Brief Communication

Intraoperative Transesophageal Echocardiographic Assessment of Aortic Valve Repair in a Child – What to Look for?

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ABSTRACT

Aortic valve (AV) repair is the desired surgical treatment option for young patients with aortic regurgitation (AR). It is considered as a class I indication for the surgical treatment of severeAR. The success of an AV repair depends on the detailed intraoperative transesophageal echocardiographic (TEE) examination which should fulfil the information required by the surgeon. The objective of this echo round is to describe the role of intraoperative TEE in systematic evaluation of the AV, before and after repair.

Keywords: Aortic regurgitation, aortic valve repair, intraoperative TEE

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Submitted: 10-Jun-2023 **Revised:** 10-Aug-2023 **Accepted:** 21-Aug-2023 **Published:** 12-Jan-2024

INTRODUCTION

Surgery for aortic regurgitation (AR) in a child is a management dilemma. Unlike in adults, an increase in aortic dimensions with age, risk of infective endocarditis and the need for anticoagulation makes aortic valve (AV) replacement a less desirable option in children. There are no specific intraoperative transesophageal echocardiographic (TEE) guidelines for AV repair in children. We routinely perform successful AV repairs in older children and often extrapolate the cutoff parameters from the adult echocardiographic guidelines for intraoperative TEE evaluation of AV repair. We describe the intraoperative TEE assessment for a successful AV repair in a child with severe AR due to multiple mechanisms.

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	DOI: 10.4103/aca.aca_92_23

CASE REPORT

A 12-year-old male child weighing 50 kilograms with a height of 160 cm and body surface area of 1.5 m^2 presented with complaints of palpitations and breathlessness on exertion for the past year. He had no chest pain or syncopal attacks. On examination, his heart rate was 100 beats per minute. On auscultation, an early diastolic murmur was audible in the aortic area. Pre-operative transthoracic echocardiography (TTE) examination revealed a tri leaflet AV, severe AR due to dilated aortic annulus of 32 mm, prolapse of the left coronary cusp, elongated right coronary cusp without prolapse and small and restrictive non-coronary cusp. The left ventricle was dilated (57 mm at the end of diastole and 36 mm at the end of systole) with preserved biventricular

How to cite this article: Munaf M, Babu S, Sukesan S, Gadhinglajkar SV. Intraoperative transesophageal echocardiographic assessment of aortic valve repair in a child – What to look for? Ann Card Anaesth 2024;27:53-7.

systolic function. The child was planned for AV repair in view of his age, history of successful outcomes in similar cases in our institute and to avoid the need for anticoagulation. In the operation room, after induction of general anaesthesia, the heart was examined with an adult TEE probe (X7-2t; IE33; Philips, Bothell, USA). The TEE examination confirmed the pre-operative TTE findings [Figure 1]. After adequate systemic heparinisation, cardiopulmonary bypass (CPB) was instituted, and AV repair was done. The AV repair procedure performed was reconstruction of the non-coronary cusp using autologous pericardium, triangular plication of the right coronary cusp, left coronary cusp resuspension and sub-commissural annuloplasty. Post-CPB, TEE examination revealed an adequate surgical AV repair with trivial AR [Figure 2a; Supplemental Video 1], aortic annulus of 21 mm [Figure 2b], coaptation height of 10.6 mm [Figure 3a], effective height of 16.6 mm [Figure 3b], and transvalvular mean pressure gradient of 9 mm Hg [Figure 3c]. His biventricular function was preserved. He was weaned off from CPB with inotropic support of injection milrinone 0.5 mcg kg^{-1} $minute^{-1}$. He had an uneventful postoperative recovery. His follow-up TTE examination showed no residual AR [Supplemental Video 2]. A written informed consent was obtained from the patient's parents for publishing this case report.

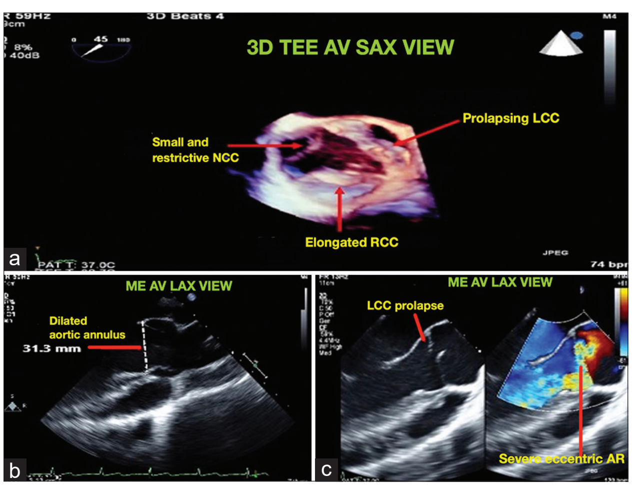

Figure 1: Pre-CPB TEE examination showing the assessment of aortic annulus and aortic valve leaflets. (a). Three-dimensional imaging of the aortic valve in short axis view shows prolapsing left coronary cusp (LCC), elongated right coronary cusp (RCC) and a small and restrictive noncoronary cusp (NCC). (b). Measurement of aortic annulus in the mid-esophageal aortic valve long axis view shows a dilated annulus of 31.3 mm. (c). Mid-esophageal aortic valve long axis view showing prolapse of left coronary cusp (LCC) and severe eccentric aortic regurgitation (AR). Abbreviations: 3D, three dimensional; AV, aortic valve; LAX, long axis; ME, midesophageal; SAX, short axis; TEE, transesophageal echocardiography

DISCUSSION

The aortic root is the region between the sinotubular junction and the aorta-ventricular junction. These two landmarks act as the functional aortic annulus. AV leaflets, sinuses, inter-leaflet triangles and commissures are the contents of the aortic root.[1] El Khoury *et al.* classified the mechanism of AR into three types [Figure 4a].[1] Type I abnormality has normal AV leaflet motion with dilatation of the functional aortic annulus or cusp perforation. The regurgitation jet is central and the coaptation length decreases in most cases due to the annular dilatation, leading to AR. Type I is further subdivided into four sub-types. Type Ia is characterised by the dilatation of the sinotubular junction and ascending aorta. Type Ib has a dilated sinus of Valsalva and sinotubular junction. The aortic annulus is dilated in type Ic, whereas cusp perforation is the defining feature of type Id lesions. Type II AR is due to the prolapse of AV leaflets with a characteristic jet that is directed away from the prolapsing leaflet. Type III AR is due to damage to AV leaflets which are often restricted in mobility, heavily calcified or fibrosed. The direction of the regurgitation jet is eccentric and towards the restricted leaflet. In our patient, the AR was due to the combination of all the above three mechanisms. The aortic annulus was dilated, and the left coronary cusp was elongated while the non-coronary cusp was short and restrictive.

Pre-surgical assessment of the AV includes evaluation of AV anatomy, identification of coronary arteries, evaluation of AV function and assessment of associated lesions and the left ventricular function.[2] The repairability of the AV and the postoperative outcome of AV repair can be strongly predicted by the functional anatomy of AR defined by TEE.[3] Type I and Type II ARs are considered repairable unless significantly calcified. AV leaflets with isolated small spots of calcification or calcification limited to the free margins with type I or type II AR can still be repaired. Type III lesions often require AV replacement.

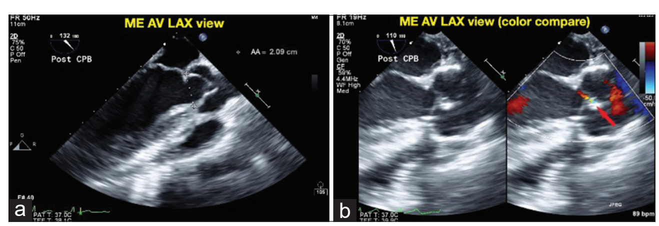

Figure 2: Post-CPB TEE examination showing the assessment of aortic annulus and residual aortic regurgitation. (a) Measurement of aortic annulus after AV repair in ME AV long axis view; (b) ME AV long axis view (colour compare) shows less than mild residual aortic regurgitation after the aortic valve repair (red arrow). Abbreviations: AA, aortic annulus; AV, aortic valve; CPB, cardiopulmonary bypass; LAX, long axis; ME, mid esophageal; TEE, transesophageal echocardiography

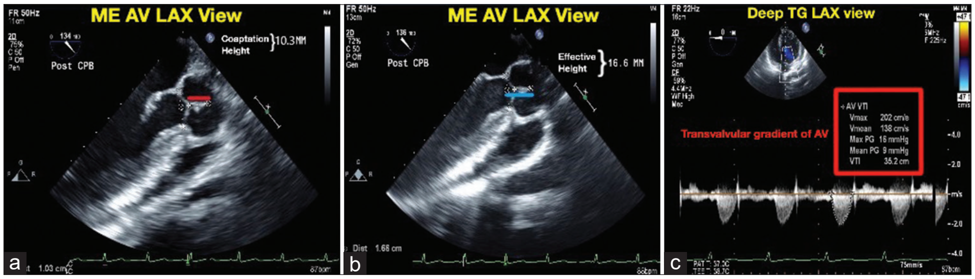

Figure 3: Post-CPB TEE examination showing the assessment of aortic root dimensions and transvalvular pressure gradients. (a). Measurement of coaptation height (distance of cusp apposition, measured in the diastolic phase) in the ME AV long-axis view; (b). Measurement of the effective height (distance measured from the aortic annulus to the coaptation tip in diastole) in the ME AV LAX view; (c). Post-CPB TEE continuous wave Doppler measurement of the mean gradient across the AV in deep TG long axis view shows a mean gradient of 9 mmHg across the AV. Abbreviations: AV, aortic valve; CPB, cardiopulmonary bypass; LAX, long axis; ME, midesophageal; TEE, transesophageal echocardiography; TG, transgastric

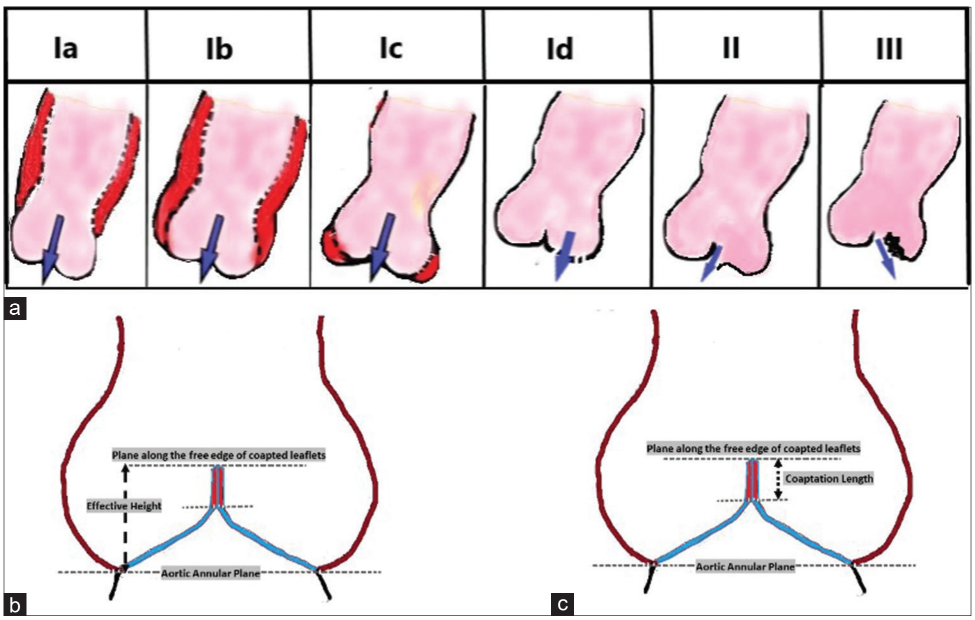

Figure 4: Illustrative diagram showing the mechanism of aortic regurgitation and echocardiographic measurement of aortic root dimensions after aortic valve repair. (a). illustrative sketch showing classification of different mechanisms of aortic regurgitation; (b). Illustrative diagrammatic representation of aortic root showing the measurement of effective height; (c). Illustrative diagram of aortic root showing the measurement of coaptation height

The AV repair procedure offers freedom from anticoagulation related to the mechanical valve and deterioration of the bioprosthetic valve. A successful AV repair demands a good knowledge of the mechanism of AR. Adequacy of cusp tissue and pliability of the valve leaflets are also important for a successful repair.[4] For a regurgitant AV, many techniques of repair are available based on the mechanism of regurgitation.[5] Type Ia lesions need sinotubular junction remodelling, often with an ascending aortic graft, in conjunction with or without a sub-commissural annuloplasty to restore aortic coaptation. In type Ib lesions, valve-sparing aortic root replacement is performed, while type Ic lesions often require sub-commissural annuloplasty with or without sinotubular junction remodelling. Type Id lesions require repair of the cusp perforation with a pericardial patch. In type II lesions, for a focal cusp prolapse, plication or triangular resection of the segment is performed. The free margin of the cusp is resuspended in case of a total prolapse of the cusp. In type III AR, cusp repair is performed by shaving or decalcification, followed by a sub-commissural annuloplasty to stabilise the functional aortic annulus, if needed.[5] Our patient underwent a combination of these procedures, namely, neocuspidisation, resuspension of the leaflet, plication of the prolapsing leaflet and sub-commissural annuloplasty.

The American Society of Echocardiography (ASE) has recommended a systematic approach for the intraoperative TEE examination of the AV following surgical AV

Table 1: Intraoperative transesophageal echocardiographic assessment of aortic valve repair[2]

TEE assessment	TEE views	TEE findings
Pre-CPB TEE evaluation of aortic valve repair		
Evaluation of aortic valve anatomy	ME AV SAX, ME AV LAX, deep TG 5 chamber, TG LAX	Morphology and motion of cusps, coaptation length and height, infective endocarditis vegetations
Evaluation of aortic valve function	ME AV SAX, ME AV LAX, deep TG 5 chamber, TG LAX, TG 2 chamber, ME DTA SAX, ME DTA LAX	Aortic stenosis: mean pressure gradient, peak velocity. Aortic regurgitation: origin and direction of regurgitant jet, vena contracta, PHT, diastolic flow reversal in the descending aorta.
Associated lesions	ME 4 chamber, ME 5 chamber, ME 2 chamber, mitral commissural view, ME LAX	Presence of MR, asymmetric septal hypertrophy, presence of systolic anterior motion
Evaluation of LV function	ME 4 chamber, ME 2 chamber, ME LAX TG basal SAX, TG mid-papillary SAX, TG 2 chamber, deep TG 5 chamber	Regional wall motion abnormalities, volumetric analysis including stroke volume
Coronary arteries	ME AV SAX, ME AV LAX	Identification of coronary anatomy and coronary ostia
Post-CPB TEE evaluation of aortic valve repair		
Severity of aortic regurgitation	ME LV LAX, ME AV LAX, ME AV SAX, deep TG 5 chamber (colour Doppler)	No or minimal residual aortic regurgitation
Aortic annulus	ME AV LAX – Zoomed	less than 25 mm
Effective height	ME AV LAX – Zoomed	more than 9 mm
Coaptation height	ME AV LAX – Zoomed	more than 4 mm
Mean trans aortic valve gradient	Deep TG 5C view, TG LAX view (spectral Doppler evaluation)	less than 10 mm Hg

AV, aortic valve; DTA, descending thoracic aorta; LAX, long axis; LV, left ventricle; ME, midesophageal; SAX, short axis; TEE, transesophageal echocardiography; TG, transgastric

repair.[2] An adequate AV repair should meet the following TEE examination criteria: 1) No or minimal residual AR. Jets that are more than mild, eccentric, or multiple require further evaluation regarding the mechanism and intervention, 2) Effective height [Figure 4b] should be more than 9 mm, and the level of coaptation should be at or above the aortic annulus, 3) Coaptation height [Figure 4c] must be more than 4 mm, 4) Post-repair aortic annulus should be less than 25 mm, and 5) Post-repair mean trans-valvular pressure gradient must be less than 10 mm Hg. We recommend the following TEE views for the intraoperative TEE assessment of the above-mentioned echocardiographic criteria following an AV repair [Table 1]. With emerging evidence that normal aortic dimensions vary significantly based on the age and sex of the patient, careful interpretation of the annular size in paediatric patients is important.[6]

After the surgery, there are three echocardiographic predictors for the failure of an AV repair.[5] The presence of more than a mild degree of AR is a strong predictor of future failure of AV repair.[6] Coaptation of cups below the level of the AV annulus is another independent predictor for the recurrence of AR, even in the absence of AR.[7] The third factor predicting the failure of the AV repair is the short coaptation length.[7] A coaptation length of more than 4 mm and an effective height of more than 8 mm with a level of coaptation above the level of the annulus is associated with a lesser risk of recurrent AR development due to better geometrical restoration.[5]

The intraoperative TEE assessment of a repaired AV is challenging for echocardiographers, as there are no well-defined objective criteria for the assessment of the success of AV repair. After the recommendations from ASE,[2] a detailed step-by-step approach of TEE assessment for AV repair can be done during the intraoperative period. In our case, we followed the imaging and assessment of AV repair as per the ASE guidelines and found that the intraoperative TEE played a crucial role in the assessment of the mechanism of regurgitation, analysing the aortic dimensions, predicting the repairability of the valve and evaluating the results of surgical repair, leading to a successful outcome.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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