Thoracoabdominal Aneurysm Repair: From Athena to Zeus

Joseph S. Coselli, M.D.

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Professor, Chief, and Cullen Foundation Endowed Chair
Division of Cardiothoracic Surgery, Baylor College of Medicine

Panhellenic Cardiology Society Meeting
Athens, Greece • October, 20 2018
<table>
<thead>
<tr>
<th>Company</th>
<th>Roles/Manner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medtronic, Inc</td>
<td>PI Clinical Trials, Consultant</td>
</tr>
<tr>
<td>WL Gore</td>
<td>PI Clinical Trials, Consultant</td>
</tr>
<tr>
<td>Terumo Aortic</td>
<td>PI Clinical Trials</td>
</tr>
<tr>
<td></td>
<td>Royalties, Consultant, Educational Grant</td>
</tr>
</tbody>
</table>
“Whoever wishes to foresee the future must consult that past.”

Niccolo Machiavelli
1469-1527
Founder of
Modern Political Science
Author of *The Prince*
The $100,000,000 160 ACRE
TEXAS MEDICAL CENTER
STARTS HERE
Get Behind it, HOUSTON!
Texas Medical Center
Texas Medical Center

The largest concentration of medical assets in the world!

- 8 million patient visits per year
- 8th largest business district US
- 180,000+ annual surgeries
- 13,600+ heart surgeries
- 750,000 ER visits per year
- 52 member institutions
- 106,000+ employees
Houston’s Aortic Innovators

DeBakey
Arrives 1948
- Matas
- Ochsner
- Leriche
- Kirschner

Cooley
Arrives 1951
- Blalock
- Lord Brock

Crawford
Arrives 1954
- Churchill
- Allen
Early Influences: Carrel & Guthrie 1902-6
Experimental: Branch Vessel Reattachment

Carrel patch, 1902
(Lyon Médical, 1902)

Vascular Anastomosis

1906 Surg, Gyn & Obst
Carrel & Guthrie (Fig 4, 13)

Vein serving as artery

Carrel wins 1912 Nobel Prize for Physiology or Medicine regarding work on suturing blood vessels
America’s first Nobel Prize

Guthrie does not . . .

Guthrie allegedly left out of Nobel Prize due to experiments with head transplantation
Fig. 2.—A, dog’s head about one and one-half hours after being transplanted on to B. Reflex and voluntary movements good.
Mid-Century Options for Aortic Repair

- All were considered more or less equivalent therapies
- Provided some measure of success
- Often used in combination

Takats 1952 Review of Surgical Treatments for Abdominal Aneurysm

Geza de Takats
1892 - 1985
University of Budapest
Northwestern University
Medical School
University of Illinois
Pioneer of Vascular Surgery
Founding member Society for Vascular Surgery
Aortic Replacement Using Homografts
Homograft Repair: Coarctation-Related Aneurysm (1950)

- Larger sections of DTA being replaced with homograft
- 8 cm homograft used
- Homograft refrigerated for 52 days in Ringer’s plasma at time of use
- 16-year-old boy
- 9 ½ hour procedure
  - Patient survives > 6m

Swan et al Archives of Surgery 1950
1951: Abdominal → 1st Replaced by Homograft

**Repair of an Abdominal Aortic Aneurysm**

- Aborted an attempt to cellophane wrap a bulky abdominal aneurysm
- Resected aneurysm (retroperitoneal)
- Replaced with homograft
- Patient lived 8 years following repair

Charles Dubost
1914-1991

Case Report
50-year-old male

Dubost et al.
1951 Mem Acad Chir
Dubost et al.
1952 Arch Surg
Similar to Dubost’s repair, but the Houston approach was transperitoneal rather than retroperitoneal.

DeBakey & Cooley, 1953 SGO
1st Houston Case 11-6-1952
6 of 7 patients recovered
Aortic Rupture (1954)

- 1st successful repair of a ruptured abdominal aneurysm
- Series of 5 repairs
- Overall mortality 60%

1953: DTA → Fully Resected Aneurysm Replaced by Homograft (Without Using Shunt)

Case Report of 1st Successful

Blood flow restored by means of an aortic homograft after aortic occlusion for 45 minutes. No complications. Discharged POD 13 and resumed duties as sheriff 1 month later.

Revisited case: Although long considered the first DTA homograft repair, this case may be considered the first thoracoabdominal aortic repair (extent I) because of exposure required during repair.
1953: Distal Arch → Fully Resected Aneurysm Replaced by Homograft

SUCCESSFUL RESECTION OF ANEURYSM OF DISTAL AORTIC ARCH AND REPLACEMENT BY GRAFT

Michael E. De Bakey, M.D.
and
Denton A. Cooley, M.D., Houston, Texas

REPORT OF A CASE

A 31-year-old white man was admitted to the Methodist Hospital, Houston, Texas, on July 5, 1953. In March, 1945, while on active duty in the Air Force, he sustained a severe crushing injury to the chest. This injury was treated by repeated thoracentesis. In July, 1953, this lesion was roentgenographically demonstrated.

- First operation: partial resection/lateral suture (July 1953)
- Reoperation: complete resection and homograft replacement (Feb 1954)

DeBakey & Cooley
1954 JAMA
Case Report of Successful Repair
Ascending → Resection Using CPB (1956)

1st successful resection of ascending aorta & homograft replacement. *Early use of CPB.*

DeWall-Lillehei pump oxygenator in this early use of cardiopulmonary bypass.
Followed successful 1956 ascending aortic repair with CPB

Aortic Arch Replacement (1957)

- First successful attempt to replace aortic arch
- Homograft
- Cardiopulmonary bypass used to perform early antegrade cerebral perfusion
- Felt 60 minutes CPB was safe
- No hypothermia

DeBakey et al  SGO 1957
Aneurysm
Chronic Dissection
The primary treatment objective for aortic aneurysms is prevention of patient death secondary to rupture.
Thoracoabdominal Aortic Aneurysm

- Estimated 3-4 cases per 100,000 per year
  - Repair indicated: symptomatic
  - Or if a diameter-based threshold of repair is reached
    - > 5.5 cm in chronic dissection
    - > 6.0 cm for aneurysm

Clouse et al JAMA 1998
Thoracoabdominal Aortic Aneurysm

- Repair itself risks ischemic and other damage to downstream organs
  - Spinal cord
  - Kidneys
  - Visceral organs
Early Thoracoabdominal Aortic Repairs

DeBakey & Cooley, 1953
JAMA
- Case report homograft repair
- DTA/extent I TAAA
- Performed by Cooley, Jan 5, 1953
- Clamp & sew

Rob & Chir, 1955
Ann Royal Coll Surg Engl
- Series of 33 abdominal repairs
- Including 6 above the renals
- Mild hypothermia

Etheredge, 1955
Surgery
- Case report homograft repair
- Shunt
Using his wife’s sewing machine, DeBakey created the world’s first Dacron artery (woven graft).

Development of Synthetic Arterial Grafts

- The 1st synthetic artery was created by Voorhees in 1952
  - Vinyon-N made of nylon, orlon, & Teflon (PFTE)
  - Columbia University
- Other material explored
- DeBakey developed Dacron grafts that are still in use today
  - 1st use 1954, sewn (woven) graft used to replace abdominal bifurcation
Dacron Permits a Shift in Approach

- Dacron permitted grafts to be used as an initial shunt
- Extra-anatomical repair possible
- Rapid restoration of renal function
- Bottom to top approach
  - Attached left renal artery first
  - Individual branch grafts

Aneurysm

Graft as "shunt"

Renals first

Celiac last

Clamps removed to restore perfusion

Aneurysm extirpated

End-to-side attachment later revised

Time magazine, 1965
In Honor of Native Son

ERNEST STANLEY CRAWFORD, M.D.

This pioneer surgeon, teacher and medical statesman was born May 12, 1922 in Evergreen. He worked at Conecuh Drug Company as a youngster, and graduated from Evergreen High School (1940). His undergraduate degree was received from the University of Alabama (1943), his M.D. from Harvard Medical School (1946), and he completed his surgical training at Massachusetts General Hospital (1954). An intense interest in the newly developing fields of open heart surgery and replacement of major blood vessels drew Dr. Crawford to Houston, Texas, where he worked for the next 37 years at Baylor College of Medicine, becoming full Professor of Surgery in July 1966. A master surgeon with tireless devotion to the education of young surgeons and to the betterment of mankind. Dr. Crawford became internationally renowned for surgical techniques he developed for the treatment of aneurysmal disease of the aorta. He became a member of every major international vascular society, lectured in many countries, and his textbook Diseases of the Aorta became a reference source in vascular surgery. Dr. Crawford profoundly influenced the field of surgery and the lives of many individuals throughout the world.

DEDICATED MAY 16, 1982 BY THE HERITAGE COMMITTEE OF EVERGREEN-CONECUGH LIBRARY AND THE CITY OF EVERGREEN
Evolution of Early TAAA Approaches

1950s

1960s

1970s
BRAT: Baylor Rapid Autologous Transfusion

- Collaboration of Drs. Yawn, Crawford, and Lou Feldman (from BCM’s machine shop)
- Device to recycle/wash blood lost during [aortic] surgery
- BRAT is commonly used to reduce the amount of transfused blood in complex surgeries
# Impact of Crawford’s Approach to TAAA

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>n</th>
<th>Bypass</th>
<th>Graft type</th>
<th>Mortality</th>
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</thead>
<tbody>
<tr>
<td>Rob <em>et al</em></td>
<td>1955</td>
<td>6</td>
<td>No</td>
<td>Homo/Orlon/sponge</td>
<td>unk</td>
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<tr>
<td>Etheredge <em>et al</em></td>
<td>1955</td>
<td>1</td>
<td>Yes</td>
<td>Homograft</td>
<td>0%</td>
</tr>
<tr>
<td>DeBakey <em>et al</em></td>
<td>1956</td>
<td>4</td>
<td>3 of 4</td>
<td>Homograft</td>
<td>50%</td>
</tr>
<tr>
<td>DeBakey <em>et al</em></td>
<td>1965</td>
<td>42</td>
<td>Yes</td>
<td>Homo/Dacron</td>
<td>26%</td>
</tr>
<tr>
<td>Crawford***</td>
<td>1974</td>
<td>28</td>
<td>Both</td>
<td>Dacron</td>
<td>8%</td>
</tr>
</tbody>
</table>

*Includes the previous 4 cases. Approach included the early use of invalid and other shunts and the later use of the Dacron tube as both preliminary shunt (or bypass) and subsequent graft

**Dacron graft used as preliminary shunt and subsequent graft

***Early experience used bypass; later experience did not

* Taken from a larger series of 33 abdominal repairs
Thoracoabdominal Aortic Aneurysms: Survival with Non-operative Management

Crawford & DeNatale 1986
TAAA: Observations Regarding the Natural Course of Disease
Thoracoabdominal Aortic Aneurysm

- Refined, standardized repair
  - Improved technique
  - Greatest aortic surgeon
  - Categorized by extent of repair

E. Stanley Crawford 1922-1992
Thoracoabdominal aortic aneurysms: Preoperative and intraoperative factors determining immediate and long-term results of operations in 605 patients

• 25 years experience “clamp & sew”
  ▪ Namesake Crawford extents by repair classification introduced
  ▪ Results presented by extent
    I → 144 patients
    II → 159 patients
    III → 157 patients
    IV → 145 patients
Evolving TAAA Repair

Crawford – 1509 TAAA repairs

Lifetime Experience

<table>
<thead>
<tr>
<th>31-year experience 1960 to 1991</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early death</td>
<td>123 (8%)</td>
</tr>
<tr>
<td>Paraplegia/-esis</td>
<td>234 (16%)</td>
</tr>
<tr>
<td>Renal dialysis</td>
<td>136 (9%)</td>
</tr>
<tr>
<td>GI complications</td>
<td>101 (7%)</td>
</tr>
</tbody>
</table>

Svensson, Crawford, Hess, Coselli, Safi
Evolving TAAA Repair

Crawford – 1509 TAAA repairs

Lifetime Experience

<table>
<thead>
<tr>
<th>Extent</th>
<th>Patients</th>
<th>Risk (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>378</td>
<td>15%</td>
</tr>
<tr>
<td>II</td>
<td>442</td>
<td>31%</td>
</tr>
<tr>
<td>III</td>
<td>343</td>
<td>7%</td>
</tr>
<tr>
<td>IV</td>
<td>346</td>
<td>4%</td>
</tr>
</tbody>
</table>

Considerable risk of spinal cord ischemia in extent II TAAA repair

SCI as manifested by paraplegia or paraparesis

Svensson, Crawford, Hess, Coselli, Safi
Risk Varies by Extent of Repair
Evolution of Open TAAA Repair

- No use of heparin
  - Moderate heparinization
- Clamp-and-sew
  - Selective use left heart bypass
  - Selective use of CSF drainage
    - Selective use visceral perfusion
    - Whenever possible cold renal perfusion
- Island technique
  - Selective use branched grafts
Intraoperative Strategy

**All extents**
- Moderate heparinization
- Permissive mild hypothermia
- Aggressive reattachment intercostal arteries
- Cold renal perfusion, whenever possible
- As needed use: stents, endarterectomy, bypass grafts

**Extents I and II**
- Cerebrospinal fluid drainage
- Selective celiac/SMA perfusion
- Left heart bypass
CSF Drainage Reduces Paraplegia after TAAA Repair

May 1997 – April 1999
156 Patients Entered in Trial

<table>
<thead>
<tr>
<th>Neurologic injury</th>
<th>CSFD (n=76)</th>
<th>Control (n=69)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>All lower extremity neurologic deficits</td>
<td>2 (2.6%)</td>
<td>9 (13.0%)</td>
<td>.03</td>
</tr>
<tr>
<td>Immediate deficits</td>
<td>1 (1.3%)</td>
<td>7 (10.1%)</td>
<td>.03</td>
</tr>
<tr>
<td>Paraplegia</td>
<td>0</td>
<td>6 (8.7%)</td>
<td>.01</td>
</tr>
<tr>
<td>Paraparesis</td>
<td>1 (1.3%)</td>
<td>1 (1.4%)</td>
<td>1.0</td>
</tr>
<tr>
<td>Delayed deficits</td>
<td>1 (1.3%)</td>
<td>2 (2.9%)</td>
<td>.60</td>
</tr>
<tr>
<td>Paraplegia</td>
<td>1 (1.3%)</td>
<td>1 (1.4%)</td>
<td>1.0</td>
</tr>
<tr>
<td>Paraparesis</td>
<td>0</td>
<td>1 (1.4%)</td>
<td>.48</td>
</tr>
</tbody>
</table>

P = .03

Third CSF Drainage Randomized Study

Cold Crystalloid Renal Perfusion

- We have performed 2 randomized clinical trials regarding cold renal perfusion
- Cold renal perfusion was found to benefit patients and reduce postoperative renal failure over normothermic
  - \( P=0.03 \) [Köksoy 2002]
- Cold crystalloid and cold blood provide equivalent renal benefit
  - \( P=1.0 \) [LeMaire 2009]
Left Heat Bypass in TAAA Repair

- 12-year period
- 710 patients with extent I or II TAAA repairs
- Retrospective review
  - 312 pts with LHB vs. 398 pts without LHB
  - 380 Extent I TAAAs
  - 330 Extent II TAAAs

Coselli & LeMaire Ann Thorac Surg 1999
330 Extent II TAAA Repairs
With vs. Without Left Heart Bypass

P = 0.007

Incidence of Paraplegia

Coselli & LeMaire • Ann Thorac Surg 1999

Incidence of Paraplegia
Cannulation

- Shift away from femoral artery
- Distal aorta used whenever possible
- *Site may dislodge atheroma*

Left inferior pulmonary vein

Outflow/Drainage cannula

Distal descending thoracic aorta

Inflow/Return cannula
Reattachment of Segmental Arteries

2010 Guidelines on Thoracic Aortic Disease
No recommendation for ICA reattachment
Reducing risk of PPP:

- Reattachment of intercostal/lumbar arteries 62% less risk;
- Heritable thoracic aortic disease 64% less risk

<table>
<thead>
<tr>
<th>Predictors of Persistent Paraplegia or Paraparesis</th>
<th>Relative Risk Ratio (Confidence Intervals)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPP (n = 86)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urgent or emergent repair</td>
<td>2.31 (1.36 – 3.93)</td>
<td>.002</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>1.80 (1.14 – 2.85)</td>
<td>.01</td>
</tr>
<tr>
<td>Chronic symptoms</td>
<td>1.76 (1.10 – 2.82)</td>
<td>.02</td>
</tr>
<tr>
<td>Reattachment of intercostal/lumbar arteries</td>
<td>0.38 (0.23 – 0.64)</td>
<td>&lt;.0002</td>
</tr>
<tr>
<td>Heritable thoracic aortic disease</td>
<td>0.36 (0.16 – 0.81)</td>
<td>.01</td>
</tr>
</tbody>
</table>
Cold Renal Perfusion

LR + 12.5 g/L Mannitol
+ 125 mg/L methylprednisolone
Selective Visceral Perfusion

Flow: 300-400 mL/min

9-Fr Pruitt catheters
Celiac axis
SMA
Left renal
Right renal

9-Fr Pruitt catheters
200mL/min

Celiac axis
SMA
Left renal
Right renal
Branched grafts avoid later visceral patch aneurysms
Reduces native aortic tissue in Marfan syndrome
Useful if visceral arteries are widely displaced, such as is common in chronic aortic dissection
Visceral patch aneurysm
May develop over time in residual native aortic tissue within patch
Not uncommon in patients with heritable thoracic aortic disease (HTAD), such as Marfan syndrome
Relatively uncommon in patients without HTAD
<1% (25 of 3053 TAAA repairs)
Coselli 2018, JTCVS “Reoperation”
Borst's Elephant Trunk

- Surgical technique developed for complex and extensive aortic pathologies (i.e. “mega-aorta”)
- Staged repair is better tolerated by patient, less strain on heart

- Later modified to 2 stages
- Later adapted by Svensson in 1992 to invert the graft at distal suture line

Open Elephant Trunk Repair
Reversed Elephant Trunk Repair

**Distal aorta > Proximal aorta**
**Distal aorta symptomatic (i.e. back pain)**

First use October, 1994 (5 months between stages)
Coselli and Oberwalder. Successful repair of mega aorta using reversed elephant trunk procedure.
Outcomes of 3309 Thoracoabdominal Aortic Aneurysm Repairs

Coselli et al JTCVS 2016

95th Annual Meeting, American Association of Thoracic Surgery (AATS)
Plenary Scientific Session: Abstract 1
Seattle, Washington • Monday, April 27, 2015
# 3309 Open TAAA Repairs

## October 1986 to December 2014

### ~30 year experience

<table>
<thead>
<tr>
<th>Early outcomes</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative death</td>
<td>249 (7.5%)</td>
</tr>
<tr>
<td>30-day death</td>
<td>159 (4.8%)</td>
</tr>
<tr>
<td><strong>Permanent paraplegia</strong></td>
<td>97 (2.9%)</td>
</tr>
<tr>
<td>Permanent paraparesis</td>
<td>81 (2.4%)</td>
</tr>
<tr>
<td>Renal failure (dialysis)</td>
<td>189 (5.7%)</td>
</tr>
<tr>
<td>Gastrointestinal ischemia</td>
<td>31 (0.9%)</td>
</tr>
</tbody>
</table>

n=914  n=1066  n=660  n=669

Coselli JTCVS 2016
## 3309 TAAA Repairs

### Select Rates of Operative Mortality

<table>
<thead>
<tr>
<th>Subgroups of interest</th>
<th>n</th>
<th>Early Death n (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients ≤ 50 y</td>
<td>439</td>
<td>14 (3.2%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Patients &gt; 79 y</td>
<td>193</td>
<td>37 (19.2%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Connective tissue disorder</td>
<td>330</td>
<td>10 (3.0%)</td>
<td>.001</td>
</tr>
<tr>
<td>Chronic aortic dissection</td>
<td>1020</td>
<td>58 (5.7%)</td>
<td>.007</td>
</tr>
<tr>
<td>Rupture</td>
<td>170</td>
<td>37 (21.8%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Prior aortic repair</td>
<td>858</td>
<td>70 (8.2%)</td>
<td>.4</td>
</tr>
<tr>
<td>Elective repair</td>
<td>2586</td>
<td>161 (6.2%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Urgent or emergent repair</td>
<td>723</td>
<td>88 (12.2%)</td>
<td>&lt;.001</td>
</tr>
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In octogenarians, the rupture rate was 14% overall but as high as 25% in extent III. (Aftab et al 2015 JTCVS)
### 3309 TAAA Repairs

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<tr>
<td>Urgent or emergent repair</td>
<td>723</td>
<td>88 (12.2%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Gap of ≥ 50</td>
<td>Date 1</td>
<td>Date 2</td>
<td>Sequential cases without paraplegia</td>
</tr>
<tr>
<td>------------</td>
<td>----------</td>
<td>----------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Oct 1991</td>
<td>May 1992</td>
<td>69</td>
</tr>
<tr>
<td>2</td>
<td>May 1992</td>
<td>Nov 1992</td>
<td>51</td>
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<td>3</td>
<td>July 1993</td>
<td>Apr 1995</td>
<td>261</td>
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<td>4</td>
<td>Apr 1995</td>
<td>Oct 1995</td>
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<tr>
<td>5</td>
<td>Sep 1996</td>
<td>May 1997</td>
<td>117</td>
</tr>
<tr>
<td>6</td>
<td>Apr 1998</td>
<td>Feb 1999</td>
<td>113</td>
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<tr>
<td>7</td>
<td>Feb 1999</td>
<td>May 1999</td>
<td>51</td>
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<tr>
<td>8</td>
<td>May 2000</td>
<td>Aug 2000</td>
<td>60</td>
</tr>
<tr>
<td>9</td>
<td>Dec 2000</td>
<td>Apr 2001</td>
<td>53</td>
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<tr>
<td>10</td>
<td>Feb 2002</td>
<td>July 2002</td>
<td>84</td>
</tr>
<tr>
<td>11</td>
<td>July 2002</td>
<td>Feb 2003</td>
<td>102</td>
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<td>12</td>
<td>Nov 2003</td>
<td>Apr 2004</td>
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<tr>
<td>13</td>
<td>June 2004</td>
<td>Dec 2004</td>
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<td>14</td>
<td>Jan 2007</td>
<td>Dec 2007</td>
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<td>15</td>
<td>Dec 2010</td>
<td>May 2011</td>
<td>50</td>
</tr>
<tr>
<td>16</td>
<td>Mar 2014</td>
<td>Dec 2014</td>
<td>67</td>
</tr>
</tbody>
</table>
Long-term Survival

Number at Risk

Survival (%)

Follow up (Years)

<table>
<thead>
<tr>
<th>Follow up (Years)</th>
<th>Number at Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3309</td>
</tr>
<tr>
<td>5</td>
<td>1684</td>
</tr>
<tr>
<td>10</td>
<td>724</td>
</tr>
<tr>
<td>15</td>
<td>194</td>
</tr>
</tbody>
</table>

Survival:
- All: 63.6 ± 0.9 (63.56-63.64)
- All: 36.8 ± 1.0 (36.73-36.87)
- All: 18.3 ± 0.9 (18.17-18.43)
Long-term Survival by Genetic Disorder

<table>
<thead>
<tr>
<th>Genetic Disorder</th>
<th>0 Yrs</th>
<th>5 Yrs</th>
<th>10 Yrs</th>
<th>15 Yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Genetic Disorder</td>
<td>82.3 ± 4.1</td>
<td>65.8 ± 2.6</td>
<td>47.4 ± 3.3</td>
<td></td>
</tr>
<tr>
<td>Genetic Disorder</td>
<td>60.3 ± 1.0</td>
<td>32.1 ± 1.0</td>
<td>14.0 ± 0.9</td>
<td></td>
</tr>
</tbody>
</table>

Number at Risk:
- No Genetic Disorder: 523, 308, 164, 60
- Genetic Disorder: 2786, 1376, 560, 134
Long-term Survival by Aortic Dissection

- Dissection
- No Dissection

Survival (%) over follow-up (Years)

Number at Risk:
- 0 years: 1196
- 5 years: 647
- 10 years: 324
- 15 years: 97

Survival at 15 years:
- Dissection: 12.2 ± 0.9 (12.02-12.38)
- No Dissection: 31.4 ± 2.0 (31.00-31.80)

P < 0.001
Freedom from Late Repair Failure in 3060 early survivors of 3309 TAAA Repairs

Coselli JTCVS 2016
Early Survivors: Stratified by Genetic Disorder

Freedom from Repair Failure (%)

Follow up (Years)

<table>
<thead>
<tr>
<th>Number at Risk</th>
<th>3060</th>
<th>1661</th>
<th>701</th>
<th>189</th>
</tr>
</thead>
</table>

Freedom from Repair Failure

Coselli JTCVS 2016
### Thoracoabdominal Aortic Aneurysm Repair

#### Patient Characteristics (n = 3550)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>n</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age, y [IQR]; range 10 y to 92</td>
<td>67</td>
<td>[59-73]</td>
</tr>
<tr>
<td>Age ≤ 50 y</td>
<td>483</td>
<td>(13.6%)</td>
</tr>
<tr>
<td>Age &gt; 79 y</td>
<td>207</td>
<td>(5.8%)</td>
</tr>
<tr>
<td>Aortic dissection involving distal aorta</td>
<td>1298</td>
<td>(36.6%)</td>
</tr>
<tr>
<td>Acute or subacute dissection</td>
<td>180</td>
<td>(5.1%)</td>
</tr>
<tr>
<td>Chronic dissection</td>
<td>1118</td>
<td>(31.5%)</td>
</tr>
<tr>
<td>Connective tissue disorder</td>
<td>372</td>
<td>(10.5%)</td>
</tr>
<tr>
<td>Marfan syndrome</td>
<td>325</td>
<td>(9.2%)</td>
</tr>
</tbody>
</table>

Jan 1986 – July 2018
## Thoracoabdominal Aortic Aneurysm Repair

### Early Outcomes ($n = 3550$)

<table>
<thead>
<tr>
<th>Event</th>
<th>$n$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative mortality</td>
<td>290 (8%)</td>
</tr>
<tr>
<td>30-day death</td>
<td>187 (5%)</td>
</tr>
<tr>
<td><strong>Persistent</strong></td>
<td></td>
</tr>
<tr>
<td>Paraplegia</td>
<td>109 (3%)</td>
</tr>
<tr>
<td>Paraparesis</td>
<td>78 (2%)</td>
</tr>
<tr>
<td>Stroke</td>
<td>87 (2%)</td>
</tr>
<tr>
<td>Renal failure necessitating dialysis</td>
<td>218 (6%)</td>
</tr>
<tr>
<td><strong>Adverse event (composite endpoint)</strong></td>
<td>533 (15%)</td>
</tr>
</tbody>
</table>

Jan 1986 – July 2018
Moulakakis 2018 J Vasc Surg
30 studies from 1989-2017

Meta-Analyses: Open TAAA Repair

- 1260 abstracts reviewed
- Excluded: 996 at stage 1 & 234 at stage 2
- 30 studies of TAAA repair were included

Inclusion Criteria

<table>
<thead>
<tr>
<th>Data: open TAAA repair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data: in-hospital mortality or mortality rate by extent of repair</td>
</tr>
<tr>
<td>Data: Surgical technique and adjuncts for spinal cord/viscera</td>
</tr>
<tr>
<td>Data: 50 or more patients</td>
</tr>
<tr>
<td>Published in English</td>
</tr>
</tbody>
</table>

Exclusion Criteria

| Only ruptured TAAAs |
| Reported hybrid or endovascular TAAA repairs |
| Only infected TAAAs |
| Data: Mixed with DTA repairs |
| Only type IV TAAA repairs |
| Described nationwide data or registries |
Open repair of thoracoabdominal aortic aneurysms in experienced centers

Meta-Analyses: Open TAAA Repair

- 1260 abstracts reviewed => 30 studies
- 9963 patients underwent open TAAA repair

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>n</th>
<th>Pooled Rates %</th>
<th>(95% CIs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-hospital mortality</td>
<td>30</td>
<td>11.26%</td>
<td>(9.56-13.09)</td>
</tr>
<tr>
<td>Extent II</td>
<td>12</td>
<td>10.32%</td>
<td>(7.39-13.63)</td>
</tr>
<tr>
<td>Permanent dialysis</td>
<td>13</td>
<td>7.92%</td>
<td>(5.34-10.92)</td>
</tr>
<tr>
<td>Stroke</td>
<td>13</td>
<td>3.11%</td>
<td>(2.36-3.94)</td>
</tr>
<tr>
<td>Paraplegia</td>
<td>23</td>
<td>5.00%</td>
<td>(4.36-5.68)</td>
</tr>
<tr>
<td>Paraparesis</td>
<td>14</td>
<td>3.61%</td>
<td>(2.25-5.25)</td>
</tr>
<tr>
<td>Bowel ischemia</td>
<td>5</td>
<td>1.72%</td>
<td>(0.81-2.92)</td>
</tr>
</tbody>
</table>

Moulakakis 2018 J Vasc Surg
30 studies from 1989-2017
Meta-Analyses: Open TAAA Repair

- 1260 abstracts reviewed
- Excluded: 996 at stage 1 & 234 at stage 2
- 30 studies of TAAA repair were included

“Meta regression analysis evidenced a statistically significant inverse association between mortality and the volume of cases performed in the vascular center (t = -2.00; P = .005).”

Moulakakis 2018 J Vasc Surg
30 studies from 1989-2017
Conclusions

• Approach to repair is multimodality
• Open repair is durable and remains an gold standard for TAAA repair
• However, surgical skill must be maintained
• High volume centers tend to have better outcomes
Opa!
Thank you!

www.notretiredyet.com
Thank you!

www.notretiredyet.com
Thank you!