CARDIOLOGY GRAND ROUNDS

Presentation: Complex Coronary Interventions
Speaker: Sary F. Aranki, MD
Cardiac Surgeon
Brigham and women's hospital
Date: Monday, May 18, 2015, 7:00 – 8:00 AM
Location: ANW Education Building, Watson Room

OBJECTIVES
At the completion of this activity, the participants should be able to:
1. Identify patients who are high risk candidates for coronary surgery.
2. Assess strategies for safe management of these patients.
3. Identify techniques and pitfalls of these strategies.

ACCREDITATION
Physicians: This activity has been planned and implemented in accordance with the Essential Areas and policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint sponsorship of Allina Health and Minneapolis Heart Institute Foundation. Allina Health is accredited by the ACCME to provide continuing medical education for physicians.

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Others: Individuals representing other professional disciplines may submit course materials to their respective professional associations for 1.0 hours of continuing education credit.

DISCLOSURE STATEMENTS
Speaker(s): Dr. Aranki has declared that he does not have a conflict of interest in making this presentation.

Planning Committee: Dr. Michael Miedema, and Eva Zewdie have declared that they do not have any conflicts of interest associated with the planning of this activity. Dr. Robert Schwartz declared the following relationships - stockholder: Cardiomind, Interface Biologics, Aritech, DSI/Transoma, InstyMeds, Intervalve, Medtronic, Osprey Medical, Stout Medical, Tricardia LLC, CoAptus Inc, Augustine Biomedical; scientific advisory board: Abbott Laboratories, Boston Scientific, MEDRAD Inc, Thomas, McNerney & Partners, Cardiomind, Interface Biologics; options: BackBeat Medical, BioHeart, CHF Solutions; speakers bureau: Vital Images; consultant: Edwards LifeSciences.
Complex Coronary Interventions

Sary Aranki
Associate Professor of Surgery
Brigham and Women Hospital
Harvard Medical School

• Disclosures: DSMB for Neograft Technology.
Complex Coronary Interventions

- Unclampable Ascending Aorta.
- Diffuse and calcified Coronary Arteries.
- Reop CABG.
CABG SURGERY GOALS

- Survival.
- Avoid MI.
- Avoid Stroke.
- Quality of Life.
MAJOR LANDMARKS IN CABG SURGERY

- Cardiopulmonary Bypass.
- Intra Aortic Balloon Pump.
- Cardioplegia.
- LIMA to LAD.
- Retrograde Cardioplegia.
- Endoscopic Vein Harvest.

CABG POPULATION

- Older patients (40% > 70 years)
- Sicker patients low EF (25%-30%)
- Women (30%)
- Diabetes (30- 40%)
- Percutaneous revascularization procedures
Case Report

It is 3 PM on a Friday and you are just starting an elective “straight forward CABG” in a 79 year old male patient. The aorta feels calcified and not suitable for clamping.
Question 1

1. Declare patient inoperable, close the chest.
2. Off-Pump CABG.
3. On-Pump CABG (no clamp).
4. On pump CABG, cross clamp the aorta, and hope for the best.

Approximately 2% of patients requiring Cardiac Surgery will have atherosclerotic changes in the ascending aorta, ranging from mild to extreme (porcelain aorta)

Mills, et al; 1993
Wareing, et al; 1992
Tobler, et al; 1988
The presence of these changes require complex change in the intra operative strategy to reduce the peri-operative morbidity and mortality

Mills, et al; 1991
Wareing, et al; 1992
Tobler, et al; 198
Preoperative computed tomography revealed severe calcification (100%) at the same level as the right pulmonary artery (right) and (48.9%) just below the innominate artery (left).

Published by European Association for Cardio-Thoracic Surgery. All rights reserved.

Palpation
EpiAortic Scanning: 500 patients mean age 68

- Significant atheromatous disease of the ascending aorta in 68 (13.6%) mean age 72
- Digital palpation identified only 38% of these patients

Option 1: Surgical Strategy

Declare patient inoperable and close the chest
- Persistent symptoms
- Consider referral to another center.

Option 2: Off-Pump CABG

- Proximals from LIMA
- Proximals from a soft spot on the ascending aorta using a proximal device other than a side biting clamp.
Option 3: On-Pump CABG

Cross-clamp and do routine surgery

- Price may be high
- No available results reported in the literature

Option 4: On-Pump CABG

No clamp-No touch technique under moderate hypothermia.

- Fibrillating heart, low flow when needed
- Proximals from LIMA
- Proximals from a soft spot on the ascending aorta using a proximal device other than a side biting clamp. Or a brief period of circulatory arrest.
Option 5: Surgical Strategy

No clamp-No touch technique under deep hypothermic circulatory arrest (DHCA)

- Endarterectomy at the site of the cross-clamp under DHCA. Apply cross-clamp then do CABG.
- Ascending aorta replacement with a tube graft under DHCA. Apply cross-clamp to graft then do CABG.

Question 2

You decide to do Off-Pump CABG. Thorough inspection of coronary arteries reveal that all 3 arteries are calcified and diffusely diseased along their entire length. You decide to:

1. Declare patient inoperable, close the chest.
2. Transmyocardial Laser Revascularization.
3. Off-Pump CABG, Coronary Endarterectomy.
4. On-Pump CABG, Coronary Endarterectomy.
Question 3

What is your surgical strategy?

1. Replace the Ascending Aorta on DHCA clamp the graft, and do multiple COE. Proximals from graft.
2. Multiple COE on a fibrillating Heart. Proximals from LIMA.

Decision

Replace the Ascending Aorta on DHCA clamp the graft, and do multiple COE. Proximals from graft.
Question 4

You decide to do On-Pump CABG, what is your arterial cannulation strategy?
1. Ascending aorta.
2. Innominate artery.
4. Right axillary artery.
Preoperative computed tomography revealed severe calcification (100%) at the same level as the right pulmonary artery (right) and (48.9%) just below the innominate artery (left).
First reported 2 cases of Coronary Endarterectomy
- Localization of lesion based on ECG
- No angiographic confirmation
- Left thoracotomy
- Off-pump

**CABG POPULATION**

- Advanced and diffuse coronary artery disease (CAD)
- CABG alone is not feasible in many patients because of inadequate distal run-off
- Coronary Endarterectomy (CoEA)-Essential for adequate myocardial revascularization as an adjunct to CABG
Coronary Endarterectomy (CoEA)

- CoEA technically challenging and time consuming
- Perceived to be associated with increased mortality and myocardial infarction
- Perceived to be associated with unfavorable long term outcomes
- Unpopular with many surgeons

Angiographic Predictors

- Multiple lesions along the entire length of the coronary artery
- Small caliber of the distal portion
- Total occlusion with no retrograde filling
- None
Surgical Technique

- TEE
- Full median sternotomy
- Epiaortic scanning
- Cardiopulmonary bypass
- Moderate hypothermia
- Cardioplegic arrest (motionless and bloodless field)
- Retrograde cardioplegia: assess completeness of CoEA and wash out residual debris

Surgical Technique

- Proximal arteriotomy
- Develop the plane between the plaque and the artery intima/media and media/adventitia
- Gently retract on the proximal portion and divide sharply
- Gentle traction/counter traction on the distal portion
- Probing with 1mm probe when resistance is encountered to loosen adhesions and allow complete retrieval
- Distal or long arteriotomies as necessary
Types of atherosclerotic plaque:

- Soft plaque: small arteriotomy.
- Calcified plaque: long arteriotomy.
- Combination plaque/multiple stents: Multiple arteriotomies/long arteriotomy

Surgical Technique

- RCA: Large artery with two main branches that arise from a singleplane. Usually done through a small arteriotomy.
- LAD: Large artery with numerous small branches that arise from two different planes. More technically challenging. May require multiple or extended arteriotomy.
- Cx: Small branches, unlikely to result in complete extraction of the plaque.
Extensive left anterior descending endarterectomy and multiple drug-eluting stent removal in a patient with in-stent occlusion

Cataldo G., Ramesh, Fazan F., et al.

Images in cardiac surgery

With stent removal performed successfully (Fig. 4C and D) followed by a subsequent PCI revascularisation and intravenous nitrovasodilator (Fig. 6C).
CoEA
A. Extensively endarterectomized LAD with a long arteriotomy.
B. Saphenous vein patch (arrows) is applied to the distal portion of the LAD.
C. Remaining arteriotomy of the LAD after vein patch application.
D. Returning flow of retrograde cardioplegic solution from vessel
E. LITA graft (arrow) applied to the LAD with edge-to-edge sutures with a vein patch
Extensive endarterectomy and reconstruction of the left anterior descending artery: Early and late outcomes

Patrick O. Myers, MD, Minoru Tabata, MD, MPH, Prem S. Shekar, MD, Gregory S. Couper, MD, Zain I. Khalpey, MD, PhD, and Sary F. Aranki, MD

Aim:
- Examine early and late results of coronary endarterectomy (CE)
- Compare 2 different reconstruction methods

Methods

14,941 patients: CABG to the LAD
- 639 (4.3%) LAD endarterectomy
- 14,302 (95.7%) conventional CABG
- 224 (1.5%) Extensive LAD endarterectomy and reconstruction
  - 191 Saphenous vein patch combined with LITA grafting (GROUP A)
  - 123 LITA onlay patch grafting (GROUP B)
## Results

### Preoperative characteristics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group A (n = 101) SVG patch</th>
<th>Group B (n = 123) LITA onlay</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (y)</td>
<td>65.8 ± 10.5</td>
<td>66.6 ± 9.9</td>
<td>0.56</td>
</tr>
<tr>
<td>Male</td>
<td>79 (78.2%)</td>
<td>110 (89.4%)</td>
<td>0.03</td>
</tr>
<tr>
<td>Recent MI (1-7 d preop)</td>
<td>18 (17.8%)</td>
<td>18 (14.6%)</td>
<td>0.59</td>
</tr>
<tr>
<td>Old MI (&gt;7 d preop)</td>
<td>59 (58.4%)</td>
<td>61 (49.6%)</td>
<td>0.23</td>
</tr>
<tr>
<td>Left main disease</td>
<td>15 (14.9%)</td>
<td>27 (22.0%)</td>
<td>0.23</td>
</tr>
<tr>
<td>Triple vessel disease</td>
<td>86 (85.1%)</td>
<td>110 (89.4%)</td>
<td>0.42</td>
</tr>
<tr>
<td>Preop IABP</td>
<td>12 (11.9%)</td>
<td>8 (6.5%)</td>
<td>0.24</td>
</tr>
<tr>
<td>Ejection fraction &lt;40%</td>
<td>27 (26.7%)</td>
<td>27 (21.9%)</td>
<td>0.53</td>
</tr>
<tr>
<td>NYHA class 3</td>
<td>33 (32.7%)</td>
<td>45 (36.6%)</td>
<td>0.58</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>50 (49.5%)</td>
<td>63 (51.2%)</td>
<td>0.89</td>
</tr>
<tr>
<td>Previous cerebrovascular disease</td>
<td>10 (9.9%)</td>
<td>19 (15.4%)</td>
<td>0.24</td>
</tr>
<tr>
<td>Renal insufficiency</td>
<td>10 (9.9%)</td>
<td>11 (8.9%)</td>
<td>0.82</td>
</tr>
<tr>
<td>COPD</td>
<td>29 (28.7%)</td>
<td>61 (49.6%)</td>
<td>0.002</td>
</tr>
<tr>
<td>PVD</td>
<td>19 (18.8%)</td>
<td>26 (21.1%)</td>
<td>0.74</td>
</tr>
<tr>
<td>Previous cardiac surgery</td>
<td>11 (10.9%)</td>
<td>4 (3.3%)</td>
<td>0.03</td>
</tr>
<tr>
<td>Previous CABG</td>
<td>9 (8.9%)</td>
<td>3 (2.4%)</td>
<td>0.04</td>
</tr>
<tr>
<td>Previous PCI</td>
<td>12 (11.9%)</td>
<td>27 (22%)</td>
<td>0.05</td>
</tr>
<tr>
<td>Nonelective operation</td>
<td>54 (53.5%)</td>
<td>80 (64.8%)</td>
<td>0.5</td>
</tr>
</tbody>
</table>

### Operative and early postoperative data

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group A (n = 101): SVG patch</th>
<th>Group B (n = 123): LITA onlay</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative mortality</td>
<td>3 (3.0%)</td>
<td>5 (4.1%)</td>
<td>0.73</td>
</tr>
<tr>
<td>Reoperation for bleeding</td>
<td>3 (3.0%)</td>
<td>2 (1.6%)</td>
<td>0.66</td>
</tr>
<tr>
<td>PMI</td>
<td>8 (7.9%)</td>
<td>8 (6.5%)</td>
<td>0.79</td>
</tr>
<tr>
<td>PMI of LAD territory</td>
<td>4 (4.0%)</td>
<td>5 (4.1%)</td>
<td>1.00</td>
</tr>
<tr>
<td>Intraop/postop IABP</td>
<td>6 (5.9%)</td>
<td>4 (3.3%)</td>
<td>0.35</td>
</tr>
</tbody>
</table>
Results
Late outcomes

- Median follow-up interval: 58 months (1-191 months)
- Survival:
  - 83.1% ± 2.7% at 5 years
  - 47.5% ± 6.1% at 10 years

Survival

All patients
- 83.1% ± 2.7% at 5 years
- 47.5% ± 6.1% at 10 years

Group A (SVG patch)
- 78.6% ± 4.3% at 5 years
- 45.4% ± 7.6% at 10 years

Group B (LITA onlay)
- 87.1% ± 3.5% at 5 years
- 49.4% ± 9.8% at 10 years

P-value: 0.18
Pt DD

- 70M with CAD experienced episode of unstable angina.
- OR on 11/17/2005
- 3v-CABG (LITA to LAD, SVG to Ramus and OM2) with LAD endarterectomy (long vein patch)
- ASA, plavix and heparin drip postop
- Discharged on POD#7.

Preop Coronary Angiogram
Pt DD- 7 years later

- Returned 7 years later for shortness of breath, fatigue and syncope
- TTE showed severe Aortic Stenosis/ mean gradient 45 mmHg/ peak gradient 73 mmHg/ calculated valve area 0.8 cm² (mild AS 7yrs ago)
- Received Cardiac Cath preoperatively.

Coronary Angiogram
Patient DD

- Pt had Reoperative AVR (23mm Mitroflow)
- Patent LITA- not dissected (Cooled to 28degrees)
- Discharged to rehab on POD#5 w/o complication
Early Results

Review of 14 published studies.

Mortality 0-10%
MI Rates 5-30%


Early Results

Predictors of Adverse Cardiac Events
• Age > 70 years
• EF < 30%
• Emergency Surgery
• Female Gender

Long Term Outcomes

Survival

1 year: 90%

5 year: 70%

Functional Status: Comparable to CABG patients

Freedom from Angina

Quality of Life

Work Status


Angiographic Follow-up

Immediate Patency 90-95%

1-year Patency 80-85%

3-year Patency 70-75%

5-year Patency 65%

10-year Patency 50%

Angiographic Follow-up

No significant difference in early or late graft patency in Endarterectomized and Non-Endarterectomized vessels.

Brenowitz et al. J Am Coll Cardiol, 1988

Choice of Conduit

ITA has unique anatomic and functional qualities.

• Secretes EDRF.

• Reduce platelet aggregation, SM migration and proliferation.

• Resistance to atherosclerosis of the ITA and the coronary artery it supplies.
Comparative results of Left Anterior Descending Artery Endarterectomy with LITA and VG based on the study by Beretta et al.

<table>
<thead>
<tr>
<th>Group</th>
<th>OM</th>
<th>MI</th>
<th>Early Patency</th>
<th>30-36 Months</th>
<th>3/5 yr Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>LITA</td>
<td>2.1%</td>
<td>2.1%</td>
<td>92.5%</td>
<td>81.5%</td>
<td>86.8/86.8%</td>
</tr>
<tr>
<td>VG</td>
<td>8%</td>
<td>10%</td>
<td>84.6%</td>
<td>66.7%</td>
<td>79.6/69.7%</td>
</tr>
</tbody>
</table>


Choice of Conduit

- Reduced incidence of adverse cardiac events
- Improved Patency
- Improved Survival

Christenson et al. Coron Artery Dis, 1998
Summary

• CoEA is an effective adjunct to CABG in otherwise inoperable patients.

• Published clinical and angiographic data are comparable to those reported for conventional CABG.

• Meticulous surgical technique with complete extraction of atherosclerotic plaque is the most important aspect in achieving favorable results.

Summary

• There is a theoretical and circumstantial evidence for using arterial grafts following CoEA.

• Post operative drug therapy to maintain graft patency is an integral part of long term management.
Reop CABG

- Declining Volume.
- Greater Operative Complexity.
- Greater Operative Mortality And Morbidity.
- Careful Pre Operative Planning.


Evolving trends of reoperative coronary artery bypass grafting: An analysis of the Society of Thoracic Surgeons Adult Cardiac Surgery Database

Reop CABG: Declining Volume

Patent LIMA to LAD.
PCI on Stenotic vein Grafts.


Reop CABG: Complexity

- Adhesions.
- Injury to Mediastinal Structures.
- Manipulation / Injury to Patent but Diseased Vein Grafts.
- Manipulation / Injury to Patent LIMA to LAD.

Reop CABG: Mortality / Morbidity

<table>
<thead>
<tr>
<th></th>
<th>Primary CABG</th>
<th>Reop CABG</th>
</tr>
</thead>
<tbody>
<tr>
<td>OM 2000</td>
<td>2.4%</td>
<td>6.1%</td>
</tr>
<tr>
<td>OM 2009</td>
<td>1.9%</td>
<td>4.6%</td>
</tr>
<tr>
<td>Stroke</td>
<td>1.6%</td>
<td>1.9%</td>
</tr>
<tr>
<td>Stroke 2009</td>
<td>1.2%</td>
<td>1.4%</td>
</tr>
</tbody>
</table>

Ghanta RK. J Thorac Cardiovasc Surg, 2013

Reop CABG: Complexity/challenges

- Injury to Major Structures.
- Injury to patent Grafts.
- Embolization / Myocardial Infarction.
- Inadequate Myocardial Protection.

Reop CABG: Pre operative Planning

- History and Physical.
- Previous Medical Records (op note).
- Current Medications.
- Imaging.


Reop CABG: Pre Operative Imaging

- Chest X-Ray.
- Cardiac Catheterization.
- CT scans.
Reop CABG : CT Scans

- Non Contrast Chest CT Scans.
- Contrast CT / 3D Multidetector Reconstruction.


Reop CABG: Operative Procedure

- External Defibrillator.
- Median Sternotomy.
- Left Thoracotomy (Rare).


Reop CABG: CPB Strategy

- Femoral Vessels Lines for emergency percutaneous cannulation.
- Exposure of Femoral Vessels.
- Central Cannulation.
- Axillary Artery Cannulation / Femoral Vein.
- Initiation of CPB May be Required prior to safe Sternal Re entry.
Reop CABG : Myocardial Protection

- Moderate Hypothermia (Patent LIMA to LAD).
- Antegrade/Retrograde Cardioplegia.
- Avoid Manipulation of Diseased Grafts prior to Cardiac Arrest to Prevent Embolization.

Cohn LC, Cardiac Surgery in the Adult. 2008.