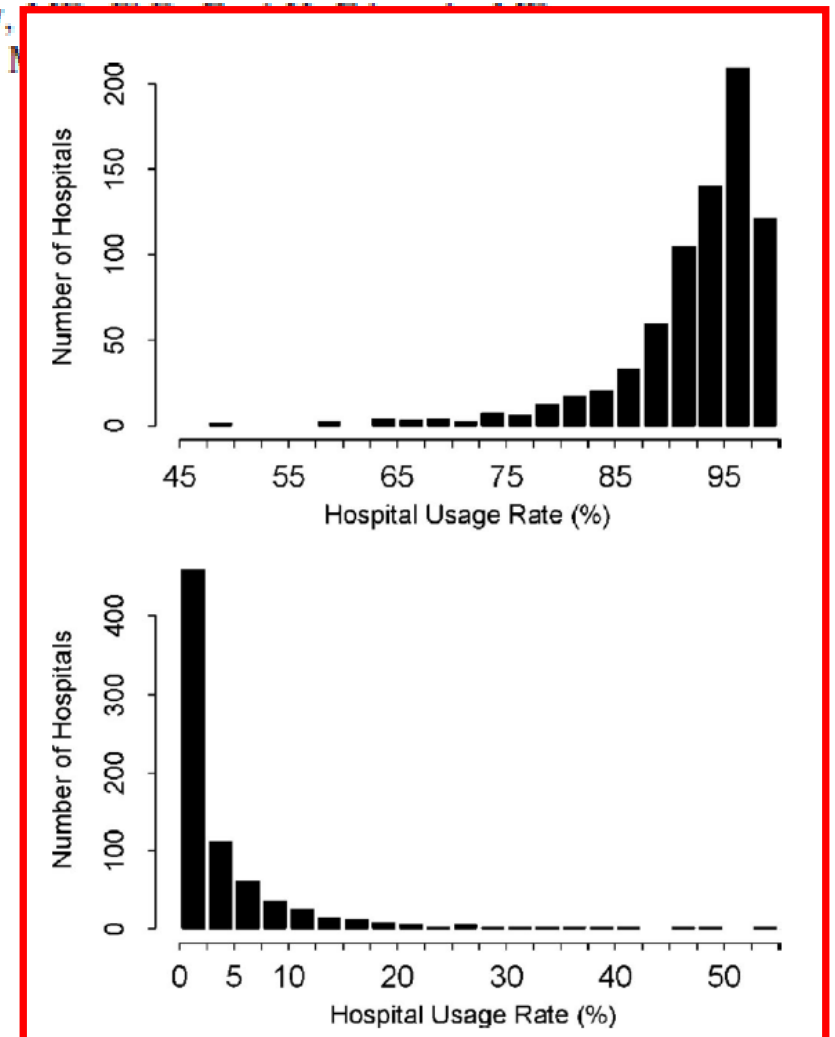
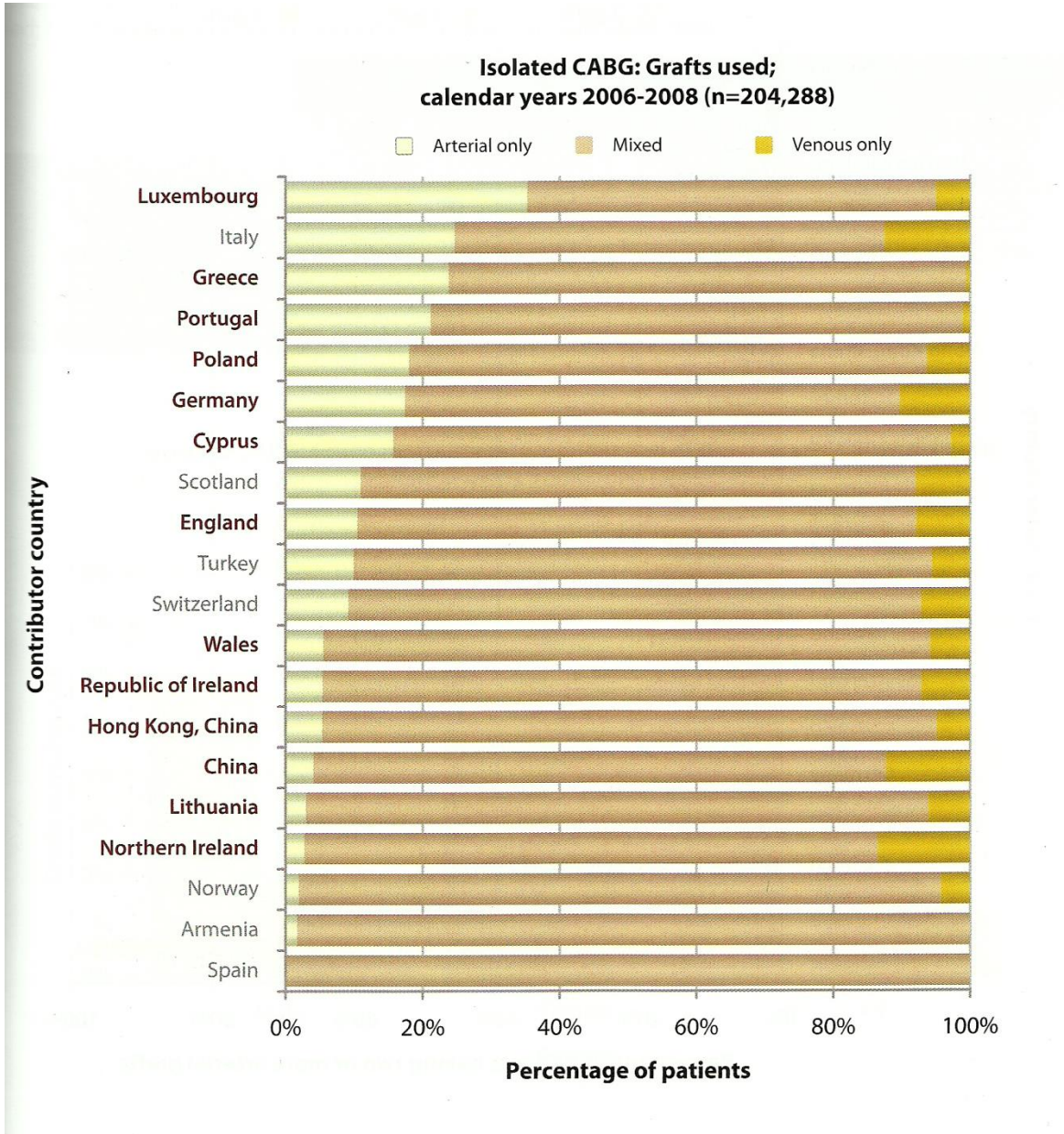


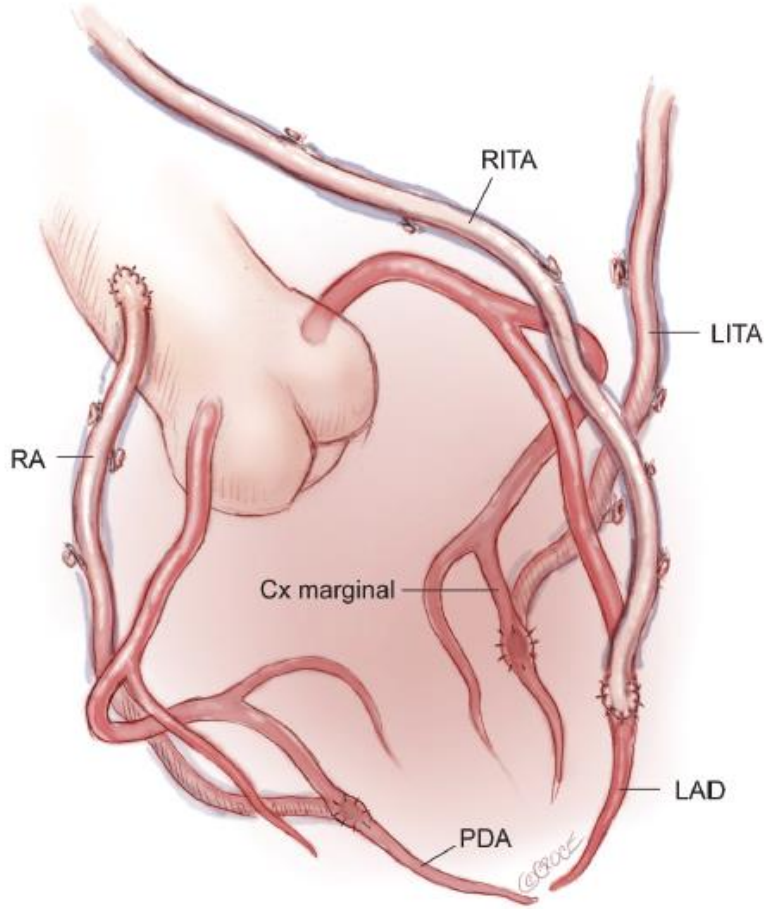
Figure 1. Histograms of the rate of using at least 1 IMA (top) and BIMA (bottom) by hospital.

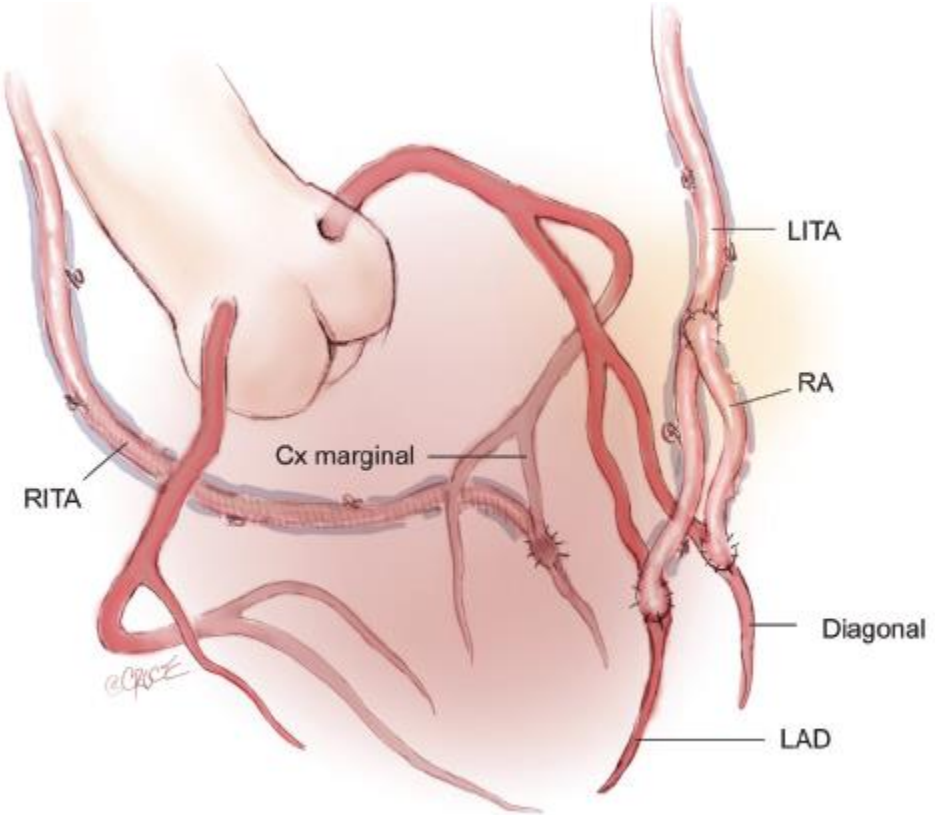

Isolated CABG: Grafts used;
calendar years 2006-2008 (n=204,288)
Arterial only
Mixed
Venous only
Contributor country
Luxembourg
Italy
Greece
Portugal
Poland
Germany
Cyprus
Scotland
England
Turkey
Switzerland
Wales
Republic of Ireland
Hong Kong, China
China
Lithuania
Northern Ireland
Norway
Armenia
Spain
0%
20%
40%
60%
80%
100%
Percentage of patients

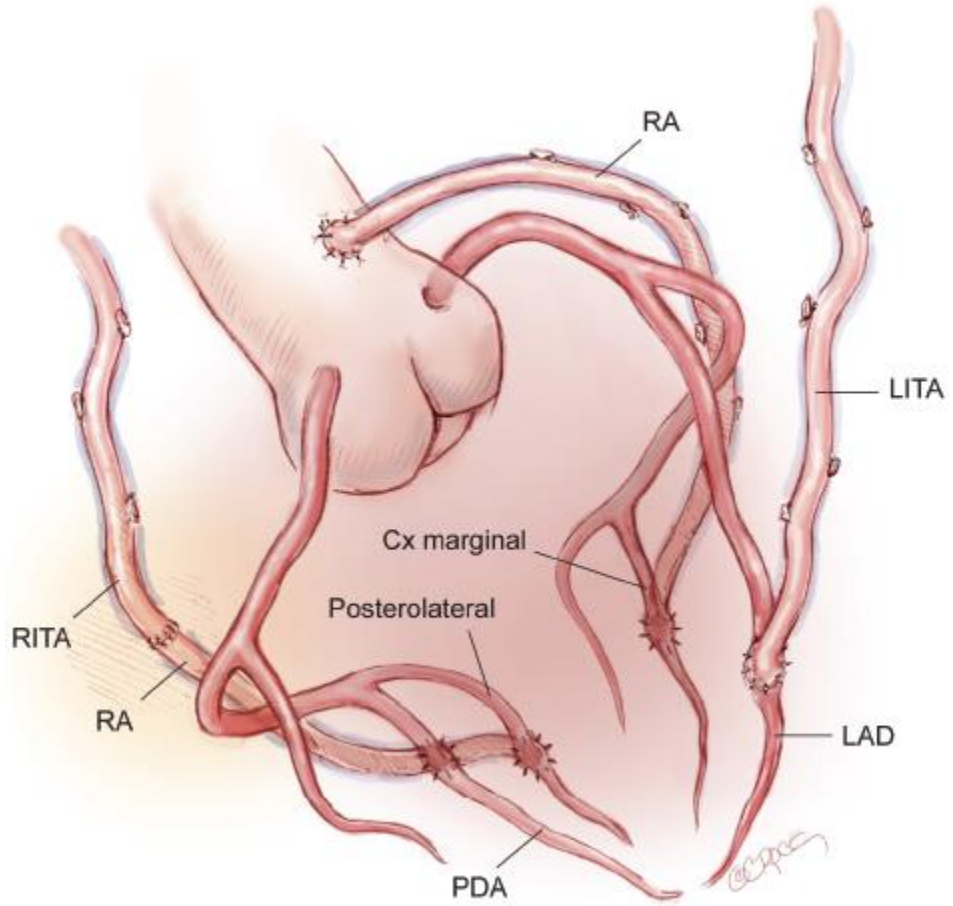
- Indication For Surgery
- Preoperative Evaluation
- Conduits decision
- Operation Decision
- ERAS

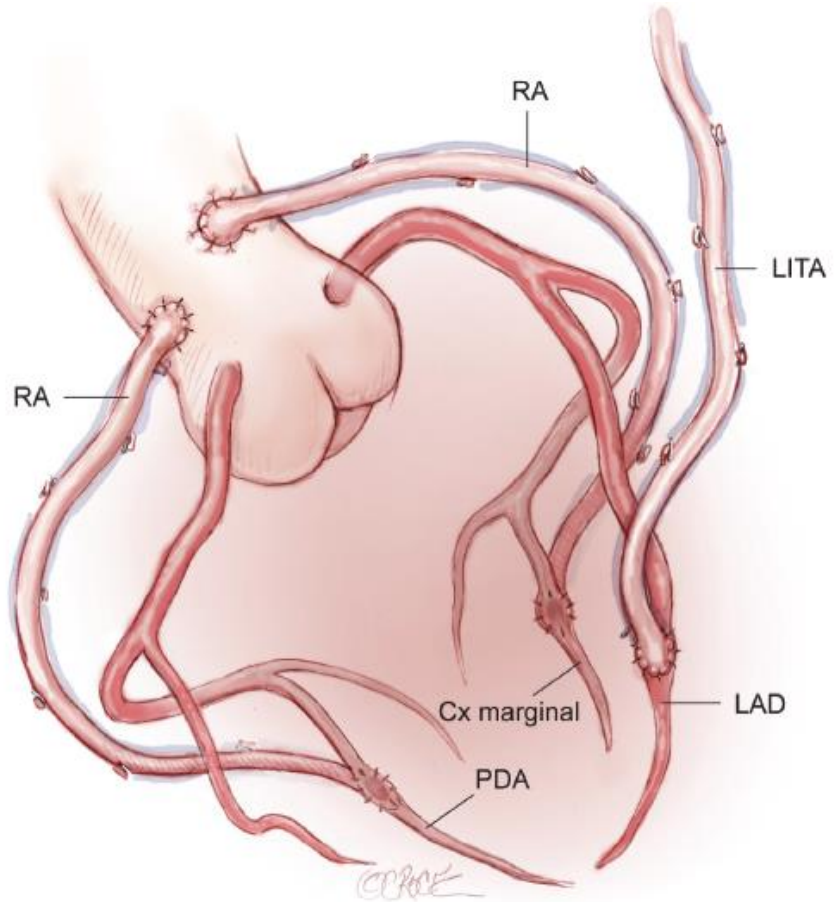
- Conduits combination
- ON Pump Vs OFF Pump

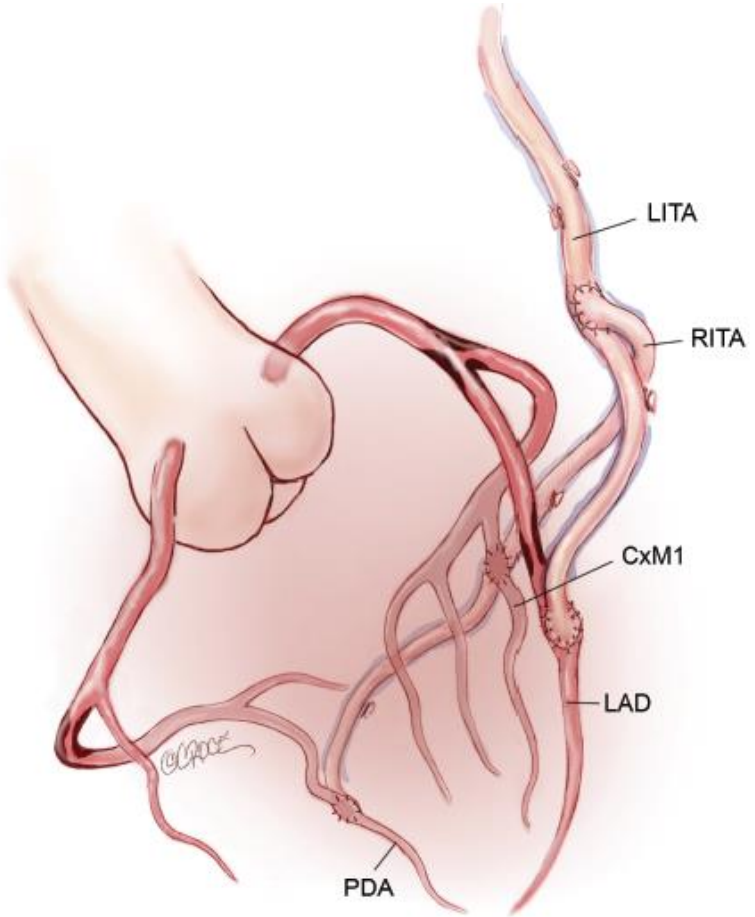
Total arterial revascularization

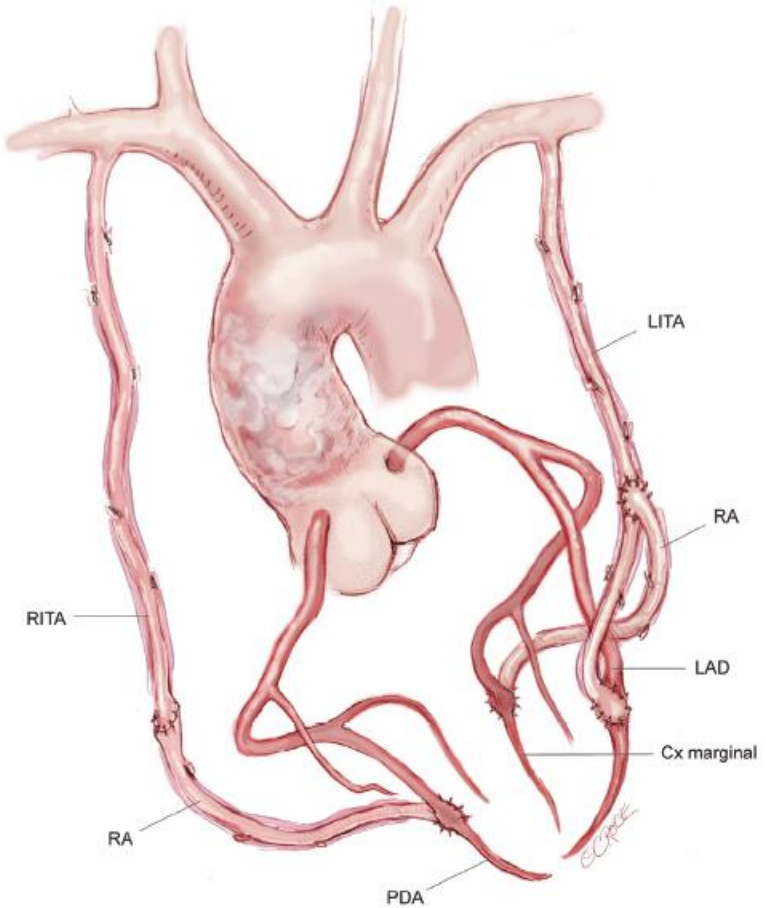


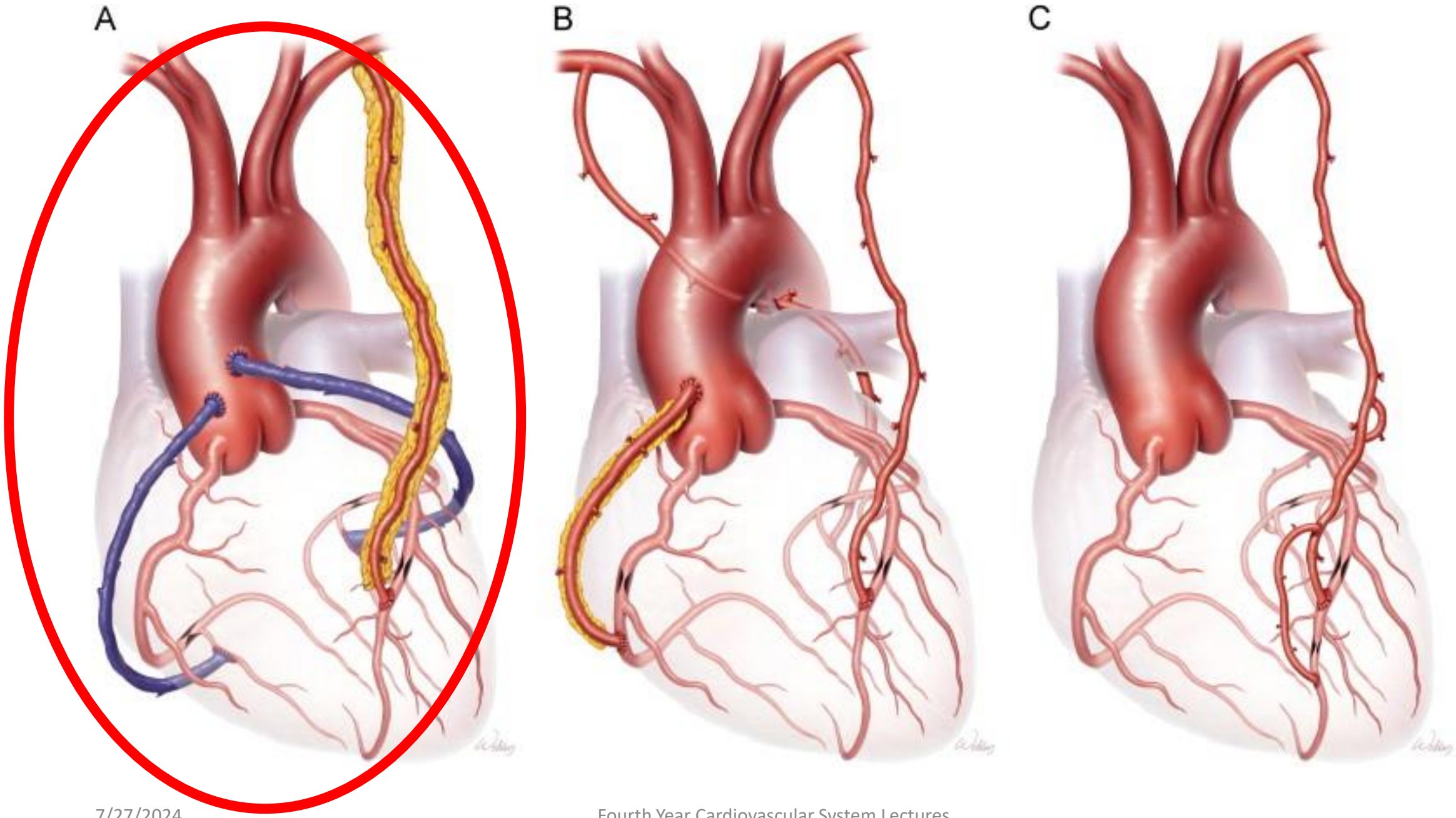

LITA
RA
Cx marginal
RITA
Diagonal
LAD


RA
LITA
Cx marginal
Posterolateral
RITA
RA
LAD
PDA


RA
LITA
RA
Cx marginal
LAD
PDA

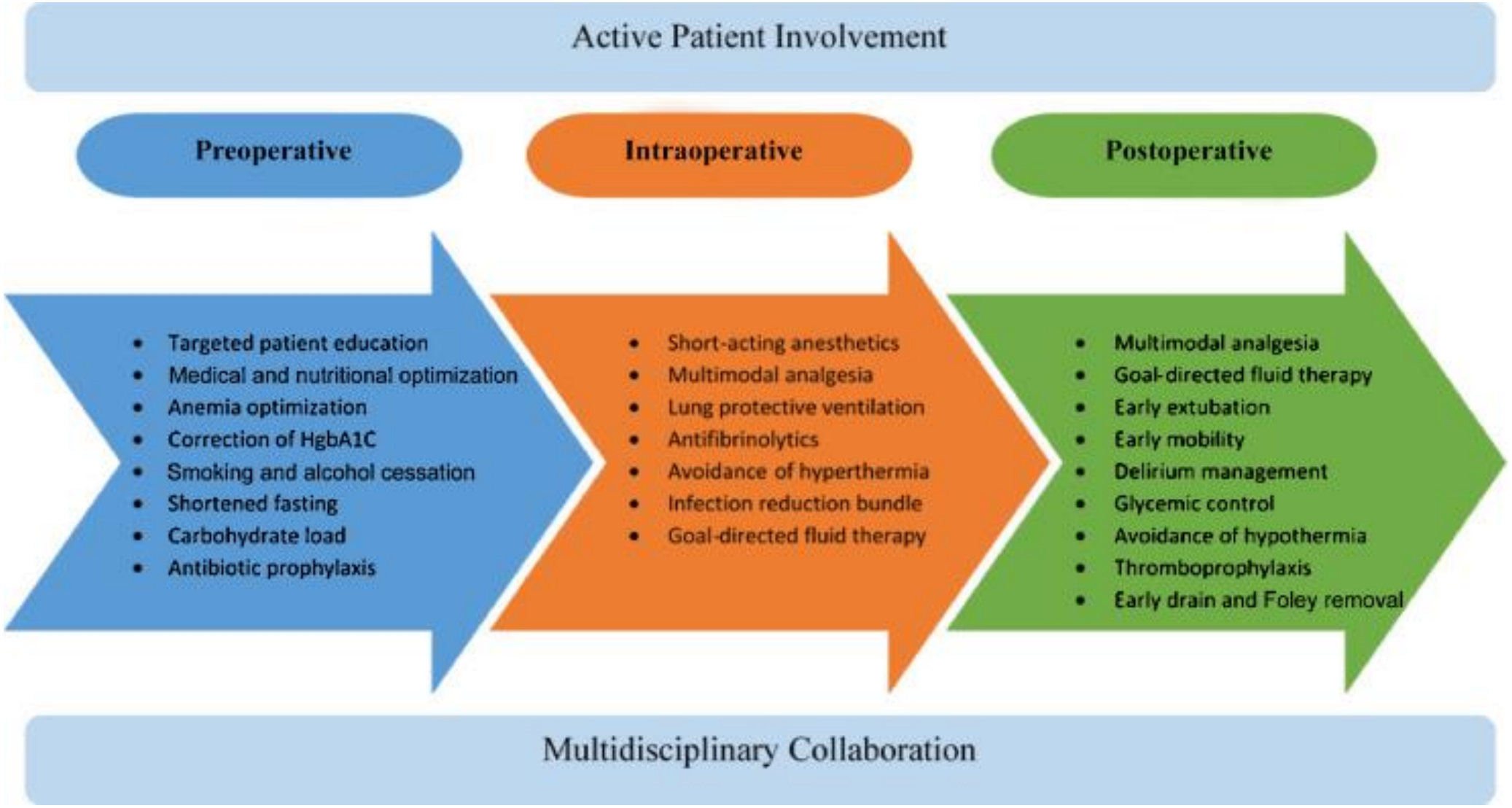

LITA
RITA
CxM1
LAD
PDA


LITA
RA
RITA
LAD
Cx marginal
RA
PDA


A
B
C

Management

- Indication For Surgery
- Preoperative Evaluation
- Conduits decision
- Operation Decision
- ERAS


Active Patient Involvement
Preoperative
Intraoperative
Postoperative
Targeted patient education
Medical and nutritional optimization
Anemia optimization
Correction of HgbA1C
Smoking and alcohol cessation
Shortened fasting
Carbohydrate load
Antibiotic prophylaxis
Short-acting anesthetics
Multimodal analgesia
Lung protective ventilation
Antifibrinolytics
Avoidance of hyperthermia
Infection reduction bundle
Goal-directed fluid therapy
Multimodal analgesia
Goal-directed fluid therapy
Early extubation
Early mobility
Delirium management
Glycemic control
Avoidance of hypothermia
Thromboprophylaxis
Early drain and Foley removal
Multidisciplinary Collaboration

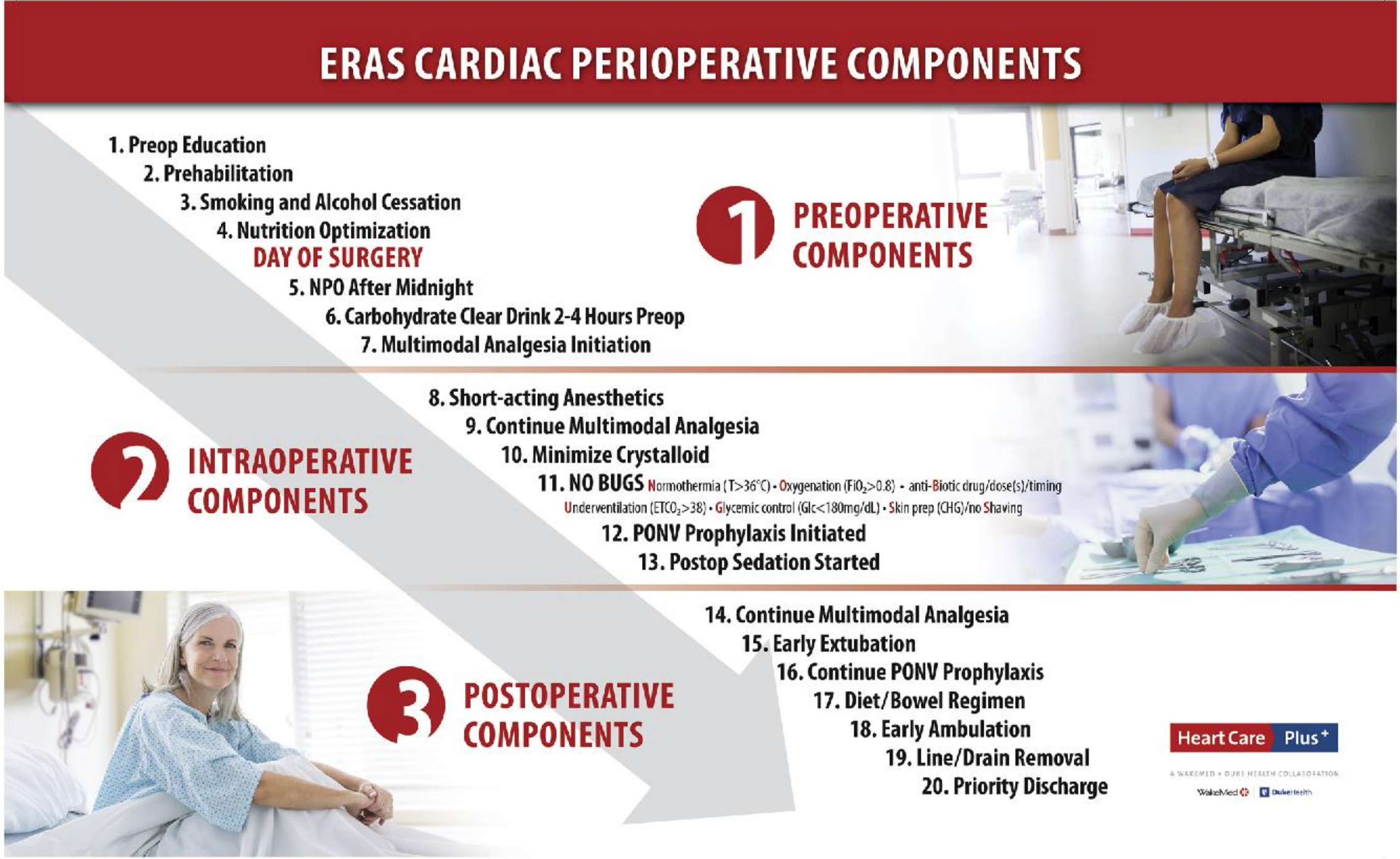


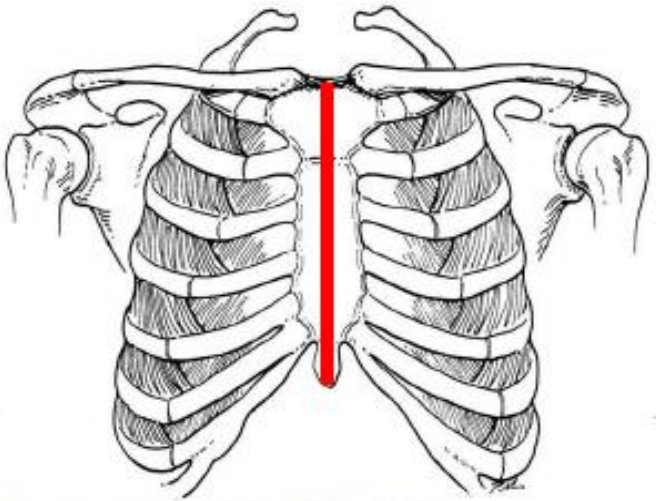
FIGURE 1 Graphic displaying the key components of the ERAS Cardiac protocol through each phase of perioperative care. *CHG*, Chlorhexidine gluco-

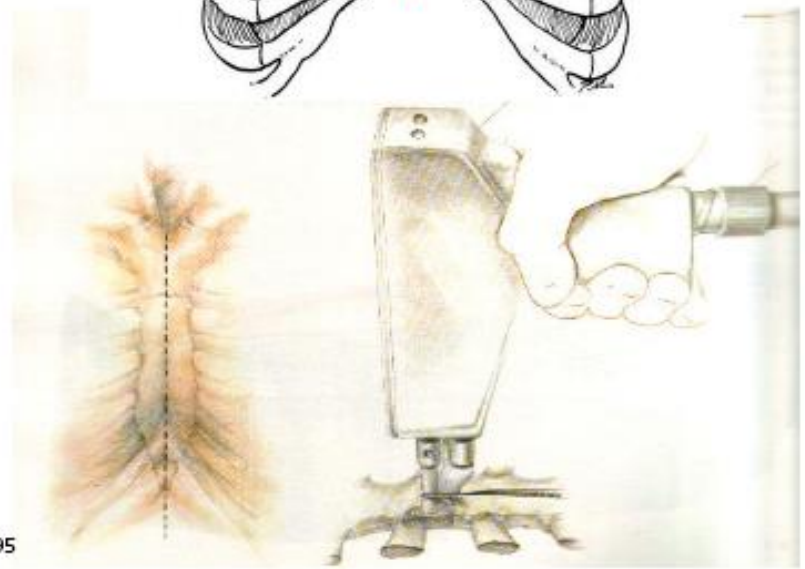
INTRODUCTION

- HISTORY OF CARDIAC SURGERY
- CORONARY ARTERY ANATOMY
- MANAGEMENT
- SURGICAL TECHNIQUES

Sternotomy

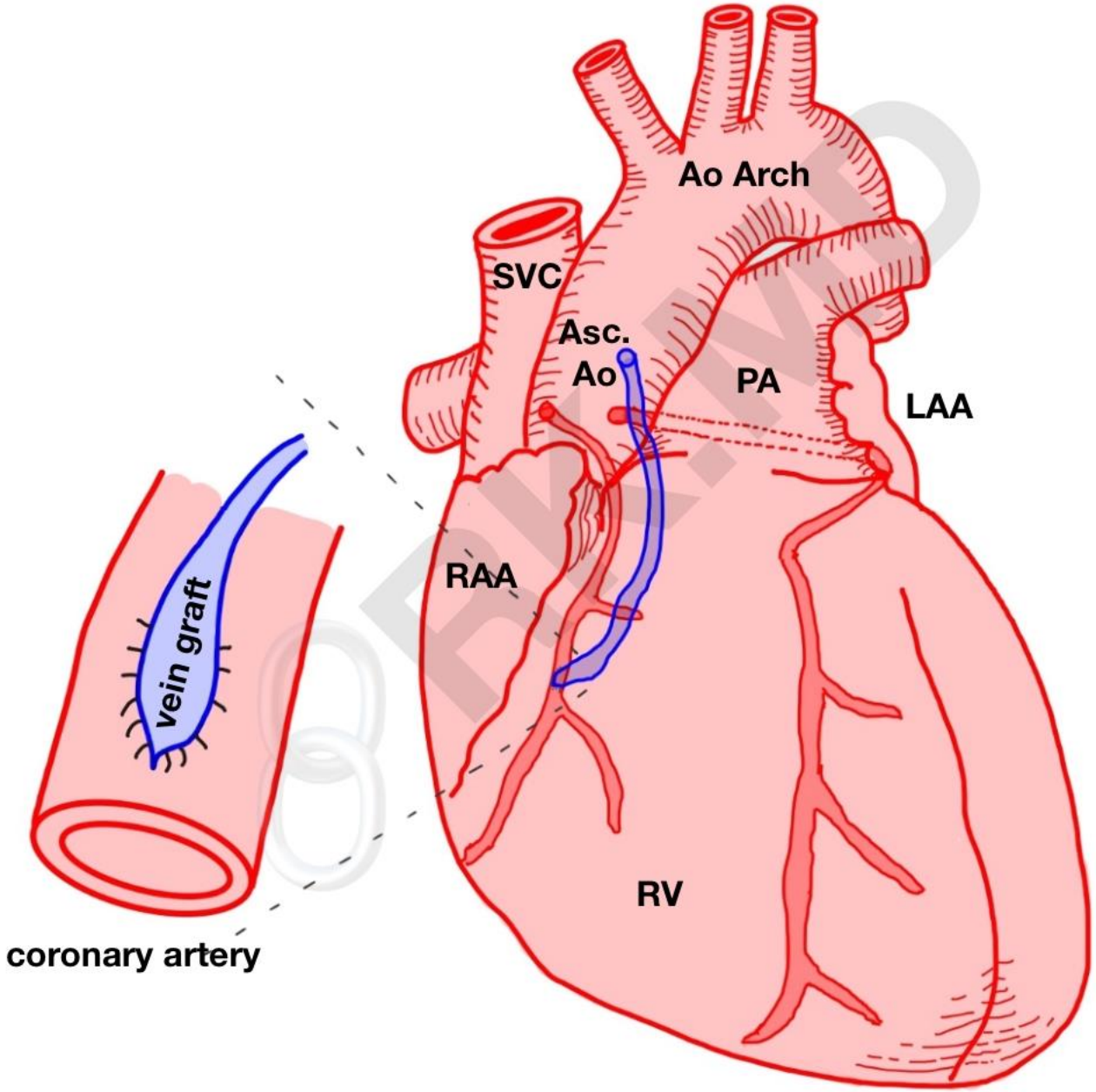
- Sternotomy approach
  - allows almost all cardiac procedures
  - best overall access to the heart
- The sternum is divided with a saw

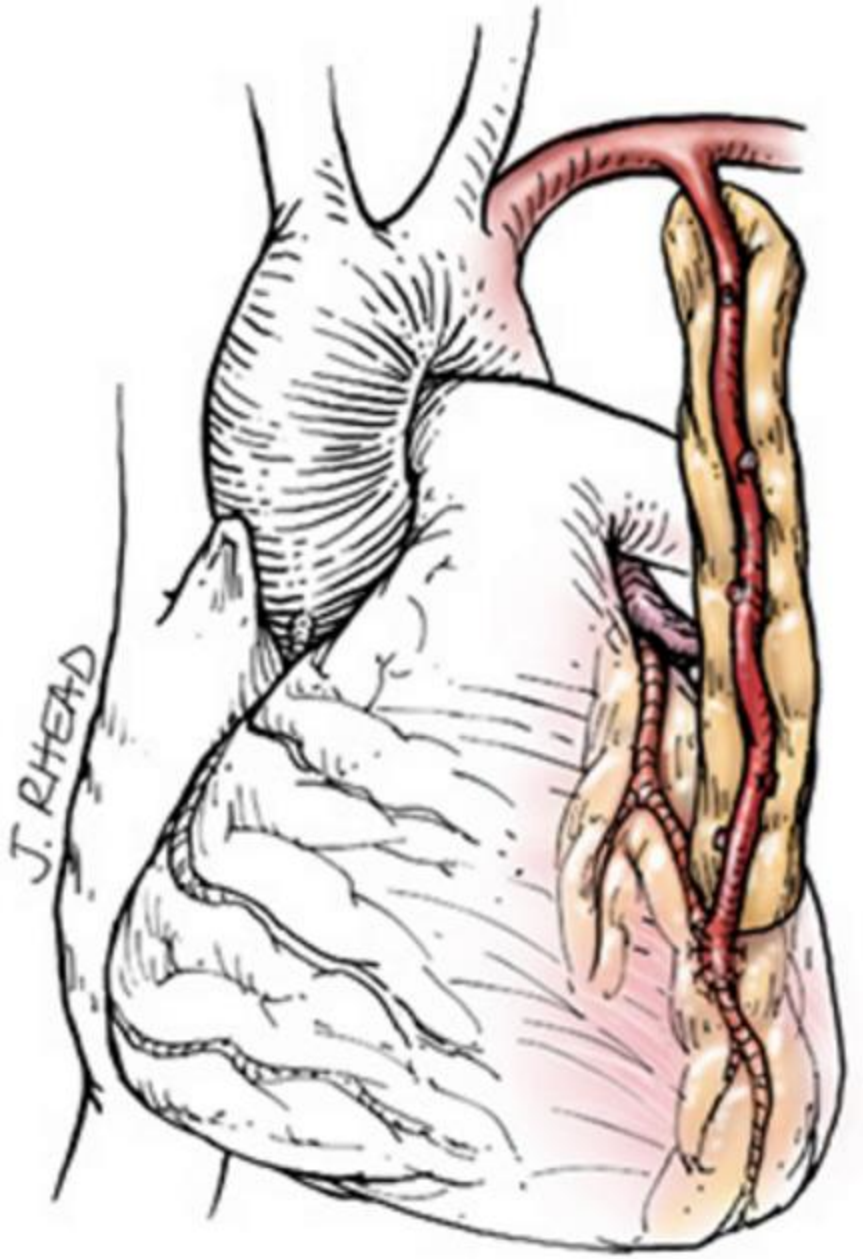




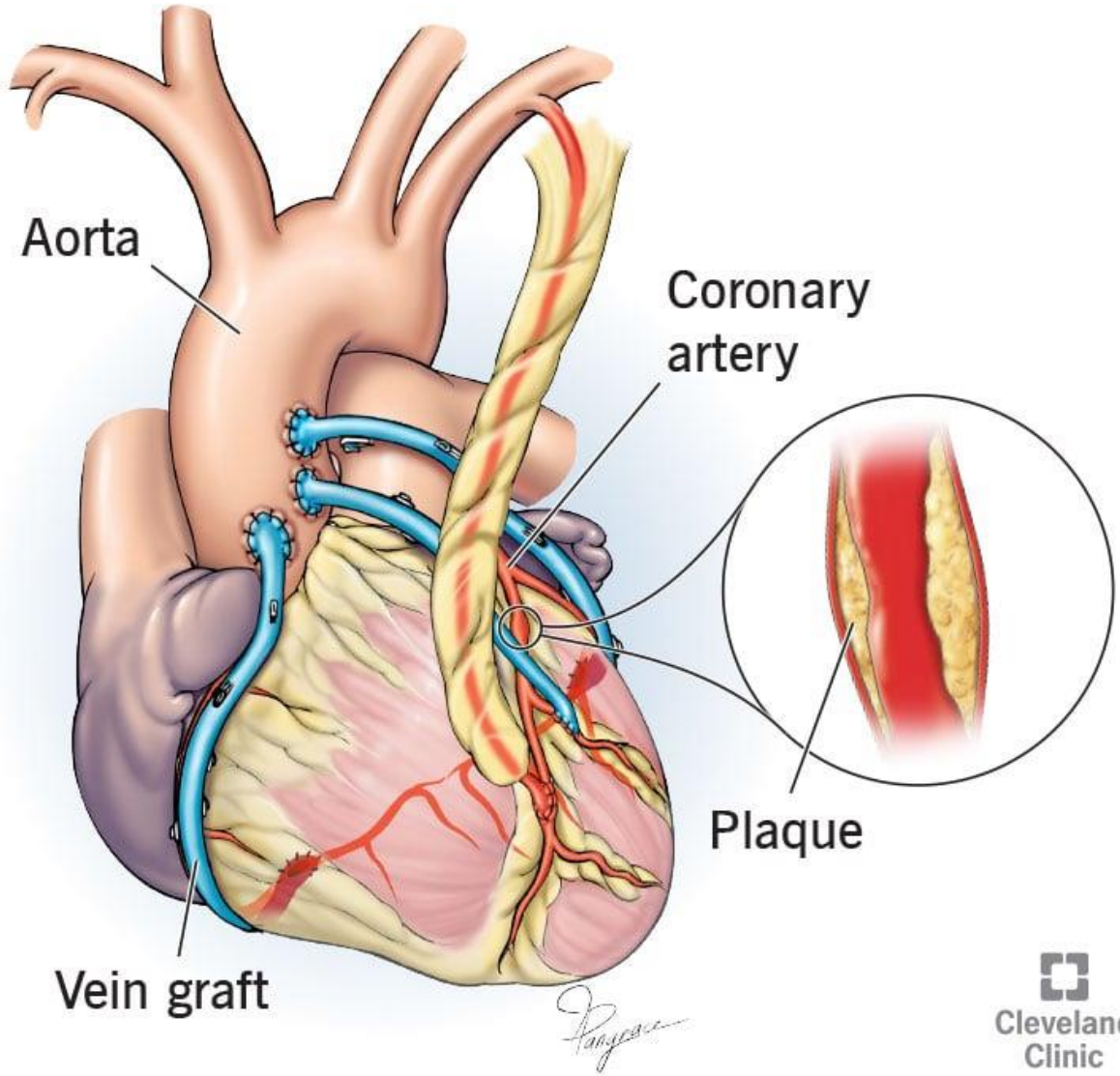
From : Manual of Cardiac Surgery, Harlan & Starr, Springer-Verlag, New York , 1995

CORONARY ARTERY BYPASS

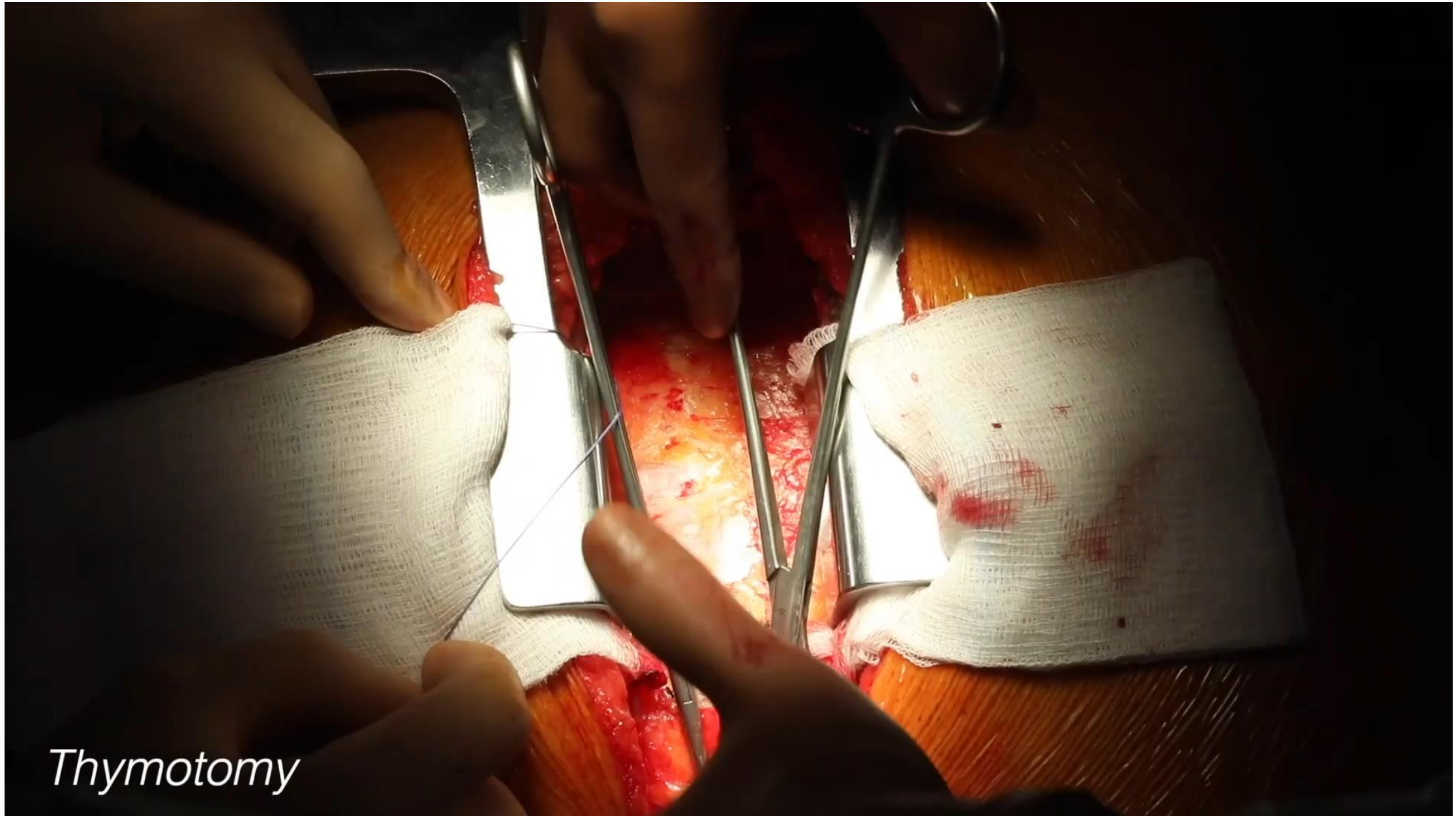


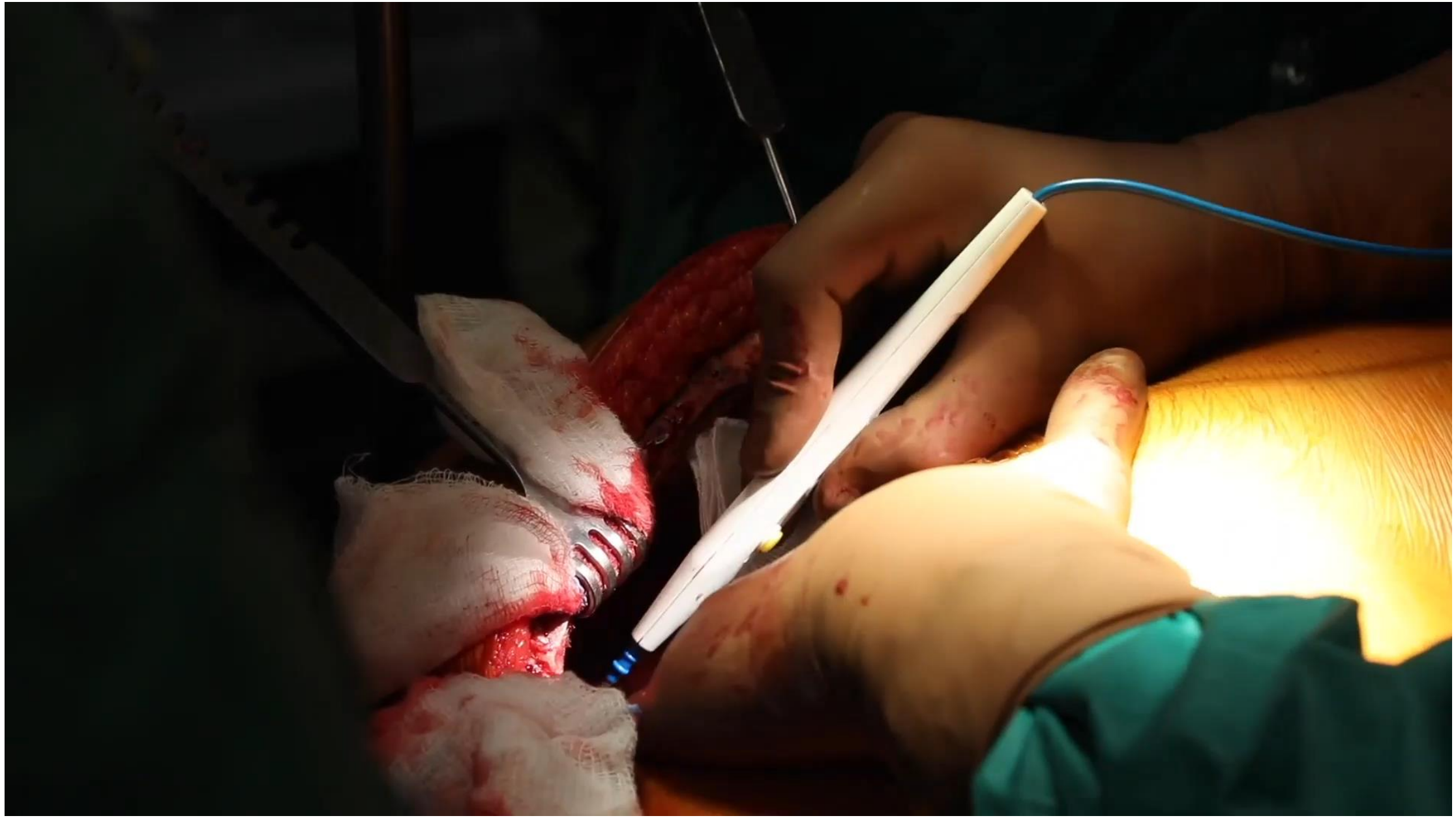

J. RHEAD

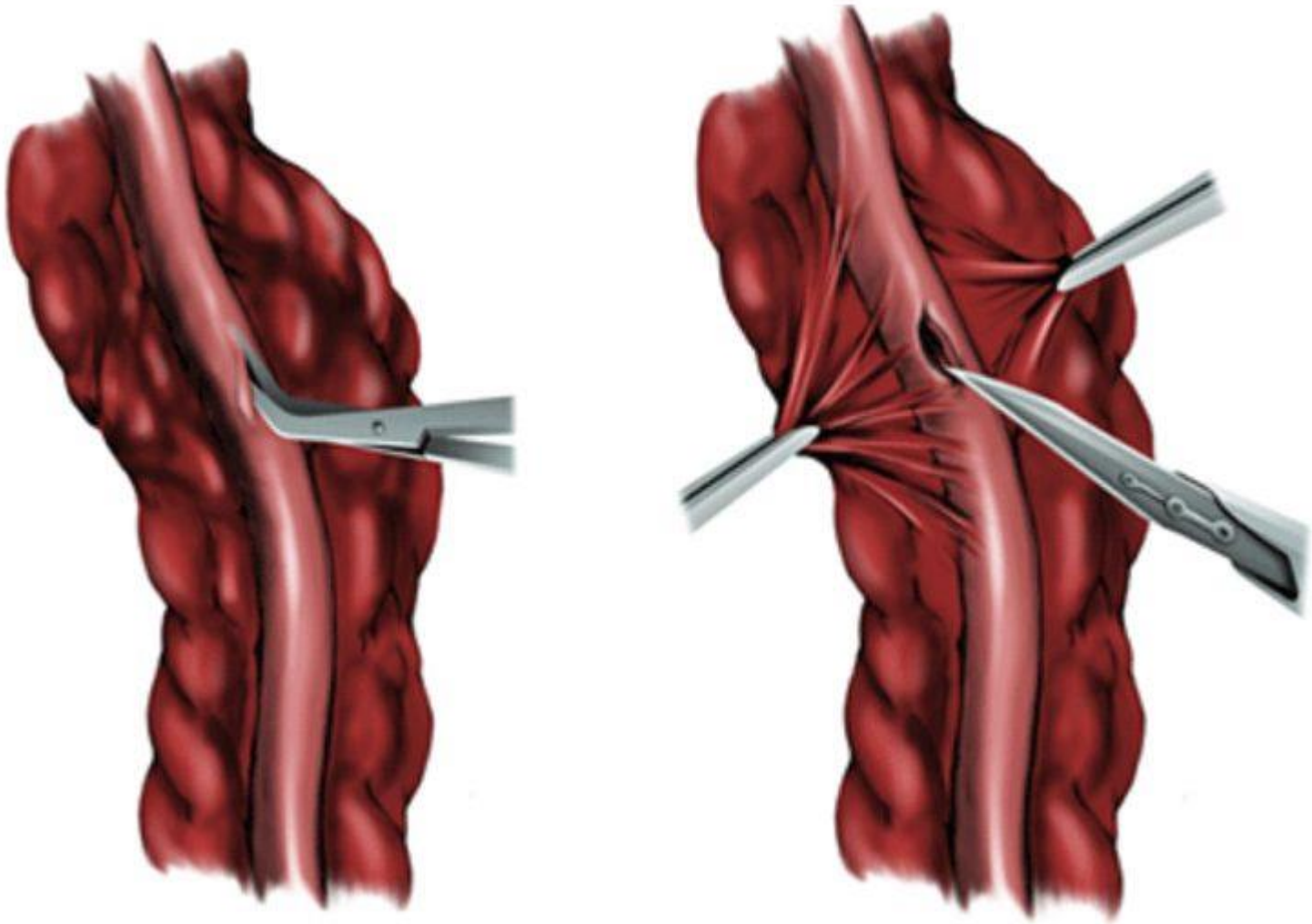
Coronary artery bypass grafting (CABG)

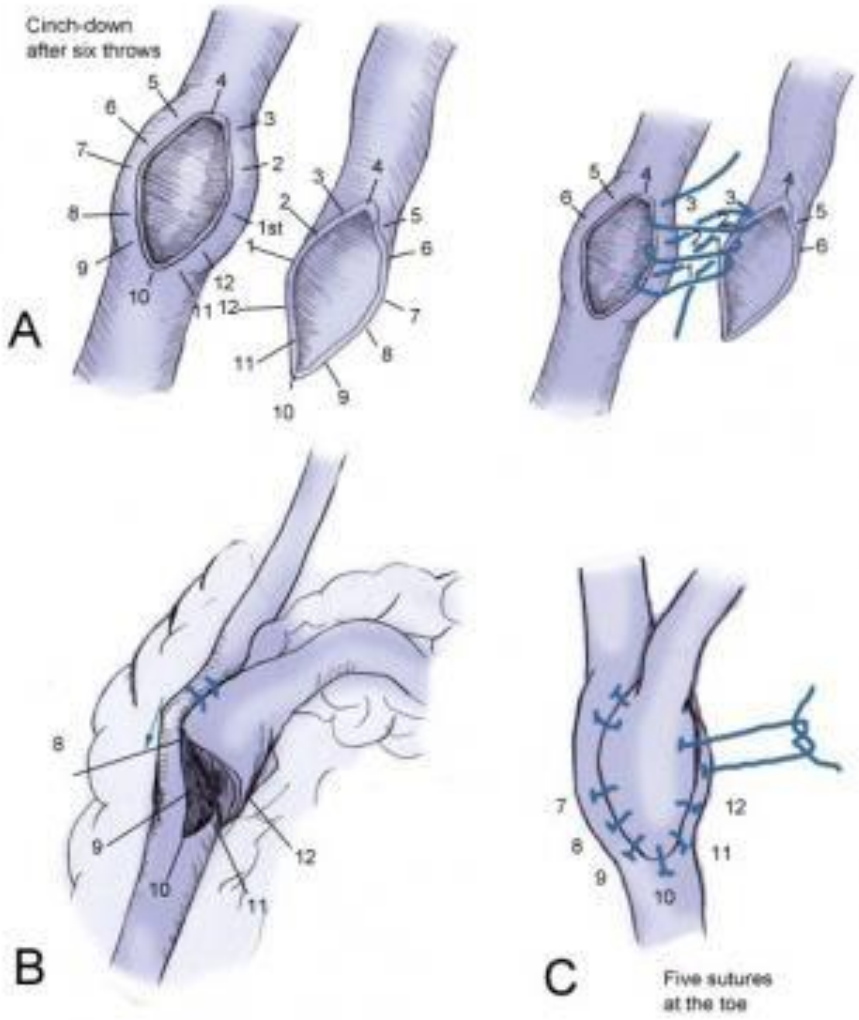


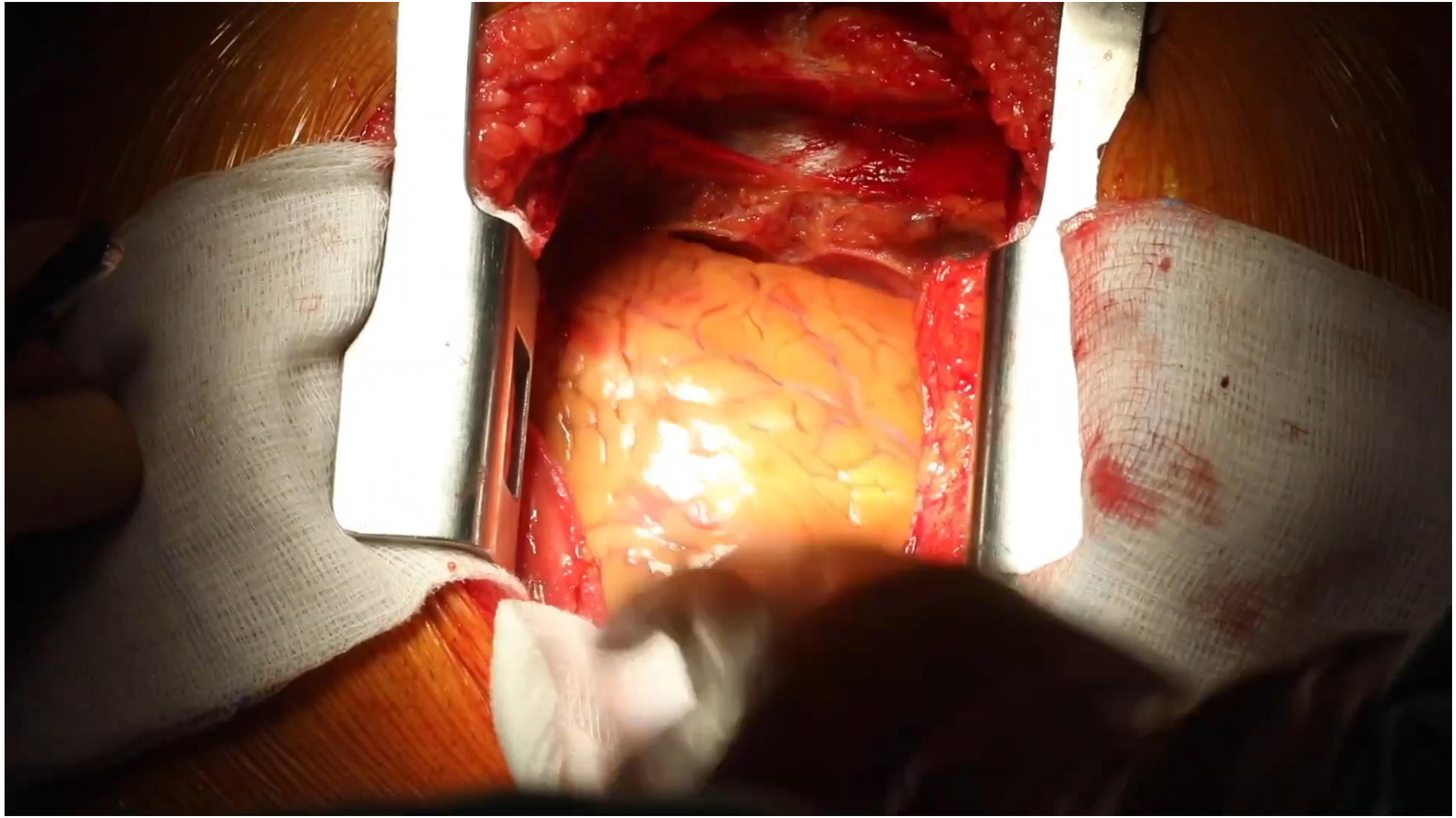
Cleveland Clinic


Thymotomy

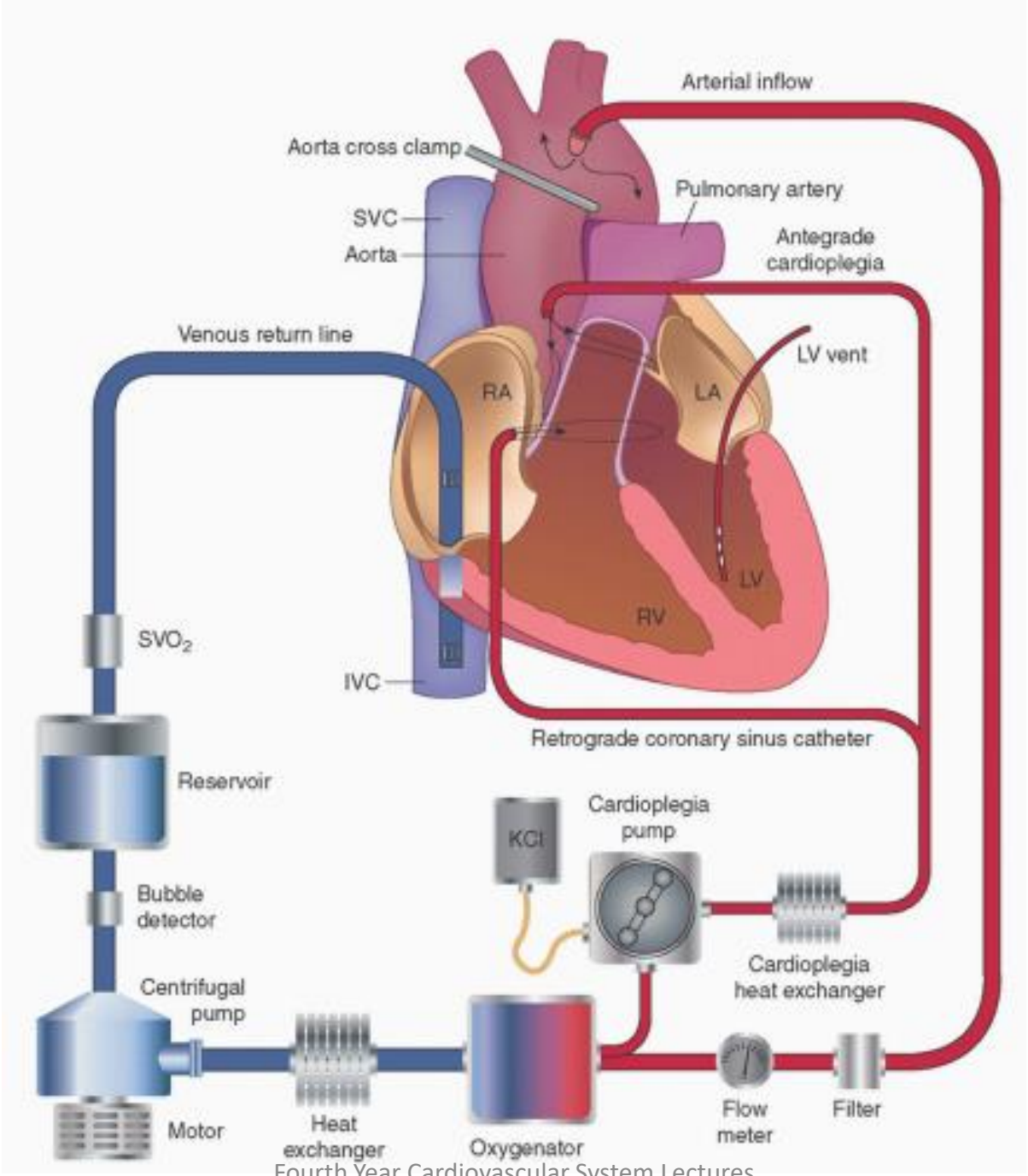


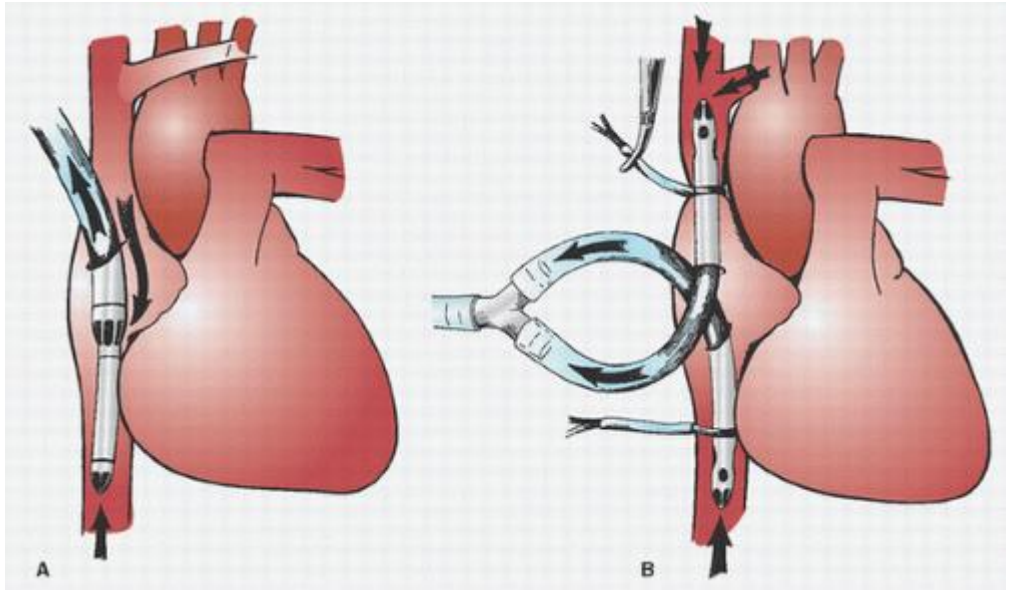


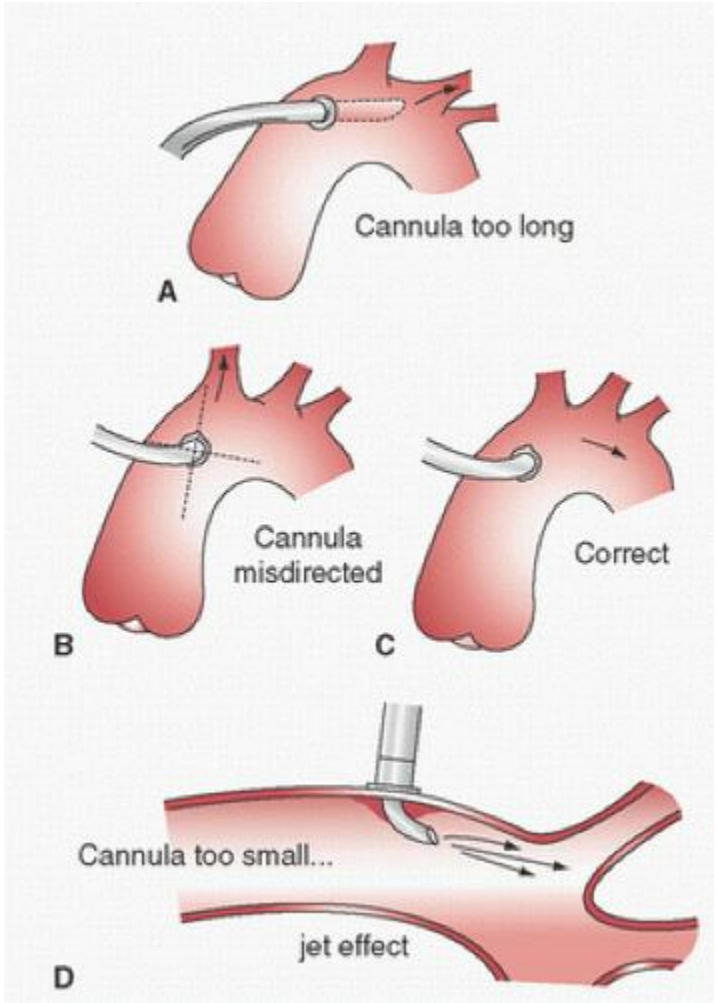

Cinch-down
after six throws
A
B
C
Five sutures
at the toe

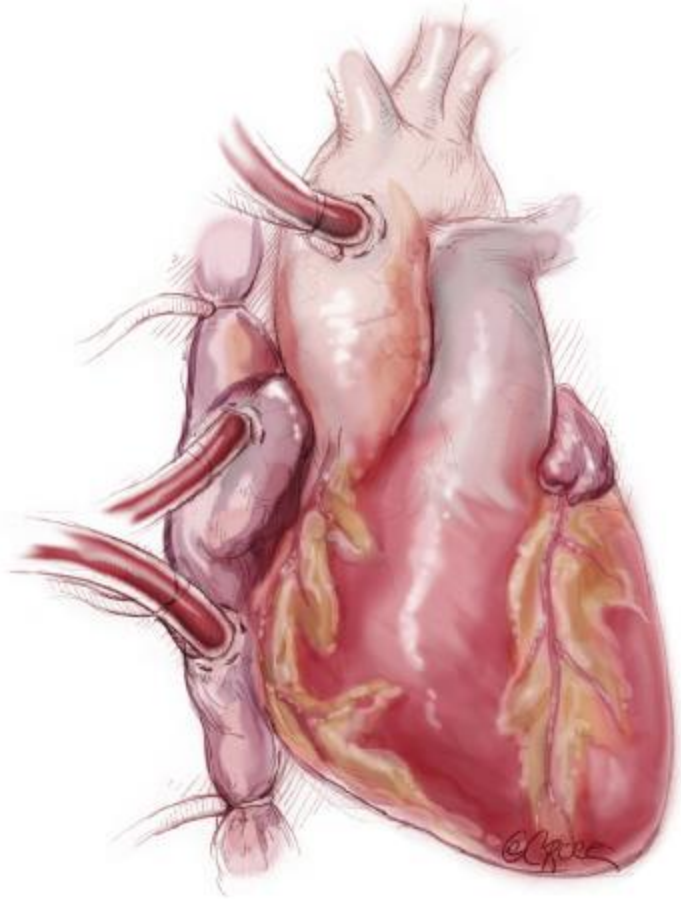


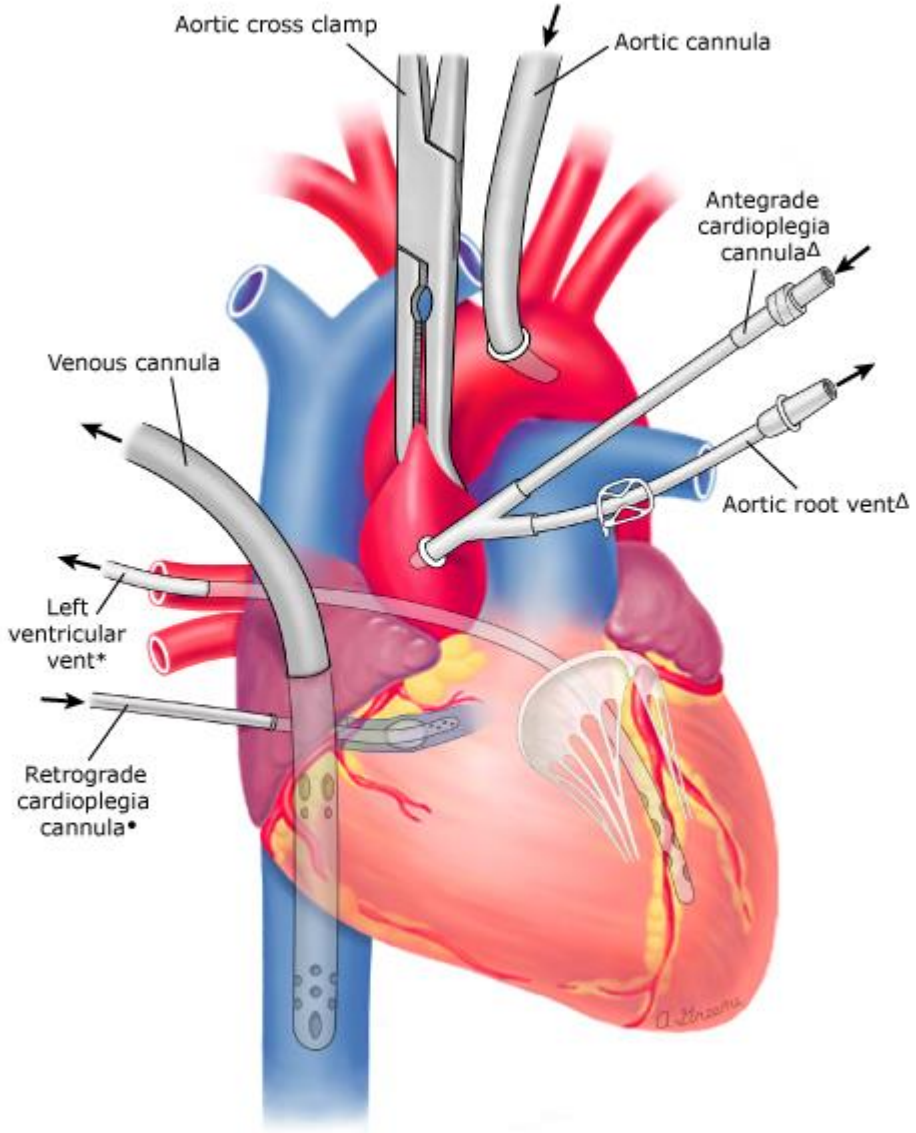
Heart Lung Machine


Arterial inflow
Aorta cross clamp
Pulmonary artery
SVC
Aorta
Antegrade cardioplegia
Venous return line
LV vent
RA
LA
LV
RV
SVO_2
IVC
Retrograde coronary sinus catheter
Reservoir
KCl
Cardioplegia pump
Bubble detector
Cardioplegia heat exchanger
Centrifugal pump
Motor
Heat exchanger
Oxygenator
Flow meter
Filter

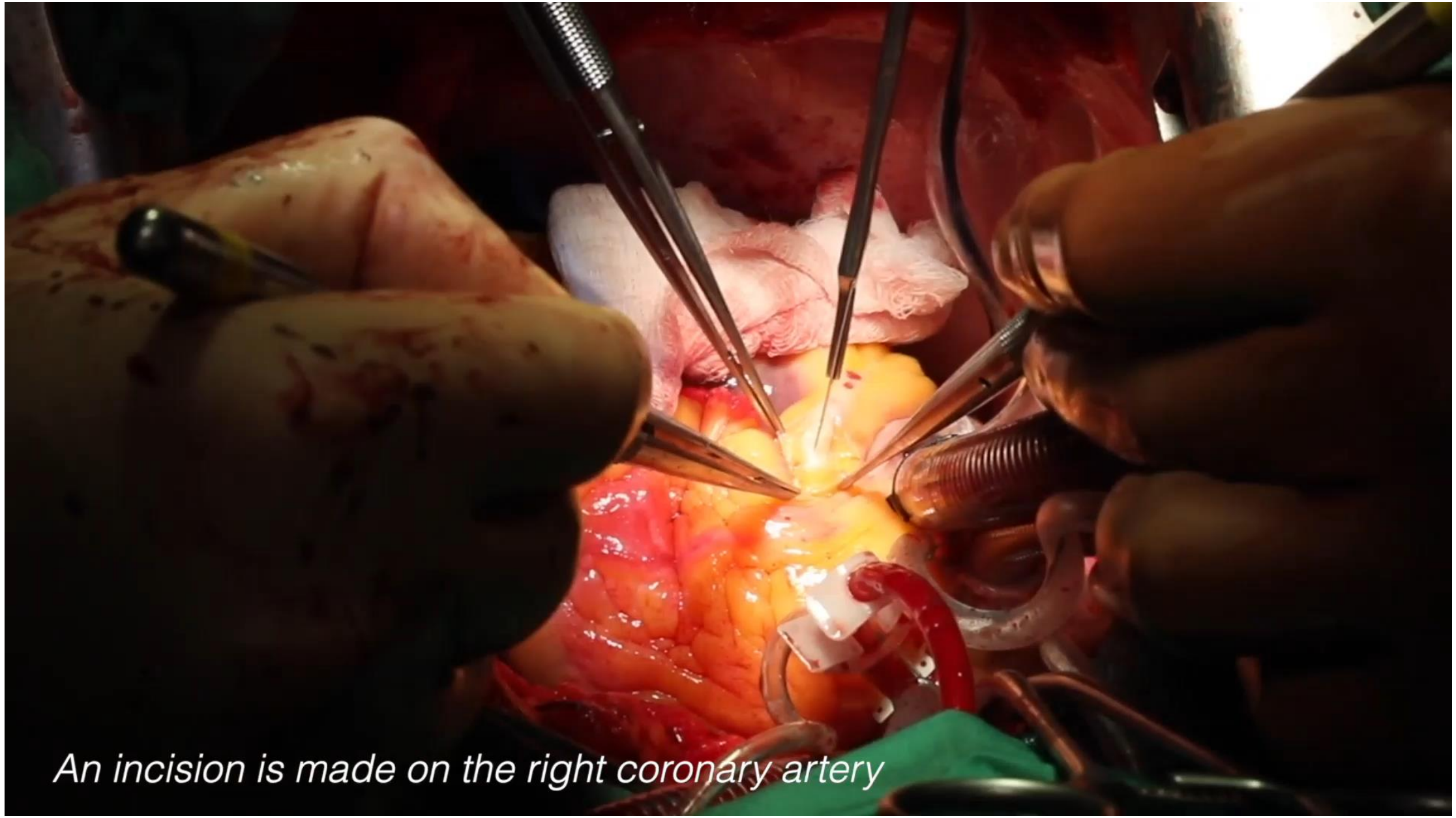

A
B


Cannula too long
A
Cannula misdirected
B
Correct
C
Cannula too small...
jet effect
D




Aortic cross clamp
Aortic cannula
Antegrade cardioplegia cannula∆
Venous cannula
Aortic root vent∆
Left ventricular vent*
Retrograde cardioplegia cannula•


Cardioplegia is administra


An incision is made on the right coronary artery

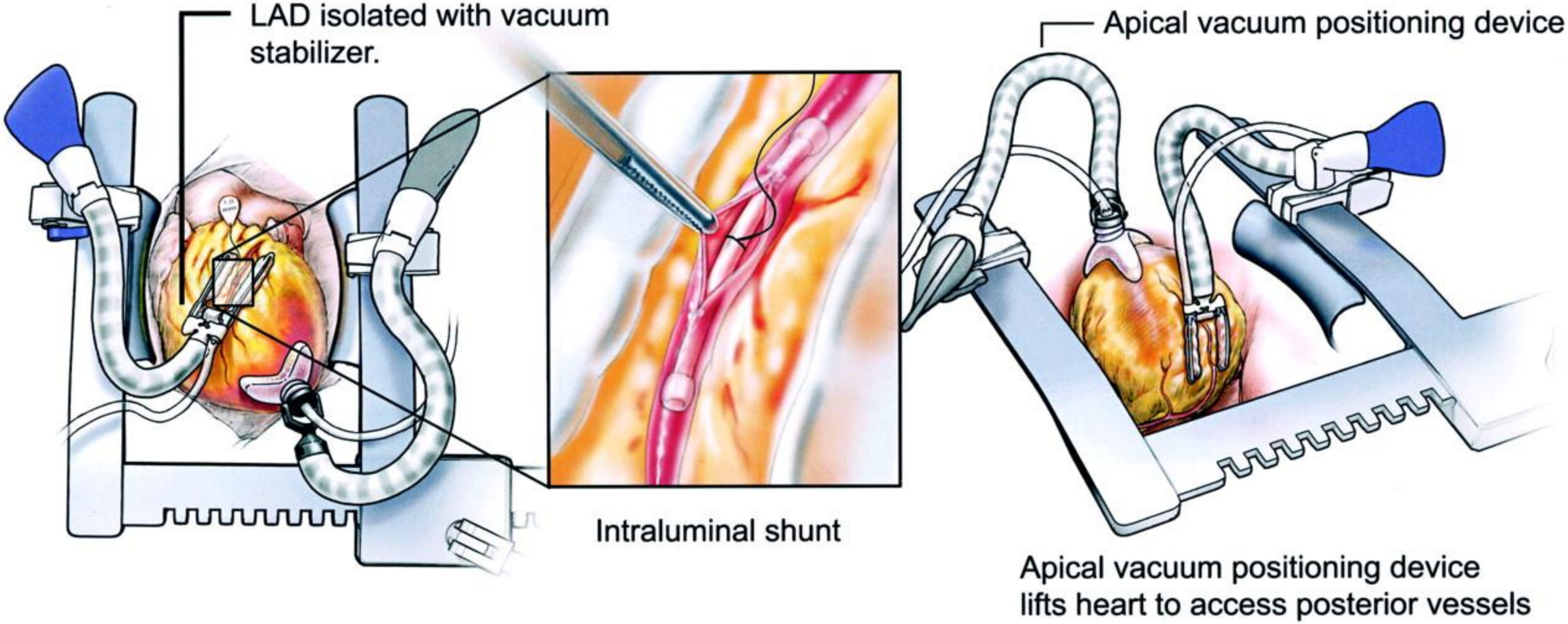
Off-Pump Coronary Artery Bypass (OPCAB)

Use of Cardiopulmonary Bypass in Patients Undergoing CABG

Recommendations for Use of Cardiopulmonary Bypass in Patients Undergoing CABG Referenced studies that support the recommendations are summarized in Online Data Supplement 40.		
COR	**LOE**	**Recommendations**
2a	**B-R**	**1. In patients with significant calcification of the aorta, the use of techniques to avoid aortic manipulation (off-pump techniques or beating heart) is reasonable to decrease the incidence of perioperative stroke when performed by experienced surgeons.**
2b	**B-R**	**2. In patients with significant pulmonary disease, off-pump surgery may be reasonable to reduce perioperative risk when performed by experienced surgeons.**

Procedure

- ☐ Median sternotomy of varying sizes.
- ☐ Depending on the physiology of the patient, the smallest incision will be made.
- ☐ Arteries or veins can be harvested from the patients chest wall, arm, and or leg.
- ☐ Betablockers are used to slow the heart rate.
- ☐ Deep pericardial sutures and the use of specialized instruments to prop the heart in a position that will allow the surgeon to access occluded arteries.


LAD isolated with vacuum stabilizer.
Intraluminal shunt
Apical vacuum positioning device
Apical vacuum positioning device lifts heart to access posterior vessels

Instrumentation

- **Octopus Device**
  - Has multiple small suction cups that are applied to the heart surface.
  - When suction is turned on, the cups stick to the surface, and hold the heart steady, with movement being less than 1 mm.

- **Star fish Device**
  - When suction is turned on, the cups stick to the surface, and hold the heart steady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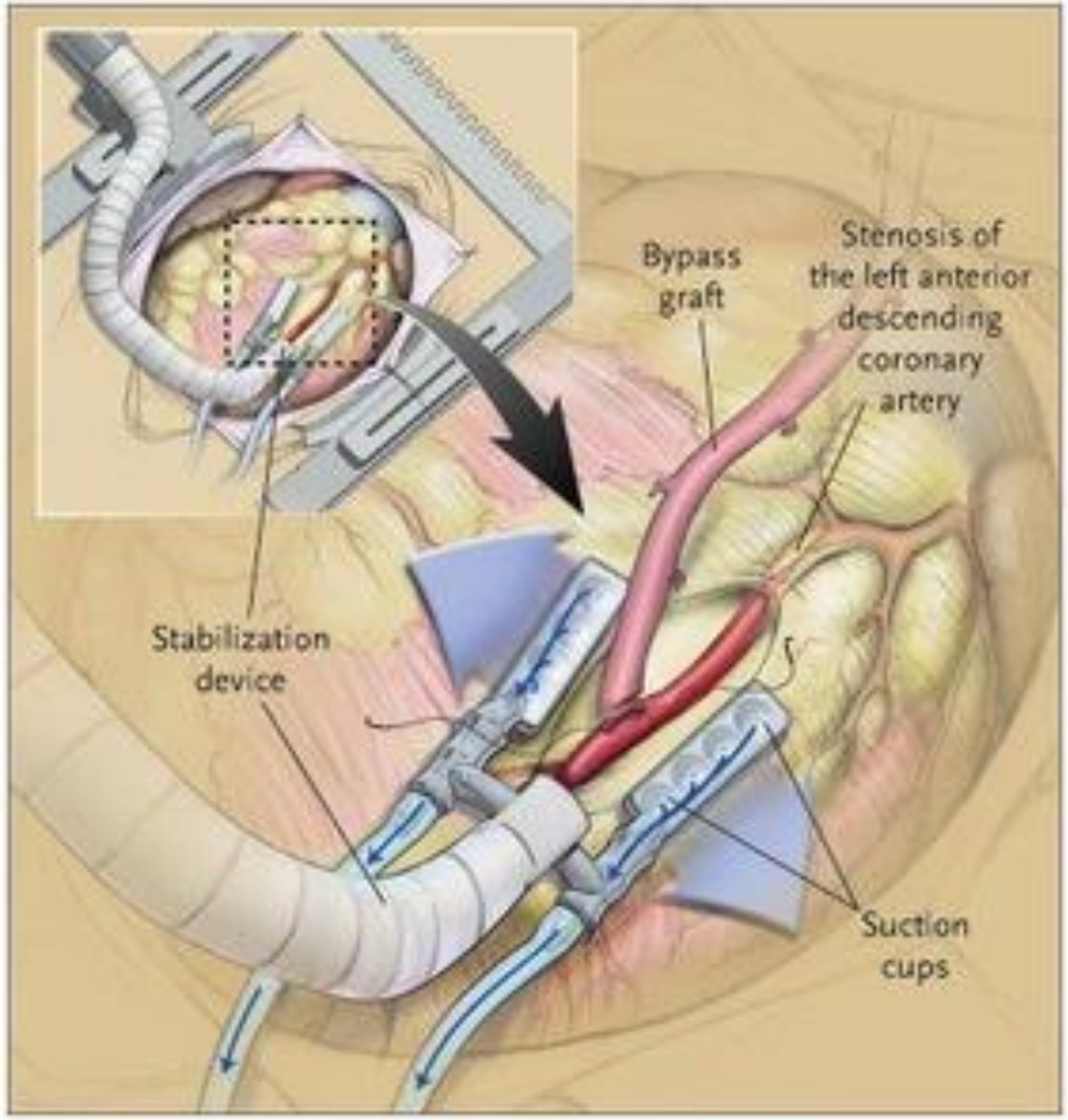
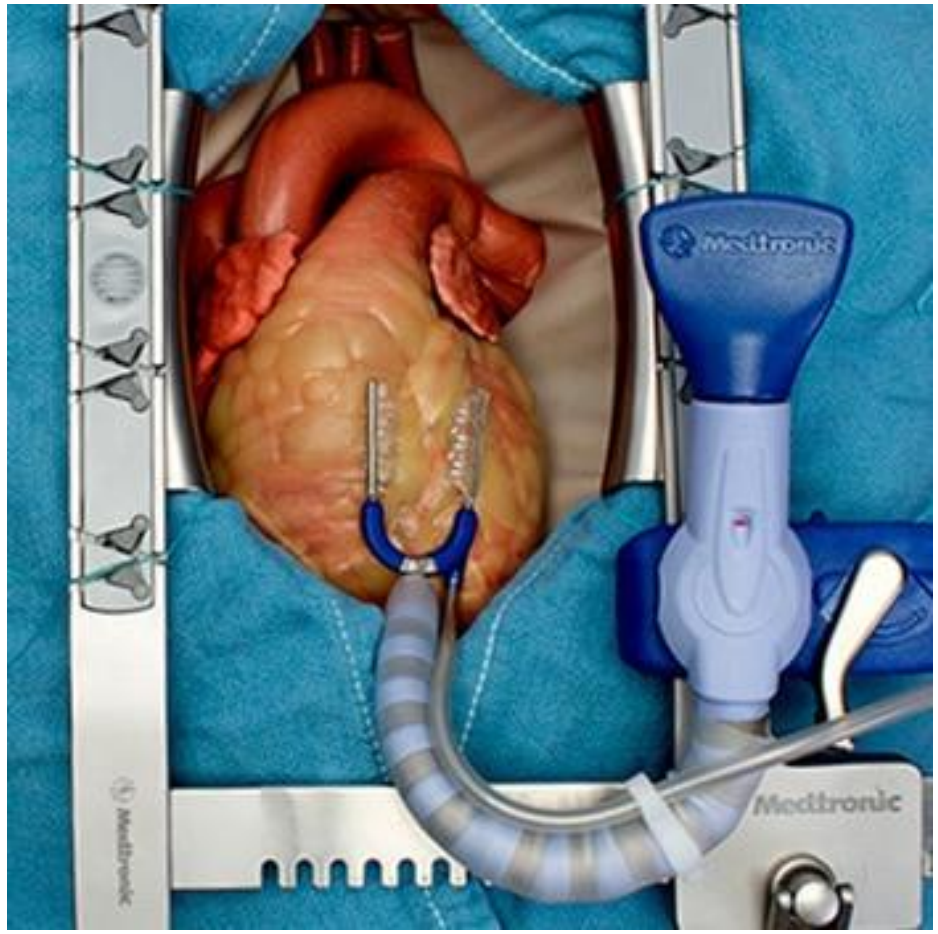
STABILIZER PODS


Bypass graft
Stenosis of the left anterior descending coronary artery
Stabilization device
Suction cups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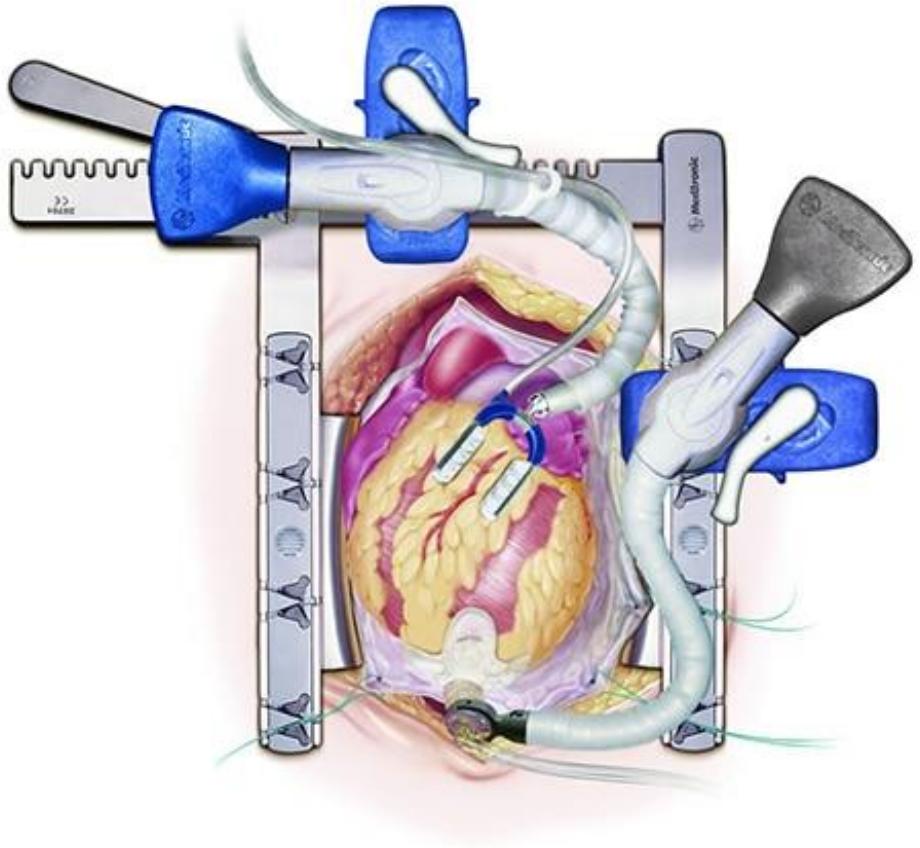
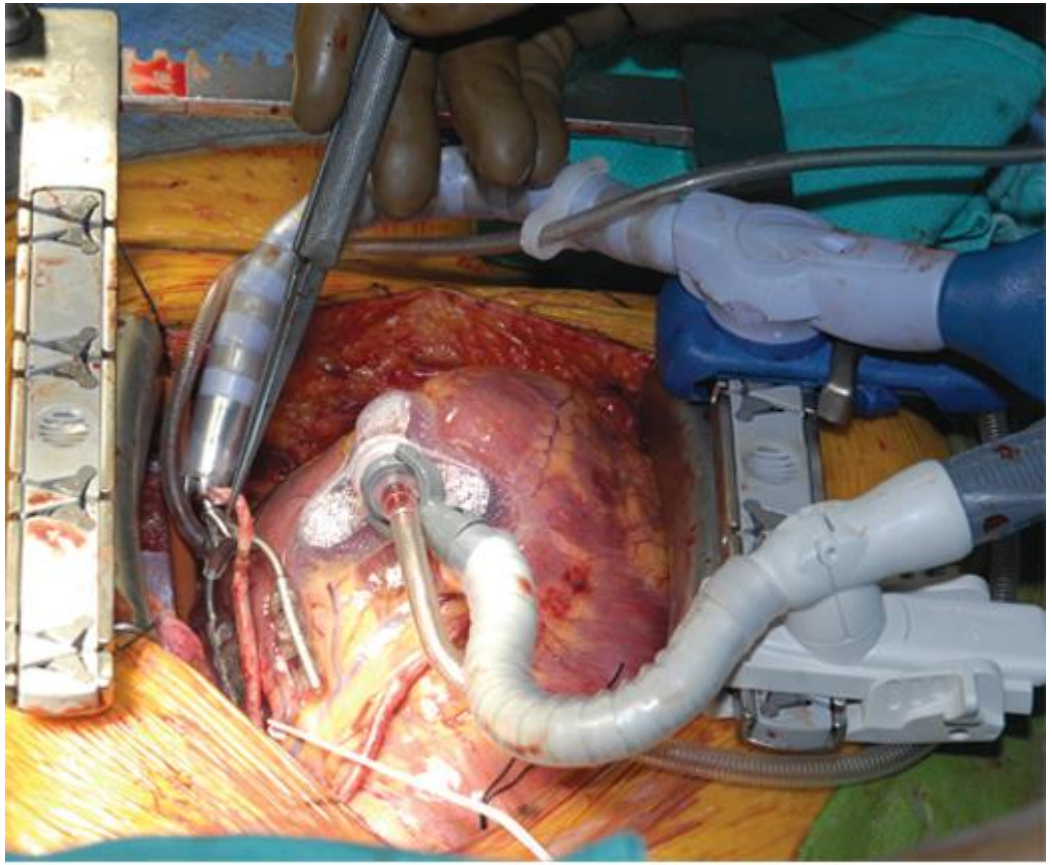




Source: Lawrence H. Cohn, David H. Adams:
Cardiac Surgery in the Adult, Fifth Edition

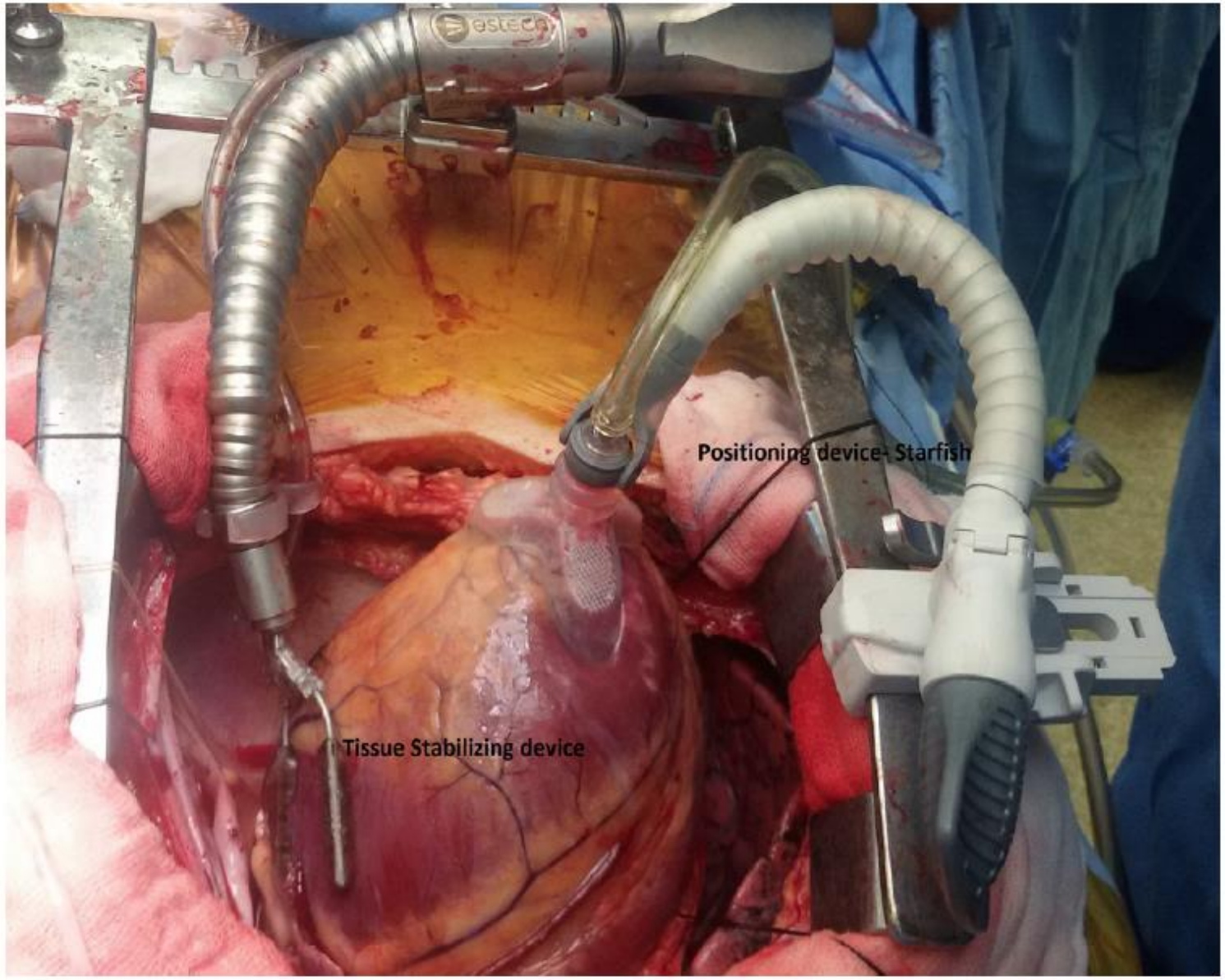
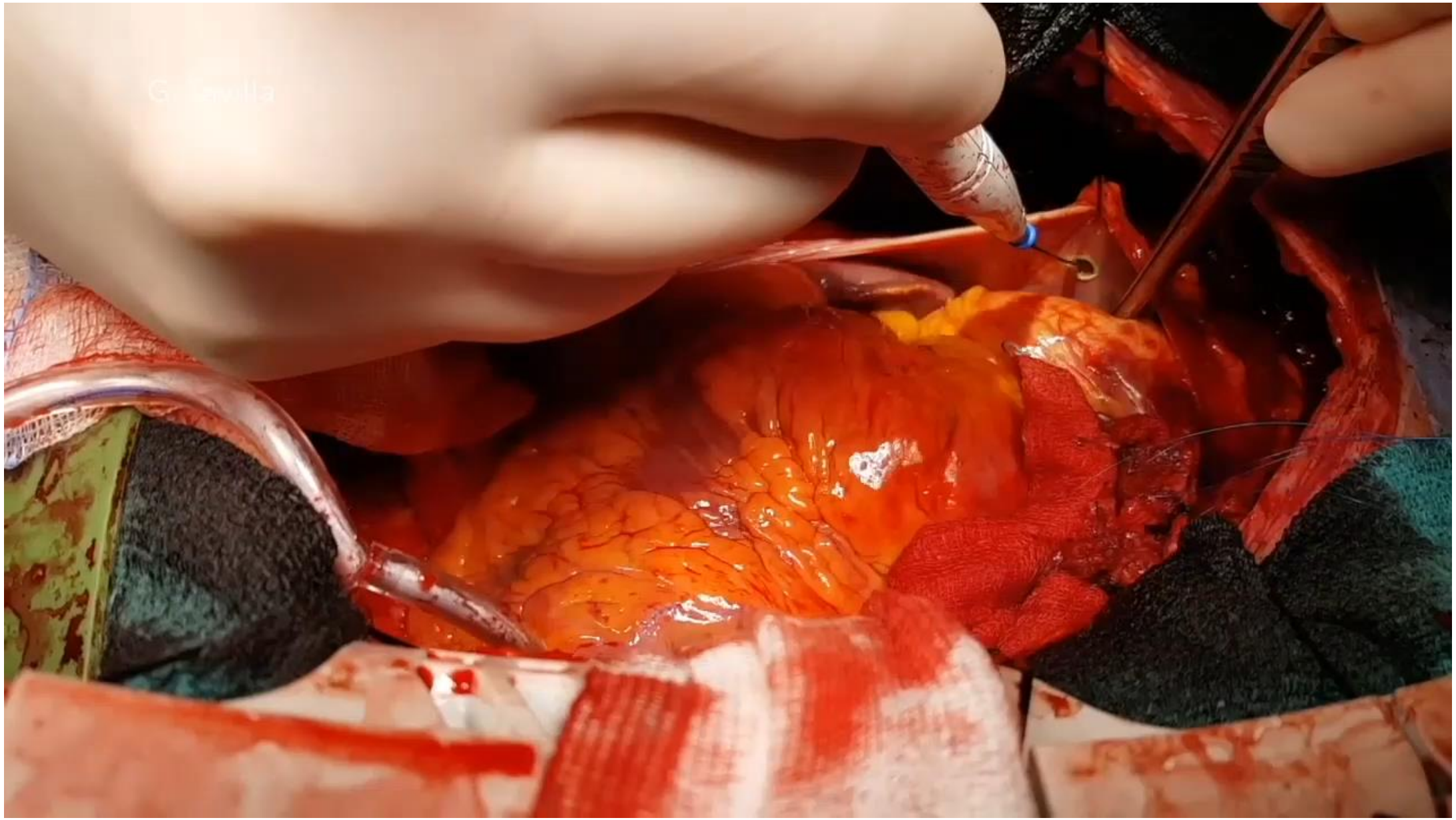
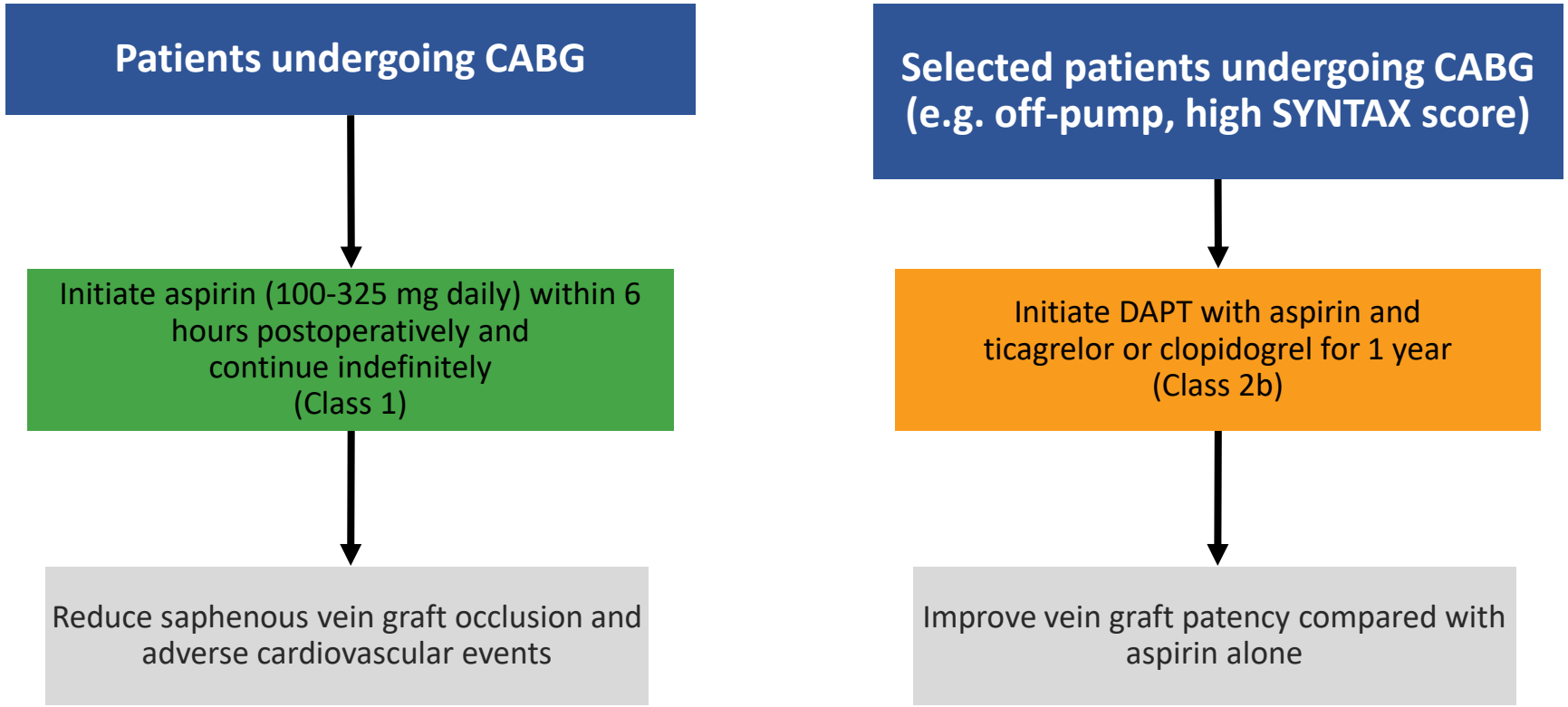


Figure 2. Positioning device (Starfish) and tissue stabilizer device on the epicardial surface



Antiplatelet Therapy in Patients After CABG



Abbreviations: CABG indicates coronary artery bypass grafting; and DAPT, dual antiplatelet therapy.

Lawton, J. S. et al. 2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization. *Circulation.*

American Heart Association.

Beta Blockers in Patients After Revascularization

Patients with SIHD and normal LV function who receive complete revascularization

↓

The routine use of chronic oral beta blockers is not beneficial to reduce cardiovascular events
(Class 3: No Benefit)

Patients after undergoing CABG

↓

Beta blockers are recommended and should be started as soon as possible (Class 1)

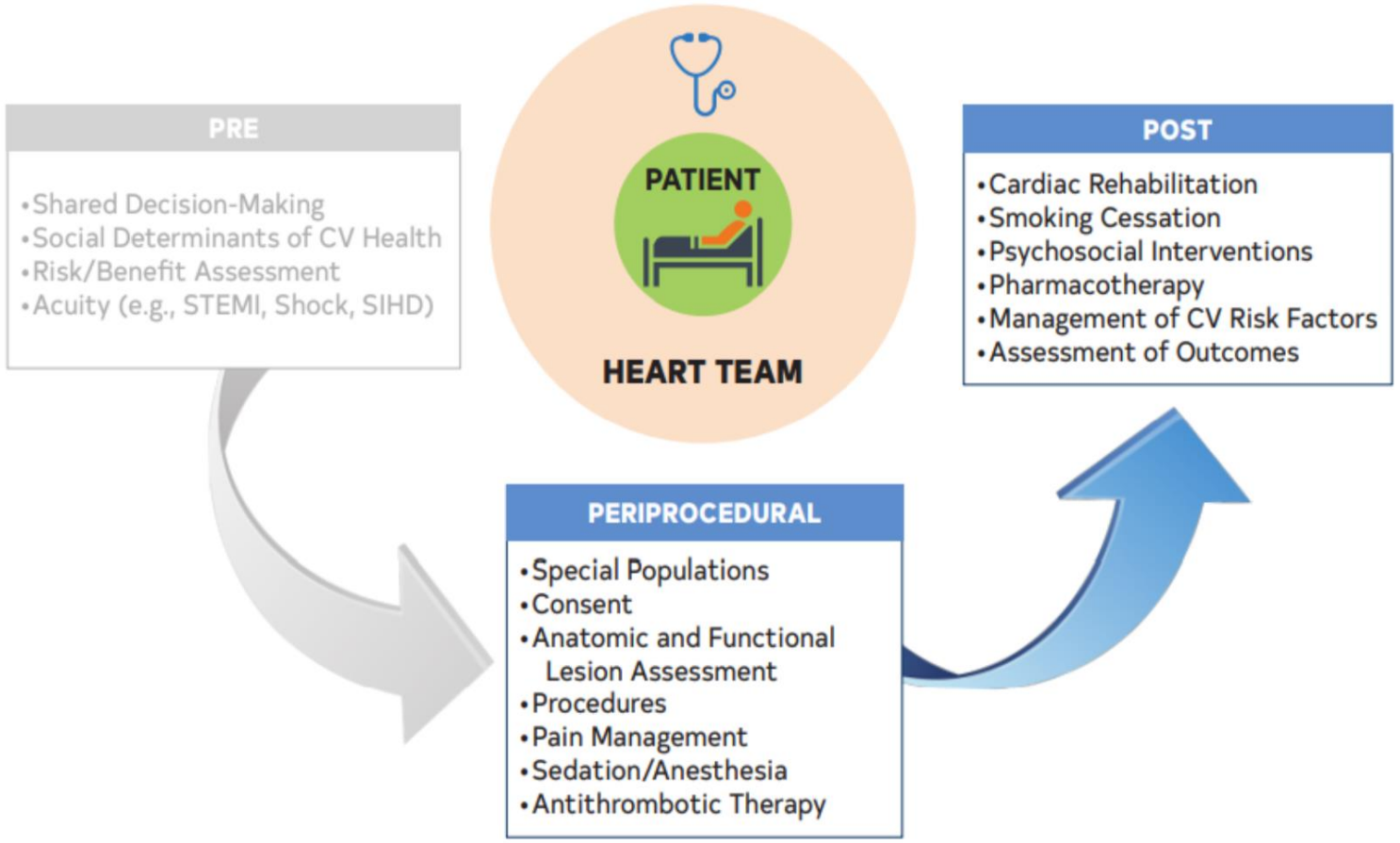
↓

Reduce the incidence or clinical sequelae of postoperative atrial fibrillation

Abbreviations: CABG indicates coronary artery bypass grafting; LV, left ventricle; and SIHD, stable ischemic heart disease.

Lawton, J. S. et al. 2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization. *Circulation.*

Focus on Perioperative Considerations in Patients Undergoing CABG and Outcomes



For patients undergoing CABG, establishment of multidisciplinary, evidence-based perioperative management programs is recommended to optimize analgesia, minimize opioid exposure, prevent complications and to reduce time to extubation, length of stay, and healthcare costs. (Class 1)

Abbreviations: CABG indicates coronary artery bypass grafting; CNS, central nervous system; CV, cardiovascular disease; LOS, length of stay; SIHD, stable ischemic heart disease; STEMI, ST segment elevation myocardial infarction; and TEE, transesophageal echo.

Lawton, J. S. et al. 2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization. *Circulation.*

Decrease Post-operative Deep Sternal Wound Infections

Intraop + Postop Target Serum Glucose Level:

<180mg/dL

(Class 1)

Administer IV insulin continuous infusion

AVOID hypoglycemia

[Click here for more best practices]

Abbreviations: IV indicates intravenous; and SWI, sternal wound infections.

American Heart Association.

Lawton, J. S. et al. 2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization. *Circulation.*

- Indication For Surgery
- Preoperative Evaluation
- Conduits decision
- Operation Decision
- ERAS

Take-Home Messages

2021 Guideline for Coronary Artery Revascularization

Take Home Messages

Treatment decisions with regard to coronary revascularization in patients with coronary artery disease should be based on clinical indications, REGARDLESS OF SEX, RACE, OR ETHNICITY, because there is no evidence that some patients benefit less than others, and efforts to reduce disparities of care are warranted.

Take Home Messages

In patients being considered for coronary revascularization for whom the optimal treatment strategy is unclear, a multidisciplinary HEART TEAM approach is recommended. Treatment decisions should be patient centered, incorporate patient preferences and goals, and include shared decision-making.

Take Home Messages

Patients with significant LEFT MAIN DISEASE, SURGICAL REVASCULARIZATION is indicated to improve survival relative to that likely to be achieved with medical therapy. Percutaneous revascularization is a reasonable option to improve survival, compared with medical therapy, in selected patients with low to medium anatomic complexity of coronary artery disease and left main disease that is equally suitable for surgical or percutaneous revascularization.

Take Home Messages

Updated evidence from contemporary trials supplement older evidence with regard to mortality benefit of revascularization in patients with stable ischemic heart disease, normal left ventricular ejection fraction, and triple-vessel coronary artery disease. Surgical revascularization may be reasonable to improve survival. A survival benefit with percutaneous revascularization is uncertain. Revascularization decisions are based on consideration of disease complexity, technical feasibility of treatment, and a Heart Team discussion.

Take Home Messages

The use of a RADIAL ARTERY as a surgical revascularization conduit is preferred to the use of a saphenous vein conduit to bypass the second most important target vessel with significant stenosis after the left anterior descending coronary artery. Benefits include superior patency, reduced adverse cardiac events, and improved survival.

Top 10 Take Home Messages

Revascularization decisions in patients with diabetes and multivessel coronary artery disease are optimized by the use of a Heart Team approach. Patients with DIABETES WHO HAVE TRIPLE-VESSEL DISEASE SHOULD UNDERGO SURGICAL REVASCULARIZATION; percutaneous coronary intervention may be considered if they are poor candidates for surgery.

Thank You for Your Attention