la pratica dev' essere e
(Practice must always
Leonardo Da Vinci

Reconstruc
A practical

Day 1

08.30	Arrival, registration	
09.00	Welcome and introduction	*H.-J. Schäfers*
09.45	Aortic regurgitation and aneurysm- Epidemiology and guidelines	*W. Fehske*
	BREAK	
10.30	Anatomy of aortic valve and root	*M. Heinemann*
11.00	AV repair – the Homburg approach	*H.-J. Schäfers*
11.30	Why and when to repair the aortic valve	*I. El-Hamamsy*
	BREAK	
13.00	Videos root repair	*H.-J. Schäfers*
14.00	Root repair – the Tel Aviv approach	*E. Raanani*
14.20	Echo assessment of AR and its mechanisms	*W. Fehske*
14.40	Repair or Ross operation	*I. El-Hamamsy*
	BREAK	
15.30	The AV junction in aortic repair	*E. Lansac*
16.00	Videos cusp repair	*H.-J. Schäfers*
17.00	Results of cusp and root repair	*C. Giebels*
18.00	Adjourn	

Day 2

07.45	Case presentations	
	Live operations: Moderation E. Raanani	
08.00	Case #1 Root repair	
09.30	Case #2 Root repair	
10.15	Shortcut to echo – intraop. echo and morphology	*F. Langer*
	BREAK	
11.15	Case #3 Root repair	
12.15	Discussion	
	BREAK	
13.00	Reimplantation should be the preferred technique	*E. Raanani*
13.15	Remodeling is my standard approach	*H.-J. Schäfers*
14.00	3-dimensional echo in aortic valve repair	*W. Fehske*
14.30	How to start root repair	*H.-J. Schäfers*
	BREAK	
15.30	Wetlab (bring your loupes!)	*Faculty*
18.00	Adjourn	

The role of multimodality imaging in the selection of patients for aortic valve repair

Madelien V. Regeer, Michel I.M. Versteegh, Nina Ajmone Marsan, Jeroen J. Bax & Victoria Delgado

To cite this article: Madelien V. Regeer, Michel I.M. Versteegh, Nina Ajmone Marsan, Jeroen J. Bax & Victoria Delgado (2016) The role of multimodality imaging in the selection of patients for aortic valve repair, Expert Review of Cardiovascular Therapy, 14:1, 75-86, DOI: 10.1586/14779072.2016.1109448

To link to this article: http://dx.doi.org/10.1586/14779072.2016.1109448

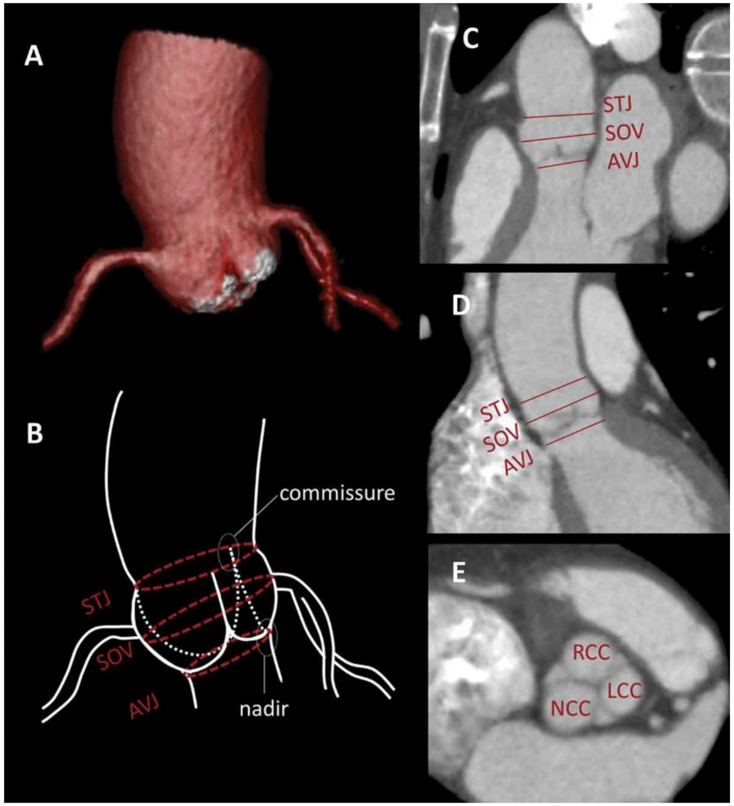

Figure 1. Anatomy of the aortic valve and root visualized with multi-detector row computed tomography. **Panel A shows the 3D volume of the aortic root. Panel B reconstructs the aortic root with the demarcation of the different components: aortoventricular junction (AVJ), sinus of Valsalva (SOV) and sinotubular junction (STJ), commissures and nadirs of the aortic valve. Panels C, D and E show the sagittal, coronal and double oblique view of the aortic root and aortic valve, respectively.**

Published in: Madelien V. Regeer; Michel I.M. Versteegh; Nina Ajmone Marsan; Jeroen J. Bax; Victoria Delgado; *Expert Review of Cardiovascular Therapy* **2016,** 14, 75-86.
DOI: 10.1586/14779072.2016.1109448

Aortic regurgitation = malcoaptation of the cusps

- intrinsic cusp damage
  - degeneration
  - Congenital (BAV; …..)
  - rheumatic valvular disease
  - infective endocarditis

- aortic root dilation
  - aortic root aneurysm (connective tissue disease, Marfan syndrome etc.)
  - aortic dissection
  - aortitis

Classification of aortic regurgitation

Type 1
- normal motion of the cusps and malcoaptation due to dilatation of the aortic root involving the sinus of Valsalva

Type 2
- excessive cusp motion with „prolapse“

Type 3
- restrictive motion of the cusps

Combination of different mechanisms should be considered

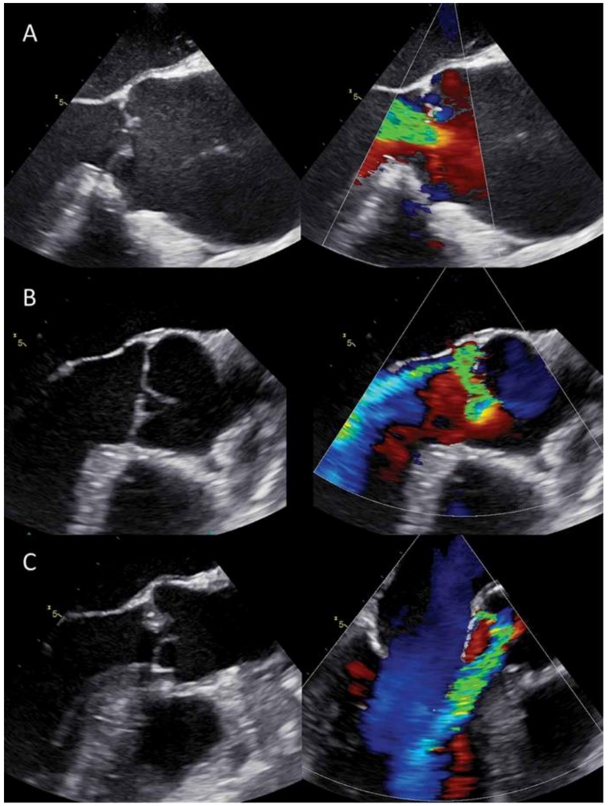

Figure 2. Mechanisms of aortic regurgitation as assessed with transesophageal echocardiography. **Mid-esophageal long-axis view of the aortic valve**. (A) **Aortic regurgitation type 1 due to aortic root dilation**. (B) **Aortic regurgitation type 2 due to leaflet prolapse**. (C) **Aortic regurgitation type 3 due to cusp restriction**.

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European Heart Journal – Cardiovascular Imaging (2013) **14**, 611–644
doi:10.1093/ehjci/jet105

RECOMMENDATIONS

Recommendations for the echocardiographic assessment of native valvular regurgitation: an executive summary from the European Association of Cardiovascular Imaging

Patrizio Lancellotti[1*], Christophe Tribouilloy[2], Andreas Hagendorff[3], Bogdan A. Popescu[4], Thor Edvardsen[5], Luc A. Pierard[1], Luigi Badano[6], and Jose L. Zamorano[7], On behalf of the Scientific Document Committee of the European Association of Cardiovascular Imaging: Thor Edvardsen, Oliver Bruder, Bernard Cosyns, Erwan Donal, Raluca Dulgheru, Maurizio Galderisi, Patrizio Lancellotti, Denisa Muraru, Koen Nieman, Rosa Sicari, Document reviewers: Erwan Donal, Kristina Haugaa, Giovanni La Canna, Julien Magne, Edyta Plonska

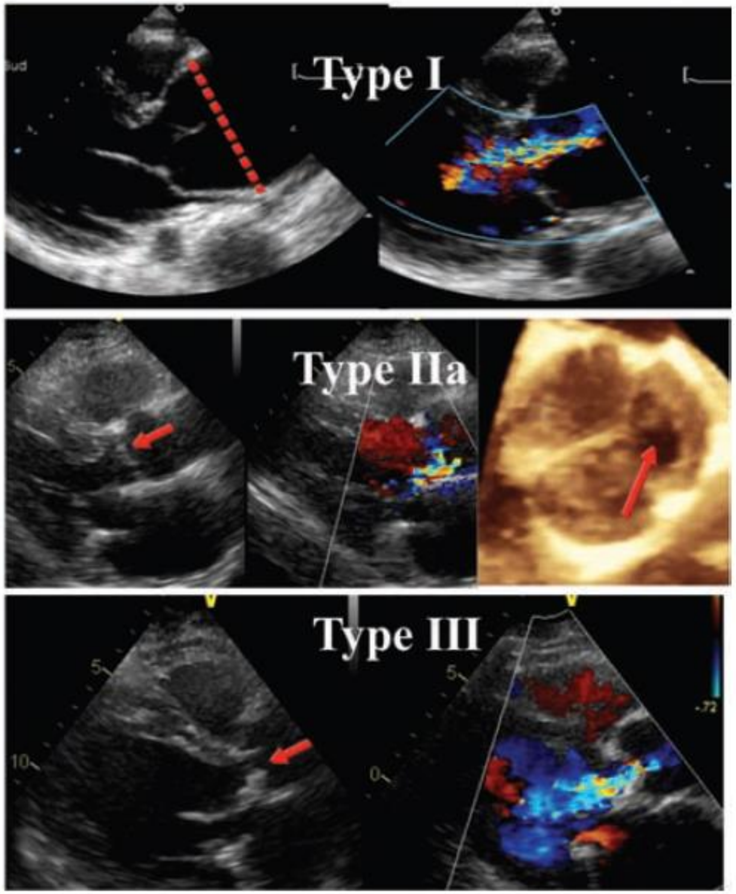

Figure 2 Mechanisms of AR according to the Carpentier's functional classification. Type: aortic annulus dilatation; Type IIa: prolapse of the left coronary cusp (arrow); Type III: rheumatic aortic valve disease with restricted cusp motion.

Table 3 Functional classification of AR lesions

Dysfunction	Echo findings
Type I: enlargement of the aortic root with normal cusps	Dilatation of any components of the aortic root (aortic annulus, sinuses of valsalva, sinotubular junction)
Type IIa: cusp prolapse with eccentric AR jet	
Cusp flail	Complete eversion of a cusp into the LVOT in long-axis views
Partial cusp prolapse	Distal part of a cusp prolapsing into the LVOT (clear bending of the cusp body on long-axis views and the presence of a small circular structure near the cusp free edge on short-axis views)
Whole cusp prolapse	Free edge of a cusp overriding the plane of aortic annulus with billowing of the entire cusp body into the LVOT (presence of a large circular or oval structure immediately beneath the valve on short-axis views)
Type IIb: free edge fenestration with eccentric AR jet	Presence of an eccentric AR jet without definite evidence of cusp prolapse
Type III: poor cusps quality or quantity	Thickened and rigid valves with reduced motion Tissue destruction (endocarditis) Large calcification spots/extensive calcifications of all cusps interfering with cusp motion

Echocardiographic criteria for the definition of severe valve regurgitation: *an integrative approach*

	Aortic regurgitation	Mitral regurgitation	Tricuspid regurgitation
Qualitative			
Valve morphology	Abnormal/flail/large coaptation defect	Flail leaflet/ruptured papillary muscle/large coaptation defect	Abnormal/flail/large coaptation defect
Colour flow regurgitant jet	Large in central jets, variable in eccentric jets	Very large central jet or eccentric jet adhering, swirling, and reaching the posterior wall of the left atrium	Very large central jet or eccentric wall impinging jet
CW signal of regurgitant jet	Dense	Dense/triangular	Dense/triangular with early peaking (peak vel < 2 m/s in massive TR)
Other	Holodiastolic flow reversal in descending aorta (EDV > 20 cm/s)	Large flow convergence zone	–

Adapted from Lancellotti, EAE Recommendations. *Eur J Echocardiogr.* 2010;11:223-244 and 307-332

Echocardiographic criteria for the definition of severe valve regurgitation: *an integrative approach*

	Aortic regurgitation	Mitral regurgitation		Tricuspid regurgitation
Semiquantitative				
Vena contracta width (mm)	≥ [illegible]	≥ 7 (> 8 for biplane)		≥ 7
Upstream vein flow	–	Systolic pulmonary vein flow reversal		Systolic hepatic vein flow reversal
Inflow	–	E-wave dominant ≥ 1.5 m/s		E-wave dominant ≥ 1 m/s
Other	Pressure half-time < 200 ms	TVI mitral/TVI aortic > 1.4		PISA radius > 9 mm
Quantitative		***Primary***	***Secondary***	
EROA (mm²)	≥ 30	≥ 40	≥ 20	≥ 40
R Vol (ml/beat)	≥ [illegible]	≥ 60	≥ 30	≥ 45
+ enlargement of cardiac chambers/ vessels	LV	LV, LA		RV, RA, inferior vena cava

Adapted from Lancellotti, EAE recommendations. *Eur J Echocardiogr.* 2010;11:223-244 and 307-332

European Heart Journal 2012 - doi:10.1093/eurheartj/ehs109 &
European Journal of Cardio-Thoracic Surgery 2012 - doi:10.1093/ejcts/ezs455).

Table 1. Imaging modalities to asse aspects of aortic regurgitation.

	2DTTE	2DTEE	3DTEE
Aortic regurgitation severity	++	++	++
Aortic regurgitation mechanism	+	+	++
Aortic root dimensions	+/–	+/–	+
Aortic valve reparability	+/–	++	++

2DTEE: two-dimensional transesophageal echocardiography, sional transthoracic echocardiography, 3DTEE: three-dimensio echocardiography, CMR: cardiac magnetic resonance, MDCT computed tomography.

Table 2. Echocardiographic parameters to assess severity of aortic regurgitation.

	Mild	Moderate	Severe
Qualitative			
Aortic valve morphology	Normal/ abnormal	Normal/ abnormal	Abnormal/ flail/large coaptation defect
Colour flow aortic regurgitation jet width	Small in central jets	Intermediate	Large in central jets, variable in eccentric jets
Continuous wave signal of aortic regurgitation jet	Incomplete/ faint	Dense	Dense
Diastolic flow reversal in descending aorta	Brief, protodiastolic flow reversal	Intermediate	Holodiastolic flow reversal (end-diastolic velocity >20 cm/s)
Semi-quantitative			
Vena contracta width	<3 mm	Intermediate	>6 mm
Pressure half-time	>500ms	Intermediate	<200 ms
Quantitative			
Effective regurgitant orifice area (mm^2)	<10	10–29	≥30
Regurgitant volume (ml)	<30	30–59	≥60

Adapted from Lancellotti *et al.* [35]

The role of multimodality imaging in the selection of patients for aortic valve repair

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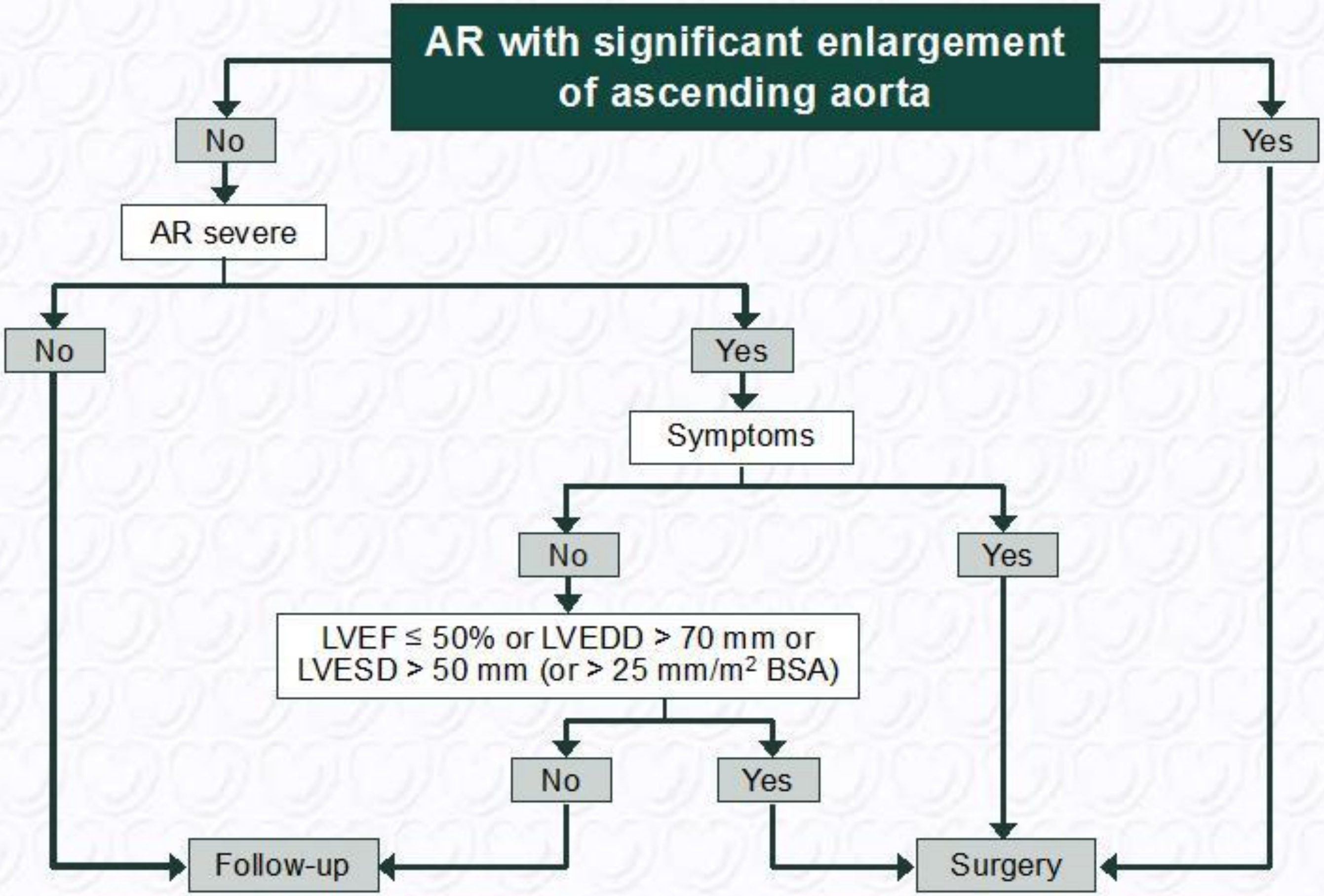
Management of aortic regurgitation



European Heart Journal 2012 - doi:10.1093/eurheartj/ehs109 & European Journal of Cardio-Thoracic Surgery 2012 - doi:10.1093/ejcts/ezs455).

Mechanism of aortic regurgitation by 2D TEE

jet direction

- central
  - normal cusp mobility
  - aortic root dilatation
- Eccentric
  - excessive cusp mobility
    - transverse fibrous band
      - prolapsing cusp

Boodhwani M, de Kerchove L, Glineur D, et al.
Repair-oriented classification of aortic insufficiency: impact on surgical techniques and clinical outcomes.
J Thorac Cardiovasc Surg. 2009;137:286–294.

Table 3. Factors associated with aortic valve reparability and the preferred imaging modality.

Factors associated with aortic valve reparability	Preferred imaging modality
Type 1 and 2 aortic regurgitation	2D/3DTEE
No or only small aortic annular or commissural calcification	2D/3DTEE, MDCT
Bicuspid aortic valve	
with commissural orientation >160°	2D/3DTEE, (gated MDCT)
with eccentric jet without commissural or cusp thickening	2D/3DTEE
with large cusp pliability and small coaptation deficiency index	2D/3DTEE
Aortoventricular junction <28 mm	MDCT, 3DTEE

2DTEE: two-dimensional transesophageal echocardiography, 3DTEE: three-dimensional transesophageal echocardiography, MDCT: multidetector row computed tomography.

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2D-TEE: maximum values for aortic root dimensions

	men	women
AV-junction	31	26
Sinus of Valsalva	40	36
Sinutubular junction	36	32

3D TEE and MSCT „better“ (?)

Roman MJ, Devereux RB, Kramer-Fox R, et al. Two-dimensional echocardiographic aortic root dimensions in normal children and adults. Am J Cardiol. 1989;64:507–512.

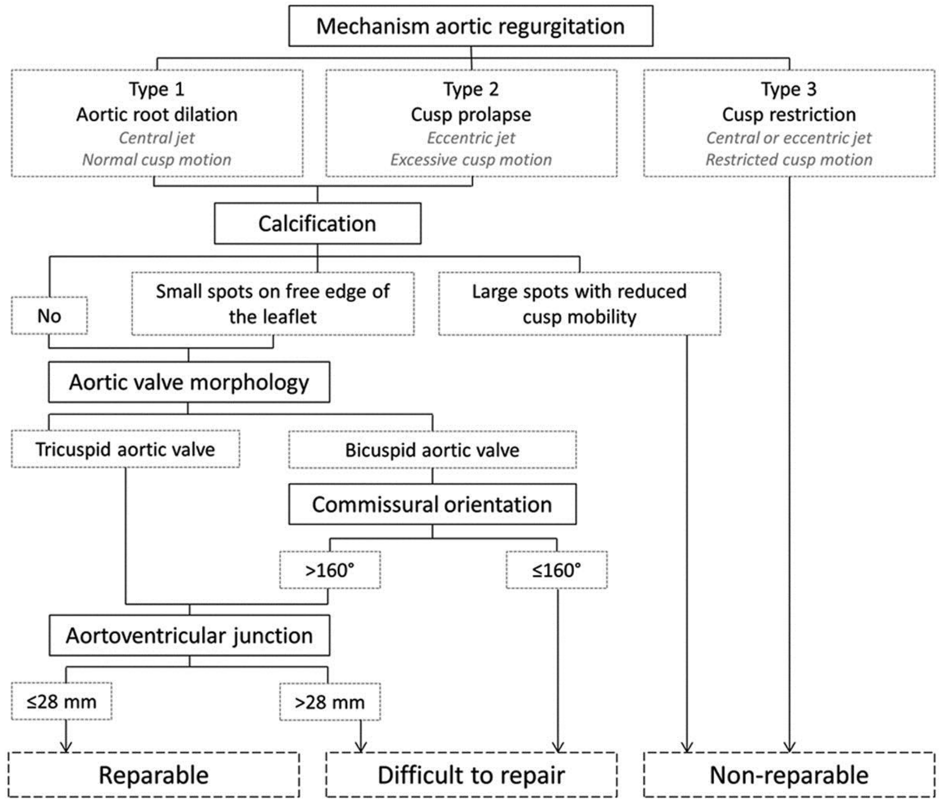

Figure 4. Flowchart to determine aortic valve reparability.

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Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association®

Functional Anatomy of Aortic Regurgitation: Accuracy, Prediction of Surgical Repairability, and Outcome Implications of Transesophageal Echocardiography

Jean-Benoît le Polain de Waroux, Anne-Catherine Pouleur, Céline Goffinet, David Vancraeynest, Michel Van Dyck, Annie Robert, Bernhard L. Gerber, Agnès Pasquet, Gébrine El Khoury and Jean-Louis J. Vanoverschelde

Circulation. 2007;116:I-264-I-269

TABLE 1. Surgical and TEE Classification of Aortic Regurgitant Lesions

Type 1	Enlargement of the aortic root with normal cusps.
Type 2	Cusp prolapse or fenestration.
Type 3	Poor cusp tissue quality or quantity.

TABLE 2. Grading of Aortic Valve Calcification

Grade 1	No calcification
Grade 2	Isolated small calcification spots
Grade 3	Bigger calcification spots interfering with cusp motion
Grade 4	Extensive calcifications of all cusps with restricted cusp motion

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Functional Anatomy of Aortic Regurgitation: Accuracy, Prediction of Surgical Repairability, and Outcome Implications of Transesophageal Echocardiography

Jean-Benoît le Polain de Waroux, Anne-Catherine Pouleur, Céline Goffinet, David

TABLE
Regurg

Type 1
Type 2
Type 3

Echocardiographic Prediction of "Repairability"

Unless severely calcified, most type 1 and 2 AR lesions were considered as "repairable", ie, amenable to some form of conservative surgery, including valve sparing surgery, cusp repair, or a combination thereof. In moderately calcified valves (<grade 3), the localization of the calcifications was taken into account. Whenever these calcifications were confined to the free margins, aortic repair was considered to be feasible. By contrast, when the calcifications involved the body of the cusp, the valve was considered as nonrepairable. Finally, type 3 lesions were a priori considered as nonrepairable.

Grade 1	No calcification
Grade 2	Isolated small calcification spots
Grade 3	Bigger calcification spots interfering with cusp motion
Grade 4	Extensive calcifications of all cusps with restricted cusp motion

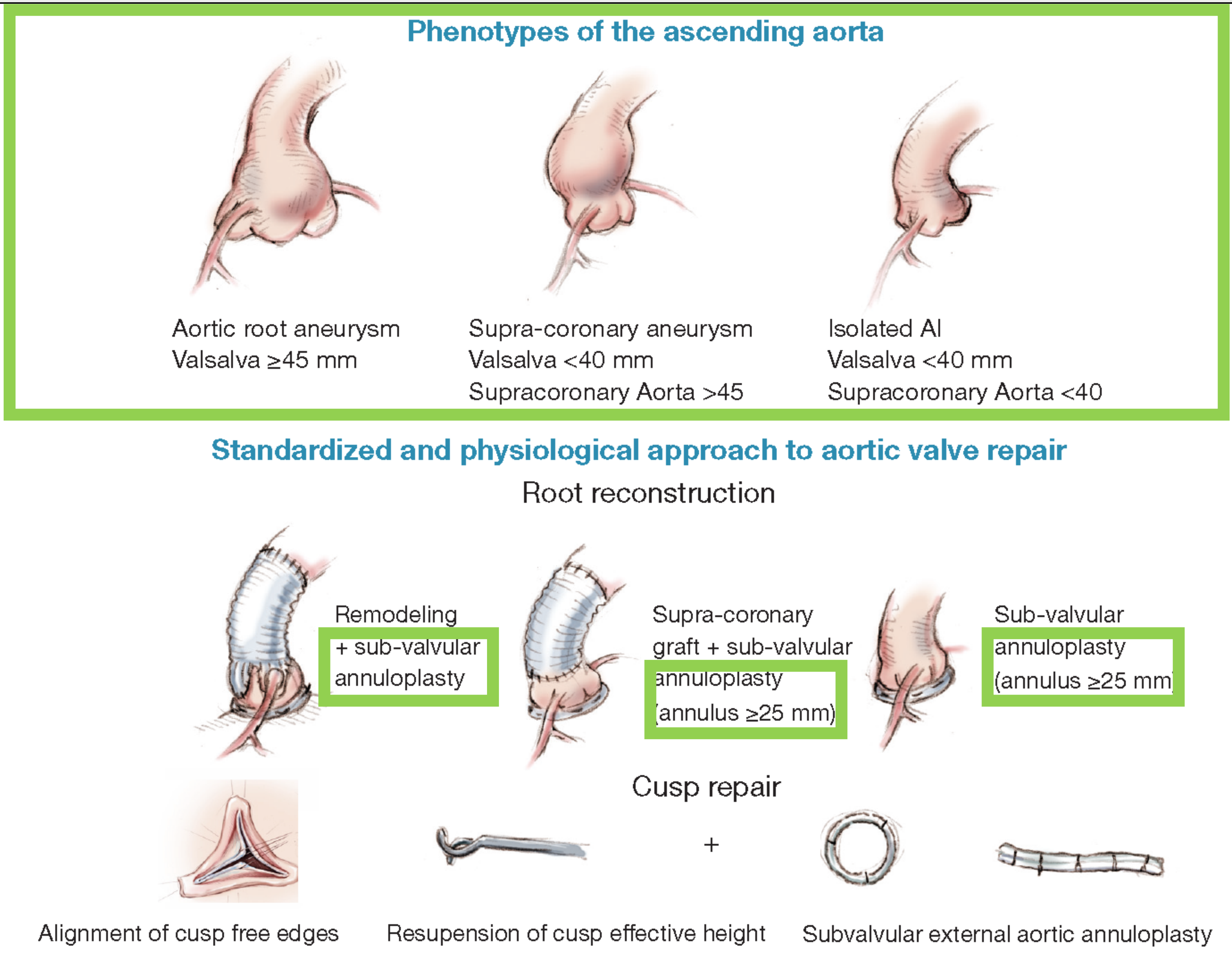

Figure 7 Standardized and physiological approach to aortic valve repair according to each phenotype of ascending aorta

Isolated aortic valve reconstruction (a: plication; b: triangular resection; c: pericardial patch) – normal sinus diameter(<40mm) and normal sinutubular junction (<33mm)

Supracommisural replacement of ascending aorta – dilated sinutubular junction (>33mm) and normal dimension of sinus (<40mm)

Aortic root remodeling (Yacoub) – dilated sinus (>40mm) and dilated sinutubular junction (>33mm)

Dilated basal ring (>25mm) additional annuloplasty in all reconstruction modalities

Aim of each reconstruction: normalisation of dimensions of Aorta adequate configuration of cusps (effective height 10 mm).

ELSEVIER

European Journal of Cardio-thoracic Surgery 38 (2010) 400–406

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

www.elsevier.com/locate/ejcts

Aortic root and cusp configuration determine aortic valve function☆

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[a] Department of Thoracic and Cardiovascular Surgery, University Hospitals of Saarland, Kirrbergerstrasse 1, 66421 Homburg/Saar, Germany
[b] Institute for Medical Biometry, Epidemiology and Informatics, University Hospitals of Saarland, Homburg/Saar, Germany

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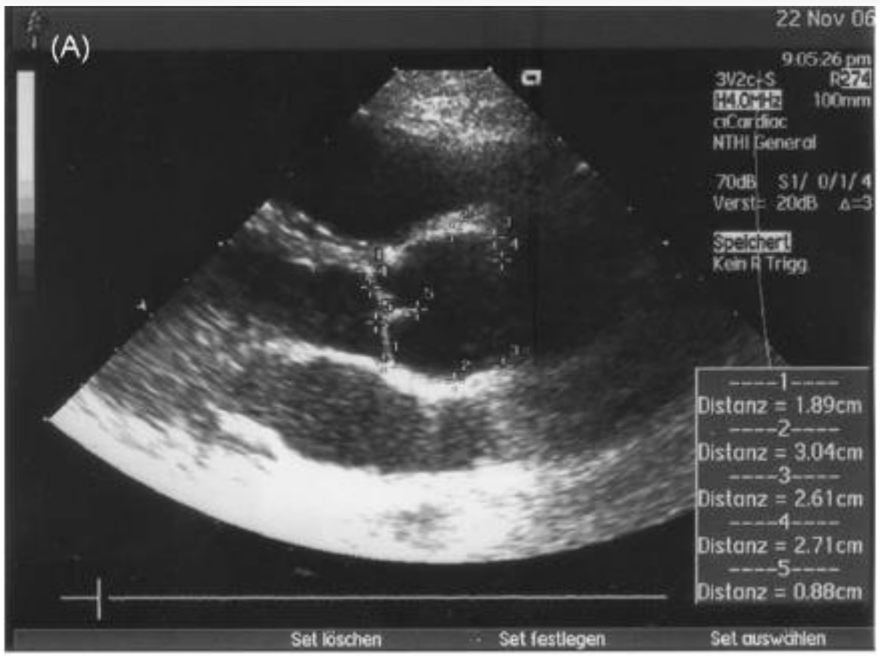


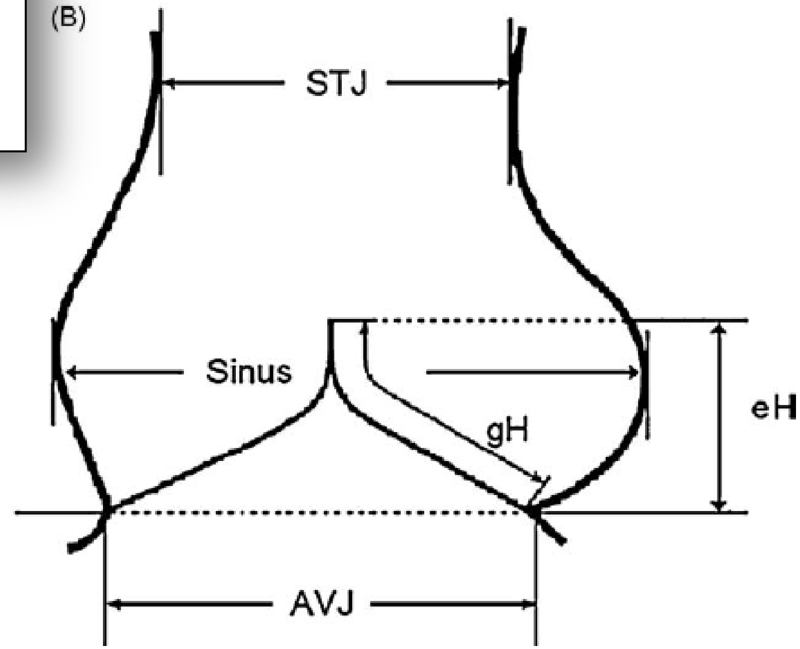
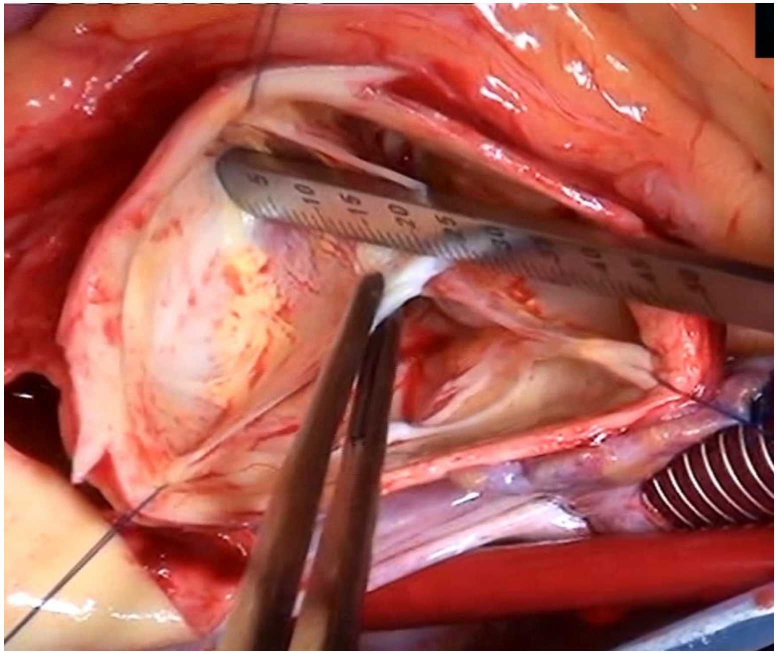


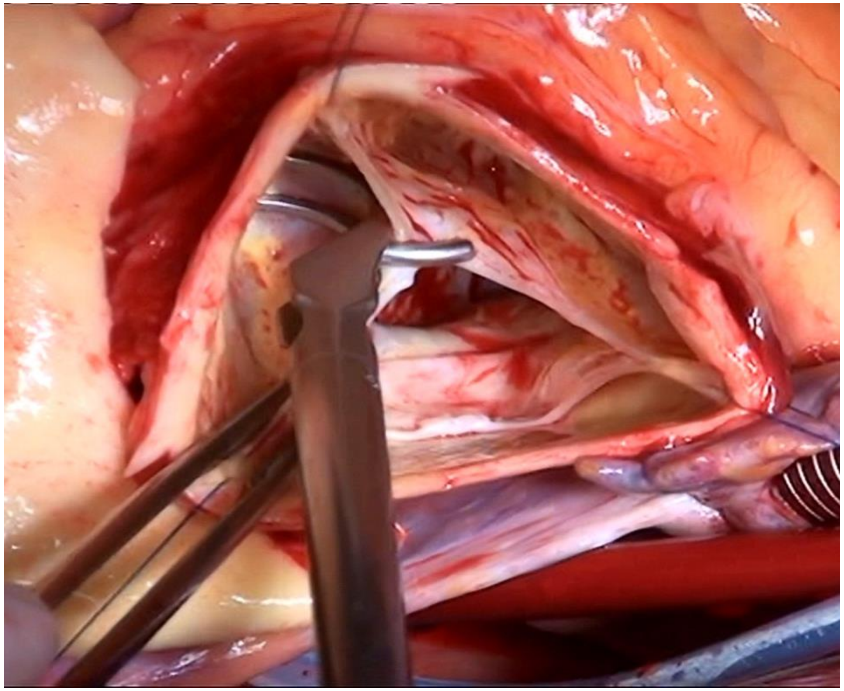
Fig. 1. Aortic root dimensions at different levels and effective height measured by transthoracic echocardiography in the long parasternal axis (A) and a schematic drawing (B). STJ: sinutubular junction; Sinus: maximum sinus diameter, gH: geometric height; eH: effective height; AVJ: aortoventricular junction.

Conclusions: Parameters of aortic root dimensions follow a seemingly constant pattern in humans of different sizes. Effective height has a constant relationship to root dimensions and body size. In AVR, normalisation of eH leads to a high probability of normal or near-

predictors of successful AV repair

Intraoperative surgical measurements





Patient examples
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