Aortic Pathologies – State of the art surgical interventions - today and tomorrow

Canadian CardioVascular Nurses Spring Meeting
Calgary, Alberta
May 6, 2017

Jehangir Appoo
Division of Cardiac Surgery
Libin Cardiovascular Institute
Cumming School of Medicine
University of Calgary
Purpose Today

I. Tour of recent and future treatment for:
   
   I. Descending Aortic Anuerysms
   II. Type B Dissections
   III. Aortic Coarctation
   IV. PDA
   V. Type A Dissection
   VI. Ascending aorta/arch

I. Infrastructure

II. Unsolved Problems
Fathers of Aortic Surgery

1953 Cooley and De Bakey repaired the first descending thoracic aortic aneurysm using homografts

1970’s Stanley Crawford – major technical improvements “30/30” club

1970’s-1980’s Randall Griep refinement of techniques neuro/spinal protection
Evolution of Aortic Surgery
Highly morbid operations

Significant risks

Pain syndrome
Evolution of Aortic Surgery
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Descending Thoracic Aortic Aneurysms

Risk of dissection or rupture of the Descending Aorta

Elefteriades et al., Yale database
Endovascular surgery improves morbidity & mortality

- ↓Mortality 2% vs. 11%
- ↓Spinal Cord ischemia 3% vs. 14%
- ↓ICU, hospital LOS

- ↑vascular cxs
- ↑re-interventions

*Endovascular stent grafting versus open surgical repair of descending thoracic aortic aneurysms in low-risk patients: A multicenter comparative trial*

Joseph E. Bavaria, MD, Jehangir J. Appoo, MD, Michel S. Makaroun, MD, Joel Verte, PhD, Zi-Fan Yu, and R. Scott Mitchell, MD, for the Gore TAG Investigators

Objective: Results are presented from the first completed multicenter trial directed at gaining approval from the US Food and Drug Administration of endovascular versus open surgical repair of descending thoracic aortic aneurysms.

Methods: Between September 1999 and May 2001, 140 patients with descending thoracic aneurysms were enrolled at 17 sites and evaluated for a Gore TAG Thoracic Endograft. An open surgical control cohort of 94 patients was identified by enrolling

*J Thorac Cardiovasc Surg 2007;133:369-77*
37y.o mother of 3

Presents with a cough

Open & Endovascular options 2011
1.5 inch groin incision
Home 2 days
@work 1 week
Distal Arch Aneurysms

TEVAR with left carotid-subclavian bypass (2011)
81y.o male
March 2016
Endovasc revasc of left subclavian artery with snorkel technique
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Type B dissection

Evolving controversy surrounding mgmt of “uncomplicated” vs. “complicated” type B
Endovascular Treatment of Type B dissection
Complicated Acute Type B Dissection

56yo male
Seen 12 hrs post presentation
Severe Malperfusion:
  Ischemic leg
  Ischemic gut
  Renal failure
Management

- Emergent OR
- Multidisciplinary team
- Right groin access
- 42mm x 216mm Cook Zenith TX2 Proform device from left CCA to mid descending aorta (Prox LZ=36mm)
- Device unsheathed distal to ostium of Left Carotid Artery
Lower extremity, visceral & renal malperfusion resolved
Hospital Survival with Acute Type B Dissection

In Hospital Mortality:

Medical Rx - 10%
TEVAR - 10%
Open surgery - 34%

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Primary Adult Coarct
Male
Early 30’s
Bicuspid Aortic Valve

2007
Primary Adult Coarct

Male
Early 30’s
Bicuspid Aortic Valve
2013
PDA Closure

Patent Ductus Arteriosus (PDA)

Vessel connecting Aorta and Pulmonary Artery

AO = Aorta
PA = Pulmonary Artery
LA = Left Atrium
RA = Right Atrium
LV = Left Ventricle
RV = Right Ventricle

Oxygen-rich Blood
Oxygen-poor Blood
Mixed Blood
PDA Closure
PDA Closure
Recent Evolution

Descending Thoracic Aortic Aneurysm

Type B Dissection

Coarctation

Patent Ductus Arteriosus
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Is there a role for endovascular therapy of acute type A aortic dissection?
2017 – Debate Emerging on:

Hemi-arch vs. Extended Arch
Dissection process can involve all first order branches of the aorta and consequently perfusion of ALL ORGANS
Why not Extended Arch ± TEVAR?
June 2016 OSH

65y.o male
car accident 2º CVA
Hemiplegic
Pulseless, mottled left leg

Acute Type A
5cm Asc Ao

Why not Extended Arch ± TEVAR?

Sample Case:
Occluded R carotid

Visceral malperfusion

Renal malperfusion

Occluded left common iliac
4 organ system malperfusion: GERAADA data suggests >50% operative mortality

- Occluded R carotid
- Visceral malperfusion
- Renal malperfusion
- Occluded left common iliac
Our patient June 2016:

On-Table completion angio after Total Arch and TEVAR:

R carotid perfusion

Renal perfusion – nephrograms
Iliac flow restored

Post op CTA:
Our evolution of acute Type A repair
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?
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Ongoing/Future Evolution
“Takumi Principle”  Perceptive, Thoughtful surgeons in new era of skill
64 y.o male
Type A repair 2009
Complicated course

2013 Chronic Dissection

Aorta growing at rate of 1cm/year
Arch dissected
Large residual primary intimal tear in arch
True lumen effaced
Total endo arch
Custom built branched arch graft
2013- VR image 3 months post op
80 yo male

Saccular distal arch aneurysm

Recent VATS for non small cell lung ca with clear margins

Being considered for novel endovascular total arch graft
Nexus Branched Arch Device
Future evolution of acute Type A repair ??

FDA Trial
April 2016
28 Zone 2 Implants
8 Zone 0 implants

Dissection Trial starting…
Future Evolution of closed chest zone 0
-new devices on horizon
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The Latest and Greatest
The Latest and Greatest

Tools and Techniques
TEAM
Surgeons
Interventional Radiologists
Diagnostic Radiologists
CV Anesthetists
Nursing & DI staff
CV ICU
Advanced NP

Biomedical Engineering
Pathology
Neurology
Admin
Conventional operating theatre & Diagnostic suite opened 2014

Cardiac Hybrid Operating Suite-a State of the Art Centre

Multimodality
Multidisciplinary team
Avoid patient transfer
Improved results
Minimally invasive Aortic therapy is:

- Safer
- More effective
- More efficient
- Less invasive/better tolerated
- Innovative
Vessel Navigator

“allows **reuse** of 3D vascular anatomical information from existing **CTA and MRA datasets** as a **3D roadmap overlay** on a live X-ray image. With its excellent visualization, Vessel Navigator provides an intuitive and continuous 3D roadmap to guide you through vasculature during the entire procedure.”

– Phillips website

Overlay of CTA data onto fluoroscopic image
Vessel Navigator

Synchronization of CTA and Fluoroscopy Data

CTA Volume Rendered 3D Image
Vessel Navigation Software – Game Changer

51yo male with aneurysmal growth and compromised flow to visceral vessels 2 yrs post acute Type A Dissection repair
March 2016 – redo Total Arch Zone 2 Technique
April 2016 – Endovascular repair of thoraco-abdominal aorta
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“Easy to make perfect decisions with perfect info. Medicine asks you to make perfect decisions with imperfect info. “

Siddharta Mukherjee
Laws of Medicine: Field Notes from an Uncertain Science, 2015
Research Interests:

Assessing efficacy of innovation
Decreasing morbidity and mortality of aortic interventions
Understanding Aortic Dissections

Risk stratification of Aortic Aneurysms – *Indolent but Catastrophic*

Why do Aneurysms Rupture?

Size & growth rate not great predictors of rupture/dissection

Need more science
“Doctors are men who prescribe medicines of which they know little, to cure diseases of which they know less, in human beings of whom they know nothing”

− Voltaire, 1694-1778
Why understanding aortic behaviour is important?

Intervention is invasive – has some risks

Dilemma:

Young patients with small aneurysms are running into trouble vs. Denominator is very large – many patients have large aortic aneurysms that are stable for prolonged periods of time

If we operated on every dilated aorta, we may do more harm than benefit
**2014 ESC Guidelines on the diagnosis and treatment of aortic diseases**

### Recommendations on interventions on ascending aortic aneurysms

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Class</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgery is indicated in patients who have aortic root aneurysm, with maximal aortic diameter ≥ 50 mm for patients with Marfan syndrome.</td>
<td>I</td>
<td>C</td>
</tr>
<tr>
<td>Surgery should be considered in patients who have aortic root aneurysm, with maximal ascending aortic diameters:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- ≥ 45 mm for patients with Marfan syndrome with risk factors.</td>
<td>IIa</td>
<td>C</td>
</tr>
<tr>
<td>- ≥ 50 mm for patients with bicuspid valve with risk factors.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- ≥ 55 mm for other patients with no elastopathy.</td>
<td>IIb</td>
<td>C</td>
</tr>
<tr>
<td>Lower thresholds for intervention may be considered according to body surface area in patients of small stature or in the case of rapid progression, aortic valve regurgitation, planned pregnancy, and patient's preference.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 2  Levels of evidence

<table>
<thead>
<tr>
<th>Level of evidence</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Data derived from multiple randomized clinical trials or meta-analyses.</td>
</tr>
<tr>
<td>B</td>
<td>Data derived from a single randomized clinical trial or large non-randomized studies.</td>
</tr>
<tr>
<td>C</td>
<td>Consensus of opinion of the experts and/or small studies, retrospective studies, registries.</td>
</tr>
</tbody>
</table>

* Aortic root ≠ Asc Aorta
Position Statement

Canadian Cardiovascular Society Position Statement on the Management of Thoracic Aortic Disease

Primary Panel: Munir Boodhwani, MD, MMSc (Co-Chair), Gregor Andelfinger, MD, PhD, Jonathon Leipsic, MD, Thomas Lindsay, MD, MSc, M. Sean McMurry, MD, PhD, Judith Therrien, MD, and Samuel C. Siu, MD, SM (Co-Chair)

Notes:
- Division of Cardiac Surgery, University of Ottawa Heart Institute, Ottawa, Ontario, Canada
- Department of Pediatrics, University of Montreal, Montreal, Québec, Canada
- Department of Radiology, University of British Columbia, Vancouver, British Columbia, Canada
- Division of Vascular Surgery, University Health Network, Toronto, Ontario, Canada
- Division of Cardiology, University of Alberta, Edmonton, Alberta, Canada
- Division of Cardiology, McGill University, Montreal, Québec, Canada
- Division of Cardiology, Western University, London, Ontario, Canada
Surgery for Aortic Dilatation in Patients With Bicuspid Aortic Valves

A Statement of Clarification From the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines

Circulation. 2016;133:680-686
Summary of 2014-2016 Guidelines for Prox Ao Intervention:

Asc Ao > 5.5cm

Asc Ao > 5.0cm with some risk factors (rate of growth, family history of dissection, hypertension, patient preference…)

Asc Ao 4.5 – 5.0cm for Connective Tissue Disease

Probably don’t need to be more aggressive if bicuspid valve
Summary of 2014-2016 Guidelines on Prox Aortic Intervention:

Level of scientific evidence is poor

- no randomized data
- no large non randomized studies
- small, retrospective studies
- consensus opinions

Lots of room for flexible interpretation including patient preference, aortic shape, rate of growth, patient size
Aug 2016

29 y.o VACTERL Syndrome

R sided aortic arch
Bicuspid valve with mild stenosis
Asymptomatic
Petite stature

Does she have an indication for surgery?
The Asc Ao is 2.7x the size of desc aorta!
Do the Guidelines convince us that this 29 y.o is safe?
July 2016

50 y.o active female

BSA 1.53m2
Bicuspid valve with mild to moderate AI
asymptomatic
normal lv size and function
family history of bicuspid valve and
ascending aortic aneurysm repair (brother)

Does she have an indication for surgery?
According to Guidelines does this 50y.o have an indication for surgery?

- <5.5cm
- <5.0cm
- no known history of rapid growth
- family history of elective aneurysm repair – no family history of dissection

indexed to BSA: 3.24!
one publication suggests >2.75cm/m² is high risk
How robust are the natural history data of Ascending Aortic Aneurysms? A Systematic Review – CCC 2016

Search Strategy

Studies Identified: 2321 by primary search
4 by reference search
Total: 2325

Duplicated Studies Removed: 50

Abstract Reviewed: 2275

Excluded by Title & Abstract: 2205

Full Text Reviewed: 70

Eliminated by Full Text Review: 59

Studies Included in Systematic Review: 11
Conclusions of our systematic review:

No single study reported all of: aneurysm growth rate, size at dissection or rupture, incidences of dissection or rupture, predictors of increase rate of growth, rupture and dissection, and overall survival.

Discrepancies between results from different studies

Data not robust enough to do a meta-analysis on topic
Proposed Multicentre Randomized Study of surgery vs surveillance for ascending aortic aneurysms 5.0-5.0 cm

Objectives:
- Describe natural history
- Establish core CT lab
- Determine a NNT for asc ao aneurysms
- Risk profile aneurysms beyond size
- Forum for prospective trials
NASA: SvS

Letters of Intent to participate from Cardiac Surgeons at 15 Canadian institutions

- Memorial University of Newfoundland
- New Brunswick Heart Centre
- Laval University
- Royal Victoria Hospital, McGill University
- Montreal Heart Institute
- Queens University
- Ottawa Heart Institute
- Toronto General Hospital
- Northern Ontario School of Medicine
- London Health Sciences Centre
- University of Manitoba
- University of Calgary
- University of Alberta
- St. Paul’s Hospital, University of British Columbia
- Royal Jubilee Hospital, University of British Columbia
NASA: SvS  
N. American Study of Ascending Aorta: Surgery vs. Surveillance

Raised $75,000 via Libin, EFW and U of Ottawa

$50,000 Seed Grant applied April 2017

Study Protocol currently being worked on @ U of Ottawa & U of Calgary
Biomechanical Engineering Analysis as a tool to determine Aortic “fingerprint”
Aneurysms rupture/dissect when wall stress > wall strength

Collaboration with Biomedical Engineering, Histo-Pathology & Imaging colleagues
3D Growth

Multidimensional growth estimation

Non linear growth measure

\[ g_d^i = \frac{1}{t} \log\left( \frac{D_i^{\text{follow-up}}}{D_i^{\text{postoperation}}} \right) \]

100 observations
3D Growth

Results

Growth rate (mm/y)

Maximum growth

Outer diameter (mm)

Maximum diameter

AATS Aortic Symposium 2014
“Aorta at Risk” Ongoing Project
Personalized Medicine – “fingerprint”

Prospective tissue sample from asc ao aneurysms
Multimodality imaging
HistoPath analysis
Tissue strength testing
Tissue stiffness testing

Once we understand properties of asc ao can we determine a non invasive risk profile?
Screening

How can we appropriately screen a population to prevent disasters?

Cavaet: Will also discover a lot of aortas that may not benefit from treatment
March 2016

20 y.o male abdo pain

Lap Appendectomy at Rural Hospital

Repeat CT POD4 for CP/unwell

Died prior to transfer
In retrospect, root dilatation and abdomen aortic dissection could be appreciated on preop CT at time of abdomen pain presentation.

Questions:
  What kind of systematic screening program can identify him early?
  How did aorta get to 8cm in young man without rupturing?

March 2016
Sept 2016

46y.o Type A and GI bleed – died prior to transfer from RGH
Screening at FMC:

Working with DI to develop “White Papers”

- incidental finding of aortic aneurysms
- screening of first degree relatives
Future:

1. Prospective multicentre randomized trials of ascending aortic aneurysms

2. Biomechanical assessment may help stratify risk assessment along with size, growth rate, indexed size, pt. age, biomarkers to develop a “FingerPrint”

3. Appropriate Screening protocols are to be determined
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CALGARY THORACIC AORTIC PROGRAM

The Calgary Thoracic Aortic Program website is designed for patient education on a variety of aortic diseases in the chest including aortic aneurysms and dissections. The Thoracic Aortic Program was established and is led by Dr. Jelena Appoo, and co-director, Dr. Eric Hargel. The Program is built on an multi-disciplinary platform for diagnosis, screening, and therapeutic management of thoracic aortic disease. Through an integrative approach involving clinical excellence, teaching, and research we aim to provide state of the art therapy for our patients and contribute to a lifelong learning process to help improve patient outcomes.

WHAT IS THE AORTA?
WHAT IS THORACIC AORTIC DISEASE?
HOW IS IT TREATED?
CONTACT

CALGARY THORACIC AORTA PROGRAM
Dr J Appoo
Foothills Medical Centre
1403 29th Street NW
Calgary, AB T2N 2T9
Fax: 403-944-2906
Telephone: 403-944-2515

REFERRALS

Physicians who would like to refer patients to be reviewed in the Calgary Thoracic Aorta Program, please attach all relevant referral letter and test results to:
LECTURES BY THE CTAP TEAM

April 2016 - Acute PAU and IMH in proximal descending aorta - I always treat aggressively

April 2016 - Hybrid Arch Type A Dissection - should the stent graft be frozen or warm?
Presented by Dr Jahanir Amin at the 2016 Canadian Thoracic Aortic Collaborative (CTAC) meeting, Toronto, Ontario
Slide presentation Warm vs. Frozen Type A Hybrid: Final 2016 CTAC

March 2016 - Immediate cause of death after surgical repair of acute type A dissection

March 2016 - Hybrid arch for acute type A aortic dissection - Should the stent graft be frozen or warm?

January 2016 - Joint Position Statement for Thoracic Aortic Intervention presented at CCS/CSCS/CVS

January 2016 Lessons learned from Zone 0 debranching and evolution to Zone 2 arch repair

October 2015 - Multidimensional Aneurysmal Growth: a novel technique derived from biomedical engineering principles to help refine assessment of aortic growth

September 2015 - The role of autopsy in the cardiac sciences patient

September 2015 - A systematic review analysis of emerging techniques of extended arch replacement for Acute Type A Aortic Dissection

September 2015 - Understanding Stroke in Presence of Aortic Dissection

June 2015 - Surgical Approach to Acute Type A Aortic Dissection
Come a long way....journey continues