Thoracoabdominal Aorta: Advances and Novel Therapies

Robert Meisner, MD FACS
Sidney Kimmel Medical Center Assistant Professor of Surgery
Vascular / Endovascular Surgeon at Lankenau Medical Center

November 18th 2017
Thoracoabdominal Mortality

- 15,000 deaths each year from rupture of aortic aneurysm
  - 6,000 deaths of the thoracic aorta (TAA)

- 5-8% of patients with acute TAA rupture survive

- 5 year survival for TAA > 5cm
  - Untreated 17%
  - Treated 50%

Spinal Cord Ischemia (SCI)

- Devastating complication with aortic repair.
- >50% of SCI patients without recovery die within 6 months.

DeSart (A. Beck) et al. (J Vasc Surg 2013;58:635-42.)
Aging Population

- Fastest growing segment of the population

TAAA Incidence
Crawford Classification of Thoracoabdominal Aortic Aneurysms

Extent I
Extent II
Extent III
Extent IV
Extent V
The Risk of Paraplegia

Crawford Classification (n=1,509)

The Risk of Paraplegia - 2016
(Crawford Classification n=3,309)

Pioneers in Aortic surgery

Stanley Crawford
1509 TAAA repairs

Joseph Coselli
3309 open TAAA

Roy Greenberg
Endovascular TAAA IDE in 2001
Incidence of spinal cord ischemia according to Crawford extent of aneurysm

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endovascular repair</td>
<td>10%</td>
<td>19%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>Open surgical repair</td>
<td>14%</td>
<td>22%</td>
<td>10%</td>
<td>2%</td>
</tr>
</tbody>
</table>

Lankenau Medical Center Experience

• Extensive open TAAA experience
• “Aortic team” approach
• Treatment approach tailored to the patient
• Outcome reporting
"Prediction is very difficult, especially if it's about the future."
Nils Bohr, Nobel Laureate in Physics

“I never think of the future, it comes soon enough.”
Albert Einstein
Key Points

• *This concentrated volume will not be repeated in the future.*
  
  – *Where we are going to improve going forward is on patient outcomes.*

• *Endovascular repair is possible.*

• *Paraplegia is still the major issue.*
Open, endovascular, hybrid repairs, that are individualized to the specific patient will continue to play a complimentary role.
Ideal Candidates for Open Repairs

- Younger patients
- Cardiopulmonary reserve
- Mandatory for familial Aortic Pathologies
  - Marfan, Collagen Vascular disease
Case Presentation

- 78 year old male
  - Type V TAAA
  - Hypertension
Case Presentation

• Repair of Type V TAAA
• Planned re-implantation:
  – Celiac Artery
  – SMA
  – Right and left renal arteries
• CBP- Fem Art / Vein
• CSF drainage
Outcome

- Successful repair
- Intubation time: 15 hours
- ICU: 4 days
- Complications: none
• “Routine sacrifice of aortic branches can be carried out ... without neurologic injury.”
• **Maintenance of hemodynamic stability**
# Thoracoabdominal Aneurysms

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>63%</td>
</tr>
<tr>
<td>Female</td>
<td>37%</td>
</tr>
<tr>
<td>Age (mean years, SD)</td>
<td>62 (+/- 13)</td>
</tr>
<tr>
<td>Total Cases</td>
<td>244</td>
</tr>
</tbody>
</table>
Etiology
(n=244)

- Medial Degen.: 38%
- Ather.: 23%
- Chr. Diss. Acute Diss.: 27%
- Other: 9%
- Other: 3%
Aneurysm Type: N=244

- Descending: 32%
- Type 1: 24%
- Type 2: 13%
- Type 3: 16%
- Type 4: 16%
## Mortality and Morbidity

<table>
<thead>
<tr>
<th>Condition</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>13</td>
<td>5.5%</td>
</tr>
<tr>
<td>Paraplegia</td>
<td>4</td>
<td>1.7%</td>
</tr>
</tbody>
</table>
## Operative Complications

<table>
<thead>
<tr>
<th>Condition</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post- Op Bleeding</td>
<td>8</td>
<td>3%</td>
</tr>
<tr>
<td>Stroke</td>
<td>6</td>
<td>2.5%</td>
</tr>
<tr>
<td>- Embolic</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>- Hemorrhage</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
New Onset Renal Complications: Cr>2.5

- New onset renal insufficiency  25  10%
- New Onset Hemodialysis  8  3.5%
- Ventilation>48h  93  38%
Hospital Stay

Mean (days) 17
Survival

1 year: 85%
3 years: 80%
5 years: 75%
10 years: 65%

Median Survival = 16.5 years
Survival and Dissection

<table>
<thead>
<tr>
<th>Follow up (months)</th>
<th>Dissection</th>
<th>Non Dissection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>95%</td>
<td>80%</td>
</tr>
<tr>
<td>3 years</td>
<td>85%</td>
<td>70%</td>
</tr>
<tr>
<td>5 years</td>
<td>80%</td>
<td>65%</td>
</tr>
<tr>
<td>10 years</td>
<td>65%</td>
<td>50%</td>
</tr>
</tbody>
</table>

$p = 0.015$
## Outcomes

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>6%</td>
<td>10%</td>
<td>8%</td>
<td>7%</td>
<td>8%</td>
</tr>
<tr>
<td>SCI*</td>
<td>2%</td>
<td>11%</td>
<td>11%</td>
<td>3%</td>
<td>13%</td>
</tr>
<tr>
<td>Dialysis</td>
<td>4%</td>
<td>10%</td>
<td>13%</td>
<td>6%</td>
<td>21%</td>
</tr>
</tbody>
</table>

*SCI- Spinal Cord Ischemia*
Adjuncts: Open TAAA Repair
Adjuncts: Open TAAA Repair

Gore® Hybrid Graft

IFU: Bypass diseased vessels in Occlusive or aneurysmal disease

What is a total Endovascular TAAA Repair?

- Endovascular stent graft repair of aorta
- Aortic branches: Celiac, SMA, left and right renal artery
  - Fenestrations
  - Branches
Current State of Endovascular TAAA Repair

• Increasing exposure
  – 106 endovascular TAAA repair publications in 2017 alone!

• No current FDA-approved endovascular graft for TAAA repair

• No multicenter pivotal trials

• Individual institution Investigational Device Exemption (IDE)

• Experience in non-FDA environments

• Off-label use common
How is this done?

- Location: Hybrid Operative Suite
- Spinal drainage
- Personal: 2 endovascular surgeons, facile scrub and circulation RNs
- Bilateral Femoral access (percutaneous); open left axillary arterial access.

How is this done?
Patient Selection for endovascular TAAA repair

• Ideal patients
  – Older patients
  – Cardiac / pulmonary marginal patients

• Contraindications
  – Marfans & collagen vascular disorders
  – Shaggy aorta
  – Younger and otherwise relatively healthy patients
  – Unsuitable vessel anatomy
Current eTAAA Options

• Physician modifications

• Parallel grafts / “Sandwich” approach

• eTAAA grafts
  – Off-the-shelf
  – Customized grafts
Current eTAAA Options

- Physician modifications
  - Physician modifies an FDA approved product
  - With or without an IDE

- Rejuvenated interest
  - 3-D printing from CTA
Current eTAAA Options

- *Physician modifications*
- Parallel grafts / “Sandwich” approach
Current eTA:\n
• Physician modifications

• Parallel grafts / “Sandwich” approach
  – Materials are easily available

Advantages:

• Grafts and Materials are readily available in the US.
• Reasonable approach for frail patients who present with a symptomatic aneurysm or rupture.

Concerns:

• “Gutter” endoleaks.
• Durability of repair.
Off the Shelf

Customized Graft
“One size fits most”

- WL Gore Thoraco-Abdominal Branch Endoprosthesis (TAMBE®)

Off the Shelf

- Modular off the shelf components
  - Viabahn and VBX bridging Stent grafts

Courtesy of M Makaroun MD; UPMC Heart and Vascular Institute
“One size fits most”

- WL Gore TAMBE®
- Early feasibility Study
  - 10 Sites
  - N=13 patients
  - Aneurysm Type:
    - TAAA IV 3
    - Pararenal 10

- 100% technical success (13/13 patients).
- No operative mortality.
- No surgical conversions.
- 51/52 branch patency.

Courtesy of M Makaroun MD; UPMC Heart and Vascular Institute
Right renal artery dissection with subsequent thrombosis.

Early Feasibility Study - TAMBE®

Courtesy of M Makaroun MD; UPMC Heart and Vascular Institute
Custom-Made Graft

3-4 weeks
Off the Shelf

Customized Graft
Endovascular TAAA Repair

Fenestrated and branched endovascular aneurysm repair outcomes for type II and III thoracoabdominal aortic aneurysms

Matthew J. Eagleton, MD, Matthew Follansbee, BS, Katherine Wolski, MPH, Tara Mastracci, MD, and Yuki Kuramochi, BScN, Cleveland, Ohio

Largest Endovascular TAAA repair series published to date.

- 354 patients TAAA type II - III
- Elective mortality: 4.8%
  - Morbidity 40% (MI, Pulm dysfunction, renal dysfunction, CVA)
- Renal failure requiring dialysis: 3%
- Permanent SCI: 4%  (any SCI 8%)
- Type I or III Endoleak: 2.8% at end of index procedure

Extent of endovascular TAAA repair and SCI


Matthew J. Eagleton, MD, Matthew Follansbe, MPH, Tolski, MPH, Tara Mastracci, MD, Yuki Kuramochi, BScN, Cleveland, Ohio.


Improving Outcomes

• Trend of extent of aneurysm repair linked to SCI risk.

• Still far from perfect:
  – How have outcomes improved?
  – Can we use these lesions learned?
Staged endovascular repair of thoracoabdominal aortic aneurysms limits incidence and severity of spinal cord ischemia

Adrian O’Callaghan, MD, Tara M. Mastracci, MD, and Matthew J. Eagleton, MD
Cleveland, Ohio


2 to 4 weeks
Staged endovascular repair of thoracoabdominal aortic aneurysms limits incidence and severity of spinal cord ischemia

Adrian O’Callaghan, MD, Tara M. Mastracci, MD, and Matthew J. Eagleton, MD, Cleveland, Ohio

<table>
<thead>
<tr>
<th></th>
<th>1 Stage</th>
<th>2 Stage</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-day mortality</td>
<td>19%</td>
<td>0%</td>
<td>0.05</td>
</tr>
<tr>
<td>Any SCI</td>
<td>38%</td>
<td>11%</td>
<td>0.02</td>
</tr>
<tr>
<td>Permanent SCI</td>
<td>16%</td>
<td>0%</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Staged endovascular repair of thoracoabdominal aortic aneurysms limits incidence and severity of spinal cord ischemia

Adrian O’Callaghan, MD, Tara M. Mastracci, MD, and Matthew J. Eagleton, MD, Cleveland, Ohio

30 day morality

Any SCI

Permanen SCI

Table: Number at Risk

<table>
<thead>
<tr>
<th>Number at Risk</th>
<th>Follow-Up Time (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Stage 32</td>
<td>13 11 3</td>
</tr>
<tr>
<td>Unintentional Stage 28</td>
<td>19 12 8</td>
</tr>
<tr>
<td>Two Stage 27</td>
<td>9 4 2</td>
</tr>
</tbody>
</table>

Aggressive revascularization / preservation of left subclavian artery and hypogastric arteries

- With any significant aortic coverage or repair
Re-interventions: eTAAA and Open Repair

<table>
<thead>
<tr>
<th></th>
<th>Any Re-intervention at 1 year</th>
<th>Aortic-Related Re-intervention at 1 year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Endo TAAA Repair</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oderich et al. 2017</td>
<td>19%</td>
<td>14%</td>
</tr>
<tr>
<td>Eagleton et al. 2016</td>
<td>24%</td>
<td>20%</td>
</tr>
<tr>
<td>Huang et al. 2016</td>
<td>24%</td>
<td>19%</td>
</tr>
<tr>
<td><strong>Open Repair</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Huang et al. 2016</td>
<td>31%</td>
<td>14%</td>
</tr>
</tbody>
</table>

- Re-interventions remain a concern in contemporary publications

Huang Y. et al. Treatment Trend & Outcomes of open versus endovascular TAAA repair in a single center. ESVS. 2016

Oderich G, et al. Prospective, nonrandomized study to evaluate endovascular repair of pararenal and thoracoabdominal aortic aneurysms using fenestrated-branched endografts based on supraceliac sealing zones

*J Vasc Surg* 2017
Trend from the Literature

• Number of open TAAA repairs has remained consistent.

• Due to the advent of endovascular repairs, the median age for open repair has decreased.
  – Open: 60 years
  – Endovascular: 78 years

Huang Y. et al. Treatment Trend & Outcomes of open versus endovascular TAAA repair in a single center. ESVS. 2016

Endovascular TAAA Repair: Key Points

- Outcomes are improving.
- Still poses a risk for SCI but results are reasonable.
- Re-interventions are not uncommon.
What is Hybrid Aortic Surgery?

- Using both open surgical techniques & Endovascular grafts.
- Typically done in stages.

1 - 4 weeks

1st

2nd

1 - 4 weeks
Hybrid Aortic Surgery

• Ideal patient?
  – Not well defined.
    • Physiologically not well enough for thoracoabdominal open aortic replacement (cardiac, pulmonary, age)
    • Re-operative surgical field

• Potential Advantages:
  – No need to cross-clamp the aorta
  – No CPB
  – No thoracotomy incision
    • Downsizes the surgical exposure.
Example: Incisions
What is Hybrid Aortic Surgery?

• Contraindications:
  – Significant distal aorta or iliac artery calcifications
Hybrid Aortic Surgery?

- Best utilization of this technique is in the setting of prior operative repair

Initial experience: 4 patients with prior open thoracic aortic repairs.

2007: 13 patients treated, all with prior aortic surgery and severe COPD.
Example

Complementary roles of open and hybrid approaches to thoracoabdominal aortic aneurysm repair

Ehsan Benrashid
Richard L. McC

Thoracoabdominal aortic aneurysm (TAAA):
Algorithmic Approach to Repair Type Selection

High-risk comorbidities?
- Age ≥ 65 years
- Frailty
- Coronary artery or valvular heart disease
- Congestive heart failure
- Chronic obstructive pulmonary disease
- Renal insufficiency

High risk anatomy?
- Prior left chest surgery
- Prior open descending thoracic/TAAA repair
- Prior open abdominal aortic repair

Connective tissue disorder (CTD) with available proximal and distal landing zones in prior Dacron grafts?

TAAA Extent
- Crawford Extent II in non-CTD patient

If No, Open TAAA repair

If Yes, Staged Hybrid TAAA Repair

Procedural Volumes Per Year

Number of Cases

Year


HTAAAR
OTAAAR

Overall Survival Open vs. Hybrid

- Overall no significant mortality difference.
- Hybrid patients were older, more comorbid.
- Reintervention: 12.5% vs. 1.2% open repair
Hybrid Repair Conclusions

• Hybrid TAAA repair is still a reasonable surgical option in specific cases.

• *Probably not the holy grail of TAAA repair.*
### Open TAAA Repair

<table>
<thead>
<tr>
<th></th>
<th>LMC Plestis et al. 2017 (n=244)</th>
<th>Hughes 2016 (n=84)</th>
<th>Cambria 2002 (n=337)</th>
<th>Coselli 2016 (n=3,309)</th>
<th>Conrad 2007 (n=445)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mortality</strong></td>
<td>6%</td>
<td>7%</td>
<td>8%</td>
<td>7%</td>
<td>8%</td>
</tr>
<tr>
<td><strong>SCI</strong></td>
<td>2%</td>
<td>8%</td>
<td>10%</td>
<td>3%</td>
<td>13%</td>
</tr>
</tbody>
</table>

### Endovascular TAAA Repair

<table>
<thead>
<tr>
<th></th>
<th>Eagleton 2016 (n=354)</th>
<th>Oderich 2015 (n=185)</th>
<th>Maurel 2015 (n=204)</th>
<th>Dias 2015 (n=72)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mortality</strong></td>
<td>5%</td>
<td>4%</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td><strong>SCI</strong></td>
<td>4%</td>
<td>5%</td>
<td>4%</td>
<td>31%</td>
</tr>
</tbody>
</table>

### Hybrid TAAA Repair

<table>
<thead>
<tr>
<th></th>
<th>Hughes 2016 (n=81)</th>
<th>Upchurch 2016 (n=25)</th>
<th>Arko 2011 (n=24)</th>
<th>Jordan 2012 (n=18)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mortality</strong></td>
<td>10%</td>
<td>4%</td>
<td>13%</td>
<td>11%</td>
</tr>
<tr>
<td><strong>SCI</strong></td>
<td>7%</td>
<td>8%</td>
<td>8%</td>
<td>11%</td>
</tr>
</tbody>
</table>
Conclusions

• Aneurysms of the thoracoabdominal aorta remain extremely complex.

• The results of all TAAA repairs have improved significantly over the last decade.

• Open and endovascular techniques are likely to remain complimentary in aortic repair.
Thoracoabdominal Aorta: Advances and Novel Therapies

Robert Meisner, MD FACS
Sidney Kimmel Medical Center Assistant Professor of Surgery
Vascular / Endovascular Surgeon at Lankenau Medical Center

November 18th 2017