Paradigm for detecting silent thoracic aneurysm disease

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Main Line Health
Case Presentation

44 yo patient

• Sever e retrosternal chest pain

• Sudden onset

• Cardiac enzymes : negative

• EKG: negative
What is next?
What is next?
What is next?
Dissection
Top 20 causes of death in the USA according to the CDC

<table>
<thead>
<tr>
<th>#</th>
<th>Cause of death</th>
<th>All ages</th>
<th>No. of deaths</th>
<th>Ages 65+</th>
<th>No. of deaths</th>
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<tbody>
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<td>496,095</td>
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<td>Malignant neoplasms</td>
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<td>Chron. low. resp. disease</td>
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<td>127,924</td>
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<td>5</td>
<td>Unintentional injury</td>
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<td>123,706</td>
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<td>Suicide</td>
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<td>34,598</td>
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<td>20,111</td>
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<td>Liver disease</td>
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<td>29,165</td>
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<td>19,584</td>
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<td>Hypertension</td>
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<td>23,965</td>
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<td>Parkinson’s disease</td>
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<td>15</td>
<td>Homicide</td>
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<td>18,361</td>
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<td><strong>AORTIC ANEURYSM</strong> 10,241</td>
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<td>Atherosclerosis 7,717</td>
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<td>Benign neoplasms</td>
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<td>Suicide 5,421</td>
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<td></td>
<td><strong>12,986</strong></td>
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<td>Anemias 3,773</td>
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<td>20</td>
<td>HIV</td>
<td></td>
<td>11,295</td>
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<td>Gallbladder Disorders 2,777</td>
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</tbody>
</table>

Silent killer

• Detection is *difficult* – only 5% of thoracic aortic aneurysms are symptomatic

• 95% of patients presenting with a thoracic aortic dissection or rupture have previously been asymptomatic

• Detection is a key unsolved problem
Must prevent this transition with TAA detection
Aortic dissection and rupture
Genetic Nature of Thoracic Aortic Aneurysm - Syndromic

- Marfan Syndrome
- Loeys-Dietz syndrome
- Ehlers-Danlos syndrome
- Turner syndrome

Explain about 5% of all aneurysms and dissections

Detectable by phenotype
• Thoracic aortic aneurysm is a genetic disease and Marfan’s is just the tip of the iceberg

• How do we identify asymptomatic aneurysms in the general population?
Factors associated with Thoracic Aortic Aneurysm

1. Intracranial aneurysm
2. Bicuspid aortic valve
3. Bovine aortic arch
4. Abdominal aortic aneurysm
5. Simple Renal Cysts
6. Family history
7. Temporal arteritis (and other autoimmune disorders)
8. Thumb-palm test
In patients with a thoracic aortic aneurysm, there is a **10%** likelihood that they harbor an intracranial aneurysm.
“Bovine arch” refers to group of congenital variants of human aortic arch vessels in which there is aberrant origin of the left common carotid artery. Two anatomic configurations*:

Common origin of innominate artery and left common carotid artery (most common)\(^1\)

Left common carotid artery originates from innominate artery at distance from aorta (less common)\(^1\)

* Note that **bovine arch is a misnomer** – the cow’s aorta does not resemble either of these configurations.\(^2\)

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Prevalence of bovine arch (BA) anomaly by TAA location vs non-TAA control group.

Other Arch Anomalies

## Familial Thoracic Aneurysm

<table>
<thead>
<tr>
<th>Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autosomal dominant</td>
<td>38.5%</td>
</tr>
<tr>
<td>Autosomal dominant or X-linked</td>
<td>23.1%</td>
</tr>
<tr>
<td>Recessive</td>
<td>26.9%</td>
</tr>
<tr>
<td>Other</td>
<td>11.5%</td>
</tr>
</tbody>
</table>
Abdominal Aortic Aneurysm

Female and Elderly Abdominal Aortic Aneurysm Patients More Commonly Have Concurrent Thoracic Aortic Aneurysm

Rebecka Hultgren\textsuperscript{12} Emma Larsson\textsuperscript{13} Carl Magnus Wahlgren\textsuperscript{12} Jesper Swedenborg\textsuperscript{12}

Background
A recent report unexpectedly revealed that one-fourth of abdominal aortic aneurysm (AAA) patients also have an aneurysm in the thoracic aorta (TAA). It remains to be investigated which AAA patients have a higher risk of also developing TAAs. The aim of this study was to identify possible differences in the risk factor profile in AAA patients with or without a TAA.

Methods
All AAA patients attending an outpatient clinic and investigated using an abdominal and thoracic computed tomography scan were included ($n = 354$). Image analysis and hospital chart review were conducted. The association between comorbidity and TAA was estimated by logistic regression and odds ratios (ORs) with 95% confidence intervals (CIs). Gender-specific and neutral criteria were used. Validation of excluded patients was performed.

Results

Ninety-four (27\%) of 354 AAA patients had a concurrent descending TAA (AAA/TAA). AAA/TAA patients were older than AAA patients (76 vs. 73 years).

More women were identified in the AAA/TAA group (39\% vs. 16\%, $P < 0.001$). In the univariate logistic regression model, female gender (OR: 3.3, 95\% CI: 1.9–5.6), hypertension (OR: 1.8, 95\% CI: 1.1–3.0), and age (70–79 years—OR: 2.4, 95\% CI: 1.3–4.6; 80–89 years—OR: 3.0, 95\% CI: 1.5–6.0) were associated with concurrent TAA. In the multivariate model, only female gender and age were associated with TAA.

Conclusions
AAA patients, in general, should be offered examination of the thoracic aorta, and special attention needs to be paid to female AAA patients and AAA patients at high age, if the AAA patient is considered operable. Surveillance of AAA patients must improve to enhance identification of the large group of patients who have developed, or will develop, TAAs. Future strategies will, of course, address pathophysiological aspects of aneurysmal development in the thoracic and infrarenal aorta.
Simple renal cyst
Thumb-Palm test

• The extension of the thumb beyond the border of the flat palm, indicates excessive long bones and lax joints

• Connective tissue disease → Aneurysm investigation

Elefteriades JA. Thoracic aortic aneurysm: reading the enemy’s playbook. Curr Probl Cardiol 2008;33:203-77
AORTA
Aortic Root and Ascending Aorta

1. Aortic annulus
2. Sinus of Valsalva
3. Sinotubular junction
4. Ascending aorta
Aortic Diameter and Location
Aortic Diameter and Age
Critical Issues for TADs (continued)

• A subset of patients with acute AoD are subject to missed or delayed detection

• Genetic alterations predispose some individuals to aortic diseases.
  – Identification of the genetic alterations
  – Biochemical alterations have the potential to serve as biomarkers
  – Targeted therapy to prevent aortic disease.

• Medical and gene-based treatments are beginning to show promise for reducing or delaying catastrophic complications of thoracic aortic diseases.
Critical Issues for Thoracic Aortic Diseases

- Thoracic aortic diseases (TADs) are usually asymptomatic.
- Identification of stable patients at risk for rupture or dissection.
- Imaging of the thoracic aorta is the only method to detect thoracic aortic diseases and determine risk for future complications.

Radiation exposure, contrast medium–related toxicity.

Imaging for asymptomatic patients is expensive.
Elective Aortic Operations

Risk of rupture or dissection

Operative risk: death or permanent neurological deficit

Surgical repair

Endovascular repair

Medical therapy Surveillance
Ascending and Arch Aneurysms
Aortic size and cumulative, lifetime incidence of natural complications

Natural History of Thoracic Aortic Aneurysms: Indications for Surgery, and Surgical Versus Nonsurgical Risks
Descending and TAAA aneurysms
Aortic size and cumulative, lifetime incidence of natural complications.

Natural History of Thoracic Aortic Aneurysms: Indications for Surgery, and Surgical Versus Nonsurgical Risks
Annual risk of rupture, dissection, or death posed by aneurysms of various sizes

Natural History of Thoracic Aortic Aneurysms: Indications for Surgery, and Surgical Versus Nonsurgical Risks
Aortic Size Index (ASI)

ASI = Aortic Diameter/BSA
### Table 5. Risk of Complications by Aortic Diameter and Body Surface Area With Aortic Size Index Given Within Chart

<table>
<thead>
<tr>
<th>BSA</th>
<th>3.5</th>
<th>4.0</th>
<th>4.5</th>
<th>5.0</th>
<th>5.5</th>
<th>6.0</th>
<th>6.5</th>
<th>7.0</th>
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<td>3.46</td>
<td>3.85</td>
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<td>4.62</td>
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<td>5.38</td>
<td>5.77</td>
<td>6.15</td>
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<td>4.64</td>
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<td>3.67</td>
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<td>5.33</td>
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<td>2.37</td>
<td>2.63</td>
<td>2.89</td>
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<td>2.00</td>
<td>2.25</td>
<td>2.50</td>
<td>2.75</td>
<td>3.00</td>
<td>3.25</td>
<td>3.50</td>
<td>3.75</td>
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<tr>
<td>2.10</td>
<td>1.67</td>
<td>1.90</td>
<td>2.14</td>
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<td>2.62</td>
<td>2.86</td>
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<td>3.33</td>
<td>3.57</td>
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<td>2.27</td>
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<td>1.96</td>
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<td>1.67</td>
<td>1.88</td>
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<td>2.50</td>
<td>2.71</td>
<td>2.92</td>
<td>3.13</td>
<td>3.33</td>
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<td>1.40</td>
<td>1.60</td>
<td>1.80</td>
<td>2.00</td>
<td>2.20</td>
<td>2.40</td>
<td>2.60</td>
<td>2.80</td>
<td>3.00</td>
<td>3.20</td>
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</table>

- = low risk (~1% per yr);  = moderate risk (~8% per yr);  = severe risk (~20% per yr).

White area indicates low risk, light gray area indicates moderate risk, and dark gray area indicates severe risk.

BSA = body surface area.

**Novel Measurement of Relative Aortic Size Predicts Rupture of Thoracic Aortic Aneurysms**
Ryan R. Davies, Ann Thorac Surg 2005
Calculation of Risk of Rupture for Descending and TAAA

\[ \ln \lambda = -21.055 + 0.0093(\text{age}) + 0.841(\text{pain}) + 1.282(\text{COPD}) + 0.643(\text{descending diameter}) + 0.405(\text{abdominal diameter}) \]

Probability of rupture within 1 year = \(1 - e^{-\lambda(365)}\).

COPD & Pain = 0 or 1
Calculator

- Unexplained pain (+)
- COPD (+)
- Age
- Descending Diameter
- Abdominal Diameter

Risk of Rupture in < 1 yr.

25%
Genetic Syndromes

Marfan`s Syndrome
Loyes-Dietz Syndrome
Turner Syndrome
Ehlers-Danlos Syndrome
Marfan`s Syndrome

- Heritable disorder
- Mutation in the FBN1 gene
- Cardiovascular, Ocular, Skeletal manifestations
- Dilatation of the aortic root
MARFAN`S

TTE immediately and 6 months thereafter

Annual imaging if stability is documented.

Aortic diameter is $\geq 4.5$ cm, more frequent imaging
LOEYS – DIETZ SYNDROME

Mutation of TGFBR1 or TGFBR2
Arterial tortuosity, hypertelorism, cleft palate

Loeys, BL et al  NEJM  2006
Loeys-Dietz syndrome

genetic mutation (*TGFBR1*, *TGFBR2*)

complete aortic imaging immediately and 6 months thereafter

Yearly MRA from the cerebrovascular circulation to the pelvis.
Recommendations for Surgery

Loeys-Dietz or $TGFBR1$ or $TGFBR2$ mutation

External Aortic Diameter $\geq 4.5$ cm

Marfan’s patient: Diameter $\geq 4.5$

Marfan’s women contemplating pregnancy

External Aortic Diameter $\geq 4.0$ cm.
Bicuspid Aortic Valve

- Affects 1-2% of the population
- Bicuspid valve +“AS” or “AI” (1)
- Familial Clustering (2)

Associated with ascending aortic aneurysm in 20-30%

(1) Pachulski: Am J Cardiol 1991; 67:781-782
(2) Huntington K: J Am Coll Cardiol 1997; 30:1809-12
Evidence that BAV is Risk Factor for Acute Aortic Dissection

• Incidence of bicuspid aortic valve (BAV)

– Normal population 1.5%

– Acute Dissection Series

  • Autopsy series 1984 8% OR 5.3
  • Autopsy series 1991 14% OR 9.3
  • Surgical path series 2006 11% OR 7.3

Larsen EW et al Am J Cardiol 1984
Roberts CS et al Am J Cardiol 1991
Aortic Dimensions in Children

Aortic Dimension / Height Ratios
- Normal vs BAV vs Marfan's -

Beroukhim, RS et al Am J Casrdiol 2006
Thickness of Aortic Wall

![Graph showing thickness of aortic wall for Bicuspid and Tricuspid]

- **Bicuspid**: Average thickness of 0.9, standard deviation of 0.05
- **Tricuspid**: Average thickness of 1.1, standard deviation of 0.05

*p = 0.62

Thickness of the Elastic Lamellae

Distances between Elastic Lamellae

- Bicuspid: 26
- Tricuspid: 24

$p=0.033$
Thickness of the Elastic Lamellae According to the Ascending Aortic Diameter


= bicuspid aortic valve; = tricuspid aortic valve disease
Location of 99th percentile wall stress in the ascending aorta in patients with (A) tricuspid and (B) bicuspid aortic valves.

Increased Ascending Aortic Wall Stress in Patients With Bicuspid Aortic Valves
Derek P. Nathan et al, Ann Thor Surg, 2011
Wall stress of a tricuspid aortic valve aorta (A), and a bicuspid aortic valve aorta (B). Increased stress in the patient with bicuspid valve.
Comparison of variables

TABLE 4. Comparison of variables that affect future aortic dilation in patients with normal ascending aorta diameters and those with mild or moderate dilation at the time of aortic valve replacement surgery

<table>
<thead>
<tr>
<th>Variable</th>
<th>&lt;4 cm (n = 115)</th>
<th>4.0–4.4 cm (n = 64)</th>
<th>4.5–4.9 cm (n = 22)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>55 ± 15</td>
<td>56 ± 15</td>
<td>61 ± 10</td>
<td>.2</td>
</tr>
<tr>
<td>Male sex</td>
<td>75%</td>
<td>72%</td>
<td>91%</td>
<td>.2</td>
</tr>
<tr>
<td>Hypertension</td>
<td>26%</td>
<td>23%</td>
<td>27%</td>
<td>.9</td>
</tr>
<tr>
<td>Aortic valve pathology</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Stenotic</td>
<td>64%</td>
<td>61%</td>
<td>64%</td>
<td>.7</td>
</tr>
<tr>
<td>Insufficiency</td>
<td>23%</td>
<td>19%</td>
<td>23%</td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td>12%</td>
<td>20%</td>
<td>14%</td>
<td></td>
</tr>
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</table>

Borger, MA et al  J Thorac Cardiovasc Surg, 2004
Survival of Patients with BAV Replacement and Various Sizes of the Ascending Aorta

Borger, MA et al  J Thorac Cardiovasc, 2004
Freedom from Ascending Aortic Complications for Patients with BAV Replacement

Borger, MA et al  J Thorac Cardiovasc, 2004
Radiological Evaluation
Normal CXR

- **Ascending aorta**
- **Descending aorta**
- **Arch**
Normal Aorta
Tortuous Aorta
Artifact
ASCENDING AORTA

PULMONARY ARTERY

AORTIC TEAR (DISSECTION)

DESCENDING AORTA
SUBCLAVIAN ARTERY

ANEURYSM OF THE DESCENDING AORTA

THROMBUS IN THE ANEURYSM
ASCENDING AORTA

PULMONARY ARTERY

AORTIC TEAR (DISSECTION)

DESCENDING AORTA
Aortic Dissection
Aortic Dissection
Mediastinal Hematoma
Intramural Hematoma
Intramural Hematoma
Penetrating Ulcer
Traumatic Rupture
DESCENDING AORTIC GRAFT
Size Criteria for Prophylactic Resection of the Aortic Root and Ascending Aorta

**Below 5.0 cm**
- Genetic predisposition to dissection
  - Marfan syndrome
  - familial TAAD
  - uncharacterized family history of dissection
- Other heart surgery involving ascending aorta

**Between 5.0 and 6.0 cm**
- Enlargement of more than 0.5 cm/yr
- Bicuspid aortic valve
- Additional considerations
  - necessity for anticoagulation
  - valve sparing
  - biological valve

**Above 6.0 cm**
- Almost always
Thank you

(914)874-7453
dplestis@gmail.com
Minimally Invasive Surgery

*It makes sense*
MIS Aortic Valve and Root Surgery

- 6 cm incision
- Sternal notch to 3d or 4th intercostal space
- J-type or T-type
Aortic Valve Repair
Case Presentation

31 yo female

- Asymptomatic
- Severe AI
- Bicuspid AV
- Ascending aortic aneurysm
Minimally Invasive Procedure

- Ascending aortic replacement
- Aortic valve repair
- Insertion of CardioCel in RCC of conjoint leaflet
- Subcomissural annuloplasty
- STJ adjustment (to 24mm)
Ascending Aortic Replacement

Outcomes

n = 309

Age 65 ± 12.0

Males 193 62%
## Complications

<table>
<thead>
<tr>
<th>Complication</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>2</td>
<td>0.6%</td>
</tr>
<tr>
<td>Stroke</td>
<td>7</td>
<td>2%</td>
</tr>
<tr>
<td>New RI</td>
<td>4</td>
<td>1%</td>
</tr>
<tr>
<td>PVS</td>
<td>22</td>
<td>8%</td>
</tr>
<tr>
<td>Bleeding*</td>
<td>15</td>
<td>5%</td>
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</table>
## Complications

<table>
<thead>
<tr>
<th>Condition</th>
<th>Count</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>CHF</td>
<td>14</td>
<td>4%</td>
</tr>
<tr>
<td>Afib</td>
<td>74</td>
<td>24%</td>
</tr>
<tr>
<td>Vfib</td>
<td>7</td>
<td>2%</td>
</tr>
<tr>
<td>MI</td>
<td>1</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

MI- Myocardial Infarction  
CHF- Congestive Heart Failure
Hospital stay

ICU days    4 ± 5.4

Hospital stay days    8 ± 14
Aortic Root Reconstruction
Aortic Root Repair

- Root Aneurysm
- Bentall procedure
- David procedure
Case Presentation

35 yo female

• Aortic Root Aneurysm
• Ascending Aortic Aneurysm
• Mild AI
• Marfan Syndrome
Procedure

• J-type partial sternotomy with extension into the 3rd right intercostal space
• Valve sparing aortic root repair
• Coronary reimplantation utilizing button technique
Discharge

• No residual AI
• Uncomplicated hospital course
• Discharge on the 6th day after procedure
Case Presentation

Bentall Procedure

77 yo male

- Root and Ascending Aortic Aneurysm
- Moderate AR
Operation

- Mini-sternotomy
- Bentall Procedure
- Button technique for CA reimplantation
Konstadinos A. Plestis, MD
Lankenau Heart Institute
Case Presentation
Florida Sleeve

• 33 yo male
• Type A Aortic Dissection
• Aortic Root : 4.5 cm
Florida Sleeve Procedure
<table>
<thead>
<tr>
<th>Event</th>
<th>AWC</th>
<th>STS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>2.7%</td>
<td>4.9%</td>
</tr>
<tr>
<td>Stroke</td>
<td>2.6%</td>
<td>3.8%</td>
</tr>
<tr>
<td>New onset of renal insufficiency</td>
<td>2.7%</td>
<td>4.3%</td>
</tr>
<tr>
<td>Reoperation</td>
<td>5.2%</td>
<td>8.9%</td>
</tr>
</tbody>
</table>
# Aortic Root Outcomes

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>n</td>
<td>254</td>
</tr>
<tr>
<td>Age</td>
<td>57±14</td>
</tr>
<tr>
<td>Males</td>
<td>183 (72%)</td>
</tr>
<tr>
<td>Complication</td>
<td>Count</td>
</tr>
<tr>
<td>--------------</td>
<td>-------</td>
</tr>
<tr>
<td>Death</td>
<td>2</td>
</tr>
<tr>
<td>Stroke</td>
<td>0</td>
</tr>
<tr>
<td>New RI</td>
<td>4</td>
</tr>
<tr>
<td>PVS</td>
<td>24</td>
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</tbody>
</table>

PVS - Prolonged Ventilatory Support  
RI - Renal Insufficiency
Hospital stay

<table>
<thead>
<tr>
<th>ICU days</th>
<th>4.0±5.9</th>
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<tbody>
<tr>
<td>Hospital stay days</td>
<td>9±7.9</td>
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## Complications

<table>
<thead>
<tr>
<th>Condition</th>
<th>Count</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Bleeding</td>
<td>18</td>
<td>7%</td>
</tr>
<tr>
<td>MI</td>
<td>1</td>
<td>0.5%</td>
</tr>
<tr>
<td>Afib</td>
<td>48</td>
<td>19%</td>
</tr>
<tr>
<td>Vfib</td>
<td>11</td>
<td>4%</td>
</tr>
<tr>
<td>CHF</td>
<td>2</td>
<td>1%</td>
</tr>
</tbody>
</table>

MI - Myocardial Infarction  
CHF - Congestive Heart Failure
Arch Procedures
Hemiarch
Aortic Arch
Case Presentation

Stage 1 ET Procedure via Partial Sternotomy

70 yo female

- Chest Pain
- SOB
PMH

- Hypertension
- COPD
- Thoracic Aortic Aneurysm
Preoperative diagnosis

- Ascending aortic aneurysm
- Aortic arch aneurysm
- Descending thoracic aortic aneurysm
- Aortic valve regurgitation
Procedure

- Mini-Sternotomy
- Aortic Valve Repair
  - Subcommissural annuloplasty – LC-NC
- Ascending Aorta Replacement
- ET stage 1 procedure
- Trifurcation Graft
- DHCA
- ACP
### Arch

**N=233**

<table>
<thead>
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<th>Event</th>
<th>AWC</th>
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<tr>
<td>Mortality</td>
<td>5%</td>
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</tr>
<tr>
<td>Stroke</td>
<td>3.4%</td>
<td>6.7%</td>
</tr>
<tr>
<td>New onset of renal insufficiency</td>
<td>6.4%</td>
<td>6.6%</td>
</tr>
<tr>
<td>Reoperation</td>
<td>11.5%</td>
<td>11.5%</td>
</tr>
</tbody>
</table>
Aortic Arch Repair
Probability of Survival

1 year 0.997
3 years 0.86
5 years 0.817
TAAA Repair

Crawford Classification of Thoracoabdominal Aortic Aneurysms

Extent I  Extent II  Extent III  Extent IV  Extent V
Case Presentation

54 yo male

• Worsening symptoms:
  intermittent claudication
  pain in the toes
  chest pain

• Enlarging TAAA
  10x8 cm
History

• TAAA
• Chronically occluded aortobifemoral grafts
• Left renal artery occlusion
• Chronic renal failure
• CAD with four previous MIs
• EF- 25%
• Peripheral vascular disease
• Endocarditis
• MRSA
1st Hospital Admission
December 2016

• Considered to be high risk and transferred to Lankenau
Admission

- BUN -31
- Creatinine 1.5
What is Next?
Procedure

- Type 3 TAAA repair
- Descending aorta replacement
- Descending to-
  - Right Common Femoral Artery Bypass
  - Left Femoral Artery Bypass
- Reimplantation of Celiac, SMA and Right Renal Artery
- Reimplantation of T9 intercostal arteries
Postoperative Course

• Stent of right renal artery for AKI
• Good vascular flow in the lower extremities
• Gradual recovery
• Discharge on postoperative day 26
<table>
<thead>
<tr>
<th></th>
<th>AWC</th>
<th>Modern Era*</th>
<th>STS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>7.9%</td>
<td>0%</td>
<td>13.3%</td>
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<tr>
<td>Stroke</td>
<td>3.4%</td>
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<tr>
<td>New onset of renal</td>
<td>10%</td>
<td>0%</td>
<td>17.9%</td>
</tr>
<tr>
<td>insufficiency</td>
<td></td>
<td></td>
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<tr>
<td>Reoperation</td>
<td>7.5%</td>
<td>16.6%</td>
<td>16.8%</td>
</tr>
</tbody>
</table>
Endovascular repair of Thoracic Aortic Aneurysm
• Dacron Fabric
• Stainless steel Z stents
• Fixed to delivery system
• Largest device 42mm
• Available in Europe
• US Phase 2 Trial enrolling
Delivery System Insertion & Stent Graft Positioning

Advance the system over guidewire to the target landing zone

Verify orientation and placement
Initial Deployment

Deploy Remaining Stent Graft

Remove Delivery System
Model Graft to Vessel

Completed Deployment
Case Presentation
Hybrid Procedure

78 yo male

- Aortic Arch Aneurysm
- CAD
Procedure

- Aortic Arch Debranching
- Trifurcation graft
- Bypass to:
  - Brachiocephalic
  - Left Carotid
  - Left Subclavian
- Stent placement from zone 0 to mid-descending thoracic aorta
- CABGx2 with SVG to LAD and First Diagonal
### Clinical Category: Cardiac Surgery (Major)

<table>
<thead>
<tr>
<th>Hospital &amp; Location</th>
<th>Rating</th>
<th>Score</th>
<th>Natl Rank</th>
<th>Mortality Overall</th>
<th>Complications Overall</th>
<th>Inpatient Quality</th>
<th>Patient Safety</th>
<th>Core Process</th>
<th>Patient Satisfaction</th>
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<td>Main Line Hospital Lankenau: Wynnewood, PA</td>
<td>ⅴ++</td>
<td>99.0</td>
<td>8</td>
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<td>ⅴ++</td>
<td>ⅴ+</td>
<td>ⅴ++</td>
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<td>Mercy Fitzgerald Hospital: Darby, PA</td>
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<td>31.0</td>
<td>778</td>
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<td>ⅴ</td>
<td>ⅴ+</td>
<td>ⅴ</td>
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</tbody>
</table>

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Volume/Outcomes

Dr. Plestis

Volume

Obs Op Mort


513  555  589  681  891  946

3.12%  2.70%  1.87%  3.08%  1.80%  1.69%
Dilated Ascending Aorta

Aortic Ratio and Prognosis in Marfan’s Syndrome

Event Free Survival % vs. Years

- Ao Ratio < 1.3
- p < 0.001
- Ao Ratio ≥ 1.3

Legget ME: Heart 1996; 75:389-95