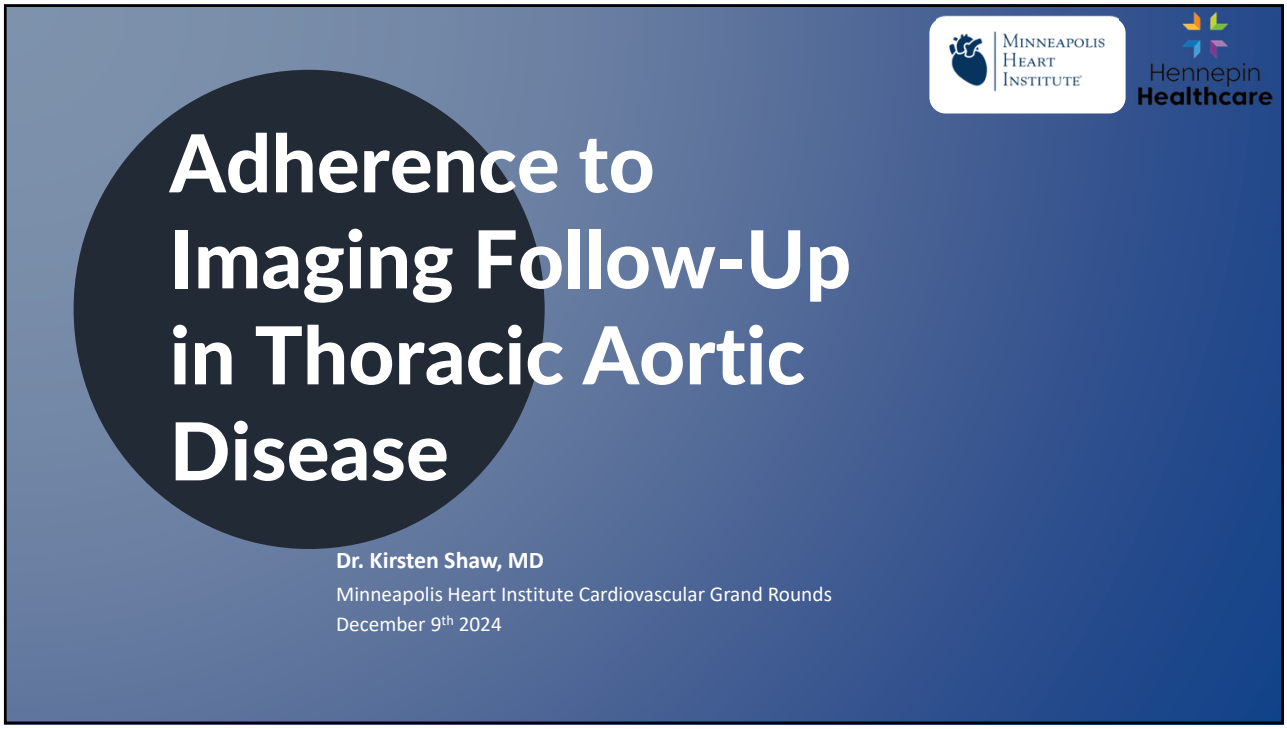

Minneapolis
Heart Institute
Foundation
GRAND ROUNDS

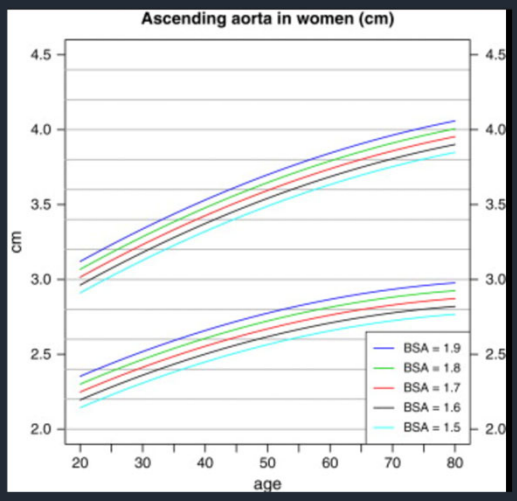
1


Minneapolis
Heart
Institute
Hennepin
Healthcare
Adherence to Imaging Follow-Up in Thoracic Aortic Disease
Dr. Kirsten Shaw, MD
Minneapolis Heart Institute Cardiovascular Grand Rounds
December 9th 2024

2

2. Grade 1 pattern of LV diastolic filling.
3. The aortic valve is normal and trileaflet, no stenosis and no regurgitation.
4. The ascending aorta is borderline dilated with a maximal diameter of 3.8 cm.

Chamber Sizes and Function
Normal left ventricular size, normal wall thickness, normal global systolic function, calculated EF of 63 %. Left atrial size is normal. Left atrial pressure is normal. Right ventricular cavity size is normal, global systolic RV function is normal. RV wall thickness is normal.



3

4

A Retrospective Chart Review Assessing Adherence to Surveillance Imaging Recommendations for Thoracic Aortic Dilation/Aneurysm

01 Patient Population
- 200 patient visits at a single primary care clinic

02 Chart Review
- Most recent echo, CT chest, CTCA, and/or CMR reviewed
- Did they receive appropriate follow-up imaging

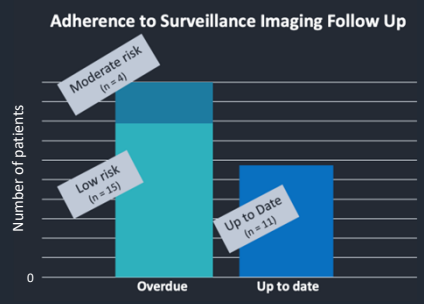
03 Results
- Aorta sizes ranged between 3.5-4.5 cm

	Study Population (n=200)
Female	98
Male	102
Age (Range)	18-95
Age (Mean)	60

5

01 19 of the 30 patients (63%) were overdue for surveillance imaging

02



03

	Thoracic Aortic Aneurysm/Dilation (n=30)
Documented on problem list	4 (13%)

A Retrospective Chart Review Assessing Adherence to Surveillance Imaging Recommendations for Thoracic Aortic Dilation/Aneurysm

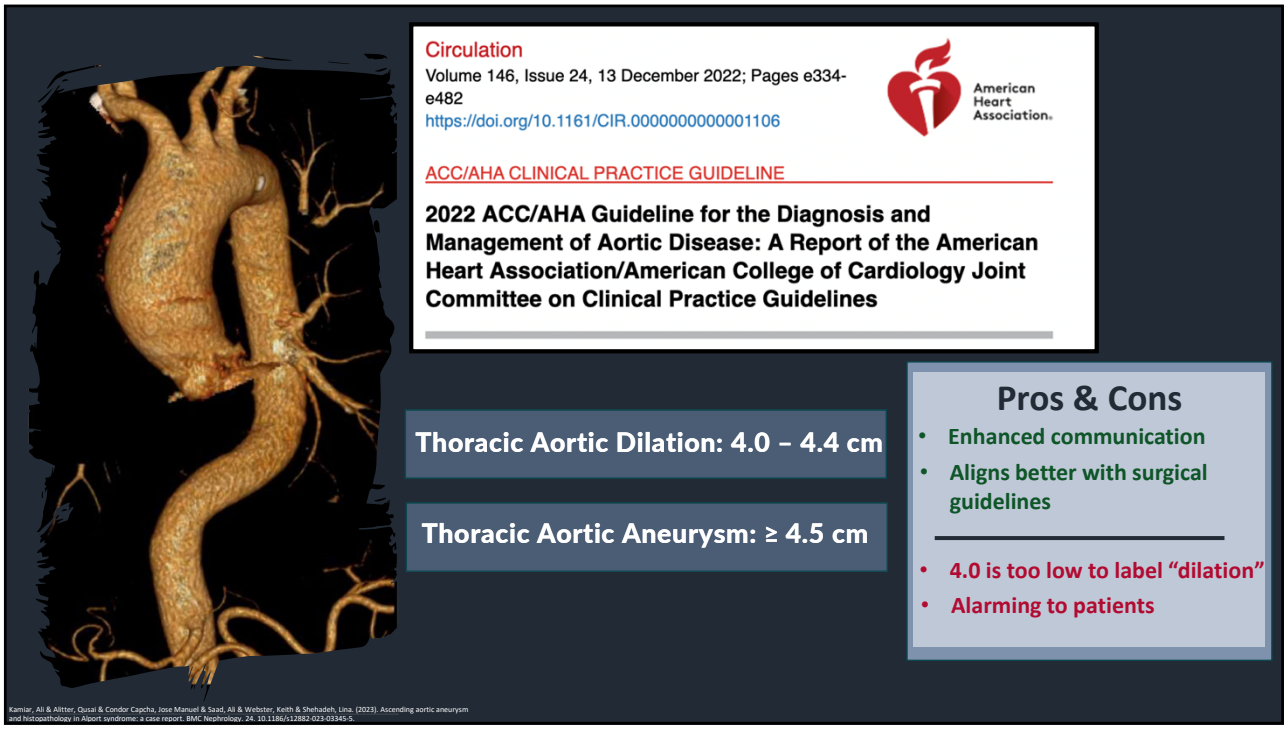
6


Aorta Size (centimeters)
3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0
Patient Height (inches)
55 2.50 2.86 3.21 3.57 3.93 4.29 4.64 5.00 5.36 5.71
57 2.41 2.76 3.10 3.45 3.79 4.14 4.48 4.83 5.17 5.52
59 2.33 2.67 3.00 3.33 3.67 4.00 4.33 4.67 5.00 5.33
61 2.26 2.63 2.90 3.23 3.55 3.87 4.19 4.52 4.84 5.16
63 2.19 2.50 2.81 3.13 3.44 3.75 4.06 4.38 4.69 5.00
65 2.12 2.42 2.73 3.03 3.33 3.64 3.94 4.24 4.55 4.85
67 2.03 2.35 2.65 2.94 3.24 3.53 3.82 4.12 4.41 4.71
69 2.00 2.29 2.57 2.86 3.14 3.43 3.71 4.00 4.29 4.57
71 1.94 2.22 2.50 2.78 3.06 3.33 3.61 3.89 4.17 4.44
73 1.89 2.16 2.43 2.70 2.97 3.24 3.51 3.78 4.05 4.32
75 1.84 2.11 2.37 2.63 2.89 3.16 3.42 3.68 3.95 4.21
77 1.79 2.05 2.31 2.56 2.82 3.08 3.33 3.59 3.85 4.10
79 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00
81 1.71 1.95 2.20 2.44 2.68 2.93 3.17 3.41 3.66 3.90
Low Risk (~4% per year)
High Risk (~12% per year)
Moderate Risk (~7% per year)
Severe Risk (~18% per year)

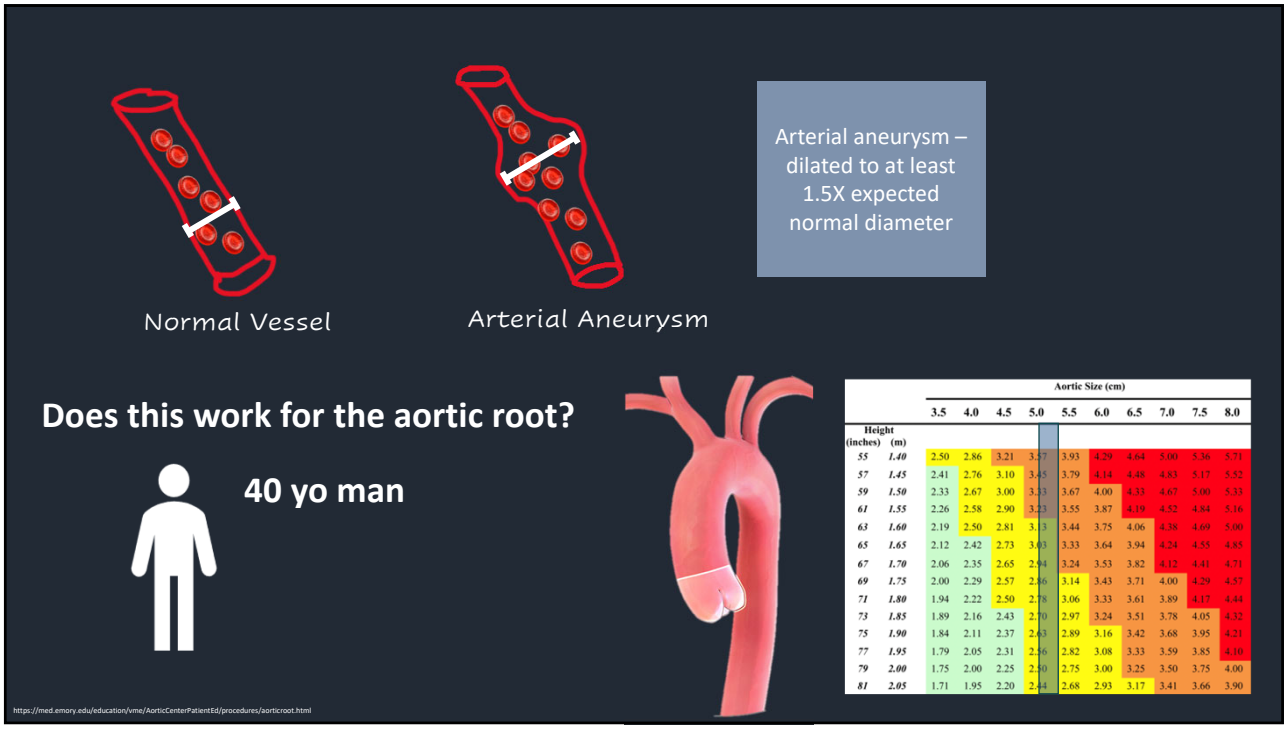
7


A Retrospective Chart Review Assessing Adherence to Surveillance Imaging Recommendations for Thoracic Aortic Dilation/Aneurysm
"Great potential for quality improvement project"
MAYO CLINIC
"Turn that abstract into a paper, and turn that paper into a grant"
Yale University School of Medicine
"Bigger sample size needed"
ESC
European Society of Cardiology

8



9



Height (inches)	(m)	Aortic Size (cm) 3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0
55	1.40	2.50	2.86	3.21	3.57	3.93	4.29	4.64	5.00	5.36	5.71
57	1.45	2.41	2.76	3.10	3.45	3.79	4.14	4.48	4.83	5.17	5.52
59	1.50	2.33	2.67	3.00	3.33	3.67	4.00	4.33	4.67	5.00	5.33
61	1.55	2.26	2.58	2.90	3.23	3.55	3.87	4.19	4.52	4.84	5.16
63	1.60	2.19	2.50	2.81	3.13	3.44	3.75	4.06	4.38	4.69	5.00
65	1.65	2.12	2.42	2.73	3.03	3.33	3.64	3.94	4.24	4.55	4.85
67	1.70	2.06	2.35	2.65	2.94	3.24	3.53	3.82	4.12	4.41	4.71
69	1.75	2.00	2.29	2.57	2.86	3.14	3.43	3.71	4.00	4.29	4.57
71	1.80	1.94	2.22	2.50	2.78	3.06	3.33	3.61	3.89	4.17	4.44
73	1.85	1.89	2.16	2.43	2.70	2.97	3.24	3.51	3.78	4.05	4.32
75	1.90	1.84	2.11	2.37	2.63	2.89	3.16	3.42	3.68	3.95	4.21
77	1.95	1.79	2.05	2.31	2.56	2.82	3.08	3.33	3.59	3.85	4.10
79	2.00	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
81	2.05	1.71	1.95	2.20	2.44	2.68	2.93	3.17	3.41	3.66	3.90

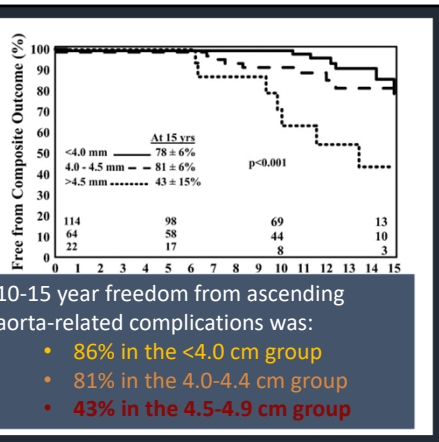
10

The Journal of Thoracic and Cardiovascular Surgery
Volume 128, Issue 5, November 2004, Pages 677-683

Should the ascending aorta be replaced more frequently in patients with bicuspid aortic valve disease?

Read at the Eighty-fourth Annual Meeting of The American Association for Thoracic Surgery, Toronto, Ontario, Canada, April 25-28, 2004.

Michael A. Borger MD, PhD [a b], Mark Preston BSc [a b], Joan Ivanov RN, PhD [a b], Paul W.M. Fedak MD, PhD [a b], Piroze Davierwala MD [a b], Susan Armstrong MSc [a b], Tirone E. David MD [a b]



10-15 year freedom from ascending aorta-related complications was:
- 86% in the <4.0 cm group
- 81% in the 4.0-4.4 cm group
- **43% in the 4.5-4.9 cm group**

- 201 patients with BAV undergoing AVR
- 10-15 years of follow up (98% of patients)
- Baseline aorta:
  - Normal (<4.0) in 57%
  - Mildly dilated (4.0 - 4.4) in 32%
  - Moderately dilated (4.5 - 4.9) in 11%
- Baseline aortic diameter 4.5-4.9 cm had significantly increased risk of dissection or sudden death compared to those with diameters < 4.5 cm ($p < 0.001$)

Borger et al, 2004, American Association for Thoracic Surgery.

11

CARDIOLOGY
Original Research
Cardiology 2015;131:265–272
DOI: 10.1159/000381281
Received: February 9, 2015
Accepted after revision: February 26, 2015
Published online: May 14, 2015

Aortic Size Distribution in the General Population: Explaining the Size Paradox in Aortic Dissection

Vijayapraveena Paruchuri[a] Kahled F. Salhab[b] Gregory Kuzmik[c] George Gubernikoff[a] Hai Fang[g] John A. Rizzo[d-f] Bulat A. Ziganshin[d,h] John A. Elefteriades[d]

$$\frac{\#\text{ of dissections at each aortic diameter}}{\text{Population at risk at each aortic diameter}}$$

- Plotted a distribution curve of ascending aortic size
- Mean age 60.7 years
- 3,573 subjects
- Relative to a control aortic diameter:
  - 4.0-4.4 cm conferred 89-fold ↑ risk* dissection

Paruchuri et al, 2015, International Journal of Cardiovascular Medicine

12

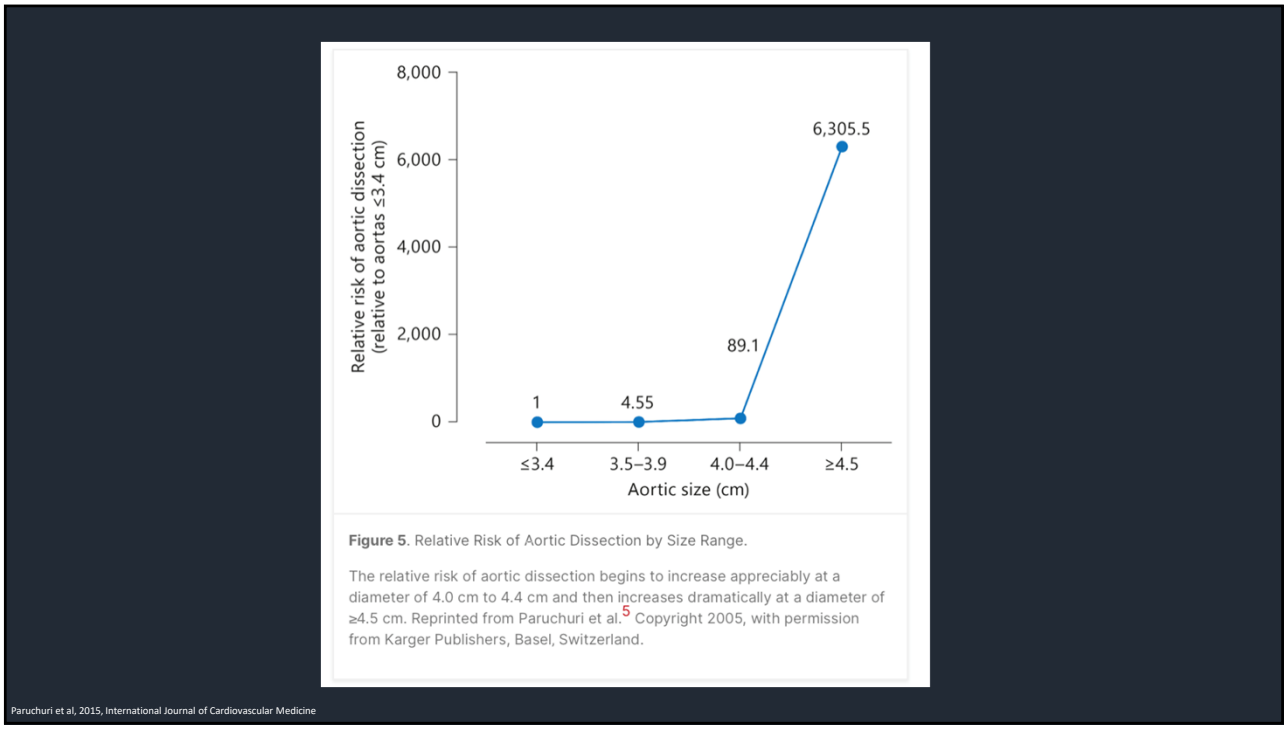


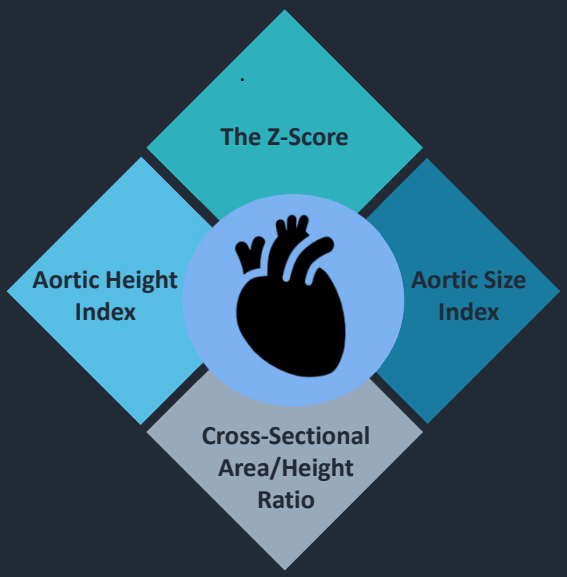
Figure 5. Relative Risk of Aortic Dissection by Size Range.

The relative risk of aortic dissection begins to increase appreciably at a diameter of 4.0 cm to 4.4 cm and then increases dramatically at a diameter of ≥4.5 cm. Reprinted from Paruchuri et al.[5] Copyright 2005, with permission from Karger Publishers, Basel, Switzerland.

Paruchuri et al, 2015, International Journal of Cardiovascular Medicine

13

What about indexing?



14

Ratio

$$Z = \frac{(\text{-}\mu)}{\sigma}$$

Table 1. List of established formulas for measuring body surface area (BSA).

Formula	Equation	Sample Size	Age (Years)	Gender (F:M)	Main Limitation(s)
Banerjee (1955) [16]	$BSA_{(m^2)} = weight_{(kg^{0.425})} \times height_{(cm^{0.725})} \times 74.66$	15	18-44	0%	Small sample size. Only relevant to Indian population. Inaccurate in SE Asian population [23].
Boyd (1935)	$BSA_{(m^2)} = weight_{(g^{0.696})} \times height_{(cm^{0.5})} \times 0.017827$	197	Unclear*	Unclear*	BSA overestimated if: infant, short, obese. BSA underestimated if: tall, thin [14, 24, 25]. Study demographics unclear.
Du Bois (1916)	$BSA_{(m^2)} = height_{(cm^{0.725})} \times weight_{(kg^{0.425})} \times 71.84$	9	Not stated	Not stated	BSA underestimated if: infant/child, obese [8, 14, 26, 27]. Significant patient heterogeneity. Study demographics unclear. Nutritional status of study sample is unrepresentative.
Gehan (1970)	$BSA_{(m^2)} = 0.0235 \times height_{(cm^{0.42246})} \times weight_{(kg^{0.51456})}$	401	Infants -Adults	Not stated	BSA overestimated if: short, obese. BSA underestimated if: tall, thin, increasing body size [14, 24, 26]. Study demographics unclear. Inaccurate in SE Asian population [23].
Haycock (1978) [7]	$BSA_{(m^2)} = weight_{(kg^{0.5378})} \times height_{(cm^{0.3964})} \times 0.024265$	81	ELBW infants -adults	Not accessible	BSA overestimated if: infant, short, obese. BSA underestimated if: tall, thin, increasing body size [24, 27, 28]. Inaccurate in SE Asian population [23].
Jones (1994) [29]	$BSA_{(m^2)} = 0.335 + 0.02 \times weight_{(kg)}$	28	3.1-10.5	46%	Small sample size. Only 4 males included. Narrow age range.
Meban (1983) [30]	$BSA_{(cm^2)} = 6.4954 \times (1{,}000 \times weight_{(g)})^{0.5563} \times height_{(cm^{0.1965})}$	79	11-42 weeks gestation	Not stated	Only pathological human fetuses studied.
Mosteller (1987) [31]	$BSA = \sqrt{\frac{height_{(cm)} \times weight_{(kg)}}{3{,}600}}$	0	NA	NA	BSA overestimated if: short, obese [26]. BSA underestimated if: infant, tall, thin, low body size [14, 24, 32]. Less accurate simplification of the Gehan equation.
Shuter (2000) [33]	$BSA_{(m^2)} = 94.9 \times (weight_{(kg)} \times 0.441) \times (height_{(cm)} \times 0.655)$	42	Not stated	Not stated	Small sample size. Patient demographics unavailable.
Yu (2003) [28]	$BSA_{(m^2)} = (0.015925 \times height_{(cm)} \times weight_{(kg)})^{0.5}$	3951	20-91	54%	No subjects under 20 years of age. Formula only validated in Chinese individuals. Whole body scanning method does not take into account overlapping and shading body parts [23].

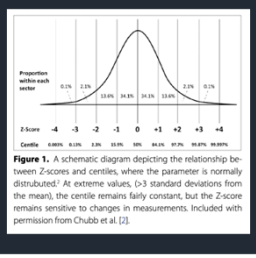


Figure 1. A schematic diagram depicting the relationship between Z-scores and centiles, where the parameter is normally distributed.[2] At extreme values, (>3 standard deviations from the mean), the centile remains fairly constant, but the Z-score remains sensitive to changes in measurements. Included with permission from Chubb et al. [2].

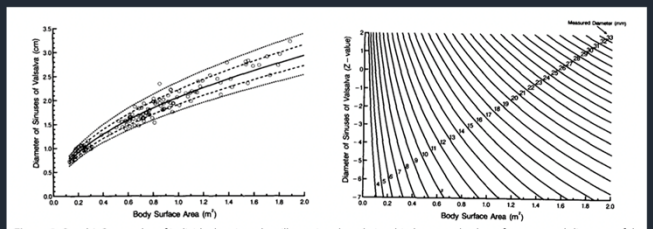


Figure 2. *Panel A.* Scatterplot of individual patient data illustrating the relationship between body surface area and diameter of the Sinuses of Valsalva. Solid line = regression equation; dashed line = confidence Intervals. *Panel B.* Nomogram generated from the scatterplot in *Panel A* for determining individual Z-score according to body surface area and diameter of the Sinuses of Valsalva. Included with permission from Daubeney et al. [5]

★ **Note: the study population had the following characteristics:**

- age range: (0 - 17)
- bsa range: (0.12 - 2.12)

Data entered for patients outside of these limits should be *used with caution.*

15

The Z-Score

Aortic Height Index

Aortic Size Index

Cross-Sectional Area/Height Ratio

ELSEVIER

The Annals of Thoracic Surgery

Volume 81, Issue 1, January 2006, Pages 169-177

Original article

Cardiovascular

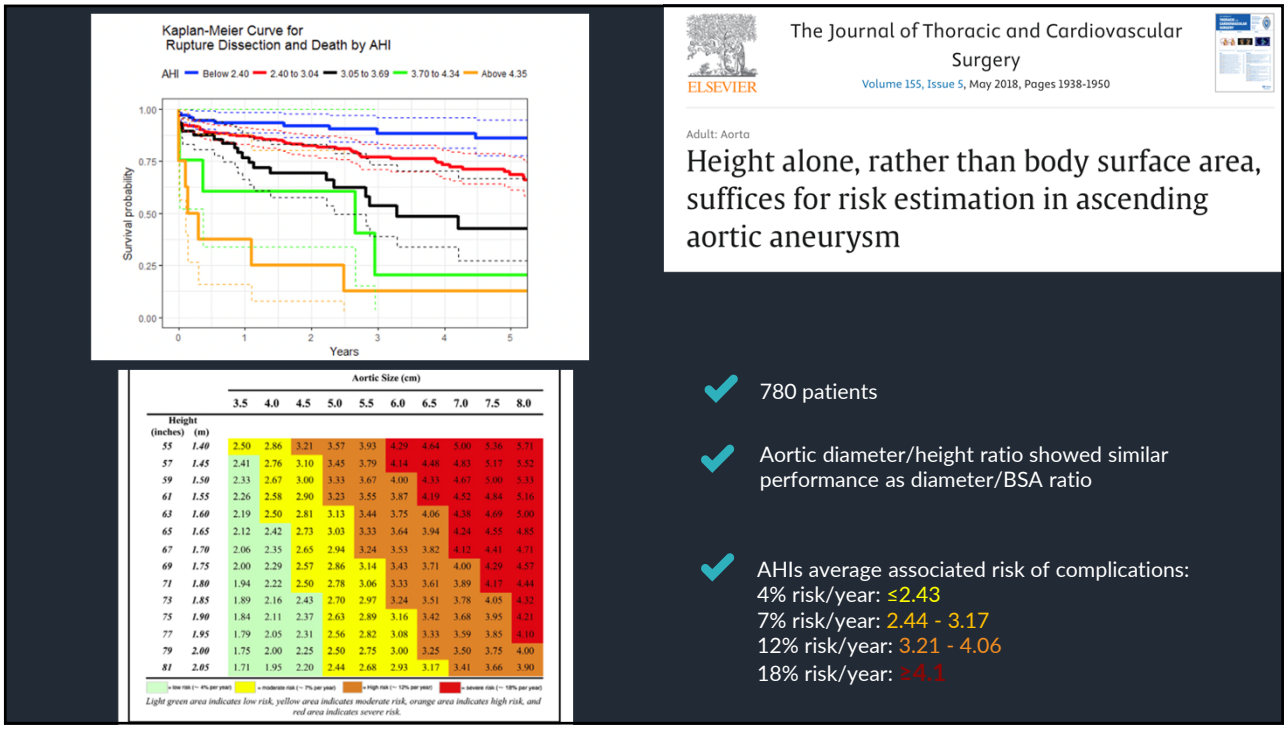
Novel Measurement of Relative Aortic Size Predicts Rupture of Thoracic Aortic Aneurysms

Presented at the Poster Session of the Forty-first Annual Meeting of The Society of Thoracic Surgeons, Tampa, FL, Jan 24–26, 2005.

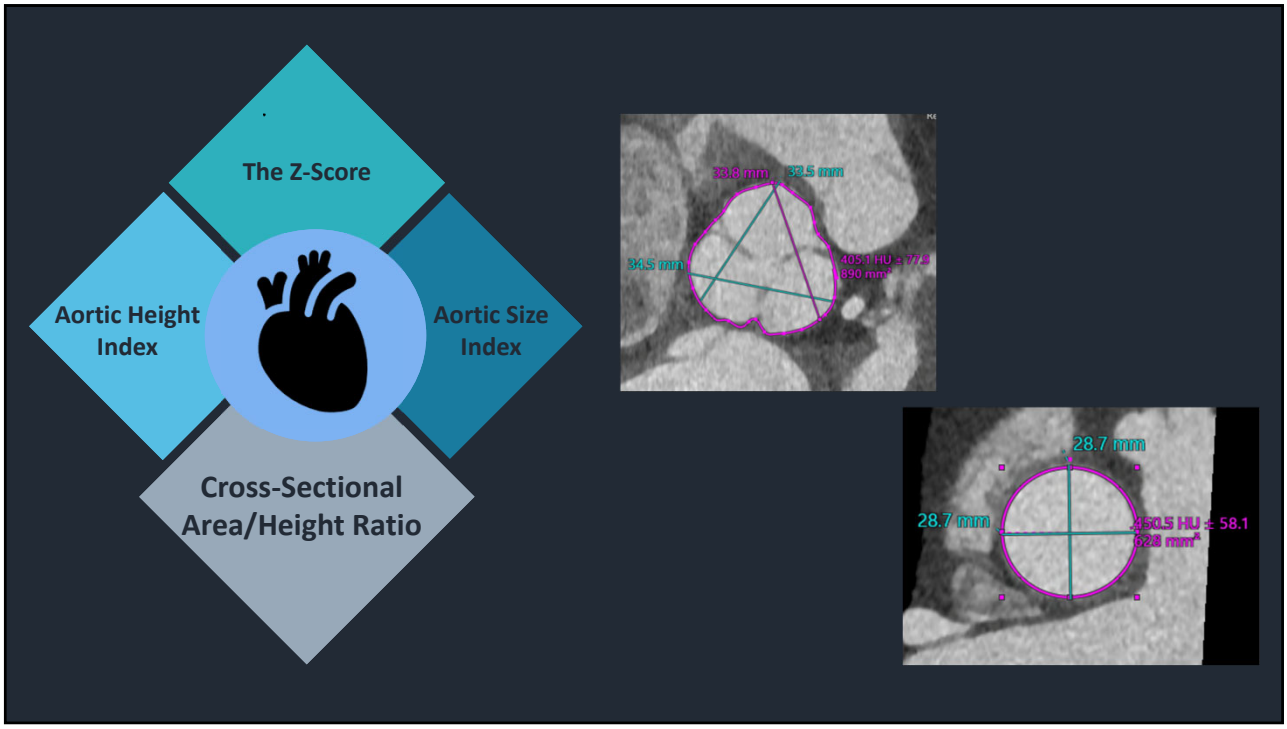
Ryan R. Davies MD, Amy Gallo MD, Michael A. Coady MD, MPH, George Tellides MD, PhD, Donald M. Botta MD, Brendan Burke BS, Marcus P. Coe BA, Gary S. Kopf MD, John A. Elefteriades MD

- 410 patients
- Increasing ASI was a significant predictor of increasing rates of rupture, dissection or death.
- Low Risk (4%/year) < 2.75 cm/m²
  Moderate Risk (8%/year) 2.75- 4.24 cm/m²
  High Risk (20%/year) > 4.25 cm/m²

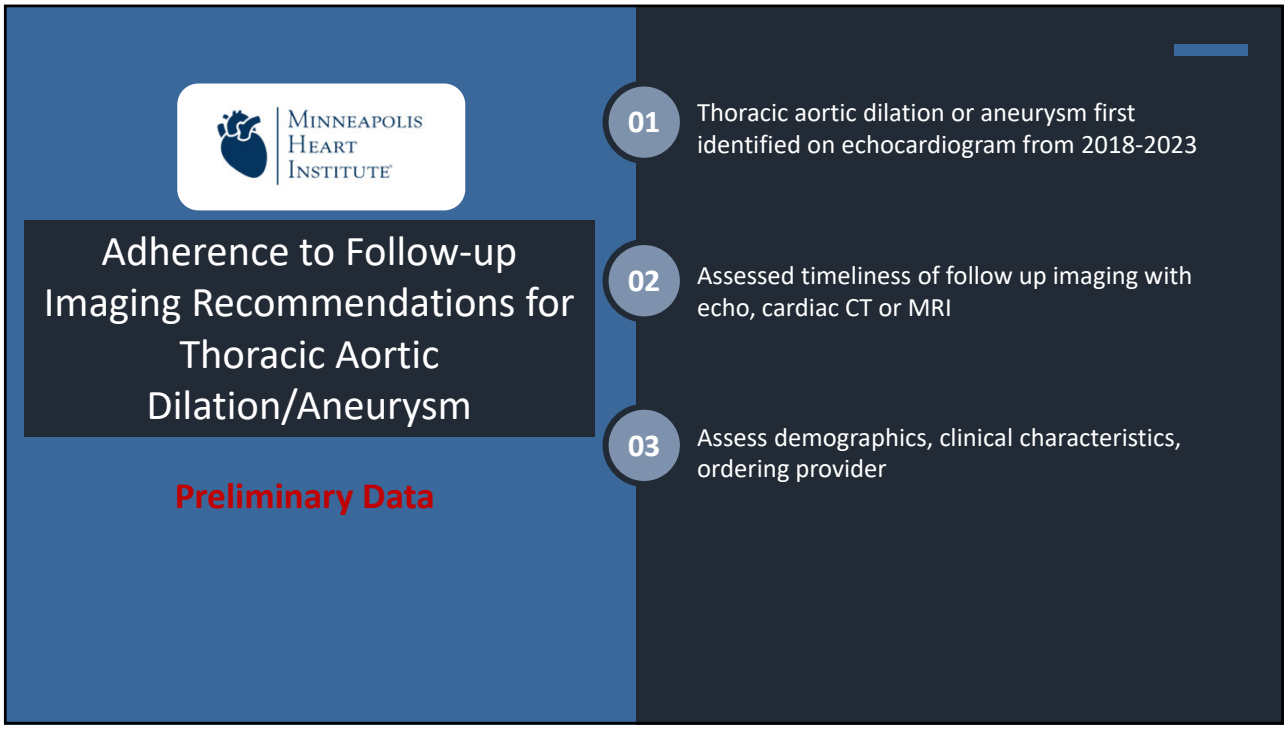
16


Kaplan-Meier Curve for
Rupture Dissection and Death by AHI
AHI Below 2.40 2.40 to 3.04 3.05 to 3.69 3.70 to 4.34 Above 4.35
Survival probability
Years
Aortic Size (cm)
Height (inches) (m)
Light green area indicates low risk, yellow area indicates moderate risk, orange area indicates high risk, and red area indicates severe risk.
The Journal of Thoracic and Cardiovascular Surgery
Volume 155, Issue 5, May 2018, Pages 1938-1950
Adult: Aorta
Height alone, rather than body surface area, suffices for risk estimation in ascending aortic aneurysm
780 patients
Aortic diameter/height ratio showed similar performance as diameter/BSA ratio
AHIs average associated risk of complications:
4% risk/year: ≤2.43
7% risk/year: 2.44 - 3.17
12% risk/year: 3.21 - 4.06
18% risk/year: ≥4.1

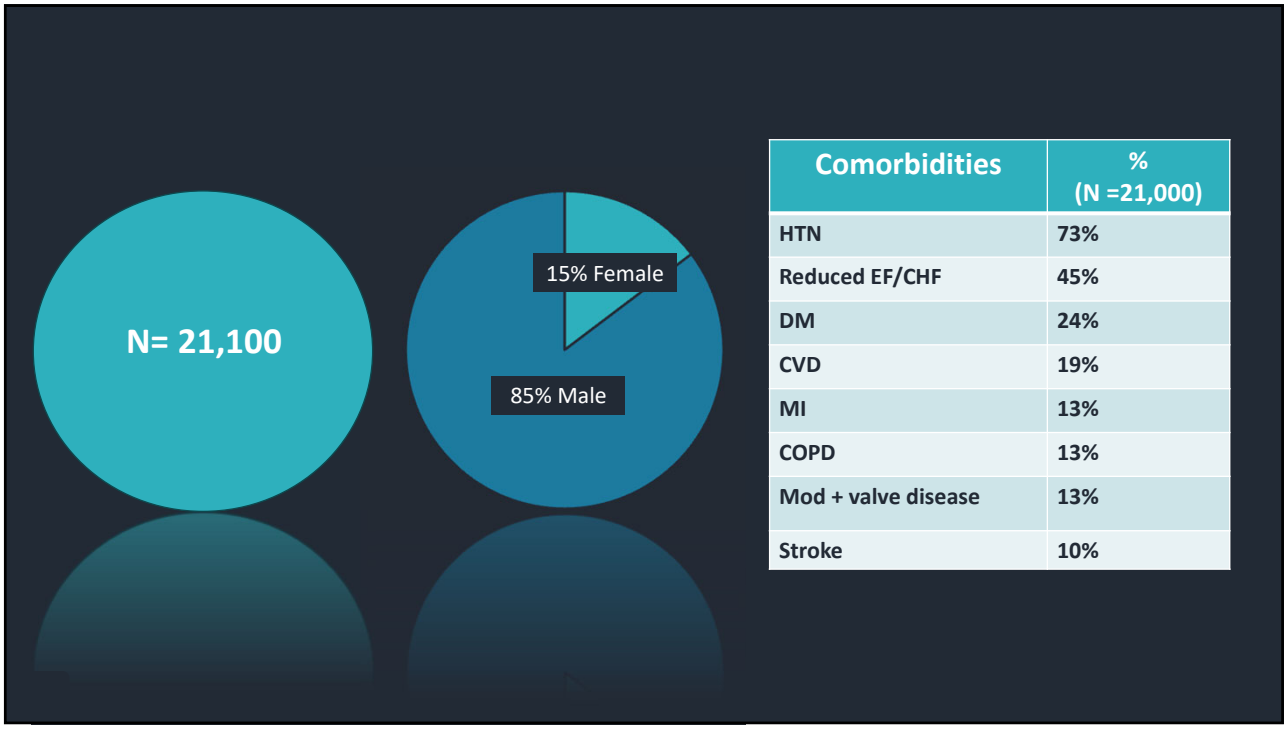
17


The Z-Score
Aortic Height Index
Aortic Size Index
Cross-Sectional Area/Height Ratio
33.8 mm
32.5 mm
34.5 mm
28.7 mm
28.7 mm

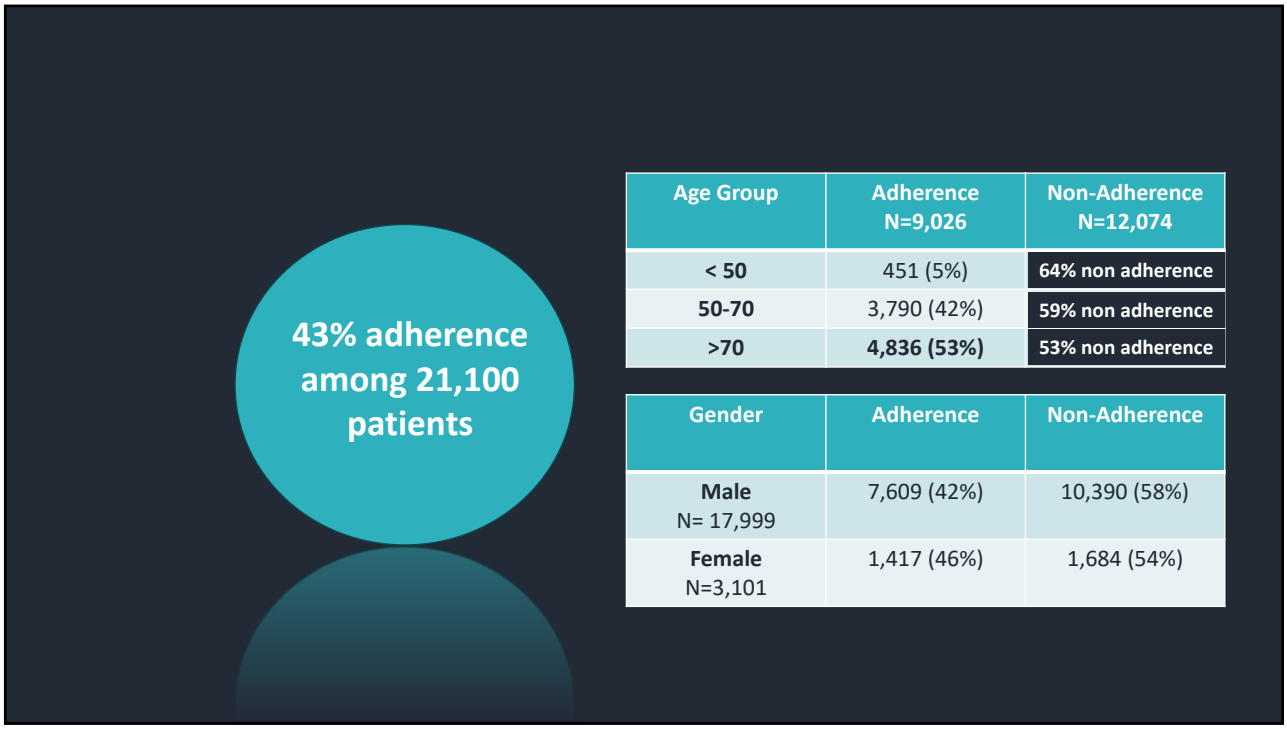
18


Minneapolis Heart Institute
Adherence to Follow-up Imaging Recommendations for Thoracic Aortic Dilation/Aneurysm
Preliminary Data
01
Thoracic aortic dilation or aneurysm first identified on echocardiogram from 2018-2023
02
Assessed timeliness of follow up imaging with echo, cardiac CT or MRI
03
Assess demographics, clinical characteristics, ordering provider

19


N= 21,100
15% Female
85% Male
Comorbidities
% (N =21,000)
HTN 73%
Reduced EF/CHF 45%
DM 24%
CVD 19%
MI 13%
COPD 13%
Mod + valve disease 13%
Stroke 10%

20



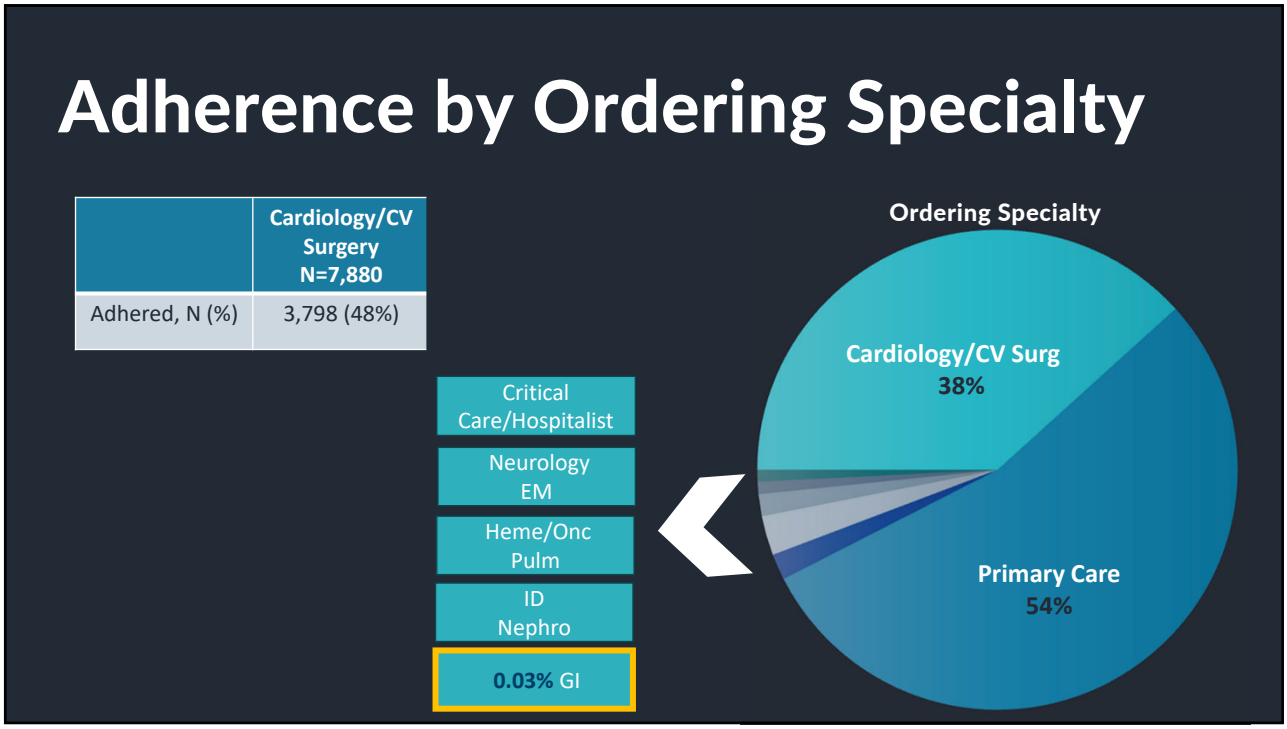
Age Group	Adherence N=9,026	Non-Adherence N=12,074
< 50	451 (5%)	64% non adherence
50-70	3,790 (42%)	59% non adherence
>70	4,836 (53%)	53% non adherence

Gender	Adherence	Non-Adherence
Male N= 17,999	7,609 (42%)	10,390 (58%)
Female N=3,101	1,417 (46%)	1,684 (54%)

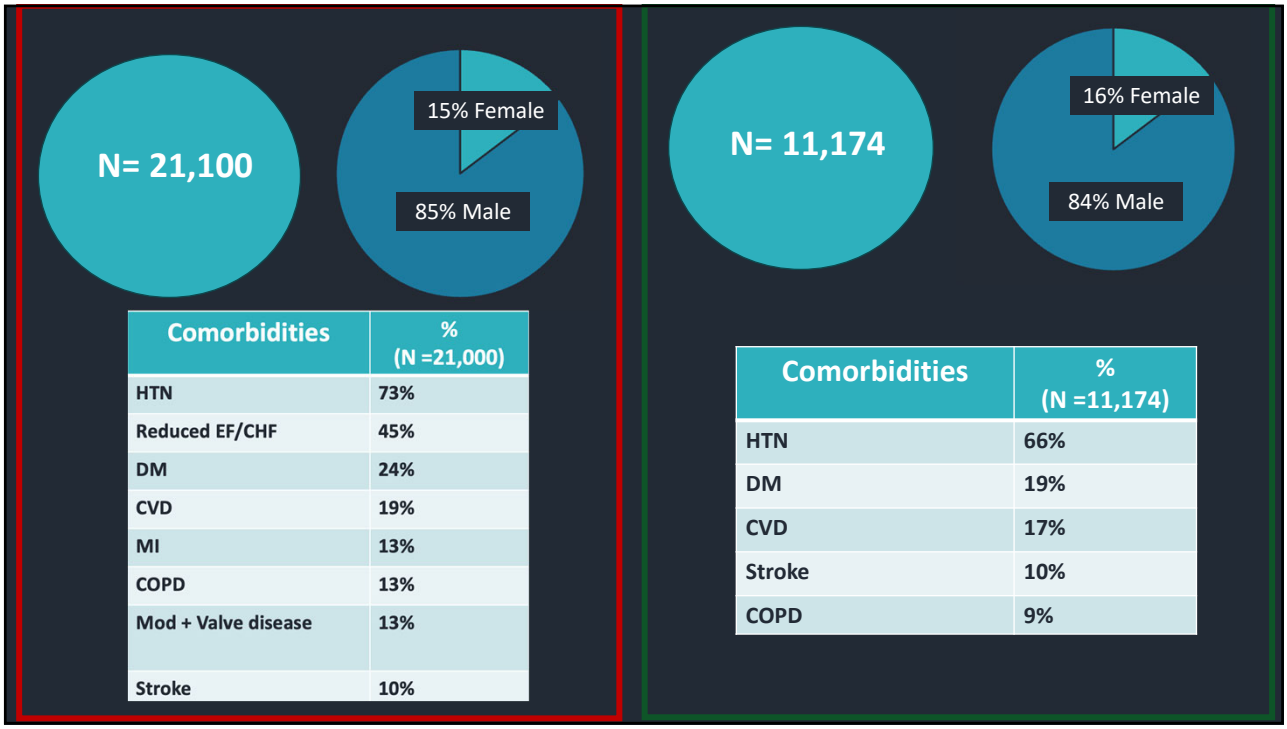
21

Adherence by Ordering Specialty

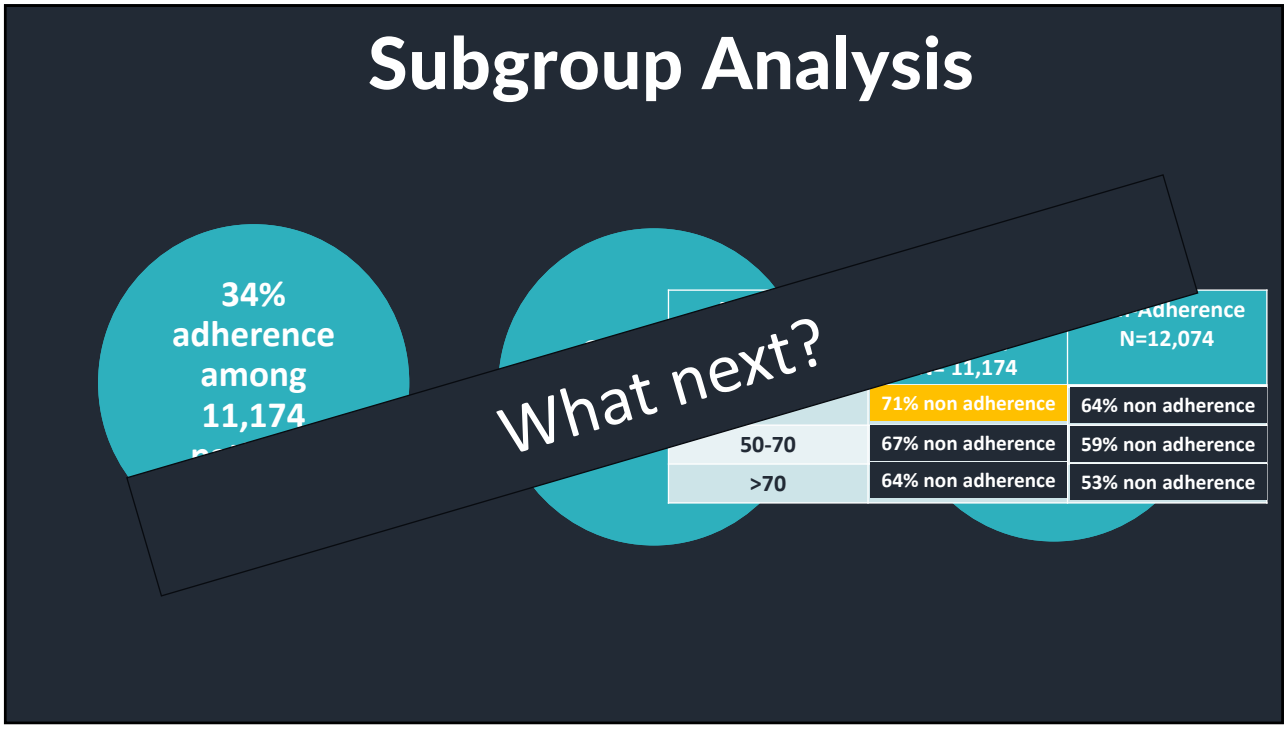
	Cardiology/CV Surgery N=7,880
Adhered, N (%)	3,798 (48%)



22

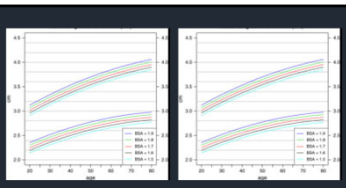

N= 21,100
15% Female
85% Male
Comorbidities
% (N =21,000)
HTN 73%
Reduced EF/CHF 45%
DM 24%
CVD 19%
MI 13%
COPD 13%
Mod + Valve disease 13%
Stroke 10%
N= 11,174
16% Female
84% Male
Comorbidities
% (N =11,174)
HTN 66%
DM 19%
CVD 17%
Stroke 10%
COPD 9%

23


Subgroup Analysis
34% adherence among 11,174
What next?
Adherence N=12,074
71% non adherence
64% non adherence
50-70
67% non adherence
59% non adherence
>70
64% non adherence
53% non adherence

24

Changes to Echo Reporting



ECHOCARDIOGRAM

ZZMSYNGO AORTASECTION

MRN:	2024110502	Accession#:	T20241152
DOB:	5/27/1954 70 years	Study Date:	11/5/2024 10:13:04 PM
Gender:	M	BP:	151/80 mmHg
Height:	173.00 cm	BSA:	2.16 m²
Weight:	103.00 kg	Tech:	
		Referring MD:	

Site:
Reading Location:
Patient Location:

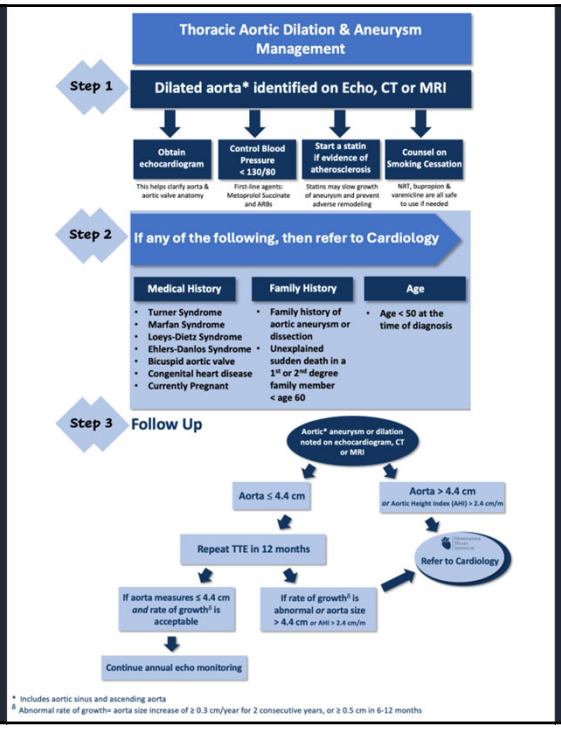
Preliminary

- **Aortic dilation =** 2SD beyond expected
- **Expected normal diameters**
- **Aortic height index**
  - - < 2.4 Low risk
  - -2.4-3.1 Moderate risk
  - -3.2-4.06 High risk
  - ->5: Surgical

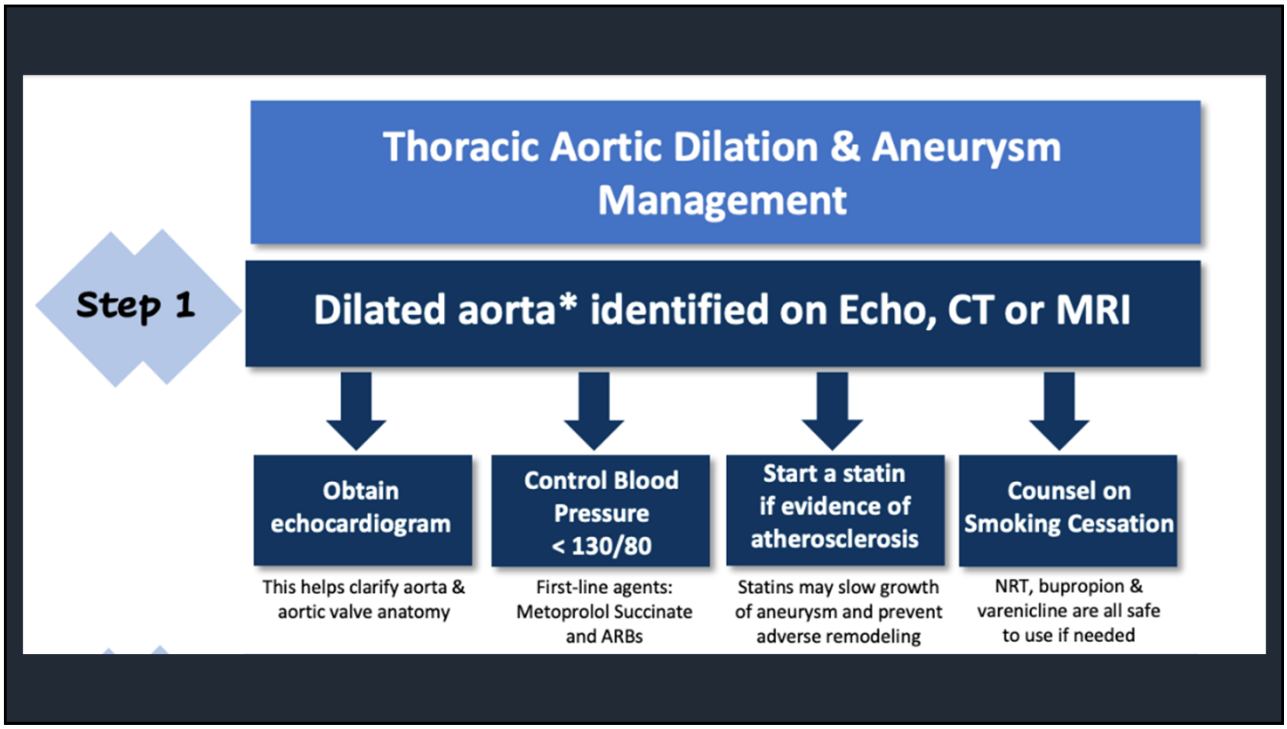
Final Impressions:

1. Severely dilated sinus of Valsalva, diameter of 5.0 cm (2.89 cm/m. The upper limit of normal for age, sex, and BSA is 4.23 cm).
2. Normal sized ascending aorta, diameter of 4.0 cm (2.31 cm/m. The upper limit of normal for age, sex, and BSA is 4.31 cm).
3. For aortic dilation follow-up recommendations, please refer to the Thoracic Aortic Dilation & Aneurysm Management flowchart (https://www.allinahealth.org/ Aorta-Management siness-units/minneapolis-heart-institute/protocols/thoracic-aortic-dilation--aneurysm-management.pdf).

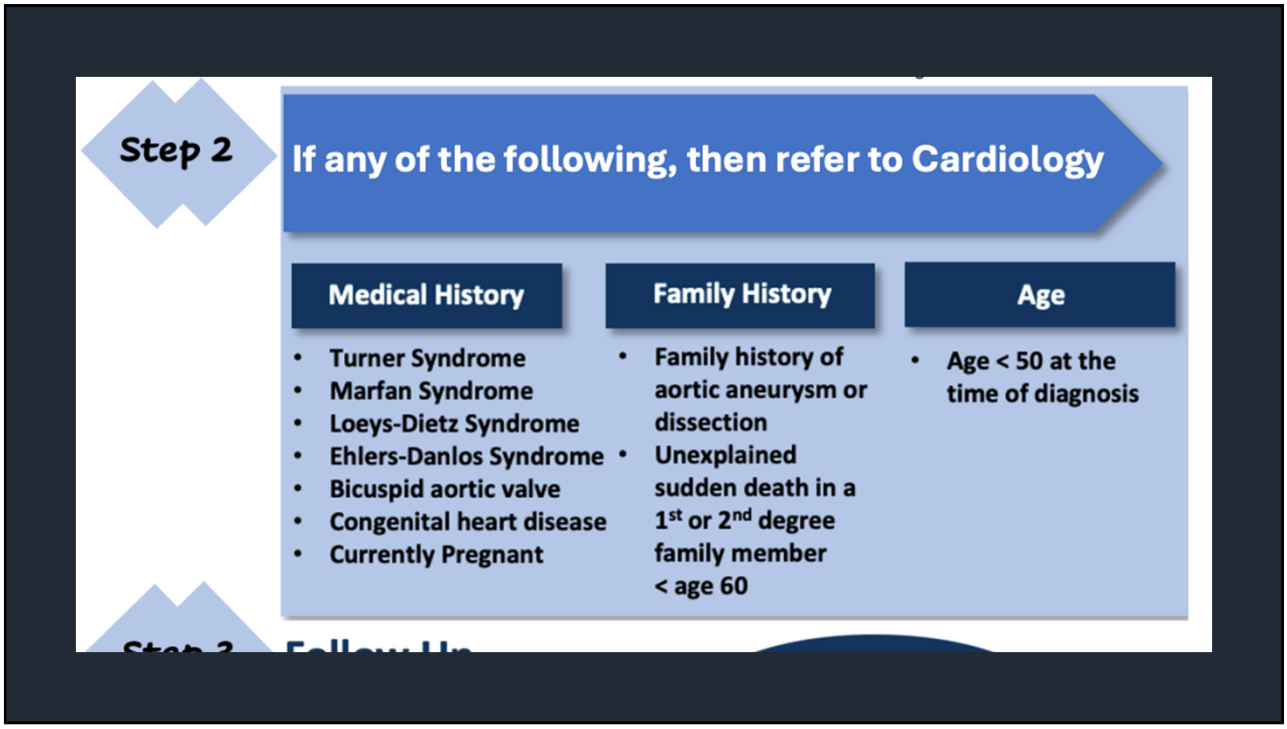
25



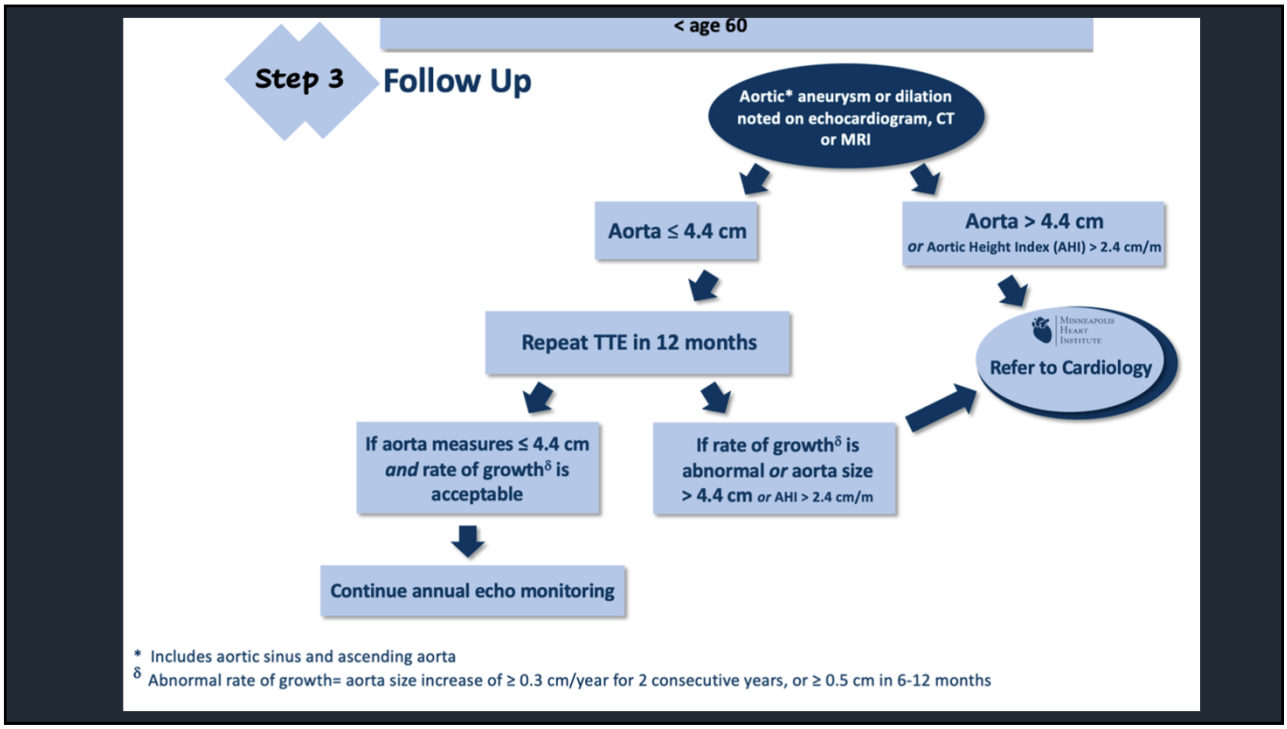
26


Thoracic Aortic Dilation & Aneurysm Management
Step 1
Dilated aorta* identified on Echo, CT or MRI
Obtain echocardiogram
This helps clarify aorta & aortic valve anatomy
Control Blood Pressure < 130/80
First-line agents: Metoprolol Succinate and ARBs
Start a statin if evidence of atherosclerosis
Statins may slow growth of aneurysm and prevent adverse remodeling
Counsel on Smoking Cessation
NRT, bupropion & varenicline are all safe to use if needed

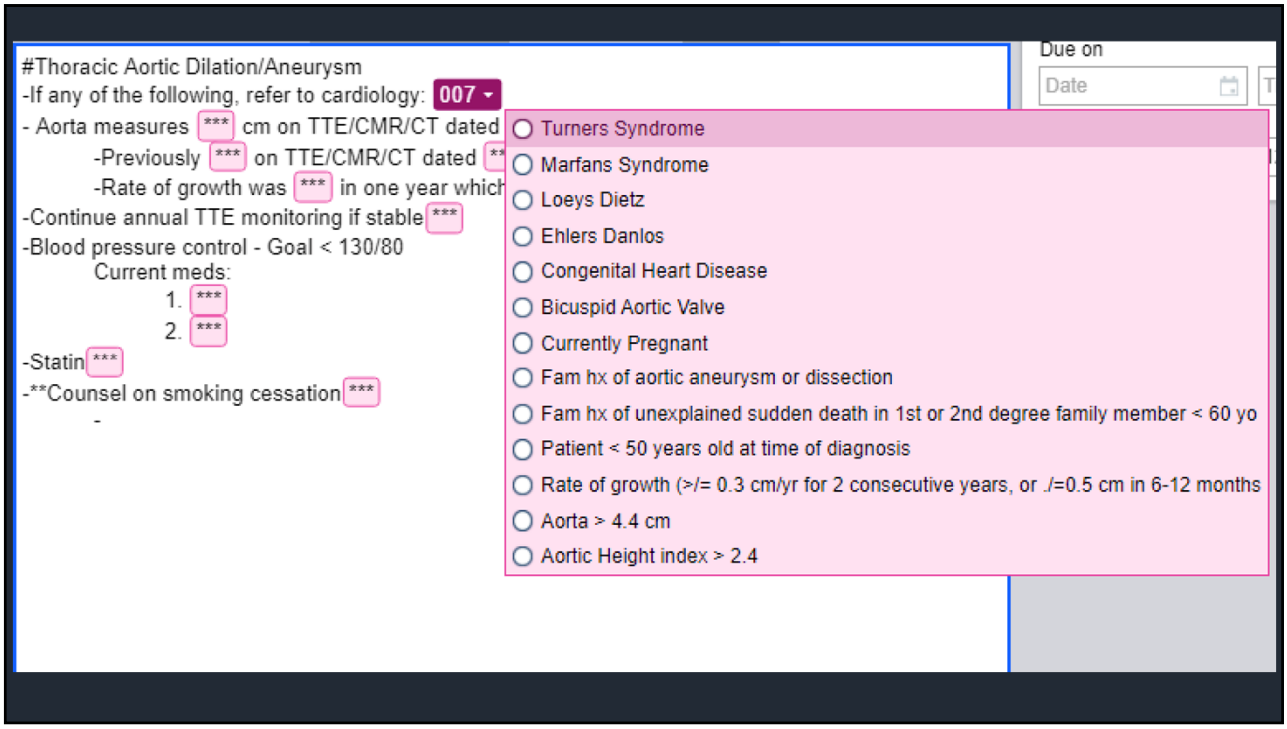
27


Step 2
If any of the following, then refer to Cardiology
Medical History
Turner Syndrome
Marfan Syndrome
Loeys-Dietz Syndrome
Ehlers-Danlos Syndrome
Bicuspid aortic valve
Congenital heart disease
Currently Pregnant
Family History
Family history of aortic aneurysm or dissection
Unexplained sudden death in a 1st or 2nd degree family member < age 60
Age
Age < 50 at the time of diagnosis

28

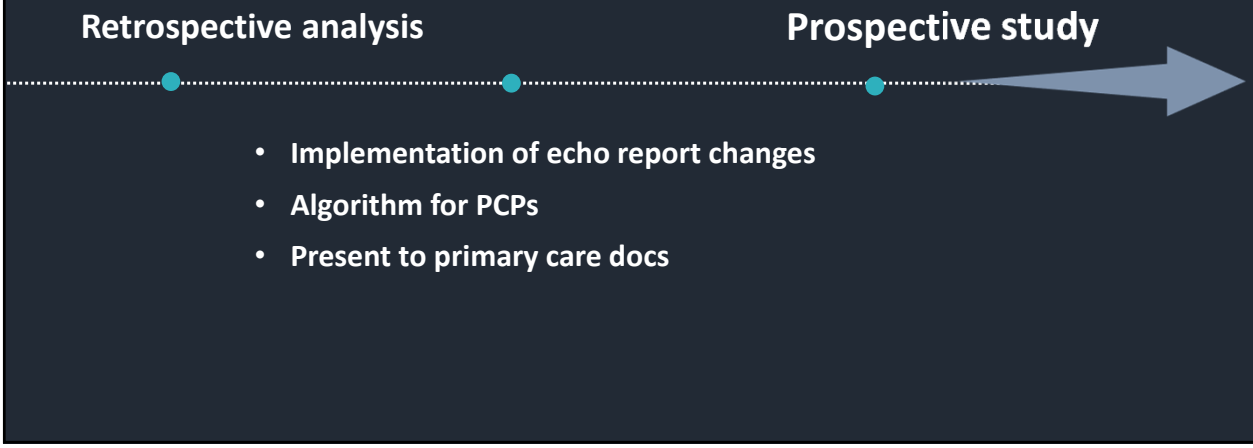

< age 60
Step 3
Follow Up
Aortic* aneurysm or dilation noted on echocardiogram, CT or MRI
Aorta ≤ 4.4 cm
Aorta > 4.4 cm
or Aortic Height Index (AHI) > 2.4 cm/m
Repeat TTE in 12 months
Refer to Cardiology
If aorta measures ≤ 4.4 cm and rate of growthδ is acceptable
If rate of growthδ is abnormal or aorta size > 4.4 cm or AHI > 2.4 cm/m
Continue annual echo monitoring
* Includes aortic sinus and ascending aorta
δ Abnormal rate of growth= aorta size increase of ≥ 0.3 cm/year for 2 consecutive years, or ≥ 0.5 cm in 6-12 months

29


#Thoracic Aortic Dilation/Aneurysm
-If any of the following, refer to cardiology: 007
- Aorta measures *** cm on TTE/CMR/CT dated
-Previously *** on TTE/CMR/CT dated
-Rate of growth was *** in one year which
-Continue annual TTE monitoring if stable ***
-Blood pressure control - Goal < 130/80
Current meds:
1. ***
2. ***
-Statin ***
-**Counsel on smoking cessation ***
Due on
Date
Turners Syndrome
Marfans Syndrome
Loeys Dietz
Ehlers Danlos
Congenital Heart Disease
Bicuspid Aortic Valve
Currently Pregnant
Fam hx of aortic aneurysm or dissection
Fam hx of unexplained sudden death in 1st or 2nd degree family member < 60 yo
Patient < 50 years old at time of diagnosis
Rate of growth (>/= 0.3 cm/yr for 2 consecutive years, or ./=0.5 cm in 6-12 months
Aorta > 4.4 cm
Aortic Height index > 2.4

30

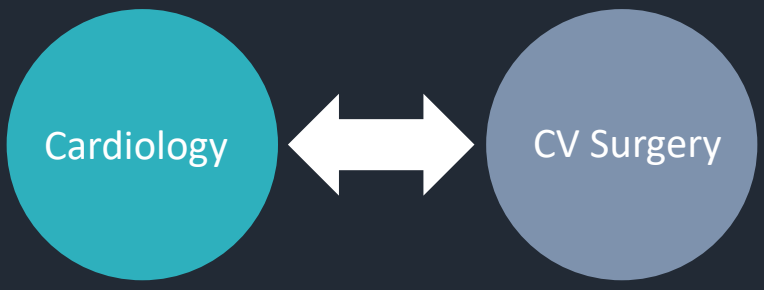
Next Steps



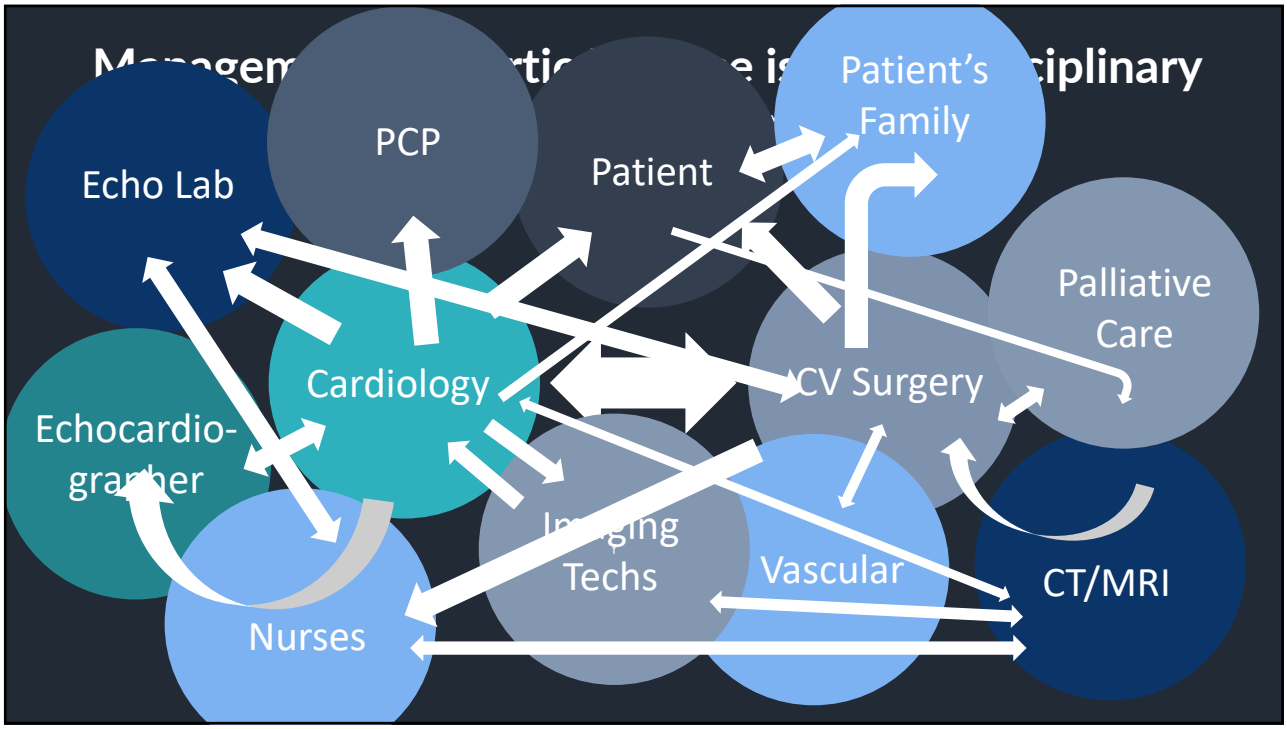
- Implementation of echo report changes
- Algorithm for PCPs
- Present to primary care docs

31

Management of Aortic Disease is a Multidisciplinary Collaboration



32



33

Thank you!

34

HeartMate 3 Pump Thrombosis: Expect The Unexpected

Rohit Masih, MD
Advanced Heart Failure & Transplant Cardiology Fellow
Minneapolis Heart Institute
12/9/2024

Minneapolis Heart Institute Foundation | GRAND ROUNDS

35

- I have no disclosures

Minneapolis Heart Institute Foundation | GRAND ROUNDS

36

- 56-year-old male with a history of CAD s/p PCI of LAD, left circumflex, and RCA, ICM with an LVEF of 25 to 30% complicated by CS
- Underwent subsequent LVAD implantation with HeartMate III (HM3) in February 2024
- Presented to the ED in August 2024 with c/o shortness of breath, chest pressure and associated weight gain

Minneapolis Heart Institute Foundation | GRAND ROUNDS

37

- On presentation, hemodynamically stable with MAP in 60-70s, HR 98 bpm and afebrile

WHITE BLOOD COUNT	21.9
HEMOGLOBIN	13.9
HEMATOCRIT	41.6
PLATELET COUNT	220

SODIUM	138
POTASSIUM	4.0
CHLORIDE	106
CO2,TOTAL	18
ANION GAP	14
GLUCOSE	129
CALCIUM	9.1
BUN	17
CREATININE	1.48

ALT (SGPT)	18
AST (SGOT)	26
BILIRUBIN,TOTAL	1.2
BILIRUBIN,DIRECT	**0.4**
BILIRUBIN,INDIRECT	0.8

Minneapolis Heart Institute Foundation | GRAND ROUNDS

38

PRO-BNP 12,397 pg/mL

LACTATE 2.8 mmol/L

8/23/24 02:11	6/3/24 08:50	4/3/24 13:10	3/22/24 14:30	2/14/24 12:25	2/1/24 10:05	1/10/24 12:40	1/4/24 09:59
12,397 ▲	573 ▲	532 ▲	1,849 ▲	2,626 ▲	1,288 ▲	1,881 ▲	4,120 ▲

Minneapolis Heart Institute Foundation | GRAND ROUNDS

39

	02:11	03:58	10:05	11:43
TROPONIN T HS	**28**	**77**	**765**	**1,036**

Minneapolis Heart Institute Foundation | GRAND ROUNDS

40

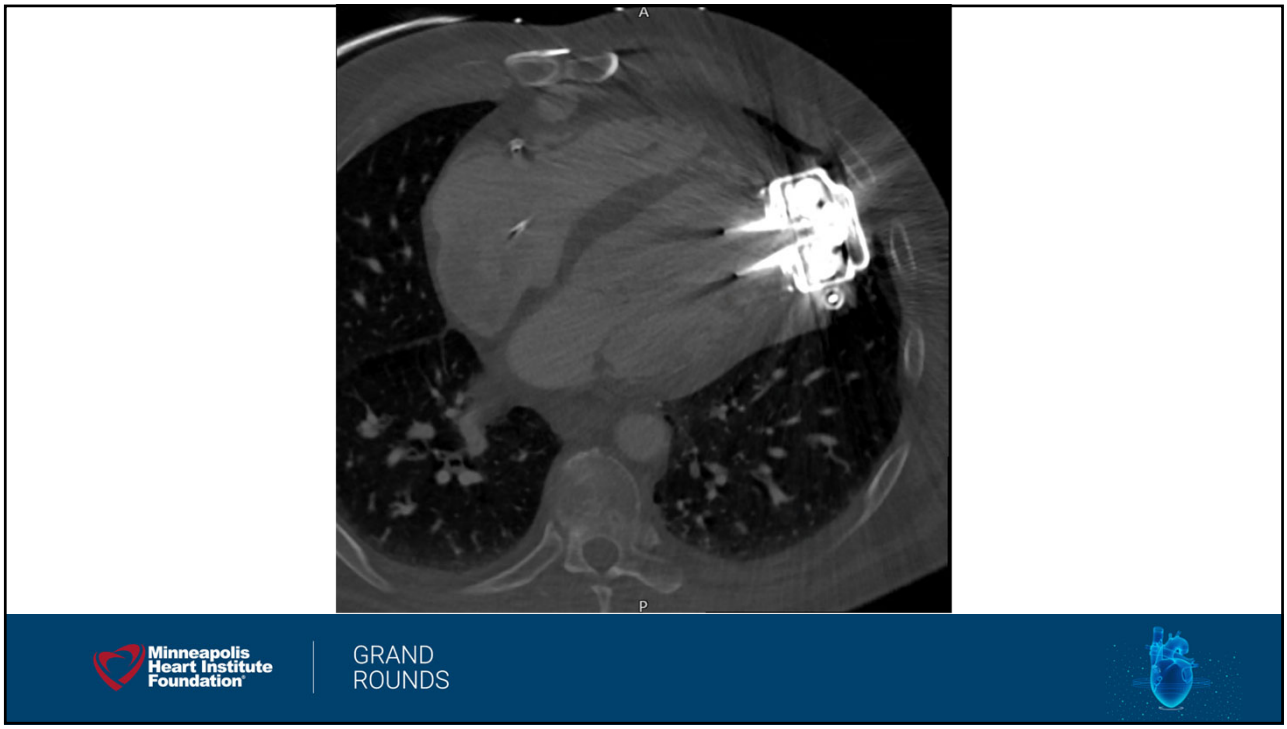
- Heartmate 3 at 5800 RPM, cannula flow not well visualized, no high velocity signals
- Severely reduced global systolic function with an estimated **EF of 10-20%**
- **Severely increased LV size; LVID(d) 7.1 cm**
- Right ventricular cavity size is not well visualized, global systolic RV function is severely reduced
- The mitral valve is sclerotic, trace mitral regurgitation
- Moderate tricuspid regurgitation

Minneapolis Heart Institute Foundation | GRAND ROUNDS

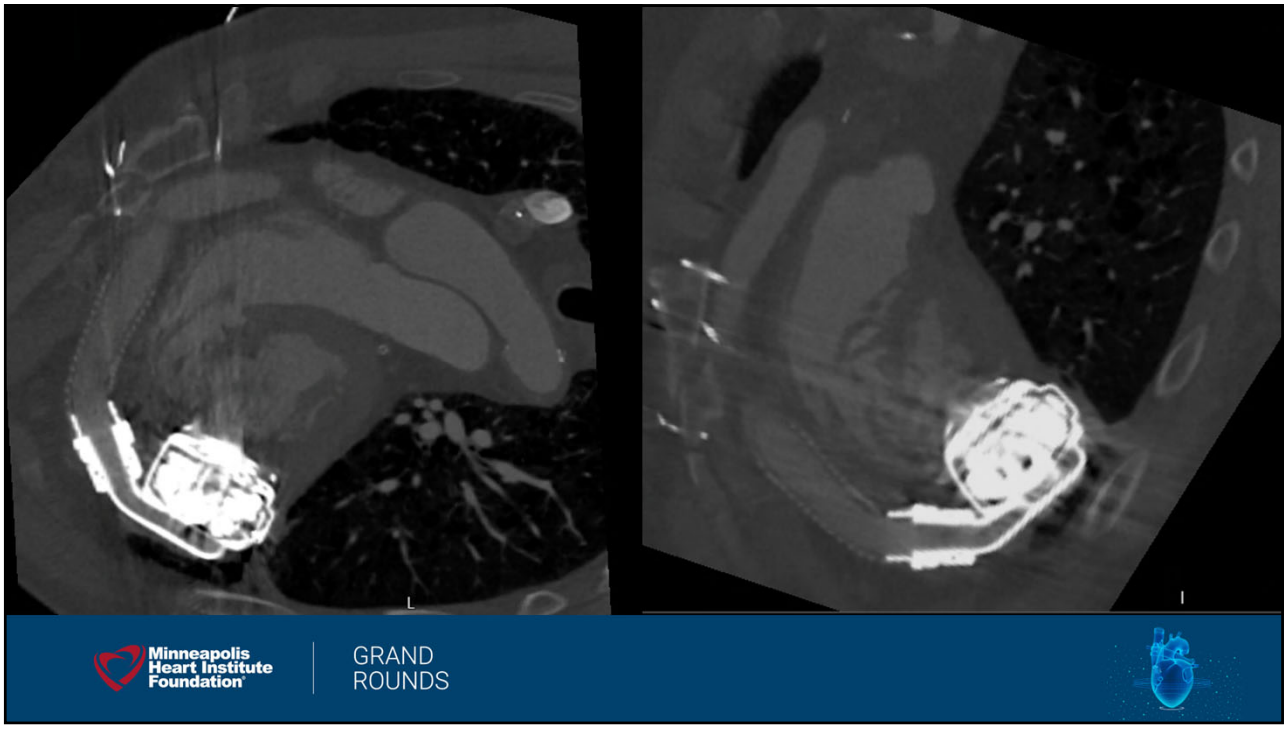
41

Minneapolis Heart Institute Foundation | GRAND ROUNDS

42


A
P
Minneapolis Heart Institute Foundation
GRAND ROUNDS

43


L
I
Minneapolis Heart Institute Foundation
GRAND ROUNDS

44

- Appropriately positioned HM3 LVAD
  - No obstruction of the inflow cannula
  - Outflow graft is widely patent
- Severely reduced biventricular systolic function
- Aortic valve is over-sewn and does not open

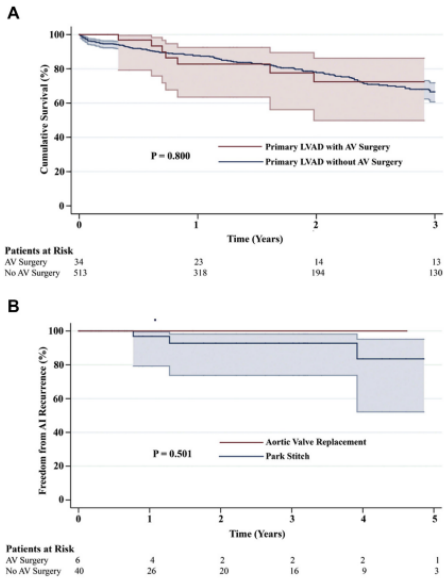
Minneapolis Heart Institute Foundation | GRAND ROUNDS

45

Aortic Valve Repair Versus Replacement Associated With Durable Left Ventricular Assist Devices

Paul C. Tang, MD, PhD,* Nadeen Sarsour, BS,* Jonathan W. Haft, MD, Matthew A. Romano, MD, Matthew Konerman, MD, Monica Colvin, MD, Todd Koelling, MD, Keith D. Aaronson, MD, and Francis D. Pagani, MD,

Figure 1. Kaplan-Meier analysis. (A) Survival in patients who had an open aortic valve (AV) repair or replacement during the first left ventricular assist device (LVAD) procedure compared with those who had an LVAD implant who never had an open AV procedure. (B) Recurrence of moderate or greater AV insufficiency (AI) comparing AVR versus AV repair with the Park stitch.



Tang, P et al. *The Annals of thoracic surgery*, *110*(4), 1259–1264

Minneapolis Heart Institute Foundation | GRAND ROUNDS

46

Table 3. Operative Parameters and Postoperative Outcomes

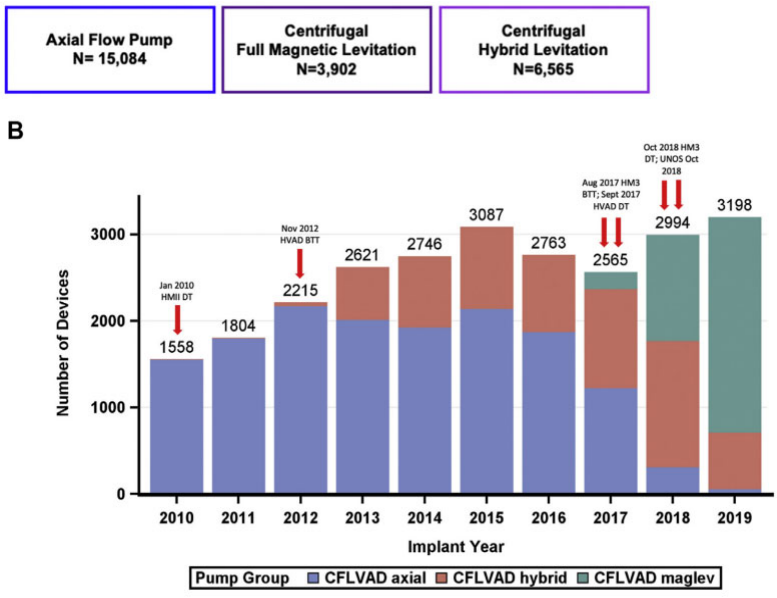
Study Groups	Aortic Valve Repair (n = 40)	Aortic Valve Replacement (n = 6)	P
Concomitant with LVAD implant/exchange	39 (97.5%)	6 (100.0%)	.695
Redo sternotomy	15 (37.5%)	2 (33.3%)	.844
Cardiopulmonary bypass, min	97.73 ± 28.97	129.33 ± 43.18	.024
Cross-clamp, min	12.35 ± 14.64	50.67 ± 35.46	<.001
Sternum closed	23 (57.5%)	4 (66.7%)	.671
Chest open (median d)	1 (IQR = 1)	1.5 (IQR = 0)	.468
Tricuspid valve repair	13 (32.5%)	2 (33.3%)	.968
Centrifugal flow LVAD	21 (52.5%)	4 (66.7%)	.516
Axial flow LVAD	19 (47.5%)	2 (33.3%)	.516
Median total length of stay (IQR)	21.00 (26.25)	19.00 (11.75)	.673
Stroke	0	0	.999
Reoperation for bleeding	4 (10.0%)	0	.437
Postoperative dialysis	0	0	1.000
30-d operative mortality	0	0	1.000
Transplant at last follow-up	10 (25.0%)	1 (16.7%)	.655

IQR, interquartile range; LVAD, left ventricular assist device.

Minneapolis Heart Institute Foundation | GRAND ROUNDS

Tang, P et al. *The Annals of thoracic surgery*, *110*(4), 1259–1264

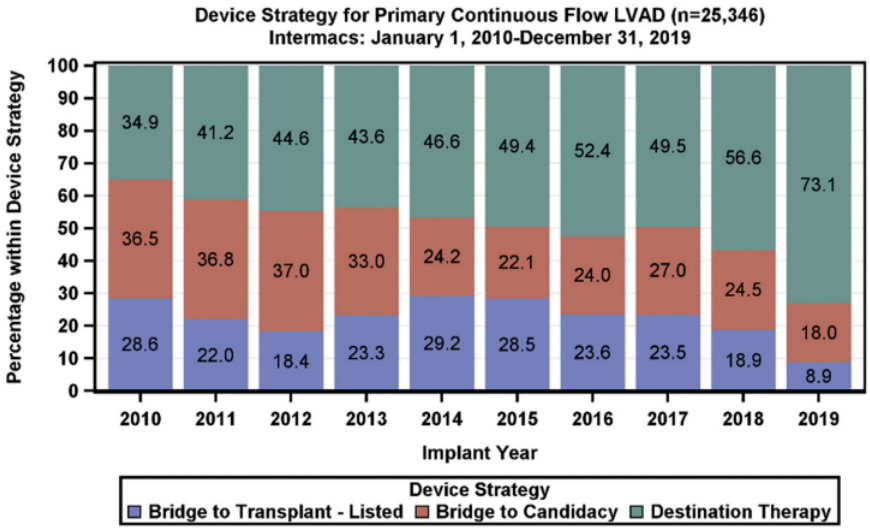
47



Minneapolis Heart Institute Foundation | GRAND ROUNDS

The Society of Thoracic Surgeons Intermacs 2020 Annual Report. The Annals of thoracic surgery, 111(3), 778–792

48



Minneapolis Heart Institute Foundation | GRAND ROUNDS

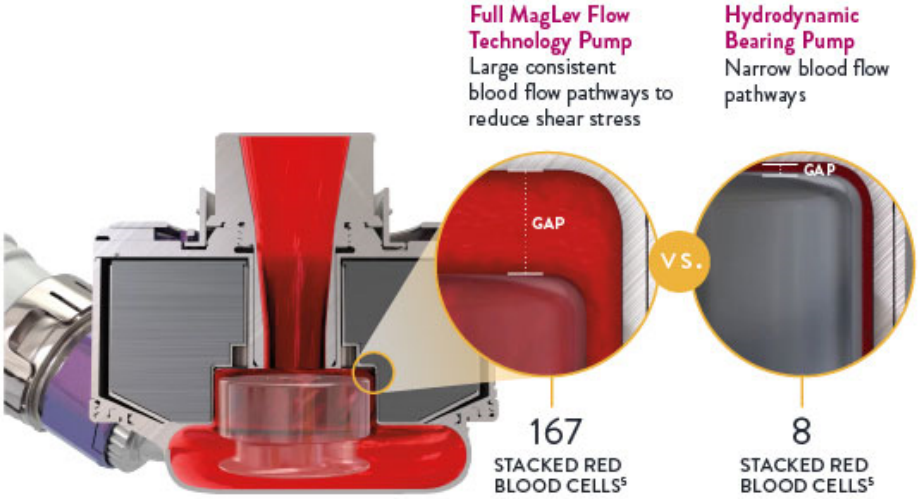
The Society of Thoracic Surgeons Intermacs 2020 Annual Report. The Annals of thoracic surgery, 111(3), 778–792

49

- Large blood flow gaps to improve hemocompatibility
- Textured blood contacting surfaces
- Centrifugal flow
- The magnetically levitated rotor

Minneapolis Heart Institute Foundation | GRAND ROUNDS

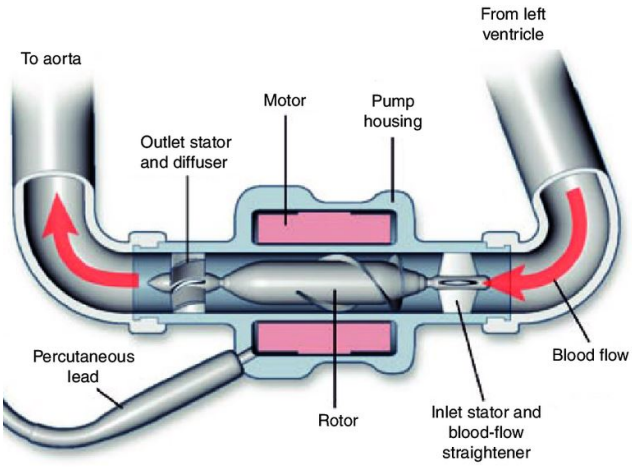
50



Minneapolis Heart Institute Foundation | GRAND ROUNDS

https://www.cardiovascular.abbott/us/en/hcp/products/heart-failure/left-ventricular-assist-devices/heartmate-3.html

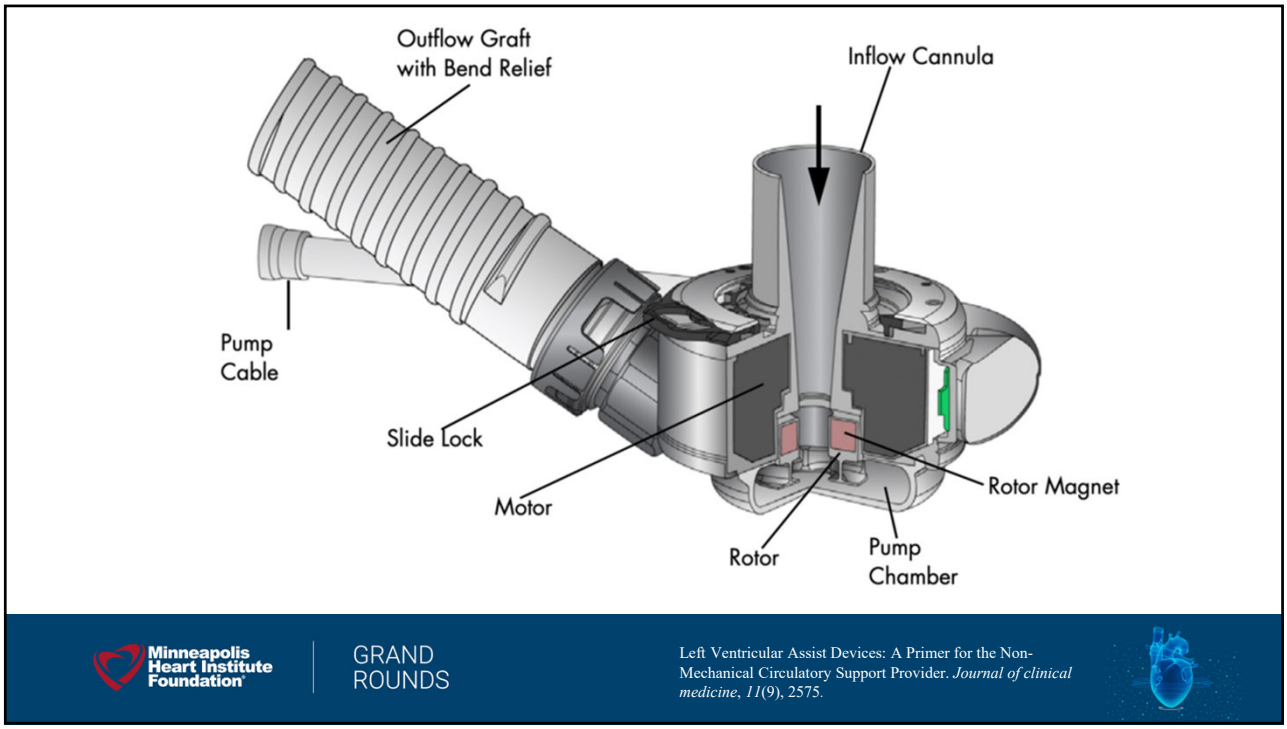
51



Minneapolis Heart Institute Foundation | GRAND ROUNDS

Sheikh, F et al. HeartMate® II continuous-flow left ventricular assist system. *Expert review of medical devices*, *8*(1), 11–21

52



53

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Two-Year Outcomes with a Magnetically Levitated Cardiac Pump in Heart Failure

M.R. Mehra, D.J. Goldstein, N. Uriel, J.C. Cleveland, Jr., M. Yuzefpolskaya, C. Salerno, M.N. Walsh, C.A. Milano, C.B. Patel, G.A. Ewald, A. Itoh, D. Dean, A. Krishnamoorthy, W.G. Cotts, A.J. Tatooles, U.P. Jorde, B.A. Bruckner, J.D. Estep, V. Jeevanandam, G. Sayer, D. Horstmanshof, J.W. Long, S. Gulati, E.R. Skipper, J.B. O'Connell, G. Heatley, P. Sood, and Y. Naka, for the MOMENTUM 3 Investigators*

Event	Centrifugal-Flow Pump Group (N =189)		Axial-Flow Pump Group (N =172)		Hazard Ratio (95% CI)	P Value†
	no. of patients with event (%)	*no. of events*	*no. of patients with event (%)*	*no. of events*		
Suspected or confirmed pump thrombosis	2 (1.1)	2	27 (15.7)	33	0.06 (0.01–0.26)	<0.001
Pump thrombosis resulting in reoperation or removal of device	0	0	21 (12.2)	25	NA	<0.001

Minneapolis Heart Institute Foundation
GRAND ROUNDS
Two-Year Outcomes with a Magnetically Levitated Cardiac Pump in Heart Failure. The New England journal of medicine, 378(15), 1386–1395

54

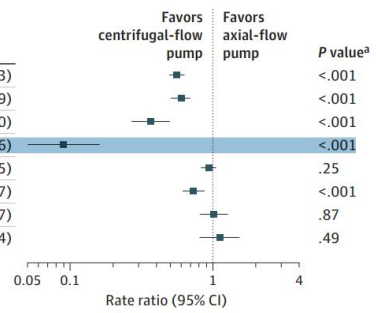
JAMA | Original Investigation

Five-Year Outcomes in Patients With Fully Magnetically Levitated vs Axial-Flow Left Ventricular Assist Devices in the MOMENTUM 3 Randomized Trial

Mandeep R. Mehra, MD, MSc; Daniel J. Goldstein, MD; Joseph C. Cleveland, MD; Jennifer A. Cowger, MD, MS; Shelley Hall, MD; Christopher T. Salerno, MD; Yoshifumi Naka, MD, PhD; Douglas Horstmanshof, MD; Joyce Chuang, PhD; AiJia Wang, MPH; Nir Uriel, MD, MSc

Figure 3. Serious Adverse Events in a Study of 5-Year Outcomes in Patients With Fully Magnetically Levitated vs Axial-Flow Left Ventricular Assist Devices

Serious adverse event	Events/patient-years: Centrifugal-flow pump (515 patients; 1234 patient-years)	Events/patient-years: Axial-flow pump (505 patients; 997 patient-years)	Rate ratio (95% CI)	*P* value[a]
Any bleeding	0.430	0.765	0.56 (0.50-0.63)	<.001
Gastrointestinal bleeding	0.252	0.423	0.60 (0.51-0.69)	<.001
Any stroke	0.050	0.136	0.37 (0.27-0.50)	<.001
Suspected or confirmed pump thrombosis	0.010	0.108	0.09 (0.05-0.16)	<.001
Any major infection	0.515	0.551	0.94 (0.83-1.05)	.25
Cardiac arrhythmia	0.207	0.283	0.73 (0.62-0.87)	<.001
Right heart failure	0.149	0.146	1.02 (0.82-1.27)	.87
Other neurologic event[b]	0.073	0.065	1.12 (0.81-1.54)	.49



Minneapolis Heart Institute Foundation | GRAND ROUNDS

Mehra MR et al. Five-Year Outcomes in Patients With Fully Magnetically Levitated vs Axial-Flow Left Ventricular Assist Devices in the MOMENTUM 3 Randomized Trial. *JAMA.* 2022;328(12):1233–1242.

55

- In view of left ventricle (LV) dilation with symptoms concerning for CS, a right heart catheterization (RHC) was pursued to evaluate hemodynamics.
- LVAD at 5800 RPMs gave a flow of 2.6L, pulsatility index of 3.6
  - ➢ RA 11
  - ➢ RV 56/3 (11)
  - ➢ PA 61/28 (38)
  - ➢ PCWP 18
  - ➢ TPG 20
  - ➢ Fick CO of 3.02 L/m and CI of 1.44 L/min/m²

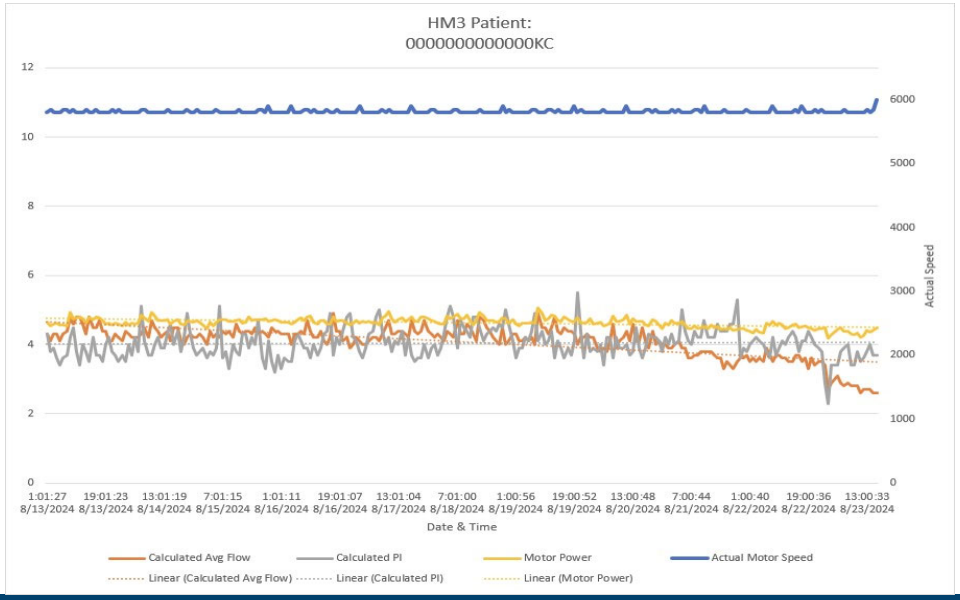
Minneapolis Heart Institute Foundation | GRAND ROUNDS

56

- LVAD speed ramped up to 6000 RPMs, flow remained unchanged and estimated CO decreased to 2.86 L/m and CI of 1.36L/min/m²

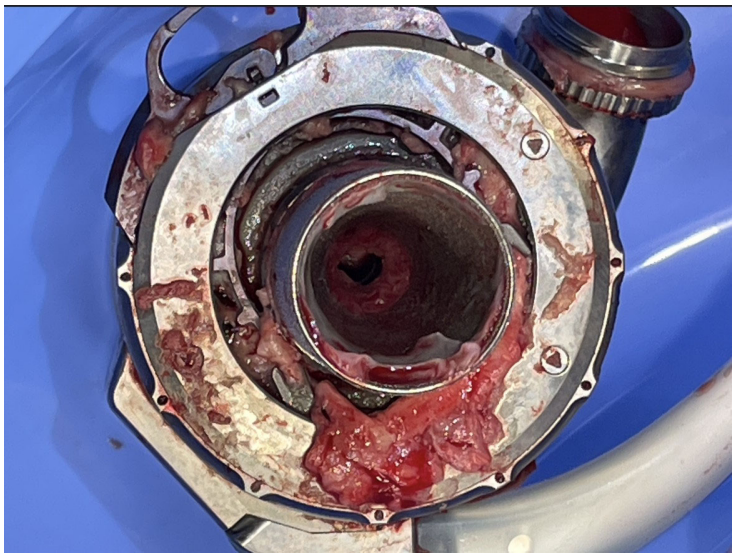
Minneapolis Heart Institute Foundation | GRAND ROUNDS

57



Minneapolis Heart Institute Foundation | GRAND ROUNDS

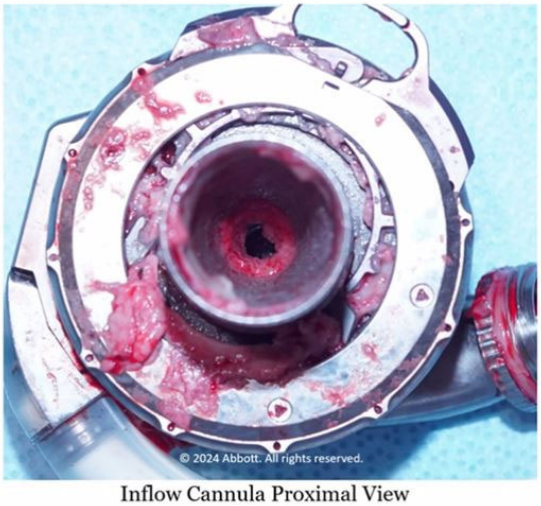
58



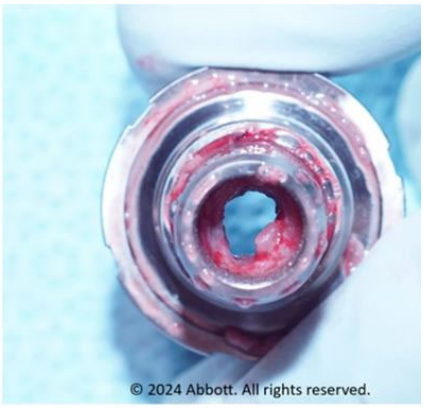
Minneapolis Heart Institute Foundation | GRAND ROUNDS

59

CS-200932 / PER-2024-0137189 Explant Analsyis



Inflow Cannula Proximal View



Inflow Cannula Distal View

Minneapolis Heart Institute Foundation | GRAND ROUNDS

60

CS-200932 / PER-2024-0137189 Explant Analysis

Thrombus Proximal View

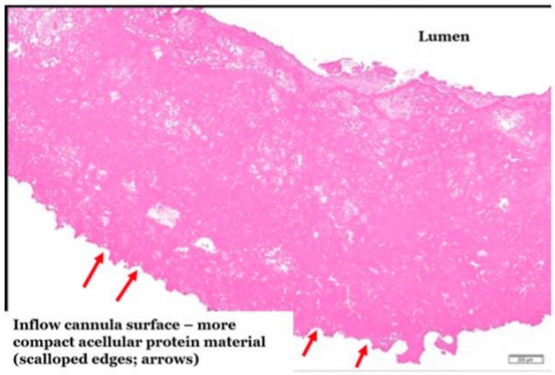
Thrombus Side View

Thrombus Distal View

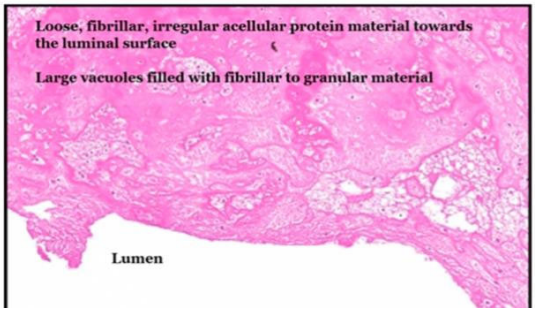
Hollow cylinder, with diameter tapering from 9.0 mm (proximal) to 6.0 mm (distal)

61

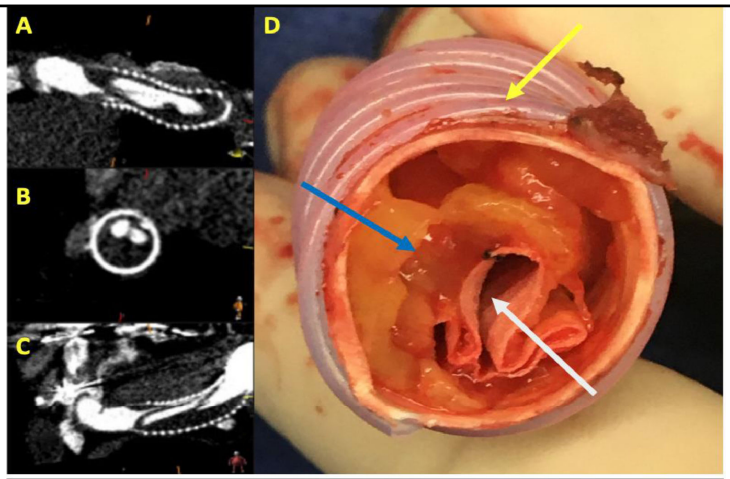
Histology – dense coagulum of acellular protein material; "pseudointima"



- "Pseudointima remodeling'" in the absence of neovasculogenesis
- No evidence of de novo active mural thrombo-genesis



62



A-C. CT of the outflow graft with lengthwise (A, C) and cross sectional (B) imaging demonstrating an extensive filling defect. **D.** Surgical specimen demonstrates proteinaceous material (blue arrow) in between the bend relief (yellow arrow) and the outflow graft (white arrow), causing extrinsic compression.

Minneapolis Heart Institute Foundation | GRAND ROUNDS

Labrada, L. et al. The Journal of Heart and Lung Transplantation, Volume 40, Issue 4, S496

63

Minneapolis Heart Institute Foundation | GRAND ROUNDS

64

- Important to be vigilant regarding this potential complication and early intervention
- Increase in LV diameter without evidence of outflow graft obstruction on imaging, should raise suspicion and warrants detailed evaluation of the LVAD log files
- Particularly, in patients with an oversewn aortic valve, one should expect rapid decompensation and VA-ECMO can be used to bridge these patients through HM3 exchange

Minneapolis Heart Institute Foundation | GRAND ROUNDS

65

Acknowledgments

- Dr. Katarzyna Hryniewicz
- Dr. Peter Eckman
- Dr. Carly Lodewyks
- Jessica Boughton
- Abbott

Minneapolis Heart Institute Foundation | GRAND ROUNDS

66


thank you & happy holidays!
Minneapolis Heart Institute Foundation
GRAND ROUNDS

67