Update on Arch Replacement for Type A Aortic Dissection

Milwaukee Aortic Symposium 2023, James Mace, MD, FACS

1

I have no financial interests or relationships to disclose. The views are my own and do not represent the views of the US Department of Defense or its components.

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Acute Aortic Syndrome

Type A Aortic Dissection
- Life-threatening emergency
- Extremely high mortality with medical management alone
- Surgical intervention remains high risk intervention

3

CLINICAL PRACTICE GUIDELINE

2022 ACC/AHA Guideline for the Diagnosis and Management of Aortic Disease

Recommendations for Initial Surgical Considerations in Acute Type A Aortic Dissection
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

COR	LOE	RECOMMENDATIONS
1	B-NR	1. In patients presenting with suspected or confirmed acute type A aortic dissection, emergency surgical consultation and evaluation and immediate surgical intervention is recommended because of the high risk of associated life-threatening complications.[1-4]

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J Am Coll Cardiol 2022;80(24):e223-e393

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CLINICAL PRACTICE GUIDELINE

2022 ACC/AHA Guideline for the Diagnosis and Management of Aortic Disease

Recommendations for Surgical Repair Strategies in Acute Type A Aortic Dissection
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

COR	LOE	RECOMMENDATIONS
1	B-NR	1. In patients with acute type A aortic dissection and a partially dissected aortic root but no significant aortic valve leaflet pathology, aortic valve resuspension is recommended over valve replacement.[1-5]
1	B-NR	2. In patients with acute type A aortic dissection who have extensive destruction of the aortic root, a root aneurysm, or a known genetic aortic disorder, aortic root replacement is recommended with a mechanical or biological valved conduit.[6-9]
2b	C-LD	In selected patients who are stable, valve-sparing root repair may be reasonable, when performed by experienced surgeons in a Multidisciplinary Aortic Team.[10,11]
1	B-NR	3. In patients with acute type A aortic dissection undergoing aortic repair, an open distal anastomosis is recommended to improve survival and increase false-lumen thrombosis rates.[12-15]
1	B-NR	4. In patients with acute type A aortic dissection without an intimal tear in the arch or a significant arch aneurysm, hemiarch repair is recommended over more extensive arch replacement.[16-18]
2b	C-LD	5. In patients with acute type A aortic dissection and a dissection flap extending through the arch into the descending thoracic aorta, an extended aortic repair with antegrade stenting of the proximal descending thoracic aorta may be considered to treat malperfusion and reduce late distal aortic complications.[19,20]

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CLINICAL PRACTICE GUIDELINE

2022 ACC/AHA Guideline for the Diagnosis and Management of Aortic Disease

Recommendations for Surgical Repair Strategies in Acute Type A Aortic Dissection
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

COR	LOE	RECOMMENDATIONS
1	B-NR	4. In patients with acute type A aortic dissection without an intimal tear in the arch or a significant arch aneurysm, hemiarch repair is recommended over more extensive arch replacement.[16-18]

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Proximal aortic repair versus extensive aortic repair in the treatment of acute type A aortic dissection: a meta-analysis

Meta-analysis of observational studies

- Studies = 9
- n = 1872

Types of repair

- Proximal (PR): replacement of ascending aorta or hemi-arch
- Extended (ER): total arch replacement

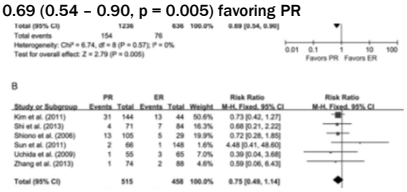
Most results had no significant heterogeneity ($\chi^2 \leq 0.1$ and $I^2 \geq 50\%$)

7

Proximal aortic repair versus extensive aortic repair in the treatment of acute type A aortic dissection: a meta-analysis

Early mortality

RR 0.69 (0.54 – 0.90, p = 0.005) favoring PR



Subgroup Hemi-arch vs ER (6/9): RR 0.71 (0.54 – 0.94, p = 0.02)

8

Proximal aortic repair versus extensive aortic repair in the treatment of acute type A aortic dissection: a meta-analysis

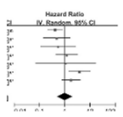
No difference in postoperative renal failure & stroke (6/9)

No difference in longterm mortality (7/9)

- + Sig. Heterogeneity (age, Marfan), but remained no diff. with excluding 2 studies

Aortic reoperation & False lumen dilation (6/9)

- RR 3.14 (1.74 – 5.67, p < 0.001)
- Subgroup Hemi-arch vs ER (6/9)
  - RR 3.19 (1.49 – 6.83, p = 0.003)



9

Hemiarch versus total aortic arch replacement in acute type A dissection: a systematic review and meta-analysis

Meta-analysis of observational studies
- Studies = 14
  - *6/9 studies from Yan 2015
- n = 2221

Types of repair
- Hemiarch (HA): replacement of hemiarch
- Total arch (TA): reimplantation of supra-aortic vessels

Most results had no significant heterogeneity ($\chi^2 \leq 0.1$ and $I^2 \geq 50\%$)

10

Hemiarch versus total aortic arch replacement in acute type A dissection: a systematic review and meta-analysis

No difference in neurological deficits, post-op ventilation, re-operation for bleeding

Contradictory findings:

In-hospital mortality
- No difference, RR 0.84 (0.65 – 1.09, p = 0.20)

Postoperative dialysis
- Hemi-arch lower, RR 0.72 (0.56 – 0.94, p = 0.02)

Longterm aortic re-intervention and freedom from reoperation, proximal or distal
- No difference, RR 1.45 (0.93 – 2.28, p = 0.10)

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Ascending aorta replacement vs. total aortic arch replacement in the treatment of acute type A dissection: a meta-analysis

Meta-analysis of observational studies
- Studies = 15
  - *8/9 studies from Yan 2015
  - *12/14 from Poon 2016
- n = 2822

Types of repair
- Ascending/Hemiarch/Partial arch (AR)
- Total arch (TR) with possible elephant trunk

Most results had no significant heterogeneity ($\chi^2 \leq 0.1$ and $I^2 \geq 50\%$)

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Ascending aorta replacement *vs.* total aortic arch replacement in the treatment of acute type A dissection: a meta-analysis

In-hospital mortality

Limited repair lower, RR 0.77 (0.61 – 0.96, p = 0.02)

Postoperative dialysis

RR 0.74 (0.56 – 0.96, p = 0.03)

No difference in 5-year survival

RR 0.73 (0.53 – 1.01, p = 0.06)

No difference in neurological events

No difference in aortic reoperation

RR 1.39 (0.94 – 2.07, p = 0.10)

*Poorly written/translated

Mixed up figures

13

Late outcomes of strategic arch resection in acute type A aortic dissection

Single institution, observational, Univ. Michigan

1997 – 2017

N = 472

Compare Hemiarch vs Aggressive (zone 2/3) arch replacement

Aggressive arch indications

Intimal tear unresectable by hemiarch alone

Arch branch vessel dissection with malperfusion

Aneurysmal arch ≥ 4 cm

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Late outcomes of strategic arch resection in acute type A aortic dissection

Aggressive arch less acute presentation by preoperative variables

Younger, CAD, acute MI, tamponade

Variables	Hemiarch (n = 322)	Aggressive arch (n = 150)	*P* value
Patient age, y	61 (50, 70)	57 (48, 66)	.03
CAD	71 (23)	15 (9)	.0004
Acute myocardial infarction	13 (4)	1 (1)	.045
Tamponade	36 (11)	6 (4)	.01

Aggressive arch fewer roots, more FETs

Longer XC, HCA, more ACP

Variables	Hemiarch (n = 322)	Aggressive arch (n = 150)	*P* value
Root replacement	117 (36)	28 (19)	<.0001
Frozen elephant trunk	11 (3)	18 (12)	.0003
CPB time, min	217.5 (176, 269)	227 (190, 274)	.056
Crossclamp time, min	144 (108, 195)	160 (133, 205)	.002
HCA			
HCA time, min	32 (26, 39)	43.5 (34, 55)	<.0001
ACP or RCP			<.0001
ACP	91 (28)	54 (36)	
RCP	194 (60)	5 (3)	
Both ACP and RCP	32 (10)	91 (61)	
Neither	5 (2)	0 (0)	

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Late outcomes of strategic arch resection in acute type A aortic dissection

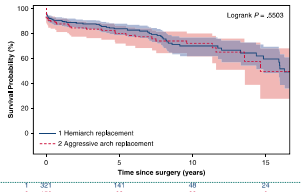
No difference in postoperative complications

including mortality: 5.3 vs 7.3 %, p = 0.38

MVLR: more re-exploration for hemorrhage in aggressive, OR 1.97 (1.001 – 3.87, p = 0.049)

Longterm

Similar survival and re-operation for aortic pathology



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Late outcomes of strategic arch resection in acute type A aortic dissection

Limitations

- Selection bias
- Michigan malperfusion protocol
- Frequency of aggressive arch indications?
- Mean f/u 5.3 y, 75.4 % response
- 3 surgeons for entire study period

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Distal Aortic Progression After Hemiarch, Zones 1-3 Arch Replacement in Acute Type A Aortic Dissection

Single institution, observational, Univ. Michigan

1996 – 2021

N = 756

Compare Hemiarch vs Zone 1 vs Zone 2 vs Zone 3 arch replacement

Same aggressive arch indications

Intimal tear unresectable by hemiarch alone

Arch branch vessel dissection with malperfusion

Aneurysmal arch ≥ 4 cm

18

Distal Aortic Progression After Hemiarch, Zones 1-3 Arch Replacement in Acute Type A Aortic Dissection

No significant difference in age

HAR more CAD than Zone 2 or 3

Zone 1 had more preoperative stroke than HAR

Longer CPB/XC/HCA with more extensive arch surgery

Intraoperative mortality

Variables	Hemiarch (n = 481)	Zone 1 (n = 65)	Zone 2 (n = 140)	Zone 3 (n = 62)	P Value
Intraoperative mortality	5 (1.0)	2 (3.1)	1 (.8)	3 (4.8)[a]	.01
Reoperation for bleeding	32 (6.7)	2 (3.1)	11 (7.4)	10 (16)[a]	.03
Operative mortality[b]	35 (7.3)	8 (12)	8 (5.4)	9 (15)	.07

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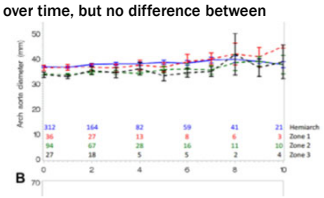
Distal Aortic Progression After Hemiarch, Zones 1-3 Arch Replacement in Acute Type A Aortic Dissection

Mean f/u for imaging 4.6 ± 4.6 y

All groups had significant growth over time, but no difference between groups



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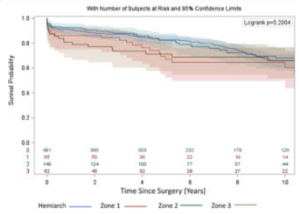
Distal Aortic Progression After Hemiarch, Zones 1-3 Arch Replacement in Acute Type A Aortic Dissection

Mean f/u for survival 7.1 ± 5.7 y

- No difference between groups
- 60-68% at 10 y



Re-operation: 13 %

- No difference between groups
- Thoracotomy 53 %
- TEVAR 34 %
- Redo sternotomy 12 %

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A tailored strategy for repair of acute type A aortic dissection

Single institution, observational, Cornell
1997 – 2019
N = 343

Compare conservative (hemiarch/root-preserving) vs extensive (root or arch replacement, or both)

Treatment philosophy: optimize survival at index surgery

Aggressive arch indications
- Total arch with island reimplantation for arch tear or aneurysm
- Total arch with branched graft for CTD or displaced great vessels

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A tailored strategy for repair of acute type A aortic dissection

Conservative group higher risk, n = 298
- age 67 vs 60, p < 0.01
- More HTN, previous MI, renal dysfunction; less CTD

Extensive group, arch = 45

Preoperative variable	Arch management: Hemiarch (n = 298)	Arch management: Total arch (n = 45)	P value
Previous MI	58 (19.6)	0 (0)	.003
Connective tissue disease	12 (4.0)	6 (13.3)	.024
Degree of preoperative AI			
Mild	69 (24.1)	17 (38.6)	.04
Moderate	124 (43.4)	17 (38.6)	.63
Severe	93 (32.5)	10 (22.7)	.22

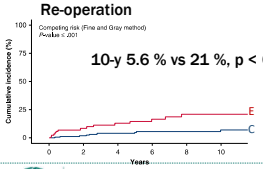
zone 2 island: 17 zone 2 debranched: 8
zone 3 island: 10 zone 3 classic elephant: 10

23

A tailored strategy for repair of acute type A aortic dissection

No difference in postoperative outcomes
- Operative mortality (arch) 6.4 vs 0 %, p = 0.16
- 10-y survival (root & arch extensive) 63.2 vs 66.2 %, p = 0.55

Re-operation



10-y 5.6 % vs 21 %, p < 0.01

Extensive was predictor of re-operation by MV regression
- HR 3.05 (1.29 – 7.2, p = 0.01)

92.6 % of re-op were distal aorta

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A tailored strategy for repair of acute type A aortic dissection

Limitations

- Selection bias
- Aortic surgery group
- Confirmation of protocol rather than specific technique for all Type A

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Summary

4. In patients with acute type A aortic dissection without an intimal tear in the arch or a significant arch aneurysm, hemiarch repair is recommended over more extensive arch replacement.[16-18]

Meta-analyses: Total arch replacement trade-offs

- Higher early complications
- Lower aortic re-operation or false lumen dilation
- Similar longterm survival

Recent high-volume, longitudinal, single-institution publications

- Effective patient-specific protocols result in similar longterm outcomes
- Question of generalizability

26

Simplifying aortic arch surgery: open zone 2 arch with single branched thoracic endovascular aortic repair completion

Single institution, case series

N = 5 acute type A

Aortic tear in either aortic arch or proximal descending aorta

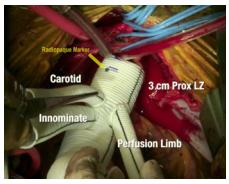
Combined zone 2 aortic arch replacement + zone 2 subclavian branch endograft

Compassionate Use because outside indications of Early Feasibility Study

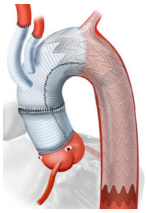
27

Simplifying aortic arch surgery: open zone 2 arch with single branched thoracic endovascular aortic repair completion

Vascutek Gelweave



Gore TBE



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Simplifying aortic arch surgery: open zone 2 arch with single branched thoracic endovascular aortic repair completion

ACP 49 ± 9 min
CPB 254 ± 28 min

Staged repair, median 19 d
One proximal extension cuff

No perioperative death, stroke, SCI
No antegrade flow in false lumen intra-op
All had false lumen thrombosis in stented portion and continued flow in distal portion from distal re-entry tears

Table 1 Patient characteristics

Characteristics	Zone 2 acute dissection
N	5
Sex (male)	5 (100%)
Age (mean ± SD)	55.6±6.1
Hypertension	5 (100%)
Diabetes	1 (20%)
Smoking Hx	2 (40%)
Family Hx cardiac disease	2 (40%)
COPD	1 (20%)
Chronic renal insufficiency	0 (0%)
Stroke history	2 (40%)
Prior ascending dissection repair	0 (0%)

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Conclusion

Patient-specific resection & reconstruction results in similar outcomes
Evidence does not support prophylactic extensive arch surgery
Optimism regarding emerging technology and longterm treatment of aortopathy

30

Options for Aortic Root replacement and reconstruction

NILTO DE OLIVEIRA MD
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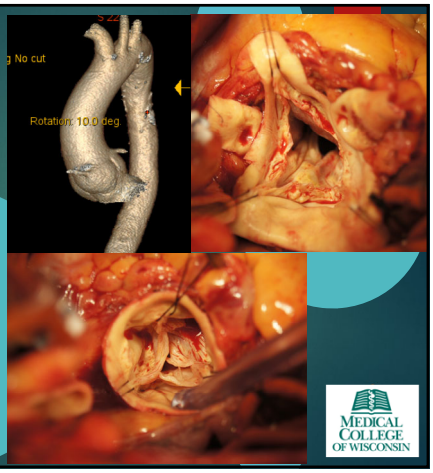
1

Bio-Bentall

2

Biological Bentall

- 77 years old male, severe aortic regurgitation, 5.2 cm aortic root
- Trileaflet aortic valve
- Preserved EF, non obstructive CAD
- Taken to OR for aortic root replacement with a size 27 biological conduit



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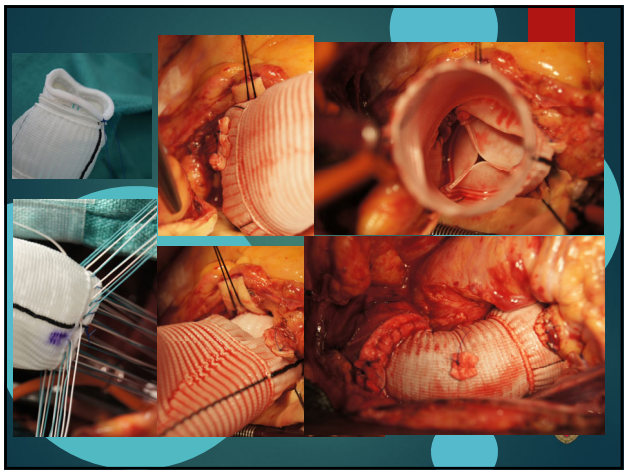

4


Porcine Root
Free style
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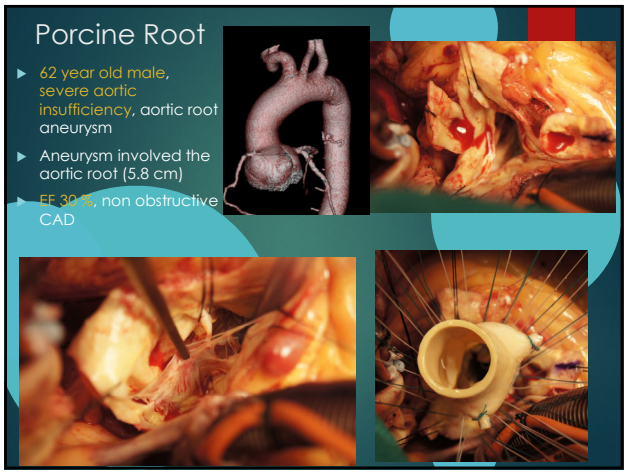
Porcine Root
62 year old male, severe aortic insufficiency, aortic root aneurysm
Aneurysm involved the aortic root (5.8 cm)
EF 30 %, non obstructive CAD

6

Left main on the non coronary sinus


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7

Valve Sparing Root Replacement: David Procedure

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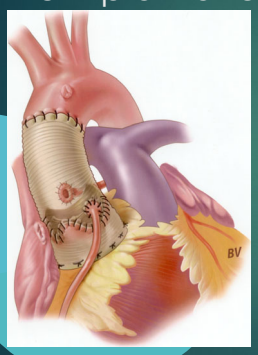
8

David Procedure – Reimplantation technique



Tirone David MD

University of Toronto

Canada

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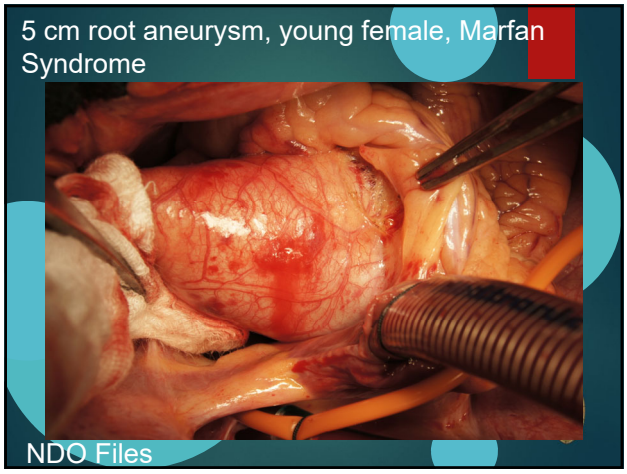
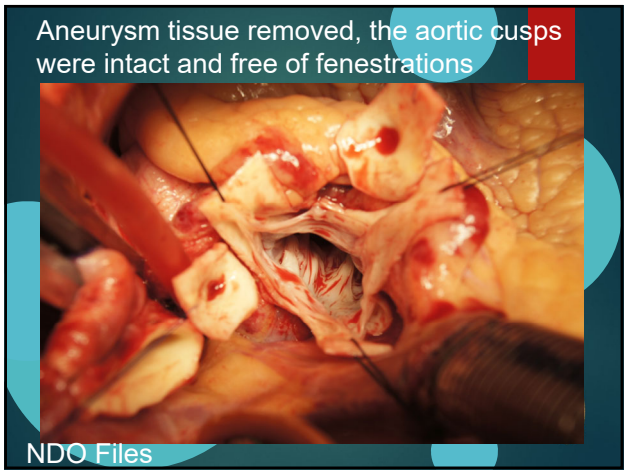
JTCVS
Log in
SURGERY FOR ACQUIRED CARDIOVASCULAR DISEASE | VOLUME 125, ISSUE 4,
P789-796, APRIL 01, 2003
PDF [101 KB]
Results of surgery for aortic root aneurysm in patients with Marfan syndrome
Nilto Carias de Oliveira, MD • Tirone E. David, MD • Joan Ivanov, PhD • ... Maria J. Eriksson, MD • Harry Rakowski, MD • Gary Webb, MD • Show all authors
DOI: https://doi.org/10.1067/mtc.2003.57
Abstract
Patients and methods
Results
Discussion
Limitations of the study
Conclusions
Abstract
Objectives: This study was undertaken to examine the long-term results of surgery for aortic root aneurysm in patients with Marfan syndrome. Methods: Forty-four patients underwent aortic root replacement and 61 underwent aortic valve-sparing operations for aortic root aneurysm. Patients who underwent aortic root replacement had more severe symptoms, worse left ventricular function, more severe aortic insufficiency, and larger
Survival (%)

10

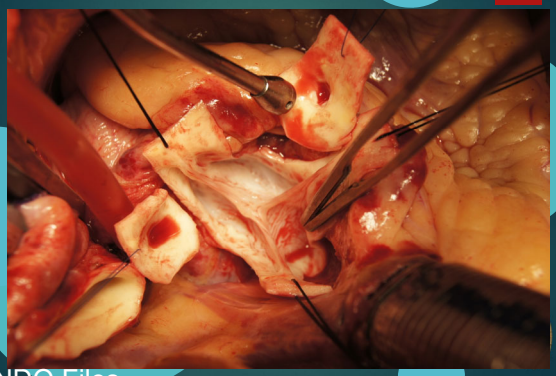

5 cm root aneurysm, young female, Marfan Syndrome
NDO Files

11


Aneurysm tissue removed, the aortic cusps were intact and free of fenestrations
NDO Files

12

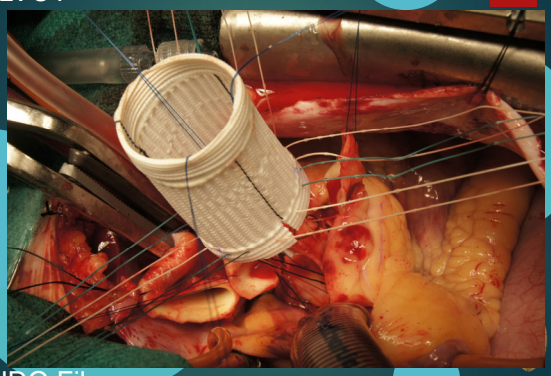
Coronaries detached, note normal and intact aortic valve cusps in the closed position



NDO Files

13

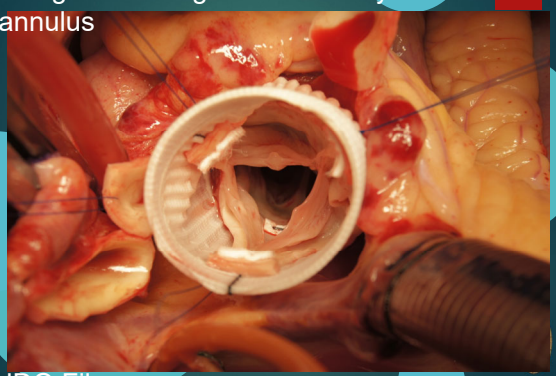
Valsalva graft ready to be brought down to the LVOT



NDO Files

14

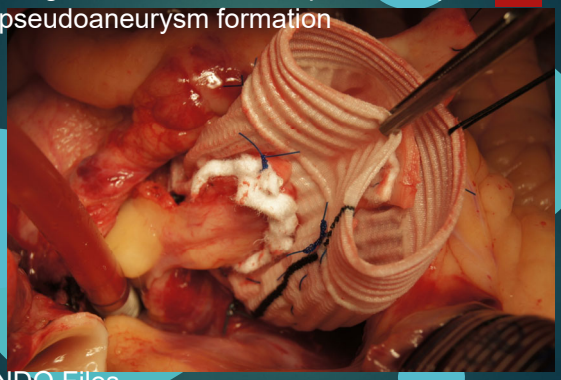
Intact aortic cusps were secured inside a 30 mm graft which goes all the way down to the annulus



NDO Files

15

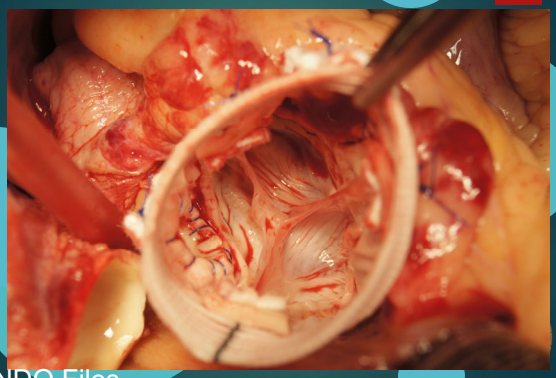
Left main coronary artery button implanted into the graft, I used a fine strip of felt to prevent pseudoaneurysm formation



NDO Files

16

Final result , valve in close position

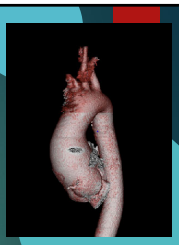


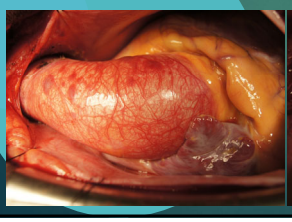
NDO Files

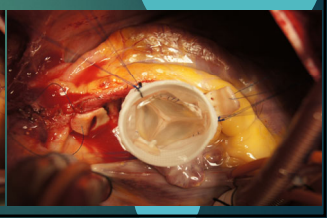
17

Reimplantation technique

- 23 years old female
- Marfan syndrome – 5 cm root



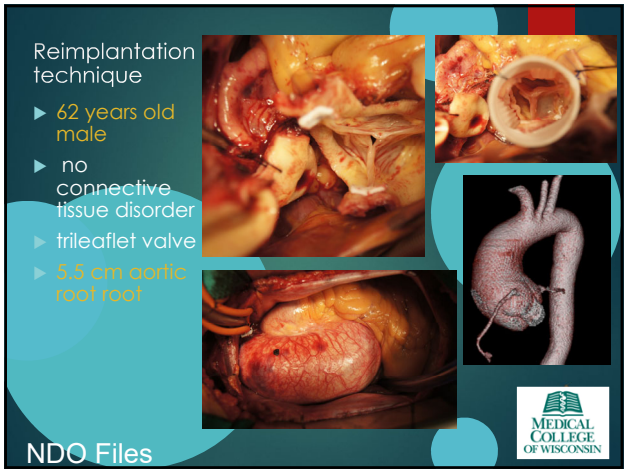




18


Reimplantation technique
55 years old male
Trileaflet aortic valve, 5.7 cm Root

19


Reimplantation technique
62 years old male
no connective tissue disorder
trileaflet valve
5.5 cm aortic root root
NDO Files
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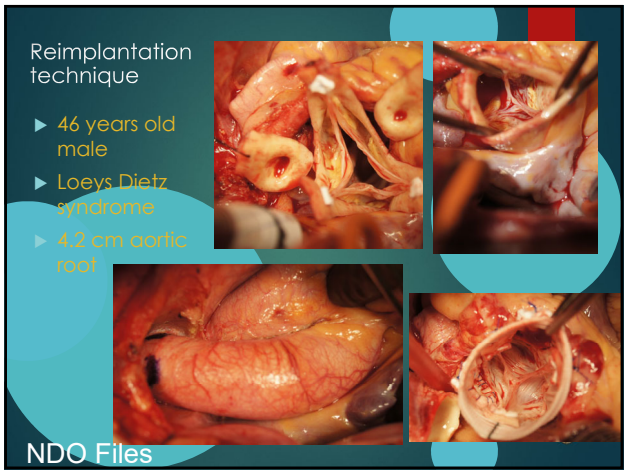

Reimplantation technique
46 years old male
Loeys Dietz syndrome
4.2 cm aortic root
NDO Files

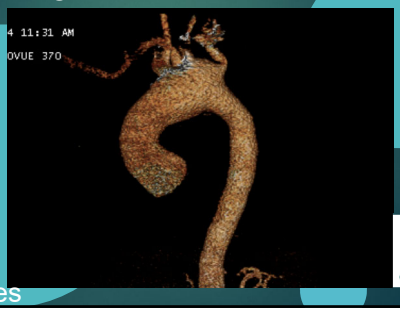
21

Total Arch Replacement and Elephant Trunk and Bentall

22

Loeys – Dietz Syndrome

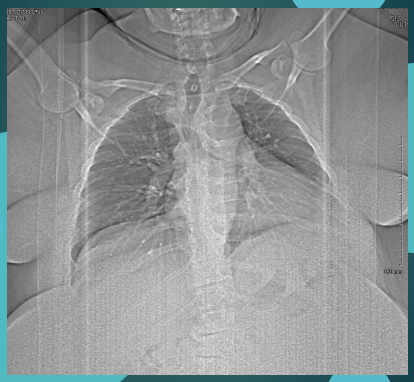
- 46 year old male, morbidly obese
- CT scan documented aneurysm extending from aortic root to distal arch



NDO Files

23

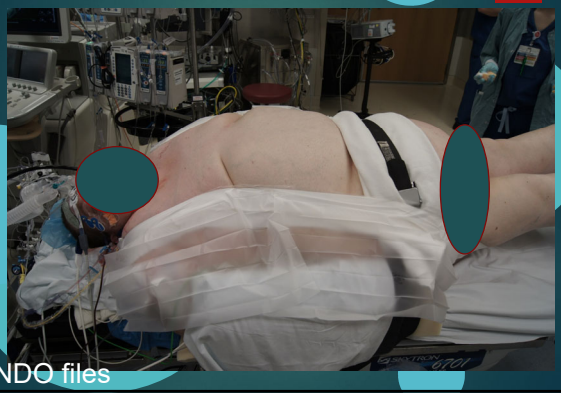
Morbid obesity



NDO files

24

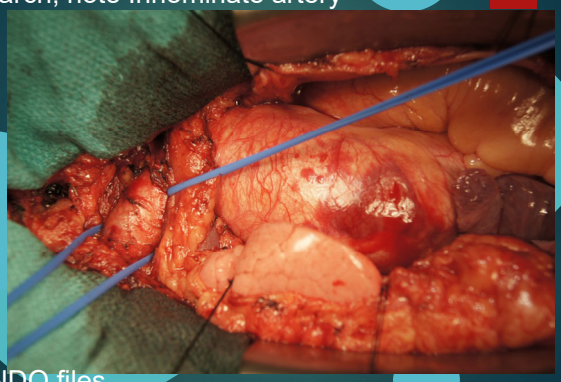
Difficulty in exposure and prepping



NDO files

25

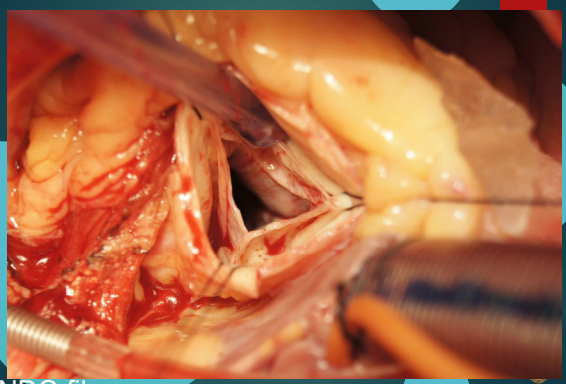
Aortic aneurysm from aortic root up into the arch, note Innominate artery



NDO files

26

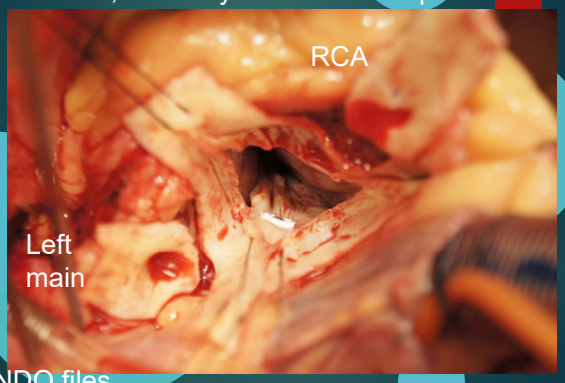
Trileaflet aortic valve, dilated aortic root



NDO files

27

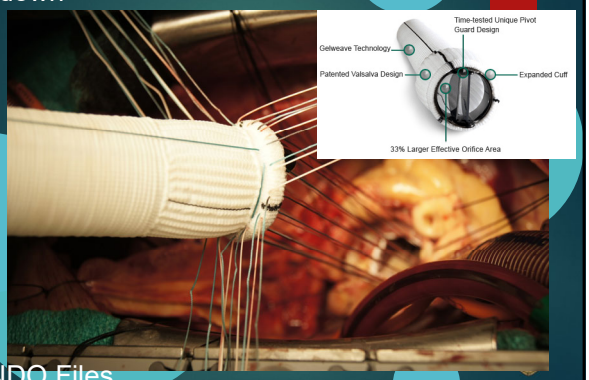
LVOT , clean, aortic valve and aortic tissue removed, coronary buttons developed



NDO files

28

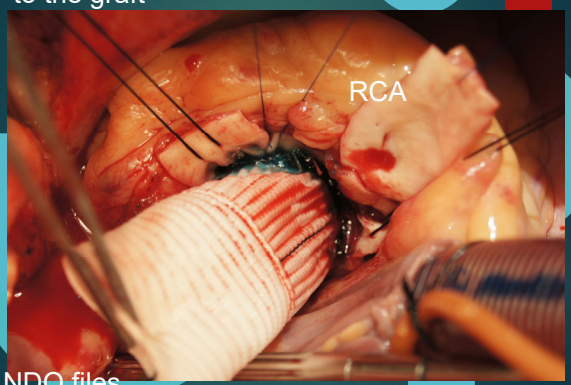
Sutures in place, conduit ready to be taken down



NDO Files

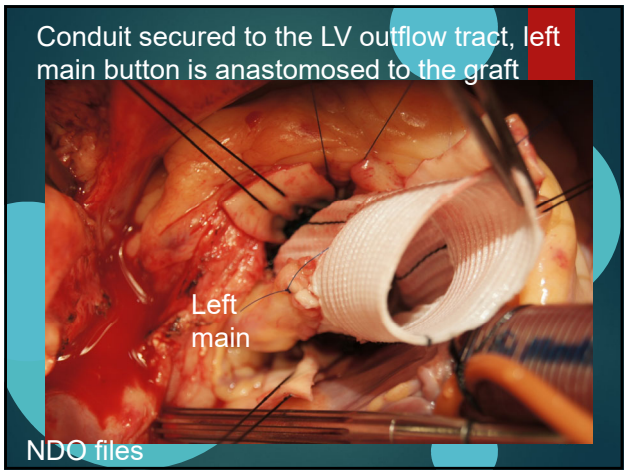
29

Right coronary button ready to be anastomosed to the graft

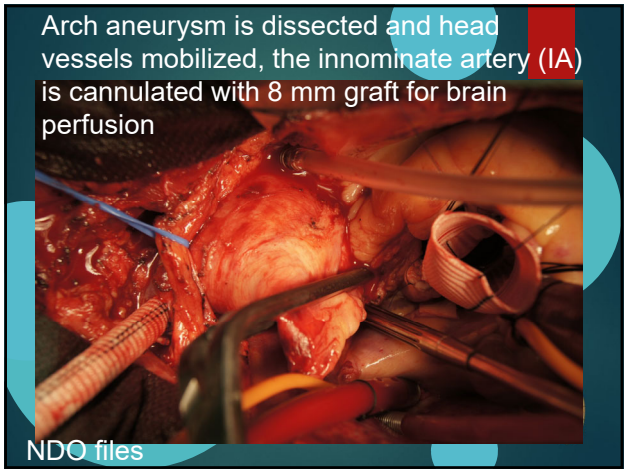


NDO files

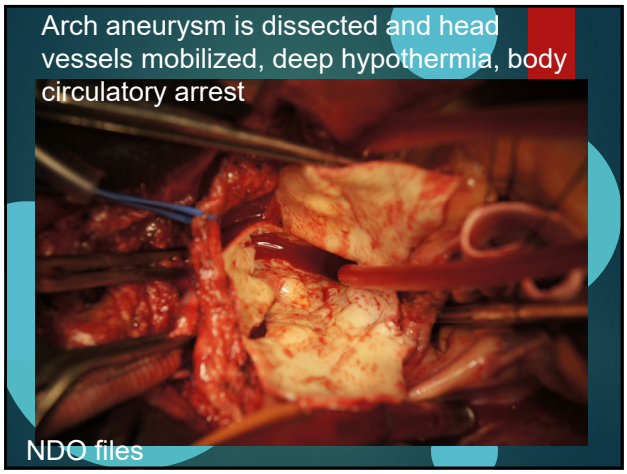
30


Conduit secured to the LV outflow tract, left main button is anastomosed to the graft
Left main
NDO files

31


Arch aneurysm is dissected and head vessels mobilized, the innominate artery (IA) is cannulated with 8 mm graft for brain perfusion
NDO files

32


Arch aneurysm is dissected and head vessels mobilized, deep hypothermia, body circulatory arrest
NDO files

33

Arch aneurysm removed completely, the distal descending aorta can be seen

NDO files

34

Total arch replacement with reimplantation of the innominate artery, left carotid and left subclavian proximally in the ascending aortic graft

NDO files

35

Diagram of the type of reconstruction performed although on the drawing the innominate artery is not completely replaced

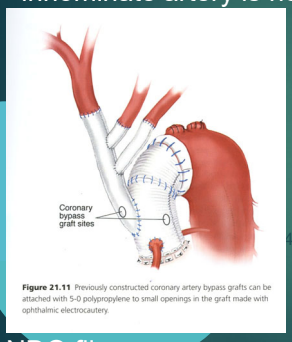
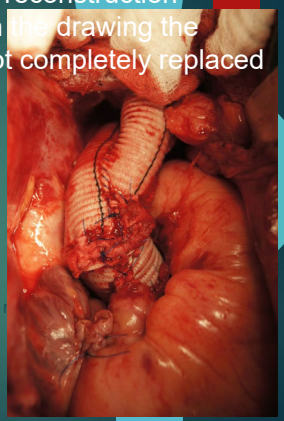


Figure 21.11 Previously constructed coronary artery bypass grafts can be attached with 5-0 polypropylene to small openings in the graft made with ophthalmic electrocautery.



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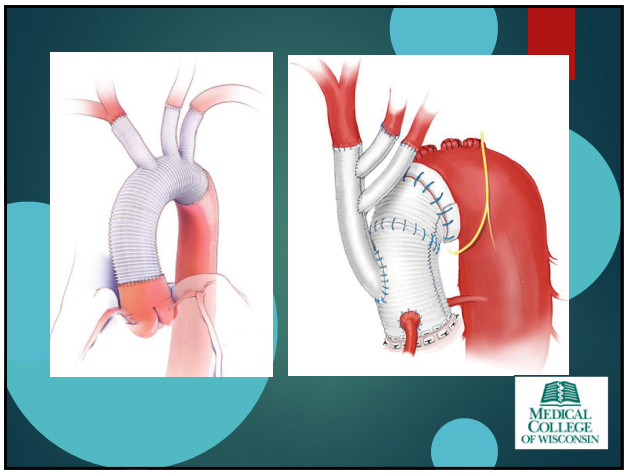
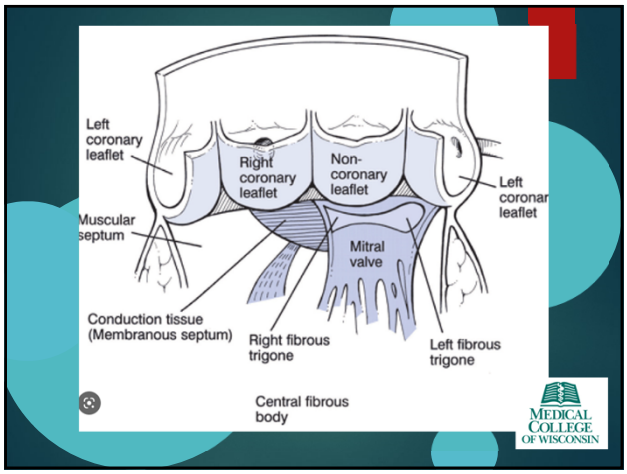


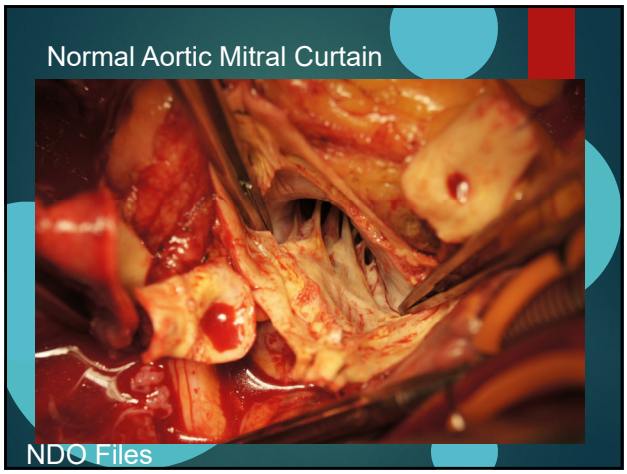
37

Aortic root and Aortic Mitral Curtain Abscess

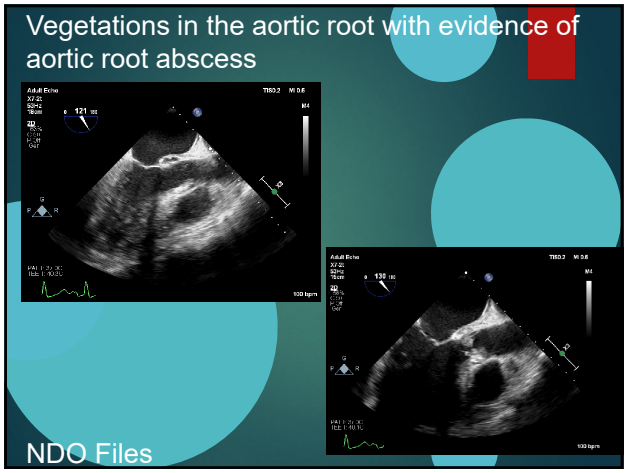
38



39


Normal Aortic Mitral Curtain
NDO Files

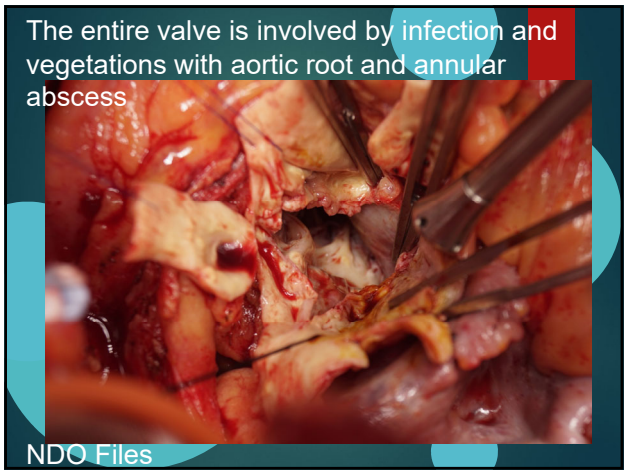
40


Vegetations in the aortic root with evidence of aortic root abscess
NDO Files

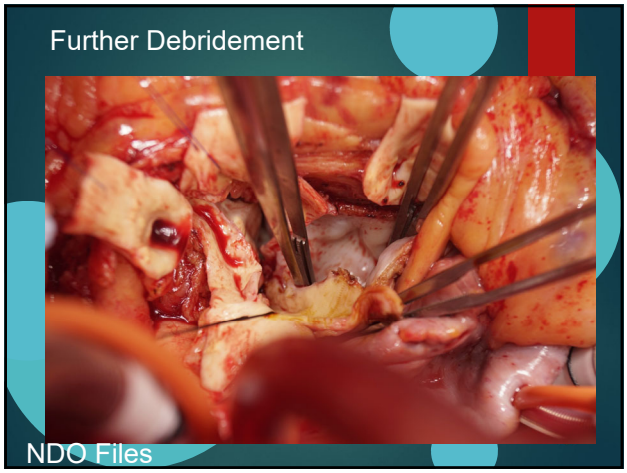
41


Vegetations on the aortic root with aortic root abscess
NDO Files

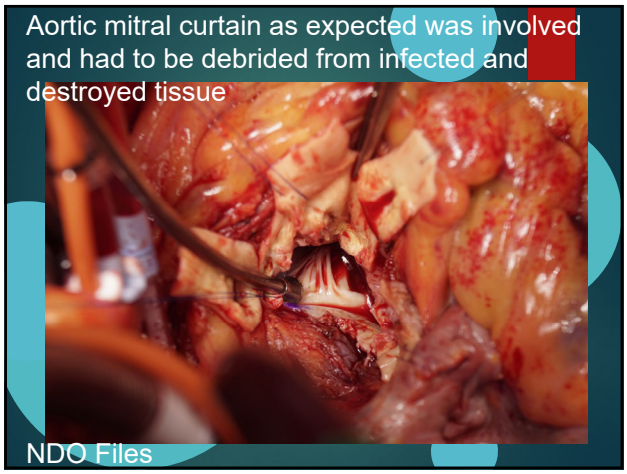
42


The entire valve is involved by infection and vegetations with aortic root and annular abscess
NDO Files

43


Further Debridement
NDO Files

44


Aortic mitral curtain as expected was involved and had to be debrided from infected and destroyed tissue
NDO Files

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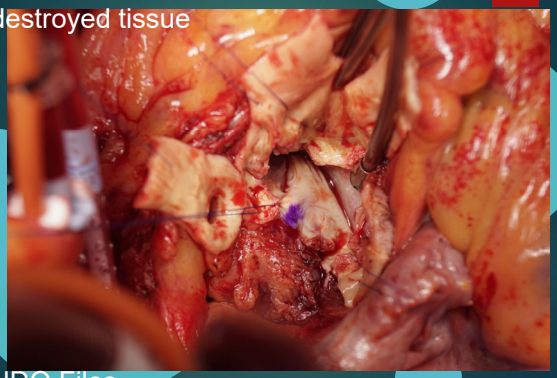
Aortic mitral curtain as expected was involved and had to be debrided from infected and destroyed tissue



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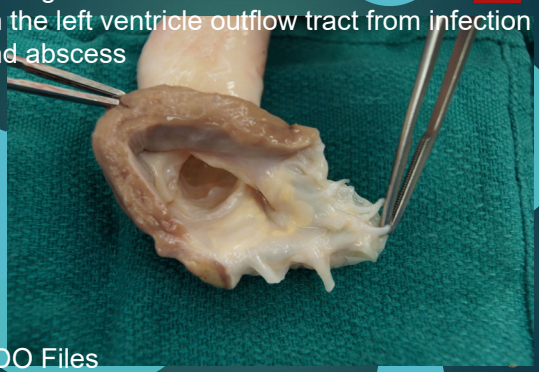
The anterior leaflet of the mitral valve on the homograft will be used to reconstruct the defect on the left ventricle outflow tract from infection and abscess



NDO Files

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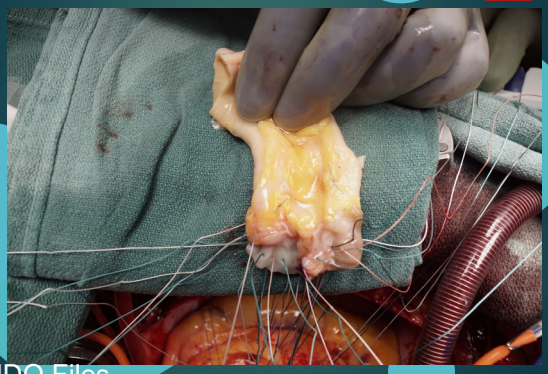
Homograft base secured to the LVOT after radical debridement of the outflow tract



NDO Files

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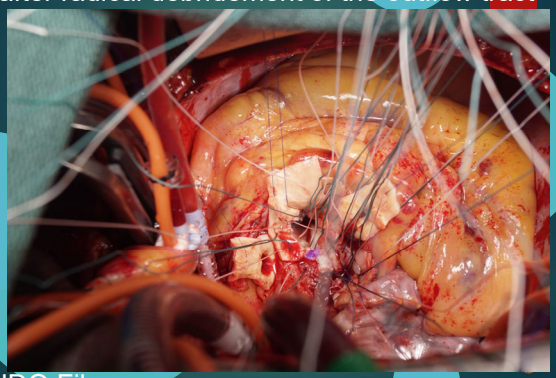
Homograft base secured was in the annulus after radical debridement of the outflow tract



NDO Files

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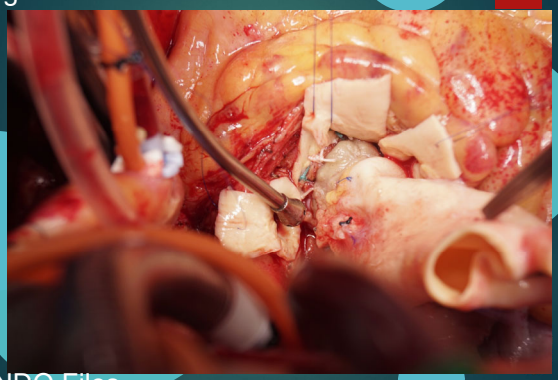
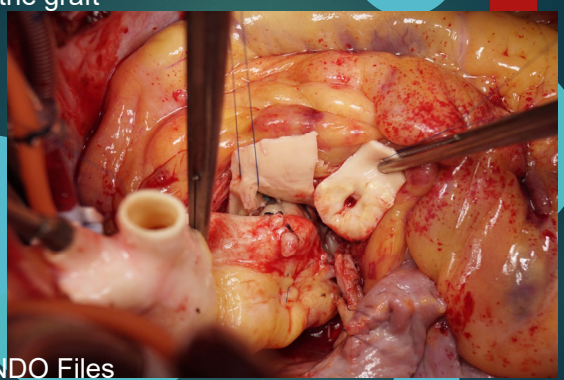
The left coronary button is anastomosed to the graft



NDO Files

50

The right coronary button is anastomosed to the graft



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Final result, homograft in place, off pump, distal anastomosis can be seen

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A few more destroyed LVOT

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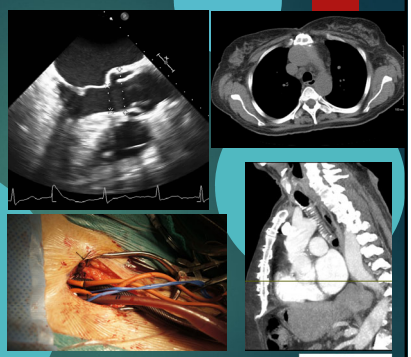
78 year old male, previous Root in 2014

- Recently admitted with progressive illness, severe debilitation, malaise, malnutrition and acute kidney injury with septic arthritis in his shoulder
- ECHO showed aortic root abscess with massive destruction of the left ventricle outflow tract and dehiscence of the root prosthesis



NDO Files

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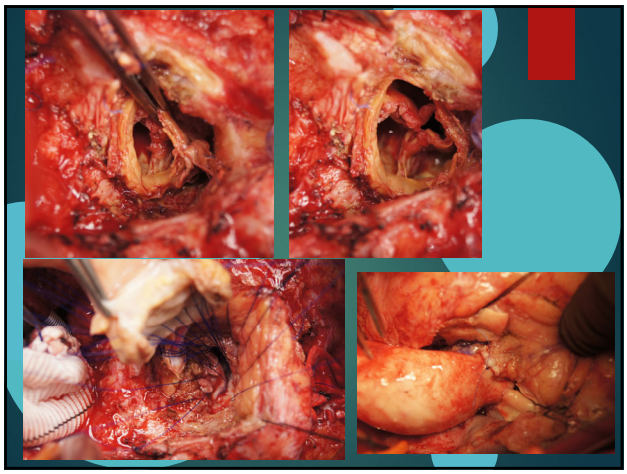

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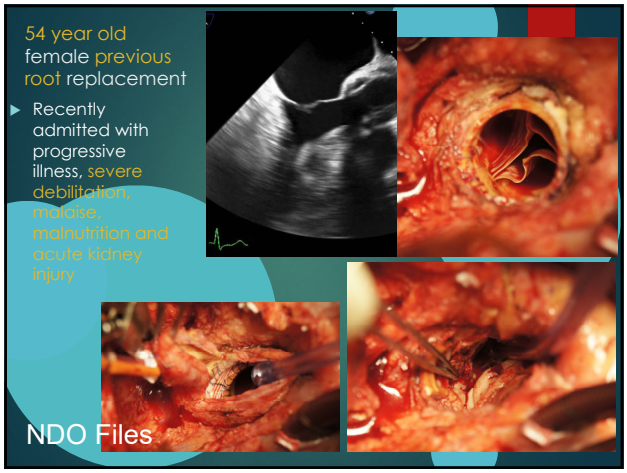
54 year old female previous root replacement
Recently admitted with progressive illness, severe debilitation, malaise, malnutrition and acute kidney injury
NDO Files

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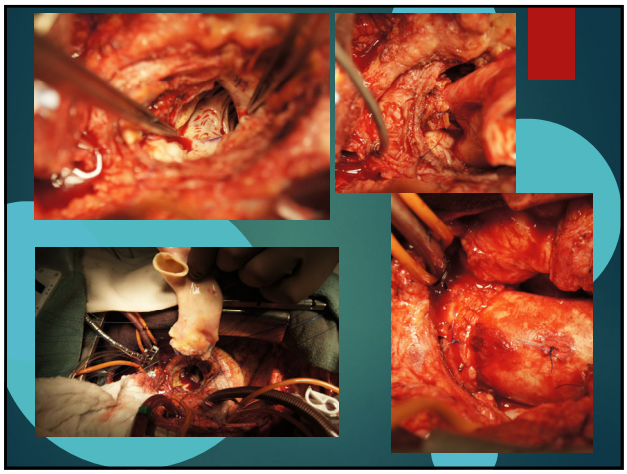
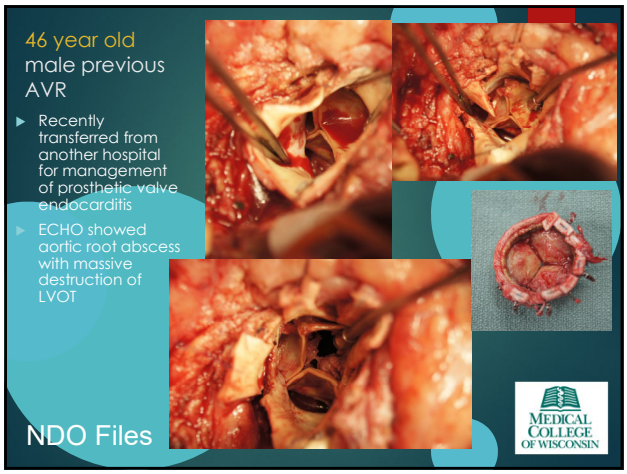


57


46 year old
male previous AVR
Recently transferred from another hospital for management of prosthetic valve endocarditis
ECHO showed aortic root abscess with massive destruction of LVOT
NDO Files
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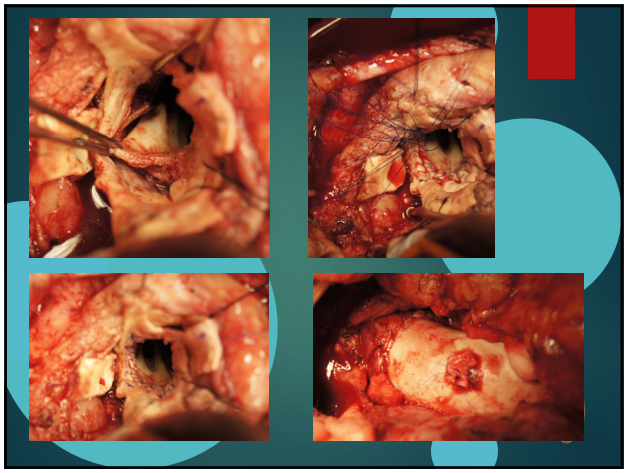
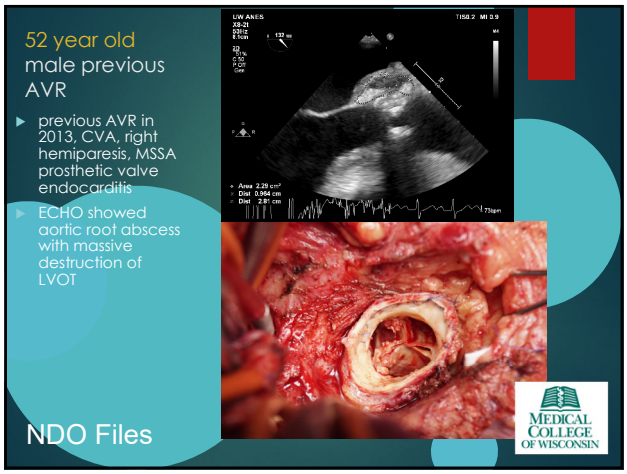


59


52 year old
male previous AVR
previous AVR in 2013, CVA, right hemiparesis, MSSA prosthetic valve endocarditis
ECHO showed aortic root abscess with massive destruction of LVOT
NDO Files
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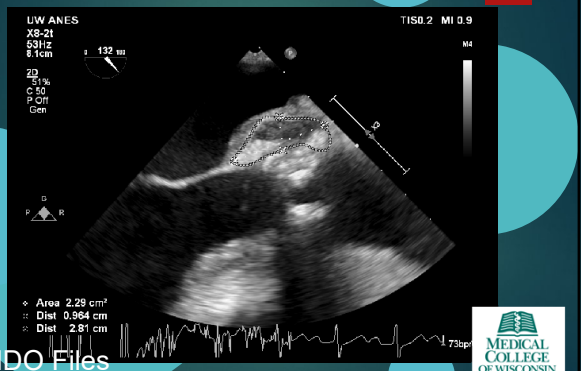
Prosthetic valve IE, aortic mitral curtain involvement with aortic root abscess



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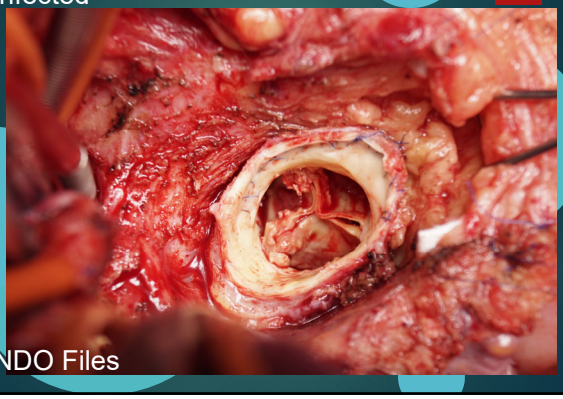
Relatively small STJ, valve degenerated and infected



NDO Files

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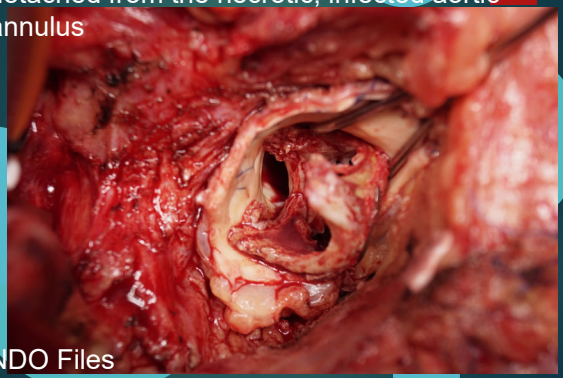
Valve removal was simple, it was easily detached from the necrotic, infected aortic annulus



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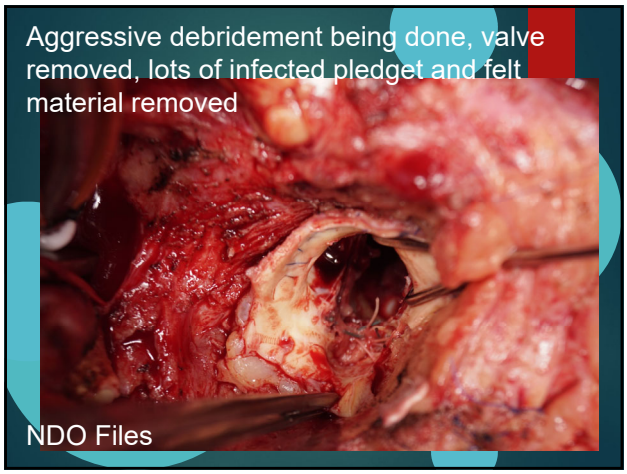
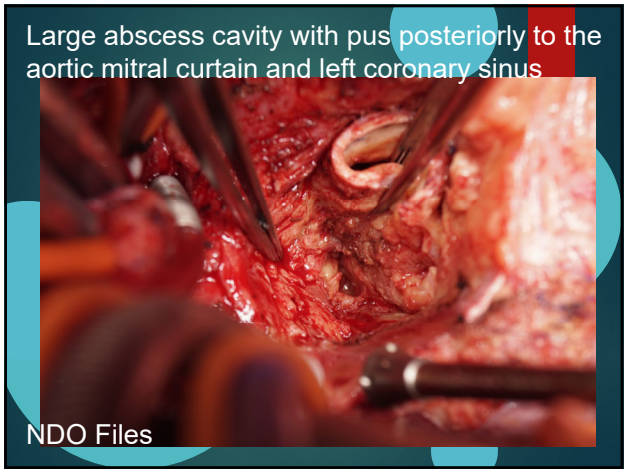
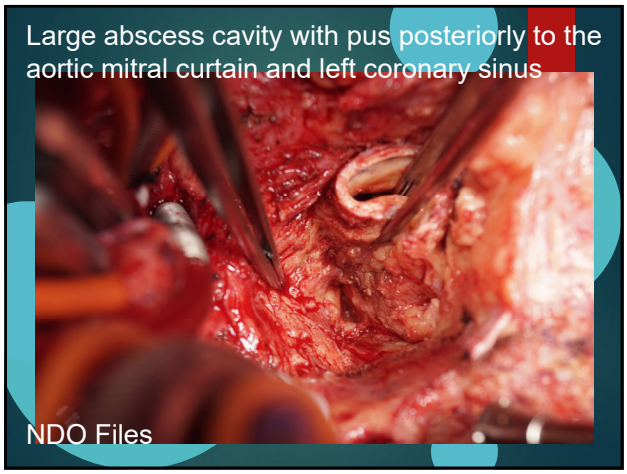

Aggressive debridement being done, valve removed, lots of infected pledget and felt material removed
NDO Files

64

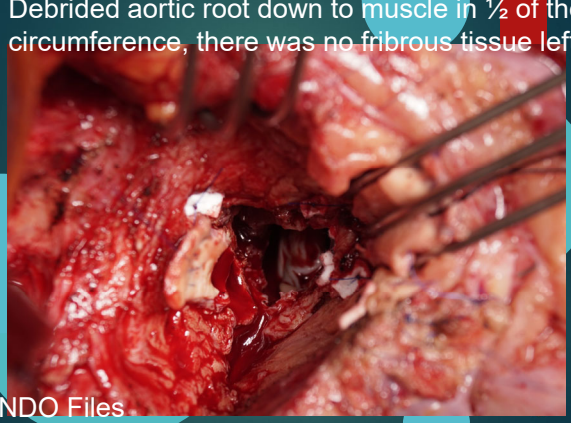

Large abscess cavity with pus posteriorly to the aortic mitral curtain and left coronary sinus
NDO Files

65


Large abscess cavity with pus posteriorly to the aortic mitral curtain and left coronary sinus
NDO Files

66

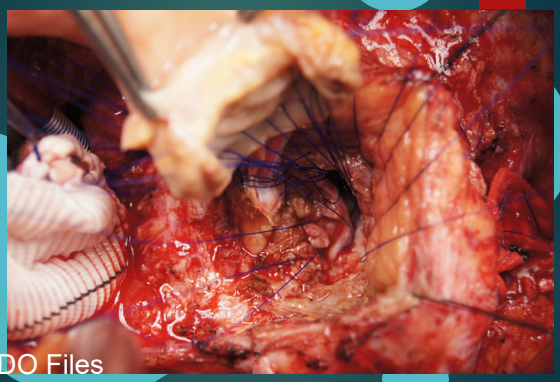
Debrided aortic root down to muscle in ½ of the circumference, there was no fibrous tissue left



NDO Files

67

Homograft base secured was in the annulus after radical debridement of the outflow tract



NDO Files

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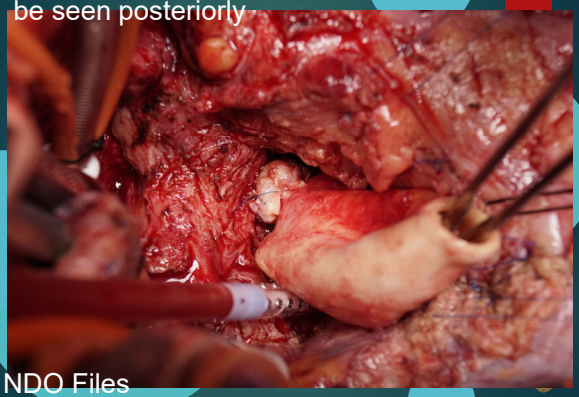
The left main coronary button anastomosis can be seen posteriorly



NDO Files

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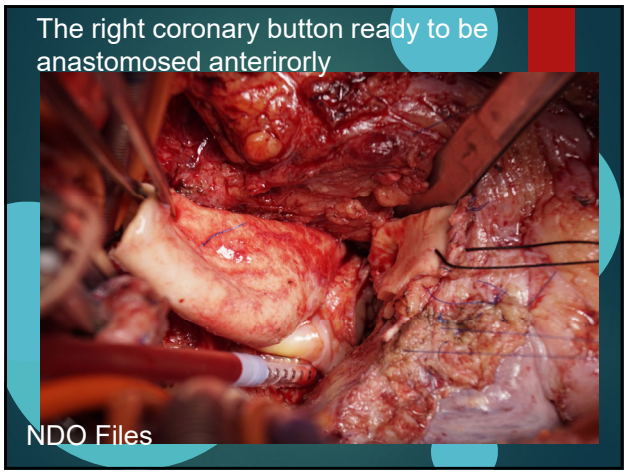
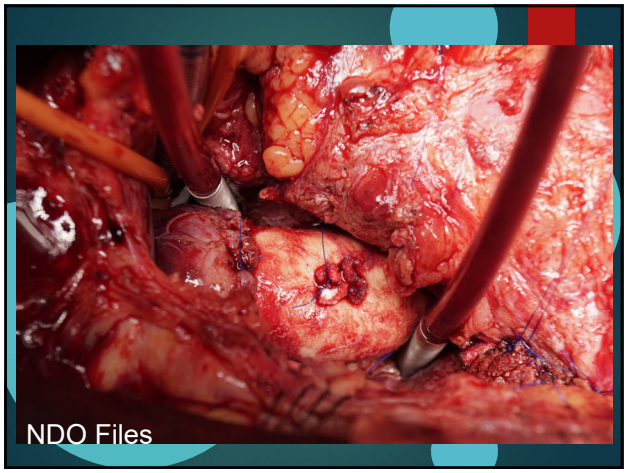

The right coronary button ready to be anastomosed anterirorly
NDO Files

70


NDO Files

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Thank you
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72

Hybrid Approach to Aortic Arch Replacement

Mitchell Dyer, MD, MSc
Assistant Professor of Surgery and Radiology
Division of Vascular and Endovascular Surgery

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1

Disclosures

Nothing to disclose

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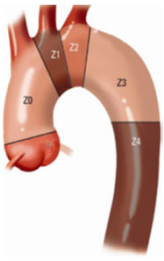
Hybrid Repair-Why?

- Open aortic arch replacement requires cardiopulmonary bypass and hypothermic circulatory arrest
  - Operative mortality 5.3%
  - Permanent neurological deficit 3.4%
- Goals of hybrid approach
  - Decrease perioperative morbidity and mortality
  - Increase eligible patient population for repair of arch disease that would otherwise be a prohibitive operative risk



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Types of Hybrid Aortic Arch Repair

- Type 1
  - Isolated arch disease
  - Normal ascending aorta
  - Avoidance of of cardiopulmonary bypass (CPB) and hypothermic circulatory arrest (HCA)
- Type 2
  - Ascending arch involved in the aortic pathology
  - CPB and HCA universally employed
- Type 3
  - Ascending arch into thoracic/thoracoabdominal aorta pathology
  - "Mega Aorta Syndrome"
  - CPH and HCA

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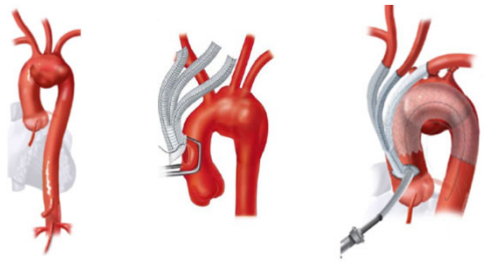
Type 1 Hybrid Arch Repair



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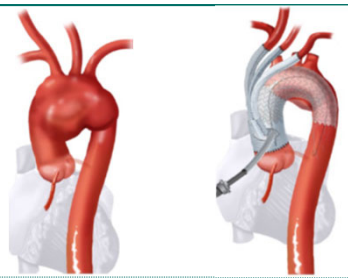
Type 2 Hybrid Arch Repair



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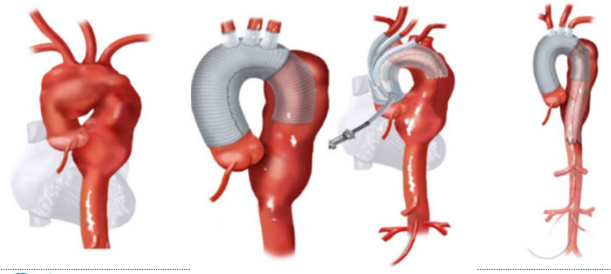
Type 3 Hybrid Arch Repair



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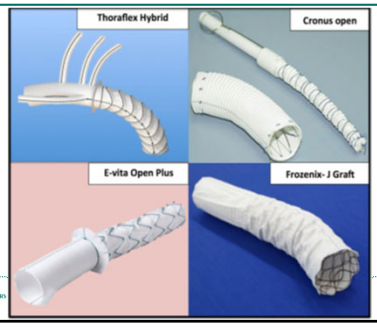
7

Frozen Elephant Trunk Grafts



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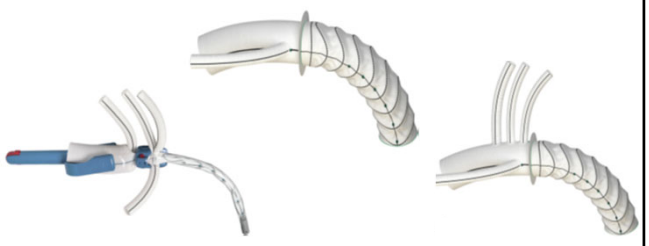
Frozen Elephant Trunk-Prefabricated

Thoraflex-Terumo Aortic



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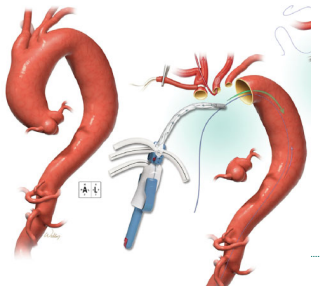
Thoraflex-Deployment



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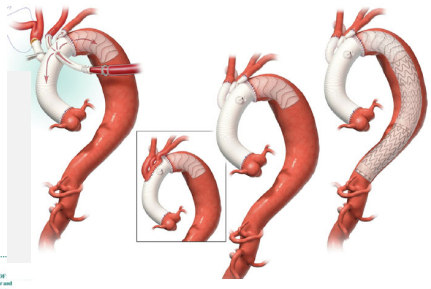
Thoraflex-Deployment



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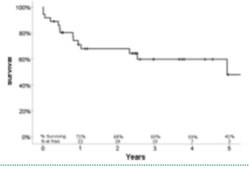
Outcomes of Hybrid Repair

Hybrid approaches in the treatment of aortic arch aneurysms: Postoperative and midterm outcomes

Joseph Bavaria, MD Prashanth Vallabhajosyula, MD, MS, Patrick Moeller, BS, Wilson Szeto, MD, Nimesh Desai, MD, PhD, and Alberto Pochettino, MD
J Thorac Cardiovasc Surg. 2013. PMID: 23260461

- Single-center review, 2005-2013, 104 patients
- 36 patients with Type 1 and 2 analyzed
- ~70 yo, 40% prior CVA, 40% chronic lung disease, 17% CKD
- In-hospital mortality 8%
- Perioperative stroke 8%
- Paraplegia 5.5%



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Outcomes of Hybrid Repair

A systematic review and meta-analysis of hybrid aortic arch replacement

Konstantinos G. Moulakakis[1,2], Spyridon N. Mylonas[1], Fotis Markatis[1], Thomas Kotsis[1], John Kakisis[1], Christos D. Liapis[1]

Ann Cardiothorac Surg. 2013. PMID: 23977592

- In-hospital mortality: 11.9% and 9.5%
- Perioperative stroke: 7%
- Paraplegia: 3.6% and 5%

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Thoraflex: US Experience

Total aortic arch replacement using a frozen elephant trunk device: Results of a 1-year US multicenter trial

Joseph S. Coselli, MD,[a] Eric E. Roselli, MD,[b] Ourania Preventza, MD,[a] S. Chris Malaisrie, MD,[c] Allan Stewart, MD,[d] Paul Stelzer, MD,[e] Hiroo Takayama, MD,[f] Edward P. Chen, MD,[g] Anthony L. Estrera, MD,[h] Thomas G. Gleason, MD,[i] Michael P. Fischbein, MD,[j] Leonard N. Girardi, MD,[k] Himanshu J. Patel, MD,[l] Joseph E. Bavaria, MD,[m] and Scott A. LeMaire, MD[a]

J Thorac Cardiovasc Surg 2022 Sep 6;S0022-5223(22)00921-7. PMID: 36253292

- Prospective, single-arm, multi-institutional trial
- 12 US sites, 65 patients in elective group, 9 in rupture group
- Primary endpoint: Freedom from major adverse event (MAE) defined as permanent stroke

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Thoraflex: Demographics

TABLE 1. Preoperative characteristics of Thoraflex Hybrid study patients (N = 74) stratified according to study group

Variable	Primary group (n = 65)	Aortic rupture group (n = 9)
Age at consent, y	68 (56-74)	70 (49-75)
Male sex	43 (66)	7 (78)
Ethnicity		
Hispanic or Latino	5 (8)	2 (22)
Not Hispanic or Latino	57 (88)	7 (78)
Not reported or unknown	3 (5)	0
Race		
Asian	6 (9)	0
Black or African American	12 (19)	2 (22)
White	44 (68)	7 (78)
Other	3 (5)	0
Aneurysm only (without dissection)[a]	27 (40)	2 (22)
Aortic dissection	38 (58)	7 (78)
Acute/subacute dissection	1 (2)	6 (67)
Chronic dissection	37 (57)	1 (11)
DeBakey type I	33 (51)	7 (78)
DeBakey type III	5 (8)	0

- Redo sternotomy in 48% and 33%
- 74% and 89% utilized the branched Plexus
- Distal anastomosis
  - 50/50 between the L CCA and L SCA or distal to L SCA
- 195 and 200 minutes CPB time
- 52 and 44 minutes of HCA

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Thoraflex: Acceptable Perioperative Results

TABLE 3. Early outcomes (at discharge or within 30 days) of Thoraflex study patients (N = 74) stratified according to study group

Variable	Primary group (n = 65)	Aortic rupture group (n = 9)
Patients with at least 1 MAE	10 (15)	3 (33)
All-cause mortality	2 (3)	1 (11)
Aortic disease-related mortality	1 (2)	0
Persistent stroke	4 (6)	2 (22)
Persistent paraplegia/paraparesis (n = 64)‡	3 (5)*	1 (11)‡
Unanticipated aortic-related reoperation	2 (3)	0
Myocardial infarction	0	0
Respiratory failure§	15 (23)	1 (11)
Renal failure‖	7 (11)	1 (11)
Thromboembolic adverse events¶	2 (3)	0
Bowel ischemia	1 (2)	0
Rescue use of cerebrospinal fluid drainage	2 (3)	2 (22)
Failed device patency	0	0
Postoperative lengths of stay, d		
Intensive care unit stay	4.5 (3-6)	4 (3-9.8)
Hospital stay	11 (7.3-17)	9 (8.8-26)

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Thoraflex: Acceptable 1-year outcomes

TABLE 4. One-year outcomes of Thoraflex study patients (N = 70) stratified according to study group

Variable	Primary group (n = 63)*	Aortic rupture group (n = 7)†
Patients with at least 1 MAE	12 (19)	2 (29)
All-cause mortality	7 (11)	1 (14)
Aortic-disease related mortality	3 (5)	0
Permanent stroke	3 (5)	2 (29)
Permanent paraplegia/paraparesis (n = 62)‡	3 (5)‖	0
Unanticipated aortic-related reoperation	3 (5)	0
Myocardial infarction	0	0
Respiratory failure§	15 (24)	2 (29)
Renal failure¶	7 (11)	1 (14)
Thromboembolic adverse events#	2 (3)	1 (14)
Bowel ischemia	2 (3)	0
Failed device patency**	1 (2)	0
Unplanned extension repairs within 1 y††	2 (3)	0

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Open Arch vs. Hybrid Arch

National Outcomes of Elective Hybrid Arch Debranching with Endograft Exclusion versus Total Arch Replacement Procedures: Analysis of the Society of Thoracic Surgeons Adult Cardiac Surgery Database

Tyler Wallen, DO[1] Timothy Carter, MD[2] Andreas Habertheuer, MD[1] Vinay Badhwar, MD[3] Jeffrey P. Jacobs, MD[1] Babatunde Yerokun, MD[4] Amelia Wallace, MS[4] Karianna Milewski, MD, PhD[1] Wilson Y. Szeto, MD[1] Joseph E. Bavaria, MD[1] Prashanth Vallabhajosyula, MD, MS[5]

Aorta (Stamford) 2021 Feb;9(1):21-29. PMID: 34607380

- STS Adult Cardiac Surgery Database queried from July 2014-December 2015
- 884 Total Arch Replacement (TAR) vs. 127 Hybrid

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Open Arch vs. Hybrid Arch: Demographics

Table 1 Baseline characteristics

Variables	Overall ($n = 1,011$)		TAR ($n = 884$)		Hybrid ($n = 127$)		*p*-Value
Demographics:							
Age	63.2 ± 13.2		62.7 ± 13.3		66.7 ± 11.8		**0.001**
Gender (female)	420	41.5%	366	41.4%	54	42.55%	0.811
Dialysis	21	2.1%	15	1.7%	6	4.7%	**0.026**
PVD	364	36.0%	301	34.1%	63	49.6%	**<0.001**
CHF	163	16.1%	151	17.1%	12	9.5%	**0.027**

- 90.6% of operations for aneurysmal disease
- Concomitant cardiac procedures higher in TAR group: 60 vs. 34.6%
- DHCA: 82.7% TAR vs. 49.6% Hybrid

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Hybrid repair associated with increased complications

Table 2 Elective outcomes

Variables	Overall ($n = 1,011$)		TAR ($n = 884$)		Hybrid ($n = 127$)		*p*-Value
30-day/in-hospital mortality	75	7.4%	59	6.7%	16	12.6%	**0.022**
STS major morbidity	356	35.2%	302	34.2%	54	42.5%	0.067
Deep sternal wound injection	6	0.6%	4	0.5%	2	1.6%	0.122
Stroke	80	7.9%	61	6.9%	19	15.0%	**0.002**
Permanent paralysis	25	2.5%	16	1.8%	9	7.1%	**0.002**
Prolonged ventilation	318	31.5%	269	30.4%	49	38.6%	0.067
New renal failure	52	5.1%	41	4.6%	11	8.7%	**0.045**
Cardiac reoperation (bleeding, valve, graft, other cardiac)	72	7.1%	60	66.8%	12	9.5%	0.281
Composite outcomes:							
Mortality and stroke	131	13.0%	101	11.4%	30	23.6%	**<0.001**
Mortality, stroke and paralysis	134	13.3%	102	11.5%	32	25.2%	**<0.001**
Mortality, stroke, paralysis and renal failure (dialysis)	149	14.7%	115	13.0%	34	26.8%	**<0.001**

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Hybrid Repair Independently associated with mortality

Table 4 Multivariable odds ratios for mortality

Variables	Odds ratio	95% CI	*p*-Value
Hybrid arch versus TAR	1.91	1.01–3.61	**0.046**
Dissection/IMH/PAU versus aneurysm	0.95	0.53–1.69	0.865
Age (centered at 75 years)	1.12	1.03–1.22	**0.007**
Age by reoperation	1.02	0.99–1.04	0.166
Creatinine	2.00	1.30–3.09	**0.002**
Ejection fraction	0.95	0.91–0.98	**0.003**
Female by BSA	0.04	0.01–0.20	**<0.001**
Left main disease	0.24	0.05–1.10	0.067
Unstable angina	8.40	2.69–26.20	**<0.001**

- Hybrid repair associated with increased OR (2.3; 1.3-4.9) of stroke
- No difference in reoperation and STS major morbidity

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Conclusions

- Hybrid arch repair represents a potential operation for patients deemed unfit for traditional arch repair
- Evolving techniques and endograft design will be important for advancement of hybrid arch repair
- Prospective trials for comparison between total arch and hybrid arch are need to truly understand the differences and identify patients that will benefit from the hybrid approach
- Role of hybrid repair with advancing endovascular technology: total endovascular arch repair?

22

References

1. Settepani F *et al.* Outcome of open total arch replacement in the modern era. *J Vasc Surg.* 2016;63:537-545
2. Sultan *et al.* Hybrid Techniques for Aortic Arch Aneurysm Repair. *Seminars in Cardiothoracic and Vascular Anesthesia.* 2016; 20(4):327-332.
3. Xydas *et al.* Hybrid repair of aortic arch aneurysms: a comprehensive review. *J Thoac Dis.* 2017;9(Suppl 7):S629-S634
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6. Moulakakis *et al.* A systematic review and meta-analysis of hybrid aortic arch replacement. *Ann Cardiothorac Surg.* 2013;2:247-260
7. Coselli *et al.* Total aortic arch replacement using a frozen elephant trunk device: Results of a 1-year US multicenter trial. *J Thorac Cardiovasc Surg.* 2022; Sep 6;S0022-5223(22)00921-7
8. Wallen *et al.* National Outcomes of Elective Hybrid Arch Debranching with Endograft exclusion versus Total Arch Replacement Procedures: Analysis of the Society of Thoracic Surgeons Adult Cardiac Surgery Database. *Aorta (Stamford).* 2021;9:21-9.

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Endovascular Aortic Arch Solutions

Milwaukee Aortic Symposium
Peter Rossi, MD, FACS, DFSVS
Professor and Chief
Division of Vascular and Endovascular Surgery
21 April 2023

1

Disclosures

- Terumo Aortic – research funding, consultant, national PI (Relay Pro-D)
- Gore Medical – research funding
- Endospan – DSMB
- I WILL be discussing non-IFU device use which I will make clear as we proceed

2

Objectives

- Identify appropriate aortic arch anatomy for on-label endovascular repair
- Understand differences between commercially available devices
- Be able to describe to patients why they are/are not candidates for these devices

3

Scope of the problem

- Aortic dissection: 4.2/100K patient-years in US[1]
  - 30 day mortality 22% for type A, 13% for type B
  - Aneurysmal degeneration is common and lethal
- Elective ascending replacement may have mortality as low as 0.6%[2]
  - Highly selected patients, including isolated ascending
  - Arch is less reported but periop mortality as high as 11%[3]
  - Doesn't usually include redo patients, high-risk, etc
- We are talking about landing in zones 0-2

1. Circulation. 2022;146:1903–1917
2. Cleveland Clinic in-house data
3. Asian Cardiovasc Thorac Ann 2022 Jul;30(6):679-687

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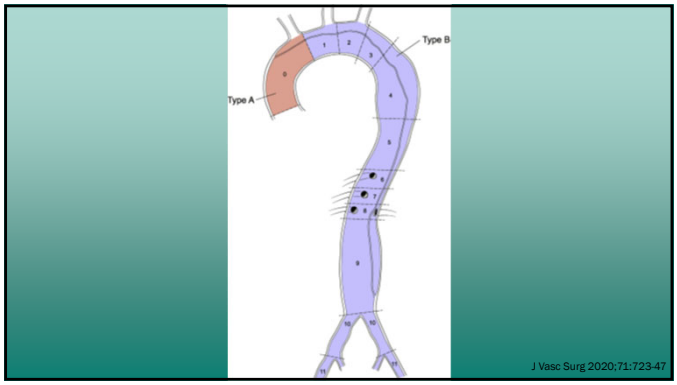

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Open Surgery or Hybrid?

- Discussed by Drs. Mace and Dyer
- Higher morbidity/mortality
  - Nerve injury
  - Stroke
  - Renal failure
  - Paralysis

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Endovascular Considerations

- Maintaining perfusion to upper extremities/head vessels
- Able to deliver femoral sheath access up to 24 French
- Availability of TEE, IVUS are mandatory
- Incidence of retrograde type A dissection
- Extensive aortic coverage – risk of spinal cord ischemia
- Bridge to either open surgery or complex endo reconstruction of visceral segment (PMEG)
- Further discussion: laser fenestration and arch PMEG

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Endovascular Considerations

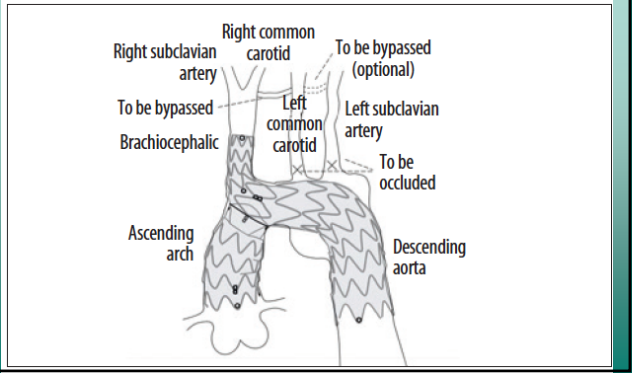
- Anatomy (TBE)
  - Maximum proximal landing zone size 42 mm (still an aneurysm)
  - Maximum diameter of branch 20 mm (up to 18 mm vessel)*
  - Iliacs may need to take up to 26 French sheath
  - 15-20 mm from branch to branch for proximal stent

8

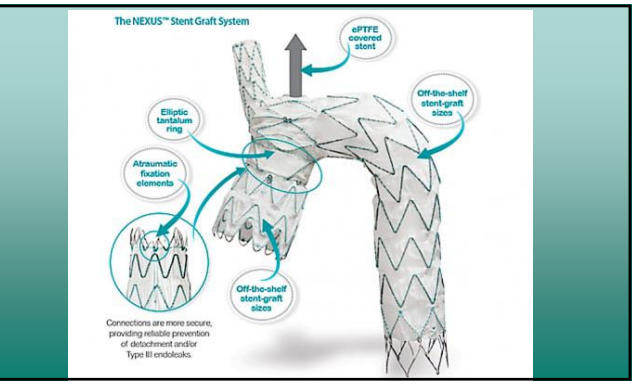
Current US Devices

- Gore Thoracic Branch Endoprosthesis (TBE)
  - Only FDA approved device commercially available
- Nexus Aortic Arch Graft (Endospan)
  - Currently in US trials, less than 25 implanted so far
- Terumo Relay Arch Graft
  - Single and double branch designs
  - Available in parts of Europe and Asia, not US

9


Right subclavian artery
Right common carotid
To be bypassed (optional)
To be bypassed
Brachiocephalic
Left common carotid
Left subclavian artery
To be occluded
Ascending arch
Descending aorta

10


The NEXUS™ Stent Graft System
ePTFE covered stent
Off-the-shelf stent-graft sizes
Elliptic tantalum ring
Atraumatic fixation elements
Off-the-shelf stent-graft sizes
Connections are more secure, providing reliable prevention of detachment and/or Type III endoleaks.

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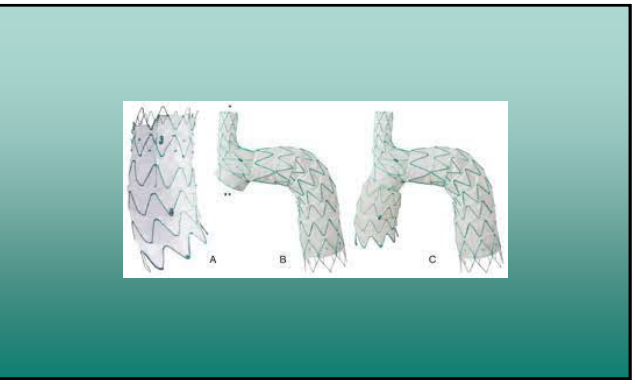
A
B
C

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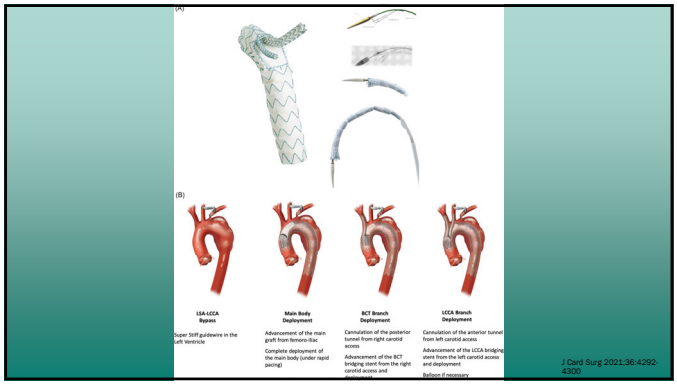

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Gore Thoracic Branch Endoprosthesis (TBE)

- Only FDA approved branched thoracic graft on US market
- Current PMA is for zone 2 landing
- Can use for zone 0 with debranching
- Based on original TAG design, and similar to branched iliac device

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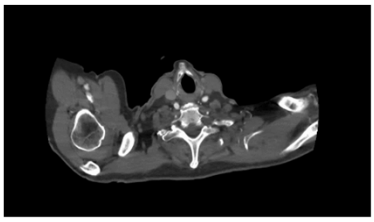
Case – distal arch PAU



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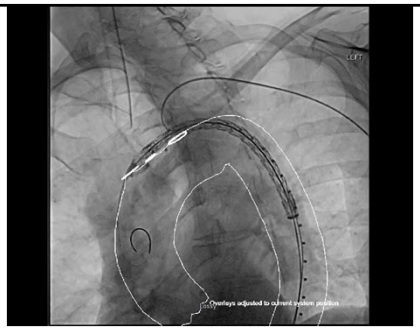

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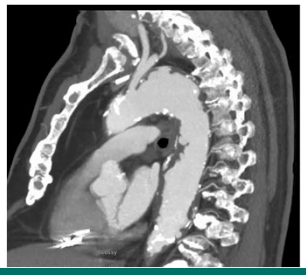
Distal arch aneurysm



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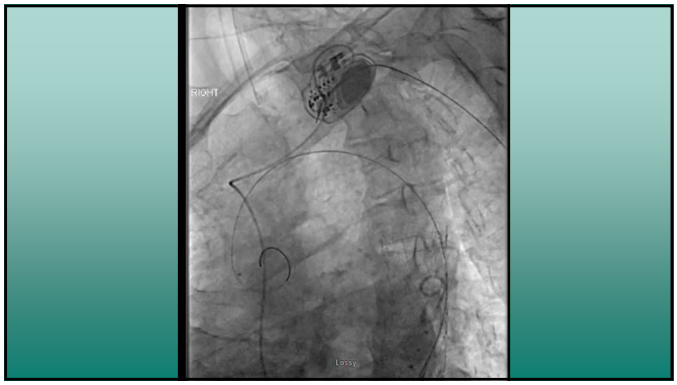

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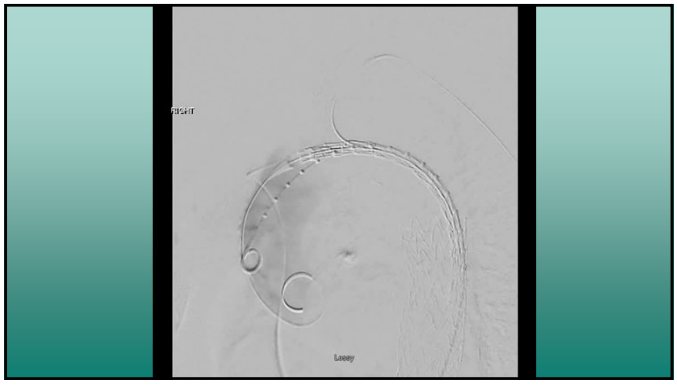

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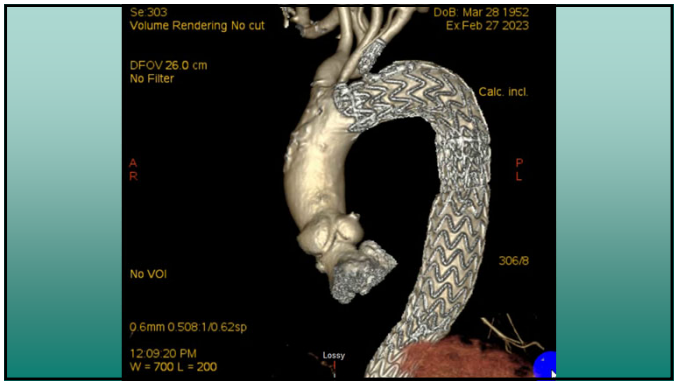

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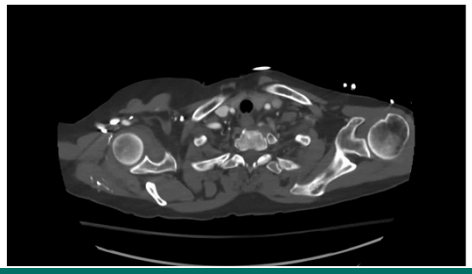
Ruptured Distal Arch Dissection



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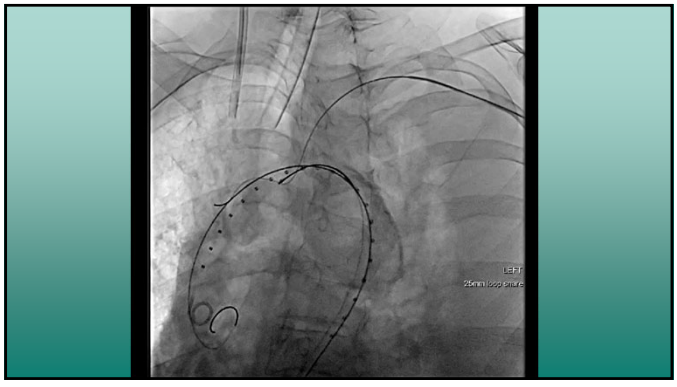

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Endovascular Arch Repair

- Challenges
  - Stroke risk remains high (up to 20%)
  - Delivery profile can be prohibitive
  - Pathology/anatomy – lots of dissections
  - Retrograde dissection with large ascending aorta
  - Still require some degree of debranching
  - Secondary interventions still a question

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Endovascular Arch Repair

- Advantages
  - Avoid redo sternotomy, DHCA
  - Lower risk of spinal ischemia
  - Much less invasive, percutaneous access
  - Short LOS
  - Overall low complication rate
  - Zone 0 landing feasible after RCCA-LCCA-LSCA bypass (off label for TBE but we are doing it)

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Conclusion

- What would YOU want?

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Thank You!

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Milwaukee Aortic Symposium
Aortic Arch Case Presentation

Austin Rogers, MD
Cardiothoracic Surgery Fellow PGY-VI
April 21, 2023

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1

Disclosures

- I have no financial disclosures or conflicts of interest

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2

Presentation

- 44yo F presented to OSH with chest, back, and neck pain. Found to have Type A aortic dissection and transferred to Froedtert
- PMH: HTN, obesity (BMI 36)
- PSH: None
- SH: active smoker
- FH: Non-contributory
- Vitals: 166/77, HR 76, RR 24, SpO2 97%
- Physical Exam: 2+ carotid, radial, femoral, and pedal pulses, no focal neurologic deficits, RRR, no murmur, abdomen soft, NT/ND

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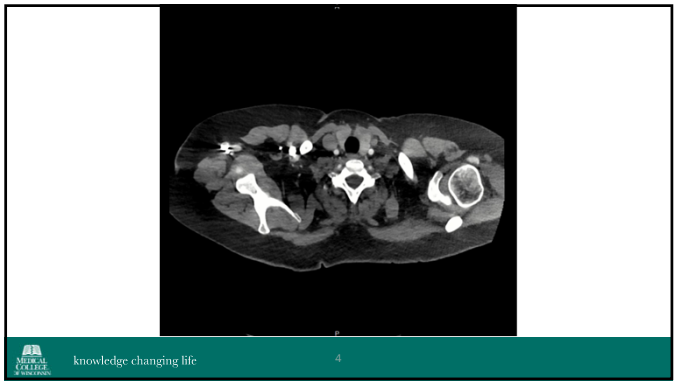
3



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TEE

- Mild aortic insufficiency
- Aneurysmal ascending aorta
- LVEF 60%

5

Index Operation

- R radial and L brachial arterial lines placed
- Cannulation
  - Direct aortic cannulation in true lumen of distal ascending aorta with TEE confirmation
  - 2-stage right atrial venous cannula
  - Retrograde cardioplegia catheter in coronary sinus
  - LV vent in right superior pulmonary vein
  - SVC cannula for retrograde cerebral perfusion
- Cardioplegia
  - Del Nido given retrograde and direct ostial
- Cooled to 18C for DHCA

6

Index Operation

- Primary tear in left lateral aortic arch adjacent to left common carotid ostium and ending at level of left common carotid
  - Non-coronary and right coronary sinuses were dissected but had intact intima
- Zone 2 aortic arch replacement (sparing of left subclavian), replacement of ascending aorta, resuspension of aortic valve
  - Gelweave 10x28 4 branch graft

7

Post-Op Day 4

8

9

Post-Op Course

- Discharged home on POD 8 with home health
- Continue to have left scapular pain radiating across lower back, worse on right side
- In follow-up noted to have degeneration of proximal descending aorta which increased by 9mm in under 6 months due to false lumen enlargement
- R kidney atrophy with R renal artery coming off false lumen

10

2 Months Post-Op

- **Dilation of proximal descending aortic 4.4cm from 3.7cm**
- **R kidney 10.6cm from 11.7**

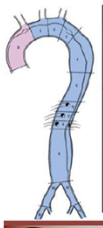
11

Residual Dissection Management

- Pt discussed in Multi-Disciplinary Complex Aortic Conference
- Referred to Vascular Surgery
- Seen in Vascular Surgery clinic 3 months post-op
- Plans made for zone 2 TEVAR with petticoat, L subclavian artery laser fenestration, right renal PTA/stent
- Lumbar drain placed pre-op

12

Society for Vascular Surgery and Society of Thoracic Surgery Reporting Standards for Type B Aortic Dissections



Type	Proximal Extent	Distal Extent
A_D Entry tear: Zone 0	0	0
	1	1
	2	2
	3	3
	4	4
B_{PD} Entry tear: ≥Zone 1	5	5
	6	6
	7	7
	8	8
	9	9
	10	10
I_D Unidentified entry tear involving Zone 0	11	11
	12	12

Anatomic Reporting of Aortic Dissections are based on:
- ✓ Location of Entry Tear (A vs B)
- ✓ Proximal & Distal Extent

EXAMPLES

Type A_9: Entry tear identified in zone 0 (A), Distal extent in zone 9.

Type $B_{4,10}$: Entry tear is identified > zone 0 (B) Proximal extent in zone 4, Distal extent in zone 10.

JVS Journal of Vascular Surgery — Lombardi et al. *J Vasc Surg, March 2020*

@JVascSurg @TheJVascSurg

Journal of Vascular Surgery 2020 71723-747DOI: (10.1016/j.jvs.2019.11.013)

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Vascular Surgery

- Type B (2, 11) aortic dissection, R renal malperfusion, HTN
- TEVAR with Cook Alpha 36 x 161 stent and Cook Zenith Dissection stent ZDEG 40-36 x 160mm
- Left brachial artery cutdown with laser fenestration and 8x 39 VBX stent placement through left subclavian artery
- Stent of abdominal aorta with Cook ZDES 36 x 180 dissection stent (Petticoat)
- Bare metal self-expanding 10 x 40mm Absolute pro stent graft into right renal artery through interstices of Cook dissection graft

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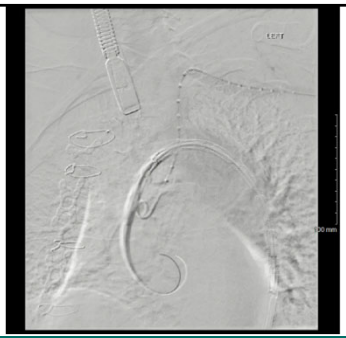

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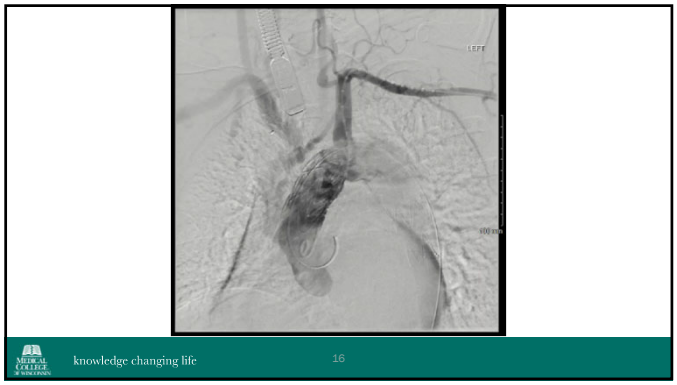
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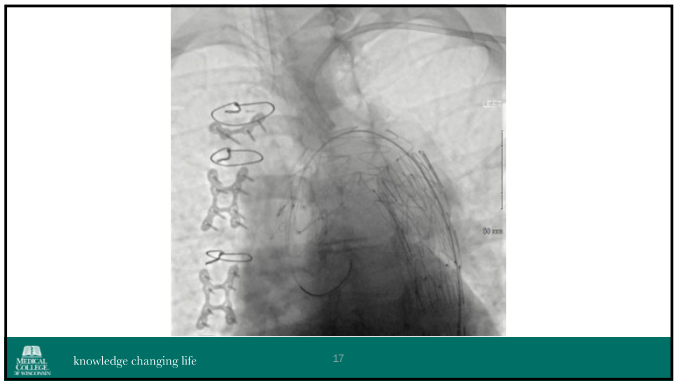
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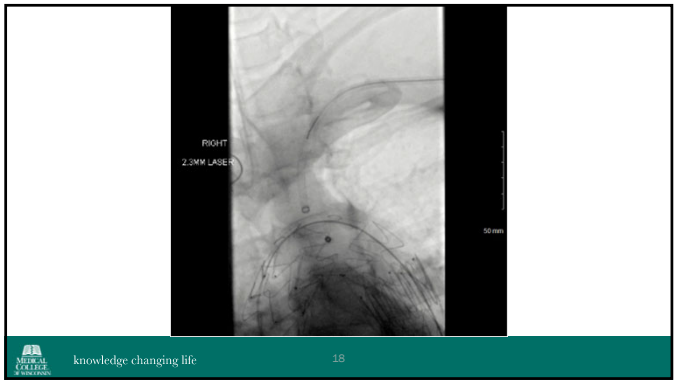
RIGHT
2.3MM LASER
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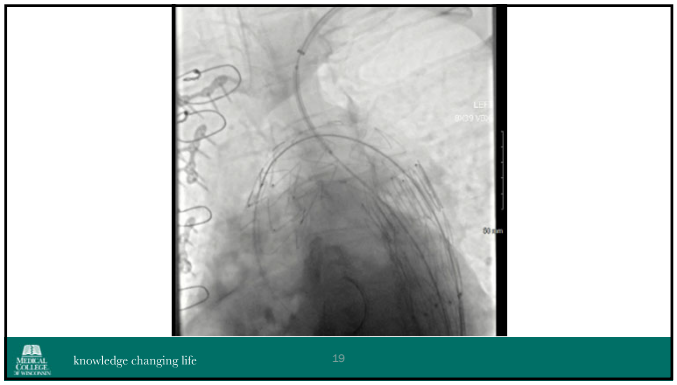

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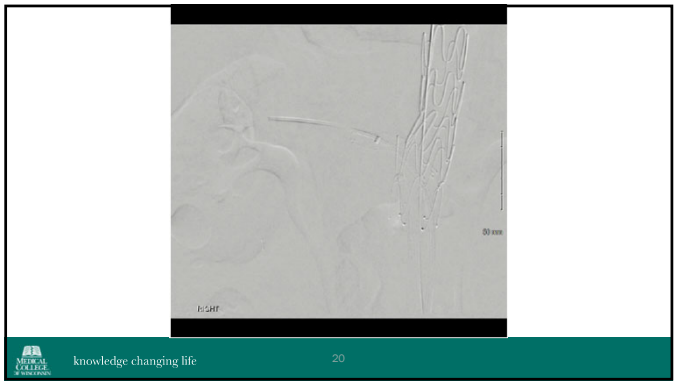

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Post-Op Course

- Uneventful recovery
- Discharged home on POD 4

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6 Months s/p TEVAR

22

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Surveillance

- Seen in CT and Vascular clinic 2 months ago and doing well
- Normal renal function
- Plan repeat CTA C/A/P in 1 year

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Management of Residual Dissection After Type A Repair

- 2022 ACC/AHA Guideline for Diagnosis and Management of Aortic Disease
  - 10 year survival is 60-65% after repair of acute Type A aortic dissection (ATAAD)
  - Growth rate of distal aorta is 1mm/yr
  - Risk of distal aortic reoperation ranges from 10-16% at 10 years
  - Surveillance imaging is crucial to monitor for progression and need for re-intervention
    - Isselbacher EM, Preventza O, Hamilton Black J 3rd, Augoustides JG, Beck AW, Bolen MA, Braverman AC, Bray BE, Brown-Zimmerman MM, Chen EP, Collins TJ, DeAnda A Jr, Fanola CL, Girardi LN, Hicks CW, Hui DS, Schuyler Jones W, Kalahasti V, Kim KM, Milewicz DM, Oderich GS, Ogbechie L, Promes SB, Gyang Ross E, Schermerhorn ML, Singleton Times S, Tseng EE, Wang GJ, Woo YJ. 2022 ACC/AHA Guideline for the Diagnosis and Management of Aortic Disease: A Report of the American Heart Association/American College of Cardiology Joint Committee on Clinical Practice Guidelines. Circulation. 2022 Dec 13;146(24):e334-e482. doi: 10.1161/CIR.0000000000001106. Epub 2022 Nov 2. PMID: 36322642; PMCID: PMC9876736.

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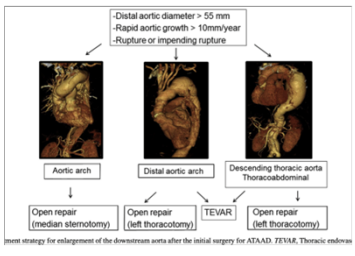
Management of Residual Dissection After Type A Repair

- 2021 AATS expert consensus document recommends addressing life-threatening conditions at initial operation, sequentially treating the lifelong complications of residual dissection in distal aorta
  - Aortic arch replacement with FET may show favorable remodeling and facilitate future completion descending aortic surgery, particularly in patients with hereditary thoracic aortic diseases
  - CTA predischarge, at 6 months, then annually for most patients

•Melaisrie SC, Szeto WY, Halas M, Girardi LN, Coselli JS, Sundt TM 3rd, Chen EP, Fischbein MP, Gleason TG, Okita Y, Ouzounian M, Patel HJ, Roselli EE, Shrestha ML, Svensson LG, Moon MR; AATS Clinical Practice Standards Committee: Adult Cardiac Surgery. 2021 The American Association for Thoracic Surgery expert consensus document: Surgical treatment of acute type A aortic dissection. J Thorac Cardiovasc Surg. 2021 Sep;162(3):735-758.e2. doi: 10.1016/j.jtcvs.2021.04.053. Epub 2021 Apr 30. PMID: 34112502.

26

Reoperation for enlargement of the distal aorta after initial surgery for acute type A aortic dissection



ment strategy for enlargement of the downstream aorta after the initial surgery for ATAAD. *TEVAR*, Thoracic endovas

- Kimura N, Itoh S, Yuri K, Adachi K, Matsumoto H, Yamaguchi A, Adachi H. Reoperation for enlargement of the distal aorta after initial surgery for acute type A aortic dissection. J Thorac Cardiovasc Surg. 2015 Feb;149(2 Suppl):S91-8.e1. doi: 10.1016/j.jtcvs.2014.08.008. Epub 2014 Aug 13. PMID: 25224548.

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Questions?

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Endovascular TAAA–Current Status and Results

Robert A. Hieb, MD, FSIR
Professor of Radiology, Surgery and Medicine

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Endovascular TAAA–Current Status and Results

Disclosures:

MAB Boston Scientific and Medtronic Medical

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Endovascular TAAA–Current Status and Results

Open surgical repair has been gold standard for repair of TAAA since one of the first successful repairs in the US was reported in 1955 by Etheredge –since then, thousands of patients over decades reported

Significant risks with open surgical repair:

30 day mortality 7-17%, spinal cord injury 2-14%, dialysis 2-32%, tracheostomy 4-12% and early reoperations for post-operative complications 2-25%

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Endovascular TAAA–Current Status and Results

Crawford's series was reported in 1993 on 1509 consecutive patients from 1960-1991 demonstrating

- 30 d mortality=8%
- spinal cord ischemia (paraplegia and paraparesis)=16%
- permanent dialysis=9%

Coselli published in 2016 with over 3,300 patients

- 30 d mortality=7.5%
- permanent spinal cord injury=5.4%
- permanent paraplegia=2.9%

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Endovascular TAAA–Current Status and Results

Revolution in development of endovascular techniques and devices

- Browne et al in 1998 first FB-EVAR

No current FDA approved devices for TAA

- US Aortic Research Consortium
- PS-IDE studies

Laundry list of procedures and devices for complex EVAR

Shared goal

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Endovascular TAAA–Current Status and Results

Evolution:

- EVAR
- FEVAR
- ChEVAR
- PMEG
- CMD
- Off-the-shelf

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Endovascular TAAA–Current Status and Results

Endo-TAAA relies on extensive pre-operative planning and advanced imaging
Advanced imaging/Hybrid ORs
Specialized software/3D workstations
Fusion imaging software and fluoro overlay
Coned beam CT
Operator(s) and center dedication and experience
Graft and related device inventory

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Endovascular TAAA–Current Status and Results

Parallel Grafting (Chimney, Periscope, and Snorkel techniques)—ChEVAR

Advantages
- profile, off-the-shelf

Disadvantages
- upper extremity access
- violates both rules of EVAR

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Endovascular TAAA–Current Status and Results

FB-EVAR

PMEG

In situ mechanical or laser fenestrations

Extensive pre-op planning, center line and clock face references
Dedicated hybrid OR, coned beam CT and advanced software

Fenestrated or branched

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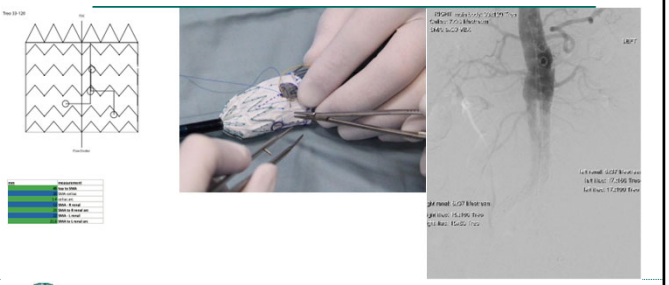
Endovascular TAAA–Current Status and Results



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Endovascular TAAA–Current Status and Results

Limitations—FB-EVAR

- Connective tissue disorders
- Hostile aorta and/or iliofemoral arteries
  - severe tortuosity, angulation, small and heavily calcified femoral and/or iliac arteries
- Stent kinks, migration, disconnection, fracture or occlusion and endoleaks
- Steep operator learning curves, sophisticated imaging requirements
- Need for secondary interventions
- Cost and required long-term imaging surveillance

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Endovascular TAAA–Current Status and Results

Comparisons:

Difficult as patient populations are different

Open repair data much more mature (thousands of patients over many decades)

Several systemic reviews:

Rocha et al showed in meta-analysis of 71 studies showed similar perioperative mortality 7.4 to 8.9% with lower cerebral events and renal failure

Patel et al similar findings

FB-EVAR has higher rates of reintervention however these do not appear to affect overall survival

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Endovascular TAAA–Current Status and Results

PMEG better than ChEVAR

PMEG has shown overall technical success rate ranging from 90-100%

Melo et al showed perioperative mortality of 3% with major complication rate of 11%

Starnes et al showed short and mid-term results with 69% freedom from reintervention, 94% freedom from aneurysm related mortality and 70% freedom from all cause mortality at 4 yrs and 30-day mortality of 5.1%

Limited data in ruptures—studies have shown acceptable mortality and that pts successfully treated with FB-EVAR at acute presentation are more likely to be discharged home c/w open repair

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Endovascular TAAA–Current Status and Results

Summary

- Endo-TAAA has become gold standard
- Lower morbidity and mortality c/w open surgery despite being used more commonly in older patients with more CV morbidities
- First option and treatment of choice in patients who have suitable anatomy and do not have C/T disorders
- As with open surgery, results likely to be better in higher volume centers
- Limitations still exist with limited access to better devices, high cost and need for secondary interventions
- Need more data with uniformly adopted reporting standards

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Endovascular TAAA–Current Status and Results

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1. Svensson LG, Crawford ES, Hess KR, et al. Experience with 1509 patients undergoing thoracoabdominal aortic operations. *J Vasc Surg* 1993;17:357-68; discussion 368-70. 10.1016/0741-5214(93)90421-H
2. Coselli JS, LeMaire SA, Preventza O, et al. Outcomes of 3309 thoracoabdominal aortic aneurysm repairs. *J Thorac Cardiovasc Surg* 2016;151:1323-37. 10.1016/j.jtcvs.2015.12.050
3. Crawford ES. Thoraco-abdominal and abdominal aortic aneurysms involving renal, superior mesenteric, celiac arteries. *Ann Surg* 1974;179:763-72
4. Tenorio ER, Dias-Neto MF, Lima GBB, Estrera AL, Oderich GS. Endovascular repair for thoracoabdominal aortic aneurysms: current status and future challenges. Ann Cardiothorac Surg. 2021 Nov;10(6):744-767. doi: 10.21037/acs-2021-taes-24. PMID: 34926178; PMCID: PMC8640886.
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6. Moulakakis KG, Karaolanis G, Antonopoulos CN, et al. Open repair of thoracoabdominal aortic aneurysms in experienced centers. *J Vasc Surg* 2018;68:634-645.e12. 10.1016/j.jvs.2018.03.410
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8. Locham S, Dakour-Aridi H, Nejim B, et al. Outcomes and cost of open versus endovascular repair of intact thoracoabdominal aortic aneurysm. *J Vasc Surg* 2018;68:948-955.e1. 10.1016/j.jvs.2018.01.053

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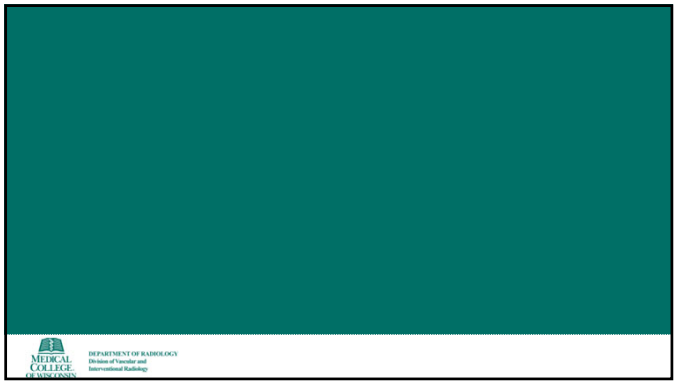
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Heritable Aortopathy - Types and Importance

Milwaukee Aortic Symposium, Michael Muriello

April 21, 2023

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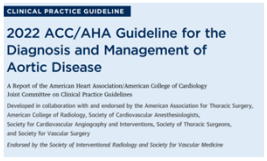
Outline

- Categorization
- Non-syndromic familial
- Syndromes to know
  - Marfan Syndrome
  - Loeys-Dietz Syndrome
  - Vascular Ehlers-Danlos Syndrome
- Genetic testing



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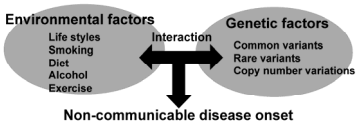
Sporadic Thoracic Aortic Aneurysm (TAA)

- Genes plus environment
- Descending versus root/ascending aneurysms



Narimatsu et al. International Journal of Molecular Sciences. 2017;18(2):302.

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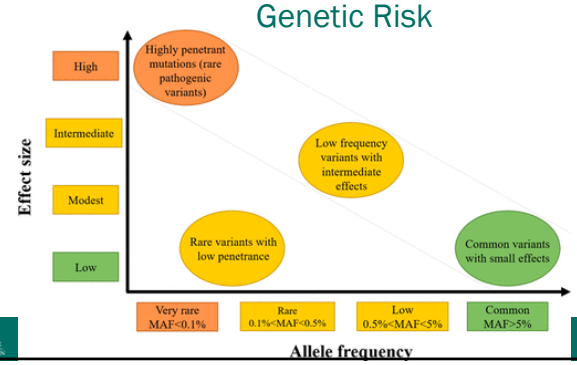
Genetic Risk



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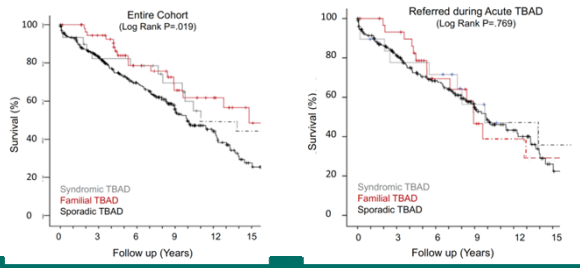
Diagnosis improves survival

Shalhub et al. *Journal of Vascular Surgery*. 2021;73(6):1906-1914.e2.



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Syndromic TAA

Caruana M et al *European Journal of Medical Genetics*. 2023;66(1):104673.

Ectopia Lentis

Wrist/thumb sign

Bifid Uvula

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Syndromic TAA

Caruana M et al *European Journal of Medical Genetics*. 2023;66(1):104673.

Pectus deformity

Severe pes planus

Arterial tortuosity

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Syndromic TAA

- Spontaneous pneumothorax or hemothorax
- Scoliosis
- Club feet
- Severe bruising with minimal trauma
- Spontaneous retroperitoneal bleeding
- Previous arterial aneurysms or dissections
- Craniosynostosis

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Syndromic TAA

Examples

- Marfan syndrome
- Loeys-Dietz syndrome
- Vascular Ehlers-Danlos syndrome
- Arterial tortuosity syndrome
- Meester-Loeys syndrome
- Cutis laxa
- Sphrintzen-Goldberg

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Diagnosis of Hereditary TAAD

Diagnosis of HTAD

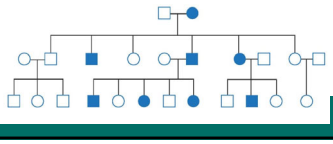
(requires one of:)

- ≥2 members of a family with TAAD
- identification of a pathogenic variant in the gene known to cause TAD in a family member
- clinical diagnosis of syndrome that confers a risk for TAD (eg, Marfan syndrome) in a family member.

"Positive" family history

≥1 first or second-degree relative with:

- TAAD or peripheral/intracranial aneurysms < age 70
- Sudden death < age 45 years with no alternative etiology.



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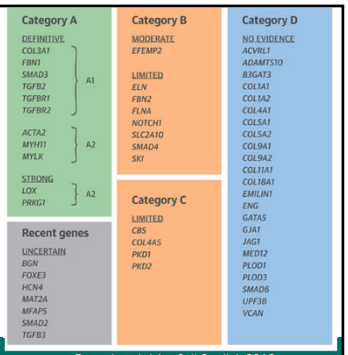
2018 ClinGen TAAD gene clasification

A = HTAAD gene
B = Unlikely to be progressive
C = Low risk
D = No evidence of HTAAD association



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Renard et al. J Am Coll Cardiol. 2018 August 07; 72(6): 605–615.

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Heredtiary TAA and *negative* genetic testing

Features Associated With an Increased Risk of Aortic Dissection

- Heritable Thoracic Aortic Aneurysms Family history of aortic dissection at an aortic diameter <5.0 cm
- Family history of unexplained sudden death at age <50 y
- Rapid aortic growth (0.5 cm in 1 y or 0.3 cm/y in 2 consecutively)

➢Case-by case surgical and non-surgical management

➢ what age did affected family members did they dissect? How large was aorta at time of dissection?

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Non-Syndromic Hereditary TAA

Most affected families have no features of a genetic syndrome

- Among non-syndromic familial TAAD families, 10% may still have a MFS or LDS disease variant
- Up to 20% of probands with TAD *without* Marfan or LDS have affected 1st degree relatives

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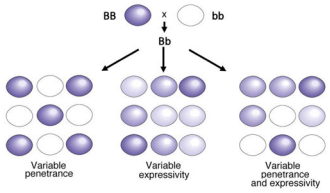
Bicuspid Aortic Valve Aortopathy

- BAV – 1% prevalence
  - >50% develop TAA
- Majority with no identifiable genetic change
  - <1% with a change in *NOTCH1* gene
  - Syndromic associations: Monosomy X, *FBN1*, *TGFBR1/2*, others



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Nonsyndromic Aortopathy - Examples

- *ACTA2*
  - HTAAD or Smooth muscle dysfunction syndrome
  - Patent ductus arteriosus, small vessel disease or stenoses
- *MYH11*
- *MYLK*
  - Dissection at small size
- *PRKG1*
  - Dissection at young age and small size

Genetic Variant	Risk Factors	Aortic Diameter (cm)
ACTA2	No	≥4.5
ACTA2	Yes†	≥4.2
PRKG1	No	≥4.2
PRKG1	Yes†	≥4.0†

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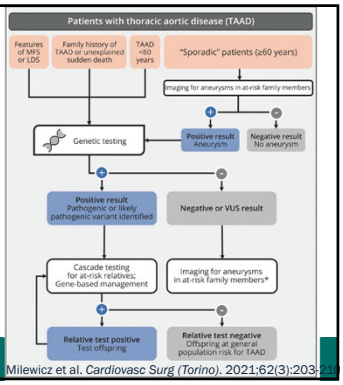
HTAAD: Genetic Diagnosis

- ✓ Genetic Counseling
- ✓ Gene panel
  - Exceptions: known familial variant or clear fit for syndrome
  - If undiagnosed consider research exome/genome
- ✓ Note importance of imaging at risk family members



Milewicz et al. *Cardiovasc Surg (Torino)*. 2021;62(3):203-210

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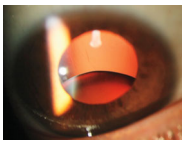
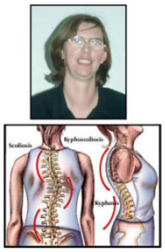
Marfan Syndrome

- Caused by disease causing change in *FBN1* gene
- Diagnosis requires ≥2 of 4
  1. Aortic root dilation
  2. Ectopia lentis
  3. Pathogenic *FBN1* variant
  4. Family history of someone meeting ≥2 of the above





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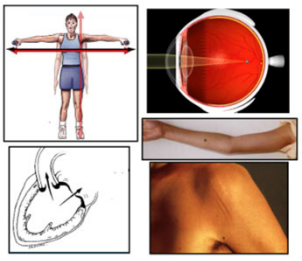
Marfan Syndrome

- Broad phenotypic continuum
  - Mild (few features) to severe, rapidly progressive neonatal onset
- Ocular, skeletal, cardiovascular systems
  - Myopia; Ectopia Lentis** (60%)
  - Aortic root aneurysm/dissection**
  - Valve prolapse
  - Bone overgrowth, joint laxity, pectus, dolichostenomelia, scoliosis



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Marfan Syndrome

- Greatest risk to aortic root; distal TAA and AAA are less common
- B-blocker or ARB therapy are most efficacious
- Replacing both root and ascending aorta recommended
- Risk for aortic complications increased with:
  - Family hx dissection
  - Rapid growth >0.3 cm/y
  - Diffuse root and ascending dilation
  - Marked vertebral tortuosity

Bhandri et al. Vasc Med. 2020;25(1):63-77.

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Loeys-Dietz Syndrome

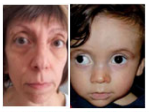
TGFβ pathway genes

- *SMAD2, SMAD3, TGFB2, TGFB3, TGFBR1, TGFBR2*
- Distinct vascular complications associated with each gene

Distinguishing features

- Cleft palate / bifid uvula
- Widely spaced eyes
- Abnormal head shape
- Clubfoot
- Joint contractures

❖ Significant clinical overlap with Marfan syndrome
❖Non-aortic arterial aneurysms and tortuosity
❖Early dissection



Loeys et al. Nature Genetics. 2005;37(3):275-281

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Genotype-guided LDS management

❖ Beyond the gene – other factors affect timing of surgical intervention
- Specific variants in some genes dissect earlier
- Familial dissection timing
- Severe extra-aortic features

Genetic Variant	Presence of High-Risk Features*	Aortic Diameter (cm)
TGFBR1	No	≥4.5
TGFBR2	No	≥4.5
TGFBR1	Yes	≥4.0
TGFBR2	Yes	≥4.0
SMAD3	-	≥4.5†
TGFB2‡	-	≥4.5†
TGFB3	-	≥5.0†

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Diagnosis-guided pregnancy TAA management

TABLE 34 Prophylactic Aortic Surgery Before Pregnancy in Women With Aortopathic Conditions

Condition	Surgical Threshold Before Pregnancy* by Aortic Diameter (cm) or Aortic Size Index (cm/m²)
Marfan syndrome	>4.5 cm
Marfan syndrome with risk factors (rapid aortic growth of ≥0.3 cm/y; family history of aortic dissection)	4.0–4.5 cm
Loeys-Dietz syndrome (attributable to pathogenic variants in *TGFBR1*, *TGFBR2*, or *SMAD3*)	≥4.0 cm
Loeys-Dietz syndrome (attributable to pathogenic variants in *TGFB2* or *TGFB3*)	≥4.5 cm
Nonsyndromic heritable thoracic aortic disease	≥4.5 cm†
Turner syndrome	≥2.5 cm/m²
Bicuspid aortic valve	≥5.0 cm‡

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Thank You

- Bhandari R, Aatre RD, Kanthi Y. Diagnostic approach and management of genetic aortopathies. *Vasc Med*. 2020;25(1):63-77.
- Caruana M, Baars MJ, Bashiardes E, et al. HTAD patient pathway: Strategy for diagnostic work-up of patients and families with (suspected) heritable thoracic aortic diseases (HTAD). A statement from the HTAD working group of VASCERN. *European Journal of Medical Genetics*. 2023;66(1):104673.
- Isselbacher EM, Preventza O, Hamilton Black J, et al. 2022 ACC/AHA Guideline for the Diagnosis and Management of Aortic Disease: A Report of the American Heart Association/American College of Cardiology Joint Committee on Clinical Practice Guidelines. Circulation. 2022;146(24):e334-e482.
- Narimatsu H. Gene–Environment Interactions in Preventive Medicine: Current Status and Expectations for the Future. International Journal of Molecular Sciences. 2017;18(2):302.
- Shalhub S, Rah JY, Campbell R, Sweet MP, Quiroga E, Starnes BW. Characterization of syndromic, nonsyndromic familial, and sporadic type B aortic dissection. *Journal of Vascular Surgery*. 2021;73(6):1906-1914.e2.
- Milewicz DM, Guo D, Hostetler E, Marin I, Pinard AC, Cecchi AC. Update on the genetic risk for thoracic aortic aneurysms and acute aortic dissections: implications for clinical care. J Cardiovasc Surg (Torino). 2021;62(3):203-210.
- Marfan.org

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Downstaging with TEVAR – Does it Work?

2023 Milwaukee MCW Aortic Symposium
Joseph Hart, MD, MHL, FACS, DFSVS

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"Temporal" Management of Complex Thoracoabdominal Aortic Pathology: A Case Presentation

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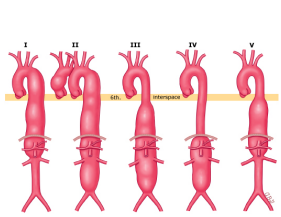
Background



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Patient Information

- Presented at age 50 to OSH with aortic root and ascending aortic aneurysm.
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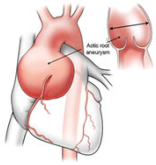

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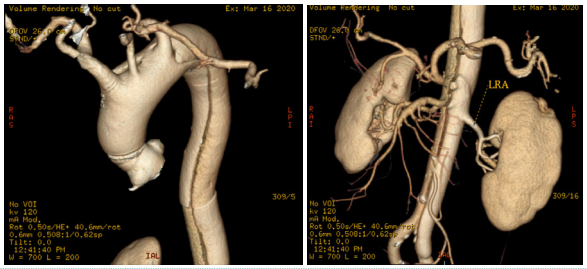
Presenting CTA



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"Temporal" Management

Aortic Root Aneurysm → Aortic Dissection

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Fast Forward…

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"Temporal" Management

Aortic Root Aneurysm → Aortic Dissection → Aortic Arch Replacement

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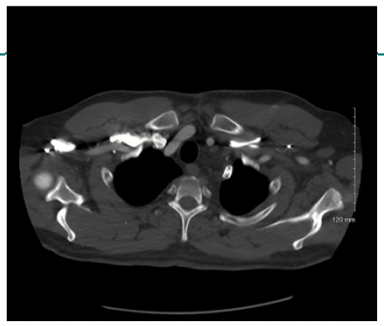

2 years after presentation

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Fast Forward…

- Recovered well but suffered from phrenic nerve palsy following repair.
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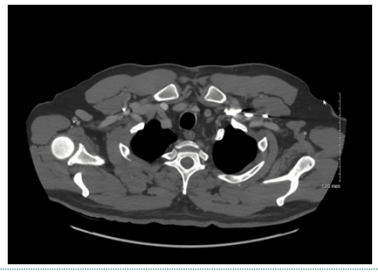
Preoperative Imaging



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Descending Thoracic Aortic Aneurysm Repair

Preoperative Admission: Spinal Drain Placement

Positioning: Right Lateral Decubitus

Exposure: Left Thoracotomy (6th Intercostal Space)

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Repair:

- Aorta exposed at the diaphragmatic hiatus and distal arch.
- Elephant trunk grasped and pulled down to the point that we were able to place a vascular clamp.
- Intercostal branches were oversewn with #1 silk
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- 24 mm Dacron graft was sutured end-to-end to the previous elephant trunk graft and then to the aorta at the diaphragm

13

Postoperative Course

- Uneventful recovery.
- Extubabted POD 1.
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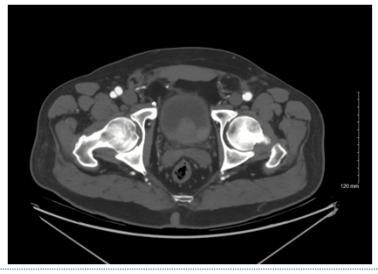
14

Current Status



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Current Status

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"Temporal" Management

Aortic Root Aneurysm → Aortic Dissection → Aortic Arch Replacement → Descending Thoracic Aortic Replacement

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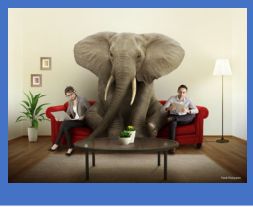
What's Next???



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Considerations for Staging

Potential need to address complex pathology in staged fashion.

Potential to avoid morbidity and morality of more extensive operations.

Allows options for future endovascular and open treatment modalities.

Can be done safely with effective and durable outcomes.

19

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63 year old who presented with complex thoracic aortic pathology safely managed with temporally staged repair.

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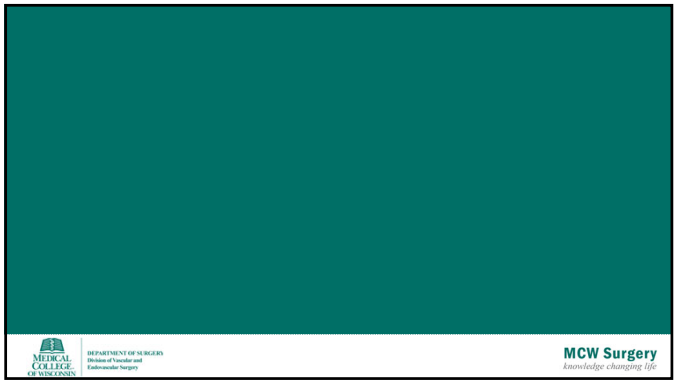

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"Temporal" Management of Complex Thoracoabdominal Aortic Pathology: A Case Presentation

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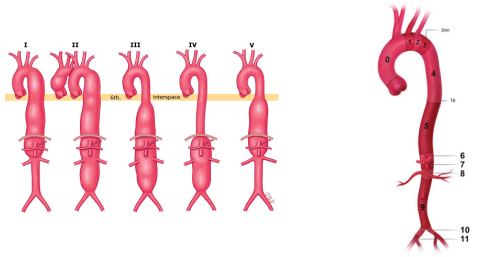

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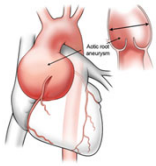

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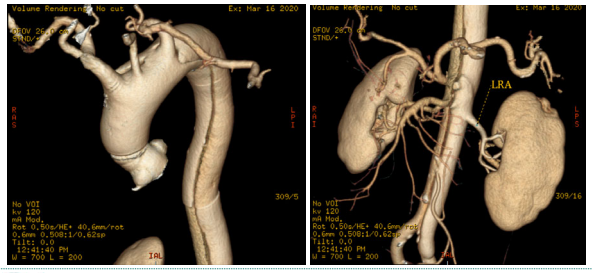

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"Temporal" Management

Aortic Root Aneurysm → Aortic Dissection

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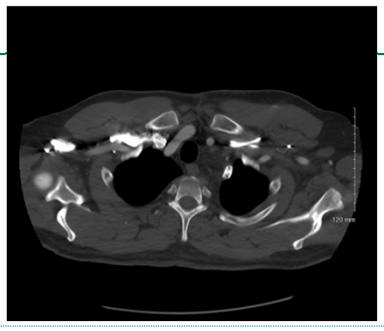

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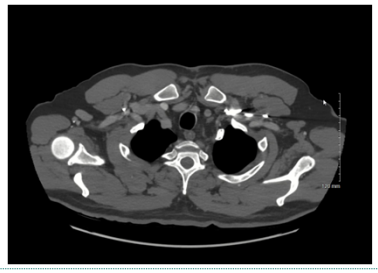

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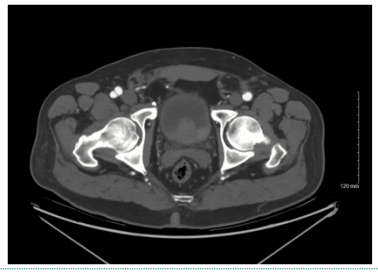

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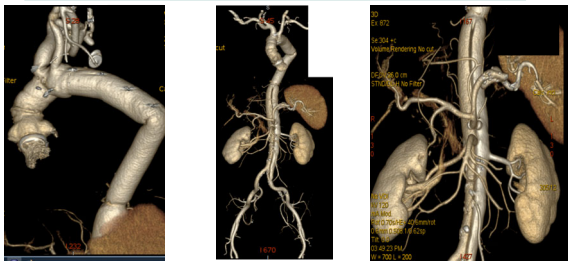

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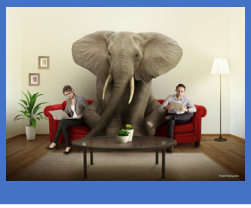

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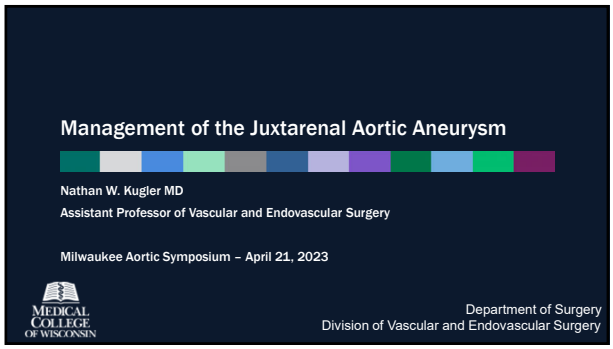
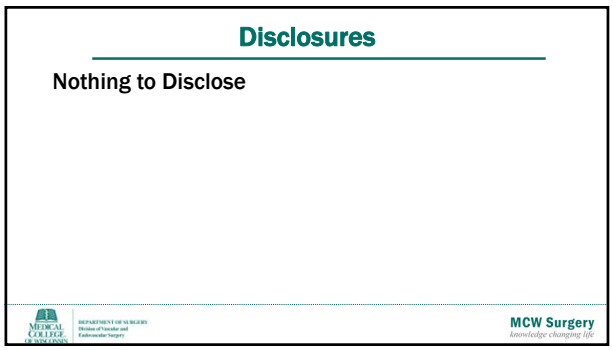

Management of the Juxtarenal Aortic Aneurysm
Nathan W. Kugler MD
Assistant Professor of Vascular and Endovascular Surgery
Milwaukee Aortic Symposium – April 21, 2023
MEDICAL COLLEGE OF WISCONSIN
Department of Surgery
Division of Vascular and Endovascular Surgery

1


Disclosures
Nothing to Disclose
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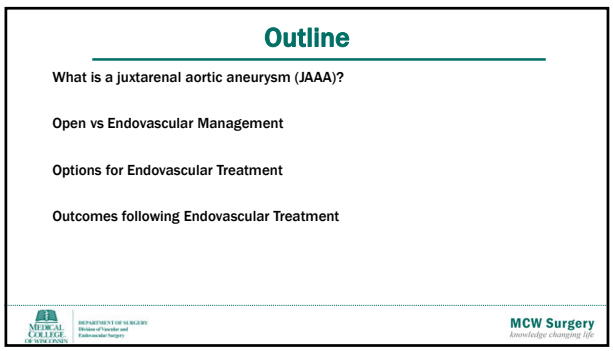
Outline
What is a juxtarenal aortic aneurysm (JAAA)?
Open vs Endovascular Management
Options for Endovascular Treatment
Outcomes following Endovascular Treatment
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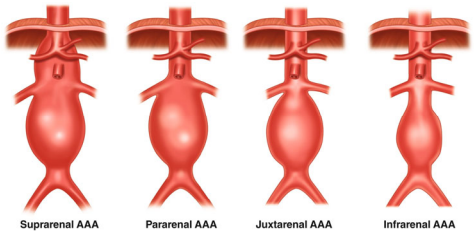
Abdominal Aortic Aneurysms



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Juxtarenal Definition

No single accepted definition in the literature but have included:

- Aneurysmal degeneration all the way to renal arteries
  - i.e. neck length 0mm
- Short neck ≤4mm
- Others by neck length <10mm
  - Essentially off label for most commercially available devices
  - Have been defined in some studies looking at Endologix® Alto for treatment of JAAA

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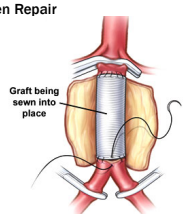
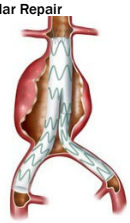
Considerations in Treatment

Open Repair



Endovascular Repair



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Open or Endovascular

How healthy is my patient?

- i.e. is he/she/they an open candidate…

Neck Anatomy

- Diameter → Neck ≤ 32mm
- Length → Infrarenal neck ≥4mm
- Angulation → Neck angulation < 60 degrees

Access Vessels

- Major consideration is sheath requirements for repair
- Endo-conduit or open conduit creation can address some of these issues

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Endovascular Options

Cook Zenith® Fenestrated Device

- ≥4mm infrarenal neck length

Endosuture Aneurysm Repair (ESAR) → Endurant™ II/s + Heli-Fx Endoanchors

- ≥4mm infrarenal neck length

Endologix Alto®

- ≥7mm infrarenal neck length

OFF-LABEL Custom Approaches to Endovascular Treatment:

- Cook Zenith Z-FEN with neck length <4mm
- Parallel Grafting (aka Snorkel, Chimney, Periscope, etc)
- Physician Modified EndoGraft (PMEG)
- Laser Fenestration of Standard Endograft

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Fundamental Difference

FEVAR → Proximal Extension of Seal Zone

ESAR → Fixation of Device and Seal Infrarenal

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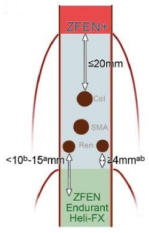
Cook Zenith® Fenestrated

Z-Fen

- Multiple configurations of fenestrations & scallops
  - Small fenestrations 6mm wide and 6-8mm in height
  - Large fenestrations are 8-12mm diameter
  - Scallops are 10mm wide, 6-12mm in height
- Fenestrated Body + Bifurcated Body + Iliac Limb Extensions

Z-Fen+

- Remains in clinical trials (ZFEN+ Pivotal Trial)
- Up to 5 fenestrations or 4 fenestrations + 1 scallop
- Small fenestrations (6mm) & large fenestrations (8mm)
- Two optional pre-loaded catheters often for renal cannulation



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Fenestration Cannulation

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Medtronic Endurant™ II/s

- Bifurcated main body device with supra-renal fixation
- Two Main Body configurations available:
  - II = ipsilateral limb with multiple configurations
  - IIs = ipsilateral limb remains short with requirement for extensions
- Bare-back delivery design
- Neck length < 10mm requires Heli-FX endoanchor utilization (ESAR)

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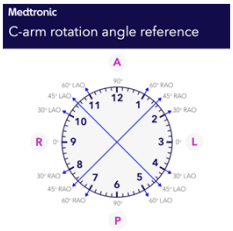
Heli-Fx Endoanchors

1. Heli-Fx Guide
2. Feli-Fx Applier
3. EndoAnchor Cassette (10 anchors)



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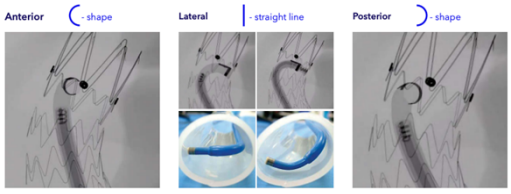
Endoanchor Deployment



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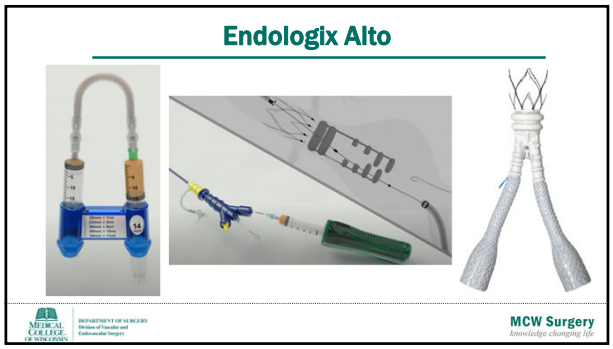
Endologix Alto
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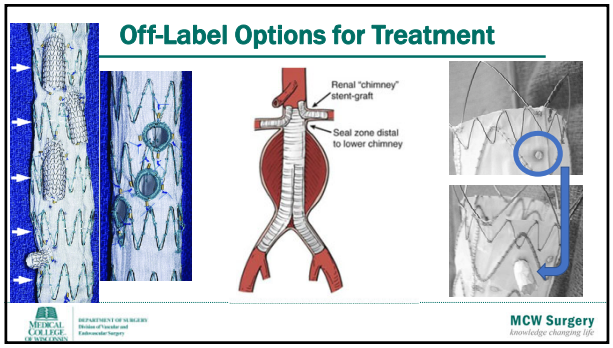
Off-Label Options for Treatment
Renal "chimney" stent-graft
Seal zone distal to lower chimney
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NICE STORY.
NOW SHOW ME THE
DATA

18

Open or Endo – Trade Offs in Treatment

Meta-Analysis of 24 studies / 7854 patients

- Open repair (OSR), FEVAR, off-label EVAR, or ChEVAR

Mortality

- Early mortality was significantly lower in FEVAR (3.1%) than OSR (4.4%)
- Mid-Term Outcomes:
  - All cause mortality significantly higher for off-label EVAR
  - No difference in aneurysm specific mortality

Reintervention

- Early reintervention not significantly different between OSR (9.7%) and FEVAR (7.9%)
  - Significant difference in types of reintervention owing to different repair approaches.
- Mid-term FEVAR re-intervention was significantly greater than OSR (HR 1.65)

Patel SR et al. Editor's Choice – Comparison of Open, Standard, and Complex Endovascular Aortic Repair Treatments for Juxtarenal/Short Neck Aneurysms: A Systematic Review and Network Meta-Analysis. European Journal of Vascular and Endovascular Surgery. 2022;63(5):696-706.

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FEVAR is Feasible in Majority of JAAA

Retrospective review of 129 JAAAs (total = 1452 AAA repairs)

Juxtarenal Aortic Aneurysm defined by neck length <10mm

Two blinded surgeons evaluated initial CT imaging for anatomic suitability

- Neck Length requirements of 2-4mm
- No severe neck calcification for parallel and ESAR

IF feasible, how many fenestrations required for treatment:

- < 3 = 31%
- 3 = 36%
- >3 = 33%

Gallitto et al. Anatomical feasibility of the current endovascular solutions for Juxtarenal aortic abdominal aneurysm repair. Vascular. 2022:17085381221097304.

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FEVAR is Feasible in Majority of JAAA

- Retrospective review of 129 JAAAs (total = 1452 AAA repairs)
- Juxtarenal Aortic Aneurysm defined by neck length <10mm (endovascular)
- Two blinded surgeons evaluated initial CT imaging to determine anatomic suitability for FEVAR (note PMEG not considered), ChEVAR, and/or ESAR
- Anatomic Requirements
  - Neck Length – 2-4mm
  - No severe neck calcification for parallel and ESAR
- Fenestrations required for treatmen

94% of cases reviewed met anatomic feasibility for FEVAR

Gallitto et al. Anatomical feasibility of the current endovascular solutions for Juxtarenal aortic abdominal aneurysm repair. Vascular. 2022:17085381221097304.

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Z-FEN 5-year Outcomes

Multi-center Trial evaluating Zenith Fenestrated AAA repair

67 patients enrolled at 14 US institutions

Infrarenal aortic neck length measured 4-14mm

Mean of 2.7 vessels incorporated per patient for appropriate treatment
- 129 renal arteries – 118 small fenestrations, 11 scallops (8 stented)

Oderich GS et al. Final 5-year results of the United States Zenith Fenestrated prospective multicenter study for juxtarenal abdominal aortic aneurysms. Journal of vascular surgery. 2021;73(4):1128-38 e2.

23

Z-FEN 5-year Outcomes

Major Adverse Events (MAE)
- 22 patients (33%) experienced 27 MAE – majority cardiac
  - Procedure related MAE (4%) all due to bowel ischemia.
- At 1- and 5-years, MAE rates were 10.4% and 38.0%

Mortality
- 30-day overall mortality was 1.5%
- 1- and 5-year freedom from all-cause was 97% and 88%, respectively
- 1- and 5-year freedom from AAA-specific was 98.5% and 96.8%, respectively

Oderich GS et al. Final 5-year results of the United States Zenith Fenestrated prospective multicenter study for juxtarenal abdominal aortic aneurysms. Journal of vascular surgery. 2021;73(4):1128-38 e2.

24

Z-FEN Renal Interventions are Durable

Renal infarcts were noted in 8 patients (12%) on follow-up imaging

- Asymptomatic in 7 patients with a patent artery and stent

Renal Stent Outcomes

- 16% of patients experienced stenosis requiring intervention (11% of all renal stents)
- Stent occlusion = 4%

Renal artery patency at 1- and 5-years was 95.2% and 82.7%, respectively

Chronic Kidney Disease requiring initiation of hemodialysis seen in only 1.5%

Oderich GS et al. Final 5-year results of the United States Zenith Fenestrated prospective multicenter study for juxtarenal abdominal aortic aneurysms. Journal of vascular surgery. 2021;73(4):1128-38 e2.

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Zenith Endoleak and Sac Size

Endoleak universally decreased over time

	Discharge	1-year	5-year
Type II	31%	21.2%	7.7%
Indeterminant	1.7%	1.8%	0%

Aneurysm sac sizes demonstrated no significant growth

	1-month	1-year	5-years
Increase > 5mm	0%	0%	2.8%
No Change	98.4%	29.8%	16.7%
Decrease > 5mm	1.6%	70.2%	80.6%

Oderich GS et al. Final 5-year results of the United States Zenith Fenestrated prospective multicenter study for juxtarenal abdominal aortic aneurysms. Journal of vascular surgery. 2021;73(4):1128-38 e2.

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Migration and Reinterventions Low with Z-FEN

Significant migration defined by ≥10mm movement

- Significant caudal migration = 3%
- Delayed presentation in both cases (2- and 5-years)

20 patients (29.9%) required a secondary interventions after Z-FEN

- Renal stent interventions were performed in 12 patients (17.9%)
- Endoleak intervention was required in 8 patients (11.9%)

1- and 5-year freedom from reintervention was 90.8% and 63.5%

Oderich GS et al. Final 5-year results of the United States Zenith Fenestrated prospective multicenter study for juxtarenal abdominal aortic aneurysms. Journal of vascular surgery. 2021;73(4):1128-38 e2.

27

Off-Label Z-FEN Remains Successful

Retrospective Single Institution review 2010-2020 (349 pts)

- Short aortic neck (<10m) = 13.5%
- Juxtarenal AAA = 68.8%
- Pararenal AAA = 17.8%

Mean infrarenal neck 1.3mm ± 2.1mm

High Technical Success @ 98%

Stent Graft Configurations

- 2 renal fenestrations + SMA scallop = 37.8%
- 3 fenestrations (renal x2, SMA) + celiac scallop = 49.3%
- 4 fenestrations (renal x2, SMA, celiac) = 12.9%

Kakavgyris A.et al. Single Centre Midterm Experience with Primary Fenestrated Endovascular Aortic Aneurysm Repair for Short Neck, Juxtarenal, and Suprarenal Aneurysms. Eur J Vasc Endovasc Surg. 2023.

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Reintervention Remains Low in Off-Label Z-FEN

Re-Intervention

- Renal artery occlusion = 1.8% (12/669)
- SMA occlusion = 0.6% (2/337)
- 47 re-interventions in 38 patients (10.9%)
  - Type Ia Endoleak = 0.9%
  - Type Ib Endoleak = 2.6%
  - Type II Endoleak = 2.9%
- 5-year freedom from re-intervention was 86.5%!

Mortality

- 30-day all-cause mortality = 0.9%
- 5-year freedom from AAA-mortality = 98.8%
- 5-year aneurysm specific mortality = 1.2%

Kakavgyris A.et al. Single Centre Midterm Experience with Primary Fenestrated Endovascular Aortic Aneurysm Repair for Short Neck, Juxtarenal, and Suprarenal Aneurysms. Eur J Vasc Endovasc Surg. 2023.

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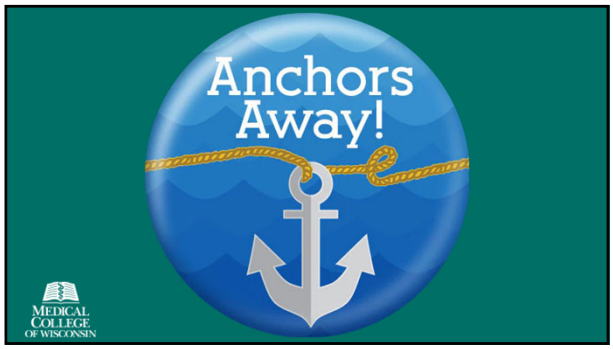

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EndoAnchor Repair is Safe and Effective

Systematic review of EndoAnchor utilization in EVAR[1]

- Majority (455 pts, 72%) at index operation with 84% prophylactic in nature
- Mean neck length = 15.4mm
- Technical success = 98.4%
- Completion type Ia endoleak = 2.1% (3.5% at follow-up)
- >5mm sac regression seen in 55% with >5mm growth noted in 1.4%

Subgroup analysis of the ANCHOR registry with short necks (4-10 mm)[2]

- 70 pts with mean neck length 6.9mm
- Technical Success 97.1% and procedural success 88.6%
- Type Ia endoleak rate was 6.8% @ 30-days and 1.9% @ 1-year
- Decreased aneurysm sac size seen in 42.6% at 1-year

1. Qamhawi Z, Barge TF, Makris GC, Patel R, Wigham A, Anthony S, et al. Editor's Choice – Systematic Review of the Use of Endoanchors in Endovascular Aortic Aneurysm Repair. European JVES. 2020;59(5):748-56.
2. Arko FR et al. Endosuture aneurysm repair in patients treated with Endurant IIIIs in conjunction with Heli-FX EndoAnchor implants for short-neck abdominal aortic aneurysm. JVS. 2019;70(3):732-40.

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ESAR vs Fenestrated

Retrospective Single Institution review 2017-2020

EndoAchors (ESAR) vs Fenestrated Endovscular Aneurysm Repair (FEVAR)

- Median neck length 8mm (ESAR) vs 10mm (FEVAR)
- Propensity matched study (36 pts) with all interventions by same vascular surgeon

Mortality

- No in-hospital morality
- All-cause mortality 22% (ESAR) vs 11% (FEVAR) – *p*=NS
- No AAA-associated mortality noted

Bordet et al. EndoSuture aneurysm repair versus fenestrated aneurysm repair in patients with short neck abdominal aortic aneurysm. JVS. 2023;77(1):28-36 e3.

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ESAR vs Fenestrated

Technical Success = 100%

Procedural Success = ESAR 94%, FEVAR 100%

No significant difference in AAA shrinkage @ median 23-month follow-up

	Decrease > 5mm	No Change	Growth >5mm
ESAR	67%	28%	5%
FEVAR	61%	33%	6%

No significant difference in re-intervention or endoleak rate

- No proximal neck interventions were required either cohort

Bordet et al. EndoSuture aneurysm repair versus fenestrated aneurysm repair in patients with short neck abdominal aortic aneurysm. JVS. 2023;77(1):28-36 e3.

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Conclusion

Endovascular Treatment of Juxtarenal Aortic Aneurysms is:

- Safe and effective
- Low all-cause mortality
- Higher re-intervention rates than OSR
- Significant aneurysm sac regression

Fenestrated (FEVAR) repair appears to provide a more durable endovascular repair when compared with ESAR.

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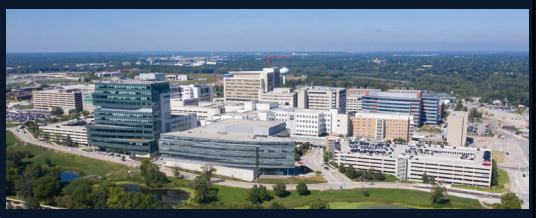
Questions



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The Geologic Overview of Mixed Atherosclerotic and Aneurysmal Disease of the Abdominal Aorta

Matthew J. Scheidt, MD, FSIR
Assistant Professor
Vascular and Interventional Radiology
4/21/2023

1

Disclosures

- None

2

Objectives

- Association between atherosclerotic disease and abdominal aortic aneurysms
- Considerations to determine best treatment plan
- Access Issues
- Downstream Treatment Options

3

PAD and AAA Association

- AAA
  - Smoking*
  - Male Gender*
  - Family History
- Atherosclerosis
  - Smoking
  - Male gender
  - Family history
  - DM*

Toghill et al. Cardiovasc Pathol., 27 (2017), pp. 71-75

Table 1
Comparison of epidemiological and risk factors associated with populations of people with abdominal aortic aneurysms (AAAs) and with established atherosclerotic plaques

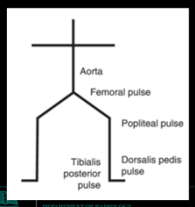
Epidemiology and risk	AAA	Atherosclerosis
Smoking	88% [21]	40% [69]
Gender	~6:1 male/female ratio [70]	66% male [69]
Ethnicity	White (90%) [71]	White (58%) [69]
Hypercholesterolemia	28% [72]	46% [69]
Hypertension	81% [21]	82% [73]
Diabetes mellitus	11% [71]	31% [74]
Comorbidity	Coronary artery disease in people with AAA was 27%–53% [21,71]	
Genetic basis	Shared and independent small effect genomic risk loci (susceptibility)	
Epigenetic basis	Global hypermethylation common, gene-specific loci different	

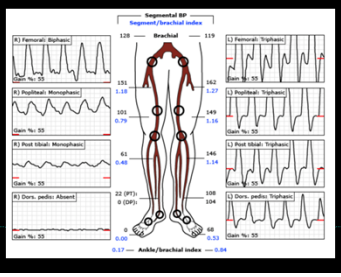
Smoking, being white, and being male are all more pronounced risk factors (% of study population) in AAA than atherosclerosis. However, hypercholesterolemia and diabetes mellitus appear higher risk for developing atherosclerosis.

4

Pre-operative Evaluation

- Physical Exam
- Non-invasive Vascular
- Cross-sectional Imaging





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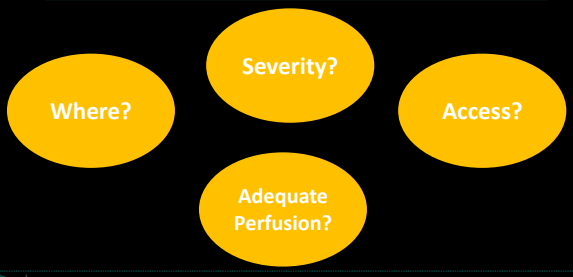
Pre-op Eval - Atherosclerotic Disease



6

Case 1

7

Case 1

- 86 y/o M with BLE claudication and enlarging saccular abdominal aortic aneurysm
- CAD with prior CABG
- Cardiomyopathy
- ABI L – 0.73
- ABI R – 0.54

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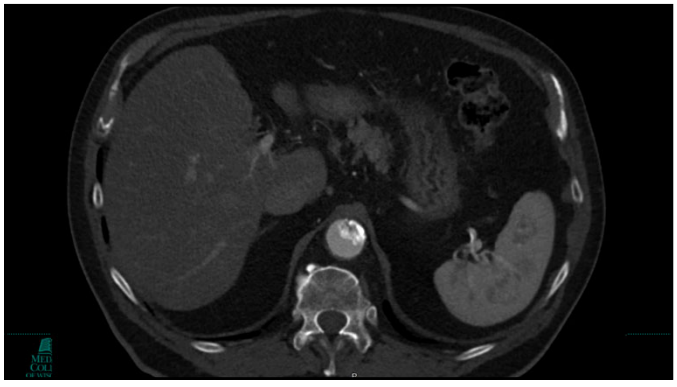

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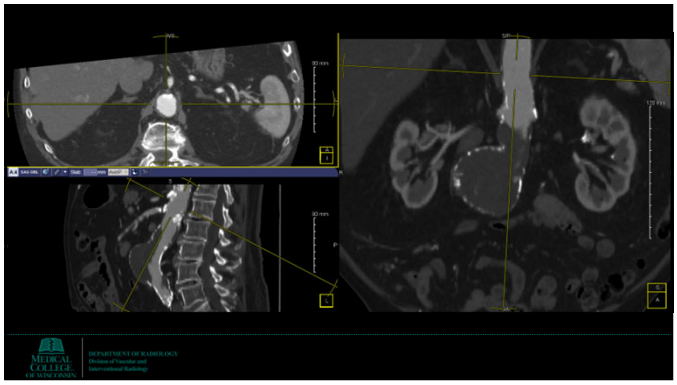

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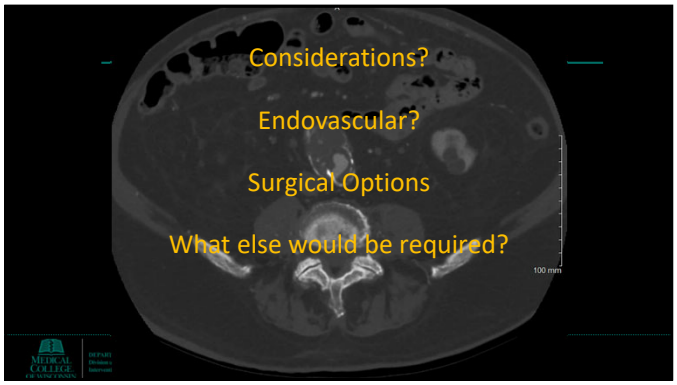
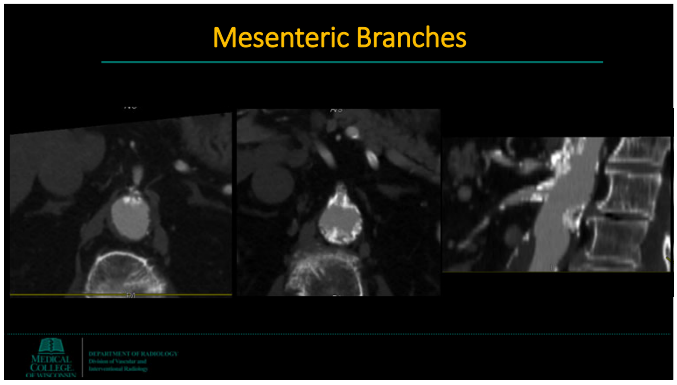

Considerations?
Endovascular?
Surgical Options
What else would be required?

11


Mesenteric Branches

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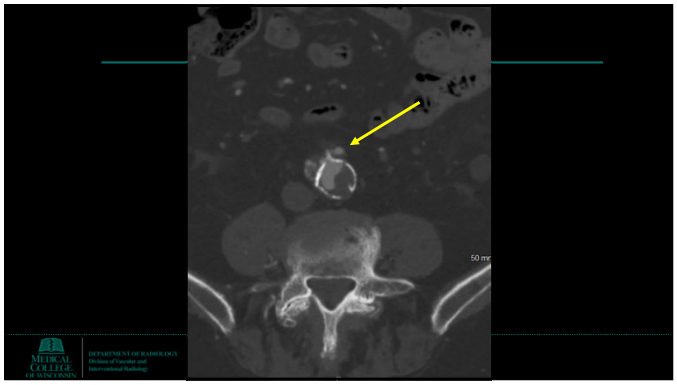

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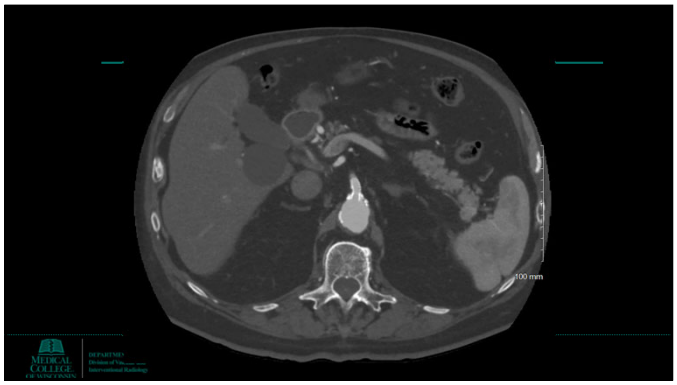

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Case 2

- 74 y/ with Stage 4 CKD, enlarging >7 cm AAA with < 5 mm infrarenal neck
- AAA has grown > 5 mm in 12 months
- GFR <24
- ABI L – 0.76
- ABI R – 0.62
- Denies any nonhealing wounds or lifestyle limiting claudication

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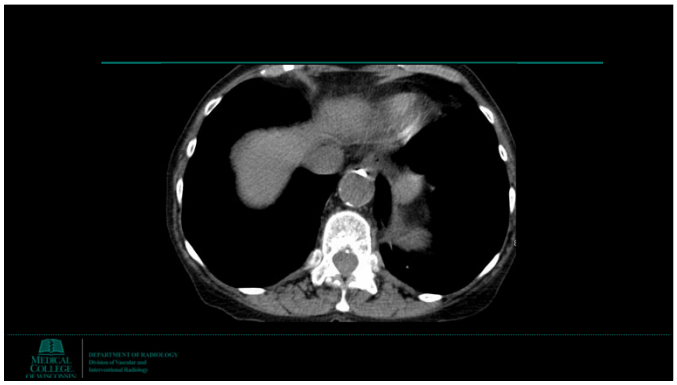

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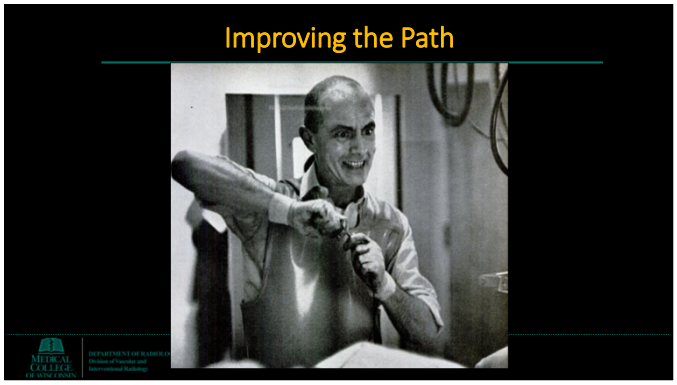
Improving the Path

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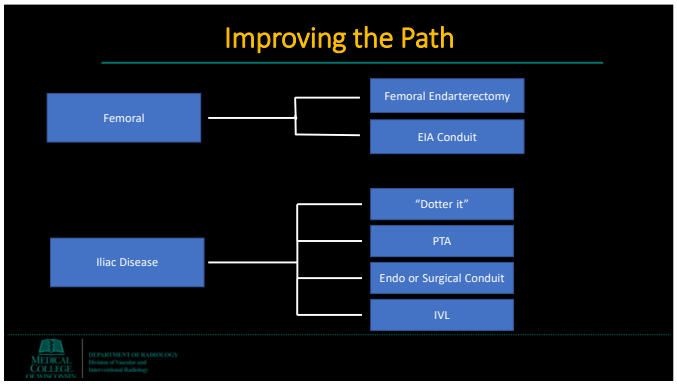
Improving the Path
Femoral
Femoral Endarterectomy
EIA Conduit
Iliac Disease
"Dotter it"
PTA
Endo or Surgical Conduit
IVL

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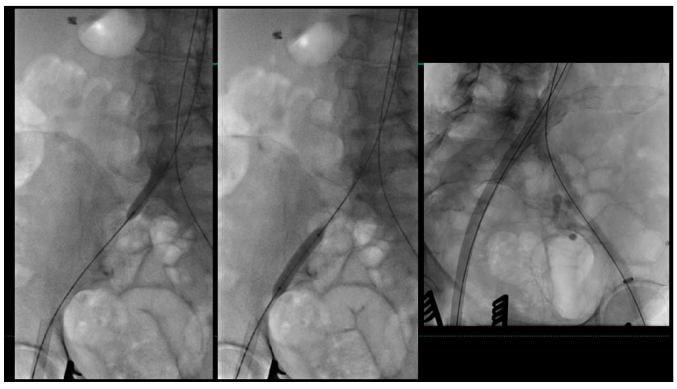

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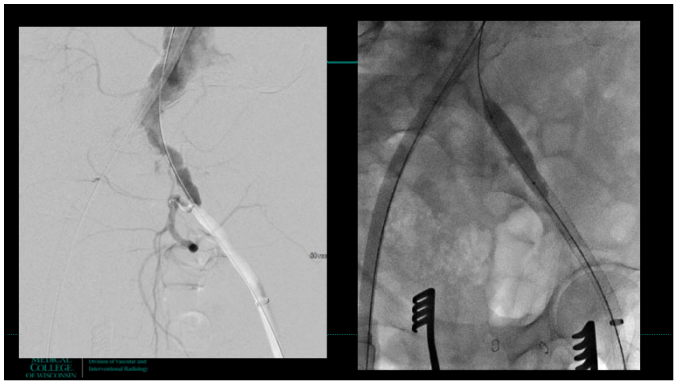

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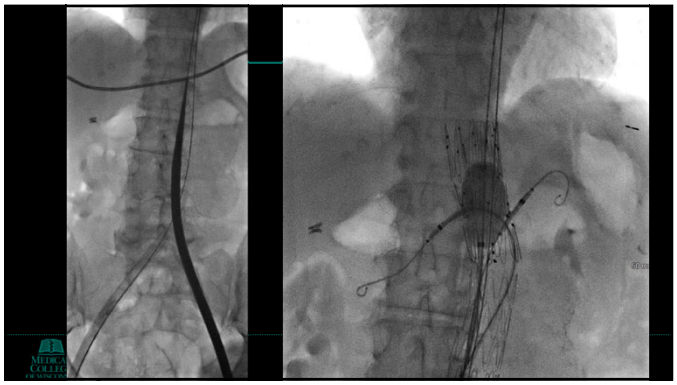

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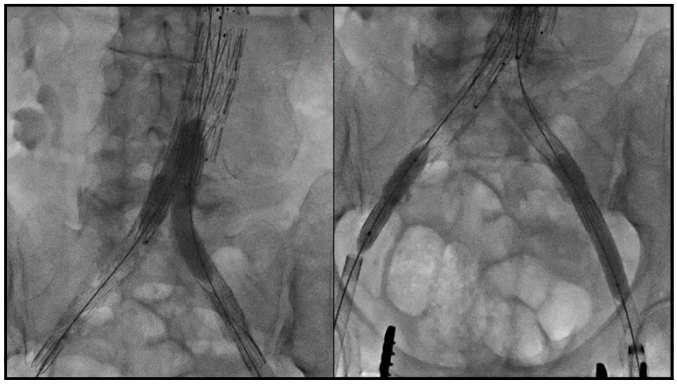

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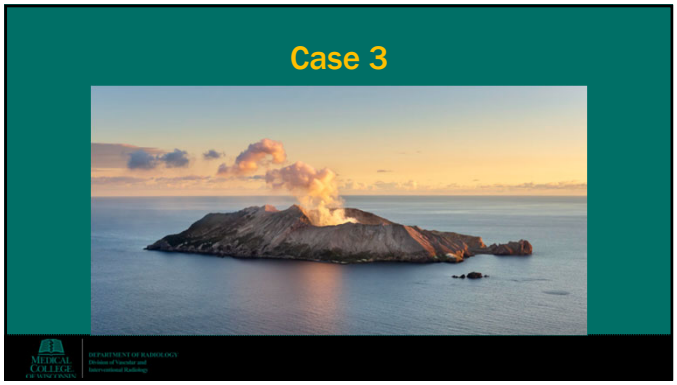

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Case 3

- 77-year-old male with 4.1 cm abdominal aortic aneurysm which has grown 8 mm over the past 2 years.
- The aneurysm itself has developed concerning features
- However, has developed concerning features of the aneurysm

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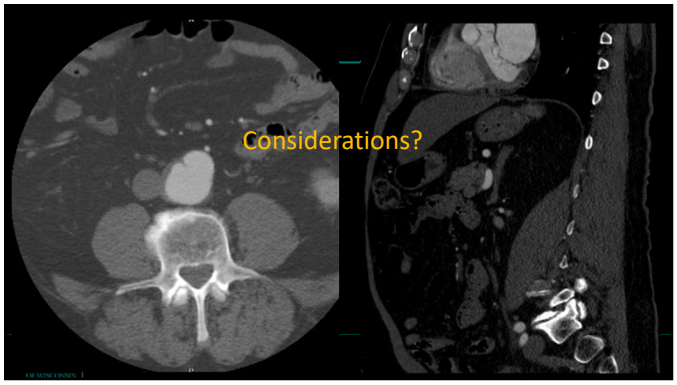

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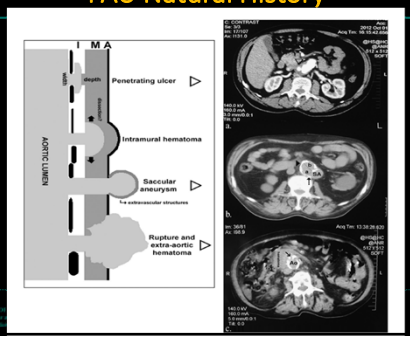
PAU Natural History



Georgiadis et al. J Vasc Interv Radiol 2013; 24:1437-1449.

29

Thoughtful Planning

- Disease process
- Current and future treatment needs of the patient
- Therapeutic options

30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RIGHT
LEFT
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Division of Vascular and Interventional Radiology

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Since no one is perfect…
RIGHT
RIGHT
LEFT

33

Conclusion

- Atherosclerotic disease affects management and treatment of AAA
- The 2 disease processes do not appear to be linked
- Thorough evaluation of pre-procedural imaging is a must
- Major considerations:
  - Adequacy of seal
  - Access for endovascular repair
  - Future treatment options of pre-existing PAD

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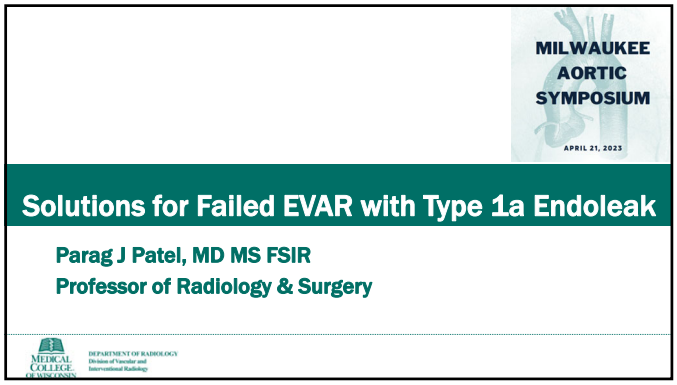

1

Failed EVAR

- Must first ask, why did it fail?
- Goal of EVAR is aneurysm sac exclusion.
- Failures are categorized as Endoleaks
- Proper identification of Endoleak type will provide reasonable endovascular options for management of the failure
- Fit the endovascular management to the problem

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Patient Selection

- Not all patients with AAA are suitable candidates for EVAR
- Successful EVAR largely depends on individualized anatomic assessment of aneurysm morphology and vascular access

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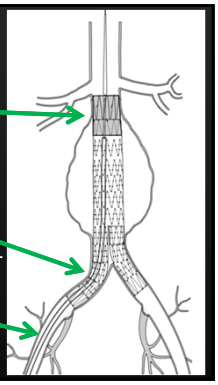
Key Anatomic Considerations

- Proximal landing zone
- Distal landing zone
- External iliac lumen size and tortuosity for advancing device
- Femoral artery size and calcification



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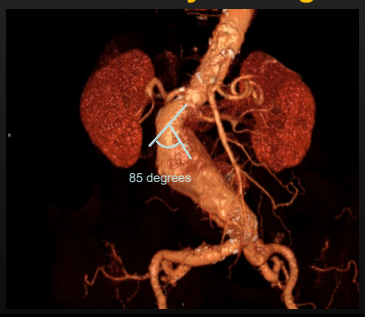
Proximal Landing Zone

- Proximal neck length > 10-15mm
- Proximal neck diameter <= 32mm
- Angulation of neck
  - Suprarenal to infrarenal aorta < 45 degress
  - Infrarenal neck to aneurysm < 60 degrees
- Hourglass or inverted funnel shaped neck Δ diameter < 20%
- Thrombus or plaque in neck

Hobo R, et al. JA Eurostart Study. J Endovas Ther 2007- 14:1-11.

5

Neck to Aneurysm Angulation



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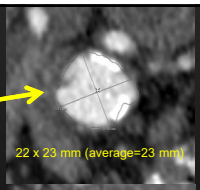
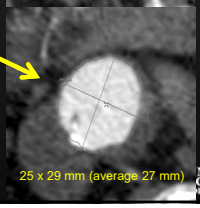
Neck Length





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Relative Risk of Hostile Neck

- Meta analysis of seven studies (1559 patients): 714 hostile anatomy and 845 friendly anatomy
- Patients with hostile anatomy:
  - ⬆Type I endoleak at 1 yr OR = 4.56 (*1.43-14.56*)
  - ⬆Adjunctive procedures OR = *3.05 (1.88-4.94)*
  - ⬆30-day morbidity OR = 2.28 (1.03-5.06)
  - ⬆Aneurysm-related mortality at 1 year OR = 9.38 (1.60-55.1)
- 5-10% will need re-intervention
- High risk population—think about aneurysm risk

Antoniou GA, et, J Vasc Surg 2012;

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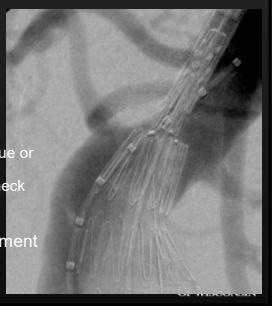
Type 1a Endoleak

- Poor sizing
  - Oversizing → graft infolding or "gutters"
  - Undersizing → poor graft to wall apposition
- Graft malposition
  - Undersized graft
  - Angulated neck → outer curve tension
  - Poor neck quality → eccentric atherosclerotic plaque or mural thrombus
  - Low deployment → not maximizing full infrarenal neck coverage
- Technical considerations with endograft deployment
  - Device and operator



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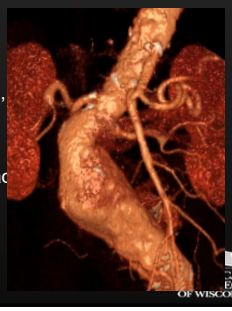
Proximal Fixation and Seal

- Dependent on
  - Neck length
  - Neck shape (conical, reverse conical,
  - Angulation
  - Diameter
  - Device / operator deployment accurac



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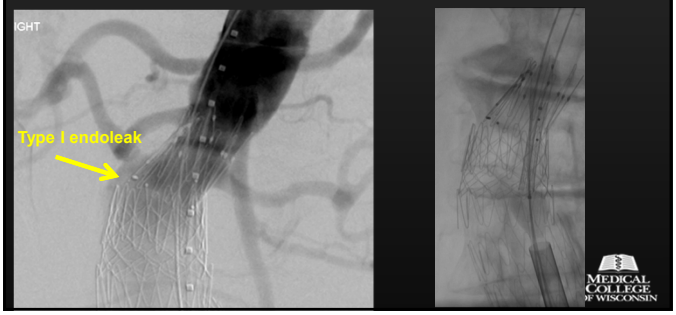
Type 1a: Poor wall apposition



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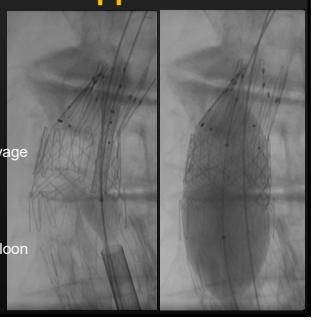
Palmaz Stent- force wall apposition

- Palmaz stenting
  - Can efface gutters secondary to oversizing
  - Improve apposition in outer curve tension
- Liabilities
  - Does not correct for undersizing
  - May complicate fenestration or chimney salvage
- Disclaimers
  - This is "off-label" use of the device
  - Careful technique for precise deployment
  - Operator must mount stent on oversized balloon



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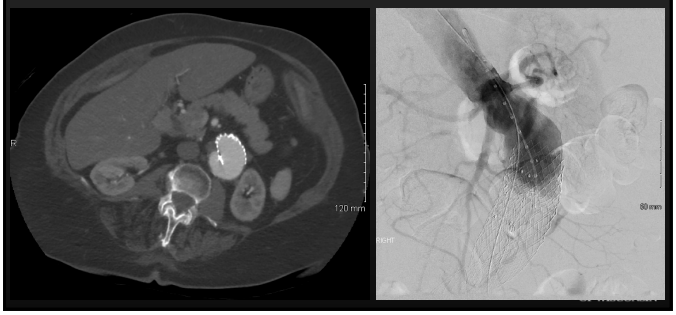
Type 1a: Endograft slip



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Type 1a: Endograft slip/Aortic cuff

- Type 1a from endograft slip
- Failure of proximal graft fixation
- Endovascular treatment = Aortic cuff to bridge slipped endograft and reinstate proximal seal
- Most current generation devices have resolved with active fixation methods

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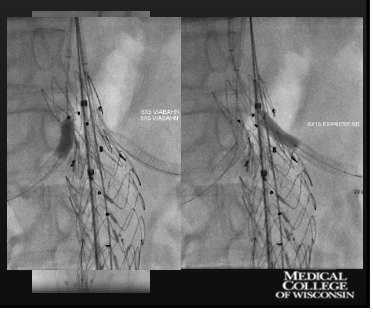
Type 1a: Chimney/Snorkel

- Prior Endologix endograft with infrarenal neck degeneration → Type 1a
- Endovascular plan: Aortic cuff with bilateral renal chimney/snorkels
- Requires groin and upper extremity access



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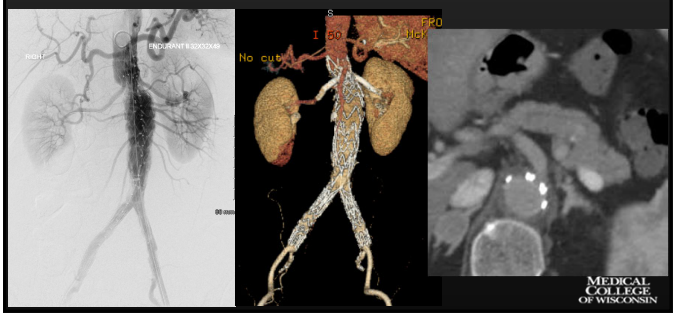
Type 1a: Chimney/Snorkel



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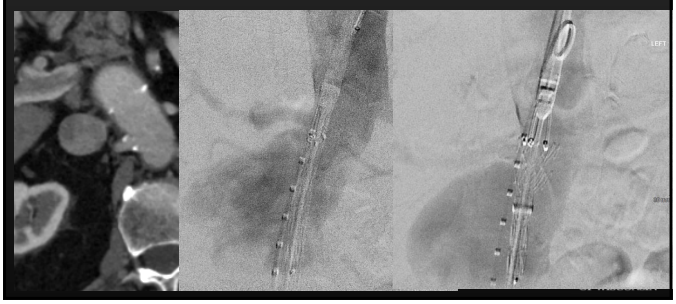
Type 1a endoleak: Short, angulated neck



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Type 1a: Poor wall apposition

- Endograft placement is at the lowest renal
- Outer curve tension, poor wall apposition
- Graft sizing appeared sufficient

- Short angulated neck with poor wall apposition at outer curve (brisk type 1a endoleak) and concern for long-term fixation

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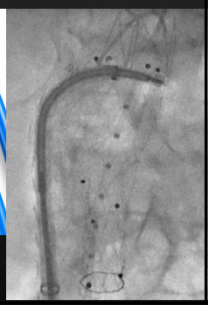
Type 1a: Endoanchor Case

- Augments longitudinal and radial fixation
- Principles of vascular anastamosis
- Will not overcome endograft undersizing
- Meticulous technique to place in appropriate configuration



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Type 1a: Endoanchor

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Type 1a: Endoanchor case

- Two year follow-up CT
- No endoleak

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Hybrid OR
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Full Endovascular Inventory
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Dedicated EVAR Inventory
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Summary

- No solution (open or endo) will work if you get the diagnosis wrong!
- Must tailor the rescue (endo salvage) to the problem at hand
- Not all things can be fixed by endovascular means
- However, not all failed EVAR should go to open repair

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Large vessel lithotripsy and EVAR

Milwaukee Aortic Symposium 2023
4/21/2023
MCW Vascular Surgery Fellow: Mohammad Rajaei

1

Not about patients with kidney stone disease

- Endovascular management of AAA in patients with kidney stone disease requiring Extracorporeal shock wave lithotripsy (ESWL)

Endovascular treatment of abdominal aortic rupture after percutaneous lithotripsy

Affiliations

Endovascular abdominal aortic aneurysm repair to prevent rupture in a patient requiring lithotripsy

Affiliation

Abstract

Extracorporeal shock wave lithotripsy (ESWL) for urolithiasis may result in rupture of a coexistent abdominal aortic aneurysm (AAA). We report a patient who required ESWL and who had an AAA. Open surgery was precluded by morbid obesity and persisting incisional hernias after mesh repair. Endovascular AAA repair (EVAR) with bifurcated grafts was precluded by an 11-mm distal aorta. EVAR with stacked tubular Aneurx components was performed, followed by ESWL. The AAA was excluded, and the integrity and position of the endografts were not altered by ESWL.

2

Background

- Complex vascular access to perform an endovascular aortic aneurysm repair

3

Intravascular Lithotripsy (IVL)

- Angioplasty of calcified lesions is associated with:
  - Residual stenosis
  - Dissection, often requiring stenting
- Intravascular lithotripsy:
  - Multiple emitters mounted on a traditional balloon catheter
  - First clinical trial result published in 2017 (1)

(1) Brodmann, Martin Werner, Todd J. Brinton, Uday Illindala, Alexandra Lansky, Michael R. Jaff, Andrew Holden Safety and Performance of Lithoplasty for Treatment of Calcified Peripheral Artery Lesions, Journal of the American College of Cardiology, Volume 70, Issue 7, 2017, Pages 908-910, ISSN 0735-1097, https://doi.org/10.1016/j.jacc.2017.06.022. (https://www.sciencedirect.com/science/article/pii/S0735109717377823)

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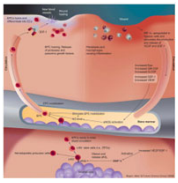
IVL Mechanism of action

- Circumferential pulsatile energy to disrupt calcified plaque
- Activates multiple angiogenic & growth pathways
- Anti-inflammatory effects by upregulation of endothelial nitric oxide synthase (eNOS)
- Improved wound healing



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Implication of IVL

- Both below & above the knee arterial calcification
  - Above knee PAD (DISRUPT PAD III randomized clinical trial)[2]:
    - IVL+DCB had 10% higher short term primary patency rate compared to PTA+DCB
    - IVL+DCB had 17% higher long term (24 month) primary patency rate compared to PTA+DCB
    - 77% decrease in dissection compared to PTA
    - 75% reduction in bail out stenting compared to PTA
  - Below knee PAD:
    - Ongoing RCT for long term results

(2) Adams G, Shammas N, Mangalmurti S, Bernardo NL, Miller WE, Soukas PA, Parikh SA, Armstrong EJ, Tepe G, Lansky A, Gray WA. Intravascular Lithotripsy for Treatment of Calcified Lower Extremity Arterial Stenosis: Initial Analysis of the Disrupt PAD III Study. J Endovasc Ther. 2020 Jun;27(3):473-480. doi: 10.1177/1526602820914598. Epub 2020 Apr 3. PMID: 32242768; PMCID: PMC7288854.

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EVAR and IVL

- First reported cases in 2019 out of Mount Sinai[3]:
  - 83 yo female with infrarenal AAA undergoing EVAR & 82 yo male with AS undergoing TAVR:
    - Heavily calcified CIAs treated with IVL, post- dilated to 10mm by DORADO for EVAR
    - Severe calcification of CIAs & EEIAs treated with IVL for TAVR
- 9 patients (5 male/4 female), between 59-97 years underwent[4]:
  - TAVER (4), TEVAR (1), EVAR (1) & FEVAR (3).
  - Six patients (66.7%) had more than one artery treated
  - Segments treated:
    - CIA (7 patients [77.8%]), EIA (7 patients [77.8%]), CFA (1 patient [11.1%])
    - The mean length of calcification was 42.1 ± 31.1 mm (range, 5.69-109.00 mm).
    - No evidence of distal embolization
    - Average effective luminal gain of 3.67 mm or 229 ± 64.39%

(3) Price LZ, Faries PL, McKinney JF, Prokash K, Tang GHL, Kovacic JC, Tadros RO. The Epidemiology, Pathophysiology, and Novel Treatment of Calcific Arterial Disease. Surg Technol Int. 2019 May 15;34:351-358. PMID: 30825317.

(4) Price LZ, Safir SR, Faries PL, McKinney JF, Tang GHL, Tadros RO. Shockwave lithotripsy facilitates large-bore vascular access through calcified arteries. J Vasc Surg Cases Innov Tech. 2020 Sep 12;7(1):164-170. doi: 10.1016/j.jvscit.2020.09.002. PMID: 33768555; PMCID: PMC7768494.

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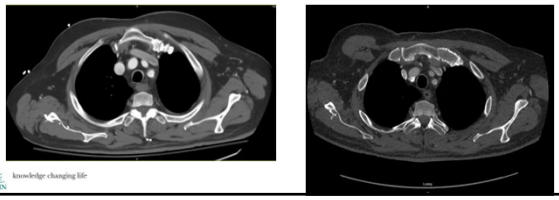
Our experience (TEVAR)

- 73 yo male with PMHx of CAD (s/p STEMI & PCI with 2 stents), HTN & descending thoracic aortic aneurysm presented with back pain:
  - CT scan showing PAU & associated IMH of descending thoracic aorta
  - Admitted to SICU for impulse control (SBP <120, HR <80) & interval CTA



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8

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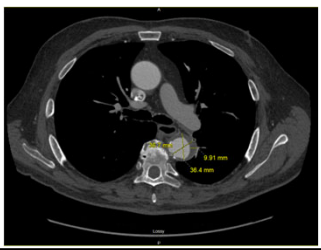

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9

Our experience (TEVAR)

- 73 yo male with PMHx of CAD (s/p STEMI & PCI with 2 stents), HTN & descending thoracic aortic aneurysm presented with back pain:
  - Shockwave IVL of the L CIA to allow for placement of the endograft
  - 8 mm x 60 mm shockwave IVL catheter with 3 cycles of lithotripsy to L CIA
  - Completion angiogram showing luminal gain
  - 2 Piece aortic endograft (both 34mm x 200mm) to treat diseased segment

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Our experience (TEVAR)

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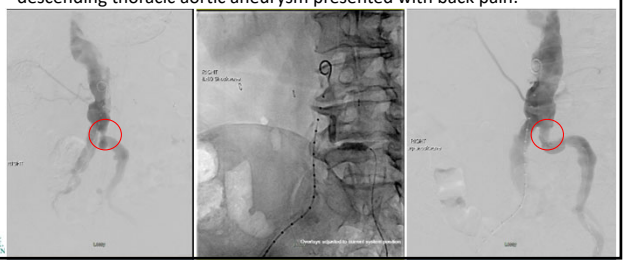

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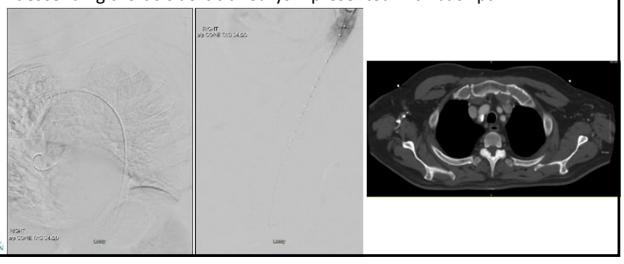
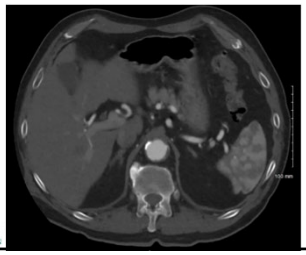
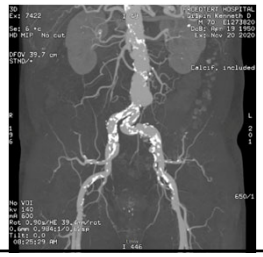


12

Our experience (FEVAR)

- 70 y/o male with a PMH of CAD (s/p 3-v CABG 2 month prior), HTN, HLD, COPD, GERD who presented with 5.8 cm juxtarenal AAA.

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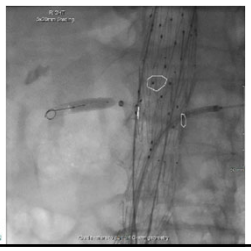
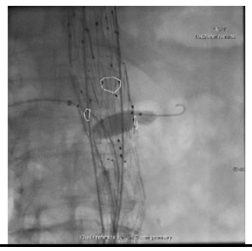

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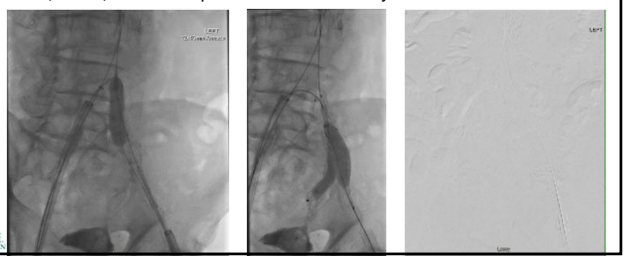

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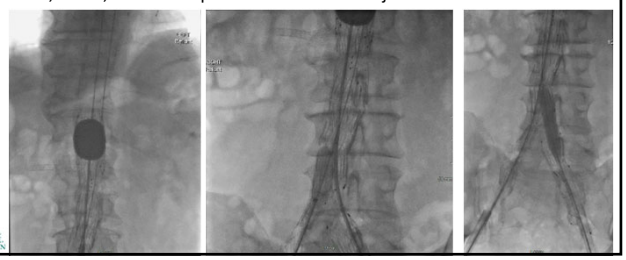

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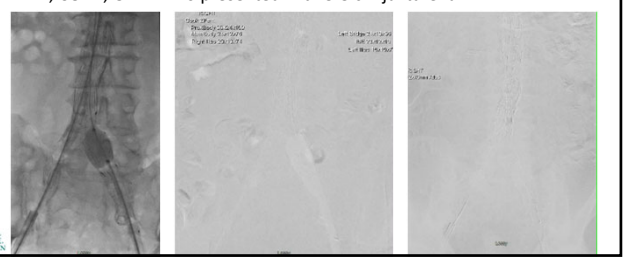

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Discussion & Conclusion

- During endovascular therapy, calcified arterial disease is commonly encountered.
  - With an aging population, this disease will become more common.
  - Despite decreasing endovascular device profiles, vascular access continues to be a frequent concern.
- Must be taken into consideration during EVAR:
  - Excessive iliac tortuosity
  - Small caliber vessels
  - Occlusive arterial disease, and vessel wall calcification.

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Discussion & Conclusion

- The IVL system can be applied based on:
  - Preoperative identification of heavily calcified access vessel
  - Intraoperative imaging
  - Degree of resistance during the introduction of an endovascular device
- Contraindications to IVL device include:
  - Inability to pass a 0.014-inch wire past the lesion
  - In-stent restenosis.

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Thank you for your attention

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Management of Acute Uncomplicated Type B Aortic Dissection

MCW Milwaukee Aortic Symposium, Brian D Lewis, MD, FACS
April 21, 2023

MEDICAL COLLEGE OF WISCONSIN SURGERY

1

Disclosures

- None

2

Acute Aortic Dissection

- Suspected acute aortic dissection
  - Acute dissection is most common aortic emergency
    - 33% are type B
  - 60% male
  - Mean age in 7th decade

3

Acute Aortic Dissection

- Causes
  - HTN 60% – 80%
  - Genetically linked, consider when younger
    - Marfan's syndrome
    - Loeys-Dietz syndrome
    - Ehlers-Danlos syndrome
    - Familial thoracic aortic aneurysm and dissection
  - Congenital
  - PAU
  - Traumatic
  - Drugs
    - Cocaine, amphetamine, methamphetamine, others

4

Confirm Diagnosis

- CTA of chest/abdomen/pelvis
  - Dissection protocol
- Possible cardiac gating
- TEE may be needed

5

Management

- Type A
  - Emergent CT surgery consultation
  - 1% - 2% mortality per hour for first 24 hours
- If malperfusion after type A repair with abnormal pulses, concern for mesenteric ischemia, worsening acidosis, oliguria then repeat imaging

6

Acute Aortic Dissection

- Acute aortic syndrome
  - PAU
  - IMH
  - Dissection

7

Acute Type B Aortic Dissection

- Aortic dissection chronicity (SVS/STS)
  - Hyperacute <24 hour
  - Acute 1 – 14 days
  - Subacute 15 – 90 days
  - Chronic >90 days

8

Acute Type B Aortic Dissection

- Impulse control
  - Limit forces on aorta
    - Limit tachycardia (lower chronotropic effects)
    - Limit SBP (limit ionotropic effects)
- Fist line agents - Beta blockers (rare not to start with Beta-blocker)
- Second line agents - IV Calcium channel blockers
- Analgesia and Anxiolytics
- Typical parameters – SBP <120 mmHg, MAP < 80 mmHg, HR <80 (SVS/STS)
- Can drive lower if tolerated by end organ perfusion/mental status

9

Management

- Type B, uncomplicated
  - Institute medical management as described
  - Monitor for complications
    - Pain, malperfusion, rupture
- Type B, complicated
  - Institute therapy to correct

Acute uncomplicated in hospital mortality of 1% - 6%
All acute in hospital mortality of 14%
Complications develop in Type B 25% - 30% of the time

10

Acute Type B Aortic Dissection

- International Registry of Acute Aortic Dissection (IRAD)
  - 57% treated medically — 10% mortality
  - 32% treated endovascularly — 11 - 14% mortality
  - 7% treated open — 21 - 34% mortality
  - 20% - 50% of those treated medically will have aortic related complications over the next 5 – 7 years

11

Acute Type B Aortic Dissection

- Intensive monitoring
- Arterial access
- Central access (?)
- Foley catheter

12

Acute Type B Aortic Dissection

- Labetalol, Esmolol, Metoprolol
  - Initial target HR <80
  - Initial target SBP 100-120 mmHg

Calcium channel blockers
Sodium nitroprusside
Nicardipine, nitroglycerine
HCTZ
ACE/ARB
Morphine, other analgesics
Anxiolytics

13

Institutional Guidelines

- Guidelines, can be tailored as clinical judgment indicates
  - Admit to ICU
    - Arterial line, adequate IV access, foley catheter
    - NPO, except po meds, at services discretion
    - BP and HR every 5 minutes
  - If HR above goal titrate
  - If BP above goal titrate
  - Add additional IV meds if refractory
  - Pain medication
  - Conversion to oral in consultation with treating service

14

Institutional Guidelines

15

Institutional Guidelines

	Medication	Mechanism	Dose	Titration	Monitoring / Notes
Heart Rate Control	Esmolol	Selective β_1-blocker	Bolus: 50mcg/kg over 1 min Infusion: 25-300mcg/kg/min	Every 5 minutes	• Adverse effects: hypotension, bradycardia
	Metoprolol	Selective β_1-blocker	5-10mg every 4-6 hours Maximum daily IV dose: 100mg IV	Every 4 hours	• Does not profoundly affect blood pressure
	Diltiazem	Non-dihydropyridine calcium channel blocker	Bolus: 0.25mg/kg Infusion: 5-15mg/hr	Every 30 minutes	• Adverse effects: decreased blood pressure • Utilize only in patients unable to tolerate beta blocker or meet heart rate goals with beta-blocker monotherapy • Long half-life; may accumulate well beyond the initial treatment period with upward rate titration
Blood Pressure Control	Nicardipine	Dihydropyridine calcium channel blocker	Infusion: 2.5-15mg/hr; initiate at 2.5-5mg/hr	Every 5 minutes until blood pressure goal is met, then cut the rate in half	• Moderately long half-life; may accumulate well beyond the initial treatment period with upward rate titration
	Nitroglycerin	Vasodilator (venous > arterial)	Infusion: 5-300mcg/min	Every 3-5 minutes	• Adverse effects: headache • Patient may develop tachyphylaxis after 48-72 hours use, resulting in decreased effectiveness and/or increased dose requirements
	Labetalol	Non-selective β-blocker, α_1 blocker	Bolus: 10-20mg IV every 10 minutes; maximum cumulative dose 80mg over 2 hours, then contact MD Infusion: 0.5-2mg / min ; physician titration only every 2-4 hours	Every 2-4 hours	• Adverse effects: decreased heart rate, hypotension • See Figure 2 for more detailed criteria for use • Risk of accumulation, do not increase rate more than every 2 hours; not an ideal agent in patients with labile hemodynamics / upcoming surgeries due to long duration of action and accumulation
	Hydralazine	Vasodilator	Bolus: 10-20mg IV q4 hours	Every 4 hours	• Adverse effects: reflex tachycardia; patients must be on scheduled beta-blocker therapy prior to initiation
	Nitroprusside	Vasodilator (non-selective)	Infusion: 0.3-10mcg/kg/min	Every 3-5 minutes	• Adverse effects: headache, cyanide toxicity (accumulates with prolonged use & in renal dysfunction) • Restricted at Froedtert Hospital to patients with aortic dissection to provide controlled hypotension to reduce bleeding during surgery

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Institutional Guidelines

Table 3. *Commonly Used Oral Medications for Blood Pressure & Heart Rate Management*

	Medication	Mechanism	Dose	Titration	Monitoring / Notes	Discharge
1st LINE AGENTS	Metoprolol tartrate	Selective β_1-blocker	Initial dose: 12.5-25mg q 6-12 hours Maximum total daily dose: 400mg	Every 6 hours	• Usual dose range up to 200mg daily, consider higher dosing pts with refractory heart rates	Recommend every 12 hour regimen
	Metoprolol succinate	Selective β_1-blocker; extended release	Initial dose: 12.5-25mg q12-24 hours Maximum total daily dose: 400mg	Every 12 hours	• Usual dose range up to 200mg daily, consider higher dosing pts with refractory heart rates	May utilize every 12 or 24 hour regimen
	Amlodipine	Dihydropyradine calcium channel blocker	Loading dose: 10mg q 12 hours x 2-3 doses Maintenance dose: 5-10mg PO daily	Every 24 hours	• Adverse effects: fluid retention / edema; consider alternative agents at risk populations (elderly patients) • Loading dose criteria (additional doses must be approved by Vascular Service): still requires nicardipine infusion to control blood pressure 12 hours after initiation of amlodipine	
	Carvedilol	Non-selective β-blocker, α_1 blocker	Initial dose: 3.125-12.5mg q 12 hours Maximum total daily dose: 50mg	Every 12 hours		Every 12 hour regimen

17

Institutional Guidelines

	Medication	Mechanism	Dose	Titration	Monitoring / Notes	Discharge
1st Line Agents	Lisinopril	ACE inhibitor	Initial dose: 5-10mg PO daily Maximum daily dose: 40mg	Every 12 hours	• Adverse effects: Hyperkalemia, acute kidney injury • Use with caution in patient with AKI or renal involvement on scans • Contraindicated in patients with a history of angioedema to ACEI or ARBs • Contraindicated in patients already taking an ACEI or ARB	
	Losartan	Angiotensin receptor blocker	Initial dose: 25-50mg PO daily Maximum daily dose: 100mg	Every 24 hours	• Adverse effects: hyperkalemia, acute kidney injury • Contraindicated in patients with a history of angioedema to ACEI or ARBs • Contraindicated in patients already taking an ACEI or ARB	
2nd Line Agents	Hydrochlorothiazide	Thiazide diuretic	Initial dose: 12.5-25mg PO daily Maximum daily dose: 50mg	Every 24 hours	• Adverse effects: Electrolyte disturbances; most commonly hyponatremia, seen frequently in the elderly	
	Clonidine	α_2 blocker	Initial dose: 0.1mg PO (or SL) every 8-12 hours Maximum daily dose: 0.3mg PO TID Patch: initiate at 0.1mg/hr-0.3mg/hr; + PO taper	Every 8 hours	• Initiation of patch requires concomitant PO taper for ~72 hours until patch reaches steady state • Abrupt discontinuation may cause withdrawal symptoms (tachycardia)	
	Hydralazine	Vasodilator	Initial dose: 25-50mg PO every 8 hours Maximum daily dose: 300mg	Every 8 hours	• Adverse effects: reflex tachycardia	Patients must be on a scheduled beta-blocker regimen
	Nifedipine XL (immediate release formulation not recommended)	Dihydropyradine calcium channel blocker	Initial dose: 30-60mg PO daily Maximum daily dose: 90mg PO daily	Every 24 hours	• Immediate release formulation not recommended as it may cause cerebral or myocardial ischemia • Do not recommend concomitant use with amlodipine	

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Summary

- Institute medical therapy
- Confirm diagnosis
- Continuously evaluate for malperfusion
- Extra caution in high-risk dissections
  - Large entry tear, large false lumen, tear on inner curve, circular false lumen, larger aortic diameter, ongoing pain, hemorrhagic effusion, end organ dysfunction
- Medical management for correct patients
- If tolerated no intervention in hyperacute/early acute phase
- Success requires a multidisciplinary team and extensive resources

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Thank you

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Medical Management of Patients with Aortopathy

Salil Ginde, MD, MPH

Director of Marfan and Related Connective Tissue Disorder Program
Adult Congenital Heart Disease
Associate Professor of Medicine and Pediatrics
Medical College of Wisconsin

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MEDICAL COLLEGE OF WISCONSIN

1

Disclosures

I have no relevant financial disclosure or commercial interests

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2

Objectives

Discuss how new insights on the genetics and molecular basis of aortic aneurysms help guide

1. *Medical management*
2. *Timing of prophylactic intervention*

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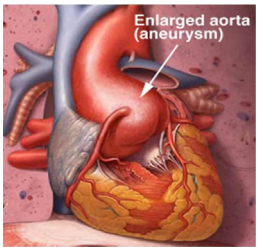
Thoracic Aortic Aneurysms

Thoracic aortic aneurysm prevalence = 1-2%

Causes:

- Degenerative or sporadic ≈ 70-75%
- Heritable conditions ≈ 20-25%
- Congenital heart disease
- Aortitis
- Trauma



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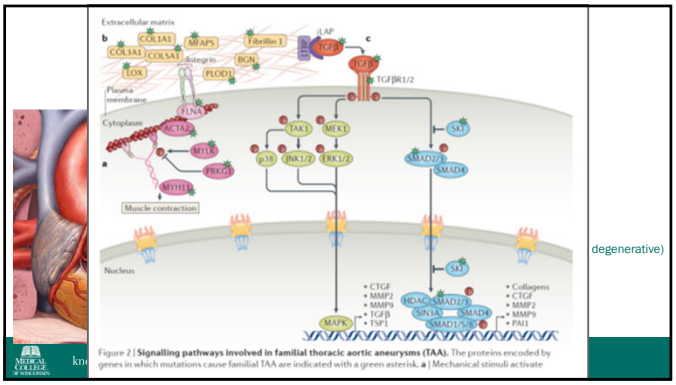
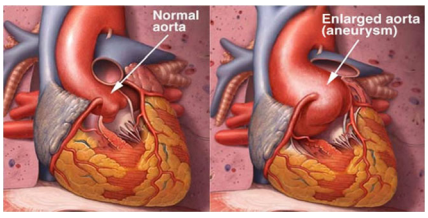


degenerative)

Figure 2 | **Signalling pathways involved in familial thoracic aortic aneurysms (TAA).** The proteins encoded by genes in which mutations cause familial TAA are indicated with a green asterisk. **a** | Mechanical stimuli activate

5

Thoracic Aortic Aneurysms



Asymptomatic

Aortic dissection

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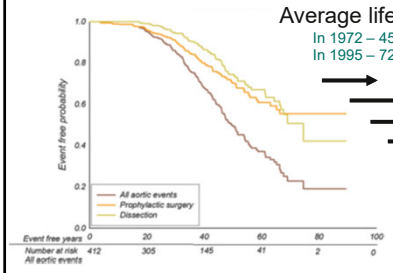
Marfan syndrome: Freedom from Aortic Event



Average life expectancy
In 1972 – 45 years
In 1995 – 72 years (similar to general population)

Goals of Medical Therapy:
- Slow aortic dilation
- Delay intervention
- Treat HTN and other risk factors for dissection
- Timely referral for intervention

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Groth et al. Clin Res Cardiol 2017
Murdoch et al. N Engl J Med 1972
Silverman et al. Am J Cardiol 1995

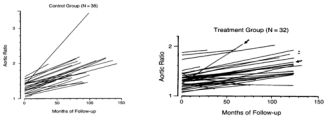
7

PROGRESSION OF AORTIC DILATATION AND THE BENEFIT OF LONG-TERM β-ADRENERGIC BLOCKADE IN MARFAN'S SYNDROME

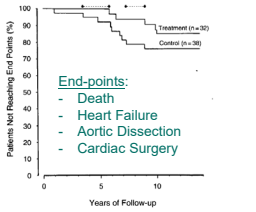
Jennifer Shores, M.D., Kenneth R. Berger, M.D., Ph.D., Edmond A. Murphy, M.D., Sc.D., and Reed E. Pyeritz, M.D., Ph.D.

70 teen/adult Marfan patients
- **32 propranolol**
- **38 placebo**
- **10 year follow-up**

Slowed rate of aortic dilation



Lowered risk for aortic complications



End-points:
- Death
- Heart Failure
- Aortic Dissection
- Cardiac Surgery

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Shores et al. N Engl J Med 1994

8

Beta-blockers and Marfan Syndrome

- Beta blockers became primary medication to slow growth of aortic aneurysms
- Subsequent studies showed that majority of patients on beta-blockers
  1. still had progression of aneurysm
  2. at risk for aortic dissection and/or needed heart surgery.

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Salim, et al. Am J Cardiol 1994
Rossi-Foulkes, et al. Am J Cardiol 1999
Salamet Tierney, et al. J Pediatr 2007
Ladouceur M, et al. Am J Cardiol 2007

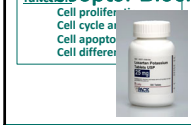
9

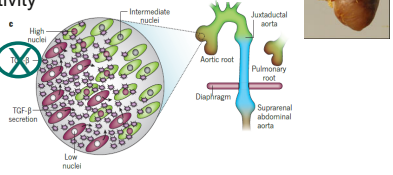
Insights from Marfan Mouse Model

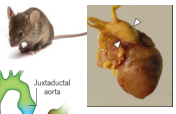
- Fibrillin-1 has a functional role in aorta:
  - Fibrillin-1 regulates a growth factor - TGF-B
  - Mice had ↑↑ TGF-B activity

Angiotensin Receptor Blockers

Regulates cellular function
Cell proliferation
Cell cycle activity
Cell apoptosis
Cell differentiation







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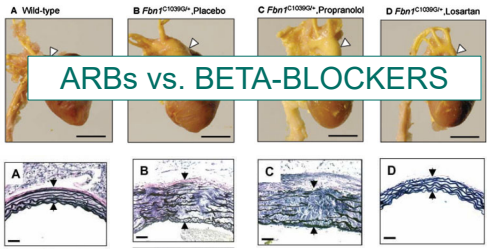
Lindsay and Dietz. Nature 2011

10

Losartan in Marfan Mouse



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Habashi, et al. Science 2006

11

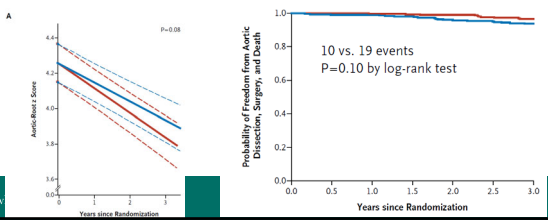
The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 NOVEMBER 27, 2014 VOL. 371 NO. 22

Atenolol versus Losartan in Children and Young Adults with Marfan's Syndrome

Lacro, et al. N Engl J Med, 2014

608 Marfan pts (1 to 25 y/o)



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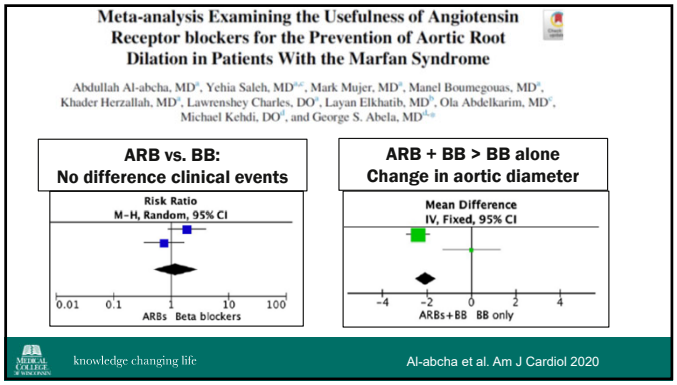
Meta-analysis Examining the Usefulness of Angiotensin Receptor blockers for the Prevention of Aortic Root Dilation in Patients With the Marfan Syndrome
Abdullah Al-abcha, MD, Yehia Saleh, MD, Mark Mujer, MD, Manel Boumegouas, MD, Khader Herzallah, MD, Lawrenshey Charles, DO, Layan Elkhatib, MD, Ola Abdelkarim, MD, Michael Kehdi, DO, and George S. Abela, MD
ARB vs. BB:
No difference clinical events
Risk Ratio
M-H, Random, 95% CI
0.01 0.1 1 10 100
ARBs Beta blockers
ARB + BB > BB alone
Change in aortic diameter
Mean Difference
IV, Fixed, 95% CI
-4 -2 0 2 4
ARBs+BB BB only
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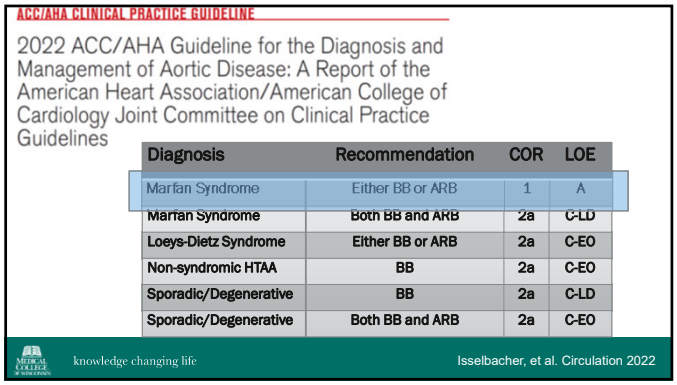
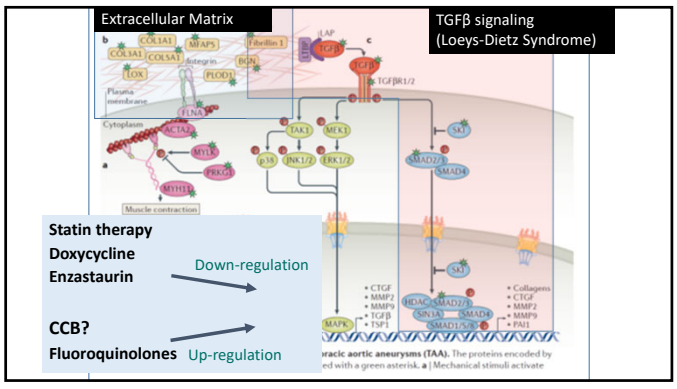
Al-abcha et al. Am J Cardiol 2020

13


ACC/AHA CLINICAL PRACTICE GUIDELINE
2022 ACC/AHA Guideline for the Diagnosis and Management of Aortic Disease: A Report of the American Heart Association/American College of Cardiology Joint Committee on Clinical Practice Guidelines
Diagnosis | Recommendation | COR | LOE
Marfan Syndrome | Either BB or ARB | 1 | A
Marfan Syndrome | Both BB and ARB | 2a | C-LD
Loeys-Dietz Syndrome | Either BB or ARB | 2a | C-EO
Non-syndromic HTAA | BB | 2a | C-EO
Sporadic/Degenerative | BB | 2a | C-LD
Sporadic/Degenerative | Both BB and ARB | 2a | C-EO
knowledge changing life
Isselbacher, et al. Circulation 2022

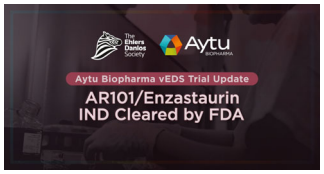
14


Extracellular Matrix
TGFβ signaling
(Loeys-Dietz Syndrome)
Statin therapy
Doxycycline
Enzastaurin
Down-regulation
CCB?
Fluoroquinolones
Up-regulation

15

Vascular EDS Phase 3 Trial

Aim: RCT to evaluate efficacy safety, pharmacokinetics of Enzastaurin in preventing arterial events in vEDS pts w/ COL3A1 mutations



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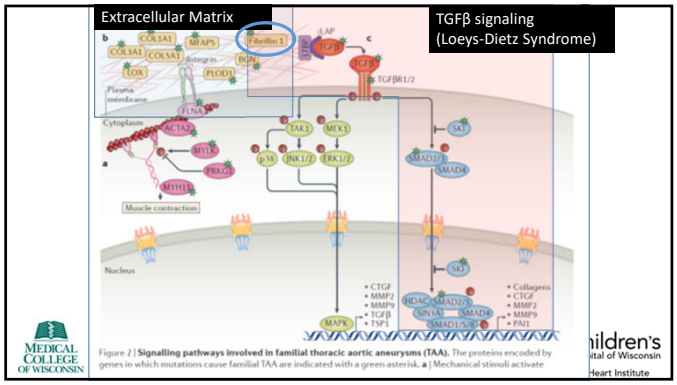

17

Marfan syndrome

Loeys-Dietz Syndrome

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ACC/AHA CLINICAL PRACTICE GUIDELINE

2022 ACC/AHA Guideline for the Diagnosis and Management of Aortic Disease: A Report of the American Heart Association/American College of Cardiology Joint Committee on Clinical Practice Guidelines

Criteria for Prophylactic Aortic Root Replacement:

Marfan syndrome = 5.0 cm

Loeys-Dietz syndrome = 4.5 cm

✓SIZE
✓GENETICS

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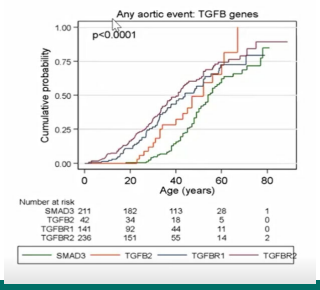
19

TGFB genes and Risk of Aortic Event

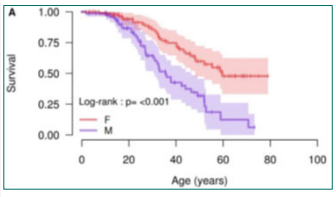


knowledge changing life Regalado, et al. J Am Coll Cardiol, 2022

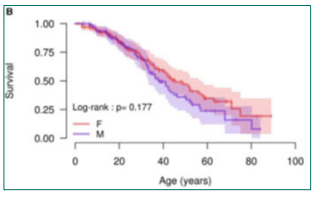
20

Gender Differences in Age of Aortic Events

TGFBR1 mutation



TGFBR2 mutation



knowledge changing life Regalado, et al. J Am Coll Cardiol, 2022

21

Loeys Dietz Syndrome: Dissections < 4.5 cm

- TGFBR 1 and 2 (6 patients)
  - Female
  - Aortic tortuosity
  - Hypertelorism
  - Wide scars
- SMAD3 (3 patients)
  - HTN
  - History of smoking

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Regalado, et al. J Am Coll Cardiol, 2022

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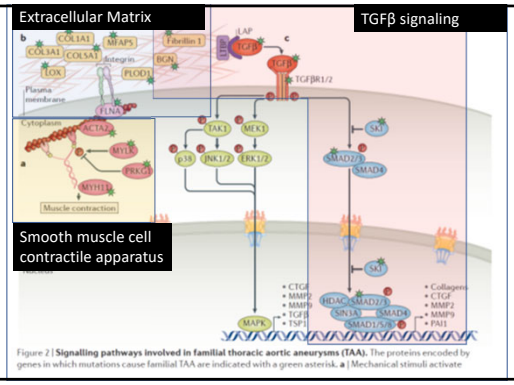

Figure 2 | **Signalling pathways involved in familial thoracic aortic aneurysms (TAA).** The proteins encoded by genes in which mutations cause familial TAA are indicated with a green asterisk. **a** | Mechanical stimuli activate

23

Nonsyndromic Hereditary Thoracic Aortic Disease

- Autosomal dominant inheritance
- Decreased penetrance, variable expression
- Minimal systemic features
- 20% of pts have a first-degree relative w/ TAAD
- Caused by genetic variants that disrupt a protein in vascular SMC contractile unit and alter smooth muscle cell force generation

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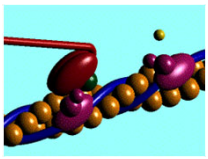
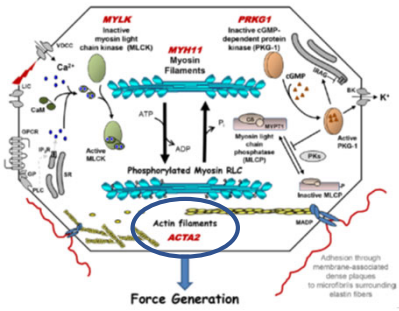
Vascular Smooth Muscle Cell Contraction





Milewicz, et al. Arterioscler Thromb Vasc Biol 2017

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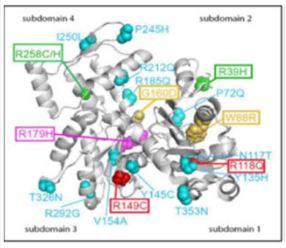
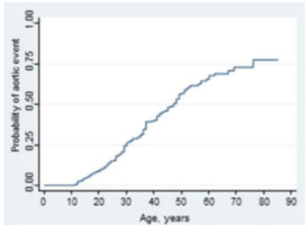
ACTA2-Associated Aortic Disease





Median Age at Aortic Event = 46 y/o
33% Dissected at Dimension < 5.0 cm

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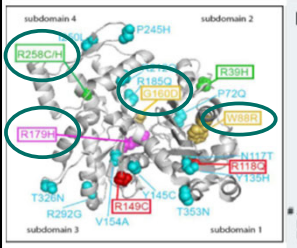
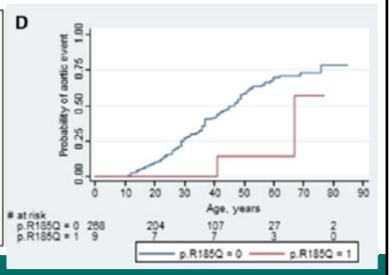
ACTA2-Associated Aortic Disease





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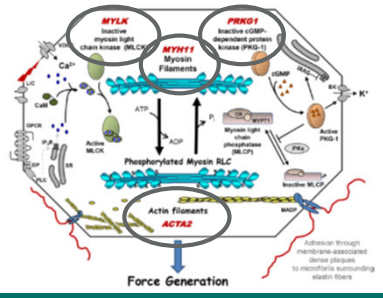
Nonsyndromic Hereditary Thoracic Aortic Disease



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Milewicz, et al. Arterioscler Thromb Vasc Biol 2017

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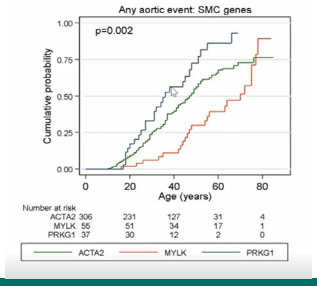
SMC Genes and Risk of Aortic Event



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Regalado, et al. J Am Coll Cardiol, 2022

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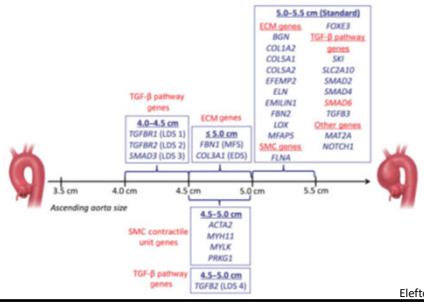
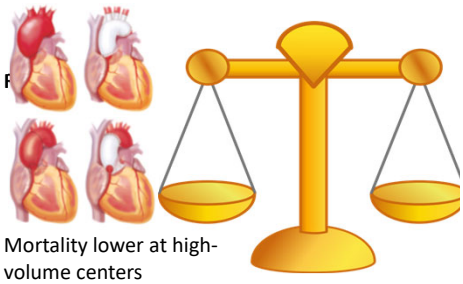
Gene-based Timing of Prophylactic TAA Surgery



Elefteriades, et al. Aorta 2018

30

Considerations of TAA Surgical Timing



Mortality lower at high-volume centers

- Loeys-Dietz syndrome
- Familial Aortopathy
- Marfan syndrome
- Bicuspid Aortic Valve
- Degenerative Aortopathy
- Congenital Heart Disease

31

Summary

- Medical management has important role to:
  - slow progression of aneurysmal growth
  - treat HTN and other risk factors for dissection
- Insights into the genetic and molecular basis for TAA can help guide medication choices and timing for intervention

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Salil Ginde, MD
414-266-3627
sginde@mcw.edu

33

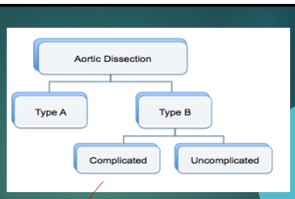
Malperfusion Syndromes in Type B Aortic Dissection

MUSTAFA HADDAD, MD

1

Disclosures: None

2



Complicated Dissection Includes:
-Malperfusion
-Uncontrolled hypertension or pain
-Rupture
-Shock

3

Introduction

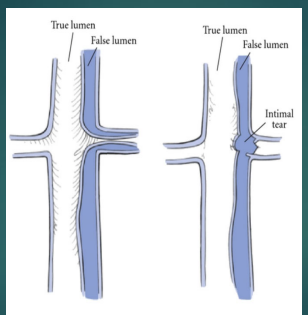
- Malperfusion syndromes manifest due to end-organ ischemia from aortic dissections.
- Signs of malperfusion can be subtle with Type B dissections.
- Symptoms onset can range from time of dissection to weeks after.
- Incidence is around 10-20% despite optimal medical management[1].

4

Pathogenesis/Why does this happen?

- Dissection disrupts the intima resulting in blood propagating within the media.
- Blood within the media is the false lumen.
- A pressure gradient develops between the true and false lumens that dictates the evolution of the dissection.
- Due to the gradient, the false lumen can propagate at aortic branch ostia[2].

5



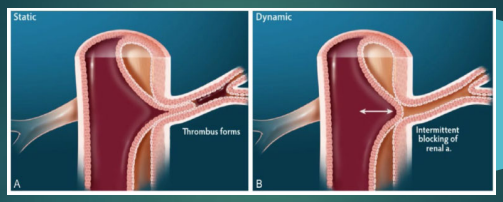
Harrington DK, Ranasinghe AM, Shah A, Oakhee T, Bonser RS. Recommendations for haemodynamic and neurological monitoring in repair of acute type a aortic dissection. Anesthesiol Res Pract. 2011;2011:949234. doi: 10.1155/2011/949234. Epub 2011 Jul 14. PMID: 21776255; PMCID: PMC3137975

6

Pathogenesis Continued

- Subsequent vessel compromise can be persistent (static) or intermittent (dynamic)[3].
- Once there is false lumen involvement of the ostia, a local inflammatory response is elicited.
- The inflammatory response results in further injury to the branch vessel in addition to releasing cytokines.
- The above results in end-organ ischemia[4].

7



Crawford TC, Beaulieu RJ, Ehlert BA, Ratchford EV, Black JH 3rd. Malperfusion syndromes in aortic dissections. Vasc Med. 2016 Jun;21(3):264-73. doi: 10.1177/1358863X15625371. Epub 2016 Feb 8. PMID: 26858183; PMCID: PMC4874056.

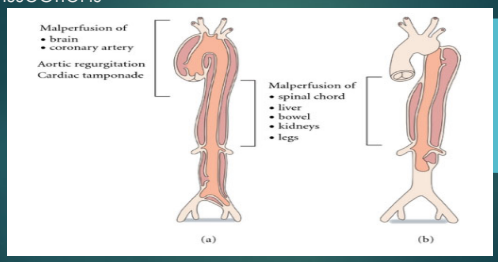
8

Symptoms

- Pain is a common manifestation of malperfusion.
  - Onset is usually abrupt.
- Symptoms can otherwise vary and depend on the affected vascular bed.
- More than one vascular bed can be involved simultaneously.

9

Malperfusion locations in type A and B Dissections



Deborah K. Harrington, Aaron M. Ranasinghe, Anwar Shah, Tessa Oelofse, Robert S. Bonser, "Recommendations for Haemodynamic and Neurological Monitoring in Repair of Acute Type A Aortic Dissection", *Anesthesiology Research and Practice*, vol. 2011, Article ID 949034, 14 pages, 2011. https://doi.org/10.1155/2011/949103

10

Physical Exam Findings

- Pain, especially an abrupt onset or change in pain, should raise concern for malperfusion.
- Changes in sensory and motor function of the extremities should raise concern for paralysis.
- Changes in pulse exam and lower extremity perfusion (pain, pallor, paresthesias, poikilothermia, etc) should elicit concern for lower extremity malperfusion.

11

Additional Clinical Findings

- Changes in urine output and refractory hypertension should raise concern for renal ischemia.
- Changes in appetite, oral intake tolerance, and bowel habits should raise concern for bowel ischemia.

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Lab Findings

- Elevated LFTs and bilirubin can be associated with hepatic ischemia.
- Change in creatinine/eGFR is associated with renal ischemia.
- Metabolic acidosis and elevated lactate and amylase is associated with mesenteric ischemia.

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Imaging

- CTA is an invaluable tool that can asses the true and false lumens and which branches they involve.
  - Can also identify signs of malperfusion such as bowel stranding with mesenteric ischemia and delayed neprhograms with renal ischemia
- MRA can also adequately evaluate the lumens and branch vessels although timing is longer and availability varies.
- US is another option that can focus on a particular vascular bed.

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Prevention

- Aggressive blood pressure and heart rate control
  - Beta-blockers, vasodilators, and calcium channel blockers
- Pain management[5]

15

Treatment

- TEVAR allows for favorable aortic remodeling with much less morbidity compared to open intervention.
  - False lumen thrombosis ranges around 80% with TEVAR[6].
- Data shows superiority of TEVAR over open intervention[7,8].
- IVUS further improves TEVAR outcomes by identifying true and false lumens and relationships between dissection flaps and ostia[9].
- Aortic scaffolding (PETTICOAT), fenestration, and branch artery stenting are additional endovascular techniques that may be required.

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Open Treatment

- Despite TEVAR being the principal treatment option, open surgical intervention still has vital roles and can be complimentary to endovascular intervention.
- Extra-anatomic bypass and open fenestration are options for visceral and lower extremity ischemia.
- With mesenteric ischemia, immediate laparotomy and removal of ischemic bowel is needed before surgical fenestration/extra-anatomic bypass or endovascular management.

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Can Early TEVAR Prevent Development of a Malperufsion Syndrome?

- Despite INSTEAD trial not showing a benefit[10], INSTEAD XL demonstrated a benefit in terms of 5 year aorta specific survival and disease progression in treating uncomplicated type B dissections with TEVAR[11].
- TEVAR allows for favorable aortic remodeling[12].
- Patients regardless require stringent blood pressure management and surveillance.

18


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Management of the Residual Dissection After Successful Type A Repair

Milwaukee Aortic Symposium – April 21, 2022
Kosta Karabetsos, MS-4
@kosta_md

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Disclosures

None

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2

Objectives

- **Type A Aortic Dissection**
  - Epidemiology
  - SVS/STS Reporting Standards
  - Surgical Management
- **The Residual Dissection in the Chronic Phase**
  - The Surveillance Period – Medical Management and Aortic Remodeling
  - Endovascular / Open
  - The Patient
- **Can We Predict who will Remodel Negatively?**
- **Future Directions**

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Aortic Dissections

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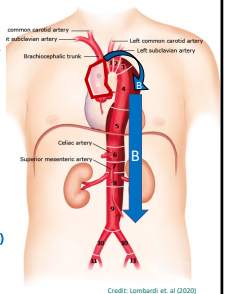
Epidemiology

- **Acute Type A Aortic Dissection (TAAD)** is the most common catastrophic event affecting the aorta and carries high mortality[1]
  - Incidence: 5-24/100,000 person-years.
  - *Mortality If untreated – 20% within 6hrs, 50% within 1 day.*
  - **In-Hospital Mortality** ↓ from 31% to **22%** in recent years
    - Driven by ↓ surgical mortality, ↑ referral to high-volume centers
  - **Mortality –** primarily cardiac in nature (extension of dissection flaps into coronaries, acute aortic regurgitation, MI).
- New SVS/STS Reporting Guidelines[2]
  - Delineated functional aortic landing zones 0-11
    - **Type A – Zone 0 origin – (~66% of primary dissections)**
      - Treatment – Impulse control + Emergent surgery
    - **Type B (TBAD) – Zn 1-11 origin – (~33% of primary dissections)**
      - Treatment – Impulse control → Medical Management ± Endovascular repair in subacute phase (Day 14-90)



Credit: Lombardi et. al (2020)

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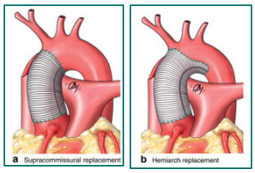
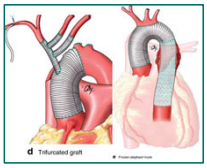
Fixing the Type A Dissection[1,3]



~59% ~27%

Limited Ascending Aortic Repairs



~12%

Extensive "Total Arch" Reconstructions
(Many Open/Hybrid variations)

92% of all operations for Acute Type A Aortic Dissection required Cardiopulmonary bypass (CpB)
↑CpB time → ↑Mortality

Image credits: British Journal of Surgery, Volume: 99, Issue: 10, Pages: 1331-1344, First published: 07 September 2012

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After Successful TAAD Repair: The Residual Dissection

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Problem: The Residual Dissection[4,5,11]

- Even if the primary entry tear is addressed by initial repair – there often remains unaddressed dissection flap distally – This is the Residual Dissection (rTAAD)
- **rTAAD is functionally managed as chronic, uncomplicated TBAD**
  - Medical management
  - CT Surveillance @ 1/6/12 months (or in-between), & annually thereafter.
    - Assesses for **Aortic Remodeling**
- **Patients with TBAD differ from those with rTAAD**
  - Receive more endovascular interventions
  - Treatment guidelines & devices within IFU for this specific indication are **well-studied** (ascending aortic endografts in development).
    - This includes optimal timing of the endovascular intervention
    - No prior surgery which would alter the natural history of the disease

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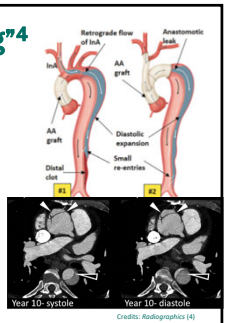
"Aortic Remodeling"[4]

Many definitions – but for our purposes – as below:

- **Positive** – aortic shrinkage, expansion of true lumen after intervention.
- **Negative** – aortic growth– *"aneurysmal degeneration"*
  - Rates estimated as high as 50-75% in rTAAD.
  - Negative remodeling occurs via mechanisms resulting in continued pressurization (patency, partial thrombosis) of FL
    - **Fenestrations** in dissection flap
      - Dissected branch vessels, renal artery origin
    - Retrograde perfusion from intercostal, lumbar arteries.
    - **Mechanical expansion of FL during diastole with fibrosis of dissection flap years later – encourages FL flow.**



Credits: Radiographics (4)

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Problem: Dissection Flap

- **INSTEAD(-XL) Trial – Optimal timing of Thoracic Endovascular Aortic Repair (TEVAR) when TBAD is primary? Is there a survival benefit relative to Medical mgmt (OMT)?[5]**
  - Best outcomes to induce positive remodeling/minimize procedure complications seen in the Subacute phase – 82-90% success rate[4,6].
    - Flap remodeling in subacute phase is optimal (not as friable as the acute phase, not as fibrotic as in the chronic phase.
  - *No added benefit of TEVAR for 2-year aortic survival.*
  - ***(-XL)*** *TEVAR > OMT in 5-year survival.*

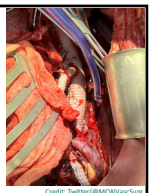
- **In rTAAD typically meets criteria for reintervention well into the Chronic Phase –** distal causes of FL pressurization become much more challenging to address.
  - **TEVAR/Knickerbocker Technique[6] → induce controlled rupture of flap by ballooning within the stent graft** → collapse FL → thrombosis of FL
  - **'Candy Plug'/'Endo Trash' Techniques[7] → modified dead-end stent grafts** deployed into FL
  - Visceral Vessels?

Credits: *Journal Endo Therapy (6) Journal Vasc Surgery (7)*

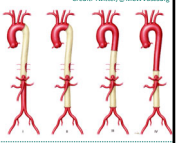
10

Can We Do It Open?[8]

- When reintervention becomes indicated in **rTAAD** (Maximal Aortic Diameter ≥55mm) and we anticipate a difficult reintervention, **we talk about it.**
  - **Complex Aortic Case Conference – Multi-disciplinary team** of Cardiac/Vascular Surgery, Interventional Radiology, Pediatric Cardiology, Genetics.
    - **TEVAR (+adjuncts) vs Open Thoracoabdominal Aortic Aneurysm Repair?**
- **Open: ↑ Risk Spinal Cord Ischemia** (Extent II 22%, All TAAA Repairs 5-11%)
  - vs ~2% for TEVAR
  - Depending on TAAA Extent, may require CpB again.
- Patient-Specific Factors
  - **Genetic Aortopathies** (e.g., Loeys-Dietz, Marfan, Familial Aortic Syndromes). VEDS may be better served by open repair (*SVS guidelines pending*).
  - **Activity Levels, comorbidities since & prior to initial dissection.**



Credit: Twitter/@MCWVascSurg



Credit: Baylor College of Medicine

11

Problem: Patient

- March 2022 – Aortic Dissection Collaborative established patient-centered priorities related to those living with AD, a 'medical trauma'.
- **Review of mental health impact of disease[9]:**
  - Chaddha, 2015 – **↑ physical inactivity**, ↑ **new-onset anxiety/depression (32%, 32%).**
  - Pasadyn, 2020 – **23% screened positive for PTSD for a median of 6.8y after AD**.
  - Meinlschmidt, 2020 – elaborated on need for psychosocial attention in the following areas
    - **Changes in every-day life, Anxiety, Tension/stress, trust in the body**
  - Luo, 2021 – **38.9% with sexual dysfunction** after surgery, ↑ prevalence in elderly.

Key Points –

- **The patient is rarely (if ever) healthier than when they first emergently presented with TAAD**
- **The psychological sequelae of TAAD pose threats to the patient's Quality of Life (QoL) that they live with between each surveillance visit.**

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Can we predict who will remodel negatively?

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Purpose

- Despite **Maximal Aortic Diameter (MAD)** being
  - a parameter that defines aortic remodeling
  - a parameter that defines an indication for reintervention to prevent rupture
- The decision to reintervene on rTAAD in the *initial hospitalization – when traditional high-risk features are absent* – remains unclear.
- Specifically – can the MAD in any aortic zone/combination of zones at the ***initial presentation*** **of acute TAAD** predict long-term negative remodeling?

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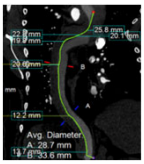
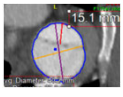
Methods - Measurements

- All initial Type A dissections treated surgically at our center between 2015→2020 by ICD-10, CPT-4 codes.
- **Pre-Operative "initial" CT scans** → MAD in each aortic zone was measured via centerline technique and according to SVS/STS Reporting standards[2].
- ALL available serial surveillance CT scans were reviewed & MAD measured to sort patients into 3 groups based on remodeling:
  - Negative (>3mm growth over all available CT scans),
  - Stable
  - Positive (>3mm shrinkage).

Exclusion

- Perioperative death (during surgery + initial hospitalization)
- Lost to follow-up/no post-op surveillance images.





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Methods - Statistics

- For patients with missing measurements (bovine arches, distal aortic zones) a binary variable (0/1) was randomly assigned to each, as to permit analysis with proportional odds regression (POR) models.
- Univariate POR
  - Independent of other zones, is zone x related to the remodeling outcome?
- **Akaike Inclusion Criterion (AIC)-guided Multivariate POR**
  - In the context of how other zone diameters change, does any zone appear to be an 'outlier'?
  - "AIC-guided" – a validated method of tailoring a multivariate analysis to assess parameters which are *most representative* of the overall study population.
    - Representative zones were informed by Univariate POR and 'Binary' variables.
- **Effect Plot**
  - Visualized odds of each remodeling outcome as a function of increasing MAD in statistically significant zones as enlightened by the multivariate model.
- Outcomes presented **as Odds Ratios (OR) for every 1-mm increase in MAD**.

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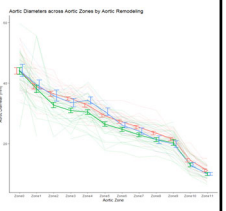
Results (1)

- Between 2015-2020, 98 patients presented to our center with Acute TAAD and were treated surgically.
- **63 patients met inclusion criteria.**
  - **n=26 (41.2%) – Negative Remodeling (NR)**
  - **n=30 (47.6%) – Stable (St)**
  - **n=7 (11.1%) – Positive Remodeling (PR)**
- *Excluded*
  - *21 – Perioperative Death*
  - *14 – Lost to Follow-Up*

Zone #	NR (n=26) [1]	St (n=30) [1]	PR (n=7) [1]	p-value [2]
0	43.1 (39.6, 48.9)	44.0 (41.0, 47.9)	44.0 (41.8, 44.7)	>0.9
1	38.7 (36.4, 41.9)	39.2 (35.8, 40.1)	38.6 (36.6, 41.0)	0.8
2	35.8 (34.1, 38.4)	33.8 (30.0, 35.2)	36.2 (33.9, 38.2)	0.02*
Bovine Arch (n)	6	7	3	-
3	35.0 (32.5, 37.2)	32.3 (27.3, 33.9)	33.2 (31.7, 36.2)	0.003*
4	32.6 (31.6, 34.1)	29.9 (28.5, 33.2)	33.4 (31.9, 36.6)	0.014*
5	29.1 (27.4, 31.1)	26.6 (24.1, 29.2)	30.2 (28.6, 33.2)	0.008*
6	27.4 (25.6, 28.8)	25.0 (22.7, 27.5)	27.1 (24.4, 27.1)	0.040*
NA (n=23)	2	2	1	-
7	25.2 (23.7, 27.0)	22.6 (21.1, 25.1)	23.4 (22.6, 26.1)	0.053
NA (n=23)	3	20	2	-
8	23.5 (22.0, 24.5)	20.8 (19.8, 22.4)	21.4 (20.2, 22.1)	0.044*
NA (n=23)	3	20	2	-
9	21.8 (20.7, 22.6)	20.4 (17.2, 23.6)	19.7 (18.8, 21.4)	0.5
NA (n=28)	3	23	2	-
10	14.4 (12.8, 16.8)	12.7 (10.6, 15.3)	13.8 (11.7, 14.0)	0.2
NA (n=28)	3	23	2	-
11	11.5 (9.5, 12.7)	9.9 (8.7, 15.4)	10.0 (9.7, 10.2)	0.3
NA (n=31)	4	24	2	-

[1] Median (IQR) mm; [2] Kruskal-Wallis Rank Sum Test



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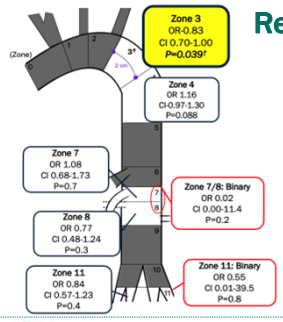
Results (2)



- **AIC-guided Multivariable Analysis**
- **For every 1-mm increase in Zone 3 MAD** at initial presentation, there is a **1.205x increased risk of negative remodeling**.
  - (1/0.83)
  - 95% Confidence Interval - 0.7-1.0

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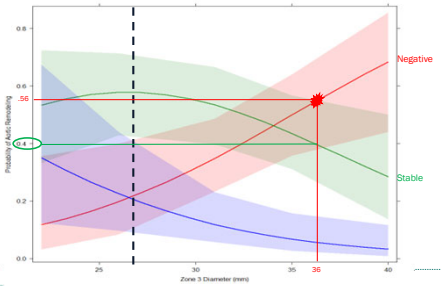
Results (3) - Effect Plot–Zone 3



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Conclusions
Future Directions

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Summary – rTAAD after Initial Repair

- Acute TAAD remains a highly lethal pathology, but surgical mortality continues to improve → **more patients surviving into the chronic phase.**
  - Rate of **negative** aortic remodeling is high at 50-75%[4]
  - Patient's likelihood of requiring reintervention with current standard of care may be relatively low regardless of initial approach (est. 15-30% at 10 years)[3,10]
- Standard of care for **rTAAD** currently mirrors that of Chronic TBAD (OMT+surveillance)
- Reintervention, when indicated, often occurs years later – less favorable conditions.
  - **Patient –** less activity post-dissection and real QoL concerns after surviving TAAD.
  - **Pathology –** Landing zones, opposition of the fibrotic flap against aortic wall, visceral perfusion.
    - **Techniques off of IFU are often applied (in varying manners) to ensure complete thrombosis of the FL.**

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Summary – rTAAD

- MAD_{Zn3} ≥36mm may identify a group that is **high-risk** for negative remodeling, eventual reintervention.
  - **56% Odds of Negative remodeling**
  - **40% Odds (and at most 56%) of remaining stable**
  - **Study Limitations**
    - Retrospective study ⟶ recency of cohort may overestimate 'stable' group;
    - Need for inclusion of 'binary' variables in analytical model d/t lack of distal zone measurements may decrease strength of association.
- Favorable pathologic/anatomic characteristics of the aorta drive the success of TEVAR (and its adjuncts) in the subacute phase when TBAD is the primary pathology.
  - **New Branched arch endograft devices can now be applied and utilized within IFU to aid safe intervention.**

Prospective studies should be applied to determine whether early re-intervention may confer a survival benefit for this subset of patients with rTAAD.

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Thank You

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Session IV Update on Dissection: Case Presentation

Paul Dyrud, MD PGY5 General Surgery Resident

1

Presentation

HPI: A.S. is a 64 yo male with PMH significant for hypertension (reported stopping antihypertensive medication 5 years ago at instruction of his PCP) who presented to the ED 2/13/2022 with sudden onset back pain and dyspnea after working out. Denied abdominal pain. He was noted to be hypertensive with systolic blood pressures up to 280.

- Started on Esmolol drip with improvement in pain and blood pressures
- Exam: well developed male, comfortable appearing, palpable left femoral pulse with faint palpable left PT. Right leg with only femoral signal, and no distal signals. Bilateral lower extremity motor and sensory intact.
- Labs: WBC 19.9, Hgb 15.1, Plt 110, BMP notable for creatinine 1.42, Lactic acid 1.1

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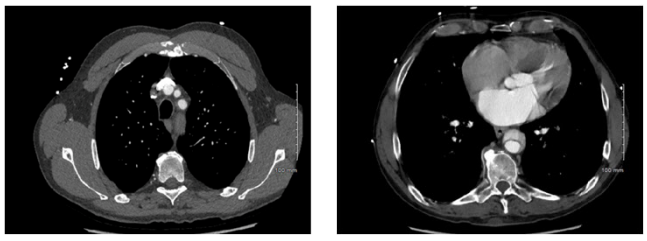
CTA Chest Abdomen Pelvis



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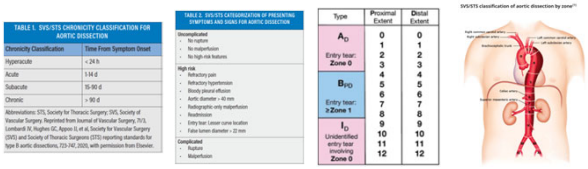
Dissection Classification



Type	Proximal Extent	Distal Extent
A_D Entry tear: Zone 0	0 1 2 3 4 5 6 7 8 9 10 11 12	0 1 2 3 4 5 6 7 8 9 10 11 12
B_{PD} Entry tear: ≥Zone 1		
I_D Unidentified entry tear involving Zone 0		

Hyperacute Complicated Type $B_{2,12}$ Dissection with Right Leg Malperfusion

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Operative and Post Operative Course

- 2/13 - Taken to the OR for Left to Right Femoral-Femoral Bypass with Externally Reinforced 8 mm PTFE
- Post Resperfusion Exam: multiphasic right DP signal
- Bilateral Groins closed in multiple layers and skin closed with monocryl and prineo dermabond tape
- Patient went to the SICU for continued blood pressure and impulse control and close monitoring of RLE s/p reperfusion
- POD1 his kidney and liver function began to worsen (creatinine up to 4.1, potassium 5.6) and his liver enzymes began rising (ALT, AST slightly elevated in the 100s, total bilirubin 5.3). Lactic acid remained normal.
  - Began discussing return to the OR for TEVAR with dissection stent placement
- POD2: Repeat CTA, CVVH initiated, Return to OR for TEVAR given ongoing left renal malperfusion and CVVH requirement, rising leukocytosis, low grade abdominal pain

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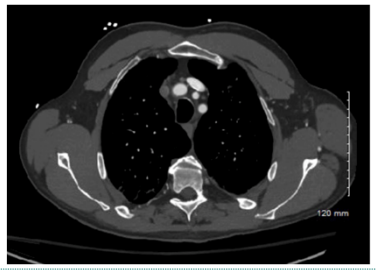
Repeat CTA 2/15 (POD2)



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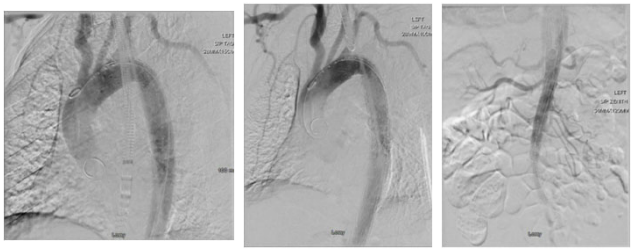
2/15: Return to OR for TEVAR with Petticoat, bilateral groin exploration, bilateral groin wound vac placement, left chest tube placement



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Post-Operative Course

- Ongoing CVVH, intermittent pressor requirement, vent wean

2/17: Return to OR for Bilateral groin exploration, explantation of fem-fem bypass with patch angioplasty of right CFA and left SFA with PTFE cuff, bilateral groin closure

2/20: Extubated, transitioned to HD briefly (renal recovery 2/23, neph signed off)

2/21: Transferred to floor

2/24: Return to OR for bilateral groin exploration and debridement and wound vac placement

2/26: Bilateral groin washout and wound vac exchange

2/28 Bilateral groin washout, explantation of bilateral PTFE patches, RGSV harvest and vein patch angioplasty of right CFA and left SFA, wound vac placement

3/2 Bilateral pedicled ALTs to bilateral groins (Plastic Surgery)

3/7 Discharged to home with HHC, 6 weeks abx per ID (EOT 4/11), planned follow up 1 month with CTA

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Follow up

- 4/19/22: Back to normal activities, CTA demonstrated good graft apposition at the proximal margin, with residual dissection present within the paravisceral segment. Stable SMA dissection extending the total length but with good filling throughout
- 6/21/22: Biking 6 miles per day, BP fairly well-controlled. Compliant with asa and statin therapy. CTA reviewed and approximately 2-3 mm of growth in his paravisceral aorta with persistent false lumen filling and split perfusion of the SMA, planned 6 month follow up with imaging.
- 1/17/23: Biking 11 miles per day, BP fairly well controlled. Compliant with asa and statin therapy. CTA stable. Plan for 6 month follow up with imaging.

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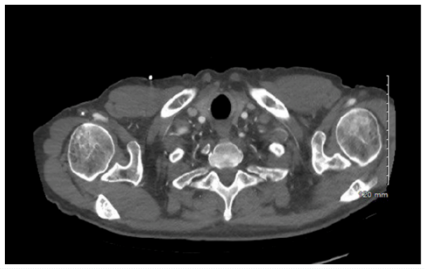
Recent CTA (1/17/23)



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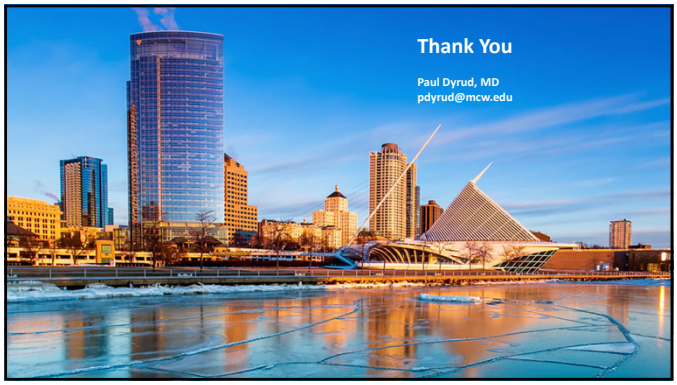

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