Evolution of Thoracic Aortic Surgery
– A Rapidly Advancing Paradigm

October 15th, 2014
Family Practice Evening Course
University of Calgary

Jehangir Appoo
Division of Cardiac Surgery
Libin Cardiovascular Institute
University of Calgary
Today:

Story:

Recent Evolution of Thoracic Endovascular Repair

Descending Thoracic Aortic Aneurysms
Complicated Type B Aortic Dissections
Aortic Coarctation

Future Evolution of Thoracic Endovascular Repair

Aortic Arch
Ascending Aorta

Infrastructure/Research Paradigm

Few Tools for Primary Care Physicians
Fathers of Aortic Surgery

1953
Cooley and De Bakey repaired the first descending thoracic aortic aneurysm using homografts

1970’s
Stanley Crawford – major technical improvements “30/30” club

1970’s-1980’s
Randall Griepf refinements of techniques neuro/spinal protection
Highly morbid operations

Significant risks

Pain syndrome
Evolution of Aortic Surgery
Recent Evolution of Thoracic Endovascular Repair

**Descending Thoracic Aortic Aneurysms**
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Current/Future Evolution of Thoracic Endovascular Repair

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Infrastructure

Research
Descending Thoracic Aortic Aneurysms

Risk of dissection or rupture of the Descending Aorta

Elefteriades et al., Yale database
Endovascular surgery improves morbidity & mortality

↓ Mortality 2% vs. 11%
↓ Cord ischemia 3% vs. 14%
↓ ICU, hospital LOS

↑ vascular cxs
↑ re-interventions

Endovascular stent grafting versus open surgical repair of descending thoracic aortic aneurysms in low-risk patients: A multicenter comparative trial

Joseph E. Bavaria, MD, Jehangir J. Appoo, MD, Michel S. Makaroun, MD, Joel Vertor, PhD, Zi-Fan Yu, ScD, and R. Scott Mitchell, MD, for the Gore TAG Investigators

Objective: Results are presented from the first completed multicenter trial directed at gaining approval from the US Food and Drug Administration of endovascular versus open surgical repair of descending thoracic aortic aneurysms.

Methods: Between September 1999 and May 2001, 140 patients with descending thoracic aneurysms were enrolled at 17 sites and evaluated for a Gore TAG Thoracic Endograft. An open surgical control cohort of 94 patients was identified by enrolling...

J Thorac Cardiovasc Surg 2007;133:369-77
37y.o mother of 3
Presents with a cough
Open and
Endovascular options
1.5 inch groin incision
Home 2 days
@work 1 week
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Type B dissection

Evolving controversy surrounding mgmt of “uncomplicated” vs. “complicated” type B
Complicated Type B Dissection
Endovascular Treatment of Type B dissection
Complicated Acute Type B Dissection

56yo male
Seen 12 hrs post presentation
Severe Malperfusion:
  Ischemic leg
  Ischemic gut
  Renal failure
Management

– Emergent OR
– Multidisciplinary team
– Right groin access
– 42mm x 216mm Cook Zenith TX2 Proform device from left CCA to mid descending aorta (Prox LZ=36mm)
– Device unsheathed distal to ostium of Left Carotid Artery
Lower extremity, visceral & renal malperfusion resolved
Hospital Survival with Acute Type B Dissection

In Hospital Mortality:
- Medical Rx - 10%
- TEVAR - 10%
- Open surgery - 34%

Log rank p < 0.001

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Research
Primary Adult Coarct
Male
Early 30’s
Bicuspid Aortic Valve
Primary Adult Coarct
Male
Early 30’s
Bicuspid Aortic Valve
Recent Evolution

Descending Thoracic Aortic Aneurysm

Type B Dissection

Coarctation
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Ongoing/Future Evolution
“Takumi Principle”

Perceptive, Thoughtful surgeons in new era of skill
Why Zone 0 TEVAR?
How did we get started?

11 yrs post Type A dissection repair
Why Zone 0 TEVAR?

Complex Patients

Diffuse aortic disease

Generally need 2 stage procedures with total arch replacement and elephant trunk

Often redo setting
<table>
<thead>
<tr>
<th>Surgeon</th>
<th>Year</th>
<th>ET1 Mortality</th>
<th>ET2 Mortality</th>
<th>Interval Mortality</th>
<th>Rx Mortality</th>
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</thead>
<tbody>
<tr>
<td>Svensson</td>
<td>2004</td>
<td>2%</td>
<td>8.5%</td>
<td>14%</td>
<td>18%</td>
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<tr>
<td>Safi</td>
<td>2007</td>
<td>6.3%</td>
<td>9.6%</td>
<td>10%</td>
<td>13.3%</td>
</tr>
<tr>
<td>Lemaire/Coselli</td>
<td>2006</td>
<td>12%</td>
<td>4%</td>
<td>25%</td>
<td>36%</td>
</tr>
<tr>
<td>Kouchoukos</td>
<td>2007</td>
<td>7.2%</td>
<td>--</td>
<td>--</td>
<td>7.2%</td>
</tr>
<tr>
<td>Grieppe</td>
<td>2008</td>
<td>6%</td>
<td>7%</td>
<td>12%</td>
<td>24.5%</td>
</tr>
</tbody>
</table>

Even in centres of experience, operative mortality with 2 stage elephant trunk technique is high
An Alternative Approach to Diffuse Thoracic Aortomegaly: On-Pump Hybrid Total Arch Repair Without Circulatory Arrest

William D. T. Kent, MD, MS, Jason K. Wong, MD, Eric J. Herget, MD, Joseph E. Bavaria, MD, and Jehangir J. Appoo, MDCM

Libin Cardiovascular Institute of Alberta, Division of Cardiac Surgery, University of Calgary, and Division of Interventional Radiology, Department of Diagnostic Imaging, Foothills Medical Centre, University of Calgary, Calgary, Alberta, Canada; and Division of Cardiothoracic Surgery, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania

Diffuse thoracic aortomegaly has conventionally been managed with a two-stage elephant trunk procedure, requiring prolonged circulatory arrest, with an inherent risk of major morbidity and mortality. Recently, to improve outcomes, several hybrid arch procedures have been proposed using off-pump techniques. We have adopted an alternative, single-stage hybrid strategy using cardiopulmonary bypass without circulatory arrest to replace the ascending aorta and perform arch debranching and antegrade endovascular stent graft deployment. Unlike off-pump procedures, pathology of the aortic valve, root, and ascending aorta is addressed while avoiding the complications of stent graft placement in the native ascending aorta.


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2010- Zone 0
Novel Approach

Follow up at 2 years
Zone 0:
Is there a role for endovascular therapy of acute type A aortic dissection?
Obliteration of false lumen in arch & prox descending aorta

Pigtail catheter in true lumen
In the future:

What % of pts would be eligible for isolated endovascular repair of acute type A dissection?

Which patients benefit from conventional surgery vs. hybrid surgery vs. endovascular?

Strategies

Surgical asc ao replacement followed by branch grafts?
Is it safe to place an endograft in the ascending aorta?

Clinical & Radiologic Follow up Zone 0
Thoracic Endovascular Aortic Repair

Jehangir Appoo, Eric Herget, William Kent, & Jason Wong
University of Calgary

Canadian Cardiovascular Congress
October 28th, 2012
64 y.o male
Type A repair 2009
Complicated course

Aorta growing at rate of 1cm/year

Arch dissected
Large residual primary intimal tear in arch
True lumen effaced
Total endo arch
Custom built branched arch graft
Complexity
2013- VR image 3 months post op
Evolution of Zone 0
Future Evolution of closed chest zone 0

-new devices on horizon
Closed Chest Total Arch

Modular branch graft

Off the shelf device

FDA trial: 10 cases done at 4 sites in US – Oct 2014
Closed Chest Arch

Chimney Technique

Off the shelf conventional devices

Concern with gutter endoleaks & branch compression

Main indication: emergencies when customized devices unavailable but being used electively in parts of world
Closed Chest Total Arch

Najuta graft

Precurved fenestrated arch graft in various configurations off the shelf

Used in over 300 aneurysm cases in Japan

Concern re: risk of stroke
Evolution of Endovascular MultiLayer Aortic Stent Grafts
Closed chest total arch

Flow Modulating devices

**Paradigm change:**
Not about “aneurysm exclusion”

Scaffold to allow thrombus deposition, flow pattern modulation while maintaining side branch patency

Laminar vs. turbulent flow
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Infrastructure/Research
Infrastructure

Team

Equipment

Research
TEAM
Surgeons
Interventional Radiologists
CV Anesthetists
Nursing & DI staff
CV ICU
Advanced NP
Biomedical Engineering
Pathology
Neurology
Research Nurse Clinician
Cardiac Hybrid Operating Suite - a State of the Art Centre

Conventional operating theatre & Diagnostic suite

Multimodality
Multidisciplinary team
Avoid patient transfer
Improved results
Precise Imaging
Minimally invasive Aortic therapy is:

- Safer
- More effective
- More efficient
- Less invasive/better tolerated
- Innovative
Research Interests:

Assessing efficacy of innovation
Decreasing morbidity and mortality of aortic interventions
Understanding Aortic Dissections

Risk stratification of Aortic Aneurysms – *Indolent but Catastrophic*

Why do Aneurysms Rupture?

Size & growth rate not great predictors of rupture/dissection

Need more science
Aneurysms rupture/dissect when wall stress > wall strength

Collaboration with Biomedical Engineering, Histo-Pathology & Imaging colleagues
3D Growth
Multidimensional growth estimation

Non linear growth measure

\[ g_d^i = \frac{1}{t} \log\left( \frac{D_i^{\text{follow-up}}}{D_i^{\text{post operation}}} \right) \]

100 observations
3D Growth

Results

Maximum growth

Maximum diameter

Growth rate (mm/y)

Outer diameter (mm)
Story:

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Today:

Few Tools for Primary Care Physicians
Position Statement

Canadian Cardiovascular Society Position Statement on the Management of Thoracic Aortic Disease

Primary Panel: Munir Boodhwani, MD, MMSc (Co-Chair), Gregor Andelfinger, MD, PhD, Jonathon Leipsic, MD, Thomas Lindsay, MD, MSc, M. Sean McMurtry, MD, PhD, Judith Therrien, MD, and Samuel C. Siu, MD, SM (Co-Chair)

aDivision of Cardiac Surgery, University of Ottawa Heart Institute, Ottawa, Ontario, Canada
bDepartment of Pediatrics, University of Montreal, Montreal, Québec, Canada
cDepartment of Radiology, University of British Columbia, Vancouver, British Columbia, Canada
dDivision of Vascular Surgery, University Health Network, Toronto, Ontario, Canada
eDivision of Cardiology, University of Alberta, Edmonton, Alberta, Canada
fDivision of Cardiology, McGill University, Montreal, Québec, Canada
gDivision of Cardiology, Western University, London, Ontario, Canada
Increased risk of Aortic complications:

- large size (≈5cm)
- rapid growth (>0.5cm/yr)
- concomitant aortic valve disease

uncontrolled hypertension
smoking history
Position Statement

Canadian Cardiovascular Society Position Statement on the Management of Thoracic Aortic Disease

RECOMMENDATION

3. We recommend that patients with complex TAD who stand to benefit from these emerging techniques and technologies be referred to teams experienced in these approaches (Conditional Recommendation, Low-Quality Evidence).
Some discrepancies between 2010 US & 2014 Canadian Guidelines

*Reasonable to screen first degree relatives of patients with acute aortic syndrome, thoracic aortic aneurysm, and bicuspid aortic valves

*Screening tool:
  Echo
  ±CTA/MRA chest

...Indolent but Catastrophic...
Position Statement

Canadian Cardiovascular Society Position Statement on the Management of Thoracic Aortic Disease

RECOMMENDATION

15. We suggest that patients with TAD be precluded from private driving if the ascending aorta diameter is > 6.0 cm or the descending aorta diameter is > 6.5 cm, and restricted from commercial driving if the ascending thoracic aorta diameter is > 5.5 cm or the descending thoracic aorta is > 6.0 cm.\(^8\) (Conditional Recommendation, Very Low-Quality Evidence).

Values and preferences. These thresholds are based on the methodology of the CMA and Canadian Cardiovascular Society Consensus Conference on the assessment of the cardiac patient for fitness to drive and fly,\(^8\) and the best available observational evidence. Risk thresholds can be reached at different aortic diameters for different aortopathies. Further studies are required to provide reliable estimates of rupture risk.

* If thoracic aorta is \(\approx 6\) cm worth having a conversation about driving
Come a long way....journey continues
The Evolution of Endovascular
The Evolution of Endovascular

- Stentgrafts
  - Many technical innovations and improvements since these pioneer series to address challenging anatomy inherent with thoraco-abdominal aneurysmal disease
    - Fenestrated
      - Custom / pre-fabricated
      - In-situ
    - Branched grafts
    - Chimney/Snorkel technique
    - Sandwich technique
The Evolution of Endovascular

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The Evolution of Endovascular

• While these novel ‘hybrid’ endovascular approaches do show promise, there are significant limitations
  • High cost and lag time (custom fabricated devices)
  • Branch thrombosis¹
  • Need for high volume centers of excellence²
  • Similar spinal cord and visceral (renal failure) complication rates compared with surgical techniques²

The Evolution of Endovascular
Distal Arch Aneurysms
Foothills Medical Centre
University of Calgary