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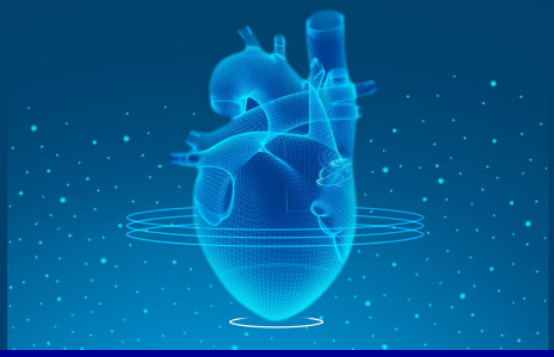
GRAND ROUNDS



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Update on 2022 ACC/AHA Guidelines for Aortic Disease

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

Developed in collaboration with and endorsed by the American Association for Thoracic Surgery, American College of Radiology, Society of Cardiovascular Anesthesiologists, Society for Cardiovascular Angiography and Interventions, Society of Thoracic Surgeons, and Society for Vascular Surgery

Kevin M. Harris, MD FACC
Erik Beckmann, MD
Minneapolis Heart Institute at Abbott-Northwestern Hospital

Minneapolis Heart Institute Foundation
Creating a world without heart disease

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Overview

- Imaging
  - Methodology
  - Surveillance
- Etiology
  - Genetics and Family screening
- Medical treatment
  - Blood pressure
  - Statin
- Multidisciplinary aortic team
- Shared decision making
- Surgical treatment options and outcomes
- Surgical thresholds

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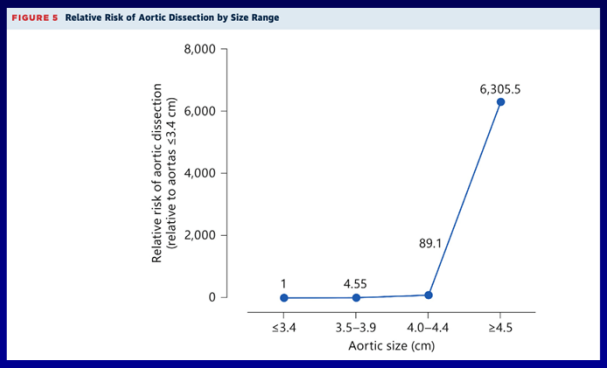
4

Aneurysm



- 4 cm = Dilated (2.6% population)
- 4.5 cm: Aneurysm (0.2%)

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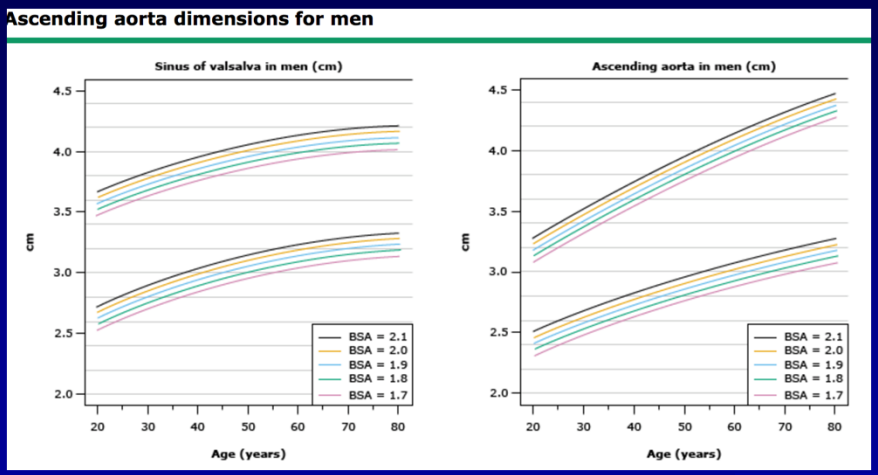
Aorta size varies by Age, Gender and Body size



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Aorta Measurements

Recommendations for Aortic Imaging Techniques to Determine Presence and Progression of Aortic Disease
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

COR	LOE	RECOMMENDATIONS
1	B-NR	1. In patients with known or suspected aortic disease, aortic diameters should be measured at reproducible anatomic landmarks perpendicular to axis of blood flow, and these measurement methods should be reported in a clear and consistent manner. In cases of asymmetric or oval contour, the longest diameter and its perpendicular diameter should be reported.[3,4]
1	C-LD	2. In patients with known or suspected aortic disease, episodic and cumulative ionizing radiation doses should be kept as low as feasible while maintaining diagnostic image quality.[5-7]
1	C-EO	3. In patients with known or suspected aortic disease, when performing CT or MR imaging, it is recommended that the root and ascending aortic diameters be measured from inner-edge to inner-edge, using an electrocardiographic-synchronized technique. If there are aortic wall abnormalities, such as atherosclerosis or discrete wall thickening (more common in the distal aorta), the outer-edge to outer-edge diameter should be reported (Table 4).

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Aorta Measurements

1	C-EO	4. In patients with known or suspected aortic disease, the aortic root diameter should be recorded as maximum sinus to sinus measurement. In the setting of known asymmetry, multiple measurements should be reported, and both short- and long-axis images of the root should be obtained to avoid underestimation of the diameter.
2a	C-LD	5. In patients with known or suspected aortic disease, it is reasonable that a dilated root or ascending aorta be indexed to patient height or BSA in the report, to aid in clinical risk assessment.[8-11]
2a	C-EO	6. In patients with known or suspected aortic disease, when performing echocardiography, it is reasonable to measure the aorta from leading-edge to leading-edge, perpendicular to the axis of blood flow.
2b	C-EO	Using inner-edge to inner-edge measurements may also be considered, particularly on short-axis imaging.

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Aorta measures

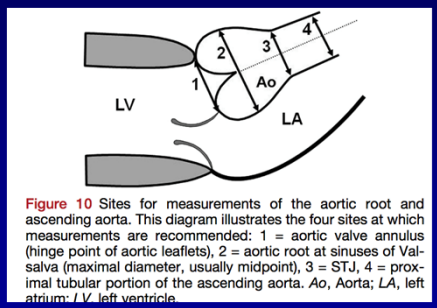
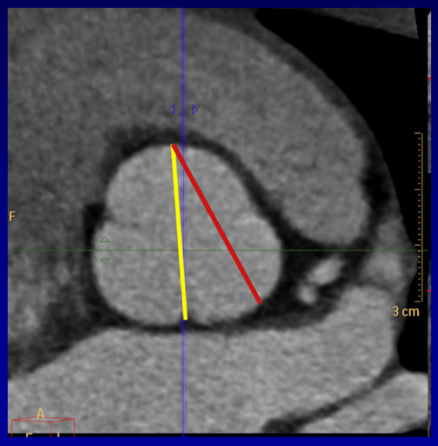


Figure 10 Sites for measurements of the aortic root and ascending aorta. This diagram illustrates the four sites at which measurements are recommended: 1 = aortic valve annulus (hinge point of aortic leaflets), 2 = aortic root at sinuses of Valsalva (maximal diameter, usually midpoint), 3 = STJ, 4 = proximal tubular portion of the ascending aorta. *Ao*, Aorta; *LA*, left atrium; *LV*, left ventricle.



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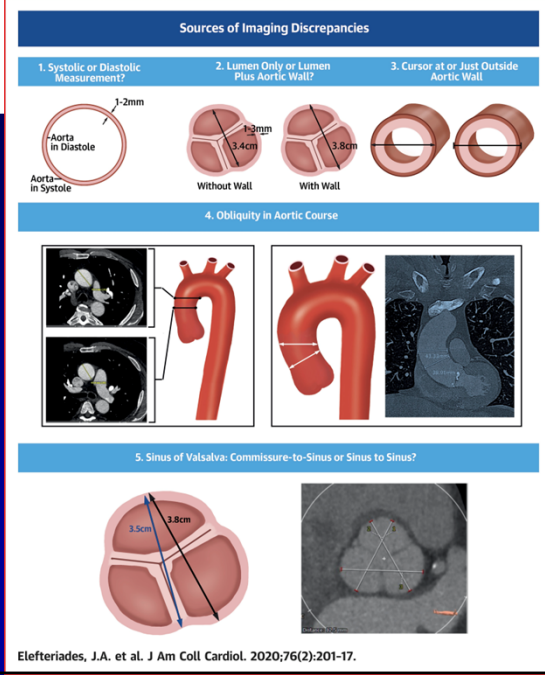
JACC REVIEW TOPIC OF THE WEEK

Discrepancies in Measurement of the Thoracic Aorta

JACC Review Topic of the Week

John A. Elefteriades, MD, PhD (hon),[a] Sandip K. Mukherjee, MD,[a,b] Hamid Mojibian, MD[a,c]

CENTRAL ILLUSTRATION: Sources of Discrepancies in Ascending Aortic Measurements



Elefteriades, J.A. et al. J Am Coll Cardiol. 2020;76(2):201-17.

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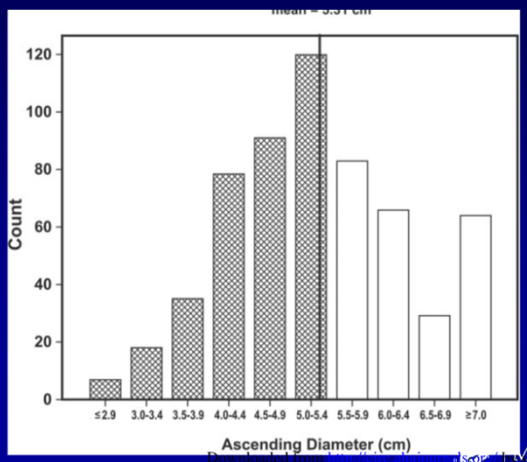
Aortic size at time of Type A aortic dissection



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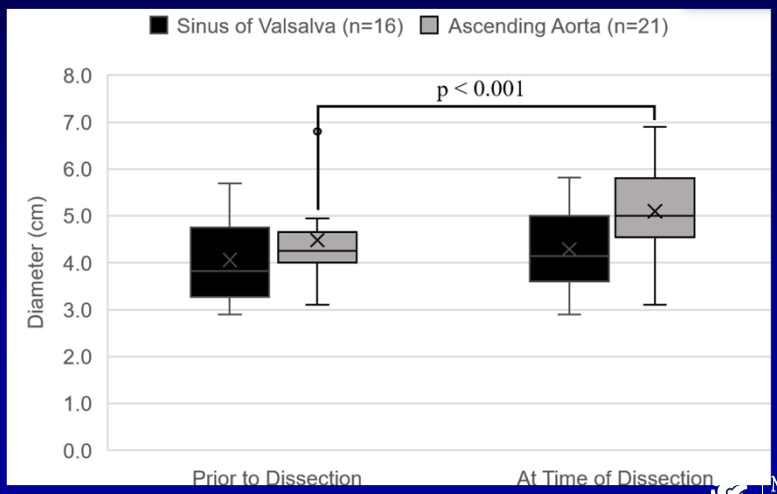
Aortic growth at time of dissection



Johnson et al. AJC

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Root Dilatation Is More Malignant Than Ascending Aortic Dilation

Paris D. Kalogerakos, MD, PhD; Mohammad A. Zafar, MD; Yupeng Li, PhD; Sandip K. Mukherjee, MD; Bulat A. Ziganshin, MD, PhD; John A. Rizzo, PhD; John A. Elefteriades, MD, PhD (Hon)

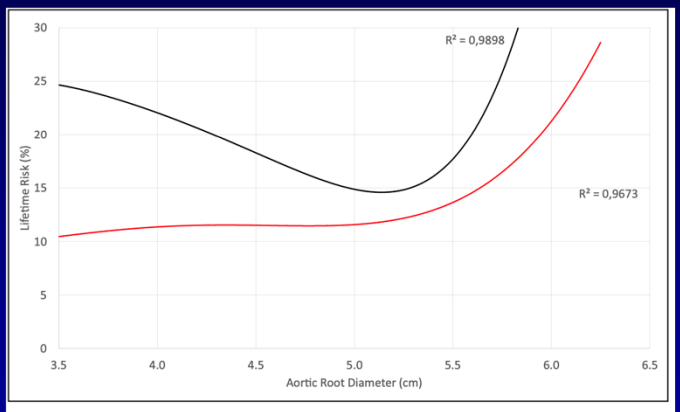

Figure 5. Lifetime risk of the first composite end point (red line) and the second composite end point (black line) against the aortic root diameter of the 1162 patients.
The risk of the first composite end point increases considerably at a diameter >5.0 cm. The risk of near normal-sized aortas is overestimated because of a selection bias with the underrepresentation of healthy individuals. At diameters >4.5 cm, the sample becomes representative. Note that the risk of the first composite end point, attributed to an aortic root 5.0 cm wide, is almost 12%, which is double compared with the respective risk of a mid-ascending aorta (Figure 4). The risk of the second composite end point increases at diameters approximately >5.0 cm. The R^2 are very close to 1, suggesting that the trend lines

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Risk of Aortic Dissection in the Moderately Dilated Ascending Aorta

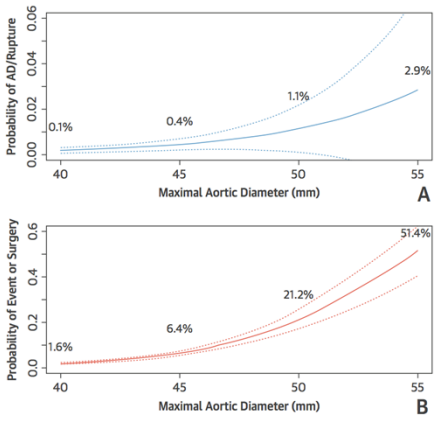
Joon Bum Kim, MD, PhD,[a] Matthew Spotnitz, MD,[b,f] Mark E. Lindsay, MD, PhD,[c,d,e] Thomas E. MacGillivray, MD,[b,e] Eric M. Isselbacher, MD,[c,e] Thoralf M. Sundt III, MD[b,e]

Patients with Aorta 4-5.5

There is risk but it is low

Bicuspid valve did not impact rupture rate

FIGURE 3 Probability of Aortic Dissection and/or Rupture, and Composite of Event and Surgery Within 5 Years



(A) Probability of aortic dissection (AD) and/or rupture, and **(B)** composite of event and surgery within 5 years based on baseline aortic diameters estimated by logistic regression models. **Dotted lines** are 95% confidence intervals.

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Aortic Height Index

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

= low risk (~ 4% per year) = moderate risk (~ 7% per year) = High risk (~ 12% per year) = severe risk (~ 18% per year)

Light green area indicates low risk, yellow area indicates moderate risk, orange area indicates high risk, and red area indicates severe risk.

FIGURE 10. Risk of complications (aortic dissection, rupture, and death) in patients with ascending aortic aneurysm as a function of aortic diameter (horizontal axis) and height (vertical axis), with the aortic height index given within the figure. *Light green* indicates low risk; *yellow*, moderate risk; *orange*, high risk; *red*, severe risk.

AHI of 3.2 signifies increased risk

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ORIGINAL RESEARCH ARTICLE

Aortic Cross-Sectional Area/Height Ratio and Outcomes in Patients With a Trileaflet Aortic Valve and a Dilated Aorta

BACKGROUND: In patients with a dilated proximal ascending aorta and trileaflet aortic valve, we aimed to assess (1) factors independently associated with increased long-term mortality and (2) the incremental prognostic utility of indexing aortic root to patient height.

Ahmad Masri, MD
Vidyasagar Kalahasti, MD
Lars G. Svensson, MD, PhD
Eric E. Roselli, MD

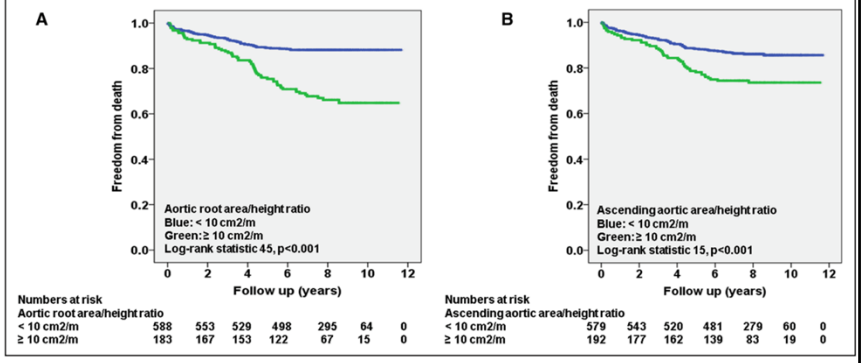

Figure 3. Kaplan-Meier survival curves of the entire study sample separated on the basis of aortic root area/height ratio of < or ≥10 cm²/m (A) and ascending aortic area/height ratio of < or ≥10 cm²/m (B).

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Imaging surveillance

Recommendations for Surveillance of Thoracic Aortic Dilation and Aneurysm

COR	LOE	RECOMMENDATIONS
1	C-LD	1. In patients with a dilated thoracic aorta, a TTE is recommended at the time of diagnosis to assess aortic valve anatomy, aortic valve function, and thoracic aortic diameters.[1-4]
2a	C-LD	2. In patients with a dilated thoracic aorta, a CT or MRI at the time of diagnosis is reasonable to assess thoracic aortic anatomy and diameters.[1,3,5-7]
2a	C-LD	3. In patients with a dilated thoracic aorta, follow-up imaging (with TTE, CT, or MRI, as appropriate based on individual anatomy) in 6 to 12 months is reasonable to determine the rate of aortic enlargement; if stable, surveillance imaging every 6 to 24 months (depending on aortic diameter) is reasonable.[1,3,4]

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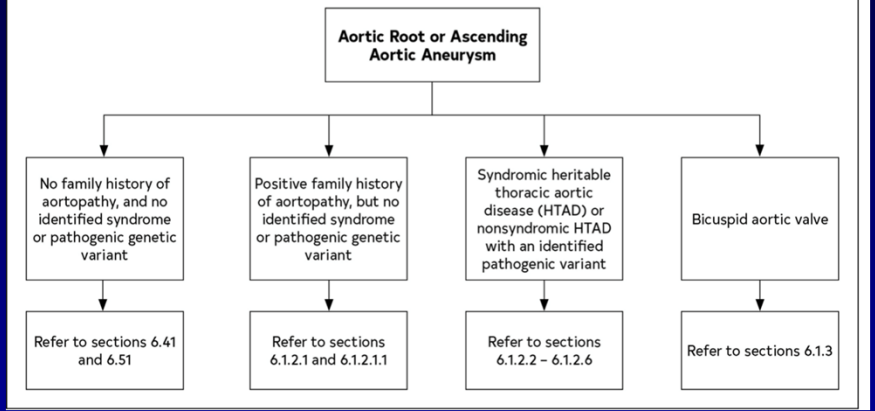
FIGURE 16 Recommendations for Management of Aneurysms of the Aortic Root and Ascending Aorta According to Known Causative Factors.



Sporadic Thoracic Aneurysm

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Hereditary Thoracic Aortic Disease (HTAD)

Syndromic Aneurysms

- Marfan Syndrome (FBN1)
- Loeys-Dietz (TGFBR1, TGFBR2, TGFB2,TGFB3)
- Vascular Ehlers-Danlos (COL3A1)
- Shprintzen-Goldberg

Non syndromic

- Bicuspid aortic valve
- Familial TAA (ACTA2, MYH11, MYLK)

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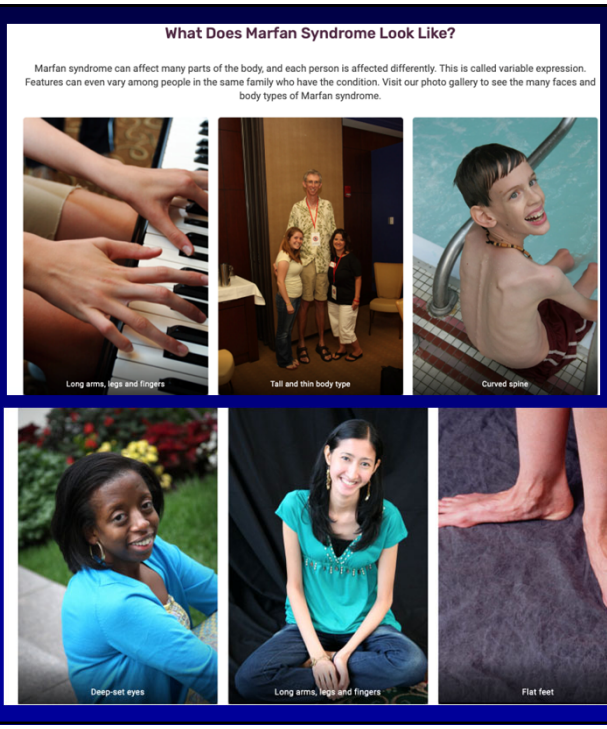

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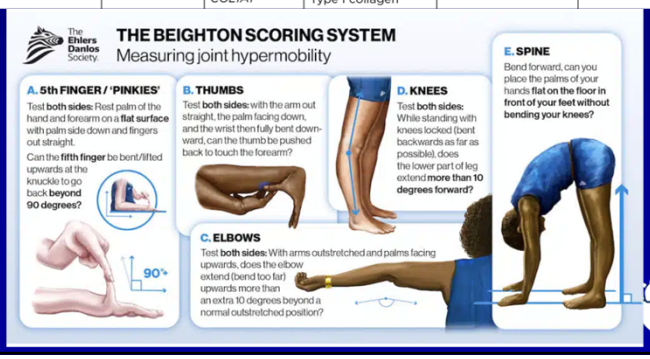
The Ehlers-Danlos Society

(In order of estimated prevalence)	Prevalence	Gene(s)	Protein(s)	Pattern	Features
Hypermobile EDS (hEDS)	1 in 3,100-5,000	Unknown	Unknown	Autosomal Dominant	Generalized joint hypermobility Joint instability Chronic pain
Classical EDS (cEDS)	1 in 20,000-40,000	*COL5A1*	Type V collagen	Autosomal Dominant	Skin fragility with extensive atrophic scarring Very stretchy skin with velvety or doughy texture
		COL5A2	Type V collagen		
		COL1A1	Type I collagen		
Vascular EDS (vEDS)	1 in 100,000-200,000	*COL3A1*	Type III collagen	Autosomal Dominant	Arterial fragility with aneurysm/dissection/ rupture
		COL1A1	Type I collagen		



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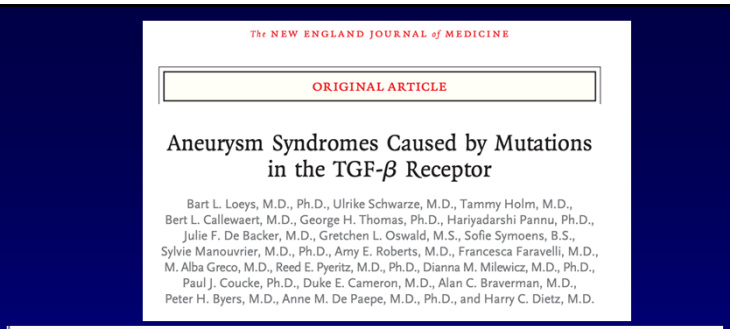

triad of arterial tortuosity and aneurysms, hypertelorism, and bifid uvula or cleft palate

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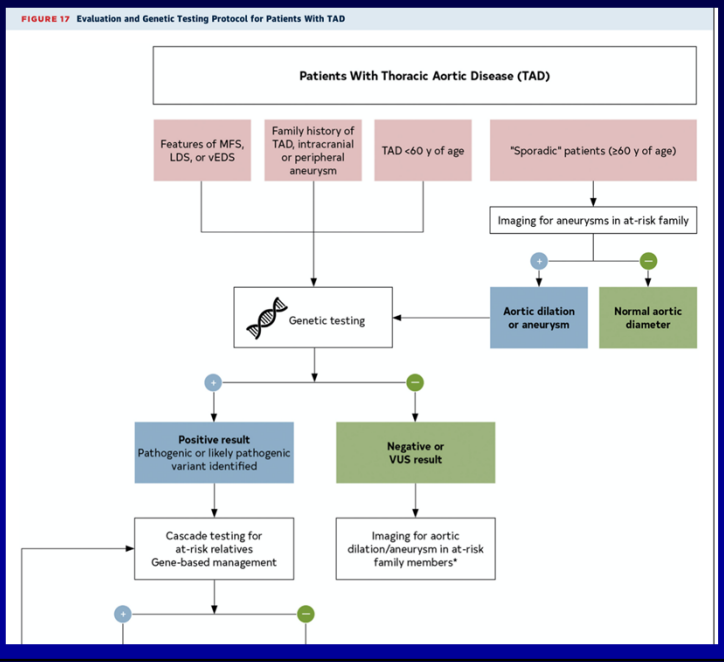
Genetic and Family screening



*SD in family member at young age

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Recommendations for HTAD: Genetic Testing and Screening of Family Members for TAD
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

COR	LOE	RECOMMENDATIONS
1	B-NR	1. In patients with aortic root/ascending aortic aneurysms or aortic dissection, obtaining a multigenerational family history of TAD, unexplained sudden deaths, and peripheral and intracranial aneurysms is recommended.[1-3]
1	B-NR	2. In patients with aortic root/ascending aortic aneurysms or aortic dissection and risk factors for HTAD (Table 8, Figure 17), genetic testing to identify pathogenic/likely pathogenic variants (ie, mutations) is recommended.[4-6]
1	B-NR	3. In patients with an established pathogenic or likely pathogenic variant in a gene predisposing to HTAD, it is recommended that genetic counseling be provided and the patient's clinical management be informed by the specific gene and variant in the gene.[7-9]
1	B-NR	4. In patients with TAD who have a pathogenic/likely pathogenic variant, genetic testing of at-risk biological relatives (ie, cascade testing) is recommended.[6,10,11] In family members who are found by genetic screening to have inherited the pathogenic/likely pathogenic variant, aortic imaging with TTE (if aortic root and ascending aorta are adequately visualized, otherwise with CT or MRI) is recommended.[4,5,12]

Risks: Syndromic features, Age<60, Fam hx of TAD or other aneurysm, sudden death in relative at young age

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Hereditary thoracic aortic disease-HTAD

1	B-NR	5. In a family with aortic root/ascending aortic aneurysms or aortic dissection, if the disease-causing variant is not identified with genetic testing, screening aortic imaging (as per recommendation 4) of at-risk biological relatives (ie, cascade testing) is recommended.[13-15]
1	C-LD	6. In patients with aortic root/ascending aortic aneurysms or aortic dissection, in the absence of either a known family history of TAD or pathogenic/likely pathogenic variant, screening aortic imaging (as per recommendation 4) of first-degree relatives is recommended.[13]
1	C-EO	7. In patients with acute type A aortic dissection, the diameter of the aortic root and ascending aorta should be recorded in the operative note and medical record to inform the management of affected relatives.

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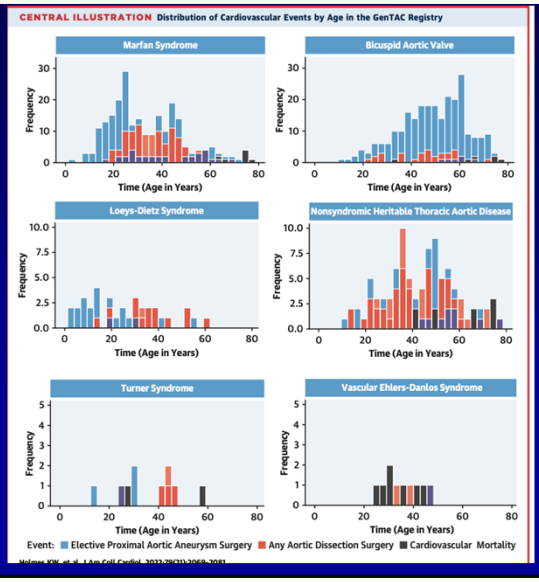
Cardiovascular Outcomes in Aortopathy

GenTAC Registry of Genetically Triggered Aortic Aneurysms and Related Conditions



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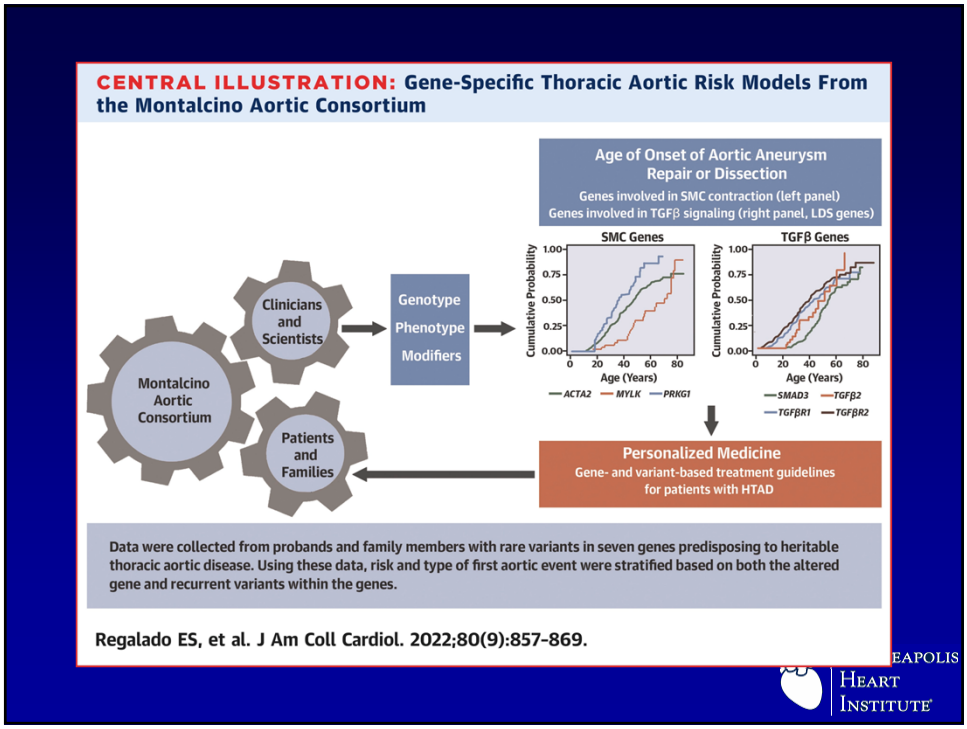
CENTRAL ILLUSTRATION: Gene-Specific Thoracic Aortic Risk Models From the Montalcino Aortic Consortium
Age of Onset of Aortic Aneurysm Repair or Dissection
Genes involved in SMC contraction (left panel)
Genes involved in TGFβ signaling (right panel, LDS genes)
SMC Genes
TGFβ Genes
Cumulative Probability
Age (Years)
ACTA2
MYLK
PRKG1
SMAD3
TGFB2
TGFBR1
TGFBR2
Clinicians and Scientists
Montalcino Aortic Consortium
Patients and Families
Genotype
Phenotype
Modifiers
Personalized Medicine
Gene- and variant-based treatment guidelines for patients with HTAD
Data were collected from probands and family members with rare variants in seven genes predisposing to heritable thoracic aortic disease. Using these data, risk and type of first aortic event were stratified based on both the altered gene and recurrent variants within the genes.
Regalado ES, et al. J Am Coll Cardiol. 2022;80(9):857-869.
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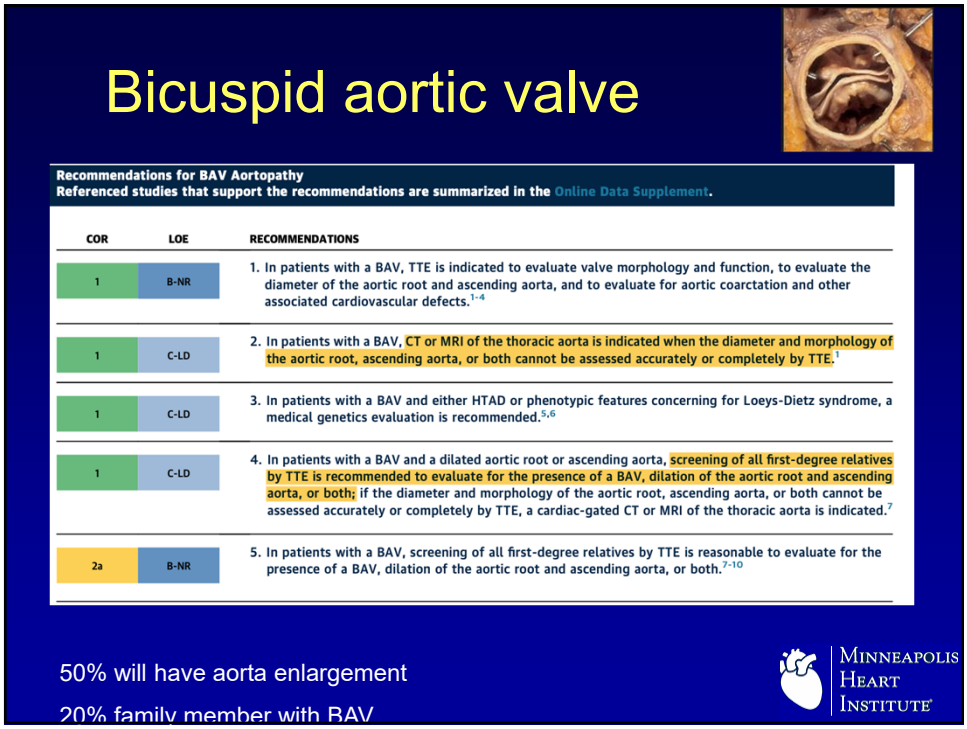
Bicuspid aortic valve
Recommendations for BAV Aortopathy
Referenced studies that support the recommendations are summarized in the Online Data Supplement.
COR
LOE
RECOMMENDATIONS
1
B-NR
1. In patients with a BAV, TTE is indicated to evaluate valve morphology and function, to evaluate the diameter of the aortic root and ascending aorta, and to evaluate for aortic coarctation and other associated cardiovascular defects.[1-4]
1
C-LD
2. In patients with a BAV, CT or MRI of the thoracic aorta is indicated when the diameter and morphology of the aortic root, ascending aorta, or both cannot be assessed accurately or completely by TTE.[1]
1
C-LD
3. In patients with a BAV and either HTAD or phenotypic features concerning for Loeys-Dietz syndrome, a medical genetics evaluation is recommended.[5,6]
1
C-LD
4. In patients with a BAV and a dilated aortic root or ascending aorta, screening of all first-degree relatives by TTE is recommended to evaluate for the presence of a BAV, dilation of the aortic root and ascending aorta, or both; if the diameter and morphology of the aortic root, ascending aorta, or both cannot be assessed accurately or completely by TTE, a cardiac-gated CT or MRI of the thoracic aorta is indicated.[7]
2a
B-NR
5. In patients with a BAV, screening of all first-degree relatives by TTE is reasonable to evaluate for the presence of a BAV, dilation of the aortic root and ascending aorta, or both.[7-10]
50% will have aorta enlargement
20% family member with BAV
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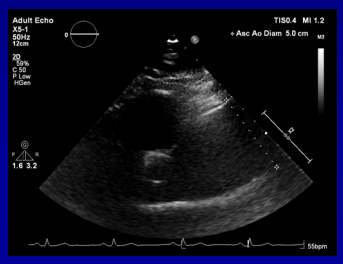
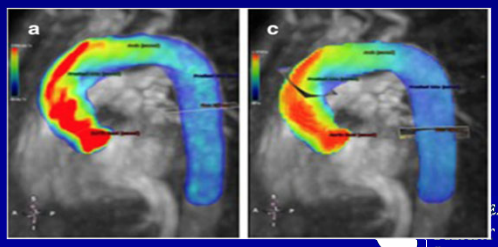
BAV Aortopathy

Recommendations for Routine Follow-Up of BAV Disease Aortopathy
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

COR	LOE	RECOMMENDATIONS
1	B-NR	1. In patients with a BAV who have undergone previous aortic valve repair or replacement and have a diameter of the aortic root, ascending aortic, or both of ≥4.0 cm, lifelong surveillance imaging of the aortic root and ascending aorta by TTE, CT, or MRI is recommended at an interval dependent on aortic diameter and rate of growth.[1-3]
1	C-LD	2. In patients with a BAV and a diameter of the aortic root, ascending aorta, or both of ≥4.0 cm, lifelong surveillance imaging of the aortic root and ascending aorta by TTE, CT, or MRI is recommended at an interval dependent on aortic diameter and rate of growth.[4,5]





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BP Management

Recommendations for BP Management in TAA
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

COR	LOE	RECOMMENDATIONS
1	B-NR	1. In patients with TAA and an average systolic BP (SBP) of ≥130 mm Hg or an average diastolic BP (DBP) of ≥80 mm Hg, the use of antihypertensive medications is recommended to reduce risk of cardiovascular events.[1-3]
2a	C-LD	2. In patients with TAA, regardless of cause and in the absence of contraindications, use of beta blockers to achieve target BP goals is reasonable.[1,4,5]
2a	C-EO	3. In patients with TAA, regardless of etiology and in the absence of contraindications, ARB therapy is a reasonable adjunct to beta-blocker therapy to achieve target BP goals.[6]

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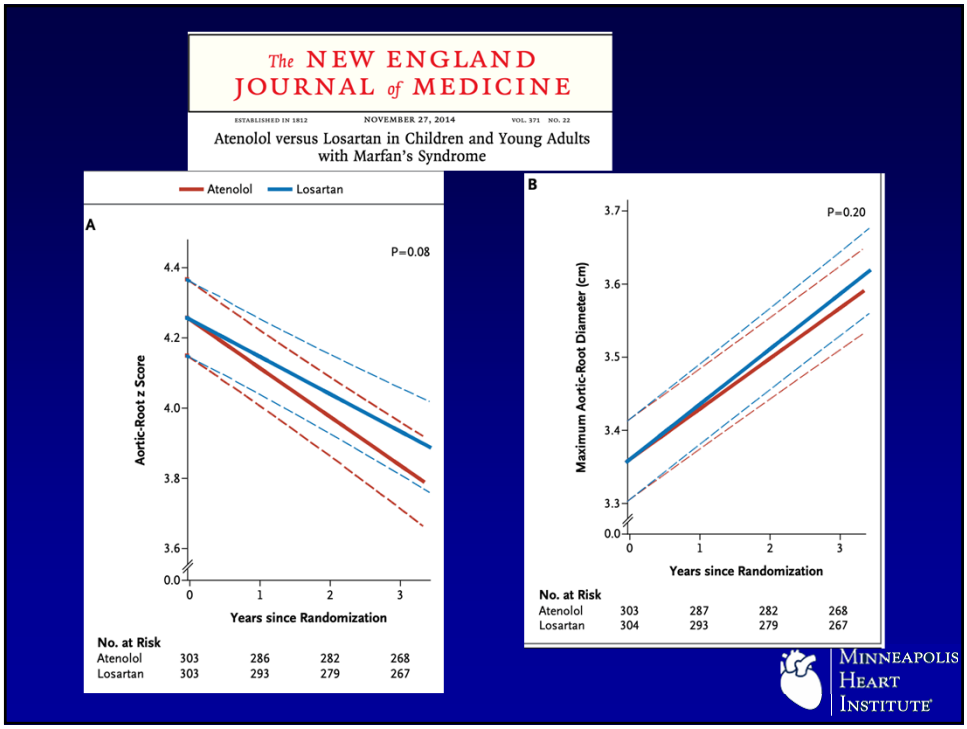
The NEW ENGLAND JOURNAL of MEDICINE
NOVEMBER 27, 2014
Atenolol versus Losartan in Children and Young Adults with Marfan's Syndrome
Atenolol
Losartan
A
P=0.08
Aortic-Root z Score
Years since Randomization
No. at Risk
Atenolol 303 286 282 268
Losartan 303 293 279 267
B
P=0.20
Maximum Aortic-Root Diameter (cm)
Years since Randomization
No. at Risk
Atenolol 303 287 282 268
Losartan 304 293 279 267
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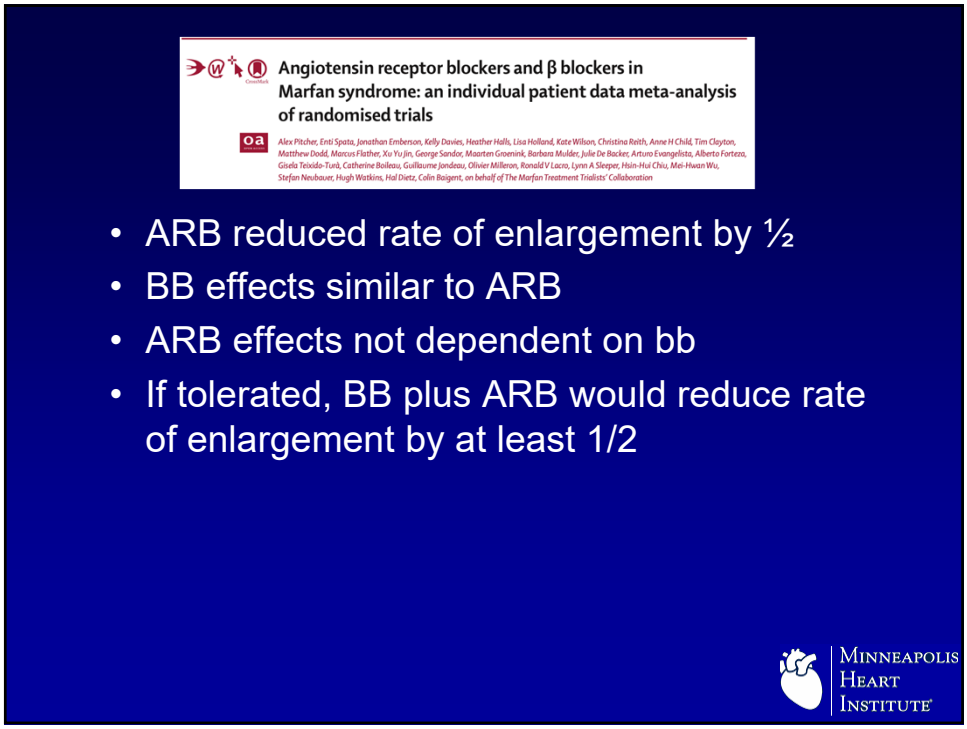
Angiotensin receptor blockers and β blockers in Marfan syndrome: an individual patient data meta-analysis of randomised trials
Alex Pitcher, Enti Spata, Jonathan Emberson, Kelly Davies, Heather Halls, Lisa Holland, Kate Wilson, Christina Reith, Anne H Child, Tim Clayton, Matthew Dodd, Marcus Flather, Xu Yu Jin, George Sandor, Maarten Groenink, Barbara Mulder, Julie De Backer, Arturo Evangelista, Alberto Forteza, Gisela Teixido-Tura, Catherine Boileau, Guillaume Jondeau, Olivier Milleron, Ronald V Lacro, Lynn A Sleeper, Hsin-Hui Chiu, Mei-Hwan Wu, Stefan Neubauer, Hugh Watkins, Hal Dietz, Colin Boigent, on behalf of The Marfan Treatment Trialists' Collaboration
• ARB reduced rate of enlargement by ½
• BB effects similar to ARB
• ARB effects not dependent on bb
• If tolerated, BB plus ARB would reduce rate of enlargement by at least 1/2
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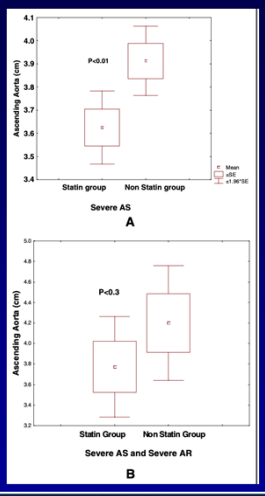
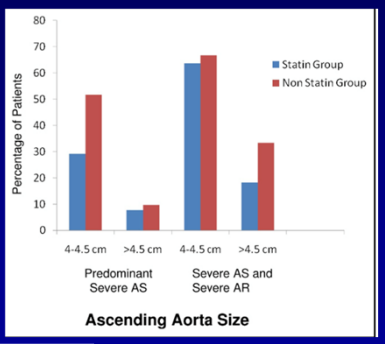
Statin



Comparison of Ascending Aortic Size in Patients With Severe Bicuspid Aortic Valve Stenosis Treated With Versus Without a Statin Drug

Sachin S. Goel, MD[a], E. Murat Tuzcu, MD[a], Shikhar Agarwal, MD, MPH[a], Olcay Aksoy, MD[a], Amar Krishnaswamy, MD[a], Brian P. Griffin, MD[a], Lars G. Svensson, MD, PhD[b], and Samir R. Kapadia, MD[a,*]



Recommendations for Treatment of TAA With Statins

COR	LOE	RECOMMENDATIONS
2a	C-LD	1. In patients with TAA and imaging or clinical evidence of atherosclerosis, statin therapy at moderate or high intensity is reasonable.[1-7]
2b	C-LD	2. In patients with TAA who have no evidence of atherosclerosis, the use of statin therapy may be considered.[3-6]

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Recommendations for Physical Activity and Quality of Life

COR	LOE	RECOMMENDATIONS
1	C-EO	1. For patients with significant aortic disease, education and guidance should be provided about avoiding intense isometric exercises (eg, heavy weightlifting or activities requiring the Valsalva maneuver), burst exertion and activities, and collision sports.[1,2]
1	C-EO	2. For patients who have undergone surgery for aortic aneurysm or dissection, postoperative cardiac rehabilitation is recommended.[3,4]
2a	C-LD	3. In patients with thoracic or abdominal aortic aneurysms whose BP is adequately controlled, it is reasonable to encourage 30 to 60 minutes of mild-to-moderate intensity aerobic activity at least 3 to 4 days per week.[5,6]
2a	C-LD	4. For patients with clinically significant aortic disease, it is reasonable to screen for anxiety, depression, and posttraumatic stress disorder and, when indicated, provide resources for support[7,8]; it is also reasonable to provide education and resources to minimize patients' concerns, support optimal decision-making, and enhance quality of life.[5,9-11]

Weight Lifting and Aortic Dissection: More Evidence for a Connection

Hatzaras I. · Tranquilli M. · Coady M. · Barrett P.M. · Bible J. · Elefteriades J.A.

CARDIOLOGY PATIENT PAGE

Activity Recommendations for Postaortic Dissection Patients

Ashish Chaddha, BS; Eva Kline-Rogers, MS, RN, NP; Elise M. Woznicki, BS; Robert Brook, MD; Susan Housholder-Hughes, MSN, RN, ANP-BC; Alan C. Braverman, MD; Linda Pitler, RN, MS, CCRC; Alan T. Hirsch, MD; Kim A. Eagle, MD

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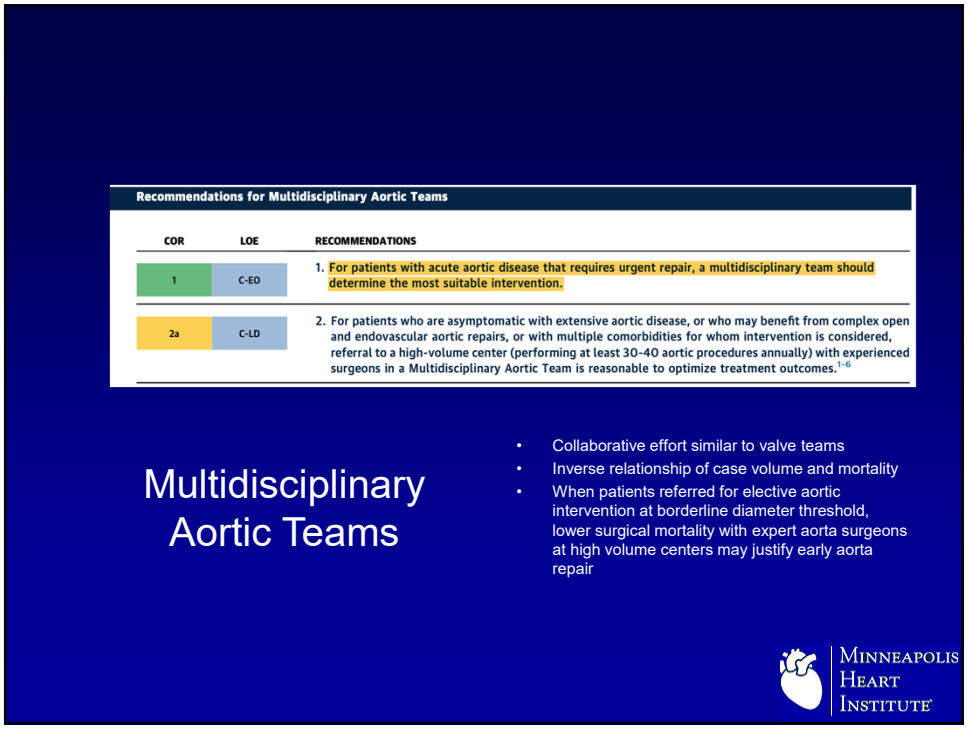
Recommendations for Multidisciplinary Aortic Teams
COR
LOE
RECOMMENDATIONS
1
C-EO
1. For patients with acute aortic disease that requires urgent repair, a multidisciplinary team should determine the most suitable intervention.
2a
C-LD
2. For patients who are asymptomatic with extensive aortic disease, or who may benefit from complex open and endovascular aortic repairs, or with multiple comorbidities for whom intervention is considered, referral to a high-volume center (performing at least 30-40 aortic procedures annually) with experienced surgeons in a Multidisciplinary Aortic Team is reasonable to optimize treatment outcomes.[1-6]
Multidisciplinary Aortic Teams
Collaborative effort similar to valve teams
Inverse relationship of case volume and mortality
When patients referred for elective aortic intervention at borderline diameter threshold, lower surgical mortality with expert aorta surgeons at high volume centers may justify early aorta repair
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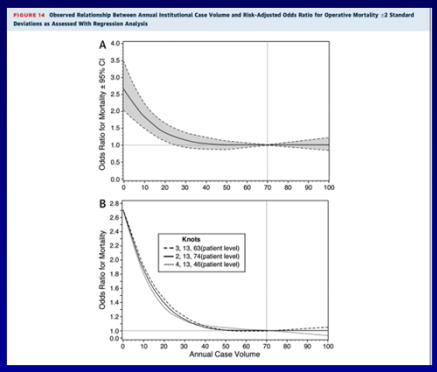
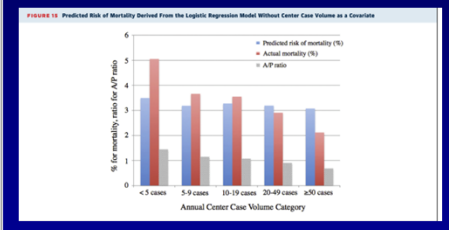
Hospital volume of Aortic surgery and Outcomes





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Shared Decision Making

- Patients and families encouraged to share their values and preferences
- Frame risk benefit especially when clinical equipoise
  - Borderline aortic size
  - Valve sparing aortic repair
  - TEVAR in Type B
  - AAA Rx options

Recommendations for Shared Decision-Making

COR	LOE	RECOMMENDATIONS
1	C-LD	1. In patients with aortic disease, shared decision-making is recommended when determining the appropriate thresholds for intervention, deciding on the type of surgical repair, choosing between open surgical versus endovascular approaches; and in medical management and surveillance.[1-6]
1	C-EO	2. In patients with aortic disease who are contemplating pregnancy or who are pregnant, shared decision-making is recommended when considering the cardiovascular risks of pregnancy, the diameter thresholds for prophylactic aortic surgery, and the mode of delivery.

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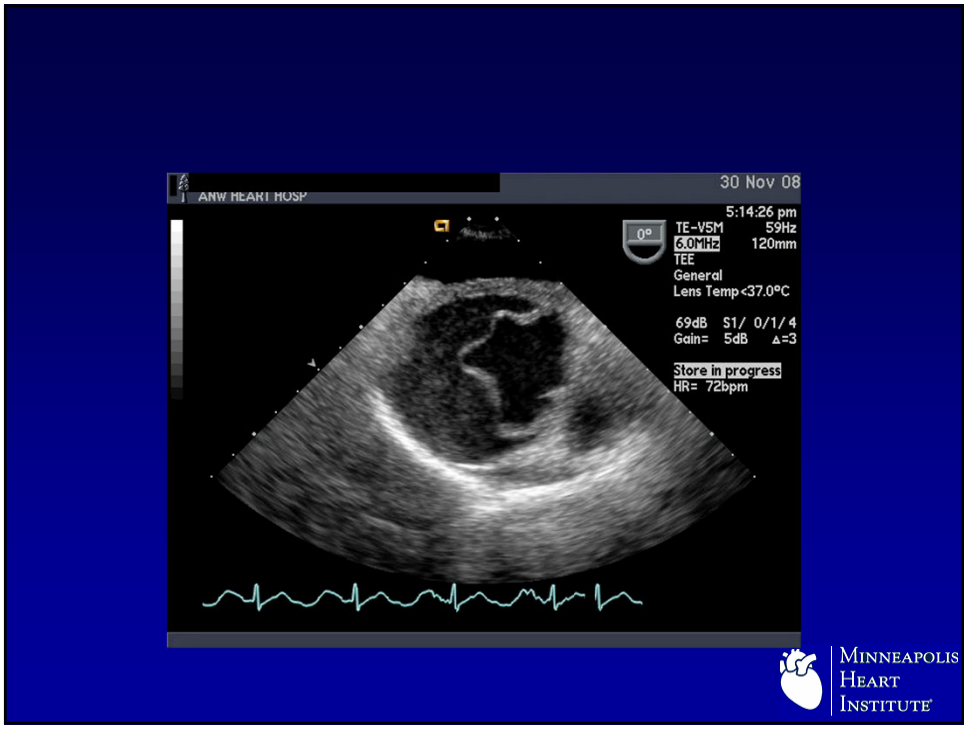
ANW HEART HOSP
30 Nov 08
5:14:26 pm
TE-V5M
59Hz
6.0MHz
120mm
TEE
General
Lens Temp<37.0°C
69dB S1/ 0/1/4
Gain= 5dB Δ=3
Store in progress
HR= 72bpm
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Thank you
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Allina Health
ABBOTT NORTHWESTERN HOSPITAL

Minneapolis Heart Institute

Surgical options and outcome

1

Recommendations for Surgical Approach for Patients With Sporadic Aneurysms of the Aortic Root and Ascending Aorta Meeting Criteria for Surgery
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

COR	LOE	Recommendations
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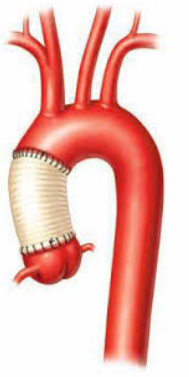
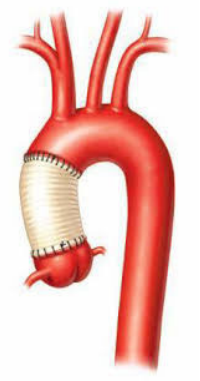
1	B-NR	2. In patients undergoing aortic valve repair or replacement with a concomitant ascending aortic aneurysm, a separate aortic valve intervention and ascending aortic graft is recommended.[3-6]
1	B-NR	3. In patients undergoing aortic root replacement with an aortic valve that is unsuitable for sparing or repair, a mechanical or biological valved conduit aortic root replacement is indicated.[1,2,7,8]
2a	B-NR	4. In patients undergoing aortic root replacement, valve-sparing aortic root replacement is reasonable if the aortic valve is suitable for sparing or repair and when performed by experienced surgeons in a Multidisciplinary Aortic Team.[9-21]

2



Ascending replacment

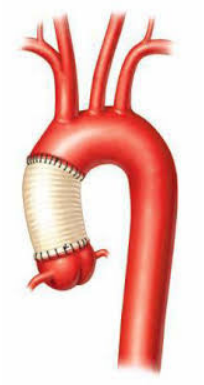
3



Ascending replacment

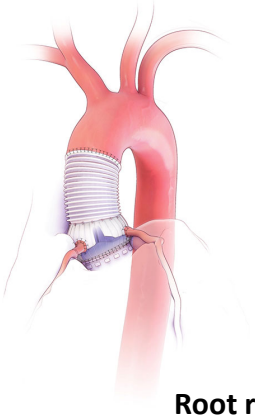
AVR + ascending replacment

4

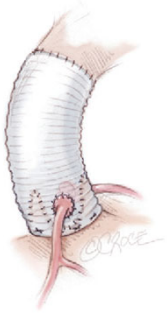


Ascending replacment

AVR + ascending replacment



Root replacment: Composite



Valve-sparing

5

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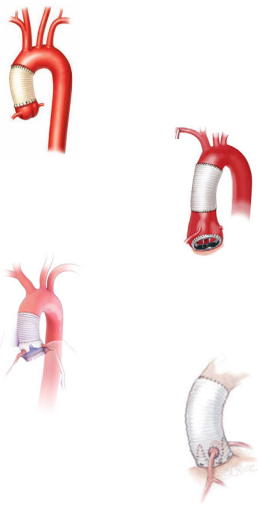
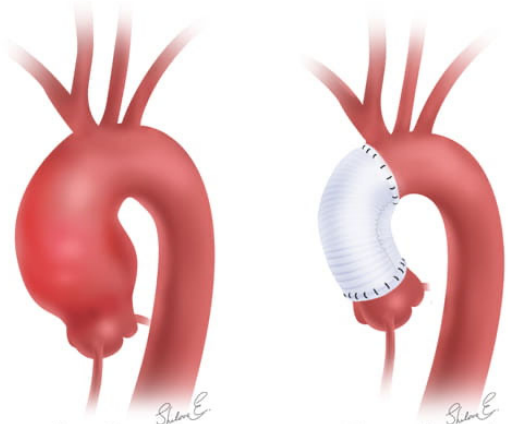


6

Outcome: ascending replacement



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Cardiac Surgery

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G. Chad Hughes, MD†

Age, yrs	64 (54–73)	Cerebrovascular disease	11.74		
Female	34.30	History of myocardial infarction	13.35		
Race		History of congestive heart failure	19.58		
Caucasian	84.85	Any previous cardiovascular surgery	15.67		
Black	7.61	Previous CABG	6.30		
Asian	2.14	Previous valve procedure	9.36		
Native American	0.15	Pre-operative cardiogenic shock	4.21		
Demographic region		Procedure status			
Midwest	32.20	Elective	55.53		
Northeast	18.08	Urgent	21.69		
South	30.25	Emergent	21.55		
West	19.46	Salvage	1.17		
Body mass index, kg/m^2	28 (25–32)	Urgent reason			
Hypertension	74.74	Anatomy	33.43		
Current or recent smoker	21.48	Aortic dissection	22.56		
Hypercholesterolemia	51.10	Valve dysfunction	20.13		
Chronic lung disease	18.54	Congestive heart failure	10.01		
Renal function stages		Emergent reason			
GFR ≥90 ml/min/1.73 m^2	21.84	Aortic dissection	93.92		
GFR 60–89 ml/min/1.73 m^2	51.76	Shock	2.0		
GFR 30–59 ml/min/1.73 m^2	23.34	Valve dysfunction	0.86		
GFR ≤29 ml/min/1.73 m^2	1.79	Concomitant CABG	28.83		
Dialysis	1.27	Concomitant mitral valve procedure	9.4		
Immunosuppressive treatment	2.70	Concomitant arrhythmia correction	5.45		
Diabetes mellitus	13.00	Operation time, h	4.8 (3.7–6.1)		
Peripheral vascular disease	19.34	Cross-clamp time, min	95 (67–129)		

Outcome	Ascending Alone (n = 22,048)
Operative mortality, in-hospital or 30-day	8.67
Elective	3.41
Nonelective	15.25
Stroke >72 h or coma >24 h	6.88
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Renal failure	8.45
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Nonelective	13.75
Dialysis	3.81
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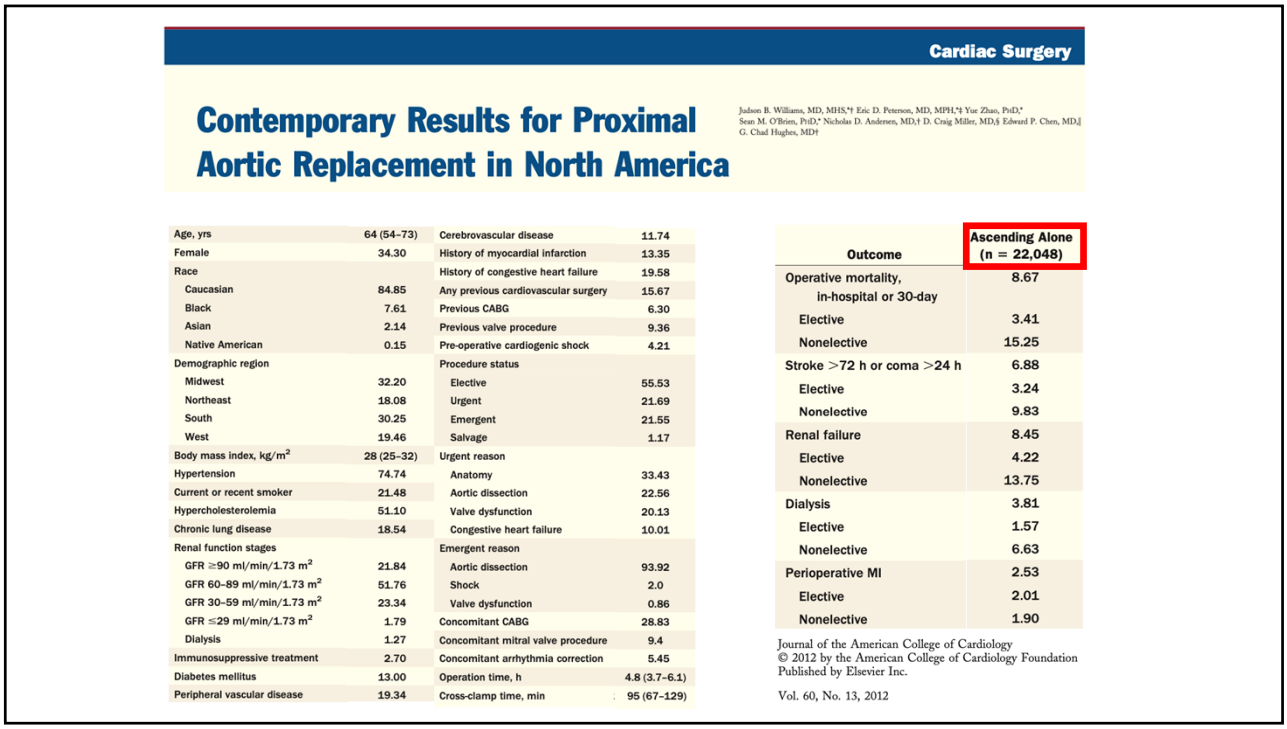

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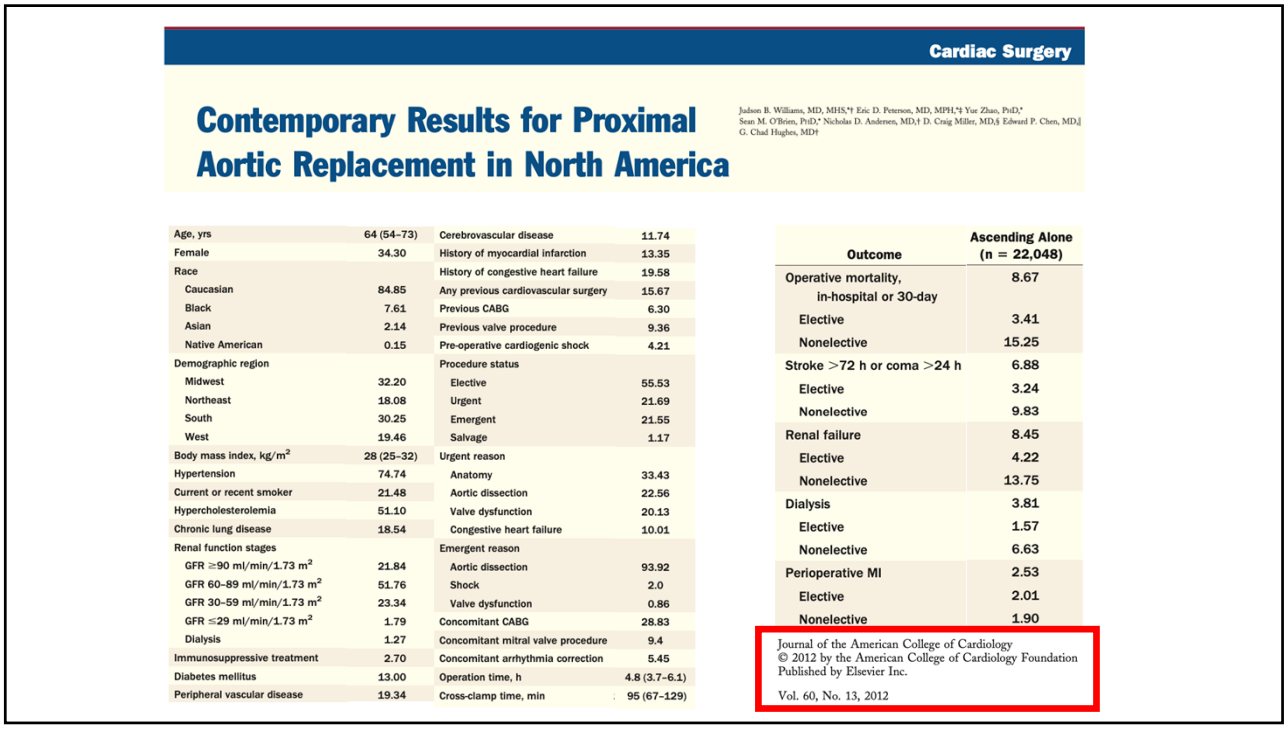

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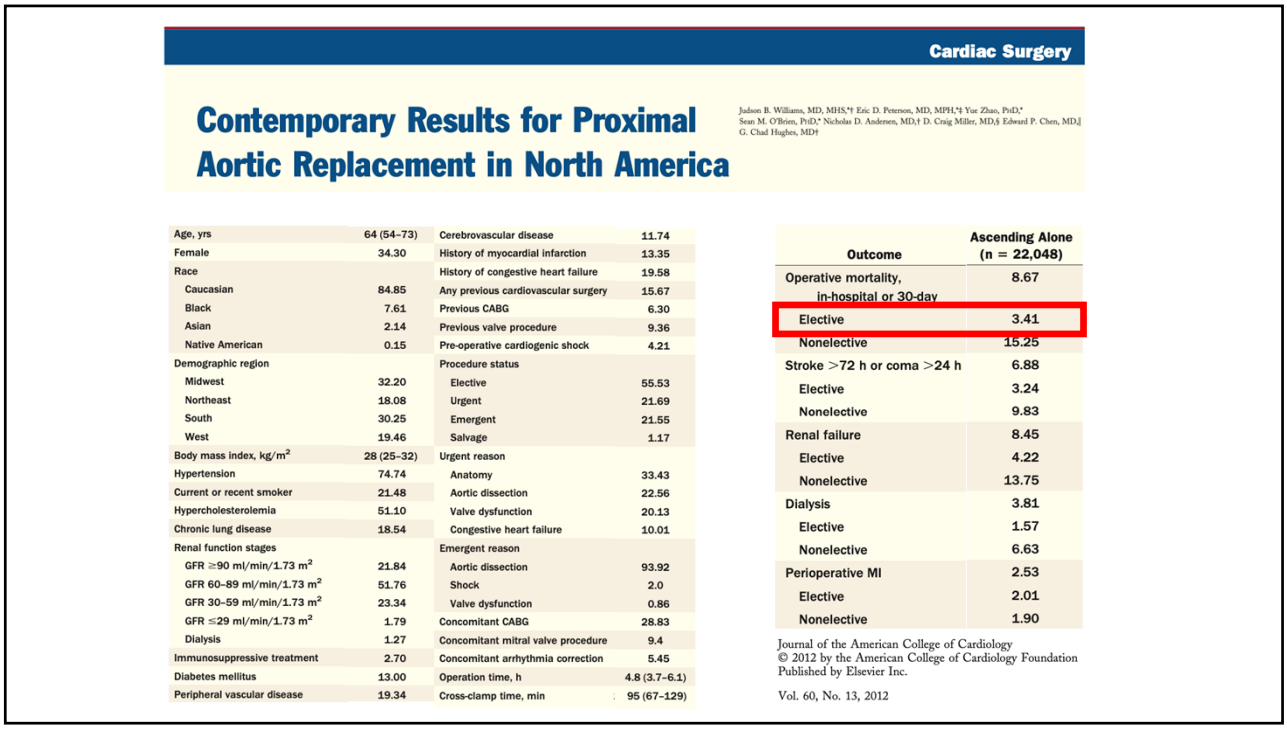

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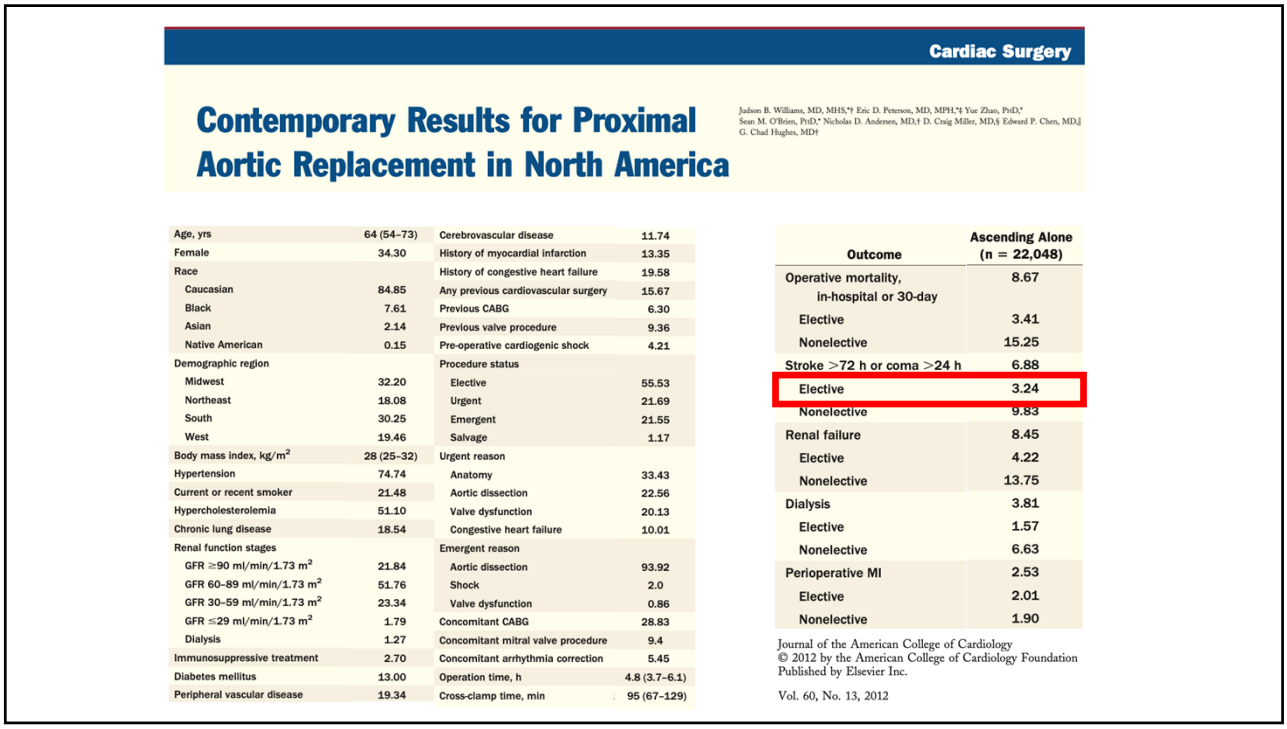

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Urgent	21.69
Emergent	21.55
Salvage	1.17
Urgent reason	
Anatomy	33.43
Aortic dissection	22.56
Valve dysfunction	20.13
Congestive heart failure	10.01
Emergent reason	
Aortic dissection	93.92
Shock	2.0
Valve dysfunction	0.86
Concomitant CABG	28.83
Concomitant mitral valve procedure	9.4
Concomitant arrhythmia correction	5.45
Operation time, h	4.8 (3.7–6.1)
Cross-clamp time, min	95 (67–129)

Outcome	Ascending Alone (n = 22,048)
Operative mortality, in-hospital or 30-day	8.67
Elective	3.41
Nonelective	15.25
Stroke >72 h or coma >24 h	6.88
Elective	3.24
Nonelective	9.83
Renal failure	8.45
Elective	4.22
Nonelective	13.75
Dialysis	3.81
Elective	1.57
Nonelective	6.63
Perioperative MI	2.53
Elective	2.01
Nonelective	1.90

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Cardiac Surgery

Contemporary Results for Proximal Aortic Replacement in North America

Judson B. Williams, MD, MHS,*† Eric D. Peterson, MD, MPH,*‡ Yue Zhao, PhD,* Sean M. O'Brien, PhD,* Nicholas D. Andersen, MD,† D. Craig Miller, MD,§ Edward P. Chen, MD,‖ G. Chad Hughes, MD†

Age, yrs	64 (54–73)
Female	34.30
Race	
Caucasian	84.85
Black	7.61
Asian	2.14
Native American	0.15
Demographic region	
Midwest	32.20
Northeast	18.08
South	30.25
West	19.46
Body mass index, kg/m^2	28 (25–32)
Hypertension	74.74
Current or recent smoker	21.48
Hypercholesterolemia	51.10
Chronic lung disease	18.54
Renal function stages	
GFR ≥90 ml/min/1.73 m^2	21.84
GFR 60–89 ml/min/1.73 m^2	51.76
GFR 30–59 ml/min/1.73 m^2	23.34
GFR ≤29 ml/min/1.73 m^2	1.79
Dialysis	1.27
Immunosuppressive treatment	2.70
Diabetes mellitus	13.00
Peripheral vascular disease	19.34
Cerebrovascular disease	11.74
History of myocardial infarction	13.35
History of congestive heart failure	19.58
Any previous cardiovascular surgery	15.67
Previous CABG	6.30
Previous valve procedure	9.36
Pre-operative cardiogenic shock	4.21
Procedure status	
Elective	55.53
Urgent	21.69
Emergent	21.55
Salvage	1.17
Urgent reason	
Anatomy	33.43
Aortic dissection	22.56
Valve dysfunction	20.13
Congestive heart failure	10.01
Emergent reason	
Aortic dissection	93.92
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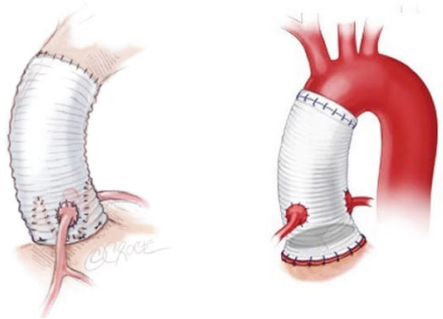
Outcome: root replacement



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ORIGINAL ARTICLES: ADULT CARDIAC

Elective Aortic Root Replacement in North America: Analysis of STS Adult Cardiac Surgery Database

Tyler Wallen, DO, Andreas Habertheuer, MD, PhD, Joseph E. Bavaria, MD, G. Chad Hughes, MD, Vinay Badhwar, MD, Jeffrey P. Jacobs, MD, Babatunde Yerokun, MD, Dylan Thibault, MS, Karianna Milewski, MD, PhD, Nimesh Desai, MD, PhD, Wilson Szeto, MD, Lars Svensson, MD, and Prashanth Vallabhajosyula, MD, MS

(Ann Thorac Surg 2019;107:1307–12)

Table 1. Patient Demographics and Preoperative Factors

Variables	Overall (n = 8,806)
Age	59.0 (50.0, 67.0)
Sex (male)	6,836 (77.6)
Previous CABG	6 (0.6)
Previous valve procedure	58 (5.9)
Myocardial infarction	547 (6.2)
Congestive heart failure	2,030 (23.1)
Procedure type	
Sparring	1,680 (19.1)
Bentall	7,126 (80.9)
Concomitant CABG	1,668 (18.9)
Concomitant MV repair	337 (3.8)
Concomitant MV replacement	117 (1.3)
Concomitant TV repair/replacement	72 (0.8)
Marfan syndrome	327 (3.7)
Bicuspid	2,965 (33.7)

Results:

In-hospital/ 30-day mortality	2.2%
Stroke	1.4%
Reoperation for bleeding	3.6%
Renal failure	2.2%
Median postoperative length of stay	6 days

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Interactive CardioVascular and Thoracic Surgery 29 (2019) 911–922
doi:10.1093/icvts/ivz211 Advance Access publication 28 August 2019

STATE-OF-THE-ART

Comparing outcomes between valve-sparing root replacement and the Bentall procedure in proximal aortic aneurysms: systematic review and meta-analysis

Mohammad Yousuf Salmasi [a,*,†], Iakovos Theodoulou [b,†], Priyanka Iyer [b], Mohaimen Al-Zubaidy [c], Danial Naqvi [c], Mohammed Snober [c], Aung Oo [d] and Thanos Athanasiou [b]

Key question

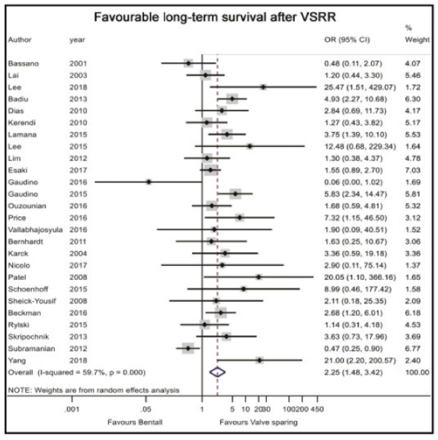
How do the outcomes of valve-sparing aortic root replacement compare to those of the well-established Bentall procedure?

Key finding(s)

Valve-sparing techniques confer fewer operative deaths, improved long-term survival and similar reoperation rates.

Take-home message

Valve-sparing root replacement should be considered as a first-line option for root aneurysms in patients with reparable aortic valves.



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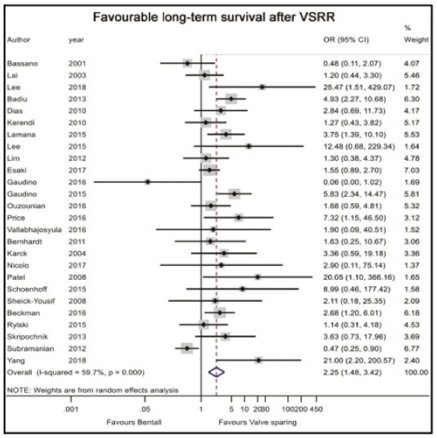

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Allina Health
ABBOTT NORTHWESTERN HOSPITAL
Minneapolis Heart Institute
Recommendations for intervention

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Allina Health
ABBOTT NORTHWESTERN HOSPITAL
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Recommendations for intervention
- Bicuspid aortic valve
- Marfan Syndrome
- Non-syndromic heritable disease
- Sporadic aneurysm

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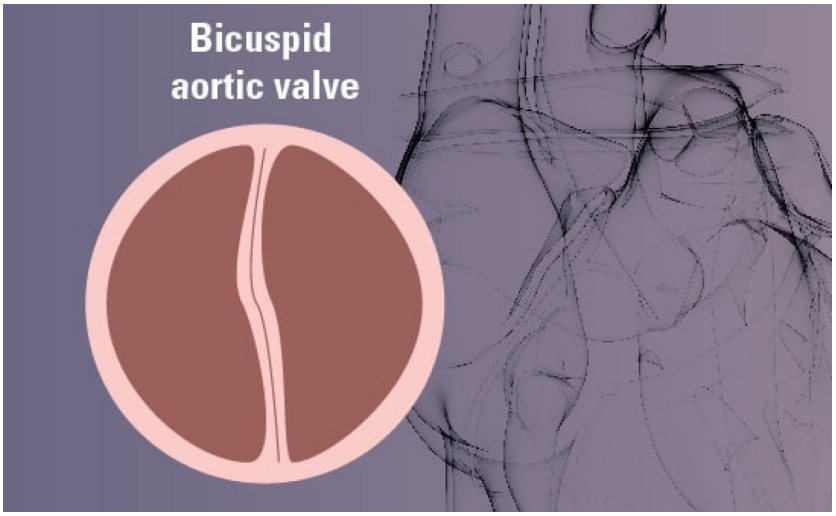

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Recommendations for BAV Aortopathy Interventions: Replacement of the Aorta in Patients With BAV
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

COR	LOE	Recommendations
1	B-NR	1. In patients with a BAV and a diameter of the aortic root, ascending aorta, or both of ≥5.5 cm, surgery to replace the aortic root, ascending aorta, or both is recommended.[1-3]
2a	B-NR	2. In patients with a BAV and a cross-sectional aortic root or ascending aortic area (cm^2) to height (m) ratio of ≥10 cm^2/m, surgery to replace the aortic root, ascending aorta, or both is reasonable, when performed by experienced surgeons in a Multidisciplinary Aortic Team.[3,4]
2a	B-NR	3. In patients with a BAV, a diameter of the aortic root or ascending aorta of 5.0 cm to 5.4 cm, and an additional risk factor for aortic dissection (Table 14), surgery to replace the aortic root, ascending aorta, or both is reasonable, when performed by experienced surgeons in a Multidisciplinary Aortic Team.[1,6]
2a	B-NR	4. In patients with a BAV who are undergoing surgical aortic valve repair or replacement, and who have a diameter of the aortic root or ascending aorta of ≥4.5 cm, concomitant replacement of the aortic root, ascending aorta, or both is reasonable, when performed by experienced surgeons in a Multidisciplinary Aortic Team.[1,6]
2b	B-NR	5. In patients with a BAV, a diameter of the aortic root or ascending aorta of 5.0 cm to 5.4 cm, no other risk factors for aortic dissection (Table 14), and at low surgical risk, surgery to replace the aortic root, ascending aorta, or both may be reasonable, when performed by experienced surgeons in a Multidisciplinary Aortic Team.[1,2,5]

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Recommendations for BAV Aortopathy Interventions: Replacement of the Aorta in Patients With BAV
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2a	B-NR	4. In patients with a BAV who are undergoing surgical aortic valve repair or replacement, and who have a diameter of the aortic root or ascending aorta of ≥4.5 cm, concomitant replacement of the aortic root, ascending aorta, or both is reasonable, when performed by experienced surgeons in a Multidisciplinary Aortic Team.[1,6]
2b	B-NR	5. In patients with a BAV, a diameter of the aortic root or ascending aorta of 5.0 cm to 5.4 cm, no other risk factors for aortic dissection (Table 14), and at low surgical risk, surgery to replace the aortic root, ascending aorta, or both may be reasonable, when performed by experienced surgeons in a Multidisciplinary Aortic Team.[1,2,5]

Bicuspid aortic valve

General:	5.5 cm
MAT:	5.0 cm (+- high risk factors) Aortic area/height >10 4.5 cm if concomitant AVR

Table 14. Risk Factors for Aortic Dissection

Family history of aortic dissection
Aortic growth rate ≥0.3 cm/y
Aortic coarctation
"Root phenotype" aortopathy

31

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Bicuspid aortic valve

General:	5.5 cm
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Table 14. Risk Factors for Aortic Dissection

Family history of aortic dissection
Aortic growth rate ≥0.3 cm/y
Aortic coarctation
"Root phenotype" aortopathy

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Marfan Syndrome

33

Recommendations for Marfan Syndrome Interventions: Replacement of the Aortic Root in Patients With Marfan Syndrome
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

COR	LOE	Recommendations
1	B-NR	1. In patients with Marfan syndrome and an aortic root diameter of ≥5.0 cm, surgery to replace the aortic root and ascending aorta is recommended.[1-4]
2a	B-NR	2. In patients with Marfan syndrome, an aortic root diameter of ≥4.5 cm, and features associated with an increased risk of aortic dissection (see Table 10), surgery to replace the aortic root and ascending aorta is reasonable, when performed by experienced surgeons in a Multidisciplinary Aortic Team.[1,3,4]
2a	C-LD	3. In patients with Marfan syndrome and a maximal cross-sectional aortic root area (cm2) to patient height (m) ratio of ≥10, surgery to replace the aortic root and ascending aorta is reasonable, when performed by experienced surgeons in a Multidisciplinary Aortic Team.[5]
2b	C-LD	4. In patients with Marfan syndrome and an aortic diameter approaching surgical threshold, who are candidates for valve-sparing root replacement (VSRR) and have a very low surgical risk, surgery to replace the aortic root and ascending aorta may be reasonable when performed by experienced surgeons in a Multidisciplinary Aortic Team.[2-4]

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Recommendations for Marfan Syndrome Interventions: Replacement of the Aortic Root in Patients With Marfan Syndrome
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Marfan Syndrome

General:	5.0 cm
MAT:	4.5 cm (high-risk) Aortic area/height >10 AVSRR

Table 10. Features Associated With Increased Risk of Aortic Complications in Marfan Syndrome

Family history of aortic dissection
Rapid aortic growth (≥0.3 cm/y)
Diffuse aortic root and ascending aortic dilation[14]
Marked vertebral arterial tortuosity[15]

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Recommendations for Marfan Syndrome Interventions: Replacement of the Aortic Root in Patients With Marfan Syndrome
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2a	B-NR	2. In patients with Marfan syndrome, an aortic root diameter of ≥4.5 cm, and features associated with an increased risk of aortic dissection (see Table 10), surgery to replace the aortic root and ascending aorta is reasonable, when performed by experienced surgeons in a Multidisciplinary Aortic Team.[1,3,4]
2a	C-LD	3. In patients with Marfan syndrome and a maximal cross-sectional aortic root area (cm2) to patient height (m) ratio of ≥10, surgery to replace the aortic root and ascending aorta is reasonable, when performed by experienced surgeons in a Multidisciplinary Aortic Team.[5]
2b	C-LD	4. In patients with Marfan syndrome and an aortic diameter approaching surgical threshold, who are candidates for valve-sparing root replacement (VSRR) and have a very low surgical risk, surgery to replace the aortic root and ascending aorta may be reasonable when performed by experienced surgeons in a Multidisciplinary Aortic Team.[2-4]

Marfan Syndrome

General:	5.0 cm
MAT:	4.5 cm (high-risk) Aortic area/height >10 AVSRR

Table 10. Features Associated With Increased Risk of Aortic Complications in Marfan Syndrome

Family history of aortic dissection
Rapid aortic growth (≥0.3 cm/y)
Diffuse aortic root and ascending aortic dilation[14]
Marked vertebral arterial tortuosity[15]

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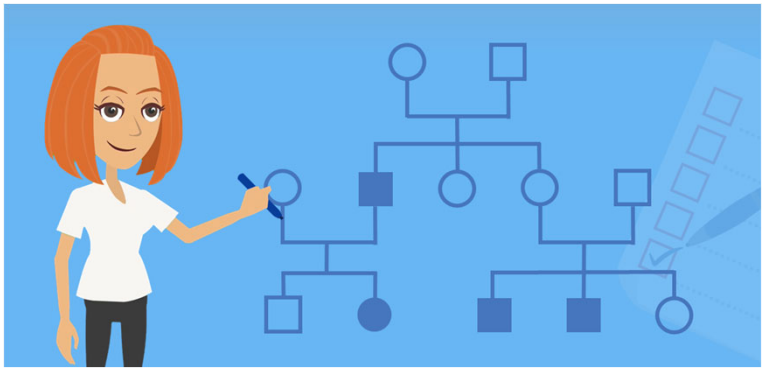
Non-syndromic heritable thoracic aortic disease



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Recommendations for Surgical Considerations for Nonsyndromic Heritable TAA and No Identified Genetic Cause		
COR	**LOE**	**Recommendations**
1	C-LD	1. In asymptomatic patients with aneurysms of the aortic root or ascending aorta with nonsyndromic heritable thoracic aortic disease (nsHTAD) and no identified genetic cause, determining the timing of surgical repair requires shared decision-making and is informed by known aortic diameters at the time of aortic dissection, TAA repair, or both in affected family members.[1-4]
1	C-LD	2. In asymptomatic patients with aneurysms of the aortic root or ascending aorta with nsHTAD and no identified genetic cause but no information on aortic diameters at the time of dissection or aneurysm repair in affected family members and who have no high-risk features for adverse aortic events (Table 9) it is recommended to repair the aorta when the maximal diameter reaches ≥5.0 cm.[1]
2a	C-LD	3. In patients with aneurysms of the aortic root or ascending aorta with nsHTAD and no identified genetic cause and a maximal aortic diameter of ≥4.5 cm, who have high-risk features for adverse aortic events (Table 9), or who are undergoing cardiac surgery for other indications, aortic repair is reasonable when performed by experienced surgeons in a Multidisciplinary Aortic Team.[5]

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Recommendations for Surgical Considerations for Nonsyndromic Heritable TAA and No Identified Genetic Cause		
COR	LOE	Recommendations
1	C-LD	1. In asymptomatic patients with aneurysms of the aortic root or ascending aorta with nonsyndromic heritable thoracic aortic disease (nsHTAD) and no identified genetic cause, determining the timing of surgical repair requires shared decision-making and is informed by known aortic diameters at the time of aortic dissection, TAA repair, or both in affected family members.[1-4]
1	C-LD	2. In asymptomatic patients with aneurysms of the aortic root or ascending aorta with nsHTAD and no identified genetic cause but no information on aortic diameters at the time of dissection or aneurysm repair in affected family members and who have no high-risk features for adverse aortic events (Table 9) it is recommended to repair the aorta when the maximal diameter reaches ≥5.0 cm.[1]
2a	C-LD	3. In patients with aneurysms of the aortic root or ascending aorta with nsHTAD and no identified genetic cause and a maximal aortic diameter of ≥4.5 cm, who have high-risk features for adverse aortic events (Table 9), or who are undergoing cardiac surgery for other indications, aortic repair is reasonable when performed by experienced surgeons in a Multidisciplinary Aortic Team.[5]

nsHTAD	
General:	5.0 cm
MAT:	4.5 cm (high-risk)

Table 9. Features Associated With an Increased Risk of Aortic Dissection in Patients With Heritable Thoracic Aortic Aneurysms

Heritable Thoracic Aortic Aneurysms and No Identified Genetic Cause
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 consecutive y)

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Recommendations for Surgical Considerations for Nonsyndromic Heritable TAA and No Identified Genetic Cause		
COR	LOE	Recommendations
1	C-LD	1. In asymptomatic patients with aneurysms of the aortic root or ascending aorta with nonsyndromic heritable thoracic aortic disease (nsHTAD) and no identified genetic cause, determining the timing of surgical repair requires shared decision-making and is informed by known aortic diameters at the time of aortic dissection, TAA repair, or both in affected family members.[1-4]
1	C-LD	2. In asymptomatic patients with aneurysms of the aortic root or ascending aorta with nsHTAD and no identified genetic cause but no information on aortic diameters at the time of dissection or aneurysm repair in affected family members and who have no high-risk features for adverse aortic events (Table 9) it is recommended to repair the aorta when the maximal diameter reaches ≥5.0 cm.[1]
2a	C-LD	3. In patients with aneurysms of the aortic root or ascending aorta with nsHTAD and no identified genetic cause and a maximal aortic diameter of ≥4.5 cm, who have high-risk features for adverse aortic events (Table 9), or who are undergoing cardiac surgery for other indications, aortic repair is reasonable when performed by experienced surgeons in a Multidisciplinary Aortic Team.[5]

nsHTAD	
General:	5.0 cm
MAT:	4.5 cm (high-risk)

Table 9. Features Associated With an Increased Risk of Aortic Dissection in Patients With Heritable Thoracic Aortic Aneurysms

Heritable Thoracic Aortic Aneurysms and No Identified Genetic Cause
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 consecutive y)

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Sporadic aneurysms

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Recommendations for Surgery for Sporadic Aneurysms of the Aortic Root and Ascending Aorta
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

COR	LOE	Recommendations
1	C-LD	1. In patients with aneurysms of the aortic root and ascending aorta who have symptoms attributable to the aneurysm, surgery is indicated.[1,2]
1	B-NR	2. In asymptomatic patients with aneurysms of the aortic root or ascending aorta who have a maximum diameter of ≥5.5 cm, surgery is indicated.[3-9]
1	C-LD	3. In patients with an aneurysm of the aortic root or ascending aorta of <5.5 cm, whose growth rate confirmed by tomographic imaging is ≥0.3 cm/y in 2 consecutive years, or ≥0.5 cm in 1 year, surgery is indicated.[10-13]
2a	B-NR	4. In asymptomatic patients with aneurysms of the aortic root or ascending aorta who have a maximum diameter of ≥5.0 cm, surgery is reasonable when performed by experienced surgeons in a Multidisciplinary Aortic Team.[14-17]

Recommendations for Surgery for Sporadic Aneurysms of the Aortic Root and Ascending Aorta (Continued)

COR	LOE	Recommendations
2a	B-NR	5. In patients undergoing repair or replacement of a tricuspid aortic valve who have a concomitant aneurysm of the ascending aorta with a maximum diameter of ≥4.5 cm, ascending aortic replacement is reasonable when performed by experienced surgeons in a Multidisciplinary Aortic Team.[18-21]
2a	B-NR	In patients undergoing repair or replacement of a tricuspid aortic valve who have a concomitant aneurysm of the ascending aorta with a maximum diameter of ≥5.0 cm, ascending aortic replacement is reasonable.[18-21]
2b	C-LD	In patients undergoing cardiac surgery for indications other than aortic valve repair or replacement who have a concomitant aneurysm of ascending aorta with a maximum diameter of ≥5.0 cm, ascending aortic replacement may be reasonable.[18]
2a	C-LD	6. In patients with a height >1 standard deviation above or below the mean who have an asymptomatic aneurysm of the aortic root or ascending aorta and a maximal cross-sectional aortic area/height ratio of ≥10 cm^2/m, surgery is reasonable when performed by experienced surgeons in a Multidisciplinary Aortic Team.[14,15,22]
2b	C-LD	7. In asymptomatic patients with aneurysms of the aortic root or ascending aorta who have either an ASI of ≥3.08 cm/m^2 or AHI of ≥3.21 cm/m, surgery may be reasonable when performed by experienced surgeons in a Multidisciplinary Aortic Team.[23]

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Sporadic aneurysms	
General:	5.5 cm Symptomatic patients Growth: 0.3 cm/2y or 0.5 cm/y 5.0 cm if other concomitant surgery
MAT:	5.0 cm Aortic area/height >10 4.5 cm if concomitant AVR ASI >3.08 or AHI >3.21

Recommendations for Surgery for Sporadic Aneurysms of the Aortic Root and Ascending Aorta
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

COR	LOE	Recommendations
1	C-LD	1. In patients with aneurysms of the aortic root and ascending aorta who have symptoms attributable to the aneurysm, surgery is indicated.[1,2]
1	B-NR	2. In asymptomatic patients with aneurysms of the aortic root or ascending aorta who have a maximum diameter of ≥5.5 cm, surgery is indicated.[3-9]
1	C-LD	3. In patients with an aneurysm of the aortic root or ascending aorta of <5.5 cm, whose growth rate confirmed by tomographic imaging is ≥0.3 cm/y in 2 consecutive years, or ≥0.5 cm in 1 year, surgery is indicated.[10-13]
2a	B-NR	4. In asymptomatic patients with aneurysms of the aortic root or ascending aorta who have a maximum diameter of ≥5.0 cm, surgery is reasonable when performed by experienced surgeons in a Multidisciplinary Aortic Team.[14-17]

Recommendations for Surgery for Sporadic Aneurysms of the Aortic Root and Ascending Aorta (Continued)

COR	LOE	Recommendations
2a	B-NR	5. In patients undergoing repair or replacement of a tricuspid aortic valve who have a concomitant aneurysm of the ascending aorta with a maximum diameter of ≥4.5 cm, ascending aortic replacement is reasonable when performed by experienced surgeons in a Multidisciplinary Aortic Team.[18-21]
2a	B-NR	In patients undergoing repair or replacement of a tricuspid aortic valve who have a concomitant aneurysm of the ascending aorta with a maximum diameter of ≥5.0 cm, ascending aortic replacement is reasonable.[18-21]
2b	C-LD	In patients undergoing cardiac surgery for indications other than aortic valve repair or replacement who have a concomitant aneurysm of ascending aorta with a maximum diameter of ≥5.0 cm, ascending aortic replacement may be reasonable.[18]
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Sporadic aneurysms	
General:	5.5 cm Symptomatic patients Growth: 0.3 cm/2y or 0.5 cm/y 5.0 cm if other concomitant surgery
MAT:	5.0 cm Aortic area/height >10 4.5 cm if concomitant AVR ASI >3.08 or AHI >3.21

Recommendations for Surgery for Sporadic Aneurysms of the Aortic Root and Ascending Aorta
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

COR	LOE	Recommendations
1	C-LD	1. In patients with aneurysms of the aortic root and ascending aorta who have symptoms attributable to the aneurysm, surgery is indicated.[1,2]
1	B-NR	2. In asymptomatic patients with aneurysms of the aortic root or ascending aorta who have a maximum diameter of ≥5.5 cm, surgery is indicated.[3-9]
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Recommendations for Surgery for Sporadic Aneurysms of the Aortic Root and Ascending Aorta (Continued)

COR	LOE	Recommendations
2a	B-NR	5. In patients undergoing repair or replacement of a tricuspid aortic valve who have a concomitant aneurysm of the ascending aorta with a maximum diameter of ≥4.5 cm, ascending aortic replacement is reasonable when performed by experienced surgeons in a Multidisciplinary Aortic Team.[18-21]
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2a	C-LD	6. In patients with a height >1 standard deviation above or below the mean who have an asymptomatic aneurysm of the aortic root or ascending aorta and a maximal cross-sectional aortic area/height ratio of ≥10 cm^2/m, surgery is reasonable when performed by experienced surgeons in a Multidisciplinary Aortic Team.[14,15,22]
2b	C-LD	7. In asymptomatic patients with aneurysms of the aortic root or ascending aorta who have either an ASI of ≥3.08 cm/m^2 or AHI of ≥3.21 cm/m, surgery may be reasonable when performed by experienced surgeons in a Multidisciplinary Aortic Team.[23]

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