A Guideline Protocol for the Assessment of Aortic Regurgitation From the British Society of Echocardiography Education Committee

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1. Introduction

1. 1 The BSE Education Committee has recently published a minimum dataset for a standard adult transthoracic echocardiogram, available on-line at www.bsecho.org. This document specifically states that the minimum dataset is usually only sufficient when the echocardiographic study is entirely normal. The aim of the Education Committee is to publish a series of appendices to cover specific pathologies to support this minimum dataset.

1.2 The intended benefits of such supplementary recommendations are to:

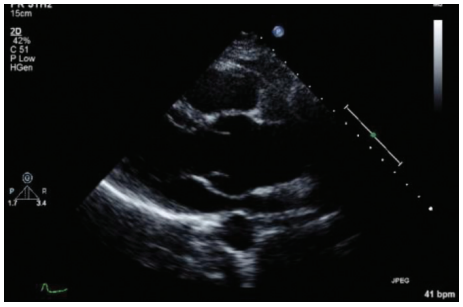
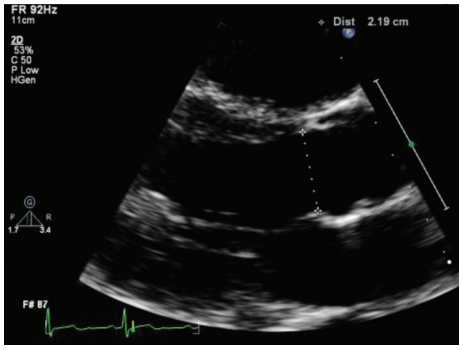
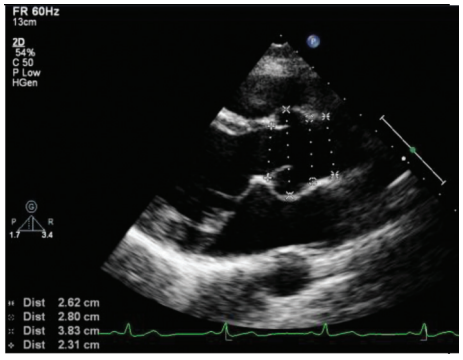
- support cardiologists and echocardiographers to develop local protocols and quality control programs for adult transthoracic study;
- promote quality by defining a set of descriptive terms and measurements, in conjunction with a systematic approach to performing and reporting a study in specific disease-states;
- facilitate the accurate comparison of serial echocardiograms performed in patients at the same or different sites.

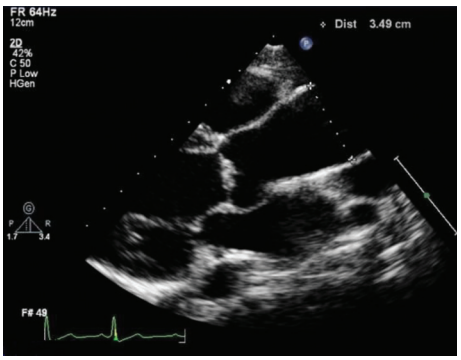
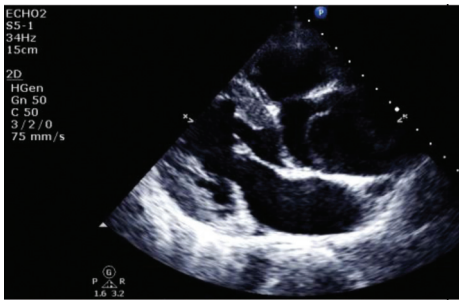
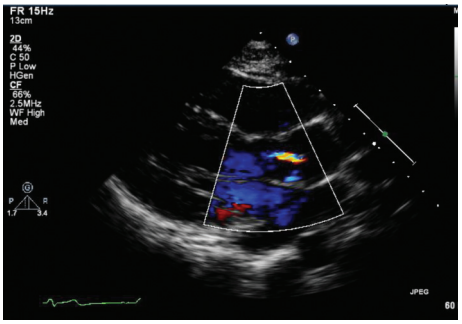
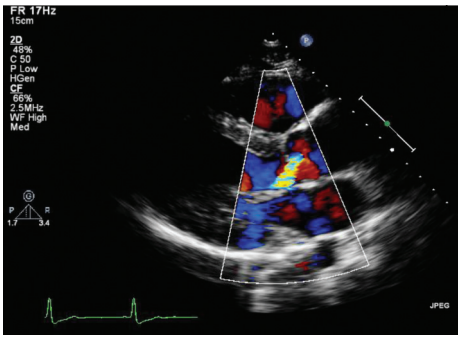
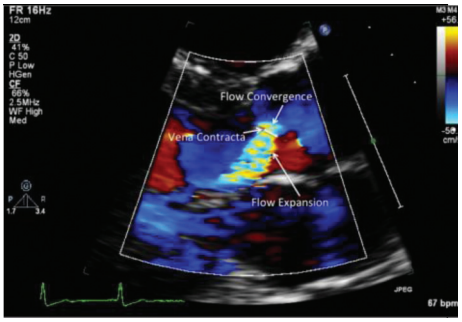
1.3. This document gives recommendations for the image and analysis dataset required in patients being assessed for aortic regurgitation. Echocardiography has become the standard method for evaluating aortic regurgitation severity. Other methods such as cardiac catheterisation are not routine except where the data is non-diagnostic or discrepant with clinical data.

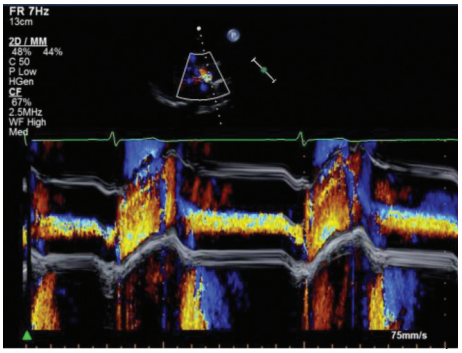
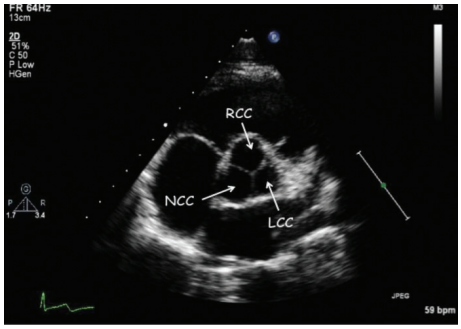
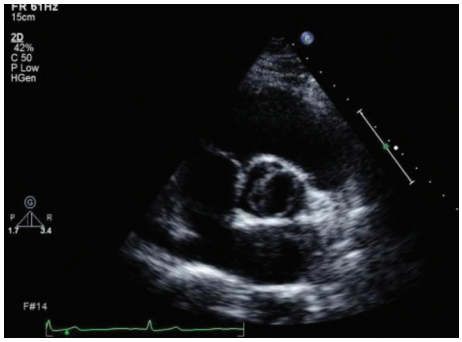
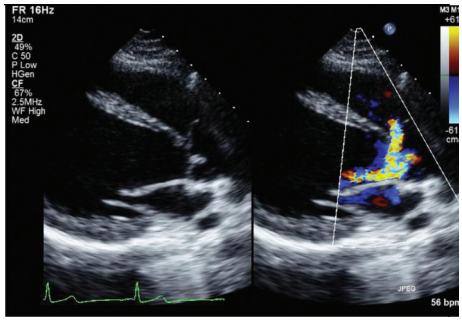
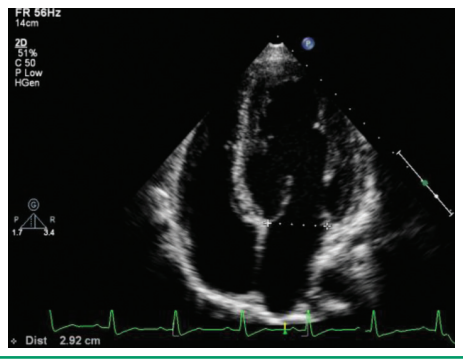
1.4. The views and measurements are supplementary to those outlined in the minimum dataset and are given assuming a full study will be performed in all patients.

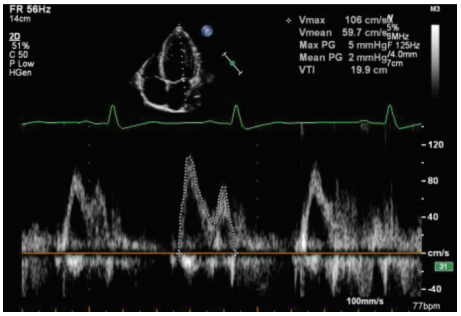
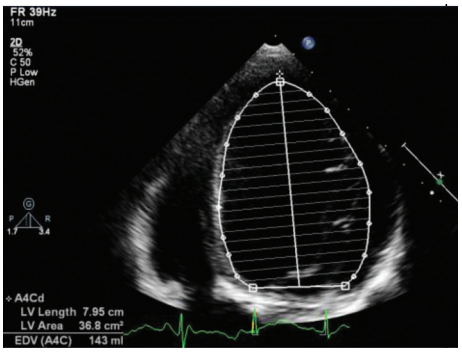
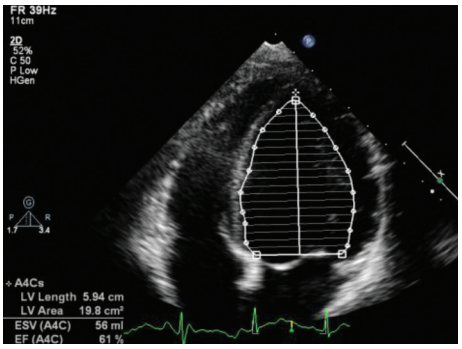
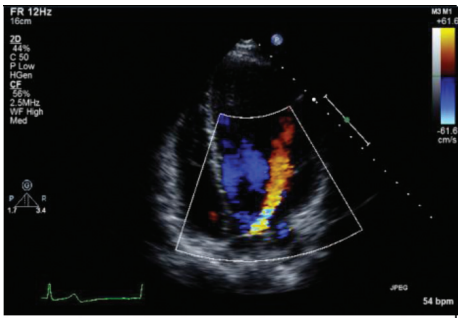
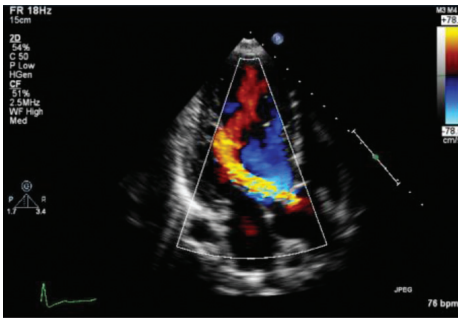
1.5 When the condition or acoustic windows of the patient prevent the acquisition of one or more components of the supplementary dataset, or when measurements result in misleading information (e.g. off-axis measurements), this should be stated.

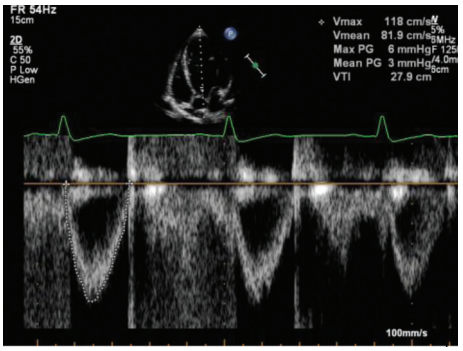
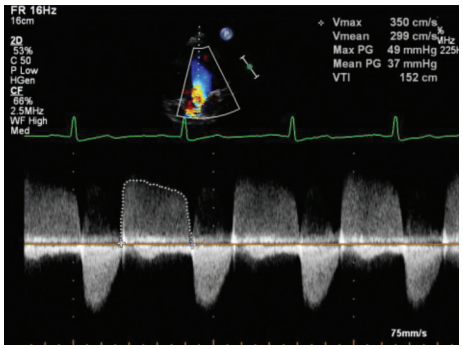
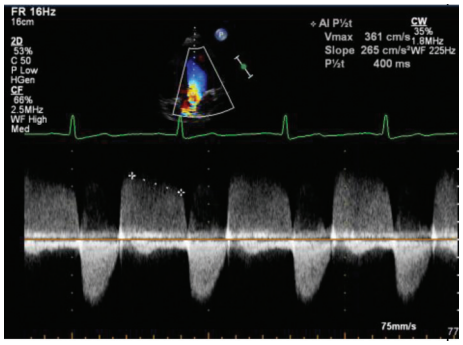
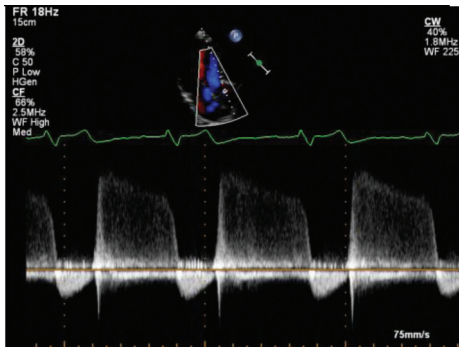
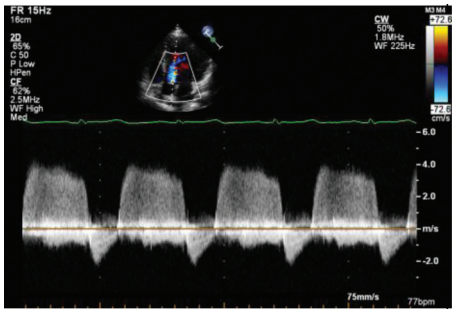
1.6 This document is a guideline for echocardiography in the assessment of aortic regurgitation and will be up-dated in accordance with changes directed by publications or changes in practice.

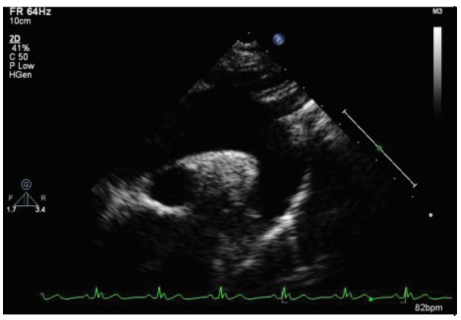
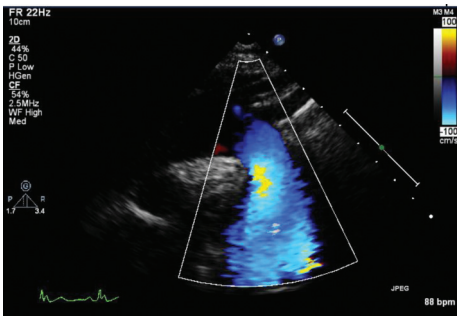
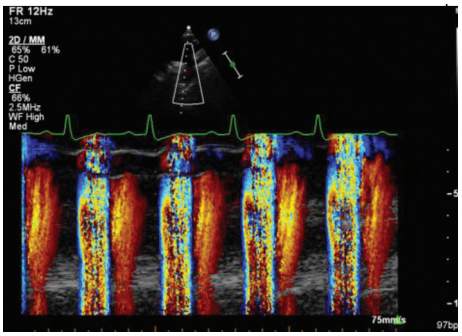
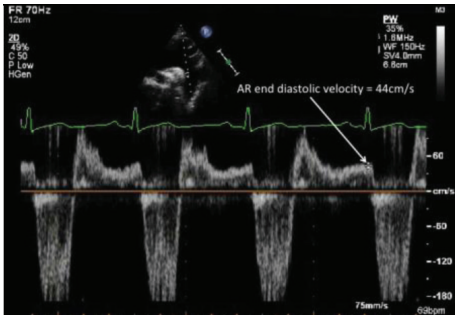
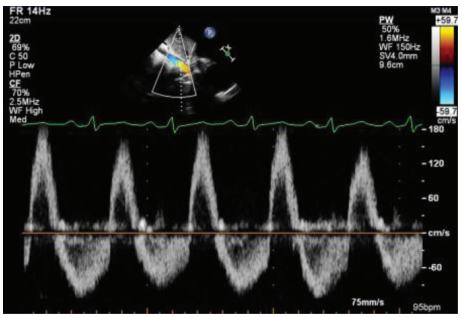
VIEW	Modality	Measurement	Explanatory note	Image
PLAX	2D	Cusps viewed	NCC/RCC	
		Cusp anatomy:	Assess aetiology and mechanism of AR (Carpentier classification) [1]	
		Appearance	Systolic doming/asymmetric closure line (?bicuspid) Commissure fusion (?rheumatic) Presence of vegetations	
		Mobility	Normal, increased (cusp prolapse, flail) or restricted. If restricted, assess degree of restriction and grade as: mild =restricted motion at basal 1/3 adjacent to hinge only, moderate =base+ body (middle third), severe =base+body+free edge (distal 1/3)	
		Thickening	Mild/moderate/severe	
		Calcification	Describe severity: mild/mod/severe mild = small isolated spots ; moderate = multiple larger spots; severe = heavily calcified, extensive Comment on extension of calcification into root.	
PLAX	2D	**Dimensions:**	Describe contour of aortic root e.g. effacement of sinotubular junction Try to obtain symmetrical aortic root sinuses with ascending aorta not foreshortened	
		LVOT (for stroke volume calculation)	As per min dataset, performed at similar level to LVOT PW Doppler velocity trace obtained from either A5CH or A3CH, see below. [Zoom mode, mid systole, min 3 beats (5 if AF) measure inner edge to inner edge]	
		Annulus, sinuses, sinotubular junction, proximal ascending aorta	Measure from cusp hinge points (at point of cusp insertion into wall), ignoring all calcification Widest diameter in zoom mode where best seen. Inner edge-inner edge (blood tissue interface).	

PLAX	2D	Mid ascending aorta at level of right pulmonary artery (inner edge-inner edge)	Modified view - beam tilted superiorly & possibly higher rib space	
PLAX	2D		Dissection flap Recommend additional views with M-Mode to help differentiate from beam-width artefact and reverberation	
PLAX	CFM	Aortic Valve (Nyquist limit 50-60 cm/s)	Jet direction: central, eccentric – towards IVS or AMVL	
			Note: may have restriction of AMVL secondary to jet	
PLAX	CFM Zoom Mode	Vena contracta width: **narrowest** portion of colour flow at the level of the aortic valve in the LVOT immediately below the flow convergence region	When measuring VC, ensure all portions of regurgitant jet are seen, including flow convergence and jet expansion. Note: VC not reliable if multiple or irregular shaped jets For eccentric jets: measure VC perpendicular to direction of jet rather than to long axis of LVOT	

	CFM Zoom M-mode	% Jet width/LVOT height: **maximal** proximal jet width measured in LVOT	Measure 0.5-1.0 cm below aortic annulus Central jets may overestimate severity& eccentric jets may underestimate severity	
PLAX	2D	LV:cavity size, wall thickness, mass, function (2D recommended in abnormally shaped LV's to ensure measurements are perpendicular to long axis)	See BSE Guidelines: Chamber Quantification Surgery is recommended in asymptomatic chronic AR if LVIDd >70mm, LVIDs > 50mm (>25mm/m^2).	
PSAX	2D AV level	Cusps viewed	NCC/RCC/LCC	
		Cusp anatomy Mobility/thickening/ calcification	See above Sweep above the AV to re-assess the appearance of the sinuses to identify sinus of valsalva or aortic root aneurysm pathology	
		Number of cusps	Bicuspid (elliptical systolic orifice with 2 commissures +/- raphe)	
		Calcification	Distribution, location and extent (See above)	
PLAX	CFM		**Origin of jet** **Central / commissural / cusp prolapse (PM VSD)**	 PM VSD with cusp prolapse
A4CH	2D	MV annulus diameter, measured in diastole at maximum opening of valve (inner edge to inner edge)	This calculation is optional but should be considered when there is discrepancy between grading of severity using other measures For stroke volume calculation: **MV stroke volume** = 0.785 x (MV annulus diameter d)^{2}x MV VTI	

A4CH	PW	MV VTI (at level of annulus)	The Doppler-based methods for calculation of regurgitant volume, regurgitant fraction and regurgitant orifice are not to be used if there is more than mild MR	
A4CH + A2CH	2D	LVEF (Simpson's Biplane)	See BSE Guidelines: Chamber Quantification Surgery is recommended in asymptomatic chronic AR if LVEF ≤50%	 
A5CH A3CH	CFM (Nyquist limit 50-60 cm/s)	Visualise course and nature of jet to give overview of severity but place into context of other assessments	Caution regarding eccentric jets as these may be underestimated Be aware of limitations of jet length as an isolated marker of severity	 

A5CH A3CH	PW	LVOT VTI (measured in LVOT up to 1 cm from aortic annulus)	**LVOT stroke volume** = 0.785 x (LVOT diameter)^{2}x LVOT VTI **AR Regurgitant Volume** = LVOT stroke volume – MV stroke volume **AR Regurgitant Fraction** = regurgitant volume ÷LVOT stroke volume x100 (%)	
A5CH A3CH	CW	AR VTI	**Regurgitant Orifice Area** = Regurgitant Volume ÷ AR VTI Need to ensure complete diastolic VTI envelope is seen to trace	
A5CH A3CH	CW	Pressure half-time	Measure: peak velocity and slope on flat part of spectral trace (needs to be good quality) Note: Changes in LV & aortic diastolic pressure may affect calculations, e.g. high LV end diastolic pressure will result in short pressure half-time which will over-estimate severity of AR Pressure half-time still valid in acute AR	
A5CH A3CH	CW	Jet density	Weak signal signifies minimal AR	
			Dense signal signifies at least moderate AR but cannot reliably distinguish from severe	

SSN	2D		Assess aortic arch morphology and exclude aortic coarctation	
SSN	CFM		Visually assess diastolic flow reversal on CFM	
SSN	CFM/M-mode		Colour M-mode may be used to improve detection & timing	
SSN	PW	Diastolic flow reversal	Sample volume placed just distal to origin of left subclavian artery Holodiastolic flow reversal may indicate at least moderate AR. End diastolic velocity >20cm/s, measured at peak R wave may suggest severe AR Note: Reduced aortic compliance (advanced age) + ↑HR may ↑duration & velocity of flow In severe, acute AR flow reversal will ↓ rapidly with no end diastolic velocity	
SC	2D/CFM/PW		Significant holodiastolic reversal in abdominal aorta is also a specific sign of severe AR	

General Considerations:

1. Aetiology and mechanisms. The report of an echocardiogram on a patient with AR should comment upon the likely cause when possible. Aetiology may usually be established from careful assessment of valve anatomy and function. AR results from disease of either the aortic leaflets or the aortic root that distorts the leaflets to prevent their correct apposition.

   Common causes of leaflet abnormalities that result in AR include senile leaflet calcification, bicuspid aortic valve, infective endocarditis, and rheumatic fever.

   Aortic causes of AR include annuloaortic ectasia (idiopathic root dilatation, Marfan's syndrome, aortic dissection, collagen vascular disease, and syphilis).

2. AR severity. Transthoracic echocardiography is indicated for the diagnosis of aortic regurgitation but quantifying severity is challenging, in particular when classifying regurgitation as mild. Flow convergence methods are often not possible in practice on transthoracic imaging and have therefore not been included here. The quantitative Doppler volumetric method also has a number of practical limitations and is a challenging technique to use reliably and with high reproducibility. Sonographers must use these methods with caution.

3. Aortic root and ascending aortic dimensions. Aortic dilatation with secondary AR is most common aetiology and particular care must be taken to make accurate measurements of aortic root dimensions, as well as extending views to obtain proximal ascending aortic and aortic arch dimensions.

4. Consequences of AR. AR is characterized by a relatively prolonged period without symptoms, when careful observation of the haemodynamic effects on LV size and function is the most important aspect of follow-up. AR imposes additional volume load on the LV, leading ultimately to LV dilatation and impairment. The presence of LV impairment at the time of surgery significantly impairs patient outcomes from valve replacement and therefore new methods to assess abnormal tissue Doppler velocities and myocardial strain are being established to act as early markers. These are not yet fully accepted in clinical practice.

5. Right heart size and function, PA pressures. These factors affect operative risk and should be identified.

6. Other valve lesions. Other valve lesions should always be taken into account when assessing AR and in deciding methods to assess severity.

7. Transcatheter Aortic Valve Implantation and Aortic Regurgitation. AR following THV presents a particular problem for assessment by echocardiography. AR following THV may be central or paravalvar, and often involves multiple small jets. Colour flow Doppler is often used semi-quantitatively but it should be remembered that jet length is inaccurate and that jet width may be difficult when jets are eccentric and irregular in shape. Quantitative methods as outlined in this document may be used but are difficult. Semi-quantitative estimation based on the proportion of the circumference of the sewing ring may be used (less than 10% mild; 10-20% moderate; more than 20% severe) but this may over-estimate severity when there are multiple jets.

BP and body surface area should be recorded.

Possible TOE indications include questions over valve anatomy, severity of AR and/or poor image quality.

References

1) European Association of Echocardiography recommendations for the assessment of valvular regurgitation. Part 1: aortic and pulmonary regurgitation (native valve disease) Lancellotti P et al on behalf of the European Association of Echocardiography European Journal of Echocardiography (2010) 11, 223-244

July 2012