Minimally Invasive Aortic Arch Surgery: Where are we? Where are we headed?

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Montreal, Canada
Disclosures:

Consultant Gore Medical
Tasks Today:

1. Define why Min Invasive Arch is important
2. Current options for “less invasive” arch surgery:
   1. Open Surgery
   2. “Closed Chest”
3. Future Directions/Challenges
Case Example for today’s tasks

June 2016

70 y.o healthy female

5.5cm arch – expanding 1-2mm/yr
2000: Mech AVR, Asc Ao & Hemiarch

In 2016 what are the feasible MIS Approaches to this case? :

Open Chest Options

Closed Chest Options
Prep for this talk: What is M.I.S?

Google Search  (of interest, no defn on ISMICS website)

“... minimizing surgical incisions to **reduce trauma** to the body”

“...one that is safe and is associated with a **lower postoperative patient morbidity** compared with a conventional approach for the same operation”
Historically, Arch Surgery used to be Maximally Invasive:

Large incision: Full sternotomy, trapdoor, clamshell

Trauma: Deep Hypothermic Circulatory Arrest with multisystem organ “trauma”

Safety: Significant mortality and stroke risk
Perspective/Big Picture

Innovation: “Doing something different that matters” – Mark Allen, STS Presidential Address Jan 2016

Why is minimally invasive arch surgery important?

- are there a lot of cases?
- are we being innovative just because we can or does it matter?
Why is Minimally Invasive Arch Important?

Descending thoracic aortic surgery has transitioned to endovascular treatment as first line therapy.
Why is Minimally Invasive Arch Important?

If closed chest arch can be solved …

…Implications?
Ascending Aorta: large number of cases compared to descending!

Final Frontier for Endovascular Surgery
Solving arch branches and angles is a critical piece of puzzle in current revolution of modular closed chest aortic reconstruction:

- TAVR
- Ascending Aorta
- Arch
- Descending Aorta
- Thoraco-abdominal Ao

...better not let this train leave the station...
Open Chest Options:

**Full sternotomy** can be *less invasive*:

- Mod hypothermia
- Continuous ACP

M.I.S. = reduce trauma & decrease postoperative morbidity
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Our full sternotomy strategy to reduce “trauma”:

25\(^\circ\) Celsius NP temp

ACP via R axillary or innominate

Clamp each head vessel to keep cerebral circulation pressurized & capillary bed perfused & avoid embolic phenomenon

Sequence of anastamosis:
1. distal arch with SACP
2. restart lower body perfusion
3. Bypass left carotid & then rewarm
4. ± left subclavian bypass
5. Proximal & take clamp off
6. Innominate whilst reperfusing

HCA time: 15-20mins
SACP time: 30-35 mins
Open Chest Options:

1. **Full sternotomy**
   - Mod hypothermia with continuous ACP to reduce “trauma” to organs and decrease postop morbidity

2. **Hemisternotomy** with moderate hypothermia and continuous ACP
   - Extension of our “mini” AVR approach

M.I.S. = reduce trauma & decrease postoperative morbidity
Hemi-Sternotomy Arch Example

Jan 2016

62y.o. male

5.8cm arch

2000 Mechanical Bentall
I use 3rd ICS for “hemi arch” & 4th ICS for total arch

Axillary vs. aorta/innominate cannulation

Percutaneous fem venous cannulation

Cool to 25 degrees

Continuous ACP

Sequence of anastamosis:
1. distal arch
2. left carotid & then rewarm
3. ± left subclavian
4. Proximal & take clamp off
5. Innominate whilst reperfusing
Redo hemi-sternotomy arch replacement – Jan 2016

HCA with continuous ACP 18mins
SACP 32 mins
What are the “Closed Chest” Options for our healthy 70 y.o patient?

Single branch endografts
  off the shelf

Multibranch Arch Endografts Grafts
  Custom
  Off the shelf
Closed Chest Options in 2016:

1. Single branch arch grafts

M.I.S. = reduce trauma & decrease postoperative morbidity
Single Branch Arch Devices

Off the shelf devices
Designed for LSA or innominate artery
Modular system
Dual wire lumens

Gore FDA study
6 sites enrolling in US
First in man: Jan 2014

Medtronic Mona LSA FDA study
First in man ≈ 2013
Single Branch Arch Grafts combined with extra-anatomic carotid carotid bypass for full arch reconstruction

June 2016
Enrollment Gore FDA feasibility study: n=30 n=9

Feasibility trial completing → moving to pivotal trial
As feasibility study finishes for arch aneurysms → Dissections:

2016

Early Feasibility Study: Acute Type A Dissection

3 sites in Houston enrolling soon

Technology is here....and future generations will improve on shortcomings...
In 2016, is single branch arch graft a good solution for our 70 y.o patient?
M.I.S. = reduce trauma & decrease postoperative morbidity

Closed Chest Options in 2016:

1. Single branch arch grafts
2. Chimney/Snorkel
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

Not a good option for our patient today
Closed Chest Options in 2016:

1. Single branch arch grafts
2. Chimney/Snorkel
3. Multibranach arch grafts

M.I.S. = reduce trauma & decrease postoperative morbidity
Cook Multibranch Arch Graft is **custom made** for alignment of patient’s arch vessels.

Carotid-subclavian bypass preop

Main body deployed transfemorally

Head vessels cannulated from above

Narrower body in arch
Closed Chest Total Arch:  

Cook Branched Arch

>200 cases worldwide

Largest published series 38 pts

Reported early Stroke rate 10-15%


Haulon et al. JTCVS 2014
Spear et al. Eur J of Vasc Endovasc Surg 2016
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

Refused repeat sternotomy/thoracotomy
Complexity
Pt. extubated on the table
Transfused 1UPRBC

VR images 3 months post op
Stable 3 years post op
"Z shape" of the Main Module

Fixation
Continuous flow path to the brain
Through and through access
Off the shelf device

Image courtesy of M. Lachat, Switzerland
NEXUS™ Modules

Fenstration (optional) for an ePTFE covered stent

Image courtesy of M. Lachat, Switzerland
June 2016:

Human Feasibility study – 6/10 patients enrolled
- Hradec Kralove, Czech Republic (Raupach J)
- Zurich, Switzerland (Lachat M)
- Rome, Italy (Mangialardi N)

Compassionate Cases – 8 patients ongoing
- Montreal, Canada (Cherrie ZA)
- Rome, Italy (Mangialardi N)
- Modena, Italy (Coppi G)
- Toronto, Canada (Lindsay T)
- San Donato, Italy (Nano G)

Data courtesy of M. Lachat, Switzerland
## Clinical Events (N=9)

<table>
<thead>
<tr>
<th>Event</th>
<th># of Patients</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical success</td>
<td>9/9</td>
<td></td>
</tr>
<tr>
<td>Death</td>
<td>1/9</td>
<td>Compassionate #3: 2 days post implantation, due to MI</td>
</tr>
<tr>
<td>Stroke</td>
<td>Stroke 2/9</td>
<td>Compassionate #1: Right side hemi-syndrome</td>
</tr>
<tr>
<td></td>
<td>Permanent Deficits 0/9</td>
<td>Compassionate #4: Right arm paresis</td>
</tr>
<tr>
<td>Spinal Cord Ischemia</td>
<td>1/9</td>
<td>Compassionate #4: arch and descending aneurysms CSFD post implantation, patient recovered.</td>
</tr>
<tr>
<td>Endoleak type Ia or III</td>
<td>1/9</td>
<td></td>
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Closed Chest Total Arch

Precurved fenestrated arch graft in various configurations off the shelf

Najuta graft

Used in over 300 aneurysm cases in Japan

Concern re: risk of stroke
In 2016 is a branched arch graft the best choice for our 70 y.o pt?
Case Example  June 2016

70 y.o healthy female
5.5cm arch – expanding 1-2mm/yr
2000: Mech AVR, Asc Ao & Hemiarch

Discussed:

- **Open Chest** Options
- **Closed Chest** Options

So, what did we do?
Hemisternotomy approach:

R Axillary a. & fem vein cannulation
25 degrees C
Continuous ACP

Prox arch exposure via hemisternotomy
Distal Arch Exposure via Hemisternotomy
Post op VR image

HCA 16mins
SACP 38mins
In 2016 why choose Hemisternotomy in our healthy 70 y.o pt?

Single branch arch graft – safety single inflow?
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Single branch arch graft – safety single inflow?

Multiple branch arch graft - stroke risk > open surgery ??
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4 branch arch

“Healthy” – good surgical candidate
In 2016 why choose Hemisternotomy in our healthy 70 y.o pt?

Single branch arch graft – safety single inflow?

Multiple branch arch graft - stroke risk > open surgery ?

4 branch arch

“Healthy” – good surgical candidate

Hemisternotomy & continuous ACP accomplished “decreased trauma & post op morbidity”

Will open surgery be first line treatment in 2021 ??
Endovascular Revolution is in Evolution
   – Arch & Asc Aorta not complete

Future tasks:

Stroke – understanding pathophysiology and then targeted therapy

Angulation control to land on inner curve of short ascending aorta

Overcome lack of good proximal landing zone

Lower profile devices

Antegrade vs. retrograde cerebral blood flow
Future:

Our preferred approach to Debakey Type I Dissection – Zone 2 Arch

Approach in near future?
Or will acute Type A Dissection be all percutaneous treatment?
Future:  
Endo Bentall?  
Platform of Aortic Valve and Ascending aortic graft followed by branched arch followed by....
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   Solving arch is a critical piece of puzzle in current revolution of modular closed chest aortic reconstruction.
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   1. Open Chest
   2. Closed Chest
3. Future Issues to overcome
“Good judgement comes from experience... Experience comes from bad judgement”

C. Walton Lillehei, 1918-1999