IAE performance standards and recommendations for a comprehensive transthoracic echocardiographic study in adults

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Over the past four decades, echocardiography has evolved in to an extremely useful diagnostic modality, which is regularly utilized for assessment of cardiac structure and function in a wide variety of clinical settings. Its non-invasive nature, safety, easy availability, portability and the ability to provide vast amount of diagnostic information are some of the reasons underlying its popularity as a diagnostic tool. However, echocardiography is an operator-dependent technique which can lead to considerable measurement variability, misdiagnoses and even missed-diagnoses. While adequate training is the most effective means to overcome this challenge, a standard protocol for image acquisition will improve diagnostic accuracy and maximize reproducibility of the technique.

AIMS AND OBJECTIVES

1) To ensure that no significant pathology is missed by a beginner or a veteran in a hurry. This is especially true if the study being interpreted has been performed by someone else. A complete study will also guard against missing a rare or relevant second pathology if a primary disease is very evident e.g. organic tricuspid valve disease (TV) in presence of significant mitral stenosis (MS).
2) To enable accurate comparison, qualitative or quantitative, of interval studies from the same patient performed by same or different echocardiographers. Serial comparison is possible only if all the studies are complete and consist of same views.
3) To permit extra, non-routine measurements or verification of reported measurements on stored studies for clinical or research purposes. For example, measuring stroke volume at LV outflow tract (LVOT) in a case of aortic stenosis (AS) with discrepant gradients to rule out low-flow, low-gradient situation or for applying newer measurement algorithms as they become available.
4) To afford medico-legal protection against potential negligence resulting from missing a pathology due to incomplete study. The study documentation conforming to the standards laid down by a professional society will serve as a major safeguard.

SCOPE OF THE DOCUMENT

1) The present document provides a set of mandatory transthoracic echocardiographic views and Doppler clips that are required to permit comprehensive evaluation of each cardiac chamber, all valves, all coronary territories, septal intactness, great arteries and veins, major cardiac structures and intracardiac hemodynamics.Any study done in emergency or unfavorable settings, not conforming to the recommended protocol, should be labelled as "focused" echo study.
2) All views and Doppler recordings have been devised for post-processing and for routine or elaborate offline measurements for clinical or research requirements. Focused views are meant for drawing echocardiographer's attention to a particular region in the zoomed image.
3) Only minimum basic measurements are recommended to be made. Additional measurements as per the requirements of a particular pathology or institutional or research protocol can be added.
4) These recommendations in no way limit the study to conventional views only. Echocardiographers are encouraged to obtain additional non- conventional and creative views in addition to (and not excluding) the protocol to improve the diagnostic accuracy and the quality of the study.
5) These recommendations do not cover training and credentialing requirements for the echocardiographers.

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THE RECOMMENDED VIEWS AND MEASUREMENTS

Table 1 and 2 list the recommended views and measurements, respectively, required for performing a complete adult transthoracic echocardiographic study. However, as mentioned above, additional views and measurements may be needed depending on the underlying pathology and the requirements of local institutional or research protocol.

When performing any echocardiographic study, it is recommended to:

1) Store ECG synchronized, minimum 3 beat loop for each two-dimensional (2D) or color Doppler image and minimum 3 Doppler spectral beats for the still images in case of pulsed-wave (PW) or continuous wave (CW) Doppler. For patients in atrial fibrillation or any other ongoing arrhythmia, minimum 5 beats are recommended.

2) For offline post-processing and measurements, archive the study in DICOM format. Other formats such as AVI/ lossless JPEG or MPEG, should be used for qualitative viewing only.

Table 1: Recommended views for a complete transthoracic adult echocardiographic study*#$

Parasternal window	Apical window	Other acoustic windows
1. PLAX 2D 2. PLAX mitral valve zoom- a. 2D b. Color Doppler 3. PLAX aortic valve zoom- a. 2D b. Color Doppler 4. PLAX ascending aorta- a. 2D b. Color Doppler 5. PLAX RV inflow view with color Doppler 6. PSAX at the level of semilunar valves- a. 2D b. Color Doppler 7. PSAX aortic valve zoom- a. 2D b. Color Doppler 8. PSAX main pulmonary artery and bifurcation a. Color Doppler b. Pulmonary flow PW spectral Doppler (optional PR jet CW) 9. LV SAX at mitral valve level 2D (optional mitral valve color Doppler) 10. LV SAX at papillary muscle level 2D 11. LV SAX at apex 2D	12. Apical 4 chamber view with pericardial space 13. Focused LV 4 chamber view 14. Focused LV 2 chamber view 15. Focused LV apical long axis view 16. Zoomed LV inflow and out flow view- a. 2D b. Color Doppler 17. Zoomed LA 2 chamber view 18. Zoomed LA 4 chamber view 19. Pulmonary vein flow PW spectral Doppler 20. Focused (LA-LV) mitral flow- a. Color Doppler b. PW spectral Doppler (optional CW for MR and MS) 21. Mitral annular tissue Doppler (PW spectral Doppler) - a. Medial b. Lateral 22. Zoomed 5 chamber LVOT- a. 2D b. Color Doppler c. LVOT PW spectral Doppler 23. Aortic valve flow CW Doppler 24. Focused RA-RV view- a. 2D b. Color Doppler at tricuspid valve c. TR jet CW spectral Doppler d. Tricuspid flow PW/CW spectral Doppler	**Subcostal window** 25. Subcostal four-chamber view (RV focused) 26. Interatrial septal view- a. 2D b. Color Doppler 27. Aorta long axis- a. 2D b. Color Doppler (PW spectral Doppler optional) 28. IVC long axis- a. 2D b. IVC/ hepatic veins color Doppler c. IVC / hepatic vein PW spectral Doppler **Suprasternal window** 29. Aortic Arch long-axis- a. 2D b. Color Doppler c. PW/CW spectral Doppler

* Additional views will be needed depending on the underlying pathology
\# All views are 2D views, unless specifically mentioned
$ All 2D and color Doppler views refer to video clips
(Please refer to text for abbreviations)

Table 2: Recommended gray-scale and color measurements*

Gray-scale measurements	Doppler measurements
• LV cavity systolic and diastolic diameters • IVS and posterior wall diastolic thickness • Aortic annulus, aortic root at sinuses, sino-tubular junction, ascending aorta diameters • LA anteroposterior diameter, LA volume • RVOT/ MPA diameter(s), RA diameter, RV basal diameter, RV free wall thickness • LV end-diastolic and end-systolic volumes using Simpson's method • TAPSE • IVC size, along with respiratory variation	• Peak RVOT/ pulmonary flow velocity • PR end-diastolic gradient • Pulmonary vein flow S,D,A velocities • Mitral flow E, A velocities, E/A ratio, E wave deceleration time • Mitral annular E' and S' velocities • LVOT VTI • Aortic flow peak gradient • TR peak gradient, estimated RVSP/ PASP (mention RA pressure)

* Additional measurements will be needed depending on the underlying pathology

The scanning technique for obtaining each specific view

This section describes the basic technique involved in obtaining each specific view, various cardiac structures that are seen in that view and the measurements that can be obtained. However, it must be remembered that these are only basic guidelines aimed at helping relatively new echocardiographers in navigating through the challenges of obtaining different views. Keeping with the individual variations in body habitus and in cardiac size, shape and orientation, constant modifications in scanning technique are required in each individual patient to obtain the best possible images. With increasing experience, the echocardiographers develop the skill required to maneuver the transducer according to the imaging requirements.

When performing an echocardiogram, it is strongly recommended to first complete the recording of the entire sequence of images for all patients with any pathology to improve the quality of the diagnostic study. The individual pathology should then be delineated in greater detail, at the end of the protocol, using various non-conventional imaging planes and Doppler recordings.

The sequence of recording the mandatory views is designed to minimize abrupt changes in the probe and the patient's positions and to maintain a seamless work flow through various echo windows to reduce recording time. However, the sequence can be changed as per the clinical situation or the availability of / access to different echocardiographic windows.

Following nomenclature is used in the present document for describing the transducer manipulations (figure: STR maneuver)-

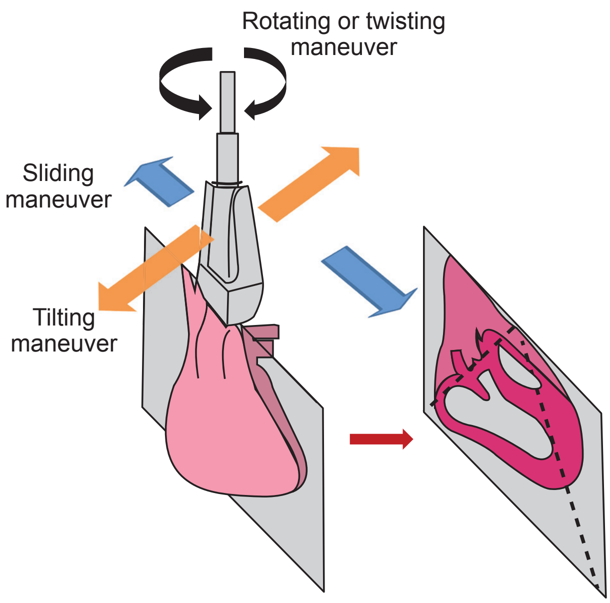

***Figure STR**: Depiction of transducer manipulations*

- Sliding: The transducer is moved in the direction parallel to its broader side, along the imaginary line passing through the orientation marker (X axis). This will move the image along the ultrasound scan plane.
- Tilting or angling: The transducer is tilted parallel to its shorter side or perpendicular to the ultrasound scan plane (Y axis). This maneuver will provide radial tomographic sections.

- Rotation or twisting: Refers to turning the index marker clockwise or counterclockwise around a fixed pivot, i.e. the long-axis of the transducer (Z axis). This maneuver will rotate the ultrasound scan plane

For each view, constant fine tuning of the transducer position and orientation is required using a combination of sliding, tilting or angling and rotating maneuvers to obtain the optimal views as described below.

Description of views

1) Parasternal long axis view (PLAX)

Purpose:

Overview of LV inflow, outflow, aortic root and LV dimensions; also helpful in assessment of perimembranous ventricular septal defect (VSD).

Measurements:

Mandatory: LV systolic and diastolic diameters; interventricular septal and posterior wall thickness.

Optional: LV fractional shortening

Technical description:

The transthor.25acic adult echocardiographic exam begins with a parasternal long axis view that profiles the left heart and the proximal right ventricular outflow tract (RVOT) in the sagital plane **(Figure 1, Video 1).** The patient is placed in the left lateral decubitus position with left arm raised. The transducer is positioned adjacent to the sternum in the left third or fourth inter-costal space. The orientation marker is directed towards the patient's right shoulder, and probe angled slightly to avoid foreshortening the LV.

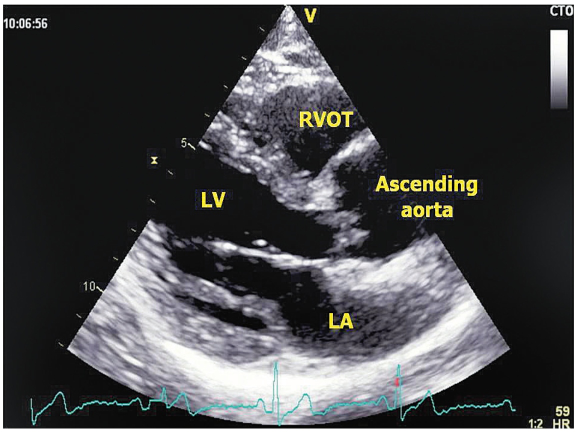

Figure 1: *PLAX view (see text for abbreviations and description).*

Depth is adjusted to include the echogenic pericardium posterior to the intefero-lateral wall. One cine loop is acquired at greater depth to rule out pericardial and pleural effusions. Sector width is adjusted to include the aortic root to the right and mid segments of the anterior septum and infero-lateral wall to the left. Record one ECG-gated loop with 3 (normal sinus) or 5 (atrial fibrillation) beats. .

Moving from left inflow to outflow, the antero-posterior cross section of the LA, mitral valve, chordae tendinae, LV cavity in long axis, left ventricular outflow tract, aortic valve and proximal ascending aorta can be appreciated in this view. The longer anterior mitral leaflet (above) and short posterior mitral leaflet (below) are visualized. The basal and mid segments of the anterior septum (above) and infero-lateral wall (below) are observed in parallel orientation. Sliding the probe one rib space inferiorly brings the distal segments into view, and is useful when profiling the LV during stress echocardiography studies. The apex is not visualized in this view. The tubular LVOT is visualized in long axis. Of the 3 aortic cusps, the right coronary cusp (above) and non-coronary cusp (below) are seen. The corresponding aortic sinuses, sino-tubular junction and proximal segment of the ascending aorta are also visualized. The proximal RVOT is visualized in its short to oblique axis.

Two-dimensional (2D) LV end-diastolic and end-systolic linear measurements: The end-diastolic frame is identified by the onset of QRS, when LV cavity is largest (the most preferred method) or in the frame just after MV closure. The end-systolic frame is identified when the LV is smallest or the frame just before the MV opens. Linear dimensions are to be taken at the level of the mitral chordae, perpendicular to the LV cavity. Measurements are made between the inner edge of the anterior septum and inner edge of the infero-lateral wall using 2D echo (preferred) or anatomical M-mode.

2A & B) PLAX mitral valve zoom 2D and color

Purpose:

2D: Mitral leaflet motion and pathology

Color: Detection of mitral regurgitation (MR), measurement of MR jet vena contracta

Measurements:

2D: Mandatory: Nil;

Optional - Mitral annulus antero-posterior diameter

Color: Mandatory: Nil;

Optional: vena contracta, proximal isovelocity surface area (PISA)

Doppler data: Qualitative

<u>Technical description:</u>

From the PLAX 2D view, a finer appreciation of the mitral valve can be obtained by magnifying the mitral apparatus using the zoom function **(Figure 2A, Video 2A).** In this view, the mitral annulus, anterior and posterior mitral leaflets and attached chordae are well visualized. A lateral and medial angulation of the probe provides for finer delineation of both antero-lateral and postero-medial commissures and papillary muscles respectively. This view is recommended when studying mitral leaflet motion and pathology. Mitral annulus antero-posterior diameter is to be measured at end-systole and end-diastole.

Placing a color window over the mitral valve in this view permits a qualitative evaluation of mitral regurgitation severity **(Figure 2B, Video 2B).** Subjects with significant jets demonstrate a well defined area of flow convergence proximal to the jet, a vena contracta at the point of coaptation, and regurgitant jet in the left atrium. Sector width is to be adjusted to cover the full extent of the regurgitant jet in the posterior left atrium.

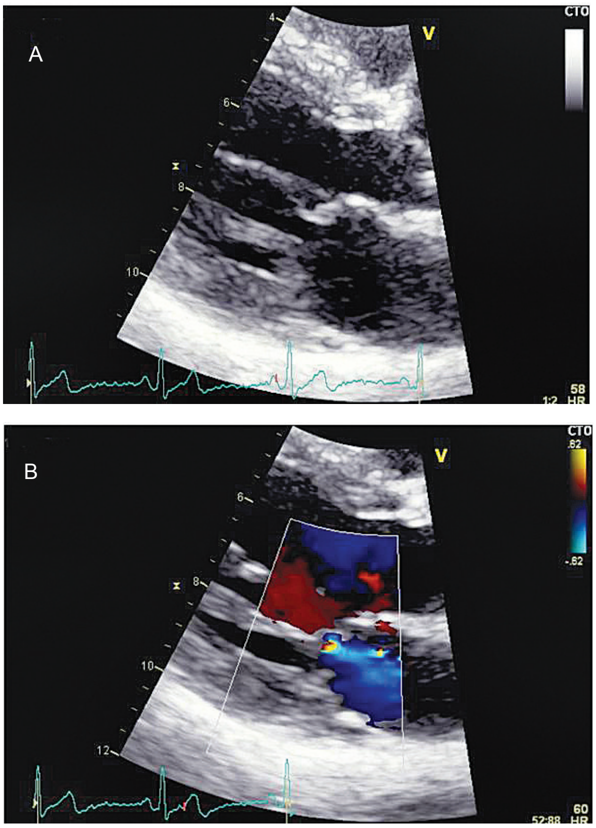

Figure 2: *Magnified view of mitral apparatus in PLAX view; (A) 2D image, (B) with color (see text for abbreviations and description).*

3A & B) PLAX aortic valve zoom 2D and color

<u>Purpose:</u>

2D: aortic valve and root pathology, LVOT size, subaortic membrane

Color: Detection of aortic stenosis (AS) or AR, measurement of AR jet vena contracta

<u>Measurements:</u>

2D: Mandatory- aortic annulus, aortic root at sinuses, sinotubular junction

Color: Mandatory - Nil
Optional: jet height, vena contracta

Doppler data: Qualitative

<u>Technical description:</u>

Acquiring a magnified view of the aortic valve provides vital information on the structure and pathologies of the left ventricular outflow tract (LVOT), annulus, aortic cusps with corresponding sinuses, the sino-tubular junction and proximal ascending aorta **(Figure 3A, Video 3A).** This is of particular relevance when measuring the LVOT diameter and cross-sectional area to calculate stroke volume, or studying structural abnormalities associated with the LV outflow tract. LVOT diameter is measured during mid systole (with the cusp maximally opened), around 0.5 to 1cm from the aortic annulus, from inner edge to inner edge. The aortic annulus itself is measured between the hinge points of aortic cusps, during mid-systole and from inner edge to inner edge.

Applying color Doppler to this view provides qualitative information on the severity and extent of valvular

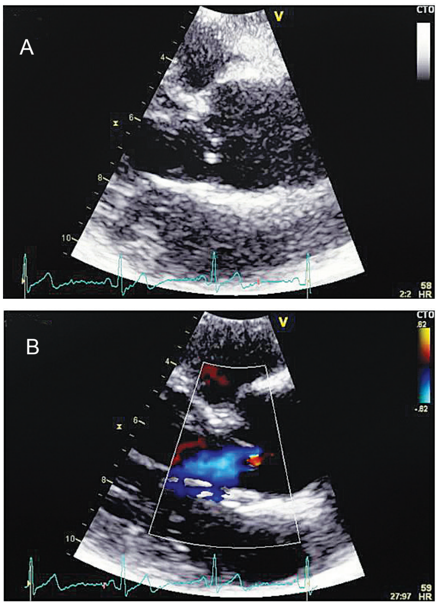

Figure 3: *Magnified PLAX view of the LVOT, aortic valve and ascending aorta; (A) 2D image, (B) with color (see text for abbreviations and description).*

regurgitation and / or valve stenosis **(Figure 3B, Video 3B).**

4A & B) PLAX ascending aorta 2D and color

Purpose:

2D: Ascending aorta dilatation, ascending aorta aneurysm, dissection flap etc.

Color: False lumen flow in case of dissection, AS jets

Measurements:

2D: Mandatory- ascending aorta size

2D: Mandatory- Nil
Doppler data: Qualitative

Technical description:

From the 2D PLAX view, the ascending aorta can be profiled by sliding the transducer one intercostal space higher **(Figure 4A, Video 4A**). With fine angulation, the long axis of the ascending aorta is profiled. Measurements made in this view include the diameter of the aortic annulus, sinus of valsalva, sinotubular junction and ascending aorta. Measurements are made at mid-systole, inner edge to inner edge. This view is recommended in the setting of ascending aorta dilatation, aneurysm and dissection. Placing a color box over this image provides qualitative information on flow profile in the ascending aorta, localizing false lumen and dissections confined to this region **(Figure 4B, , Video 4B).**

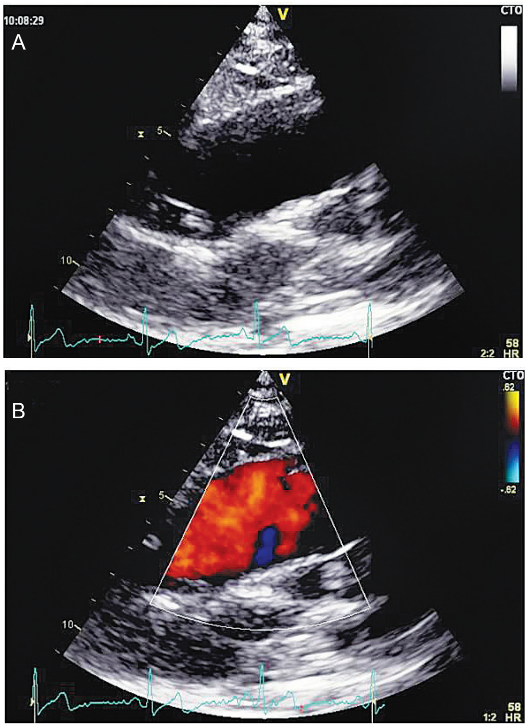

Figure 4: *Magnified view of the ascending aorta in PLAX; (A) 2D image, (B) with color (see text for abbreviations and description).*

5) PLAX RV inflow view with color

Purpose:

Tricuspid leaflet pathology, tricuspid regurgitation (TR) mechanism and severity

Measurements:

Mandatory- Nil
Doppler data: Qualitative for TR, also CW for estimation of TR gradient

Technical description:

The PLAX RV inflow view can be obtained by angling the transducer medially, towards the right hip **(Figure 5, Video 5).** In this view, the RA, TV, and RV can be visualized. The ostium of the inferior vena cava, including Eustachian valve, is seen draining into the RA. With slight angulation, the coronary sinus is also seen. The anterior tricuspid leaflet is seen to the right of the display and posterior leaflet towards the left of the display. This is the only view which shows the posterior tricuspid leaflet. The anterior wall of the RV is seen towards the right of the display and the inferior wall towards the left.

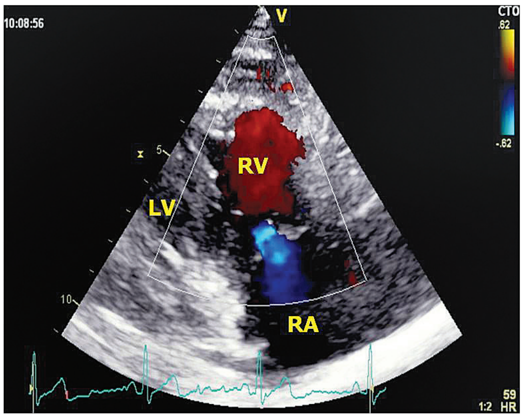

Figure 5: *PLAX RV inflow view with color doppler (see text for abbreviations and description).*

TR jet parameters can be measured in this view using color and CW Doppler provided the jet is parallel to the ultrasound beam.

6A & B) PSAX at the level of semilunar valves- 2D and color

Purpose:

2D: Aortic valve, RVOT, pulmonary valve pathology, may also be helpful in assessment of atrial septal defect (ASD)

Color: To detect perimembranous / supra-cristal VSD, RVOT stenosis, TR

Measurements:

2D: Mandatory – Pulmonary valve annulus size

Color: Mandatory- Nil
Doppler data: Qualitative

Technical description:

The parasternal short axis view is obtained from the PLAX view by rotating the transducer orientation mark by 90 degrees in the clockwise direction, such that it points to the patient's left shoulder. Moving the transducer superiorly with a slight cranial angulation provides a cross-section of the aortic root **(Figure 6A, Video 6A).** The commonly referred to "circle and sausage" view profiles the aortic root (circle) surrounded by the right ventricular outflow tract (sausage). Additionally, this view profiles the RA, the anterior and septal leaflets of the TV, the RV, RVOT, PV, and main pulmonary artery. With slight angulation, the bifurcation of the pulmonary artery into the right and left branches can be visualized. Angulating the probe posteriorly brings the LA appendage into view. A shift in rib interspace may occasionally be necessary to optimize the view. Applying color Doppler to this view **(Figure 6B, Video 6B)** provides a qualitative assessment of stenosis or regurgitation related to the aortic, tricuspid or pulmonic valves. In addition, ventricular septal defects can be characterized based on location as either peri-membranous (9 to 12 o'clock position), or outlet / supracristal / subpulmonic (12 to 3 o'clock position).

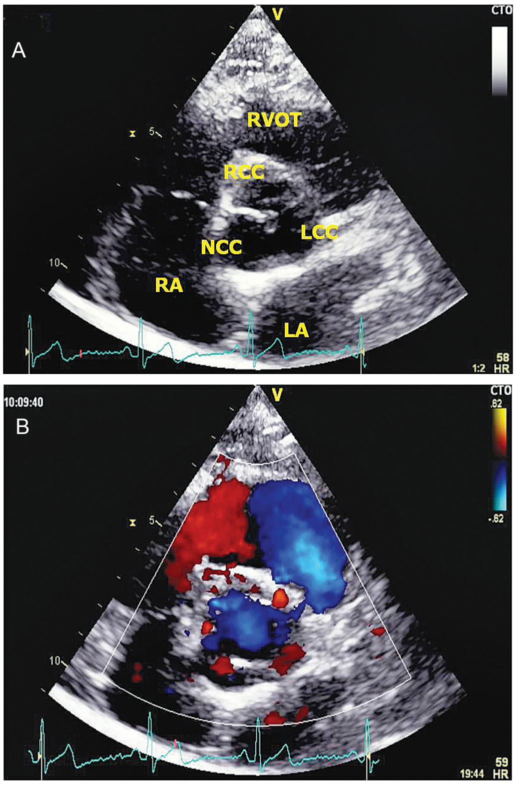

***Figure 6:** PSAX view at the level of semilunar valves (see text for abbreviations and description).*

7A & B) PSAX aortic valve zoom 2D and color

Purpose:

2D: Aortic leaflet pathology, coronary ostia

Color: Detection and assessment of AR jet origin and severity

Measurements:

2D: Mandatory- aortic valve planimetry in patients with AS in patients with adequate visualization of the aortic cusps

Color: Mandatory- Nil
Optional- AR jet area
Doppler data: Qualitative

Technical description:

A magnified view of the aortic root provides a clear demonstration of aortic cusp morphology and motion **(Figure 7A, Video 7A).** With a slight superior angulation, the proximal right coronary artery and left coronary artery can be visualized arising from the anterior (right sinus) and left and posterior (left sinus) sinuses respectively. The non coronary sinus (right and posterior) is identified by the attachment of interatrial septum Coronary arteries are best visualized using a higher transducer frequency with careful adjustment of the focus. The left coronary artery arises at the 4 o' clock position at the level of the pulmonary valve, and the right coronary artery is seen at the 11 o'clock position coursing between the RA and the RV. Fine angulation permits the visualization of the bifurcation of the left coronary artery into the left anterior descending and the left circumflex in select patients. Placing a color Doppler window in this view permits for qualitative

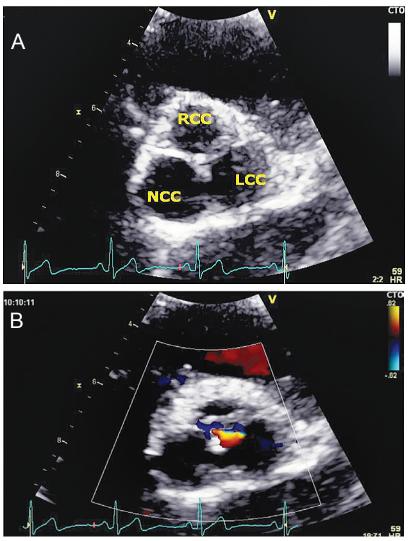

***Figure 7:** PSAX aortic valve zoomed view; (A) 2D image, (B) with color (see text for abbreviations and description).*

estimation of AR severity by comparing AR jet area to the Ao root area. With a reduction of the Nyquist limit, diastolic flow in the proximal coronary arteries can be visualized in select patients **(Figure 7B, Video 7B).**

8A & B) PSAX main pulmonary artery (MPA) and bifurcation with color and spectral Doppler [optional pulmonary regurgitation (PR) jet CW]

Purpose:

Color Doppler: To detect pulmonic stenosis (PS), PR or ductal flow

PW / CW: PS, high pulmonary vascular resistance (PVR) pattern etc.

Measurements:

Mandatory: Peak pulmonary velocity, peak PS gradient when present, end-diastolic PR gradient when present, peak and trough gradient across patent ductus arteriosus when present.

Optional: pulmonary velocity time integral (VTI), pulmonary acceleration time etc. Doppler data: Quantitative for shunt, PVR calculation

Technical description:

A fine anterior angulation of the probe from this position brings the RVOT, MPA, the left pulmonary artery and the right pulmonary artery into view. Color Doppler provides for a qualitative assessment of pulmonary regurgitation (PR) and localizes a region of turbulence in the setting of infundibular, valvular or branch stenosis **(Figure 8A, Video 8).** In subjects with congenital heart disease, this view is also employed to visualize a patent ductus arteriosus flowing from the descending aorta into the left pulmonary artery. A pulse wave Doppler sample volume placed in the RVOT at the level of pulmonary annulus provides information on the peak flow velocity **(Figure 8B).** Alternatively, the spectral tracing also provides for assessment of pulmonary hypertension from PR and calculation of pulmonary vascular resistance. In the setting of an increased velocity, PW can be used to map the area to locate the specific region of flow increase, and a subsequent switch to CW Doppler allows for quantification of the jet velocity and corresponding pressure gradient.

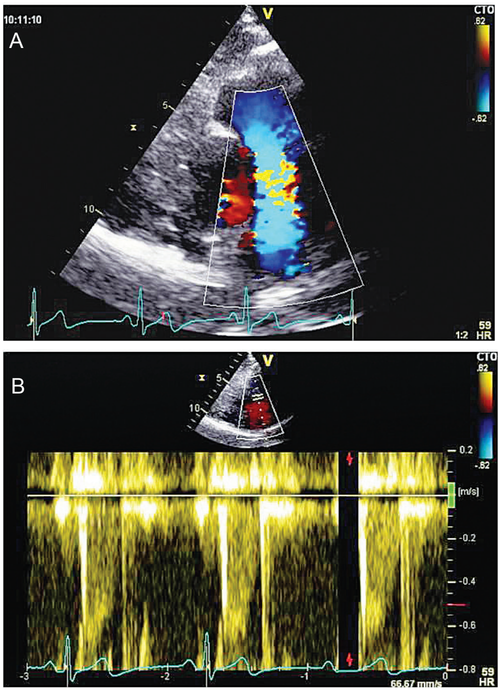

Figure 8: *PSAX view showing RVOT, MPA and its bifurcation; (A) with color, (B) RVOT flow spectral signal on PW (see text for abbreviations and description).*

9) LV SAX at mitral valve level 2D (optional mitral color Doppler)

Purpose:

RWMA, mitral valve end-on view for the assessment of mitral valve pathologies such as prolapse, MS (planimetry, commissures, etc)

Measurements:

Mandatory: Nil; mitral valve area in those with MS.

Optional: 2D circumferential and radial strain, basal rotation

Doppler data: Qualitative for regurgitant orifice

Technical description:

From the PSAX at the level of the semilunar valves, an inferior sweep by sliding the probe caudal and leftwards provides for imaging the left ventricle from base to apex in SAX. A change in intercostal space is necessary to ensure a perpendicular orientation of the short axis planes. The LV SAX at the mitral valve level is characterized by a "fish

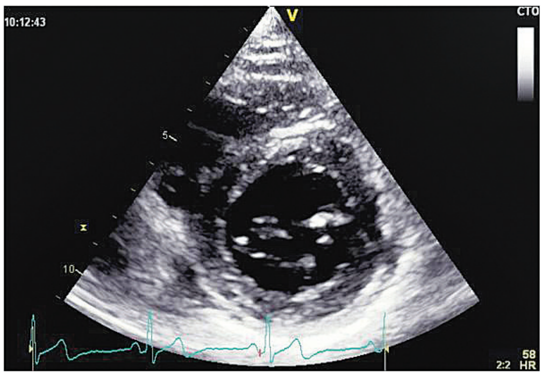

Figure 9: *LV SAX view at the level of the mitral valve (see text for abbreviations and description).*

mouth" appearance of the anterior and posterior mitral leaflets **(Figure 9, Video 9).** Alternatively, an M Mode performed across the valve with a sweep speed of 100 mm/sec provides details of leaflet motion during the cardiac cycle. Pathologies such as mitral valve prolapse can be further characterized using high temporal frame capture on M-Mode. In the setting of MS, a careful sweep starting from the papillary muscles till the LVOT SAX provides for an accurate planimetry of the mitral valve area at the level of the leaflet edges and the extent and morphology of commissural and chordal fusion. Mitral annular and leaflet calcium can also be demonstrated using a careful upward and downward sweep of the transducer. The basal 6 segments of the LV can be identified in this view in keeping with the current 17-segment nomenclature. Starting from the basal anterior septum adjacent to the right ventricle, moving in a clockwise direction, the basal anterior wall, basal anterolateral wall, basal infero-lateral wall, basal inferior wall and basal inferior septum are visualized.

10) LV SAX at papillary muscle level

Purpose:

Assessment of LV ejection fraction (LVEF), RWMA; LV mass estimation; papillary muscle geometry and morphology

Measurements:

Mandatory: Nil

Optional: LV mass calculation, 2D circumferential ` and radial strain

Technical description:

From the LV SAX at the base of the heart, an inferior sweep and slide provides for an assessment at the level of the mid papillary muscles **(Figure 10, Video 10)**. An optimal transducer position demonstrates a circular LV cross-section with the antero-lateral papillary muscle at the 4 o' clock position, and postero-medial papillary muscle at 8 o' clock position. Care is to be taken to avoid a non-perpendicular cut plane that distorts internal dimensions, and overestimates LV size and contractility.

The mid papillary muscle level clip provides for a convenient eye-balling of LV systolic function and assessment of regional wall motion abnormalities in the 6 segments at the mid LV cavity plane. Starting from the mid anterior septum adjacent to the right ventricle, moving clockwise, the mid anterior wall, mid antero-lateral wall, mid infero-lateral wall, mid inferior wall and mid inferior septum are visualized. Asymmetric wall thickness, if observed, can be measured using corresponding M-Mode measurements of the septal and inferior wall. This view also provides information on papillary muscle morphology and geometry.

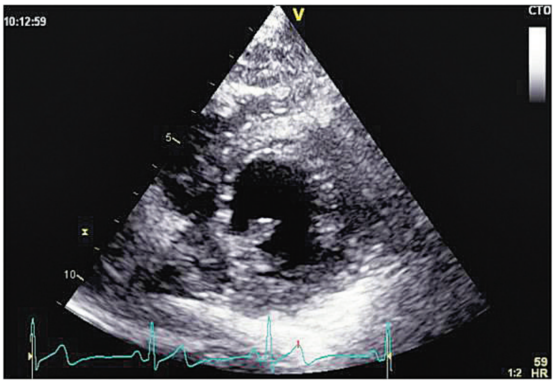

Figure 10: *LV SAX view at the level of the papillary muscles (see text for abbreviations and description).*

11) LV SAX at apex 2D

Purpose:

Assessment of RWMA; detection of LV apical clot; assessment of pathologies such as non-compaction

Measurements:

Mandatory- Nil

Optional- 2D circumferential and radial strain, apical rotation

Technical description:

From previous view, by angling and sliding the transducer even more inferiorly, a uniform tapering and reduction in cavity size is observed with the LV apex coming

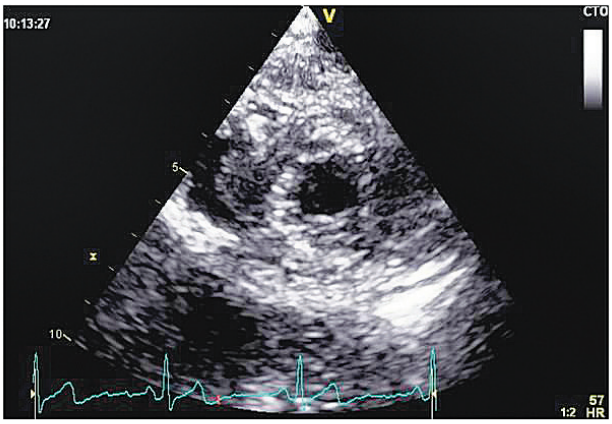

Figure 11: *LV SAX view at the level of apex (see text for abbreviations and description).*

into view (**Figure 11, Video 11).** The apico-anterior wall, apico-lateral wall, apico-inferior wall and apical septum are visualized. The apical 4 segments provide information on regional wall motion abnormality, pathologies such as LV non-compaction, apical aneurysms and thrombus.

12) Apical 4 chamber view with pericardial space

Purpose:

Overview of chambers, pericardial or extra cardiac pathology, ASD

Measurements:

Mandatory- LA, RA, RV diameters; LA area

Optional- RA area, RV fractional shortening; LV length

Technical description:

The apical 4 chamber view is acquired with the patient positioned in the steep left lateral decubitus position. A bed with a cut-out section that allows convenient access to the region under the left breast tissue is recommended for optimal imaging. The apical pulse is palpated and the probe positioned slightly lateral to this position. The orientation marker is positioned at the 5 o'clock position to image the four chambers of the heart. The patient may be requested to suspend respiration at end-expiration during image acquisition to reduce translational disturbances.

The apical 4 chamber showcases the ventricles above and atria below **(Figure 12, Video 12).** The insertion of the septal TV leaflet is seen slightly apical to the MV leaflet. The mitral and tricuspid leaflets should be seen during the earliest systole and diastole. The smooth walled, ellipsoidal LV forms the true apex of the heart, while the thin walled, trabeculated, wedge-shaped RV is observed to the right (left of the display). To ensure that the LV is not foreshortened, the lowest possible apical window is suggested, and the apex should be seen triangular and thickening in systole (in a normal heart). Generally, the length of the LV is 2 - 3 times that of the major linear axis of the LA. Once in the correct position, fine adjustments to transducer frequency, focus, time gain compensation, and overall gain are made to ensure optimal delineation of the endocardium across all segments of the LV. Use of tissue harmonics is recommended to improve tissue-blood pool demarcation.

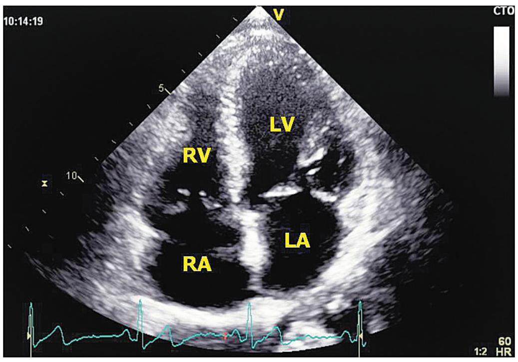

***Figure 12:** Apical four-chamber view (see text for abbreviations and description).*

13) Focused LV 4 chamber view

Purpose:

RWMA in lateral wall and septum, LV volume estimation, high frame rate images for 2D strain etc.

Measurements:

Mandatory- LV volume and EF by Simpson's method

Optional- 2D longitudinal strain

Technical description:

A magnified view of the LV provides a more detailed evaluation of LV volumes and function. In the focused LV 4 chamber view, the septum is vertically positioned in the center of the screen and divides the two ventricles **(Figure 13, Video 13).** A rightward orientation of the septum can be corrected by moving the probe laterally and a leftward deviation, by moving the probe medially. The focal point should be adjusted at the mid cavity level. For accurate assessment of LV volumes and regional wall motion abnormality, an optimal delineation of the endocardium is essential. Selective enhancement of the antero-lateral and septal segments is possible on certain equipments employing lateral gain compensation. In the eventuality of inability to track the endocardial surface in > 80% of the segments, or in the absence of clear visibility of 3 or more segments, use of contrast is recommended.

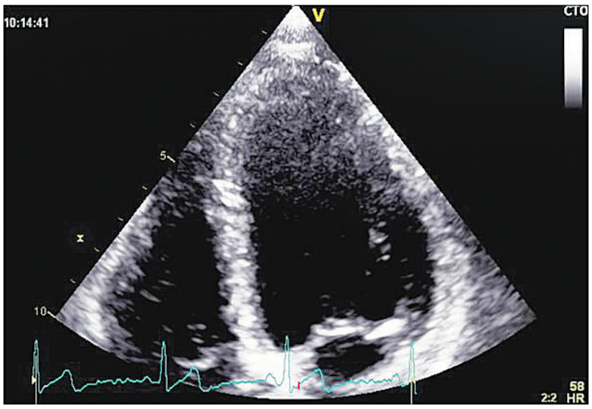

***Figure 13:**Focused LV apical four-chmaber view (see text for abbreviations and description).*

To obtain LV volumes and EF using Simpson's method of discs, first ensure optimal endocardial definition in the focused LV four-chamber view and then trace the endocardial border in the end-diastolic frame (the frame showing the largest LV cavity size, usually the frame immediately after mitral valve closure) and the end-systolic frame (the frame showing the smallest LV cavity size, usually the frame just before mitral valve opening). The endocardial border is traced from the point of insertion of anterior mitral leaflet into the septum in a clockwise direction till the insertion of the posterior leaflet into the lateral wall. The system then calculates a volume based on the summation of 2D generated discs. These steps are repeated in the end-systolic frame. When both end-diastolic and end-systolic measurements are repeated in the focused 2 chamber view, the system generates an automated biplane 2D EF based on these volumetric measurements.

14) Focused LV 2 chamber view

Purpose:

RWMA in anterior and inferior wall, high frame rate images for 2D strain etc.

Measurements:

Mandatory- LV volume and EF by Simpson's method

Optional- 2D longitudinal strain

Technical description:

The focused LV 2 chamber view can be obtained from the focused 4 chamber view by rotating the transducer counterclockwise by approximately 60 degrees **(Figure 14, Video 14).** This view provides a complete visualization of the anterior wall to the right of the display and the inferior wall to the left of the display. Asking the patient to take a shallow inspiration can often help improve visualization of the anterior wall. The left atrial appendage is seen to the right of the display. The RV should not be visible in this view. Avoid showcasing papillary muscles. However, by tilting the transducer one should be able to image both the papillary muscles from their origins to insertions into the mitral valve. Descending thoracic aorta can be visualized beneath the aria.

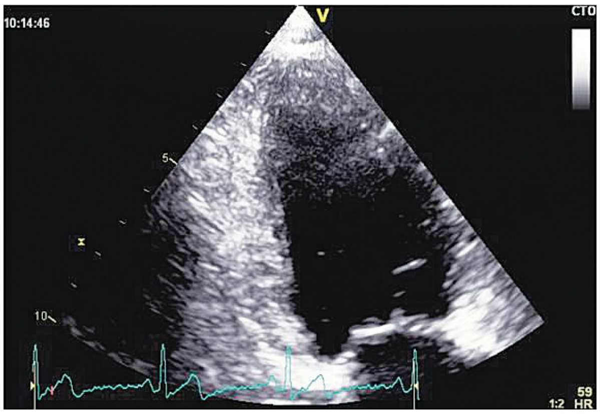

Figure 14: *Focused LV apical two-chamber view (see text for abbreviations and description).*

15) Focused LV apical long axis view

Purpose:

RWMA in anterior septum, infero-lateral or posterior wall; high frame rate images for 2D strain etc.

Measurements:

Mandatory- Nil

Optional- 2D longitudinal strain

Technical description:

A further 60 degree counterclockwise rotation with a slight anterior angulation reveals the apical long axis view,

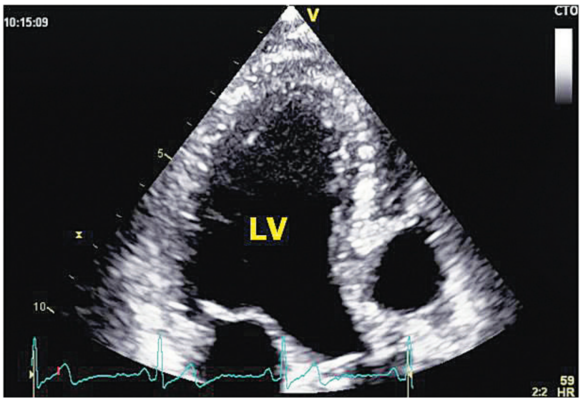

Figure 15: *Focused LV apical long-axis view (see text for abbreviations and description).*

also called the apical 3 chamber view **(Figure 15, Video 15).** This view is analogous to the PLAX view, except that distal LV segments and apex are also seen in this view. The infero-lateral wall is seen to the left of the display and anterior septum to the right of the display. The apical 3 chamber is recommended to visualize systolic anterior motion of the mitral leaflets, LVOT dynamic obstruction, and aortic valve stenosis or regurgitation.

16A & B) Zoomed LV inflow and out flow view 2D and color

Purpose:

2D: LVOT dynamic narrowing, systolic anterior motion of mitral leaflets / chordae, mitral valve pathology etc.

Color: LVOT dynamic obstruction, MR/ AR jet delineation etc

Measurements:

2D: Mandatory- Nil

Color: Mandatory- Nil
Doppler data: Qualitative, quantitative for MR effective regurgitant orifice area by PISA method.

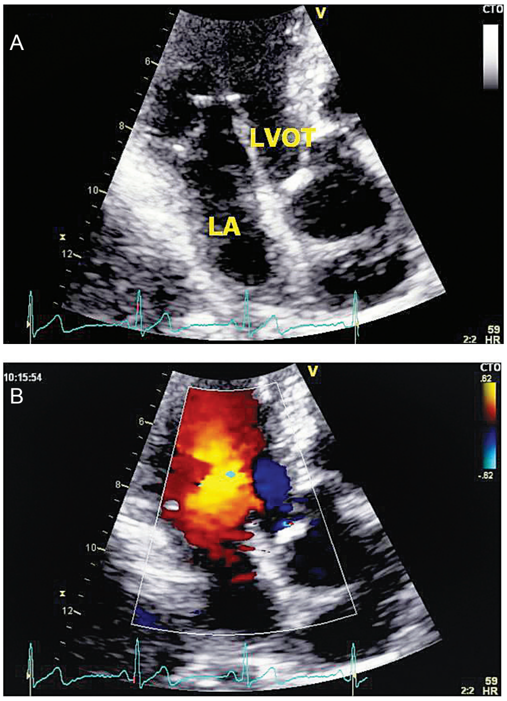

Figure 16: *Magnified view of the LV inflow and outflow; (A) 2D image, (B) with color (see text for abbreviations and description).*

Technical description:

A magnified view of the LV inflow and outflow can be obtained by employing the zoom function **(Figure 16A, Video 16A).** This view is of particular interest when assessing systolic anterior motion of the mitral valve, chordal pathology, or dynamic narrowing across the LVOT. Applying a color window across this frame provides qualitative information on flow across the mitral inflow and LV outflow **(Figure 16B, Video 16B).**

17) & 18) Zoomed LA 2-chamber and 4-chamber views 2D

Purpose:

LA intra-cavity pathology, LA volume estimation

Measurements:

Mandatory- LA area for volume estimation

Optional- 2D LA strain

Technical description:

The left atrium is best assessed employing a magnified view of the LA, as seen in the apical 2-chamber **(Figure 17, Video 17)** and 4-chamber views **(Figure 18, Video 18).** The zoom function is employed after identifying the LA as the region of interest. For optimal penetration, a lower transmit frequency is recommended, with the focal plane adjusted at the level of the LA cavity. LA area and volume is measured when the LA is maximally dilated during the end-systolic frame. The pulmonary veins and LA appendage are excluded while tracing the LA borders. LA length is measured as the distance between the LA roof and the level of the mitral annulus. The shorter of the two lengths measured in the 4 chamber and 2 chamber view is employed to calculate LA volume by the area-length method. All measurements should

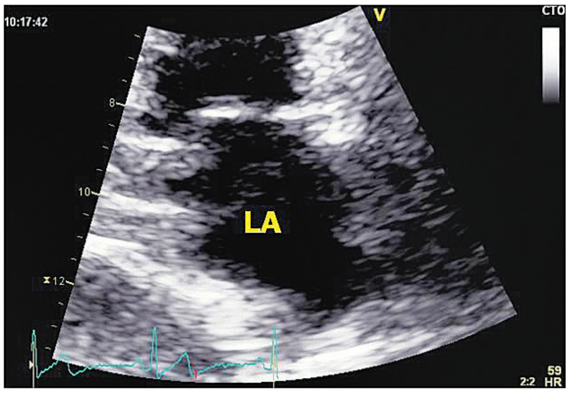

Figure 17: *Magnified view of the LA seen in the apical two-chamber view*

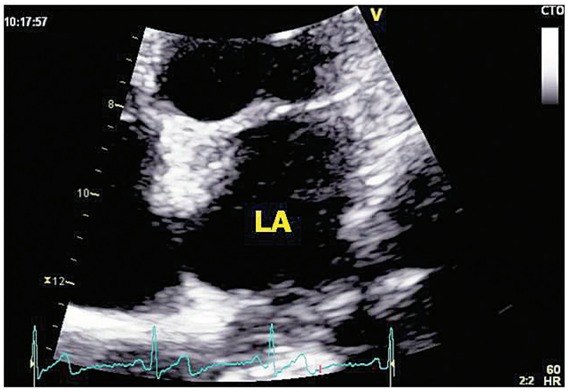

Figure 18: *Magnified view of the LA seen in the apical four-chamber view.*

be indexed to body surface area.

19) Pulmonary vein flow PW spectral Doppler

Purpose:

Assessment of LV diastolic function

Measurements:

Mandatory – Pulmonary vein flow systolic, diastolic and atrial reversal velocities

Optional- Duration of atrial reversal wave
Doppler data: Qualitative

Technical description:

In the apical 4 chamber view, an assessment of pulmonary venous flow provides complimentary information on LV diastolic function **(Figure 19, Video 19).** Lower transmit

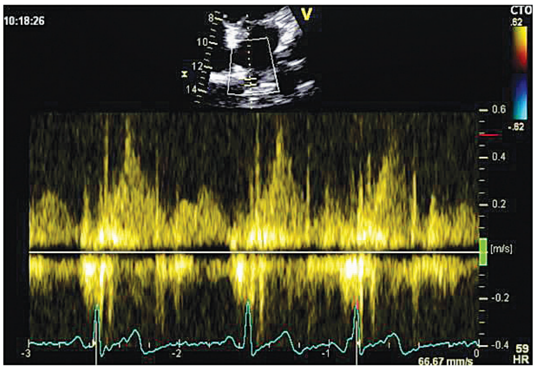

Figure 19: *Pulmonary venous flow into the LA seen on PW doppler (see text for abbreviations and description).*

frequencies are recommended and the focal point adjusted at the plane of the LA roof. To obtain an optimal spectral flow pattern, the probe is angled slightly posterior from the apical position to image the right lower pulmonary vein breaking into the LA. A 2-3 mm sample volume is placed >0.5 cm into the vein, and the velocity scale decreased to accommodate low velocity flow. Certain equipment provide a low pulse repetition frequency function that can be activated to profile pulmonary venous flow. Wall filters may need to be adjusted to minimize noise. Sweep speed is adjusted between 50 and 100 mm/sec at end expiration and an average of 3 consecutive cardiac cycles are obtained.

20A & B) Focused (LA-LV) mitral flow color and PW spectral Doppler (Optional CW for MR and MS)

Purpose:

Detection and evaluation of MR

LV diastolic function assessment, mitral stenosis severity

Measurements:

Mandatory- Mitral inflow early and late diastolic velocities, deceleration time of early diastolic wave

Optional- LV inflow flow propagation velocity, PISA for MR, isovolumic relaxation time, MS severity assessment (pressure gradients, valve area by pressure half-time), MR dP/ dt

Doppler data- Color image: Qualitative for MR, quantitative for PISA

PW: Quantitative for LV diastolic function, MS & MR, transvalvar diastolic forward flow measured at mitral annulus

Technical description:

Applying color flow across the mitral valve in the focused LA-LV view provides information on the hemodynamic severity of MR, in addition to studying mitral inflow **(Figure 20A, Video 20).** Care is to be taken to ensure a color window as narrow as possible that covers the MV to avoid a drop in frame rate, and maintain a Nyquist velocity of approximately 50 to 60 cm/sec.

A PW Doppler interrogation of mitral inflow lends significant information to the assessment of LV filling **(Figure**

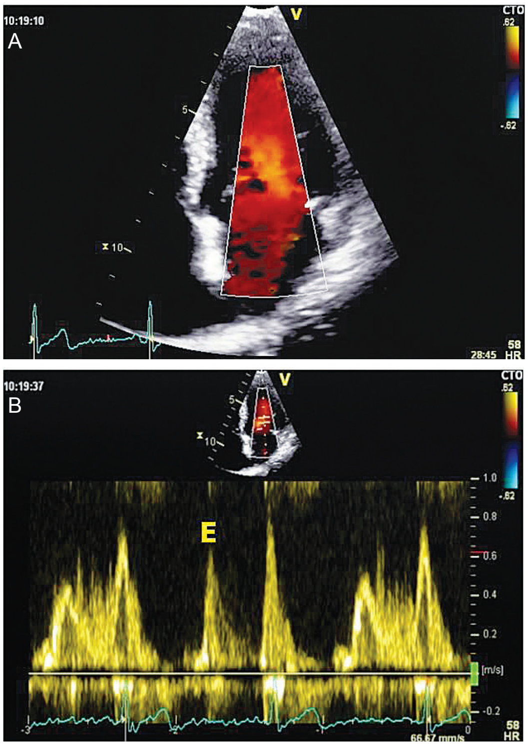

Figure 20: *(A) demonstrates color flow across the mitral valve in the color LA-LV view; (B) mitral inflow PW spectral Doppler (see text for abbreviations and description).*

20B). A 1-3 mm sample volume is placed at the tips of the mitral leaflets in the LV and positioned slightly closer to the lateral wall in keeping with flow direction across the valve. Color flow imaging may assist in optimal alignment of the Doppler beam. Spectral mitral inflow velocities are initially obtained at a sweep speed of 25 to 50 mm/sec to evaluate respiratory inflow variation. In the setting of no respiratory variation, the sweep speed is adjusted to 100cm/sec, averaged over 3 cardiac cycles and captured at end-expiration.

Spectral gain and reject are adjusted to display a crisp diastolic profile across the valve. The resultant spectral pattern should demonstrate a well-defined E wave generated by early filling, and A wave generated by atrial contraction (in normal sinus rhythm).

21A) & 21B) Mitral annular tissue Doppler (medial and lateral)

Purpose:

LV systolic longitudinal function, diastolic function

Measurements:

Mandatory: Mitral annular early diastolic velocity (E’), mitral annular systolic velocity (S’)

Optional: Late diastolic velocity (A’)

Doppler data: Quantitative for LV diastolic function

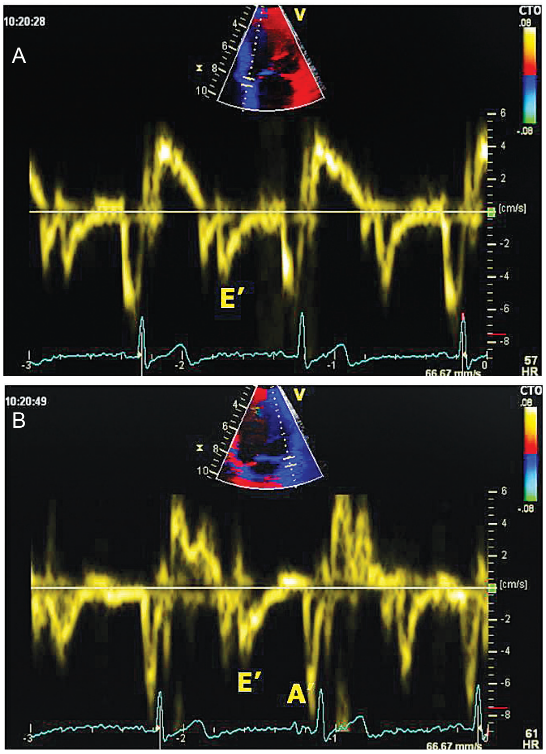

Figure 21: *Mitral annular velocities on PW tissue Doppler imaging; (A) medial annulus, (B) lateral annulus (see text for abbreviations and description).*

Technical description:

Mitral annular tissue Doppler is obtained from the apical 4 chamber view by placing the PW sample volume on the medial and lateral annular junctions **(Figures 21A & B, Video 21).** All tissue Doppler presets on equipment are set to filter out high velocity, low amplitude signals and amplify low velocity, high amplitude signals generated by the myocardium, hence no gross manual adjustments may be required. By narrowing the tissue Doppler color TDI window to cover the medial annulus and lateral annulus separately, an optimal frame rate of 100 -120 frames per second can be acquired.

A 5-10mm sample volume is placed at or 1cm within the insertion sites of the mitral leaflets on septal or lateral walls, and adjusted to cover the longitudinal excursion of the annulus in both systole and diastole. Care is to be taken to ensure an angulation of less than 20 degrees between the ultrasound beam and plane of annular motion. The velocity scale is adjusted to 20 cm/sec to profile myocardial velocities above and below the baseline. The tracing is recorded at a sweep speed of 100 cm/sec at end-expiration. 2D reference frame is frozen to improve delineation of the spectral waveform, and an average of 3 consecutive cardiac cycles is considered. The S’, E’ and A’ are measured in this view. In conjunction with the early mitral inflow velocity (E), acquired using PW Doppler, a non-invasive assessment of LV filling pressures (E/E’) is possible. Myocardial performance index can also be measured from these images, considering mitral closure to opening time and ejection time.

22A), 22B) & 22C) Zoomed 5 chamber LVOT- 2D, color, PW spectral Doppler

Purpose:

2D: LVOT dynamic or fixed stenosis, perimembranous VSD etc

Color: LVOT dynamic or fixed stenosis, perimembranous VSD etc

PW: LV stroke volume, LVOT dynamic or fixed stenosis, etc.

Measurements:

2D: Nil

Color: Nil

PW: Quantitative for stroke volume, continuity equation

Technical description:

A more detailed evaluation of the LVOT is essential to assess dynamic or fixed obstruction, in addition to providing a frame for accurate PW/CW measurements **(Figure 22A, Video 22A)**. Color flow across the LVOT provides a qualitative assessment of AR and localization of the site of obstruction, if present **(Figure 22B, Video 22B)**. Systolic anterior motion (SAM) of the mitral valve is well visualized in this view. To assess LVOT flow or measure stroke volume using PW Doppler, a sample volume is placed just proximal to the aortic valve in the center of the LVOT (**Figure 22C**). In calcified, degenerative aortic stenosis, care should be taken to avoid placing the sample volume too close to the aortic cusps, as this can cause an artifactual increase in LVOT velocities. The sample volume position should also correspond to the location used to assess LVOT cross-section in the 2D PLAX view. In the event of an aliasing spectral pattern, the sample volume can be moved towards the LV to localize the site of obstruction. In a normal heart, the peak velocity should rapidly decline with this maneuver.

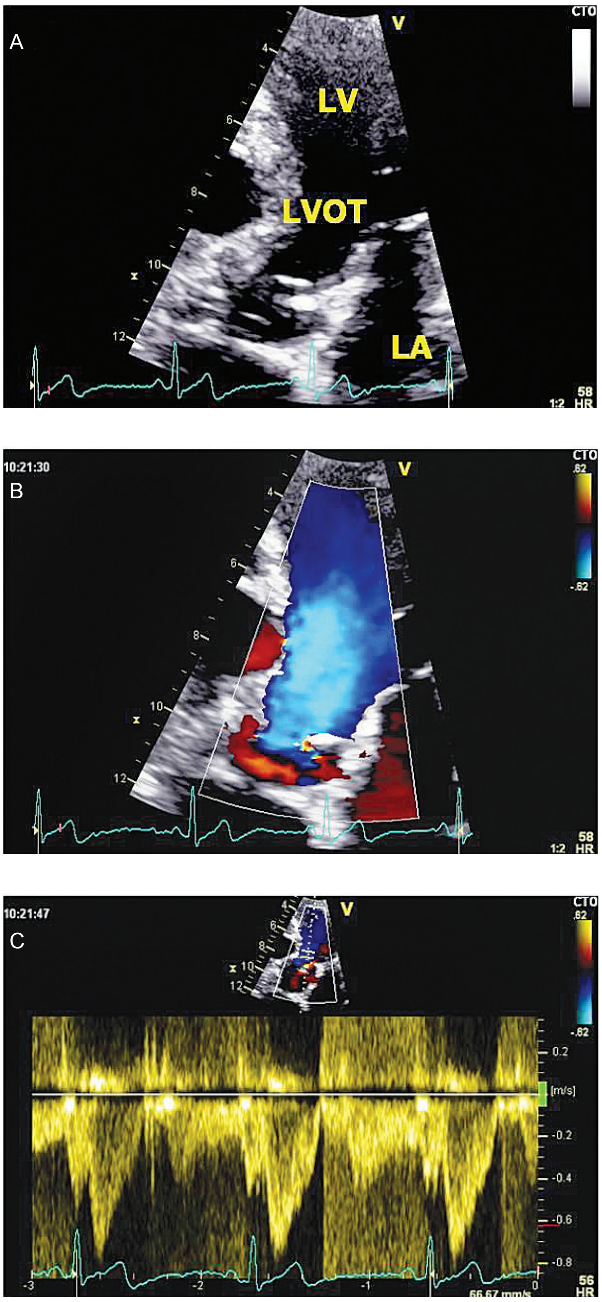

Figure 22: *Magnified view of the LVOT; (A) 2D image, (B) with color, (C) LVOT flow on PW Doppler (see text for abbreviations and description).*

23) Aortic valve flow CW Doppler

Purpose:

Quantification of AS severity Measurements:

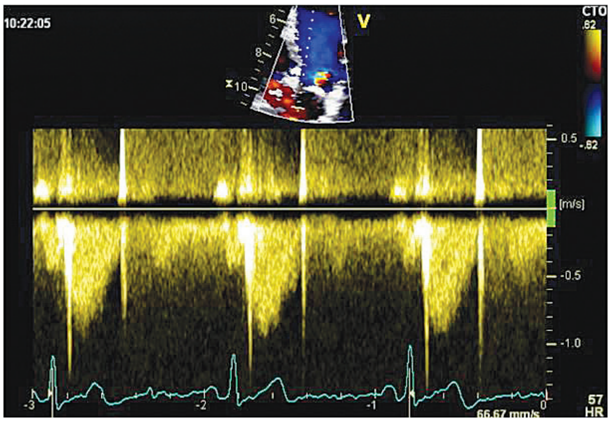

Figure 23: *Demonstrates flow across the aortic valve assessed by CW Doppler (see text for abbreviations and description).*

Mandatory: AS peak and mean gradients, aortic flow VTI

Doppler data: quantitative for aortic valve area estimation by continuity equation

Technical description:

Switching to CW Doppler in the previous view provides an assessment of the maximum flow across the AoV **(Figure 23, Video 23).** A peak velocity and VTI obtained from CW can be used in conjunction with the corresponding values obtained in the LVOT to assess AVA using the continuity equation. All spectral Doppler frames are to be recorded at 100 mm/sec, adjusting baseline and velocity scale to ensure optimal measurement. Like all Doppler evaluations, care is to be taken to ensure the beam is as parallel as possible to blood flow.

24A, B, C & D) Focused RA-RV view 2D, Tricuspid flow color Doppler, CW and PW

Purpose:

- 2D: RV size and function, interventricular septal motion, intracavity clot, mass etc.
- Color: Detection of TR
- CW: RV / PA systolic pressure
- PW: RV diastolic function, tricuspid stenosis etc.

Measurements:

- 2D: Mandatory- RA, RV dimensions

  Optional - Tricuspid annular plane systolic excursion (TAPSE), TV annular size
- Color: Mandatory- Nil

  Optional - TR jet PISA
  Doppler data: Qualitative
- CW: Mandatory - TR jet peak gradient
  Doppler data: Quantitative for PASP, RV dp/dt etc.
- PW: Mandatory - Tricuspid inflow early diastolic velocity

  Optional - Tricuspid inflow late diastolic velocity, deceleration time of early diastolic wave, pressure half-time

  Doppler data: Quantitative

Technical description:

To perform a focused evaluation of the RV, one would need to begin with the apical 4 chamber view and align the RV with the center of the screen. This view is obtained by moving the transducer slightly medially and reducing the sector width to encompass the RA and RV. In a normal heart, the RV is less than two-thirds the size of the LV (**Figure 24A, Video 24)**. RV size is assessed by measuring diameters at the base and mid-cavity region at end-diastole, when the chamber size is largest. The length of the RV is assessed from the plane of the TV annulus till the RV apex in this view.

Tricuspid annular plane systolic excursion (TAPSE) is an evaluation of the systolic longitudinal excursion of the RV annulus and is representative of RV systolic function. This is performed by placing an M mode cursor through the annulus and measuring the displacement at peak systole.

Placing a color Doppler window across the TV in this view allows one to qualitatively assess the severity of TR,

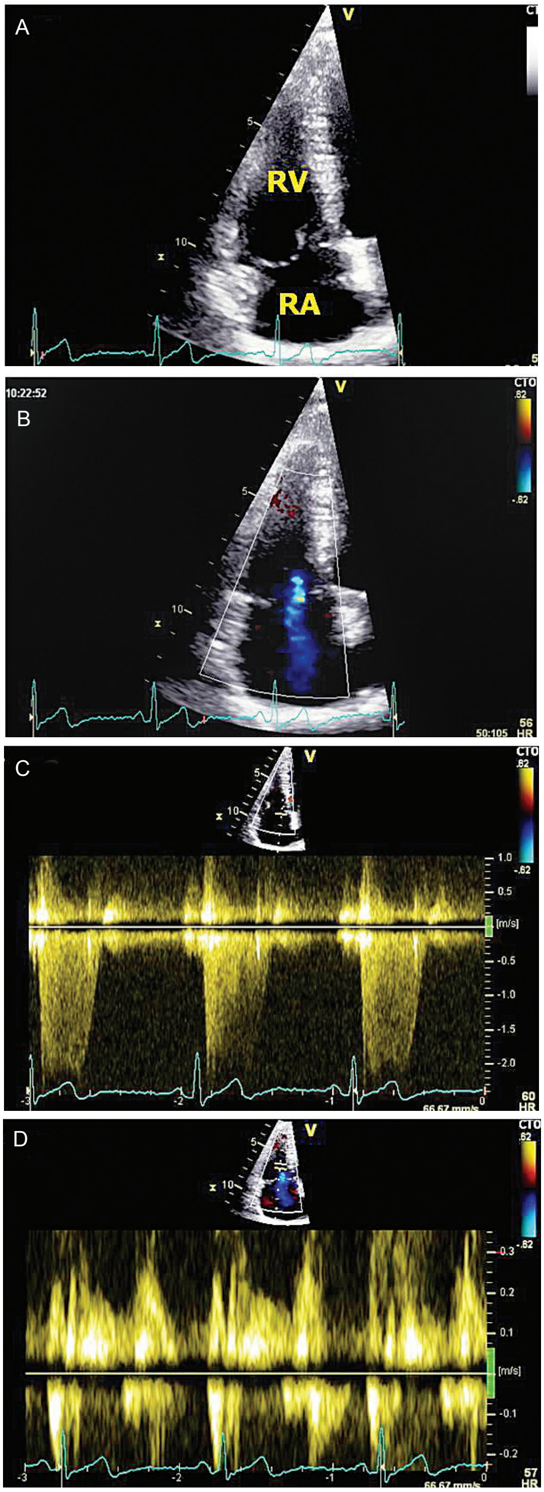

Figure 24: *Demonstrates an RV focused view obtained from the apical 4 chamber view; (A) 2D image, (B) with color showing TR jet, (C) TR jet assessed by CW Doppler, (D) flow acoross the TV assessed by PW doppler (see text for abbreviations and description).*

or turbulence across the TV **(Figure 24B, Video 24)**. An approximation of RV systolic pressure can be obtained by assessing the TR jet with CW Doppler **(Figure 24C)** and adding the resultant peak pressure gradient to RA mean pressure as assessed by inferior vena cava (IVC) size and collapsibility. The cursor is aligned as parallel to the flow as possible. Once the spectral Doppler is obtained, the baseline and velocity scale are adjusted to measure the peak velocity. Spectral gain can be adjusted to provide an optimal delineation of flow pattern. An additional measure of forward flow using PW/CW Doppler across the valve may be useful to study diastolic properties of the RV, or measure TS gradient **(Figure 24D).** Tissue Doppler of the lateral tricuspid annulus can also be performed, in a manner analogous to the mitral valve, to measure systolic and diastolic function of the RV.

25) Sub-costal four-chamber view (RV focused)

Purpose:

2D: RV free wall thickness measurement

Measurements:

2D: Mandatory: Nil

Optional: RV free wall thickness measurement

Technical description:

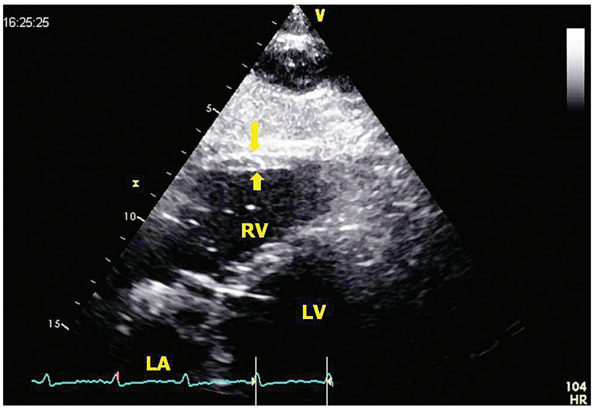

Figure 25: *RV focused subcostal four chamber view for measurement of RV free wall thcikness*

To obtain sub-costal views, the subject is rolled over to a supine position and knees are bent to relieve muscle strain in the abdominal region. The transducer is placed in the sub-xiphoid region with the orientation marker pointing towards the patient's left, in the 3 o' clock position. Angling the scan plane cephalad brings the sub-costal four-chamber into view. Inspiration generally improves the quality of the image by bringing the heart closer to the transducer.

In this view, the LA, RA, IAS, LV, RV and IVS are visualized **(Figure 25, Video 25)**. The two ventricles are seen above the atria, with the RV visualized anterior to the LV. A focused view of the right ventricular free wall permits measurements of wall thickness in the setting of elevated RV afterload. Measurements are taken at end-diastole, beyond the tricuspid valve leaflets at the level of the chordae.

26A) and 26B) Sub-costal interatrial septal view 2D and color

Purpose:

2D: Intactness of inter-atrial septum

RV free wall thickness measurement (from RV focused view)

Color: To exclude ASD, patent foramen ovale

Measurements:

2D: Mandatory - Nil

Optional - ASD size

RV free wall thickness

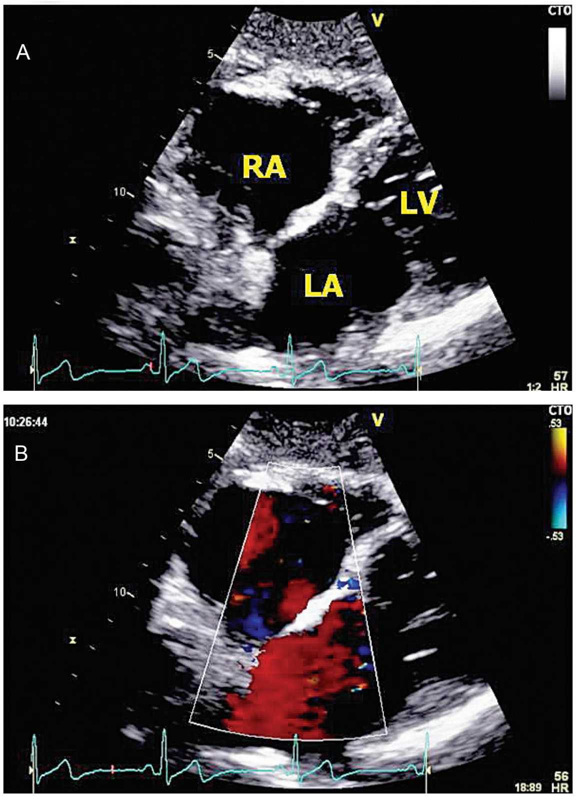

Figure 26: *Magnified view of the IAS obtained from the subcostal 4 chamber view; (A) 2D image, (B) with color (see text for abbreviations and description).*

measurement from RV focused view

Color: Mandatory - Nil

Optional - ASD size

Doppler data: Qualitative detection of shunt

Technical description:

From the standard sub-costal four chamber view, a slight posterior angulation of the transducer stretches out the inter-atrial septum and brings the two atria into focus. A magnified view of the inter-atrial septum can be obtained by using the zoom function **(Figure 26A, Video 26A)**. In this view the IAS is aligned perpendicular to the ultrasound beam, and hence, is the recommended view to profile a patent foramen ovale or ASD. Placing a color Doppler window on this image permits the evaluation of the intactness of the septum **(Figure 26B, Video 26B).**

27A) and 27B) Sub-costal aorta long axis 2D and color (PW spectral Doppler optional)

Purpose:

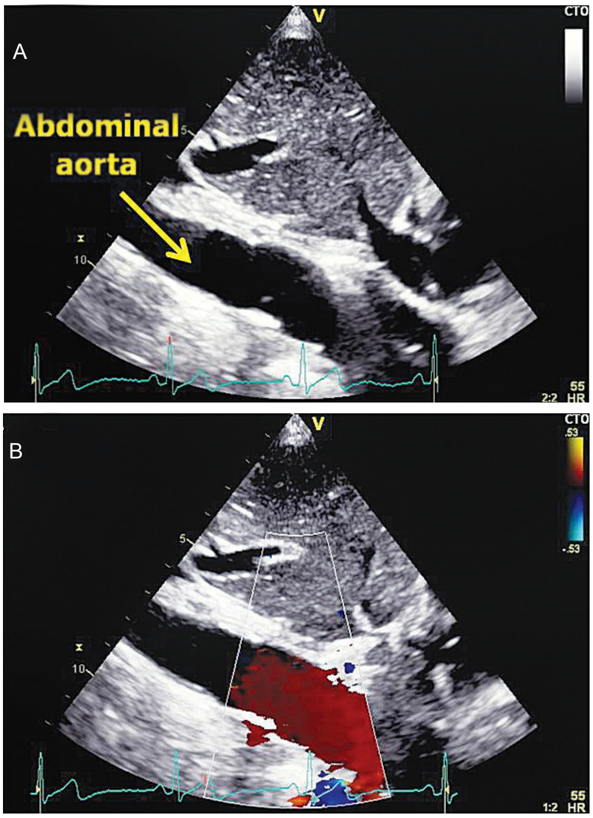

Figure 27: *Long axis view of the abdominal aorta; (A) 2D image, (B) with color (see text for abbreviations and description).*

2D: Aortic pulsations, aneurysm, dissection flap etc.

Color: phasic versus continuous flow (to diagnose coarctation), flow reversal, differential flow suggestive of aortic dissection

Measurements:

2D: Mandatory - Nil

Optional - aorta size

Color: Mandatory - Nil
Doppler data: qualitative

Technical description:

To obtain the long axis of the aorta, the probe is turned in the counterclockwise direction till the orientation marker faces the patient's head, and the scan plane is tilted inferiorly, or towards the abdomen. A slight leftward angulation profiles the upper abdominal aorta in long axis **(Figure 27A**). The upper abdominal aorta can be identified as thick walled and pulsatile. This view is useful to look for an aneurysm or dissection flap. Placing a color Doppler window over this frame **(Figure 27B, Video 27)** provides qualitative information on flow hemodynamics such as continuous flow in the setting of coarctation and reversal in the setting of significant AR. Optionally, PW Doppler can be used to assess the flow spectral pattern.

28A), 28B), 28C) IVC long axis 2D, IVC / hepatic vein color, PW

Purpose:

2D: Preload status, respiratory variation in IVC size

Color: Respiratory variation of IVC /hepatic vein flow

PW: Estimation of RA pressure

Measurements:

2D: IVC size, along with respiratory variability.

Color: Mandatory - Nil
Doppler data: qualitative

PW: Mandatory - Nil

Optional- systolic, diastolic forward and reversal velocities VTI
Doppler data: Respiratory changes in flow reversal

Technical description:

From the subcostal aorta long axis view, angling the probe to the patient's right will demonstrate the IVC in

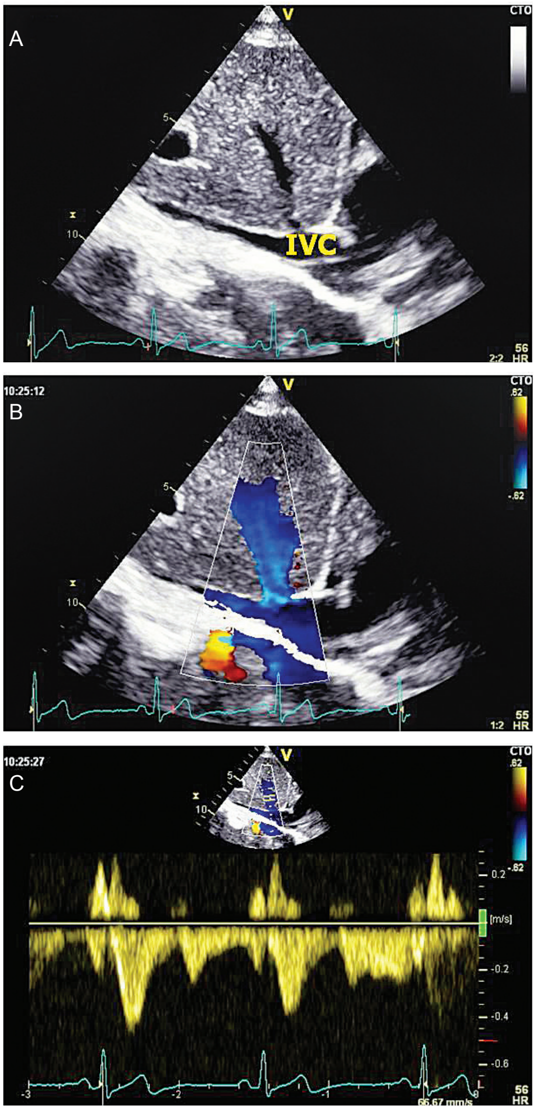

Figure 28: *(A) demonstrates a subcostal view of the IVC in long axis, (B) color flow across the hepatic vein entering into the IVC, (C) PW Doppler signal across the hepatic vein (see text for abbreviations and description).*

long axis **(Figure 28A, Video 28A)**. The IVC is identified as a thin-walled structure that collapses on inspiration in patients with normal RA pressures. With fine angulations, the IVC should be opened to a maximum diameter and clip recorded during quiet inspiration. A sniff, or sudden forceful inspiration, demonstrates collapsibility of the IVC and provides information on central venous pressures. Measure the maximal diameter of the IVC when not collapsed, just proximal to the entry of the hepatic veins.

With fine angulation, the hepatic veins can be demonstrated draining into the IVC **(Figure 28B, Video 28B).** A color flow window placed over the hepatic vein provides qualitative information on flow direction. PW Doppler can be employed for additional information on systolic, diastolic and flow reversal velocities **(Figure 28C).** To obtain an optimal spectral wave form, a 3-5mm PW sample volume is placed in the hepatic vein, taking care to align the Doppler axis parallel to the vessel flow.

29A), 29B) & 29C) Suprasternal long axis of Aortic Arch 2D, color and PW/CW

Purpose:

- 2D: To look for aortic dissection, coarctation etc.
- Color: Assessment of diastolic flow reversal in AR; differential flow in aortic dissection, turbulence in coarctation etc.
- PW/CW: Assessment of diastolic flow reversal in AR, coarctation severity

Measurements:

- 2D: Mandatory - Nil
  - Optional - Linear measurements of aortic arch and isthmus

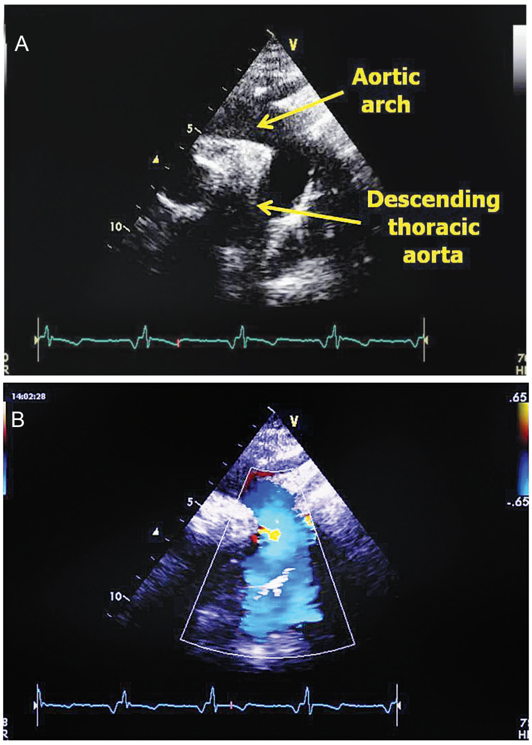

Figure 29: *Suprasternal long-axis view showing aortic arch and proximal segment of descending thoracic aorta; (A) 2D image, (B) with color (see text for abbreviations and description).*

Color: Nil; color M-mode for qualitative assessment of diastolic flow reversal in case of AR

PW/CW: Mandatory- Nil

Optional - Descending aorta PW for diastolic flow reversal, CW Doppler for coarctation gradient

Technical description:

The suprasternal long axis of the aortic arch is obtained by placing the transducer in the suprasternal notch with the orientation marker pointing towards the patient's left shoulder. With a slight anterior angulation, the aortic arch and branch vessels are seen **(Figure 29A)**. Moving from proximal to distal arch, the aortic arch first gives rise to the brachiocephalic artery, followed by the common carotid and the left subclavian artery respectively. Applying a color window to this frame provides information of blood flow characteristics, turbulence or reversal **(Figure 29B, Video 29)**. PW or CW Doppler may be applied to measure flow reversal or high gradient forward flow respectively.

30) Pathology specific additional non-conventional views.

Apart from the above described standard views, additional non-conventional views may need to be obtained to better define specific cardiac pathologies. For example, off axis views may be required to image eccentric regurgitation jets, or for spatial delineation of cardiac masses or any other structure.

RECOMMENDED FORMAT FOR REPORTING A COMPREHENSIVE ADULT TRANSTHORACIC ECHOCARDIOGRAPHIC STUDY

Although, as mentioned above, each institution has its own style of reporting echocardiographic findings, it is recommended that the final report should mandatorily include the following details.

Patient data:

Name, age, gender, blood pressure, heart rate, rhythm, body-surface area

Impression: The description should include (but not limited to) following points:

1) *Etiological diagnosis:*

Etiological diagnosis relevant to the case should include (but not be limited to) the following as applicable: Ischemic, Infective, Degenerative, Rheumatic, Congenital, Idiopathic etc.

2) *Anatomical/ structural diagnosis:*

Anatomical or structural description relevant to the pathology should include (but not be limited to) the following as applicable: chamber enlargements, hypertrophies, myocardial regional wall abnormalities (thickness, scars, aneurysm), valve/annulus/outflow morphologies, septal defects, IVC size, pericardial/ pleural disease, great vessel disease, prosthetics, intracardiac masses (clot/vegetation/tumor) etc.

3) *Functional/ hemodynamic diagnosis:*

Functional or hemodynamic status description relevant to the should include (but not be limited to) the following as applicable (description can be combined with anatomical details for maintaining continuity): LV/ RV systolic regional / global function (qualitative or quantitative parameters/indices), diastolic function grading, valve gradients, valvular regurgitation grades and mechanism , shunt qualitative estimates, intracardiac pressure quantitative and/or qualitative estimates, prosthetic function, dyssynchrony measurements etc.

4) *Therapeutic comment:*

Therapeutic or management guidance comment relevant to the pathology should include (but not be limited to) the following as applicable: timing/suitability of intervention, optimal medical management, future echo follow up, need of additional imaging, family screening etc.

Reporting templates can be created for common pathologies using the above principles (see Appendix for ischemic and valvular heart disease templates).

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ABBREVIATIONS

2D:	two-dimensional
A':	mitral annular late diastolic velocity
AP2C:	apical two-chamber view
AP4C:	apical four-chamber view
AR:	aortic regurgitation
AS:	aortic stenosis
ASD:	Atrial septal defect
CW:	continuous wave
E:	mitral inflow early diastolic velocity
E':	mitral annular early diastolic velocity
IVC:	inferior vena cava
LA:	left atrium / atrial
LV:	left ventricle / ventricular
LVEF:	left ventricular ejection fraction
LVOT:	left ventricular outflow tract

MPA:	main pulmonary artery
MR:	mitral regurgitation
MS:	mitral stenosis
PISA:	proximal isovelocity surface area
PLAX:	parasternal long-axis
PR:	pulmonary regurgitation
PS:	pulmonary stenosis
PSAX:	parasternal short-axis
PVR:	pulmonary vascular resistance
PW:	pulsed-wave
RA:	right atrium / atrial
RV:	right ventricle / ventricular
RVOT:	right ventricular outflow tract
RWMA:	regional wall motion abnormality
S’:	mitral annular systolic velocity
TAPSE:	tricuspid annular plane systolic excursion
TR:	tricuspid regurgitation
VSD:	ventricular septal defect
VTI:	velocity time integral

APPENDIX

Illustrative examples of templates for reporting final impressions from an echocardiographic study

(Please note, these templates are only for reporting final impressions. A complete report will also include various measurements and other findings, in addition to the final impressions)

A. Ischemic heart disease report template (strike out whatever is not relevant)**:**

1) Ischemic heart disease

2) Regional wall abnormalities

- LV ***basal / mid / apical*** segments of anteroseptum, apical lateral wall, apical inferior wall are ***hypokinetic / akinetic*** with ***thinning (…mm) / scarring / preserved thickness.***
- LV ***basal / mid*** segments of inferior, posterior wall are ***hypokinetic / akinetic with thinning (…mm) / scarring / preserved thickness***.
- LV ***basal / mid*** segments of lateral wall are ***hypokinetic / akinetic with thinning (…mm) / scarring / preserved thickness.***

Graphical representation of RWMA may be added to textual description.

3) LV shows ***normal size / dilatation / LVH/ spherical remodeling / anatomical aneurysm.*** LV clot ***present / absent***.4) LV systolic function is ***normal /depressed***. (LVEF= LVEDV= LVESV= GLS=)

5) LV diastolic function ***normal/ dysfunction*** grade=… suggestive of ***normal/raised*** LVEDP.

6) LA size is **normal/ increased**. RA/ RV are **normal in size/ dilated**.

7) Aortic and mitral valves ***Normal/ sclerotic***. MR and AR ***present/absent*** grade….

8) PH ***present/absent***. PASP=… TR grade… IVC ***normal/ congested***.

9) RV function ***normal/ depressed***. TAPSE=…

10) LV clot present / absent. Pericardial effusion **none/ present** (further description ………………).

11) Additional abnormalities………………

B. Valvular heart disease template (strike out non relevant)**:**

1) ………. valvular heart disease ***with/ without*** evidence of infective endocarditis.

2) ***Mild / moderate/ severe*** aortic stenosis.

Tricuspid / bicuspid aortic valve. Calcification ***nil/mild/ severe***.

AVA=…….sq cm by Doppler/planimetry at Stroke volume=…..ml/sq.m

Annulus=……mm, aortic root= ……….. mm, Asc Ao=……. mm

AV gradient peak=… mean=…. mm of Hg at HR=….. BP=…….(Imaging window: Apical/ right parasternal/ suprasternal)

3) ***Mild / moderate/ severe*** aortic regurgitation. Grade=…

AR due to……(mechanism flail leaflet/ fibrosed retracted/ bicuspid/ annular dilatation etc)

AV annulus=……mm, aortic root at sinuses=……..mm, STJ=……..mm Asc Ao= ….mm

4) ***Mild / moderate/ severe*** mitral stenosis.

MVA =…… sq cm by planimetry / PHT.

MV gradient Peak=……Mean=……mm of Hg at HR= Sinus/AF rhythm.

MV score=

AML thickened, ***pliable/nonpliable***, calcification ***absent/ present*** at…

PML thickened, ***pliable/nonpliable***, calcification ***absent/ present*** at…

Medial/lateral commissure ***fused/open***, calcification ***absent/ present*** at……

Subvalvular apparatus: chordae ***thickened/fused***, calcification ***present/absent*** at..

5) ***Mild / moderate/ severe*** mitral regurgitation. Grade=…..

MR due to…….. (Mechanism leaflet tethering, PML p1/p2/ p3 scallop, AML A1/A2/A3 segment thickened retracted/ myxomatous / prolapsing/ flail, chordae shortened/ elongated/ ruptured/tenting, papillary muscle medial/ lateral…)

Mitral annulus ***normal/ dilated***. Anteroposterior=…… mediolateral=…mm

6) LV shows ***normal size / dilatation / LVH (concentric/ eccentric)/ spherical remodeling.*** LVIDd= LVIDs=

LV systolic function is ***normal /depressed***. (LVEF= LVEDV= LVESV= GLS=)

7) LA /RA size ***normal/ dilated***. LA appendage clot ***present/ absent***.

8) RV size ***normal/dilated***. RV function ***normal/depressed***. TAPSE=…

8) Tricuspid regurgitation ***present/ absent***, ***functional/ organic***. Grade=….. Tricuspid valve annulus size=…… TV leaflets ***non-coaptation/ thickened, retracted/fused commissures***.

9) PH ***present/absent***. PASP=…. IVC ***normal/congested.***

10) Aortic arch **normal/ dilated**. Coarctation **present/ absent**.

11) Additional abnormalities ………………

Video legends (videos provided separately):

Video 1: PLAX view.

Video 2: Magnified view of mitral apparatus in PLAX view; (A) 2D image, (B) with color.

Video 3: Magnified PLAX view of the LVOT, aortic valve and ascending aorta; (A) 2D image, (B) with color.

Video 4: Magnified view of the ascending aorta in PLAX; (A) 2D image, (B) with color.

Video 5: PLAX RV inflow view with color doppler.

Video 6: PSAX view at the level of semilunar valves; (A) 2D image, (B) with color.

Video 7: PSAX aortic valve zoomed view; (A) 2D image, (B) with color.

Video 8: PSAX view showing RVOT, MPA and its bifurcation with color.

Video 9: LV SAX view at the level of the mitral valve.

Video 10: LV SAX view at the level of the papillary muscles.

Video 11: LV SAX view at the level of apex.

Video 12: Apical four-chamber view.

Video 13: Focused LV apical four-chmaber view.

Video 14: Focused LV apical two-chamber view.

Video 15: Focused LV apical long-axis view.

Video 16: Magnified view of the LV inflow and outflow; (A) 2D image, (B) with color.

Video 17: Magnified view of the LA see in the apical two-chamber view.

Video 18: Magnified view of the LA see in the apical four-chamber view.

Video 19: Pulmonary venous flow into the LA seen on color Doppler.

Video 20: Color flow across the mitral valve in the color LA-LV view.

Video 21: Tissue Doppler image for recording mitral annular velocities.

Video 22: Magnified view of the LVOT; (A) 2D image, (B) with color.

Video 23: Demonstrates flow across the aortic valve assessed by CW Doppler.

Video 24: Demonstrates an RV focused view obtained from the apical 4 chamber view.

Video 25: RV focused subcostal four chamber view for measurement of RV free wall thcikness.

Video 26: Magnified view of the IAS obtained from the subcostal 4 chamber view; (A) 2D image, (B) with color.

Video 27: Long axis view of the abdominal aorta with color.

Video 28: (A) Demonstrates a subcostal view of the IVC in long axis, (B) color flow across the hepatic vein entering into the IVC.

Video 29: Suprasternal long-axis view showing aortic arch and proximal segment of descending thoracic aorta with color.