Assistance by Echo, 2D- and 3D-TEE

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Echocardiographic Assistance

Table 10. Potential Approaches for Imaging in TAVR

Preprocedural Assessment

1. Assessment of aortic annular size and shape (CT, CMR, 2D and 3D echocardiography)
2. Assessment of aortic valve for number of cusps, degree of calcification and valve area by planimetry (CT, CMR, 2D and 3D echocardiography)
3. Measurement of the distance between annulus and coronary ostia (CT, CMR, 2D and 3D echocardiography)
4. Planning for precise coaxial alignment of the stent-valve along the centerline of the aortic valve and aortic root (CT)
5. Assessment of aortic dimensions (2D and 3D echocardiography, CT or CMR) and atherosclerosis (echocardiography, CT, or CMR)
6. Assessment of dimensions and atherosclerosis of iliofemoral vessels (CT, MR, angiography)

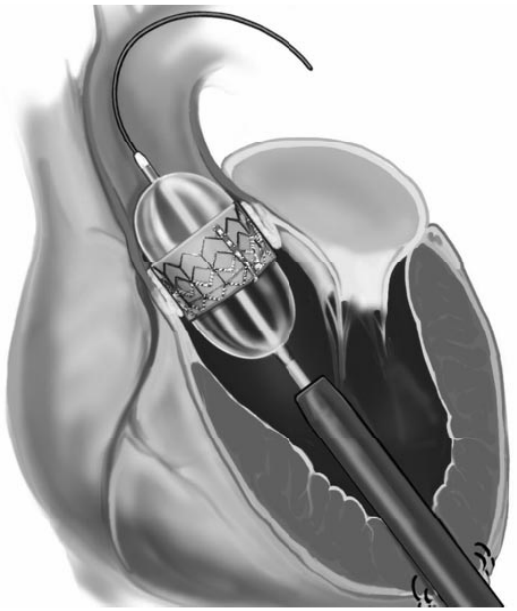
Postprocedural Assessment

1. Assessment of degree of aortic regurgitation (echocardiography or CMR)
2. Assessment of cerebral embolization (cerebral MRI)

2D = 2-dimensional; 3D = 3-dimensional; CMR = cardiac magnetic resonance; CT = computed tomography; MRI = magnetic resonance imaging; TAVR = transcatheter aortic valve replacement.

Ann Thorac Surg 2012;93:1340–95

Evaluations using TTE



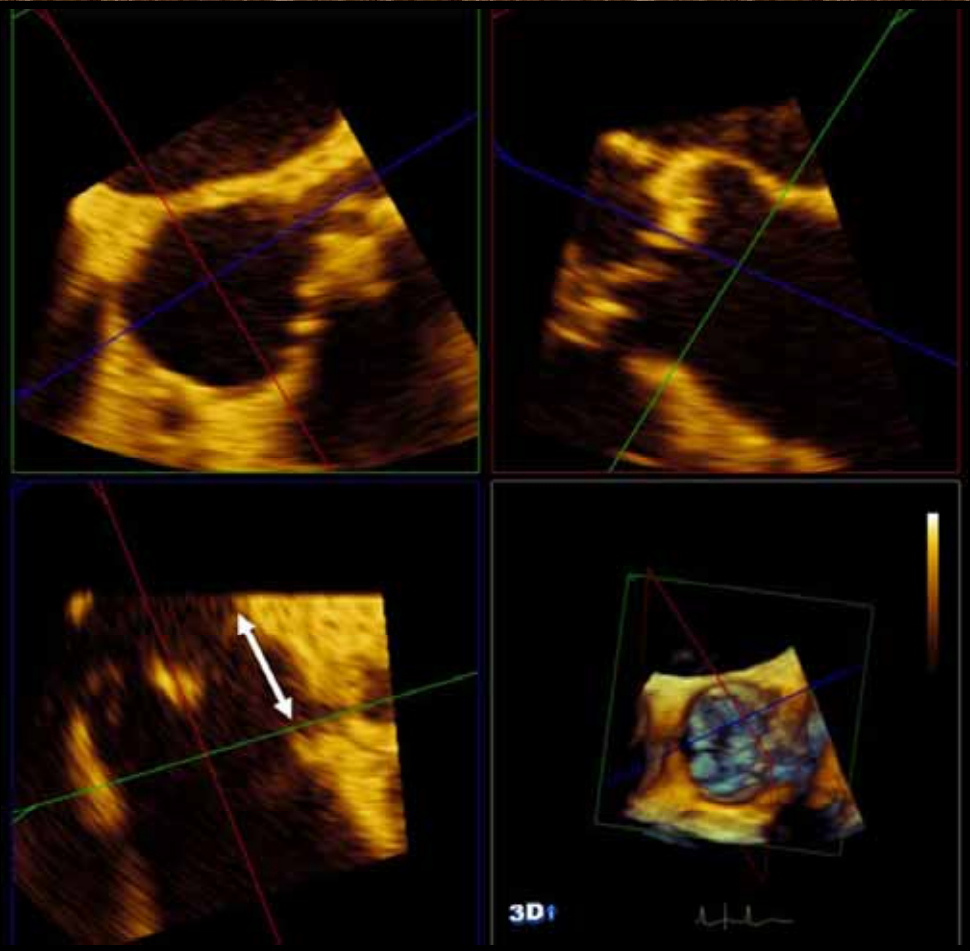
Transapical TAVI

- Position of the LV apex
  - Use two orthogonal TTE apical views
  - Surgeon and echocardiographer should agree on the optimum intercostal space.
  - Once the skin is marked with the optimal position, it is essential that the patient and/or the skin not be moved.

Preprocedural Assessment using TEE

- **Presence of septal bulge**
  - An obstacle to proper seating
- **Opening of the AV**
  - Central or eccentric
- **AV calcification**
  - Severity, location, symmetry
- **Distance from the aortic annulus to the coronary ostia**
  - RCA: 2D TEE
  - LCA: 3D TEE (or MSCT)
- **Presence of aortic arch atheroma**
- **Assessment of aortic dimensions**

Localization of LCA by 3D TEE



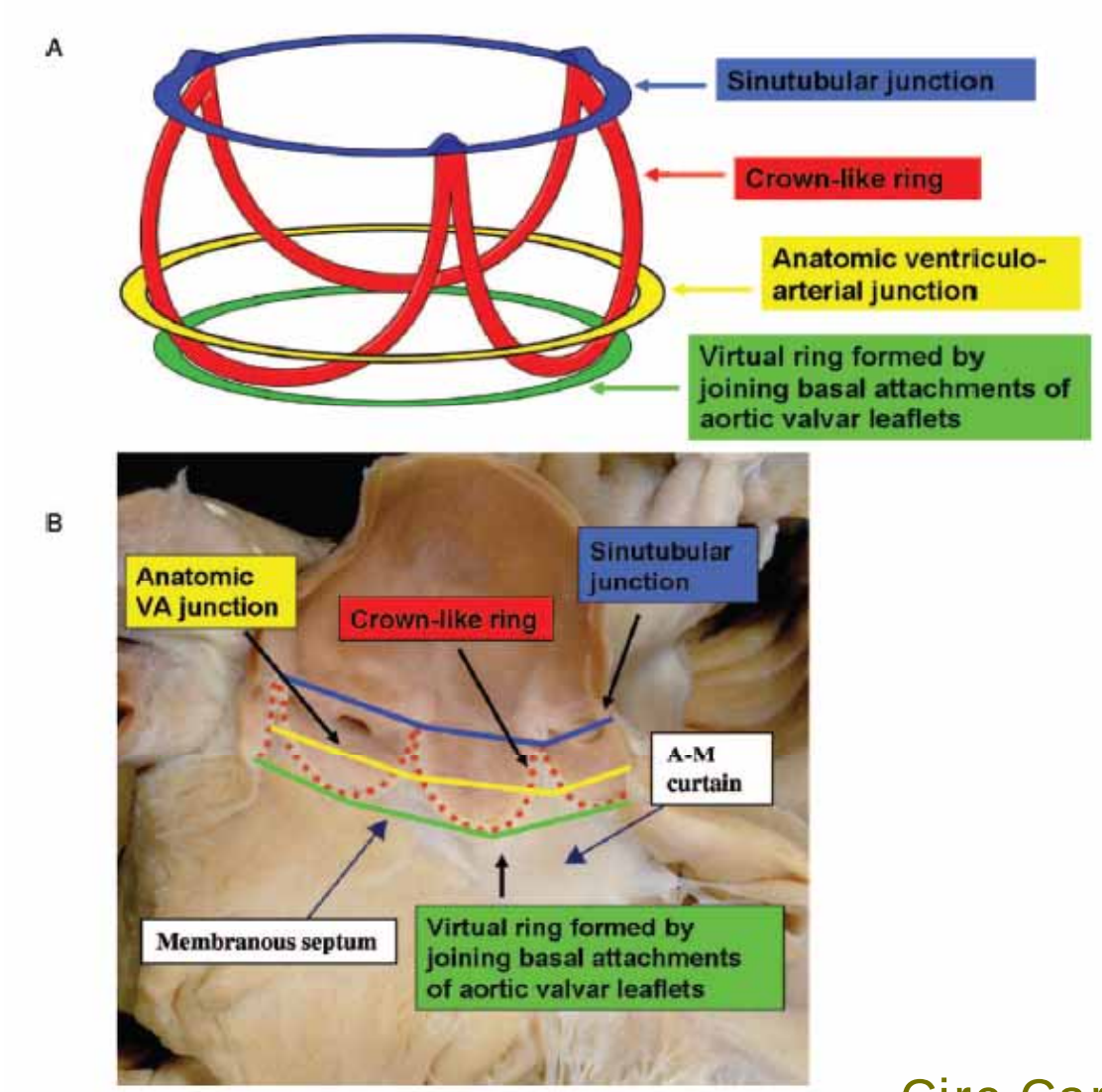
In general, a distance of >**10 mm** is desirable for the 23 mm balloon-expandable valve and a distance of >**11 mm** is desirable for the 26 mm valve.

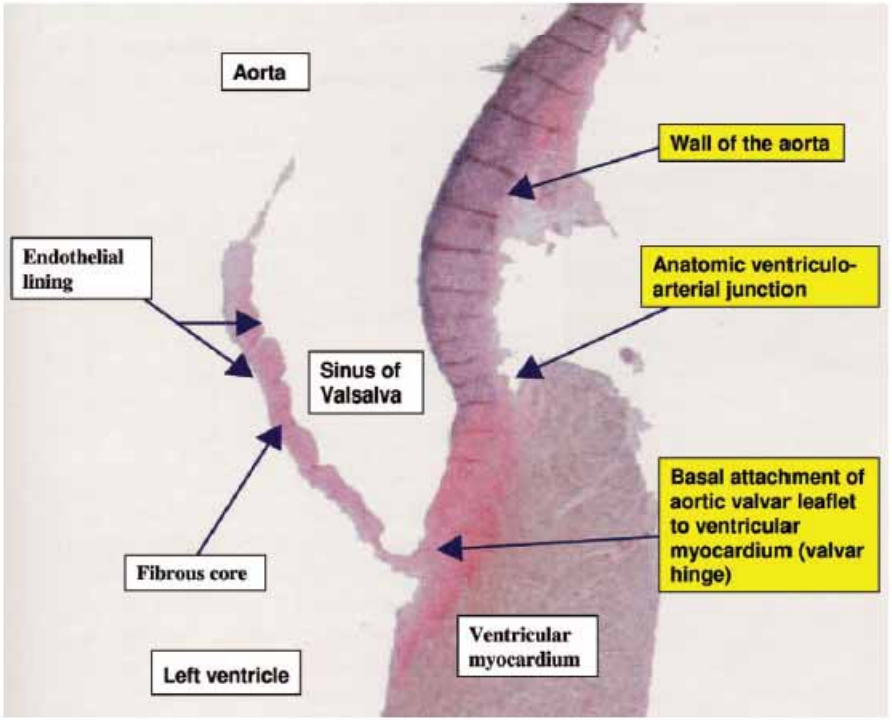
JASE 2013;26:359-69

Annulus Size Measurement

- **Undersizing**
  - Device migration
  - Significant paravalvular AR
  - Prosthesis mismatch
- **Oversizing**
  - Complications related to vascular access
  - Difficulties when crossing the native AV
  - Under-expansion
    - redundancy of leaflet tissue
    - creating folds that may cause central AR or reduction in valve durability
  - Catastrophic annular rupture

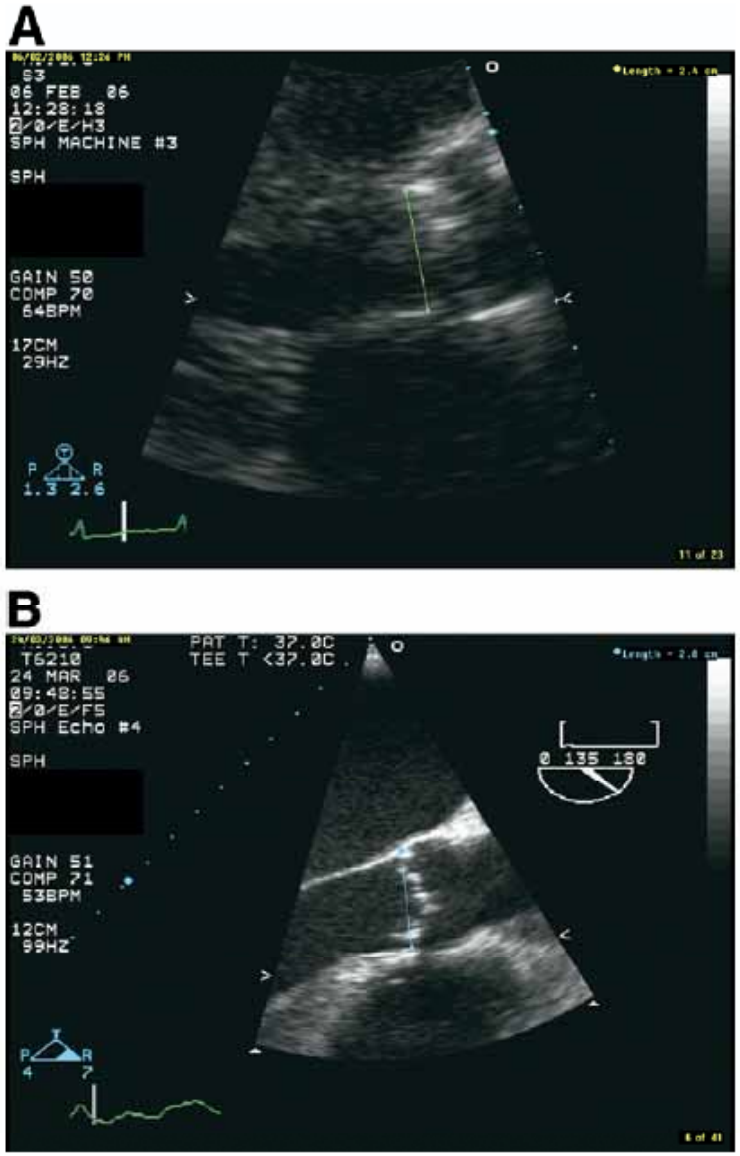
Aortic Valve Annulus

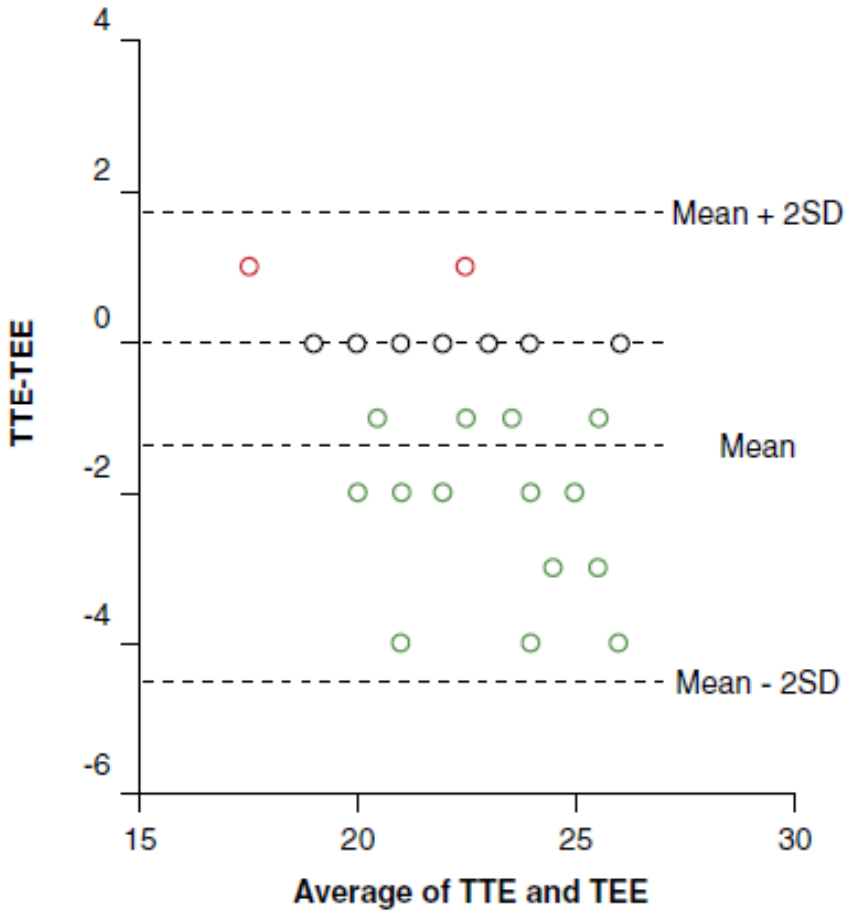




Circ Cardiovasc Intervent. 2008;1:74-81

Measurement of Aortic Annulus Size

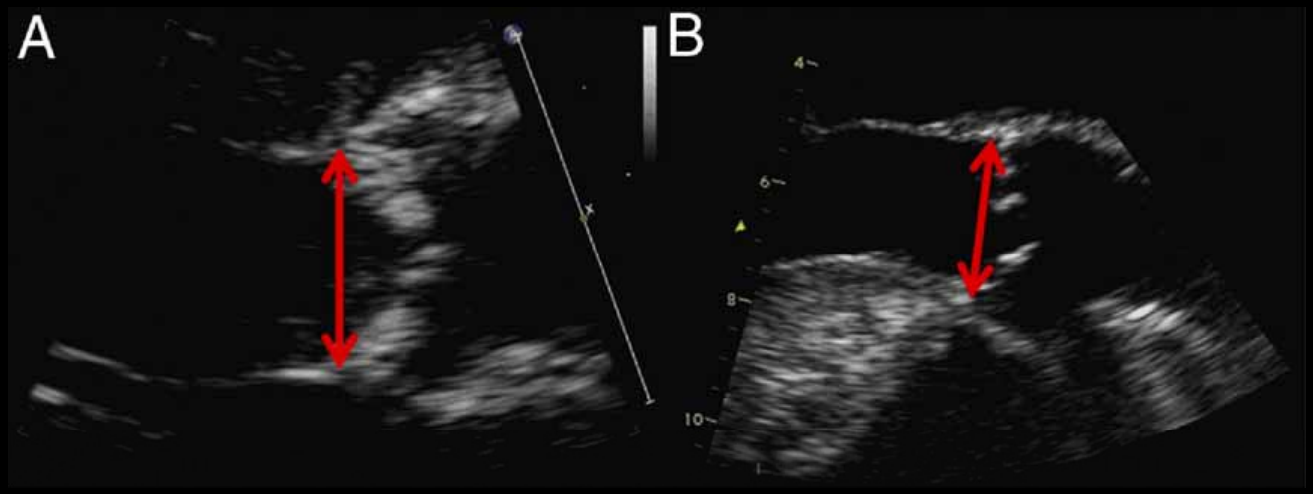


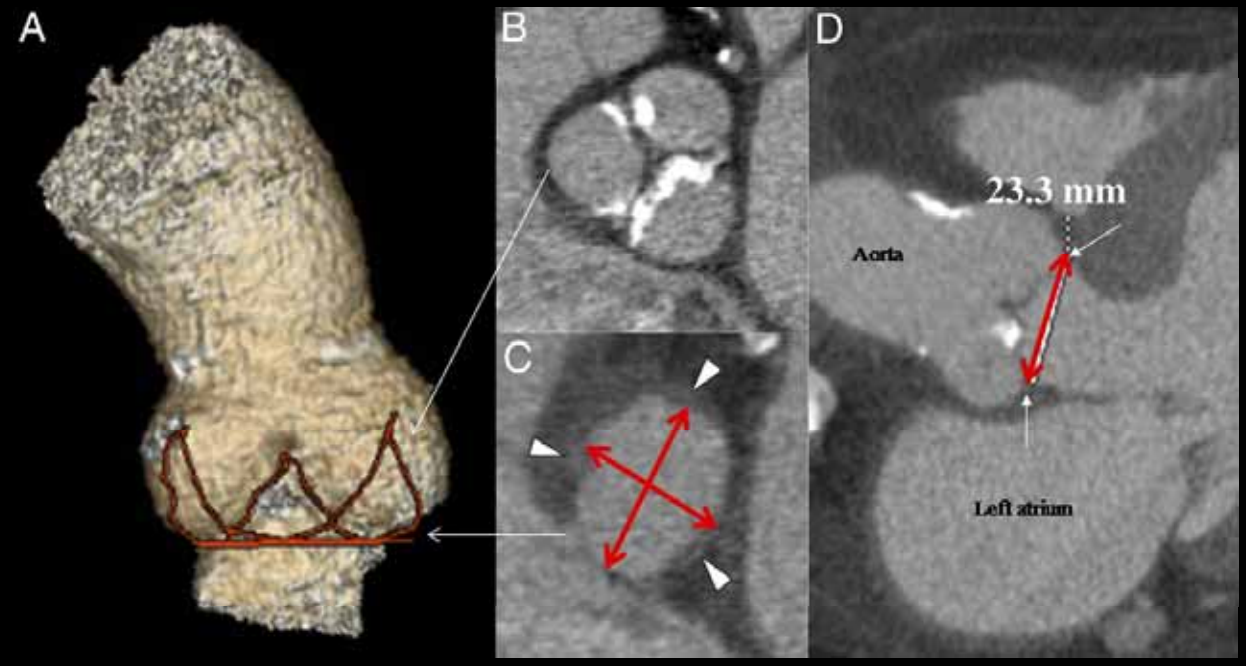


The mean difference (TTE-TEE) is -1.36 mm (2 SD -4.48 to +1.75 mm).

Moss, JACC Img 2008;1:15–24

TTE, TEE & CT





JACC 2010;55:186-94

TTE, TEE & CT

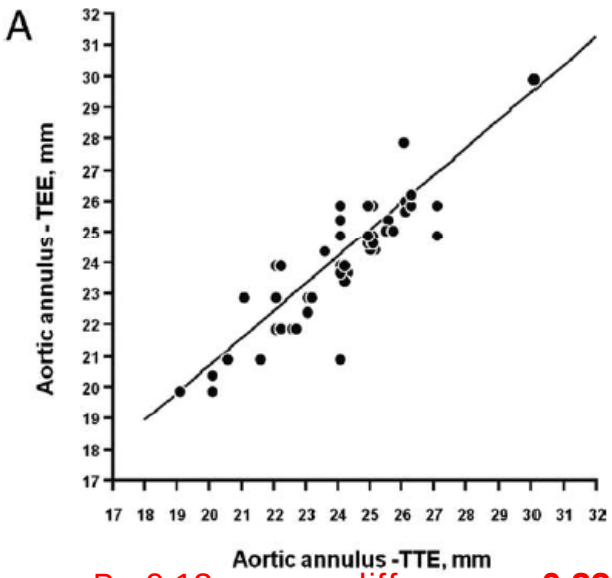
Table 1 Comparison Between Echocardiographic and MSCT Measurements

	Mean Annulus Diameter (mm)	Median	Range	p Value vs. TTE	R vs. TTE	p Value vs. TEE	R vs. TEE
Echocardiographic measurements							
TTE	23.9 ± 2.1	24	19–30	—	—	0.13	0.89
TEE	24.1 ± 2.1	24.5	20–30	0.13	0.89	—	—
MSCT measurements							
Virtual basal ring							
Long-axis	27.5 ± 3.1	27	22–34	<0.0001	0.69	<0.0001	0.67
Short-axis	21.7 ± 2.3	22	17.5–28	<0.0001	0.73	<0.0001	0.69
Mean	24.6 ± 2.4	24	19.8–29.5	0.004	0.80	0.07	0.77
3-chamber view	23.8 ± 2.6	24	18–29	0.73	0.71	0.26	0.70

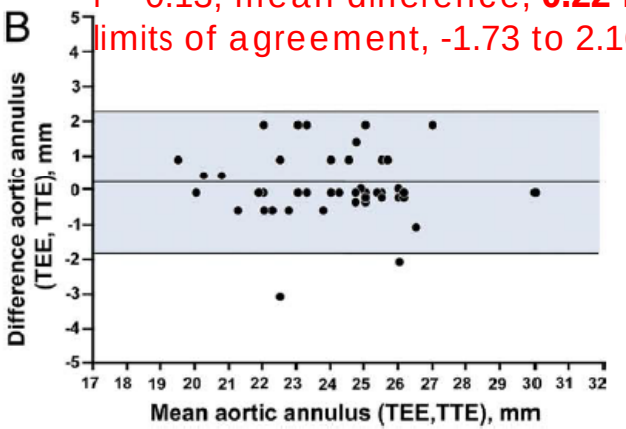
Data presented are mean ± SD. R is coefficient of correlation.
MSCT = multislice computed tomography; TEE = transesophageal echocardiography; TTE = transthoracic echocardiography.

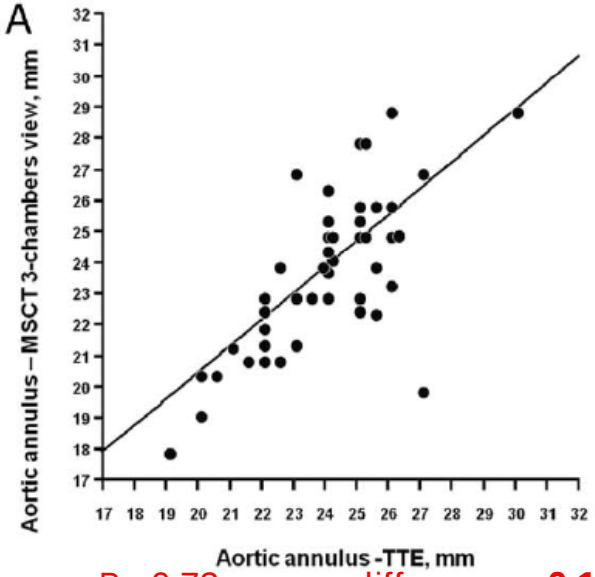
JACC 2010;55:186-94

TTE, TEE & CT

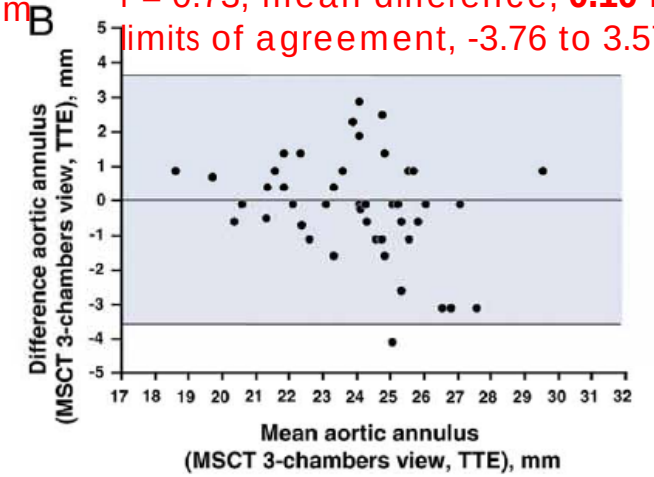


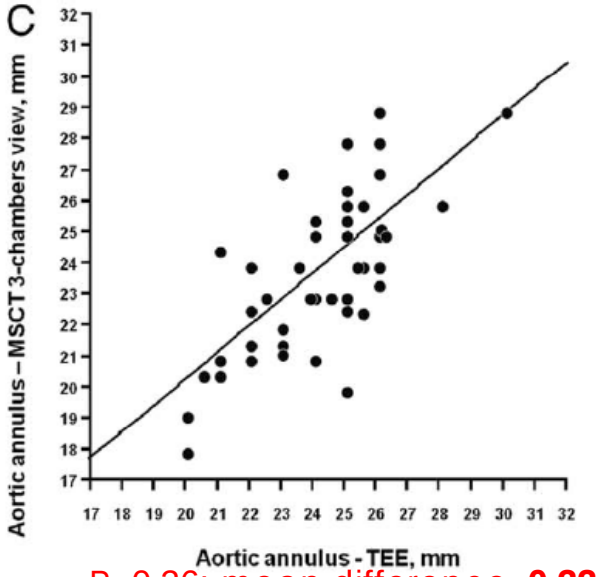
P= 0.13; mean difference, **0.22** mm
limits of agreement, -1.73 to 2.16



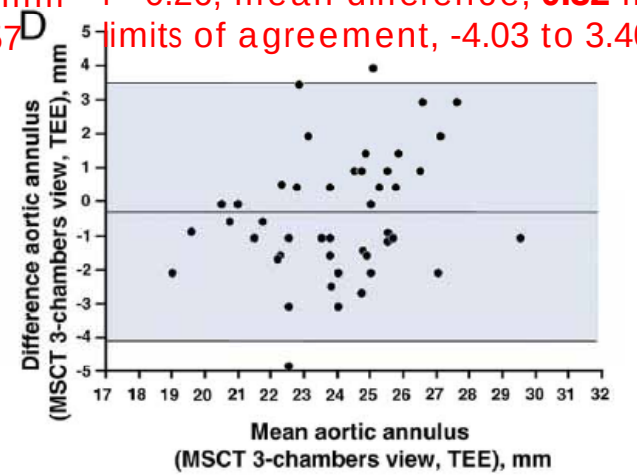


P= 0.73; mean difference, **0.10** mm
limits of agreement, -3.76 to 3.57





P=0.26; mean difference, **0.32** mm
limits of agreement, -4.03 to 3.40



JACC 2010;55:186-94

TTE, TEE & CT

Table 2 Impact of the Method of Aortic Annulus Measurement on TAVI Strategy

	TAVI Strategy			Agreement With TTE		Agreement With TEE	
	23-mm Prosthesis	26-mm Prosthesis	No Implantation	n (%)	Kappa	n (%)	Kappa
Echocardiographic measurements							
TTE	5	29	11	—	—	37 (83)	0.68
TEE	6	25	14	37 (83)	0.68	—	—
MSCT measurements							
Virtual basal ring							
Long-axis	0	10	35	16 (36)	0.03	19 (42)	0.07
Short-axis	16	21	8	21 (47)	0.13	19 (42)	0.09
Mean	4	24	17	28 (62)	0.32	28 (62)	0.34
3-chamber view	7	25	13	27 (60)	0.28	26 (58)	0.27

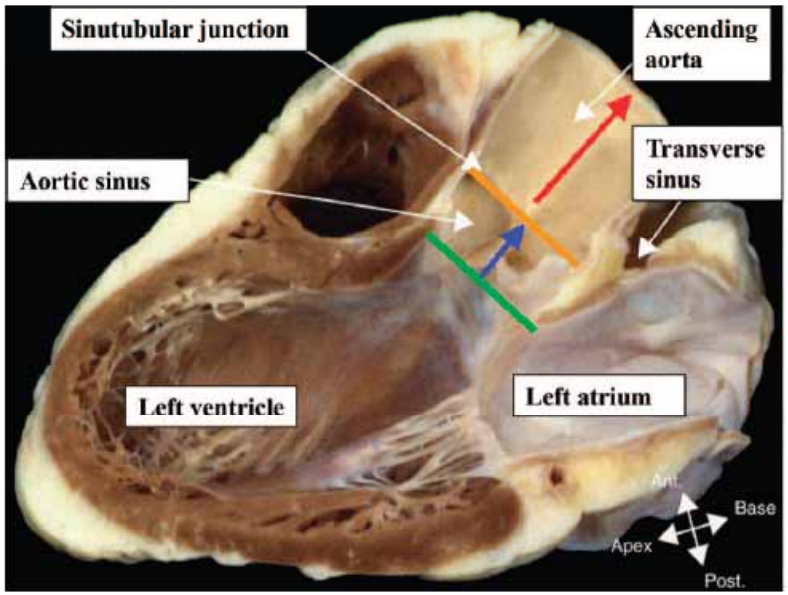
Data presented as number of patients.
TAVI = transcatheter aortic valve implantation; other abbreviations as in Table 1.

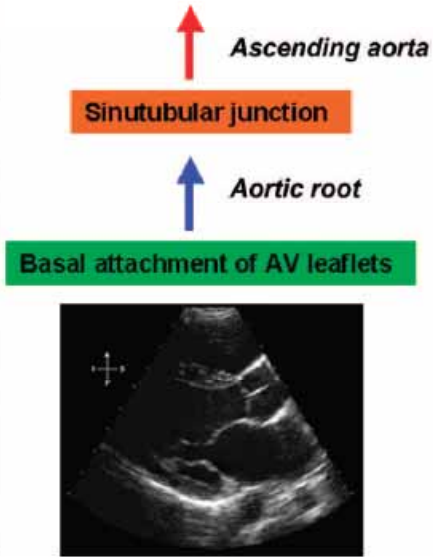
In the absence of a gold standard, a strategy based on TEE measurements provided good clinical results.

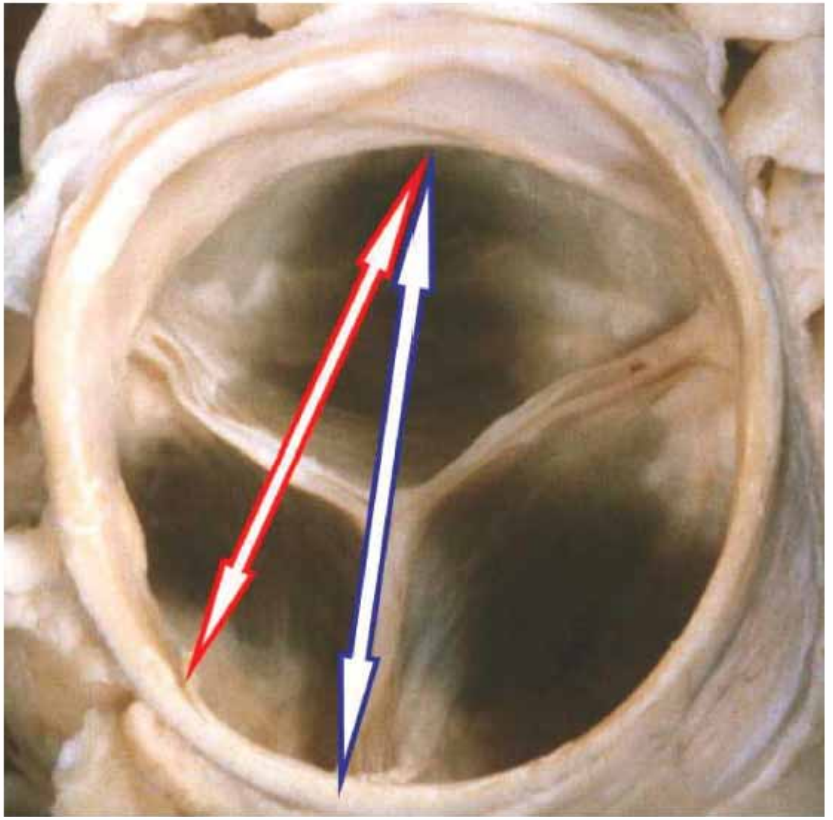
Implantation, performed in 34 patients (76%) based on TEE measurements, was successful in all but 1 patient with grade 3/4 regurgitation.

JACC 2010;55:186-94

Measurement of Aortic Valve Annulus

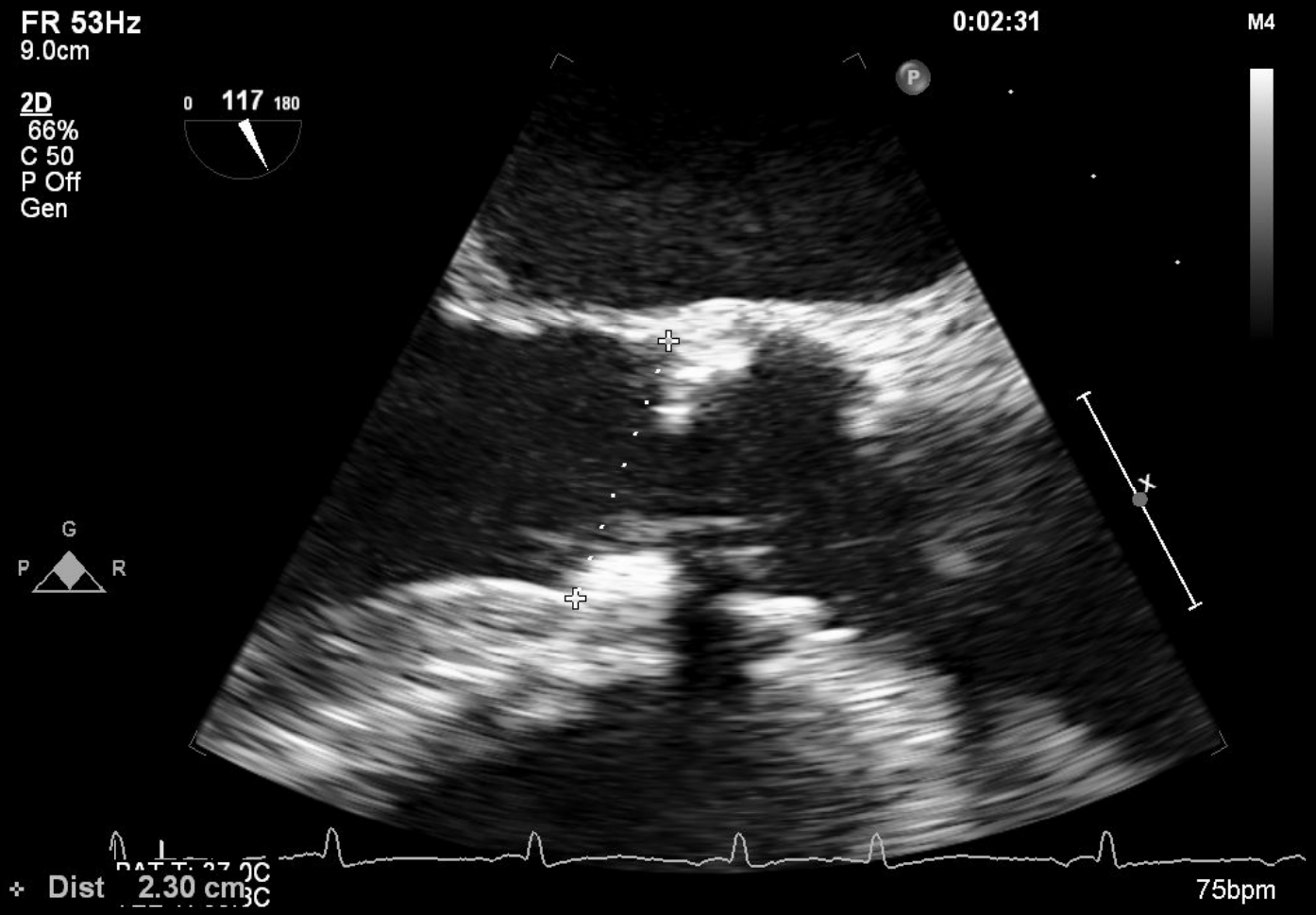




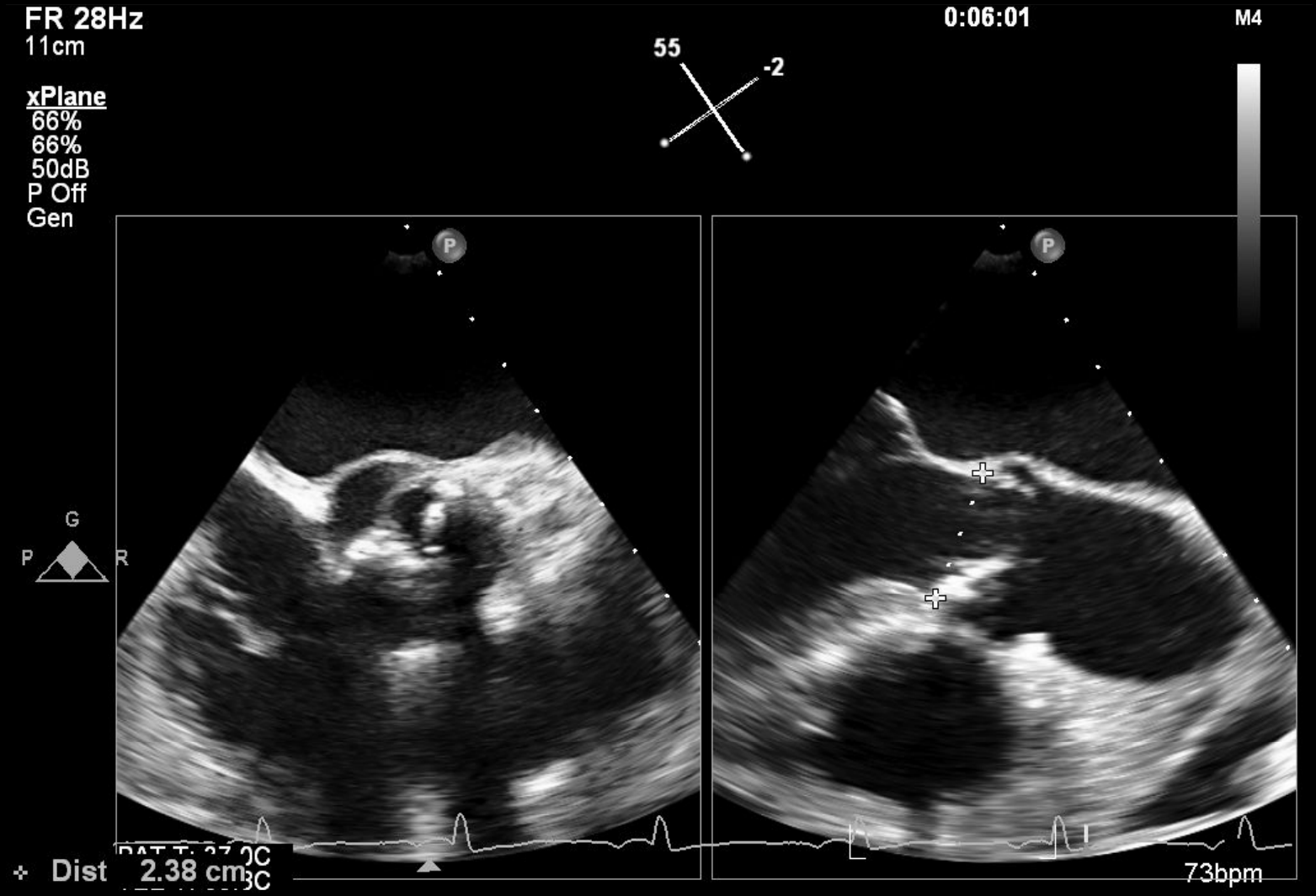


Circ Cardiovasc Intervent. 2008;1:74-81

Annulus Diameter by TEE



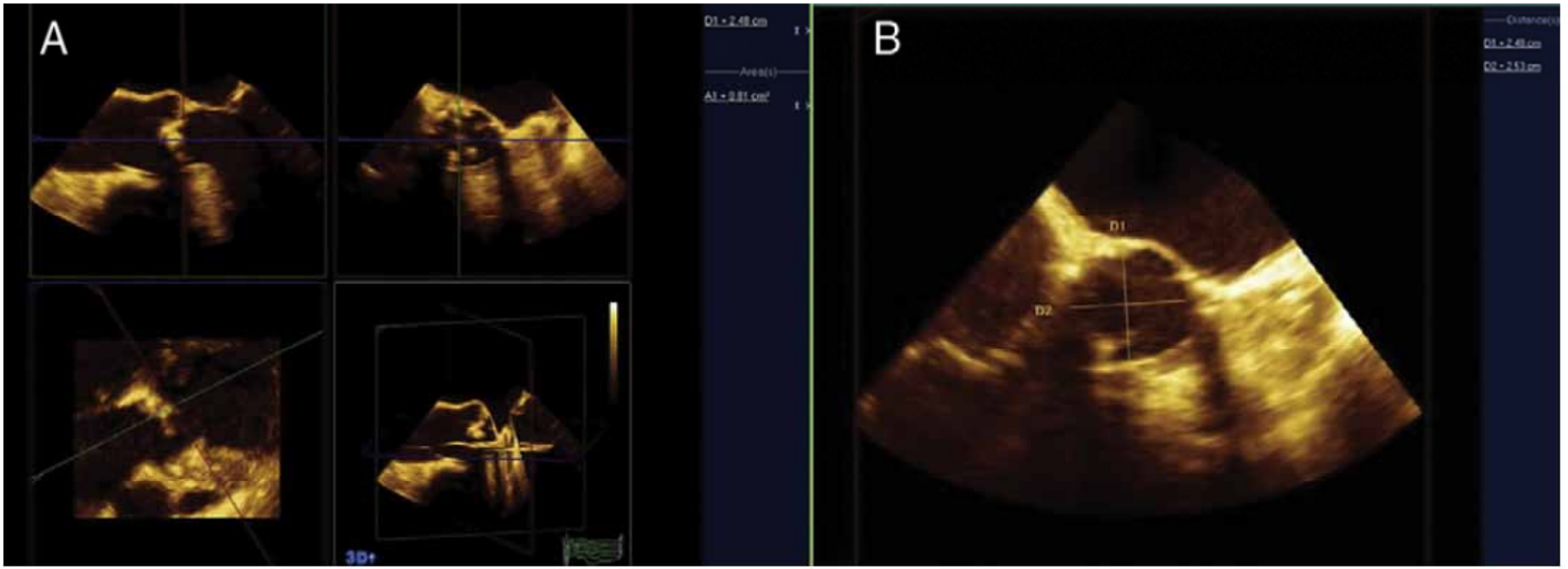
Biplane Image



AV on 3D TEE

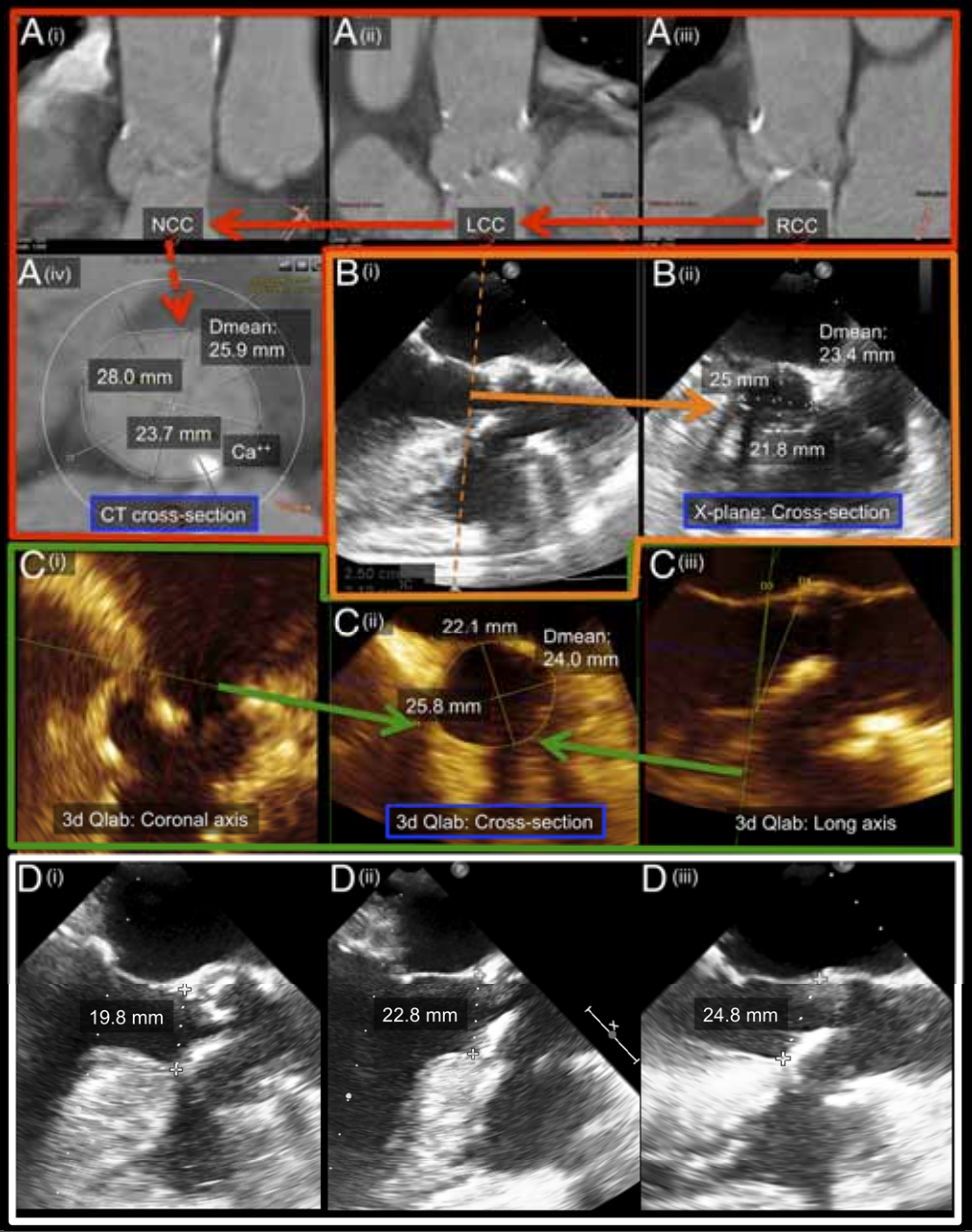

FR 28Hz
11cm
Live 3D
3D 42%
3D 40dB
Gen
0
35
180
M4
JPEG
50 bpm
PAT T: 37.0C
TEE T: 39.1C

Annulus Measurement by 3D TEE



JASE 2011;24:937-65

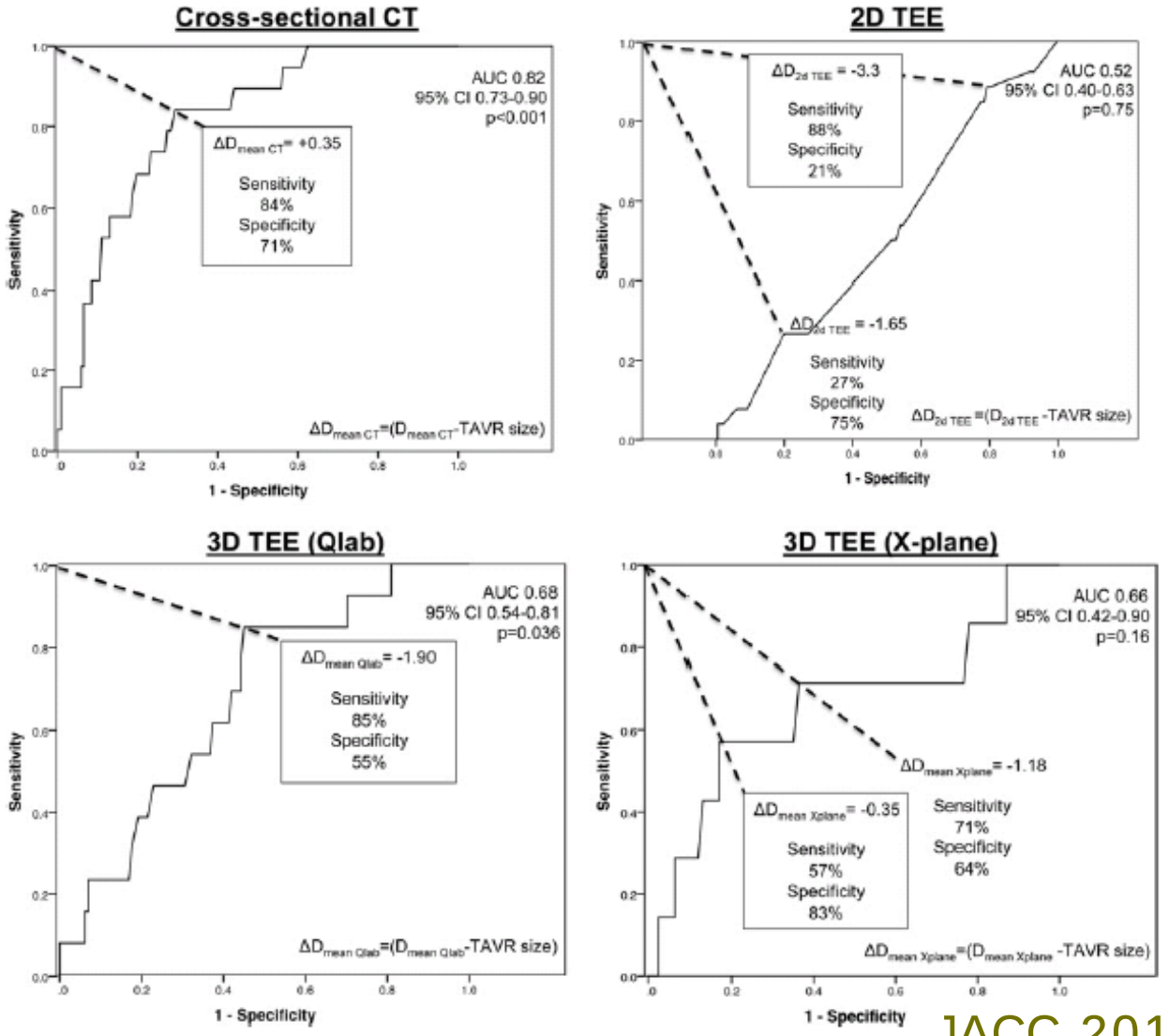
CT & 2D-/3D-TEE



JACC 2013;61:908–16

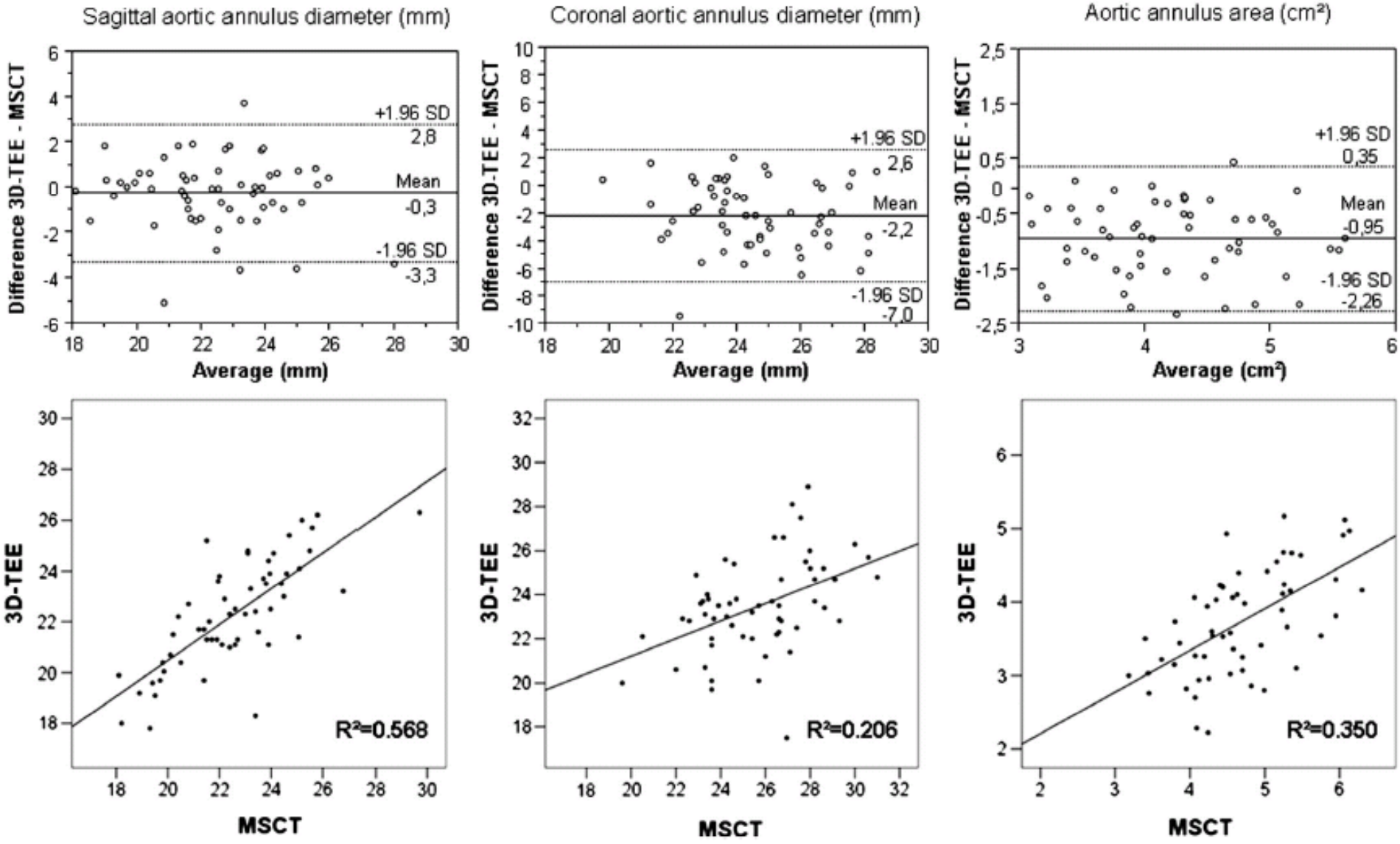
CT & 2D-/3D-TEE

For predicting significant paravalvular AR



JACC 2013;61:908–16

CT & 3D-TEE



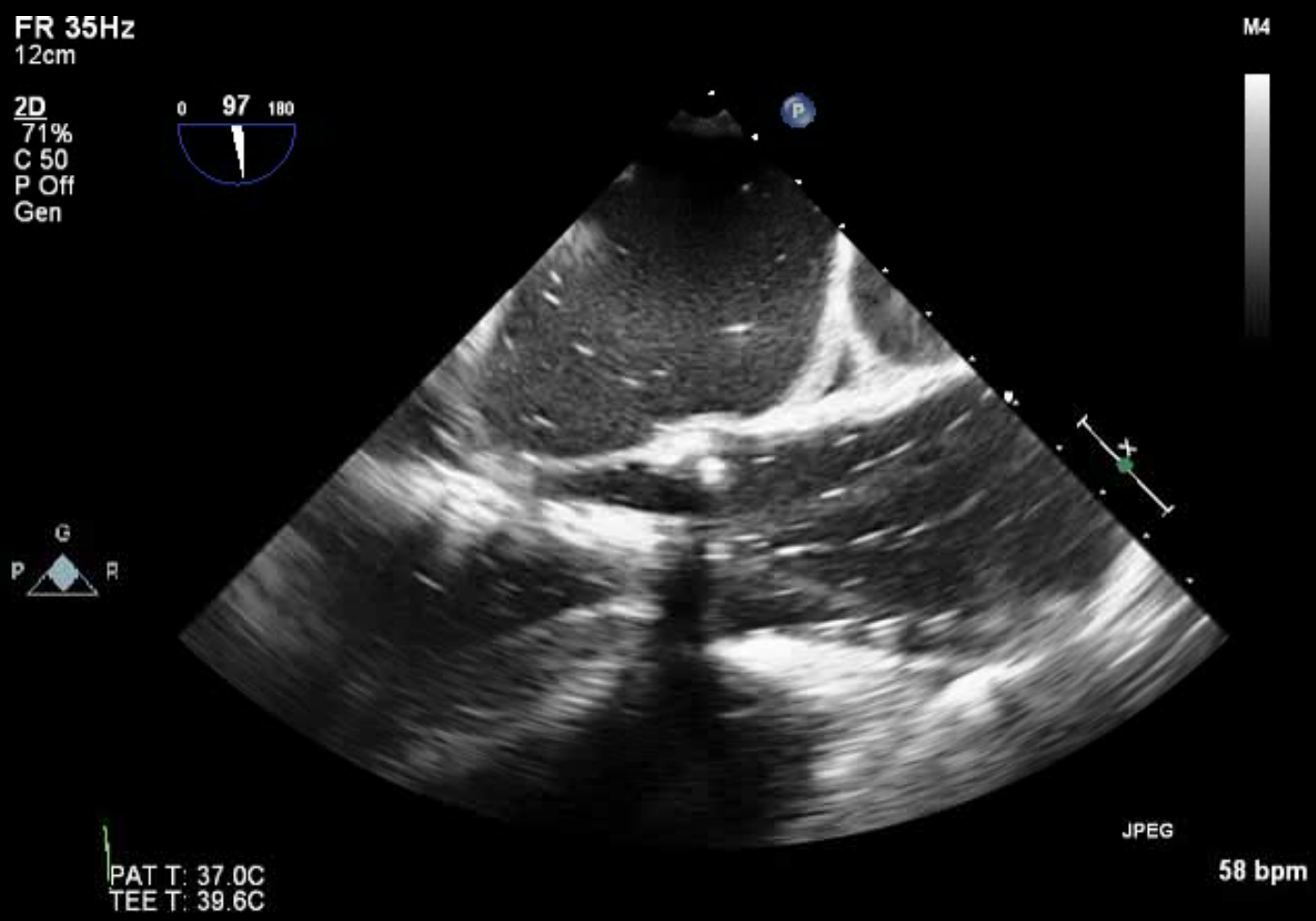
IJC 2013 (Epub)

TEE Monitoring during TAVI

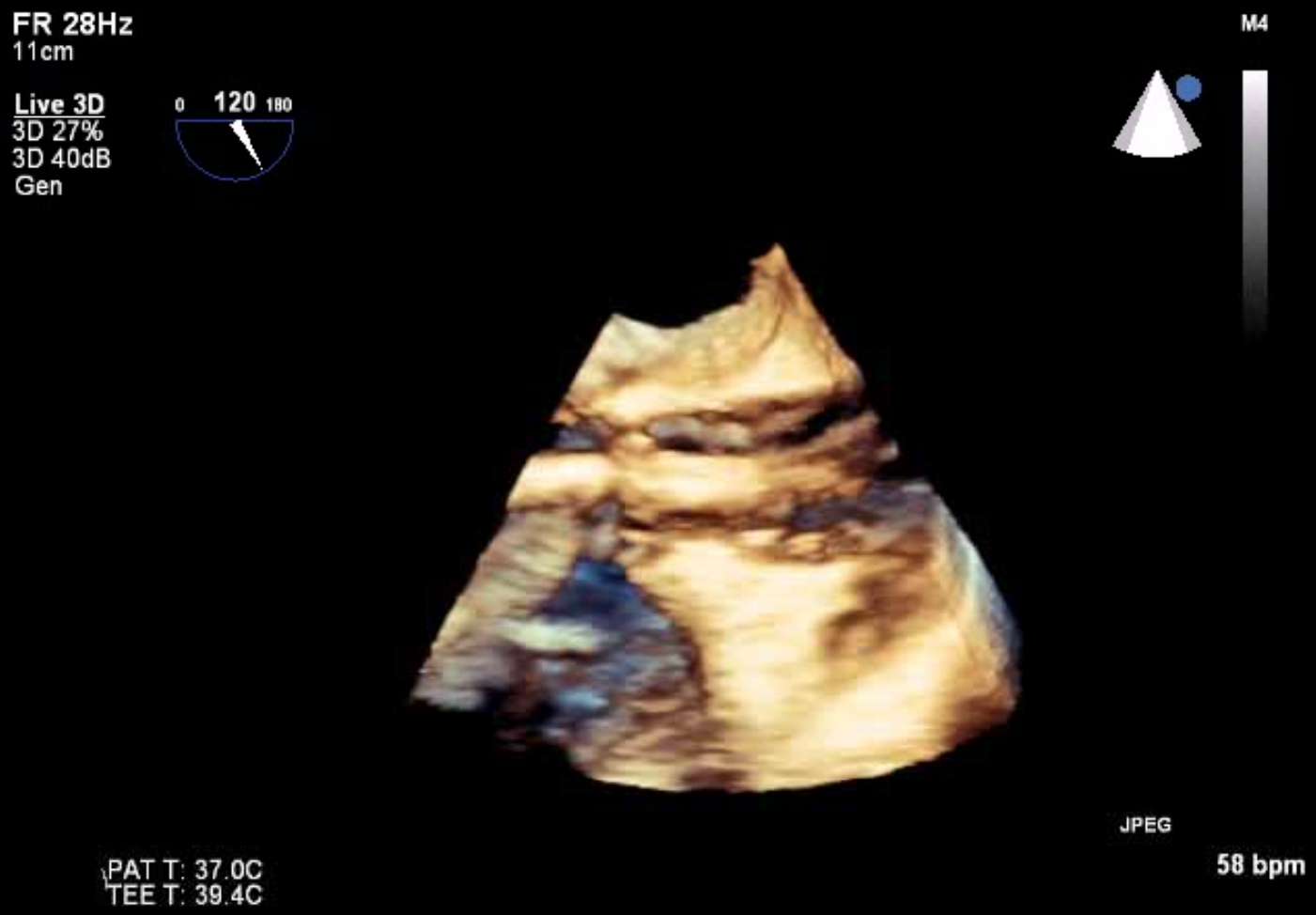
- Balloon positioning during valvuloplasty
- Post-valvuloplasty aortic regurgitation

- Prosthesis positioning during implantation
  - When AV is not very calcified and consequently, difficult to image on fluoroscopy
  - Valve-in-valve procedures
  - 3D TEE

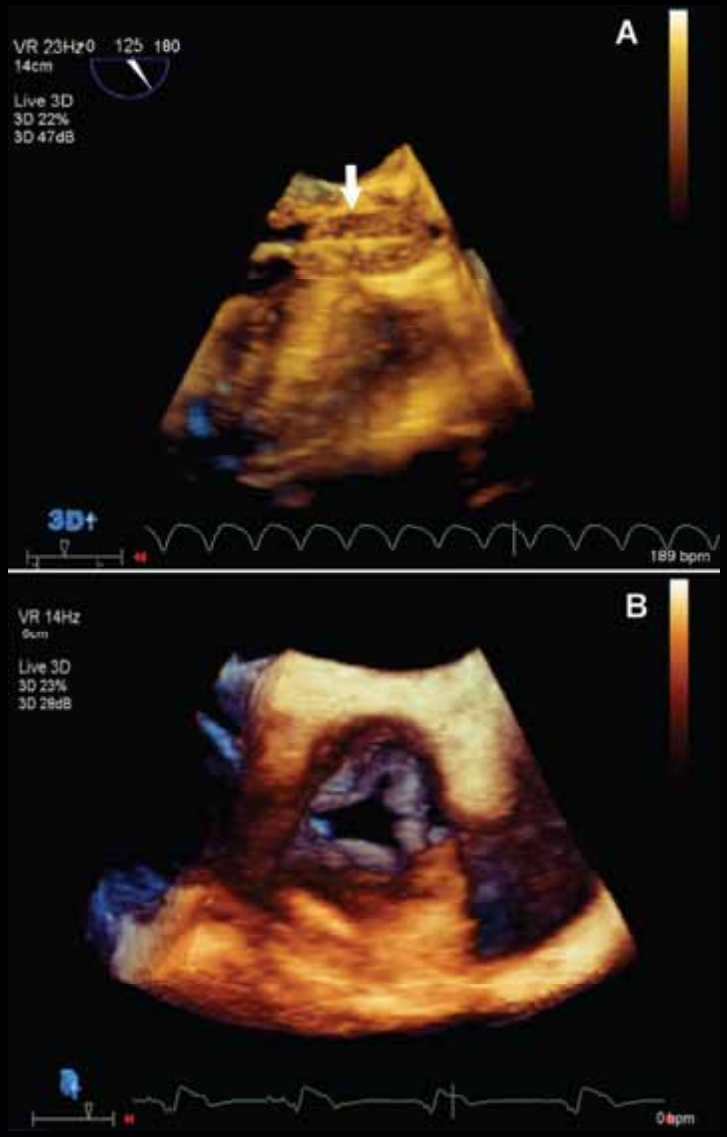
TEE Monitoring of TAVI

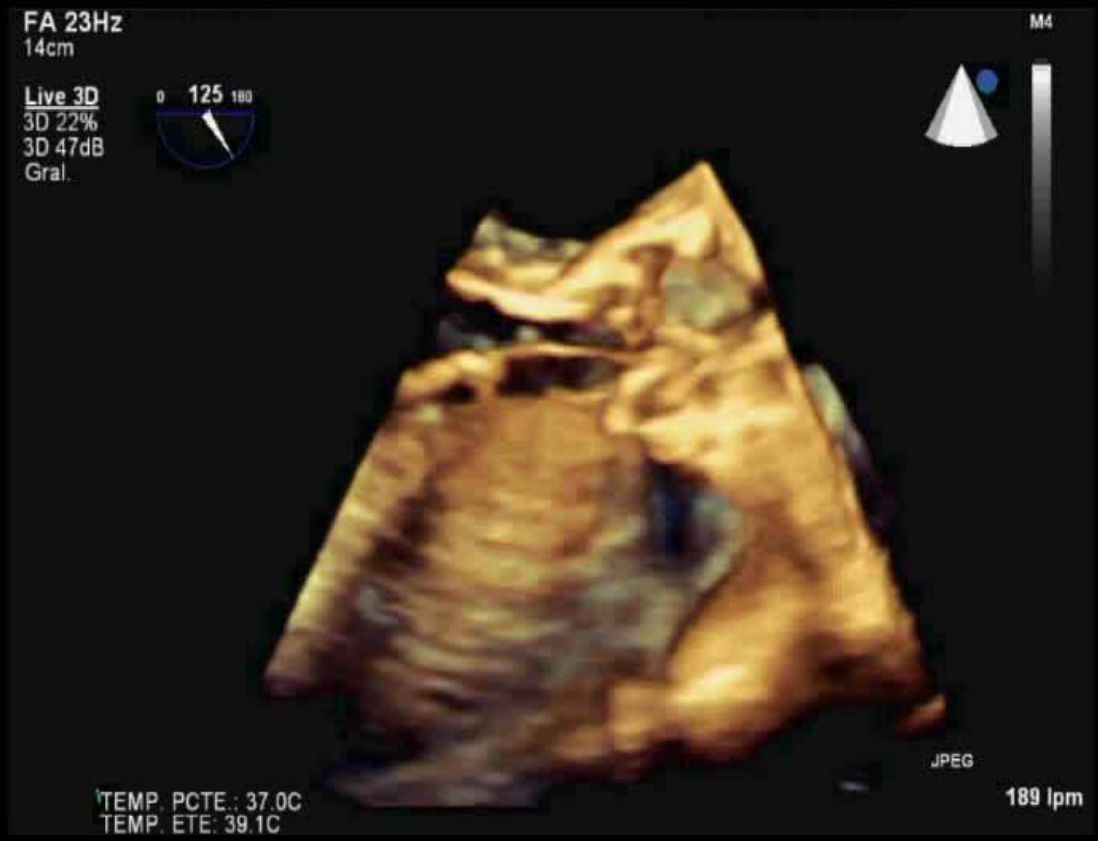


Posistioning of Balloon on 3D TEE



3D TEE for Percuteneous AVR

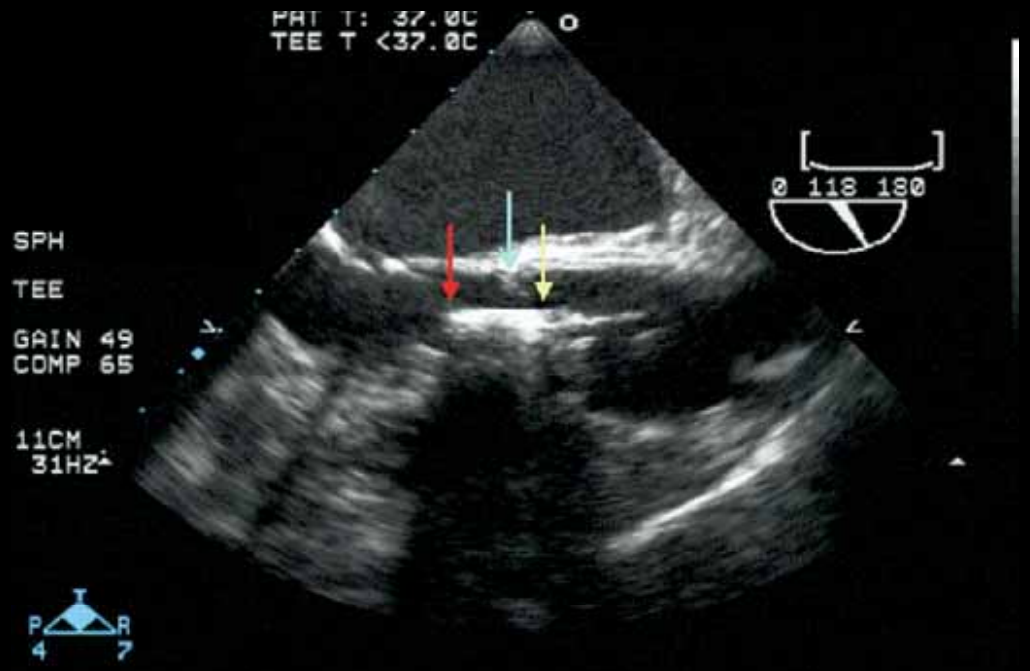


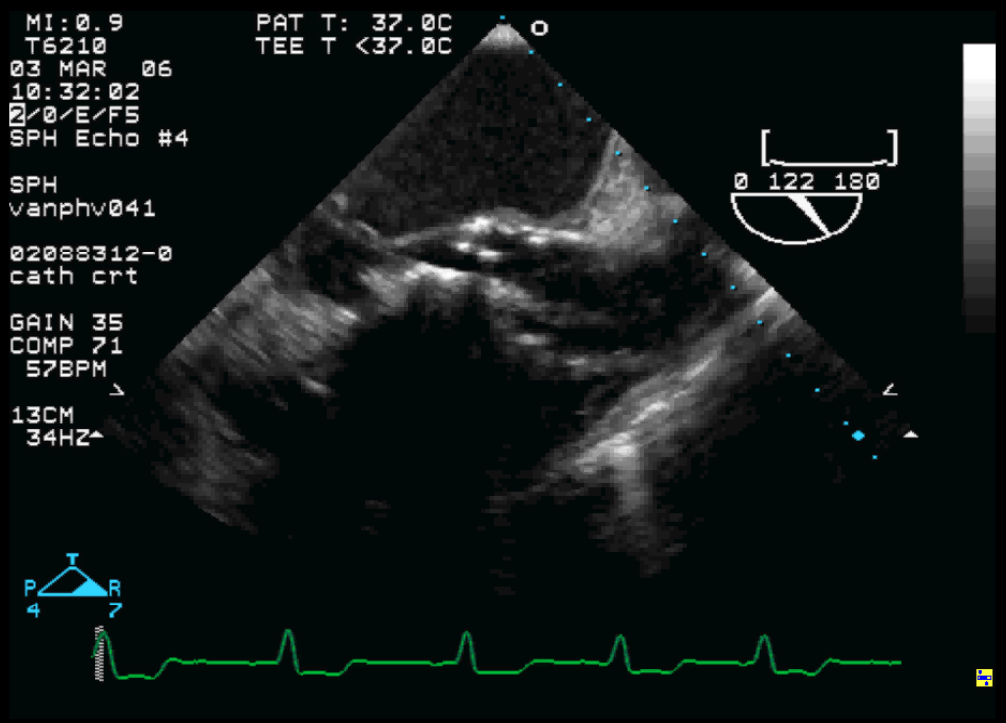


Filgueiras-Rama, Echocardiography 2010;27:84-86

Balloon Dilatation on 3D TEE

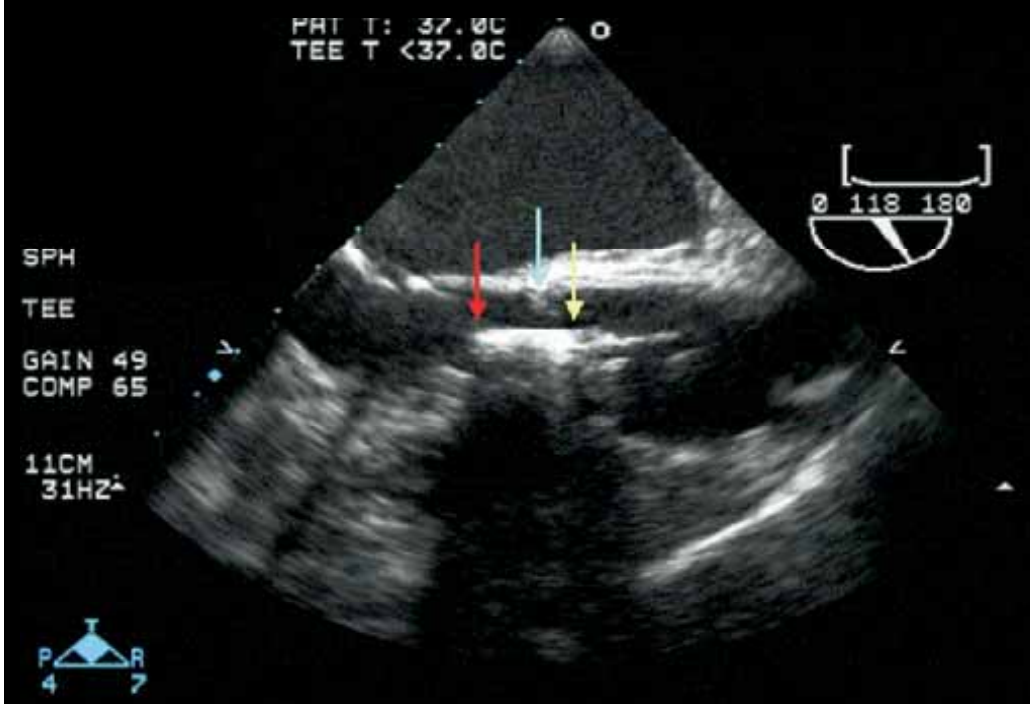
Positioning of Prosthetic Valve

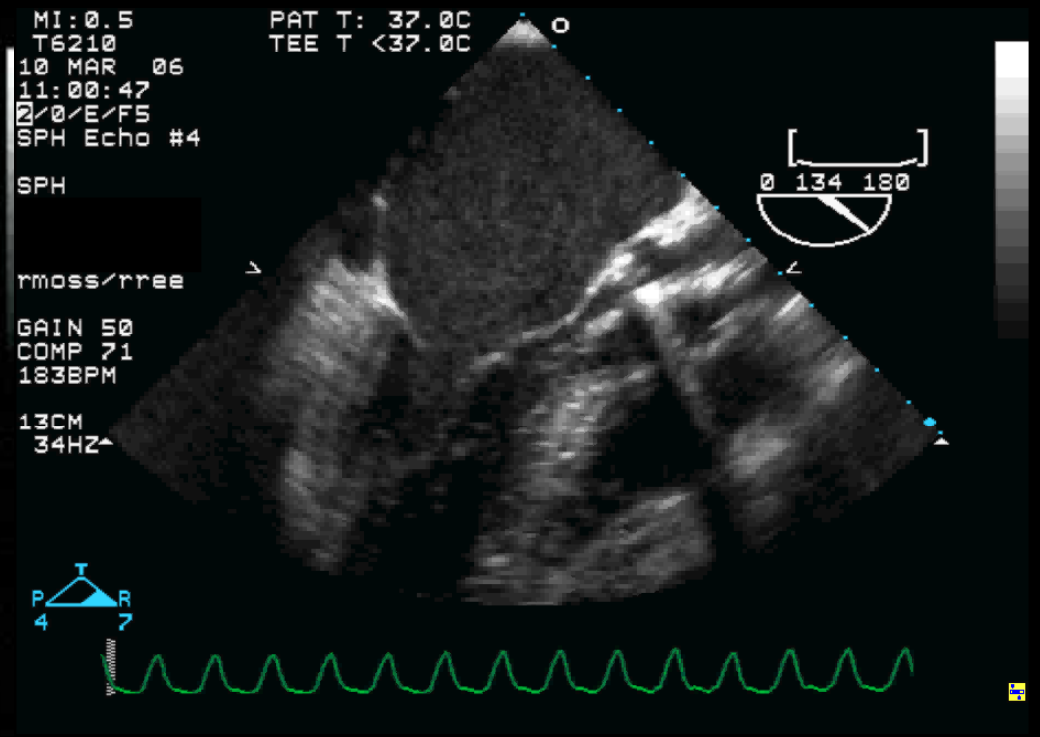




Moss, JACC Img 2008;1:15–24

Inflation of Prosthetic Valve

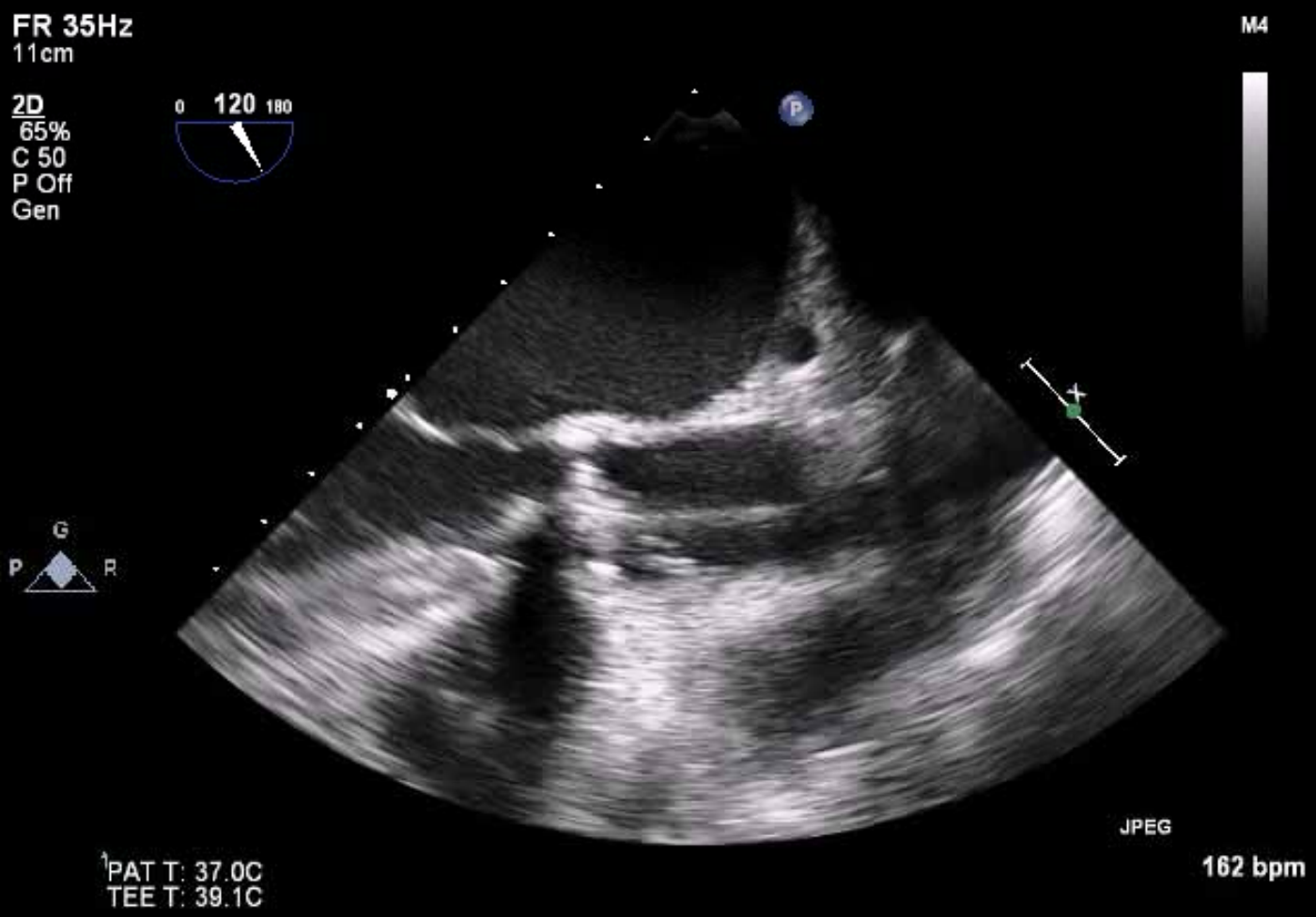




Moss, JACC Img 2008;1:15–24

Positioning of Prosthetic AV on 3D TEE

TEE Monitoring of TAVI



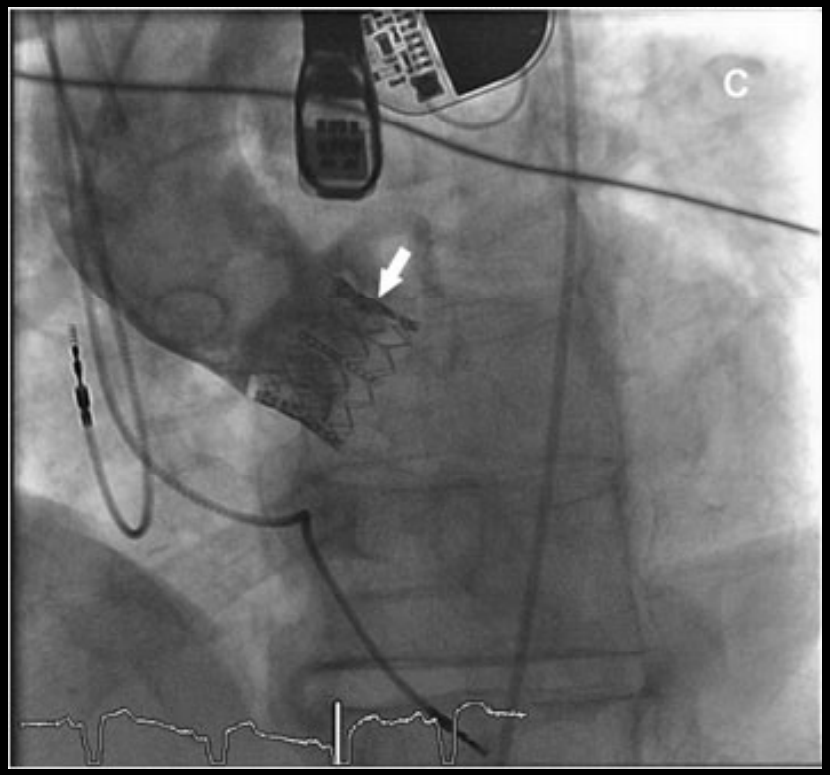
TEE Monitoring after TAVI

- Confirm prosthesis function immediately post-implantation
  - Movement of prosthetic cusps
  - Circular valve stent configuration
  - Valvular or paravalvular AR
- Rapid detection of complications

Post-Implantation

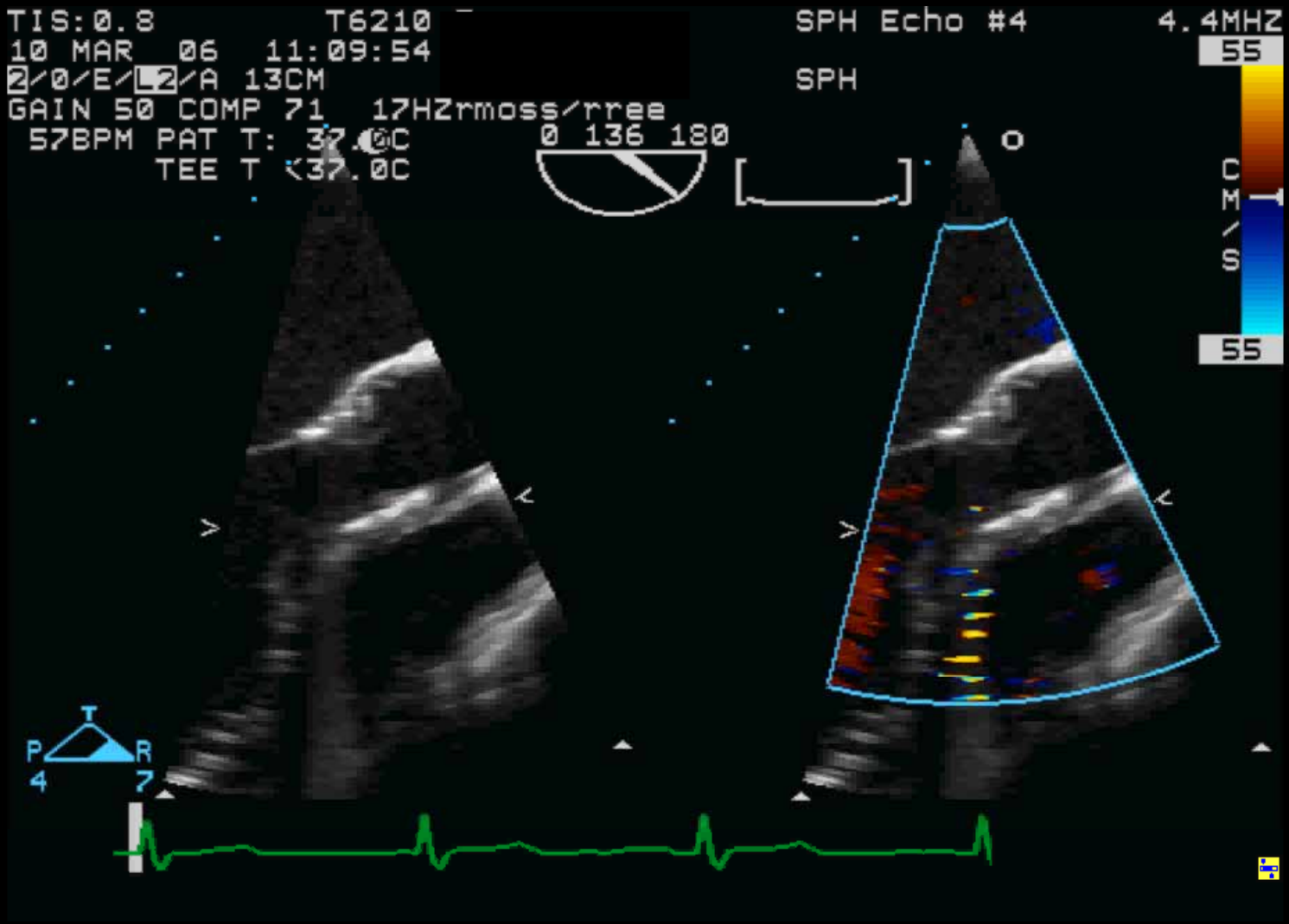
Moss, JACC Img 2008;1:15–24

3D TEE for Percuteneous AVR



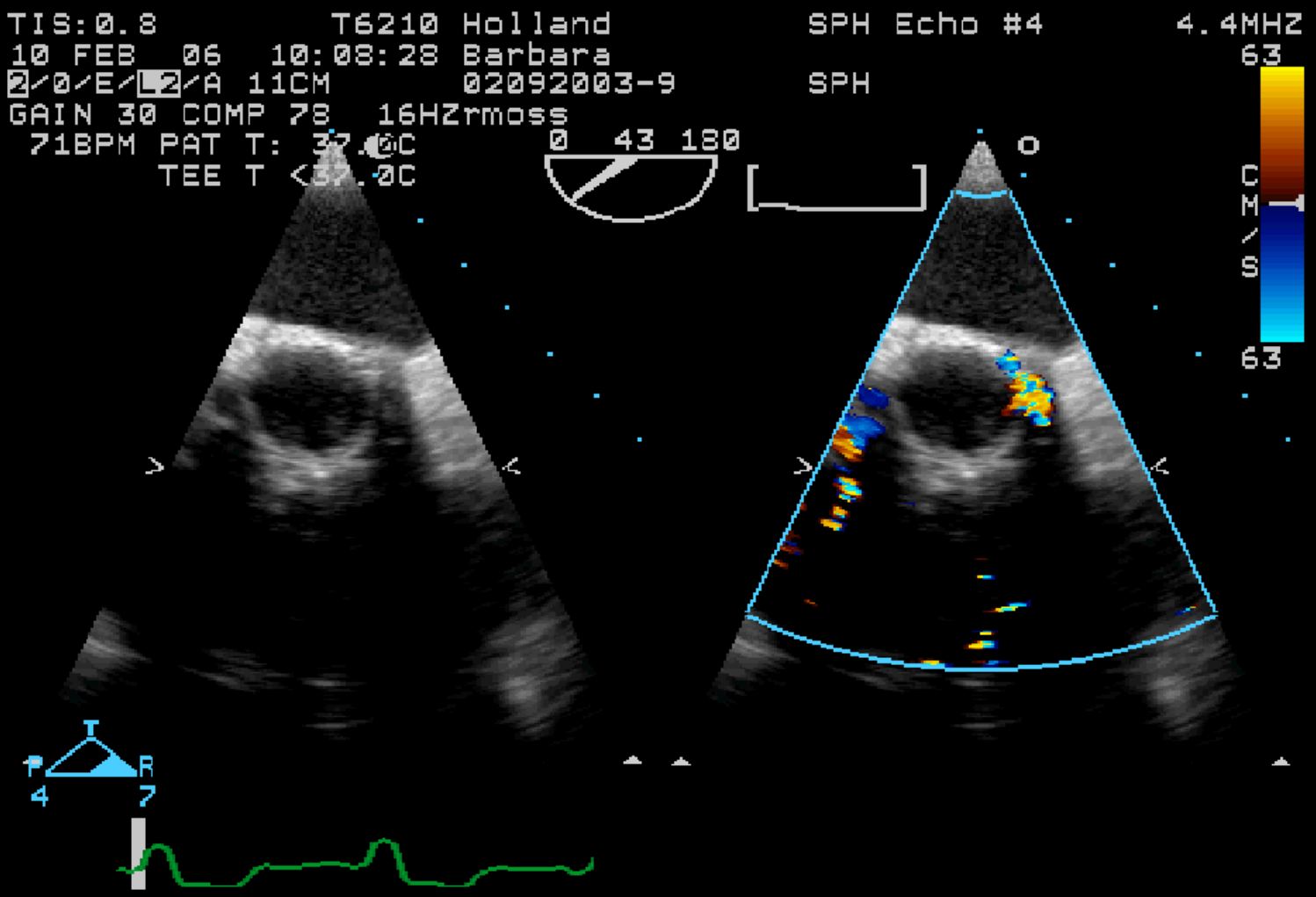
Filgueiras-Rama, Echocardiography 2010;27:84-86

Post-Implantation



Moss, JACC Img 2008;1:15–24

Paravalvular AR After Implantation



Moss, JACC Img 2008;1:15–24

Significant AR after TAVI

- **Paravalvular AR**
  - Undersized prosthesis
  - Asymmetric severe calcification
- **Valvular AR**
  - Incomplete expansion
  - Incorrect positioning of the device
  - Restricted cusp motion
  - Oversized prosthesis
    - Suboptimal stent expansion
    - Impaired cusp mobility

Severity of AR

Table 10 Prosthetic Valve Dysfunction

	Prosthetic Aortic Valve Stenosis[a]		
	Normal	Mild Stenosis	Moderate/Severe Stenosis
Quantitative parameters (flow-dependent)†			
Peak velocity (m/s)	<3 m/s	3–4 m/s	>4 m/s
Mean gradient (mmHg)	<20 mm Hg	20–40 mm Hg	>40 mm Hg
Quantitative parameters (flow-independent)			
Doppler velocity index‡	>0.35	0.35–0.25	<0.25
Effective orifice aread§	>1.1 cm^2	1.1–0.8 cm^2	<0.8 cm^2
Effective orifice area‖	>0.9 cm^2	0.9–0.6 cm^2	<0.6 cm^2

	Prosthesis-Patient Mismatch (PPM)		
	Insignificant	Moderate	Severe
Indexed effective orifice area¶ (cm^2/m^2)	>0.85 cm^2/m^2	0.85–0.65 cm^2/m^2	<0.65 cm^2/m^2
Indexed effective orifice area# (cm^2/m^2)	>0.70 cm^2/m^2	0.90–0.60 cm^2/m^2	<0.60 cm^2/m^2

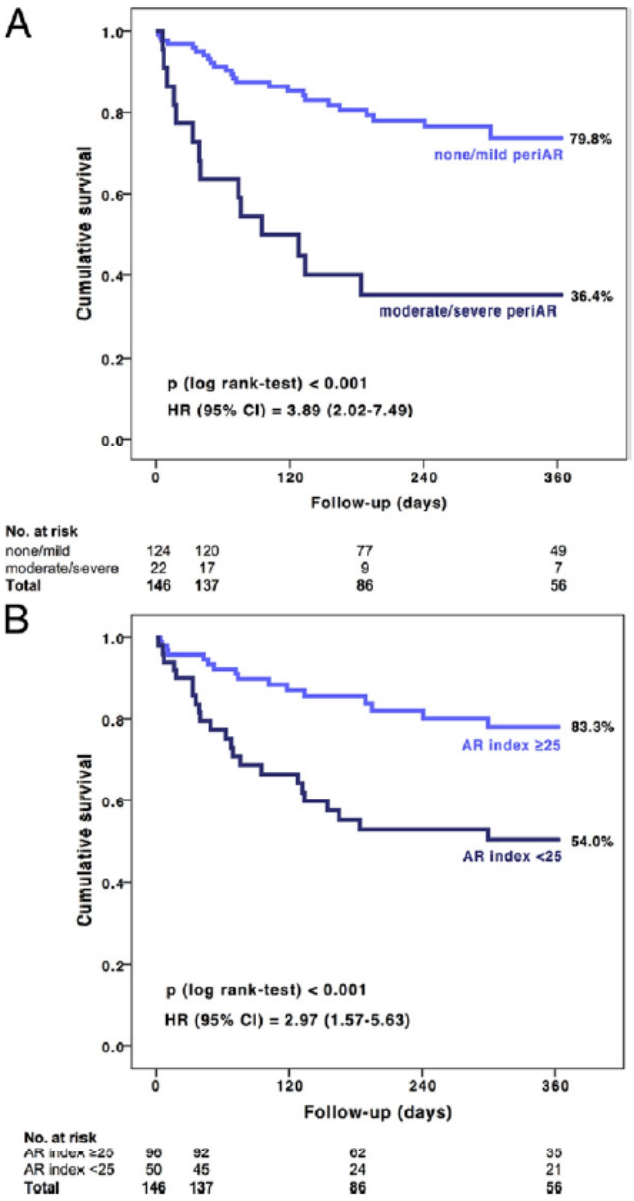
	Prosthetic Aortic Valve Regurgitation		
	Mild	Moderate	Severe
Semi-quantitative parameters			
Diastolic flow reversal in the descending aorta—PW	Absent or brief early diastolic	Intermediate	Prominent, holodiastolic
Circumferential extent of prosthetic valve paravalvular regurgitation (%)**	<10%	10–29%	≥30%
Quantitative parameters‡			
Regurgitant volume (mL/beat)	<30 ml	30–59 ml	≥60 ml
Regurgitant fraction (%)	<30%	30–49%	≥50%
EROA (cm^2)	0.10 cm^2	0.10–0.29 cm^2	≥0.30 cm^2

*In conditions of normal or near normal stroke volume (50–70 ml). †These parameters are more affected by flow, including concomitant aortic regurgitation. ‡For LVOT >2.5 cm, significant stenosis criteria is <0.20. §Use in setting of BSA ≥1.6 cm^2 (note: dependent on the size of the valve and the size of the native annulus). ‖Use in setting of BSA <1.6 cm^2. ¶Use in setting of BMI <30 kg/cm^2. #Use in setting of BMI ≥30 kg/cm^2. **Not well-validated and may overestimate the severity compared with the quantitative Doppler.

EROA = effective regurgitant orifice area; PW = pulsed wave.

JACC 2012;60:1438–54

AR index & Prognosis



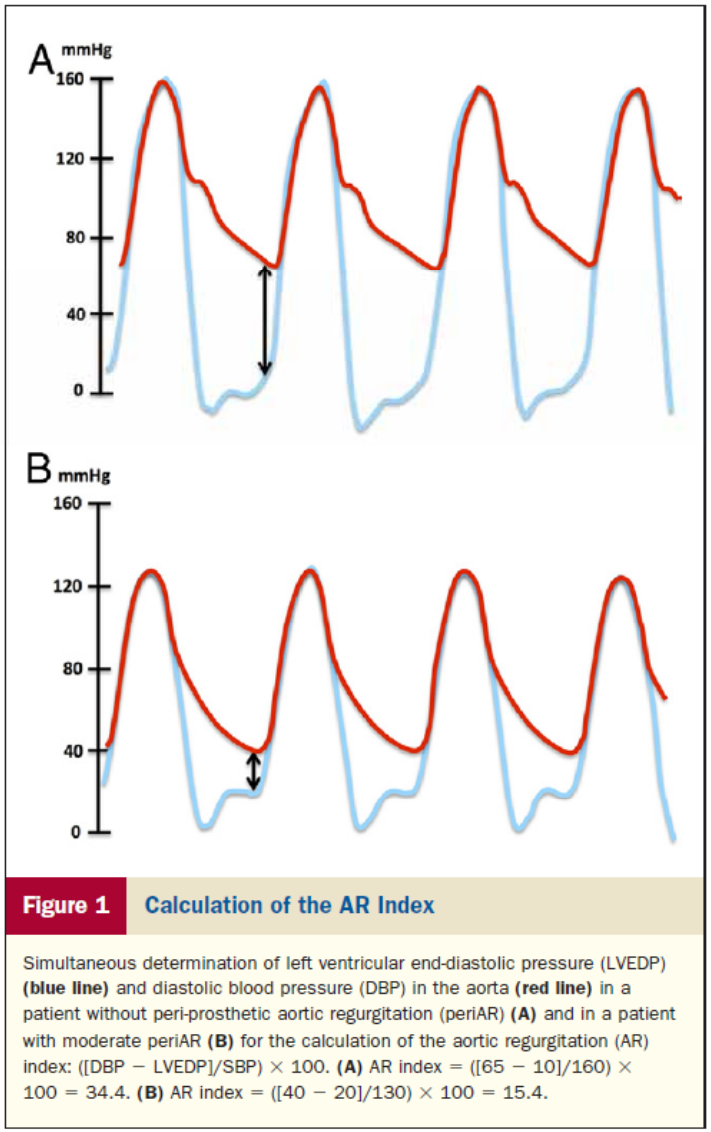
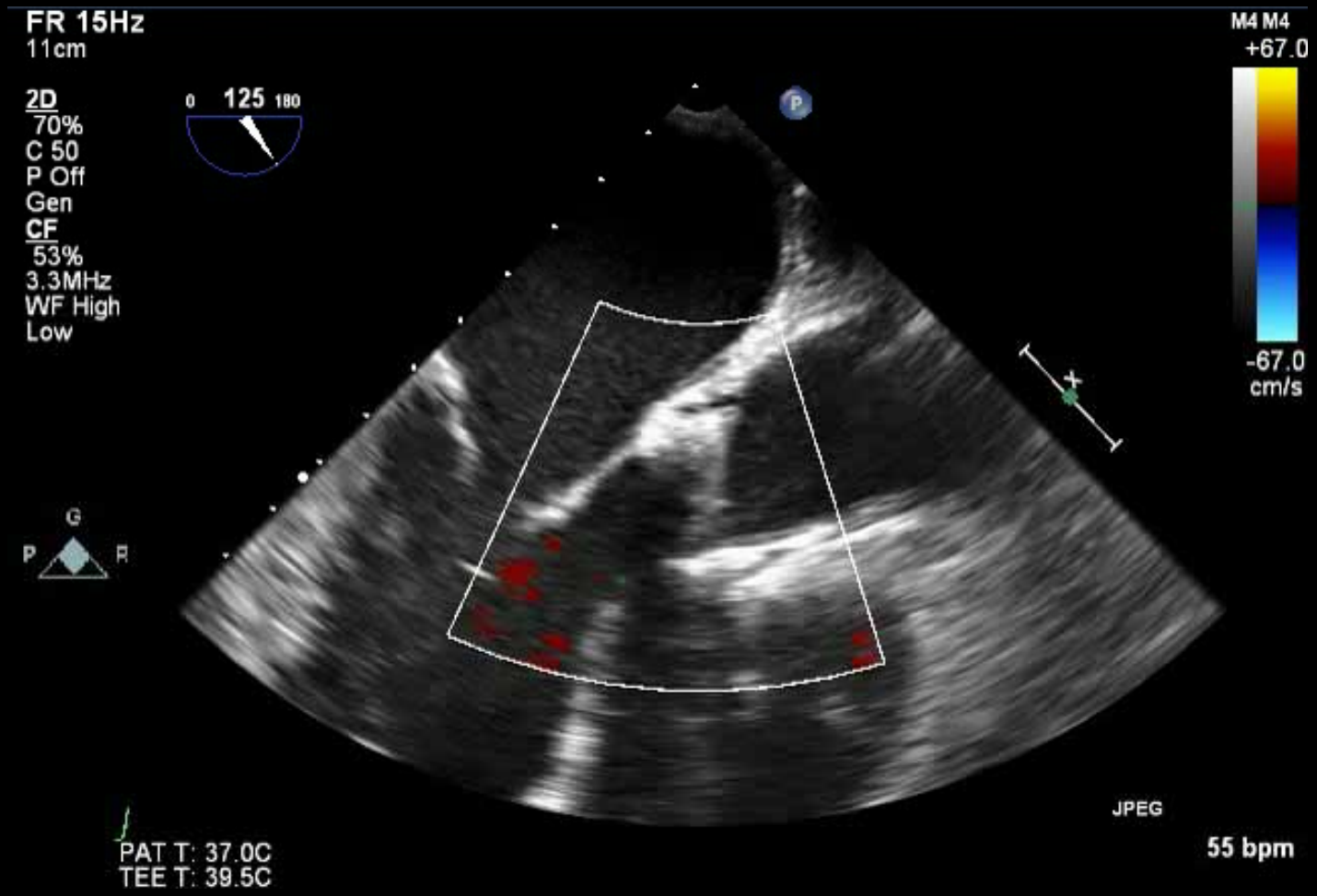


Figure 1 Calculation of the AR Index

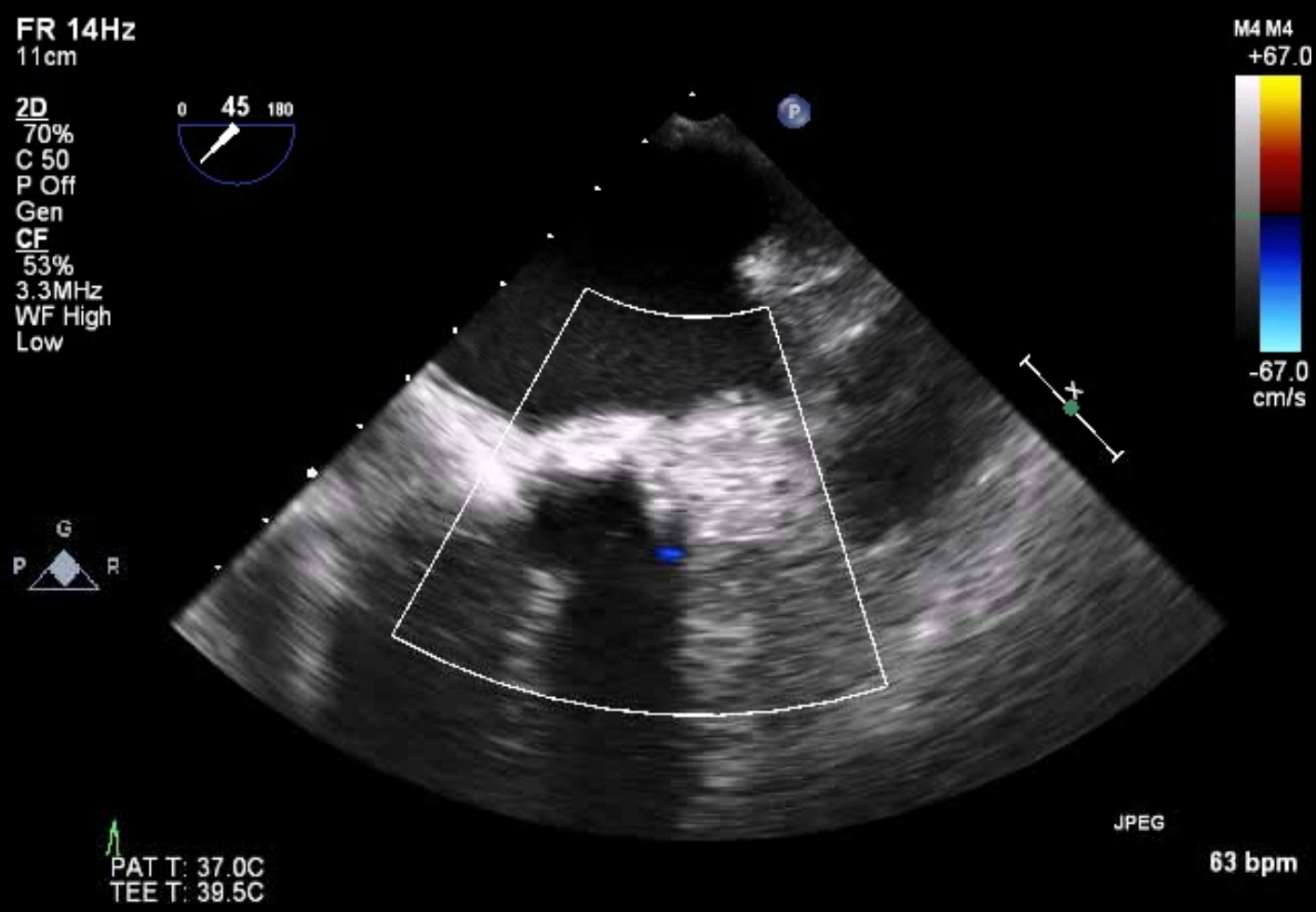
Simultaneous determination of left ventricular end-diastolic pressure (LVEDP) **(blue line)** and diastolic blood pressure (DBP) in the aorta **(red line)** in a patient without peri-prosthetic aortic regurgitation (periAR) **(A)** and in a patient with moderate periAR **(B)** for the calculation of the aortic regurgitation (AR) index: ([DBP − LVEDP]/SBP) × 100. **(A)** AR index = ([65 − 10]/160) × 100 = 34.4. **(B)** AR index = ([40 − 20]/130) × 100 = 15.4.

JACC 2012;59:1134–41

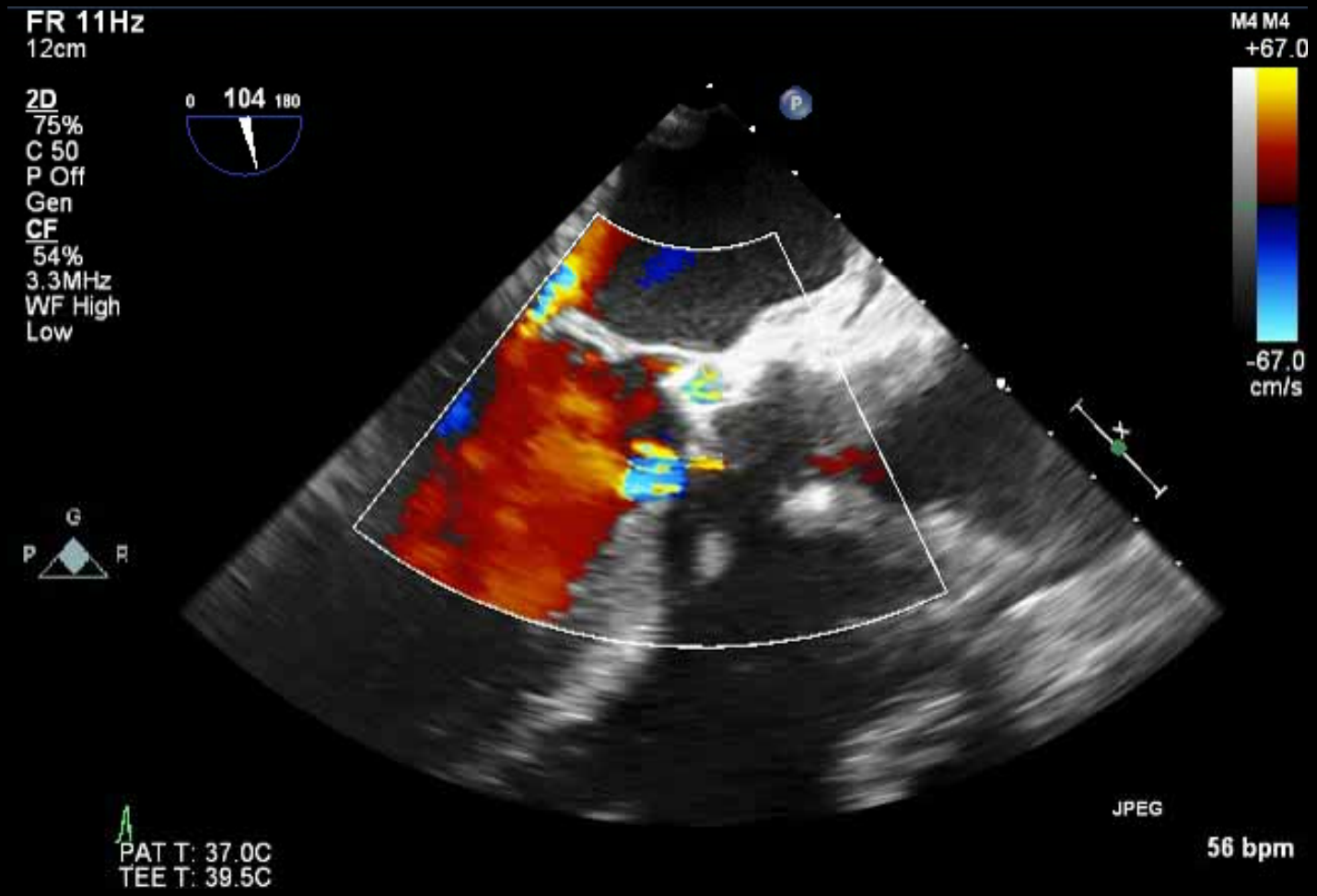
Evaluation after TAVI



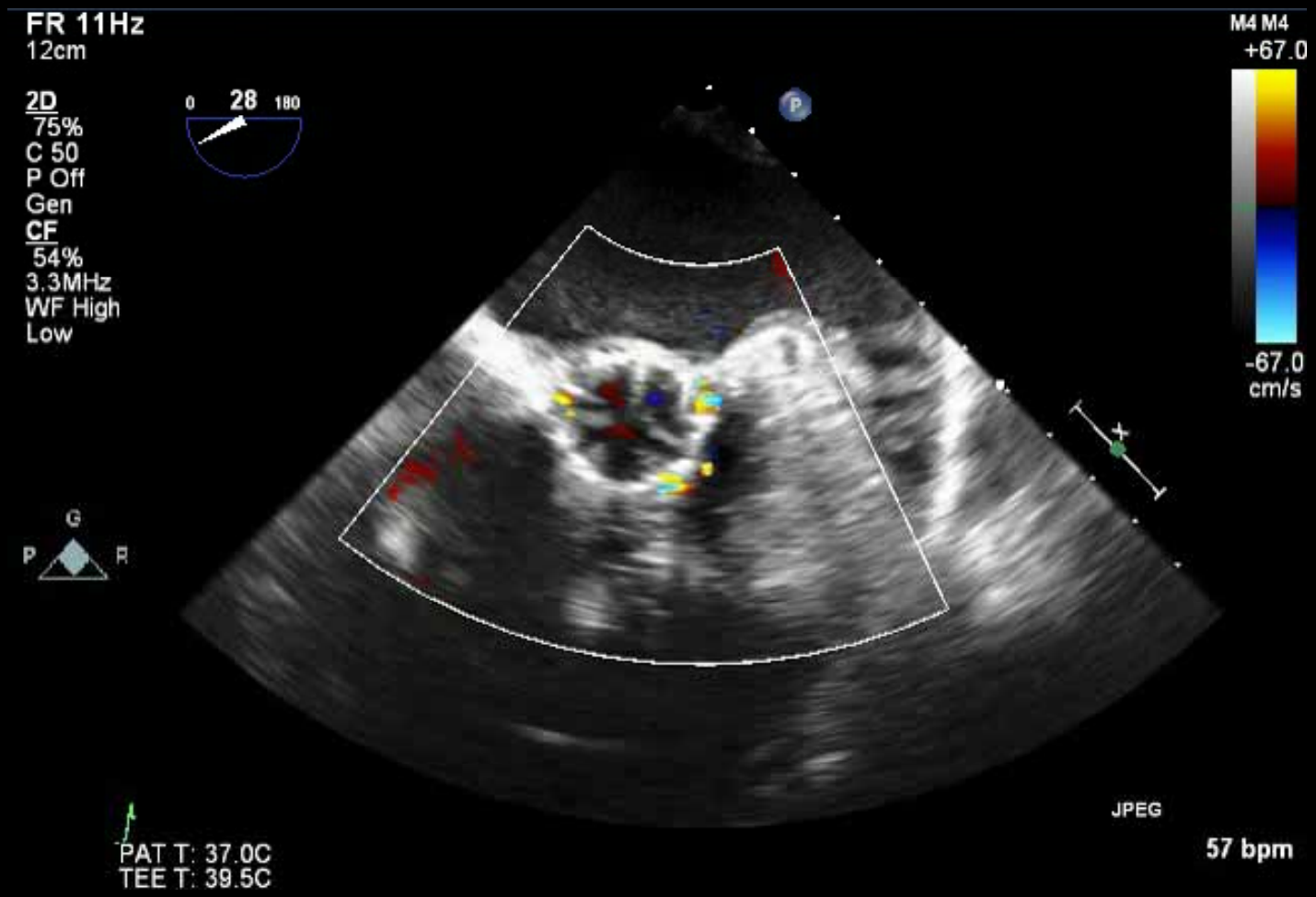
Mild Paravalvular Leakage



Paravalvular Leakage after TAVI



Severe Paravalular Leakage



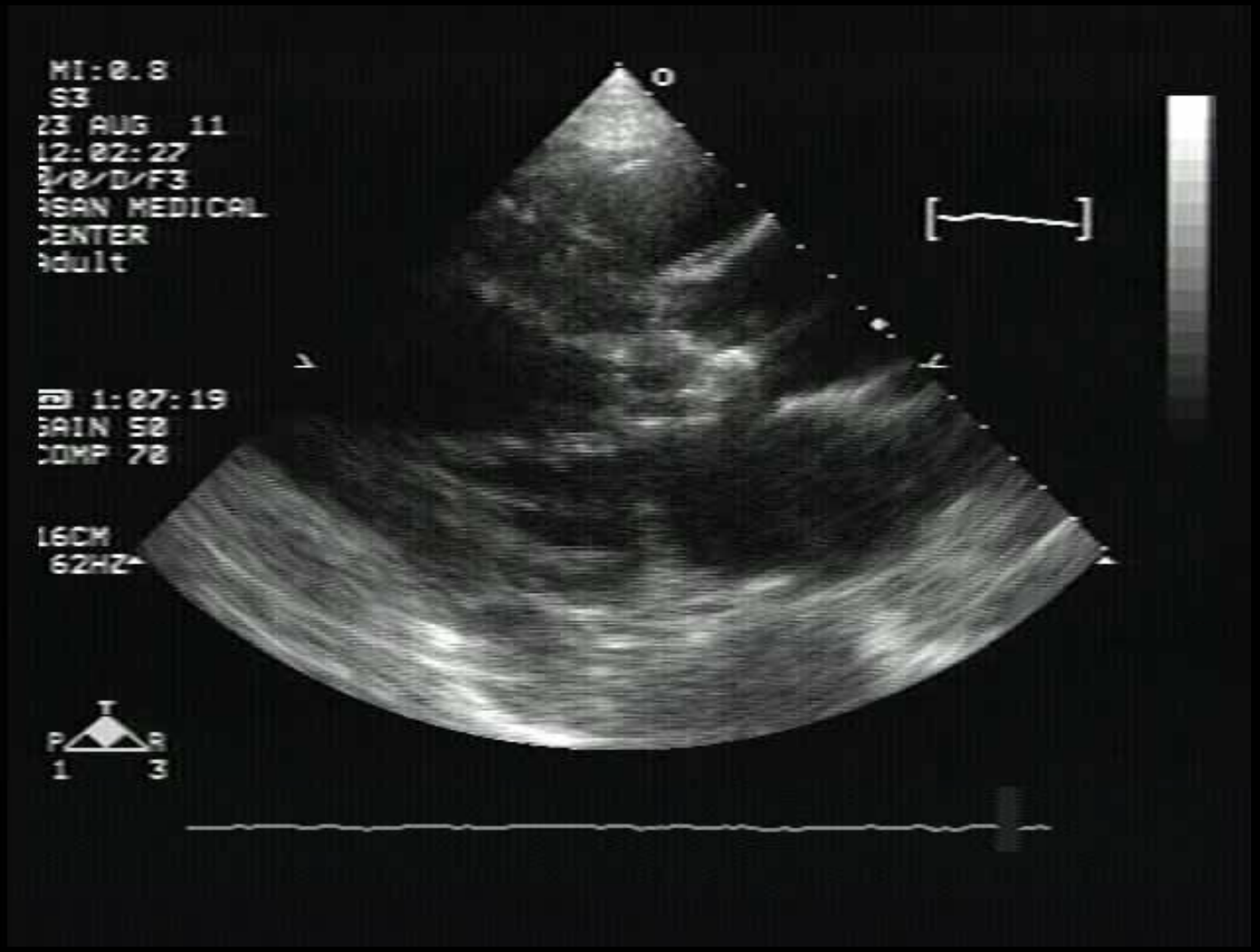
Complications of TAVI

Table 1 Peri-procedural complications of transcatheter aortic valve implantation assessable by echocardiography

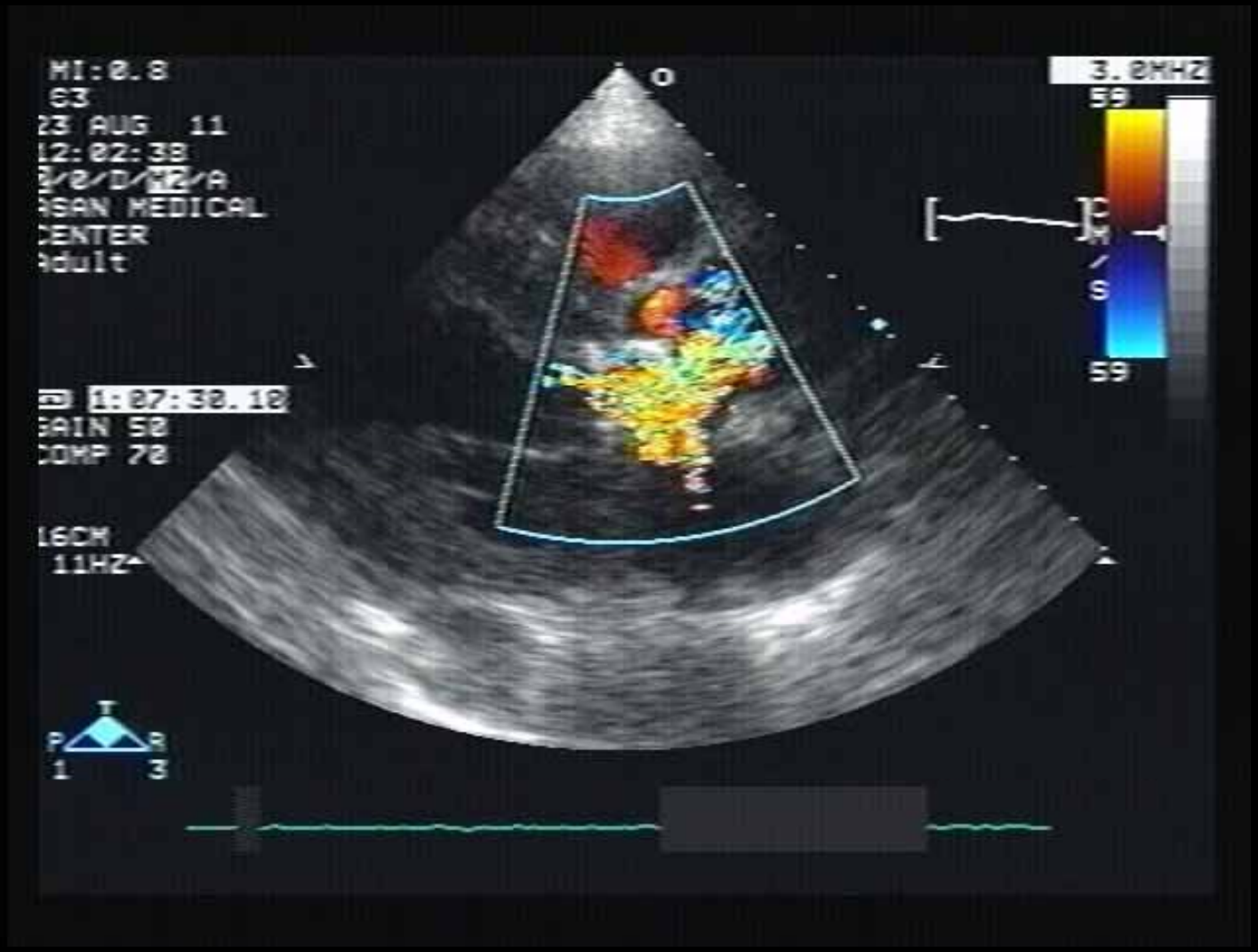
Aortic prosthesis misplacement
Embolization towards the aorta or left ventricle
Deployed valve is positioned too high (towards the aorta) or too low (towards the mitral valve apparatus)
Aortic regurgitation
Central
Paravalvular
Mitral regurgitation
Aortic prosthesis impinges on the anterior mitral leaflet
Left ventricle asynchrony caused by right ventricular pacing
Damage or distortion of the subvalvular mitral apparatus by delivery system
New left ventricular wall motion abnormalities
Acute coronary ostial occlusion
Cardiac tamponade
Perforation of the left or right ventricle
Dissection or rupture of the aortic root

JASE 2011;24:937-65

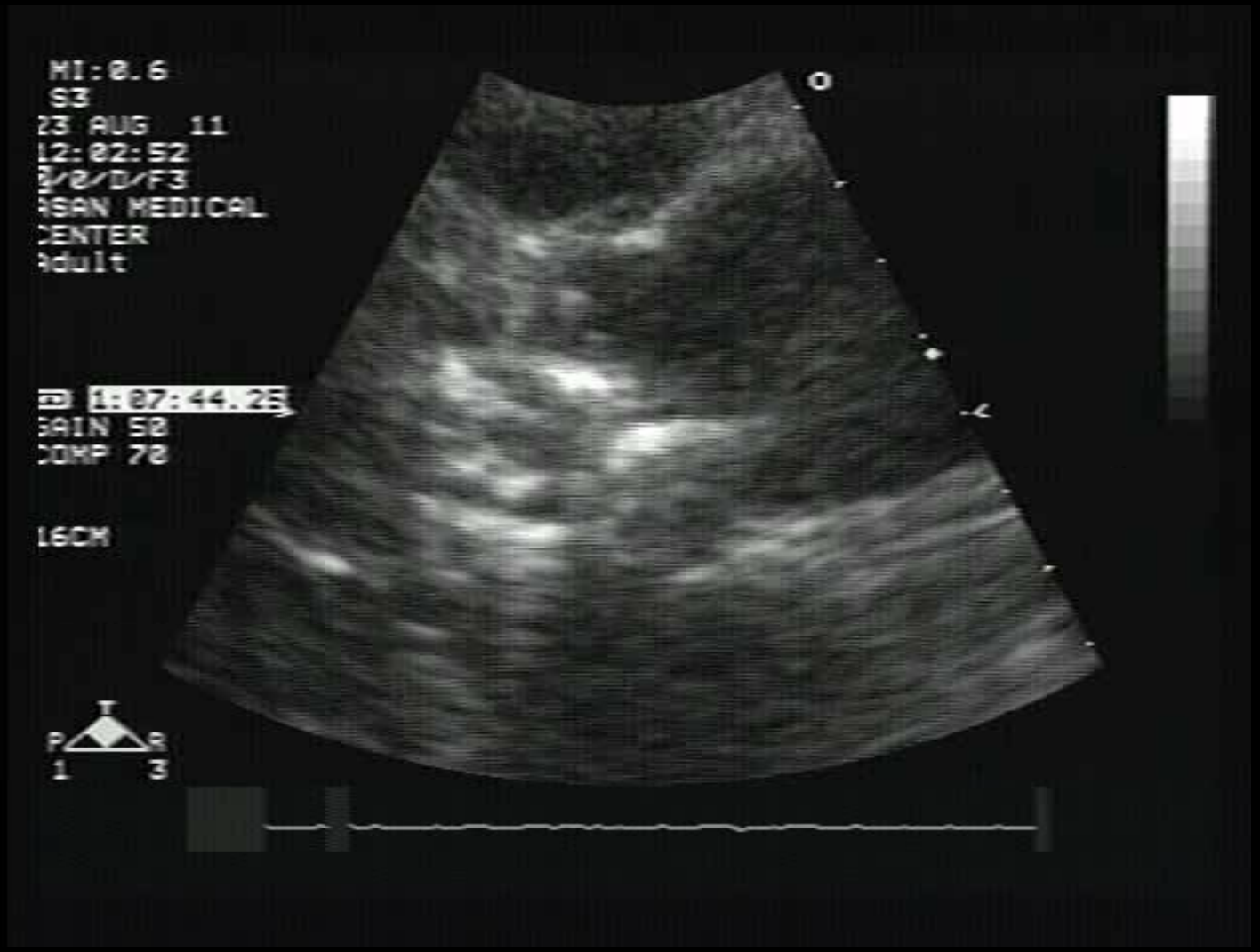
Displacement of Prosthetic AV



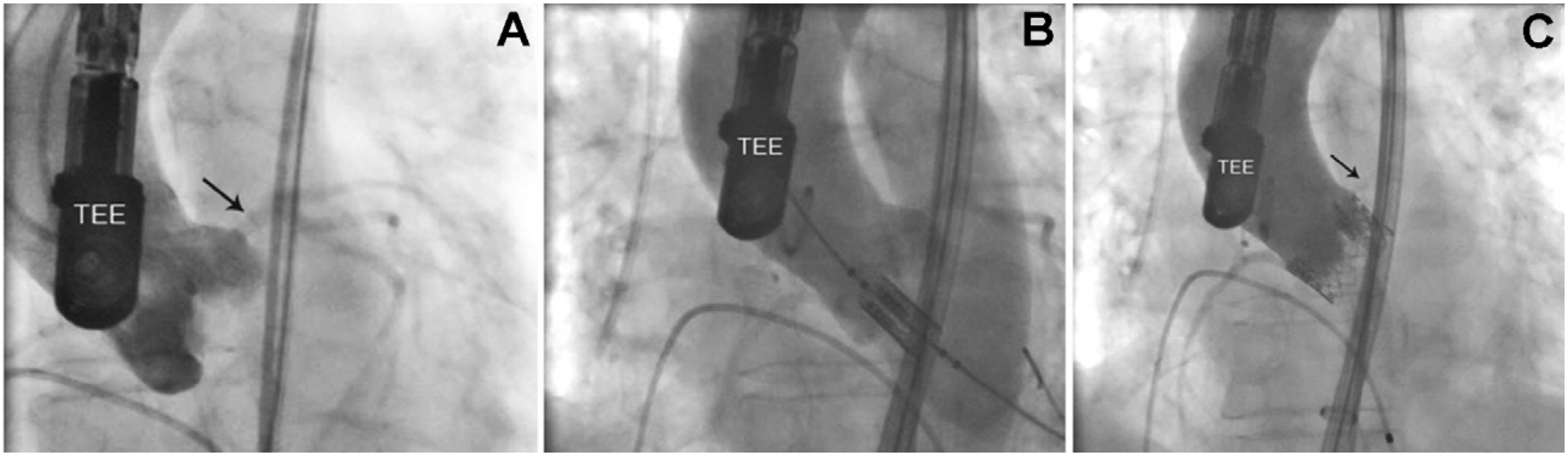
Displacement of Prosthetic AV

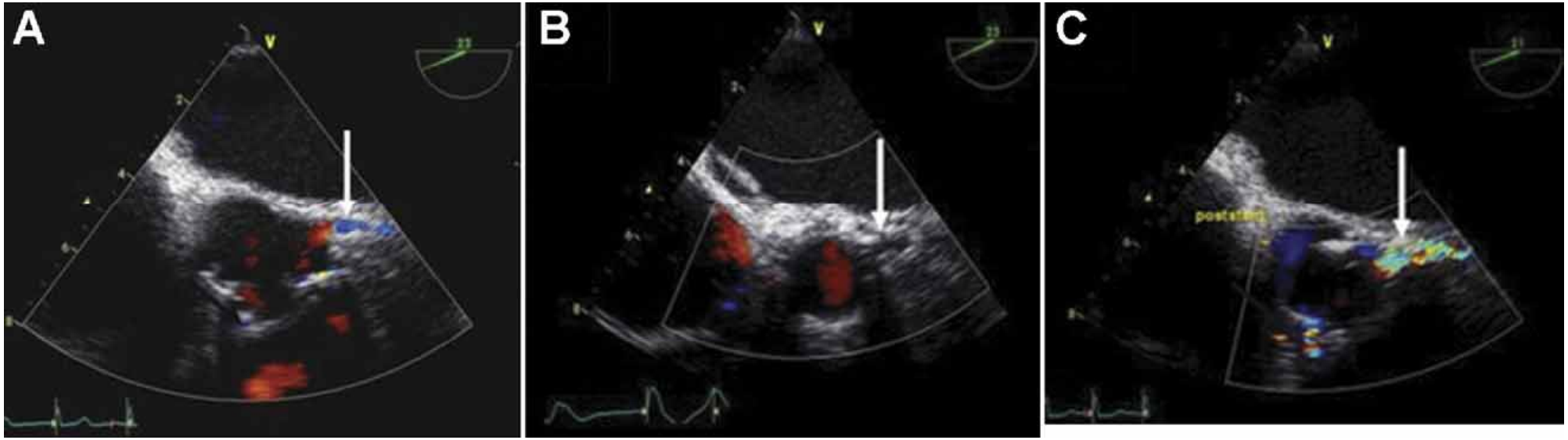


Displacement of Prosthetic AV



LM Ostial Occlusion after Percutaneous AVR





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