Emerging Roles for Distal Aortic Interventions in Type A Dissection Surgery

CVAnaesthesia
Foothills Medical Centre
October 24th, 2014

Jehangir Appoo
Libin Cardiovascular Institute
University of Calgary
Current “standard of care” for acute Type A Dissection

Very good operation
Saves many lives in distressful times

but, is it enough in all cases?
does it treat the full disease process?
does it make our patients “whole”? 
Case Example: 46y.o male flown in from OSH – May 2014

Hemodynamic shock

Abdomen distended, tender
Case Example: 46y.o male flown in from OSH – May 2014

Both legs pulseless, cold, mottled and paralyzed
Evidence of renal infarct/malperfusion
Our 46y.o patient

Is standard “hemiarch” surgery the right operation?

Will visceral, renal, & peripheral perfusion be restored?

Will he have use of his legs?

Will he survive?
**Problem:**

- Long term survival is compromised
- Distal aortic problems may be higher than we appreciate

**Immediate op mortality is high:**

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<td>US Registry Data (2014)</td>
<td>25%</td>
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Example of possible (not often) outcome of conventional surgery
51 y.o. Male
SMAD 3 Connective Tissue Disorder
Distal Arch Tear
Conventional Surgery Spring 2014– Asc/Open Distal

Pre-op
Intimal tear in distal arch

2 weeks post op
3.8 cm descending aorta

3 months post op
5.3 cm distal arch/descending aorta

Presents with CP/Back Pain
Given known CT disorder, rapid rate of growth, residual dissected arch, 4 branch arch with dominant left vertebral, redo sternotomy setting

Progressed to urgent thoracotomy & resection of distal arch and descending aorta

Profound Hypothermia
L chest circ arrest
CSF drain for Safi type C aneurysm
Problem:

Long term survival is compromised

Distal aortic problems may be higher than we appreciate

Immediate op mortality is high:

IRAD (2005) 25%
GERAAD (2014) 17%
US Registry Data (2014) 25%

Question:

Can extended distal aortic repair decrease long term mortality?

Can increase complexity be accomplished without increased periop morbidity?
**Need:**

- Long term survival is compromised
- Distal aortic problems may be higher than we appreciate

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**Question:**

Can extended distal aortic repair decrease long term mortality? Can increase complexity be accomplished without increased periop morbidity?

**Goal with Extended Distal Aortic Repair:**

Decrease both long term and short term mortality
Primary entry tear located in distal arch or descending thoracic aorta up to 20-30%

Replacing ascending aorta does not satisfy surgical principle of resecting primary entry tear
Global evolving technical approaches to extended distal repair

Classification according to extent of aorta resected:

I. Zone 2/3 Arch + Stent graft

II. Arch Debranching + Zone 0 Stent Graft

III. Conventional Hemiarch + Stent Graft under Circ Arrest (FET)
Uchida 2013 (Personal Communication)
Zone 2 Arch

118 pts
6% op mortality
Indications for frozen elephant trunk in type A aortic dissection

Younger Patients (Age < 70 Years) 
N=40

Age ≥ 70 yrs

Primary Entry: Located on the distal arch
N=36

True Lumen: Occluded or severely Collapsed
N=27

Arch Dilatation > 40 mm
N=15
398 patients with acute Type A

Mortality 7.8%
Stroke 2.5%
SCI 2.5%
False lumen thrombosis: 95%

Ma et al. Ann Cardiothorac Surg 2013
E-Vita
E-vita open registry

416 patients
10 high aortic volume European centres

142 acute dissection cases

Op. Mortality 16%
CVA 7%
SCI 4%

Global evolving technical approaches to extended distal repair

Classification according to extent of aorta resected:

I. Zone 2/3 Arch + Stent graft

I. Arch Debranching + Zone 0 Stent Graft

I. Conventional Hemiarch + Stent Graft under Circ Arrest (FET)
Arch Debranching and Zone 0 TEVAR for acute Type A Dissection
Transforming “difficult distal” operation to a more “proximal” operation

Siena technique
Staged approach
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

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 aneurysm and infrarenal aortic 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.

Arch Debranching and Zone 0 TEVAR for acute Type A Dissection

  Siena technique
  Staged approach

  Single stage total arch repair
  Without circ arrest
Arch Debranching and Zone 0 TEVAR for acute Type A Dissection

Siena technique
Staged approach

Ann Cardiothoracic Surg 2013
Single stage total arch repair without circ arrest

Chang et al. JTCVS 2013
Single stage total arch repair without circ arrest
21 patients with TypeA
Global evolving technical approaches to extended distal repair

Classification according to extent of aorta resected:

I. Zone 2/3 Arch + Stent graft

I. Arch Debranching + Zone 0 Stent Graft

I. Conventional Hemiarch + Stent Graft under Circ Arrest (FET)
Total arch repair with open triple-branched stent graft placement for acute type A aortic dissection: Experience with 122 patients

Liang-Wan Chen, MD, Lin Lu, MD, Xiao-Fu Dai, MD, Xi-Jie Wu, MD, Gui-Can Zhang, MD, Guo-Feng Yang, MD, and Yi Dong, MD

Indications:

- Age < 55
- Intimal tear in arch/descending aorta
- "Serious" involvement of arch vessels

J Thorac Cardiovasc Surg 2014;148:521-8
Simultaneous replacement of the ascending aorta and total arch is a far more invasive and risky procedure than conventional ascending replacement for acute type A aortic dissection, mainly because it requires elaborate anastomoses of the graft to the dissected and fragile descending aorta and 3 arch vessels. These time-consuming steps under emergency conditions could confer additional risks to the patients. Whether this total arch replacement with the possible additional operative risk could be justified from the viewpoint of the potential long-term benefits remains controversial.
SACP 32 ± 10mins

Op Mortality 4.93%

CVA 1.6%

FL Thrombosis:
Around stent graft 89%
Diaphragmatic level 63%

Antegrade Thoracic Stent Grafting During Repair of Acute DeBakey I Dissection Prevents Development of Thoracoabdominal Aortic Aneurysms

Alberto Pochettino, MD, William T. Brinkman, MD, Patrick Moeller, BS, Wilson Y. Szeto, MD, William Moser, CRNP, Katherine Cornelius, BSN, Frank W. Bowen, MD, Y. Joseph Woo, MD, and Joseph E. Bavaria, MD

Division of Cardiovascular Surgery, Department of Surgery, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania

Technique currently used by some surgeons at N. American Centres: Penn, Mayo & Texas

Early Outcomes of FET
2005-2012

Vallabhajosyula J Thorac Cardiovasc Surg 2014
Preventza J Thorac Cardiovasc Surg 2014

<table>
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Patient selection issues

Multiple surgeon vs. single surgeon practice

Timeline bias
Early Outcomes of FET 2005-2012

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Vallabhajosyula J Thorac Cardiovasc Surg 2014  
Preventza J Thorac Cardiovasc Surg 2014
## Early Outcomes of FET 2005-2012

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<td>87</td>
<td>84% vs. 54% (p &lt; 0.05)</td>
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Vallabhajosyula Preventza J Thorac Cardiovasc Surg 2014

Vallabhajosyula Preventza J Thorac Cardiovasc Surg 2014
Imaging Research

Does standard surgical repair of Debakey Type 1 Dissection alter true lumen geometry downstream?

Conventional hemiarch → true lumen/total aortic ratio distally:
- Increased 44%
- Decreased 56%

2006-2013
128 Type A Dissections

Harmse, Appoo, Herget, Merchant, Wong & Ferris. 2014 In submission
Our 46y.o patient

Is standard “hemiarch” surgery the right operation?

Will visceral, renal, & peripheral perfusion be restored?

Will he have use of his legs?

Will he survive?

50/50 chance that complicated malperfusion resolves with standard repair
Simplified frozen elephant trunk repair for acute DeBakey type I dissection

![Diagram of the simplified frozen elephant trunk repair for acute DeBakey type I dissection]

J Thorac Cardiovasc Surg 2013

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<th>Single anastomosis frozen elephant trunk repair</th>
<th>n = 17 (%)</th>
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<tr>
<td><strong>Acute outcomes</strong></td>
<td></td>
</tr>
<tr>
<td>Hospital mortality</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Stroke</td>
<td>2 (12)</td>
</tr>
<tr>
<td>Paraplegia</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Temporary paraparesis</td>
<td>2 (12)</td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>2 (12)</td>
</tr>
<tr>
<td>New hemodialysis</td>
<td>3/16 (19)</td>
</tr>
<tr>
<td>Mean length of stay (mean ± SD)</td>
<td>20 ± 12</td>
</tr>
<tr>
<td>ICU</td>
<td>10 ± 9</td>
</tr>
<tr>
<td><strong>Intermediate outcomes</strong></td>
<td></td>
</tr>
<tr>
<td>Late deaths</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Reintervention</td>
<td>1 (6)</td>
</tr>
<tr>
<td>False lumen thrombosis</td>
<td>14/16 (88)</td>
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Depending on whether you are at CCF, Mayo, Calgary, Penn, Germany, Japan or China & which surgeon is on call, variety of novel operations being carried on for Type A dissection.

Not Standardized
  Type of extended distal repair
  Indications for extended distal repair
  Results

Early Stages
2014 ESC Guidelines on the diagnosis and treatment of aortic diseases

Document covering acute and chronic aortic diseases of the thoracic and abdominal aorta of the adult

The Task Force for the Diagnosis and Treatment of Aortic Diseases of the European Society of Cardiology (ESC)
Validation!
Share local experience with some of these techniques

Share our thought process
Multidisciplinary Clinical Team
CV Anaesthesia
CV nurses
IR
Cardiac Surgery
CVICU

Portable or Fixed fluoroscopy
Example of Arch Debranching for acute Type A Aortic Dissection
69y.o male with Type A dissection and Distal Arch Tear
69y.o male with Type A dissection and Distal Arch Tear

Type II Hybrid Arch Repair

Total arch reconstruction without circ arrest
Example of Siena Technique

Debranch then re-assess
39 y.o acute Type A
BMI 60!

Pulseless/Ischemic leg

Debranch then re-assess – may or may not need stent graft

Debranched but no stent graft

Stable at 2 year follow up
Example of Frozen Elephant Trunk for acute Type A Aortic Dissection
52 y.o with acute Type A & high risk features on preop CT:

- Primary Intimal Tear in distal arch
- No flow in FL – lack of re-entry tears
- Large false lumen
- Intima Intussusception /windsock
52 y.o with acute Type A & high risk features on preop CT:

Frozen Stented Elephant Trunk
Ascending/Hemi Arch Anastomosis
Aorto-Subclavian bypass
Our 46y.o male flown in from OSH – May 2014
Type A dissection with shock, visceral, renal & LE malperfusion
Post CPB on table Angio after FET, HemiArch, Asc Ao Replacement, Ao valve repair.

Thoracic Ao TL expansion seen on angio & TEE.

Good perfusion of celiac, SMA & nephrograms visible.
Our next stage of evolution:

With refinement in cerebral perfusion and surgical techniques:

Zone 2 Arch
Zone2 Arch
Going forward:

Strategies to improve short term AND long term outcomes:

1. Need to understand nuanced anatomy and physiology of dissection process – “flapology”

2. Elucidate risk factors for long term complications AND short term complications (Remember op. mort 17-25% in good centres)

3. Understand what type of extended distal operation works in the hands of different surgeons/centres for individual patient anatomy
Going Forward

Imaging Research

Classification of Primary Intimal Tear

How often can we identify given current standard imaging?
Location?
  Asc, Arch, Desc
distance from coronaries/head vessels
Size?
Re-entry tears?
Etc...
Five-point Research Plan

1. Systematically evaluating current literature
2. Achieving clinical consensus
3. ARCH Project (I) - Multi-institutional retrospective database
4. ARCH Project (II) - Multi-institutional randomized controlled trial
5. ARCH Project (III) - Multi-institutional prospective registry
Going Forward

Establishment of Canadian Thoracic Aortic Network

Cross country group of cardiac surgeons interested in aortic surgery

Share data

Work on thoracic aortic research projects
Going Forward

Society Level:

Joint CCS/CSCS/CSVS Position Statement on Thoracic Aortic Disease Intervention
Going Forward

Hybrid operating room concept for combined diagnostics, intervention and surgery in acute type A dissection

Konstantinos Tsagakis*, Thomas Konorza*, Daniel Sebastian Dohle†, Eva Kottenberg*, Thomas Buck*, Matthias Thielmann*, Raimund Erbel* and Heinz Jakob*
Anaesthetic Implications for extended distal aortic repair and malperfusion:

Arterial Monitoring pressures different in various branches of dissected aorta
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<td>Bleeding</td>
<td>Surgically challenging to deal with in case of co-existing LV/RV dysfunction</td>
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<td>Long CPB operations</td>
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<td>Various degrees of cooling</td>
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Summary

Contemporary results of Conventional Surgery of Acute Type A Dissection

IRAD
GERAADA

Operative Mortality ≈ 20%
Substantial long term morbidity and mortality
World wide tour of novel techniques used by select cardiac surgeons – not institution wide yet

Early results 2012-2014

Currently on a steep learning curve

Latest guidelines supportive for malperfusion indication
Question:

Can extended distal aortic repair decrease long term mortality?

Can increase complexity be accomplished without increased periop morbidity?

Goal:

Decrease both long term and short term mortality
Summary

Consideration for extended distal repair:

- Primary Intimal Tear in distal arch
- Distal malperfusion syndrome
- Enlarged false lumen/true lumen ratio
- Dilated arch
- Young patients
Thank You
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?
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<td>12%</td>
<td>13.8%</td>
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<td>8%</td>
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<td>10.3%</td>
<td>NS</td>
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<tr>
<td>Transient SCI</td>
<td>6%</td>
<td>2%</td>
<td>NS</td>
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<td></td>
<td>8%</td>
<td>2.4%</td>
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<td>35mins</td>
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<td>NS</td>
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<td></td>
<td>~50%</td>
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<tr>
<td>Malperfusion Resolved</td>
<td>NA</td>
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<tr>
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<td>84.2%</td>
<td>54.2%</td>
<td>P &lt; .037</td>
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**Early Outcomes of FET**

Pochettino/PENN (Vallabhajosyula JTCVS 2014)
Coselli/Texas (Preventza JTCVS 2014)

Study Period: 2005-2012
### Pochettino/UPENN Early outcomes

#### 2005 – 2012

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Mean f/u 2.7 yrs

Vallabhajosyula JTCVS 2014
Extended aortic repairs

• Improved false lumen obliteration
  – Reduced potential malperfusion
  – Reduced late dilatation
• Reduced late re-interventions
• Reduced late mortality
• Improve our late outcomes with minimal morbidity

= No brainer
Significance of malperfusion syndromes prior to contemporary surgical repair for acute type A dissection: outcomes and need for additional revascularizations

Arnar Geirsson a, Wilson Y. Szeto a, Alberto Pochettino a, Michael L. McGarvey b, Martin G. Keane c, Y. Joseph Woo a, John G. Augoustides d, Joseph E. Bavaria a, *

a Division of Cardiothoracic Surgery, Hospital of the University of Pennsylvania, 3400 Spruce Street, Philadelphia, Pa 19104-4283, United States
b Department of Neurology, University of Pennsylvania Medical Center, Philadelphia, Pennsylvania, United States

c Department of Cardiovascular Medicine, University of Pennsylvania Medical Center, Philadelphia, Pennsylvania, United States
d Department of Anesthesiology and Critical Care, University of Pennsylvania Medical Center, Philadelphia, Pennsylvania, United States

Received 5 February 2007; received in revised form 29 March 2007; accepted 3 April 2007; Available online 17 May 2007

Operative Mortality
Malperfusion: 30%
No malperfusion: 6%
Total Aortic Arch Grafting for Acute Type A Dissection: Analysis of Residual False Lumen

Yoshiharu Takahara, MD, Yoshio Sudo, MD, Kenzi Mogi, MD, Mituyuki Nakayama, MD, and Manabu Sakurai, MD
Division of Cardiovascular Surgery, Funabashi Municipal Medical Center, Funabashi, Japan

Is Emergency Total Arch Replacement With a Modified Elephant Trunk Technique Justified for Acute Type A Aortic Dissection?

Hirotaka Watanuki, MD, Hitoshi Ogino, MD, Kenji Minatoya, MD, Hitoshi Matsuda, MD, Hiroaki Sasaki, MD, Motomi Ando, MD, and Soichiro Kitamura, MD
Department of Cardiovascular Surgery, National Cardiovascular Center, and Department of Thoracic Surgery, Fujita Health University, Osaka, Japan

Operative Strategy for Acute Type A Aortic Dissection: Ascending Aortic or Hemiaortic Versus Total Arch Replacement With Frozen Elephant Trunk

Naomichi Uchida, MD, Hidenori Shimamura, MD, Akira Katayama, MD, Norimitsu Shimada, MD, Miwa Sutoh, MD, and Hiroshi Ishihara, MD
Division of Cardiovascular Surgery, Hiroshima-city Asa General Hospital, and Kajikawa Private Hospital, Hiroshima, Japan

---

Background. In surgery unresected dissection an causes of the progression c grafted the ascending aort grafting possible through all patients with type A descending aorta, wherever.

Methods. A total of 37 type A dissection under grafting between August 1 bral protection was achieved. The distal anastomosis “Elephant Trunk” technique evaluated using computer the operation.

Results. The hospital n

---

Background. We assess the outcome of arch replacement with a modified technique for acute type A aortic dissection. Our aggressive approach is justified.

Methods. Between 2000 and 2006, all underwent emergency total arch replacement with aortic dissection. The aortic arch was removed using open distal anastomosis. Gradual cerebral perfusion under arch replacement with individual aortic arch was applied in the following cases: tear in the transverse arch or the p aorta, massive arch dissection, Marfan syndrome, and atheromatous arch. A modified elephant trunk was used for secure anastomosis and early to the false channel in the descending

Background. This report compares long-term results with total arch replacement with frozen elephant trunk (FET) to ascending aortic or hemiaortic replacement (AHR) for acute type A aortic dissection.

Methods. The subjects were 120 consecutive patients, including 65 who received FET and 55 who had AHR for acute type A aortic dissection from 1997 to 2008. The late results after surgery were retrospectively compared between the FET and the AHR groups.

Results. Three patients in the FET group died, and 2 patients in the AHR group died. In long-term follow-up (mean, 67 months), the survival rate after 5 years was 95.3% for the FET group and 69.0% for the AHR group

• Very good results but not likely reproducible worldwide led to introduction of
  – “Frozen Elephant Trunk”
E-Vita Results

106 patients ~ half acute/half chronic
SACP 74mins + 8mins HCA
12% operative mortality
False lumen thrombosis 92% (acute) & 66% (chronic)
An Alternative Approach to Diffuse Thoracic Aortomegaly: On-Pump Hybrid Total Arch Repair Without Circulatory Arrest

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

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(Ann Thorac Surg 2011;xxx:xxx) © 2011 by The Society of Thoracic Surgeons
Completed Arch Debranching
Acute Type A Case
Completed Hybrid Procedure
Potential Advantages of our Hybrid Total Arch for Acute Type A

Early

- Avoidance of circulatory arrest
  - Hypothermia
  - Stroke?
- Decreased bleeding
  - From distal anastomosis
  - Mild Hypothermia
- Avoid/Treat Malperfusion

Late

- No residual flap in aortic arch
- Obliteration of false lumen
- Good potential landing zone if needed
- Disease specific approach
Surgical Correction of Ascending Type A Thoracic Aortic Dissection: Simultaneous Endoluminal Exclusion of the Arch and Distal Aorta

Edward B. Diethrich, MD; Marwan Ghazoul, MD; Grayson H. Wheatley III, MD; Jeffrey Alpern, DO; Julio Rodriguez-Lopez, MD; Venkatesh Ramaiah, MD; and James Williams, BA
Hybrid Aortic Arch Debranching With Staged Endovascular Completion in DeBakey Type I Aortic Dissection

Antonino G.M. Marullo, MD, PhD, Samuele Bichi, MD, Rocco A. Pennetta, MD, Gerardo Di Matteo, MD, Antonio M. Cricco, MD, Luigi Specchia, MD, Fausto Castriota, MD, and Giampiero Esposito, MD

Department of Cardiovascular Disease, Città di Lecce Hospital, GVM Research and Care, Strada Provinciale per Arnesano, Lecce, Department of Surgery and Bioengineering, Unit of Cardiac Surgery, University of Siena, Siena, Italy

Background. We assess midterm results of a hybrid approach to DeBakey type I aortic dissection using a new multibranched Dacron graft to create, by relocation of the inflow openings to the arch vessels toward the aortic root, a new aortic arch for an easier and safer second-staged endovascular stent grafting of the distal thoracic aorta.

Methods. From March 2006 to July 2008 24 patients with DeBakey type I aortic dissection underwent ascending aorta and aortic arch replacement with debranching of epi-aortic vessels using a new prosthesis to create an optimal landing zone for possible subsequent endovascular stent grafting of the distal thoracic aorta. Fifteen patients, who postoperatively presented a residual patent distal false lumen, underwent a successful second-stage endovascular stent-graft implantation.

Results. One patient died after the surgical stage while there was no death after the endovascular stage with hospital mortality of 4.2%. Follow-up confirmed complete thrombosis of the residual distal false lumen in 95.6% and partial thrombosis in 4.4% of patients with no evidence of endoleaks in the cases that required the endovascular procedure. Overall actuarial survival at 28 months is 92.1% ± 7.9% with 100% freedom from reoperation.

Conclusions. Hybrid treatment of DeBakey type I aortic dissection with aortic arch debranching, using a new multibranched prosthesis (Lupiae Graft; Vascutek Terumo Inc, Scotland, United Kingdom) is confirmed to facilitate the subsequent endovascular completion. Midterm results in terms of survival and distal false lumen thrombosis are satisfactory. Further study of this operation is warranted to confirm the effectiveness and the durability of this approach.

Siena Technique
Staged Operation

Circulatory Arrest Used for Distal Aortic Anastomosis
Hybrid Total Arch for Acute Dissection

- Evolving experience
- No right answer/dogma
- Multiple options
- Pros & Cons
Hybrid Total Arch for Acute Dissection

• Who should we be doing this “disease specific” operation for?

  • Intimal tear in aortic arch
  • Retrograde dissections

  • Arch re-entry tears
  • CT disorder?
  • Arch aneurysm
  • Younger age
Results of “Type II” Hybrid Arch Repair with Zone 0 Stent Graft Deployment

Jehangir Appoo, William Kent, Eric Herget, Jason Wong, Alberto Pochettino and Joseph Bavaria

Division of Cardiac Surgery, Libin Cardiovascular Institute of Alberta & Division of Diagnostic Imaging, University of Calgary & Hospital of the Univ. of Pennsylvania, Dept. of Cardiac Surgery, University of Pennsylvania
Evolution of Management Options for Diffuse Pathology of the Ascending, Arch and Descending Thoracic Aorta

I. Conventional open two-stage procedure
   I. Treatment mortality including first stage, second stage and interval mortality as high as 36% in contemporary series
      Etz, Grieppe et al. EJCTS 2008;34;605-615

II. Frozen stented elephant trunk concept (E-vita Registry)
   I. 15% operative mortality and 8% SCI
III. Type I Hybrid – Arch Debranching Procedure

I. 122 of 195 cases were Zone 0 TEVAR:
   – 10.5% incidence of proximal Type I endoleak, retrograde Type A dissection and graft migration

   Antoniou et al., Eur J Vasc Endovasc Surg 2010;39:683-690

IV. Type II Hybrid Arch Procedure

I. Novel approach which may have advantages for managing both acute and chronic diffuse thoracic aortic pathology
Milewski, Bavaria et al., JTCVS 2010;140:590-7
The “Type II” Hybrid Option

Advantages:

1. Single stage

2. “Bavaria graft” replaces diseased ascending aorta, provides robust fixation for stent graft and minimizes risk of endoleak and retrograde dissection
Advantages:

3. Avoidance of prolonged circulatory arrest

4. CPB is advantageous:
   - Cerebral protection
   - Perfusion during arch debranching
   - Resection of ascending aorta
28 mm Tube Graft

Left Common Carotid and Left Subclavian Branches

Brachiocephalic Trunk Branch

Endovascular System Delivery Branch
Native Ao Arch

Branches to Left Carotid and Left Subclavian Arteries

Branch to Innominate Artery Under Innominate Vein

Native Ao Arch

Proximal Stent Graft Landing Zone in Replaced Ascending Aorta
Procedure

- Replacement of Ascending +/- aortic valve and root repair
- Arch debranching
- Antegrade endovascular stent graft deployment

<table>
<thead>
<tr>
<th>Operative Details</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Intraoperative Temperature</td>
<td>25 - 30°</td>
</tr>
<tr>
<td>Mean CPB time</td>
<td>259 min</td>
</tr>
<tr>
<td>Mean Cross-Clamp Time</td>
<td>100 min</td>
</tr>
<tr>
<td>*Circulatory Arrest (Simple open distal)</td>
<td>9/18 patients</td>
</tr>
<tr>
<td>Stent’s Deployed Antegrade (mean #)</td>
<td>1.9</td>
</tr>
<tr>
<td>Aortic valve repair +/- root work</td>
<td>4/18 patients</td>
</tr>
</tbody>
</table>
# Results: Perioperative

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Successful technical deployment</td>
<td>18 (100)</td>
</tr>
<tr>
<td>In-hospital mortality</td>
<td>1 (5.5)</td>
</tr>
<tr>
<td>Transient paraplegia</td>
<td>3 (16.7)</td>
</tr>
<tr>
<td>Renal Failure (Dialysis)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Reoperation for bleeding</td>
<td>4 (22.2)</td>
</tr>
<tr>
<td>Stroke</td>
<td>1 (5.5)</td>
</tr>
</tbody>
</table>
## Results: Late
Mean Follow-up: 24 months

<table>
<thead>
<tr>
<th>Condition</th>
<th>Pt. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late mortality</td>
<td>2 (11.1)</td>
</tr>
<tr>
<td>Stent fracture</td>
<td></td>
</tr>
<tr>
<td>Stent migration</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Retrograde Type A Dissection</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Aneurysm growth</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Endoleak</td>
<td>2 (11.1)</td>
</tr>
</tbody>
</table>
Type II Hybrid Procedure:

Two year follow-up:

• Technically achievable repair
• Less invasive and potentially improved perioperative outcomes
• No incidence of rupture, aneurysm progression, or retrograde type A dissection at 2 year follow up. No delayed type 1 endoleak
• Attractive option for patients with diffuse thoracic aortic pathology
• Long-term results yet to be determined
### Table: Surgeon Year ET1 Mortality ET2 Mortality Interval Mortality Rx Mortality

<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>
</tr>
</thead>
<tbody>
<tr>
<td>Svensson</td>
<td>2004</td>
<td>2%</td>
<td>8.5%</td>
<td>14%</td>
<td>18%</td>
</tr>
<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>

ET1 Mortality – 6-7% in high volume leading centres.  
Interval mortality may be decreased with endo stage II but is still real
Thus, best case scenario for open total arch in real world is likely a treatment mortality of at least 15%, possibly higher.

Significant mortality in an asymptomatic lesion in an elderly patient

Morbidity of bleeding, stroke, prolonged ICU

Role for decreasing “dimensions” of this operation
Large data bases show us that mortality for all cardiac surgery increases with age.

AVR: 
60 y.o $\rightarrow$ 80 y.o 
3x increase in op risk

Total arch/Elephant Trunk 
60 y.o $\rightarrow$ 80 y.o 
?
Defn of Hybrid Arch:
   Combination of sternotomy & endovascular surgery

Idea behind Hybrid Arch:
   Decrease the scope of invasive surgery to improve
upon    morbidity and mortality
Many techniques
   On pump – off pump
   Circ arrest, no circ arrest
   single stage vs. two stage
   location of stent placement
   antegrade vs. retrograde stent placement
   cardiac surgery vs. vascular surgery vs. IR
Bavaria classification for Hybrid Arch

Type I

Type II

Type III

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

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.

Anna Thorac Surg 2012/3:26–8 © 2012 by The Society of Thoracic Surgeons

General Principles of our Type II Hybrid Arch Strategy

Sternotomy

On CPB with Mild-Mod Hypothermia

Replacement of Ascending aorta

Short Circ arrest or avoid circ arrest

Arch Debranching

Antegrade Deployment

Single Stage Repair

Diffuse Aortomegaly → Acute Type A Dissection
Advantages of Hybrid Strategy for diffuse aortic disease

Avoidance of prolonged circ arrest

Avoid effects of deep hypothermia

Avoid dissection around recurrently laryngeal

Challenging distal operation converted to proximal repair

Single stage repair
Total arch replacement: A 2% to 6% risk of death and a 2% to 7% risk of stroke have been reported for these extensive and high-risk procedures. Emergency operation mortality and stroke rates are higher (15% and 14%, respectively) (778). Careful brain and myocardial protection, correction of coagulopathies, and improved operative techniques, including the use of elephant trunk procedure, have led to improved outcomes (680,779).

2010 TAD guidelines
Elements of a good talk

1. Audience-centric
   1. Material developed from a place of empathy towards audience
      1. I.e: how difficult dissections are/ how worrisome/challenging middle of the night cases therefore we are hard wired not to do more surgery than necessary, but is this the optimal thing – from a physiologic and anatomic aspect

2. Role as mentor
   1. Giving audience a tool/gift that will help them in some way.
   2. If audience rejects your idea, the idea dies – thus speaker needs the audience more than audience needs the speaker
   3. Humility rather than arrogance
   4. I.e: tool:
      1. Consider the importance of the effaced true lumen to your patients. Which of their organs are perfused by this narrow channel? What is at risk?
      2. One simple way to help is to monitor perfusion during CPB and have low threshold to add an additional arterial cannula.
      3. Consider adding endovascular surgery to your armamentarium/to your group’s armamentarium – ask a colleague for help
1. Wrap content in a story
   1. “Story” of pt. Humber?
   2. Story of making your patient whole
2. Think about the point you are trying to make
   1. We are in a new paradigm in understanding and treatment of the disease.
   2. Midst of exciting revolution where we are trying newer operations newer techniques to improve patient outcomes
3. Capture resistance
4. Have a call to action