Quo Vadis Cardiovascular Surgery: The Role of Open and Endovascular Techniques in the future (21st Century)

Joseph E. Bavaria, MD
Roberts-Measey Professor of Surgery
Vice Chair, Division of Cardiovascular Surgery
University of Pennsylvania
Immediate Past-President; Society of Thoracic Surgeons (STS)

Aorta Live; Hamburg, Germany 2017
I’m here to “Set Up” this excellent Session!!
Proximal Aortic Surgery in 21st Century

• I’m ALSO here to tell you that we are at the beginning of a Revolution
Aortic Arch Surgery in 21\textsuperscript{st} Century

- Recently, We (The Aorta Community) spent much energy and time trying to “Optimize” and answer the Question: What is the best Circulation Management Technique during Aortic Arch Reconstruction?
  - Temperature
  - HCA, RCP, ACP, Unilateral, Bilateral, etc.
The “Optimization” revolved around: What is the **KEY CONCEPT** Regarding Circulation Management of the Open Aortic Arch???

- The mortality and morbidity of **SHORT** arch reconstructive times (<30-35min) is **EMBOLIC** (lateralized CVA).
- The mortality and morbidity of **LONGER** arch reconstructive times (>35-40min) is **GLOBAL** neurological deficit.
Aortic Arch Surgery in 21\textsuperscript{st} Century

- **General Consensus on Circulation Management**
  - Tepid Temperatures are reasonable with “good” ACP technique
  - ACP thought to be best, RCP reasonable especially for Short Arch reconstructive times, HCA Alone should be abandoned.
On Circulation Management: Cerebral Oximetry

TAA-Hybrid With AVR and CABG X 1

- Baseline L=80; IR=79; S1=80, S2=89
- 13:38 LCC clamped slow rSO2 drop 44%
- 13:57 Innominate Artery Clamped, disbranched, and bypassed. Slow rSO2 drop to 46%

Graph showing cerebral oximetry over time with various events and measurements.
Aortic Arch Surgery in 21st Century

Recently, We spent much energy and time trying to “Optimize” and answer the Question: What is the best Circulation Management Technique during Aortic Arch Reconstruction?

But Now: We are Changing Practices and Developing Reconstructive Operations ……

Based on the Availability of New Devices. New Technology!!
Proximal Aortic Surgery in 21st Century

• Aneurysm
Proximal Aortic/Arch Aneurysm: Future

CT Chest, Ascending Ao SAX

Ascending Aorta and Arch
Aortic Arch Surgery in 21st Century: Aneurysm

- All open (proximal) operations will be performed with an “Attitude” looking towards Distal TEVAR Solutions.
- The Classic elephant trunk will be rare
- FET will be victorious
- All “Conduct of Operation” will be geared towards “Proximalization” into Zones 2, 1, and 0
  - The (New) Debranching concept
The Arch in Acute Type A Dissection?

• What is State of the Art …… Now/Future??
## Acute Type A Dissection: Design of an Operation (What is Missing?)

<table>
<thead>
<tr>
<th>Cause of death</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute CHF due to AI resuspension</td>
<td>Aortic valve resuspension</td>
</tr>
<tr>
<td>Coronary malperfusion</td>
<td>Aortic root repair</td>
</tr>
<tr>
<td>Cerebral malperfusion</td>
<td>Asc aortic replacement</td>
</tr>
<tr>
<td>Free Ascending rupture</td>
<td>Asc aortic replacement</td>
</tr>
</tbody>
</table>

**Fate of Distal Descending Aorta!**
Do we have a problem with the downstream aorta??

  - Follow-up 12 to 90 month (58 pat.): 77.5% patent false lumen
  - Year aortic growth rate: \(0.56 \text{ cm PDFL vs. } 0.11 \text{ cm TFL}\)
  - During 7 year period: 27.5% re-op due to increasing diameter

  - Follow-up 60 month (87 pat.): 72% patent false lumen
  - Most common cause for late death: related to distal aortic disease
Distal re-operation rate after Type A Dissection Repaired “Classically”

Senior Surgeon Series

- Bavaria et al, 2007 (USA), 26% Reoperation at 12 years
  - Included Debakey II
- Ishihara et al, 2009 (Japan), 27% Aortic Events at 5 years
- DeBartolomeo et al, 2001 (Italy), 27% Reoperation at 7 years
- Grieppe et al, (USA), 16% reoperation at 8 years
  - Included Debakey II
- Glauber and Murzi, 2010, 39% reoperation at 10 years (proximal and distal)
Freedom from Reoperation after Type A: Proximal and Distal

Glauber, Murzi, et al; 2010:
Late Outcome after Debakey Type 1 Repair
Late Complications: Aneurysmal Dilation of the Dissected Aorta (8.0 cm)

53y.o male
Rapidly Expanding False lumen
Larger Tear site = More Time Averaged Wall Shear Stress

Fig 2. Flow velocity maps of the thoracic segments of the aortic dissections in Fig 1 showing the acceleration of blood through dissection tears and its subsequent impingement on the far aortic wall. A, An aortic dissection with a stable transaortic diameter. B, An aortic geometry that demonstrated rapid expansion.
40 y.o male 1 year post Type A repair (6.4 cm)
68y.o male 10 years post type A repair (7.3 cm)
The fate of the distal aorta after repair of acute type A aortic dissection

Fate of the Residual Distal and Proximal Aorta After Acute Type A Dissection Repair Using a Contemporary Surgical Reconstruction Algorithm

Evolution of Aortic Dissection After Surgical Repair

Rossella Fattori, MD, Letizia Bacchi-Reggiani, MSc, Paola Bertocchini, MD, Gabriella Napoli, MD, Francesca Fusco, MD, Massimo Longo, MD, Angelo Pierangieli, MD, and Giampaolo Gavelli, MD

Patients after aortic dissection repair still have long-term unfavorable prognosis and need careful monitoring. The purpose of this study was to analyze the evolution of aortic dissection after surgical repair in correlation to anatomic changes emerging from systematic magnetic resonance imaging (MRI) follow-up between January 1992 and June 1998. Seventy-two patients underwent surgery for type A aortic dissection. Fifty-eight patients were discharged from the hospital (17% operative mortality) and were followed by serial MRI for 12 to 90 months after surgery. In all, 436 postoperative MRI examinations were analyzed. In 13 patients (22.5%) no residual intimal flap was identified, whereas 45 patients (77.5%) presented with dissection, with a partial thrombus of the false lumen in 24. The yearly aortic growth rate was maximum in the descending aortic segment (0.37 ± 0.43 cm) and was significantly higher in the absence of thrombus in the false lumen (0.56 ± 0.57 cm) (p < 0.05). There were 4 sudden deaths, with documented aortic rupture in 2. Sixteen patients underwent reoperation for expanding aortic diameter. In all but 1 patient, a residual dissection was present (in 13 without any thrombosis of the false lumen). Close MRI follow-up patients after dissection surgical repair can identify the progression of aortic pathology, providing effective prevention of aortic rupture and timely reoperation. Thrombosis of the false lumen appears to be a protective factor against aortic dilation. © 2000 by Excerpta Medica, Inc.
Do we have a problem with the distal aorta after repair of acute type A dissection? ....

YES

Especially if we use a COMPOSITE function of Index Operation Failure: 1. Aortic Death; 2. Reoperation; 3. Aneurysm > 6.0 cm.
What can we do??
What Options are available??
STS/EACTS Aortic Symposium:
Management of the Aortic Arch during Type A Dissection

Moderators:
Joseph Bavaria (STS)
Ruggero DePaulis (EACTS)
Not worry about it: The Hemi-Arch (+/- Root)

Aggressive Hemi-Arch with “felt Neo-Media” Reconstruction
Technical: Conventional Total Arch for with “deep” Distal anastomosis +/- Elephant Trunk:

**Standard Zone 3 Arch**

Total Arch +/- Elephant Trunk with 4-branch graft
Selective ACP
“More Proximal” Aortic Arch Surgery ENABLING later TEVAR if anatomy Suitable
Acute Type A “Stented Elephant Trunk”
Pochettino, Szeto, and Bavaria; AnnThor Surg 2009

77% of Stented Descending Aorta cases with Obliterated False Lumen vs only 25% for Standard hemi-Arch Repair
However .......

Let’s look at these
Aortic Arch Surgery in 21st Century

• The Future Arch Treatment “Civil War” ....
Technical: Conventional Total Arch with Frozen Elephant Trunk: Standard Zone 3 Arch FET
So how should we handle the ARCH?
Or … **ZONE 2 Arch with Sequential Branched TEVAR completion**

- Advantages
  - Simpler Distal Anastomosis
  - Can address most complex arch tears and eliminate flap in proximal head vessels
  - Shorter ACP times
  - Definitive TEVAR options
  - Less risk of Recurrent laryngeal nerve injury
  - Not doing unnecessary distal procedure at Index operation
  - Griepp/Etz Collateral Network theory friendly!

Desai, Bavaria (First presented) STS 2015; AATS 2016 JTCVS 2017 (in press)
Zone 2 TBE (12 mm Portal) in “Residual” Type A Dissection (Downstream Aorta) 10 days

Side branch sheath positioned in LSA
Note nice horizontal access

3 cm Dacron LZ previously constructed with Zone 2 Arch (10 days earlier)
Type A Repair with Zone 2 Arch:
Zone 2 Arch with 14 day Branched TEVAR Completion: 1st in MAN
The “Classic” Type A Operation is under Siege!! There are reasonable arguments to “extend” the operation BOTH distally and proximally….

However, The Arch and Distal imperative is MORE IMPORTANT!!
Conclusions on Management of the Arch in Acute DeBakey I Dissection 21st Century

- There are Multiple Ways to manage the ARCH in an Acute Type A Dissection

- My Prediction on the future based on our data, our increased sophistication, and the available technology:
  - In Patients with < 10-15 years life expectancy (>65) ...... Use Classic Hemi-Arch
  - In Patients with an arch tear or distal Malperfusion ...... FET
  - In patients < 65 and stable ........ Zone 2 Arch with possible (60%) SEQUENTIAL Arch branch TEVAR

- Coming to you SOON!
Rapid Supra-Aortic Arch Vessel Anastomosis Using the Gore “Hybrid” Prostheses (90 seconds and better!!)

 Courtesy of Jim Williams, Peoria IL

Endovascular Arch Repair?
Endovascular Arch Repair?

Gore Zone 0 TBE
What does an “Arch Endograft” really mean vis-à-vis Arch pathology??

- Isolated Arch Pathology?
- Arch Pathology **WITH** Ascending Pathology?
- Arch Pathology **WITH** Root/Valve Pathology?
- Arch Pathology as a Proximal extension of Descending pathology?
Aortic Arch Surgery in 21\textsuperscript{st} Century

- This anatomy only represents 1-3\% of \textbf{ALL ARCH} cases

There is already a TOTAL TEVAR (Endo) Solution for this anatomy
Bolton Relay: Fenestrated Arch Grafts

Pre

Intra – Final angiogram

Post – 3D V.R. 2 weeks

Courtesy of Bolton Medical
Cook Branch Arch Prosthesis (Significant Worldwide experience)

Cook Branched Arch Graft
Courtesy of Cherrie Abraham, MD, Montreal, Canada
What does an “Arch Endograft” really mean vis-à-vis pathology??

- Isolated Arch Pathology?
- Arch Pathology **WITH** Ascending Pathology?
- Arch Pathology **WITH** Root/Valve Pathology?
- Arch Pathology as a **Proximal extension** of Descending pathology?
Zone o Landing: Achilles Heal??

Most “Arch TEVAR” will be Secondary or Sequential to PROXIMAL OPERATION DACRON
Aortic Arch Surgery in 21st Century

- There are Significant Proximal Landing Zone Issues
Giant Fusiform Thoracic Aortic Aneurysm: Isolated Arch Endograft?? Where’s the LZ??

CT Chest, Ascending Ao SAX

Ascending Aorta and Arch

Asc Ao, Des Ao, IA, LCA
Hypertensive Ascending Aneurysm with partial Proximal Arch Extension AND Distal Arch Aneurysm:

Isolated Arch TEVAR?? ……**Where’s the LZ??**

---

May Want to Replace Ascending Aorta?!
Bicuspid Valve Phenotype Aorta: Isolated Arch TEVAR?? ..... Where’s the LZ??
Water Hammer Pulse AI Aneurysm: Major LZ Issue!!

+3 AI BAV Aneurysm
Ascending Aorta Motion in multiple planes: Major Proximal LZ Issues?

- Long Term TEVAR stability will possibly have issues
Aortic Arch Surgery in 21st Century

• Despite all of That!!
The Future of Ascending TEVAR?: Repair of Ascending Aneurysm **Trans-Apically** with Stent Graft

Szeto, Bavaria, et al; AnnThorSurg 2010
Medtronic Ascending Endograft
FDA Physician IDE (Type A Dissection)

Valiant Captiva
46x46x80 mm

Courtesy of Khoynezhad/White;
Cedars-Sinai /UCLA
Proximal Aortic Surgery in 21st Century

• The Audit Function
  – Data and Outcomes
Presentation of a Newly Designed Thoracic Aortic Surgery Database:
A Report from the STS Adult Cardiac Surgery Database

Nimesh D. Desai MD. PhD., E. Chen, M.D., J. Bavaria, MD on Behalf of the STS Aortic Surgery Task Force
(First reported at the Jan. 2017 STS Annual Mtg, Houston, TX)
Proximal Aortic Surgery in 21st Century

• Conclusions
Proximal Aortic Surgery in 21st Century:

- Index **Proximal** operations will be **driven** and **conceived** by the **NEW** Availability of New Technology Endografts
  - Zones 0, 1, and 2 TEVAR Branched Arch grafts

- "**Proximalization**" of the Conduct of Operation" will continue (reduced Nerve injury and Collateral Network friendly)

- **Supra-Aortic Vessel** anastomosis will also improve with Technology … Much faster and easier
Proximal Aortic Surgery in 21st Century:

- Index Operation “Tactics” will be driven to REDUCE Total CPB TIME (more important than Circ Arrest time)
- It’s too early to have Guidelines on Aortic ARCH Surgery!!
  - Very (Too) Dynamic at this Stage
  - The only thing we should do is “Outlaw” HCA alone
- Better Outcomes Data (Global)
Questions?
Thomas Eakins: Gross Clinic (1878@JEFF) and Agnew Clinic

Great Progress in 10 years!

Thank You