

When to extend resection into the arch in BAV aortopathy surgery

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No conflict of interest

The Guidelines



2010 ACCF/AHA/AATS/ACR/ASA/SCA/SCA/SIR/STS/SVM Guidelines for the Diagnosis and Management of Patients With Thoracic Aortic Disease

Class IIa

1. For thoracic aortic aneurysms also involving the proximal aortic arch, partial arch replacement together with ascending aorta repair using right subclavian/axillary artery inflow and hypothermic circulatory arrest is reasonable.^{222,449,450} (Level of Evidence: B)



European Heart Journal doi:10.1093/eurhearti/ehu281

ESC GUIDELINES

2014 ESC Guidelines on the diagnosis and treatment of aortic diseases

Document covering acute and chronic aortic diseases of the thoracic and abdominal aorta of the adult

In the case of distal aneurysmal extension to the aortic arch, leaving no neck-space for clamping the aorta at a non-diseased portion, an open distal anastomosis with the aortic arch or a hemiarch replacement should be performed. This technique allows the inspection of the aortic arch and facilitates a very distal anastomosis. A short period of antegrade cerebral perfusion and hypothermic lower body circulatory arrest are required, as the aortic arch needs to be

- Issues: no diameter cut-off
 - not BAV-specific
 - Iow LoE



What's the current practice like?



Knowledge, attitudes, and practice patterns in surgical management of bicuspid aortopathy: A survey of 100 cardiac surgeons

Subodh Verma, MD, PhD, FRCSC,^a Bobby Yanagawa, MD, PhD,^a Sameer Kalra,^a Marc Ruel, MD, PhD, FRCSC,^b Mark D. Peterson, MD, PhD, FRCSC,^a Michael H. Yamashita, MDCM, MPH, CPH,^c Andrew Fagan, MD,^d Maria E. Currie, MD,^e Christopher W. White, MD,^f Stephane Leung Wai Sang, MD, MSc,^g Cristian Rosu, MD,^h Steve Singh, MD, PhD, FRCSC,ⁱ Holly Mewhort, MD,^j Nandini Gupta, MD,^b and Paul W. M. Fedak, MD, PhD, FRCSC^{j,k}

Survey: procedure of choice in a hypothetical BAV patient with ascending aneurysm, non-dilated root and *non-dilated proximal arch*

There was <u>a cohort of surgeons</u> who would perform AVR, replacement of <u>ascending aorta and hemiarch</u> (15% [15/ 99]), Bentall (12% [12/99]), or <u>Bentall and hemiarch</u> (7% [7/99]). When grouped, this cohort (34% [34/99]) performed more than 10 Bentall procedures (42% [14/33] vs 10% [6/64]) and more than 10 arch replacements with circulatory arrest (33% [10/33] vs 6% [4/64]) per year. In

J Thorac Cardiovasc Surg 2013;146:1033-40



Long-Term Survival After the Bentall Procedure in 206 Patients With Bicuspid Aortic Valve

Christian D. Etz, MD, Tobias M. Homann, MD, Daniel Silovitz, MS, David Spielvogel, MD, Carol A. Bodian, DrPh, Maximilian Luehr, MD, Gabriele DiLuozzo, MD, Konstadinos A. Plestis, MD, and Randall B. Griepp, MD

Departments of Cardiothoracic Surgery and Anesthesiology, Mount Sinai School of Medicine, New York, New York



Ann Thorac Surg 2007;84:1186-94

Surgical Technique

All patients included in this study had a button Bentall operation, a modification of the original technique described by Kouchoukos and coworkers in 1991 [6]. <u>All</u> operations were performed with an open distal anastomosis using a period of deep hypothermic circulatory arrest, often with so-called hemiarch replacement, but occasionally involving replacement of the entire arch.

- all BAV (206 patients), all Bentall op.
- Early post-op. mortality: 2.9%
- Long-term survival comparable to ageand sex-matched population
 - No comparison to Bentall w/o hemiarch

Fate of remnant sinuses of Valsalva in patients with bicuspid and trileaflet valves undergoing aortic valve, ascending aorta, and aortic arch replacement

Rita Karianna Milewski, MD, PhD, Andreas Habertheuer, MD, PhD, Joseph E. Bavaria, MD, Mary Siki, BS, Wilson Y. Szeto, MD, Eric Krause, MD, Varun Korutla, Nimesh D. Desai, MD, PhD, and Prashanth Vallabhajosyula, MD, MS



Surgical Procedure

In all cases, aortic valve replacement, ascending aorta replacement, and aortic arch reconstruction under hypothermic circulatory arrest were performed (Central Image).

J Thorac Cardiovasc Surg 2017;154:421-32

TABLE 4	. Postoperative	outcomes
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	TAV	BAV	Р
Variable	(n = 174)	(n = 254)	value
Stroke/transient ischemic attack	6 (3.4%)	2 (0.8%)	.046
Renal failure	6 (3.4%)	1 (0.4%)	.014
Renal failure requiring dialysis	3 (1.7%)	1 (0.4%)	.160
Prolonged ventilation (>24 h)	50 (28.7%)	27 (10.6%)	<.001
In-hospital/30-d mortality	9 (5.2%)	4 (1.6%)	.033

3% overall mortality (TAV+BAV) Significantly lower in BAV (1.6%)



What's the risk of adding arch replacement?



The addition of hemiarch replacement to aortic root surgery does not affect safety

Sukit Christopher Malaisrie, MD,^a Brett F. Duncan, MD,^a Chris K. Mehta, MD,^a Mitesh V. Badiwala, MD,^a Dan Rinewalt, MD,^a Jane Kruse, RN, BSN,^b Zhi Li, MS,^b Adin-Christian Andrei, PhD,^b and Patrick M. McCarthy, MD^a



J Thorac Cardiovasc Surg 2015;150:118-24

TABLE 3. Perioperative characteristics and outcomes of propensity score-matched groups				
Variable	ARR alone (no hemiarch) (N = 133)	ARR/hemiarch (N = 133)	P value	
Total ICU LOS (h)	29.4 (23.4-66.1)	31.6 (23.8-51.7)	.91	
Postoperative LOS (d)	5.0 (5.0-7.0)	6.0 (5.0-7.0)	.70	
Total hospital LOS (d)	6.0 (5.0-8.0)	6.0 (5.0-8.0)	.50	
Complications	49 (36.8%)	62 (46.6%)	.11	

Operative mortality was 1.4% (3/207) in the ARR alone group versus 3.4% (6/177 patients) in the ARR/hemiarch group (P = .21). The 30-day mortality was 1.4% (3/207) in the ARR alone group versus 2.8% (5/177 patients) in the ARR/hemiarch group (P = .35). A bioprosthetic valve

- TAV+BAV, all Bentall op. (266 propensity matched pts)
- Hemiarch indicated when distal ascending diameter >40 mm

Mortality at 30 days in the hemiarch group: **2.8%**, twice the rate in the isolated ascending group (NS) Open hemiarch versus clamped ascending aorta replacement for aortopathy during initial bicuspid aortic valve replacement

Kevin L. Greason, MD $\stackrel{>}{\sim}$ \boxtimes • Juan A. Crestanello, MD • Katherine S. King, MS • ... Richard C. Daly, MD •

Joseph A. Dearani, MD • Hartzell V. Schaff, MD • Show all authors

J Thorac Cardiovasc Surg 2021





We identify no advantage of hemi-arch replacement over ascending aorta replacement with respect to follow-up repeat aortic arch operation or survival in patients without aortic arch aneurysm.

What's the risk of leaving the arch unaddressed?



The aortopathy of bicuspid aortic valve disease has distinctive patterns and usually involves the transverse aortic arch

Shafie S. Fazel, MD, PhD,^a Hari R. Mallidi, MD,^a Richard S. Lee, MD,^a Michael P. Sheehan, MSN, RN, FNP,^a David Liang, MD, PhD,^c Dominik Fleischman, MD,^b Robert Herfkens, MD,^b R. Scott Mitchell, MD,^a and D. Craig Miller, MD^a

J Thorac Cardiovasc Surg 2008;135:901-7





"73% BAV aortopathy patients presented an involvement of the aortic arch"

BICUSPID AORTOPATHY OR BICUSPID AORTOPATHIES? THE RISK IN GENERALIZING To the Editor:

We read with interest the article by Fazel and coworkers,¹ which highlighted the previously underreported issue of transverse aortic arch involvement in aortopathy related to the bicusthe observed patterns may not be unique to the BAV setting, and the definition itself of arch dilatation was not done by comparison with normal values. Moreover, as evident from Figure 3,¹ only cluster III (ascending+arch pattern) was quite homogeneous in terms of transverse arch involvement, whereas many patients plex and multifaceted matter. The identification of a definite BAV phenotype representing a more "malignant" form of disease, amenable to more extensive surgical resections, still requires special research efforts.

Alessandro Della Corte, MD

J Thorac Cardiovasc Surg 2008:136;1604



Cluster III (28%)

Mean distal asc: 46mm Mean mid arch: 35mm Cluster IV (45%)

Mean distal asc: 36mm Mean mid arch: 29mm



Bicuspid Aortic Valve Associated With Aortic Dilatation A Community-Based Study

Vuyisile T. Nkomo, Maurice Enriquez-Sarano, Naser M. Ammash, L. Joseph Melton III, Kent R. Bailey, Valerie Desjardins, Robin A. Horn, A. Jamil Tajik

TABLE 2.	Aortic Dimensions by Sex Among Olmsted County, MN	
Residents	With BAV and Their Age- and Sex-Matched Controls	

	BAV	Control	Р
Both sexes combined			
Ν	44	44	
Aortic anulus, mm	23.2 ± 2.4	21.6±2.4	0.002
Aortic sinus, mm	$33.5 {\pm} 4.6$	30.3±4.1	0.0001
Proximal ascending aorta, mm	$33.3 {\pm} 6.5$	27.9 ± 3.6	0.0001
Aortic arch, mm	24.2±3.6	25.3±3.4	0.16

Arterioscler Thromb Vasc Biol 2003

Aortic dimensions in patients with bicuspid and tricuspid aortic valves

Veronica Jackson, MD,^a Christian Olsson, MD, PhD,^a Per Eriksson, PhD,^b and Anders Franco-Cereceda, MD, PhD^a

J Thorac Cardiovasc Surg 2013

Dilatation of the ascending aorta in bicuspid aortic valve disease: a magnetic resonance imaging study

Clin Res Cardiol 2009



TABLE 2. Aortic dimensions according to valvular morphology

	TAV (n = 35)	$\begin{array}{c} BAV\\ (n=62) \end{array}$	P value
Annulus	2.40 (0.40)	2.50 (0.40)	>.2
	[1.19 (0.23)]	[1.27 (0.19)]	.054
Sinus of Valsalva	4.30 (1.75)	4.10 (0.80)	>.2
	[2.14 (0.63)]	[2.16 (0.40)]	>.2
Sinotubular junction	4.30 (1.18)	3.85 (0.90)	.057
	[2.06 (0.48)]	[1.97 (0.41)]	.085
Ascending aorta	5.30 (0.78)	5.20 (0.40)	.108
,	[2 76 (0.01)]	[2.60.(0.43)]	
Proximal arch	3.80 (0.68)	3.20 (0.60)	15
	[1.92 (0.64)]	[1.68 (0.43)]	.0.
Distal arch	3.40 (0.50)	2.90 (0.60)	<.001

Acute type A aortic dissection: characteristics and outcomes comparing patients with bicuspid versus tricuspid aortic valve

Christian D. Etz^{a,}, Konstantin von Aspern^{a,**}, Alexandro Hoyer^a, Felix F. Girrbach^b, Sergey Leontyev^a, Farhad Bakhtiary^a, Martin Misfeld^a and Friedrich W. Mohr^a

Eur J Cardio-Thorac Surg 2014:1-9

Table 1: Patient characteristics				
Variable	All	IAV	BAV	P-value
Aortic pathology				
Aortic regurgitation (≥II°)	262 (69.1)	233 (67.1)	29 (90.6)	0.005
+Aortic stenosis (≥II°)	108 (28.5)	95 (27.4)	13 (40.6)	0.150
Dissection characteristics				
Primary dissection entry verified	361 (95.3)	329 (94.8)	32 (100)	0.626
Root	32 (8.4)	22 (6.3)	10 <mark>(</mark> 31.3)	<0.001
Ascending aorta	241 (63.3)	221 (62.4)	20 (62 5)	1.000
Aortic arch	76 (20.1)	74 (21.3)	2 (6.3)	0.039
Descending aorta/not identified	30 (7.9)	30 (8.6)	0(0)	0.094

The primary entry tear in BAV patients presenting with acute type A AD warmore rarely (6%) in the arch than in TAV patients

International consensus statement on nomenclature and classification of the congenital bicuspid aortic valve and its aortopathy, for clinical, surgical, interventional and research purposes

Hector I. Michelena,^a Alessandro Della Corte,^b Arturo Evangelista,^c Joseph J. Maleszewski,^d William D. Edwards,^d Mary J. Roman,^c Richard B. Devereux,^c Borja Fernández,[†] Federico M. Asch,^g Alex J. Barker,^h Lilia M. Sierra-Galan,¹ Laurent De Kerchove,^J Susan M. Fernandes,^{k,J} Paul W. M. Fedak,^m Evaldas Girdauskas,^a Victoria Delgado,^o Suhny Abbara,^p Emmanuel Lansac,^q Siddharth K. Prakash,^f Malenka M. Bissell,^s Bogdan A. Popescu,[†] Michael D. Hope,^a Marta Sitges,^V Vinod H. Thourani,^w Philippe Pibarot,^{*} Krishnaswamy Chandrasekaran,^a Patrizio Lancellotti,^{3,d} Michael A. Borger,^{am} John K. Forrest,^{ali} John Webb,^{ac} Dianna M. Milewicz,^f Raj Makkar,^{ad} Martin B. Leon,^{ae} Stephen P. Sanders,^{ali,ag} Michael Markl,^{ah} Victor A. Ferrari,^{au} William C. Roberts,^{aj} Jae-Kwan Song,^{ak} Joseph Bavaria,^{ad} Thoralf M. Sundt,^{ad} Gebrine El Khoury,¹ Ruggero De Paulis,^{as} Maurice Enriquez-Sarano,^a Jeroen J. Bax,^o Catherine M. Otto,^{at} and Hans-Joachim Schäfers^{au}

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Radiol Cardiothorac Imaging 2021



Should the proximal arch be routinely replaced in patients with bicuspid aortic valve disease and ascending aortic aneurysm?

Chan B. Park, MD,^{a,b} Kevin L. Greason, MD,^a Rakesh M. Suri, MD,^a Hector I. Michelena, MD,^c Hartzell V. Schaff, MD,^a and Thoralf M. Sundt III, MD^a

J Thorac Cardiovasc Surg 2011;142:602-7

- Retrospective

- 470 AAR patients
- 48 needed hemiarch
- Median follow-up: 4 yrs



Open hemiarch versus clamped ascending aorta replacement for aortopathy during initial bicuspid aortic valve replacement

Kevin L. Greason, MD $\stackrel{>}{\sim}$ ⊡ • Juan A. Crestanello, MD • Katherine S. King, MS • ... Richard C. Daly, MD • Joseph A. Dearani, MD • Hartzell V. Schaff, MD • Show all authors

J Thorac Cardiovasc Surg 2021





We identify no advantage of hemi-arch replacement over ascending aorta replacement with respect to follow-up repeat aortic arch operation or survival in patients without aortic arch aneurysm.

The American Association for Thoracic Surgery consensus Check for updates guidelines on bicuspid aortic valve-related aortopathy: Full online-only version

Michael A. Borger, MD, PhD,^a Paul W. M. Fedak, MD, PhD,^b Elizabeth H. Stephens, MD, PhD,^c Thomas G. Gleason, MD,^d Evaldas Girdauskas, MD, PhD,^e John S. Ikonomidis, MD, PhD,^f Ali Khovnezhad, MD, PhD,^g Samuel C. Siu, MD,^h Subodh Verma, MD, PhD,ⁱ Michael D. Hope, MD,^j Duke E. Cameron, MD,^k Donald F. Hammer, MD,¹ Joseph S. Coselli, MD,^m Marc R. Moon, MD,ⁿ Thoralf M. Sundt, MD.º Alex J. Barker, PhD.^p Michael Markl, PhD.^q Alessandro Della Corte, MD, PhD.^r Hector I. Michelena, MD,8 and John A. Elefteriades, MD¹

.227



J Thorac Cardiovasc Surg 2018;156:e41-74

Repair of the aortic arch is recommended in	I/B ^{221,22}
patients with an aortic arch diameter of	
≥55 mm.	
Concomitant repair of the aortic arch should	IIa/C ²²⁸

be performed in patients undergoing cardiac surgery with an aortic arch diameter of >50 mm.

Concomitant repair of the aortic arch may be performed in patients undergoing cardiac surgery with an aortic arch diameter of \geq 45 mm, provided the patients are at low surgical risk and operated on by an experienced aortic team with established surgical results.

It is recommended that patients undergoing elective aortic arch repair be referred to an experienced aortic team with established surgical results.

 IIb/C^{220}

I/B^{224,225}



Any knowledge substrate for a tailored approach?



Phenotypic risk markers

The ascending aorta with bicuspid aortic valve: a phenotypic classification with potential prognostic significance[†]

Alessandro Della Corte^{*}, Ciro Bancone, Giovanni Dialetto, Franco E. Covino, Sabrina Manduca, Marco V. Montibello, Marisa De Feo, Marianna Buonocore and Gianantonio Nappi

Eur J Cardio-Thorac Surg 2014:46;240–7



Root phenotype

Ascending phenotype

A dilatation of the proximal arch and/or distal ascending aorta (data available in 329 patients) was observed in 39% RN patients vs 13% RL (P < 0.0001).

Some degree of distal ascending / proximal arch dilatation is more common in association with the less common valve type (R-N fusion)





RN

RL

Flow-related risk markers?

Bicuspid Aortic Cusp Fusion Morphology Alters Aortic Three-Dimensional Outflow Patterns, Wall Shear Stress, and Expression of Aortopathy

Riti Mahadevia, MD; Alex J. Barker, PhD; Susanne Schnell, PhD; Pegah Entezari, MD; Preeti Kansal, MD; Paul W.M. Fedak, MD; S. Chris Malaisrie, MD; Patrick McCarthy, MD; Jeremy Collins, MD; James Carr, MD; Michael Markl, PhD

Circulation 2014;129:673-682

Aortic Dilation in Bicuspid Aortic Valve Disease Flow Pattern Is a Major Contributor and Differs With Valve Fusion Type

Malenka M. Bissell, MD, BM, MRCPCH; Aaron T. Hess, PhD; Luca Biasiolli, DPhil; Steffan J. Glaze; Margaret Loudon, MBChB, MRCP; Alex Pitcher, BMBCh, MRCP; Anne Davis, BSc Hons; Bernard Prendergast, DM, FRCP, FESC; Michael Markl, PhD; Alex J. Barker, PhD; Stefan Neubauer, MD, FRCP, FMedSci; Saul G. Myerson, MB ChB, MD, MRCP, FESC

Circ Cardiovasc Imaging 2013;6:499-507







Right-handed helical flow associated with higher wall shear stress and greater arch diameter

Conclusions

- BAV aortopathy heterogeneity is never emphasized enough
- The form involving the (proximal) arch is relatively rare
- The native arch rarely dilates and is rarely the site of primary dissection entry tear
- Even in experienced centers the addition of HCA increases morbility
- Routine emiarch replacement in BAV aortopathy surgery is not justified
- It should be selectively added to ascending/root replacement based on arch diameter and phenotypic associations
- Research should focus on identifying risk factors for arch involvement with BAV





