



BC's HEART FAILURE NETWORK
Quality care for quality life.

Diagnostic Imaging Working Group

Principles to Ensure Best Practice for Heart Failure *Echocardiography* Services in British Columbia

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Principles to Ensure Best Practice For Heart Failure Echocardiography Services in British Columbia (BC)

1. Sonographers:
 - a. Recommendation: Prefer sonographers to have extra training in cardiac ultrasound prior to being hired into the department.
2. All hospital Echocardiography referral forms must contain the provincially identified key elements for an Echocardiography referral form OR a hospital may adopt the Standardized Provincial Echocardiography referral form.
3. Adopt the American Society Echocardiography (ASE) definitions for:
 - a. Right Atrium
 - b. Right Ventricle Wall Thickness
 - c. Right Ventricular Outflow Tract
 - d. Right Ventricle Dimensions
 - e. Right Ventricle Systolic Function
 - f. Right Atrial Pressure
 - g. Peak Systolic Pulmonary Pressure
 - h. Left Atrial Volume
 - i. Left Ventricle Dimensions and Mass
 - j. Left Ventricle Ejection Fraction
4. Prior to procedure patients:
 - a. Height and weight must be documented
 - i. BSA should be calculated
 - b. Heart rate, heart rhythm and blood pressure should be documented
 - i. Blood pressure measurement may be particularly useful in patients with mitral regurgitation or heart failure
5. Both systolic and diastolic *function* should be measured, documented and *reported* especially when the indication includes heart failure, shortness of breath, hypertension, left ventricular function.
6. A comprehensive 2 dimension and M mode, doppler study should be performed in order to determine the mechanism of congestive symptoms. This should include an assessment of the left and right heart function, size, volume, left sided filling pressure (diastolic function), right atrial pressure, pulmonary artery pressure, valves and pericardium. Details on recommendations for measuring and reference values are outlined in Appendix 1.

7. Minimum data elements that should be measure

- i. Quantification of all measurements
- ii. Left Ventricular (LV) dimensions
 - Septal and posterior wall thickness
 - Indexed LVIDd
 - Indexed LV End Diastolic Volume (LVEDV)
 - LV Mass
 - Qualitative Function
 - Left Ventricle (LV) cavity at end diastole and end systole
 - Quantitative Ejection Fraction should be performed when possible provided image quality is adequate. If visual estimate of the LVEF is abnormal then quantitative EF is mandatory, when image quality is adequate. It is also recommended that LVEF quantification using the Modified Simpson' or 3D method be employed. The visual EF and quantitative EF should correspond.

Reference Values for LVEF

	Normal	Mild Dysfunction	Moderate Dysfunction	Severe Dysfunction
Ejection Fraction (%)	>greater than or equal to 55	45-54	30-44	<30

*** Contrast opacification should be considered in cases of poor image quality or where there are concerns regarding the possible presence of left ventricular thrombus**

- iii. Left Atrium (LA) dimensions
 - Basal Minor Axis Dimension
 - Volumes
 - Qualitative Function
- iv. Right Ventricle (RV) dimensions
 - Volume
 - Wall thickness
 - Systolic function
 - Outflow tract
 - Tricuspid annular plane systolic excursion
- v. Right Atrium
 - Minor Axis Dimension Area
 - Pressures

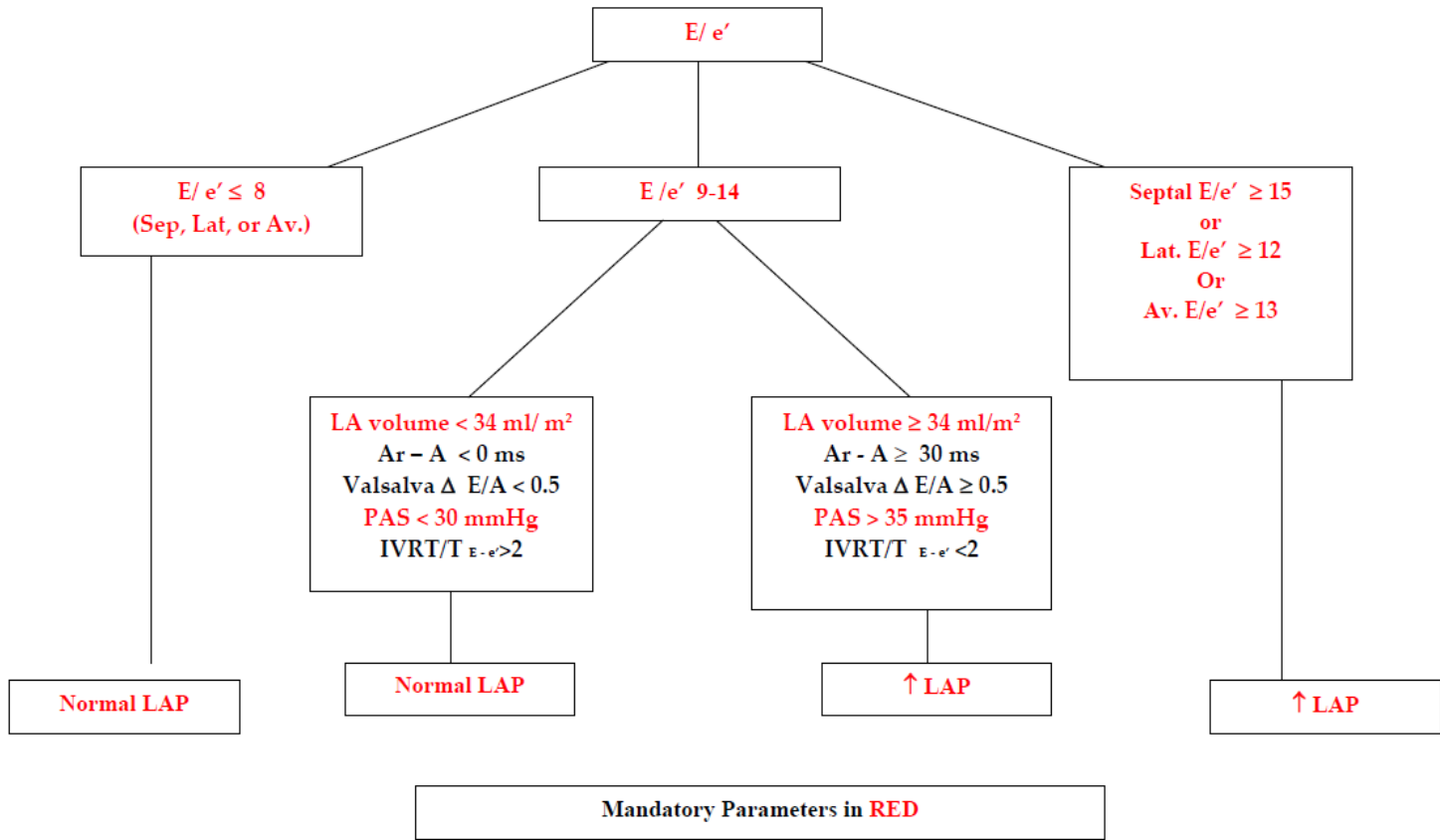
vi. Hemodynamics

- Right Atrial Pressure
- Systolic Pulmonary Pressure

vii. Diastolic Parameters

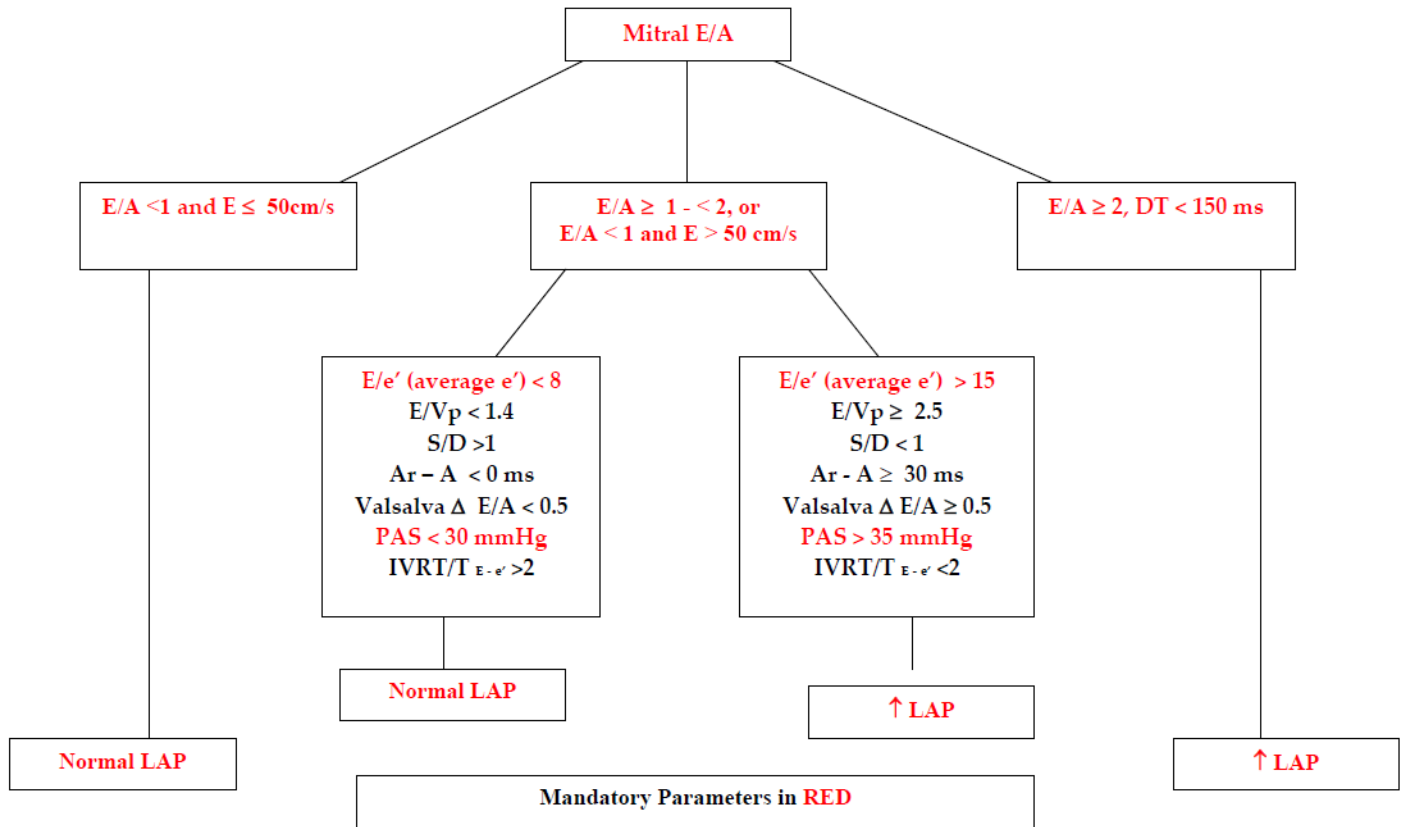
- Mitral E/A
- Mitral decel Time
- Septal e'
- Lateral e'
- E/e' Septal, E/e' lateral, E/e' average
- Valsalvin
- LA volume
- PA systolic pressure
- Optimal
 - i. Ar-A
 - ii. E/VP
 - iii. IVRT
 - iv. Pulmonary vein

Diastolic Dysfunction: Estimation of Left Ventricular Filling Pressures in Patients with Normal EF



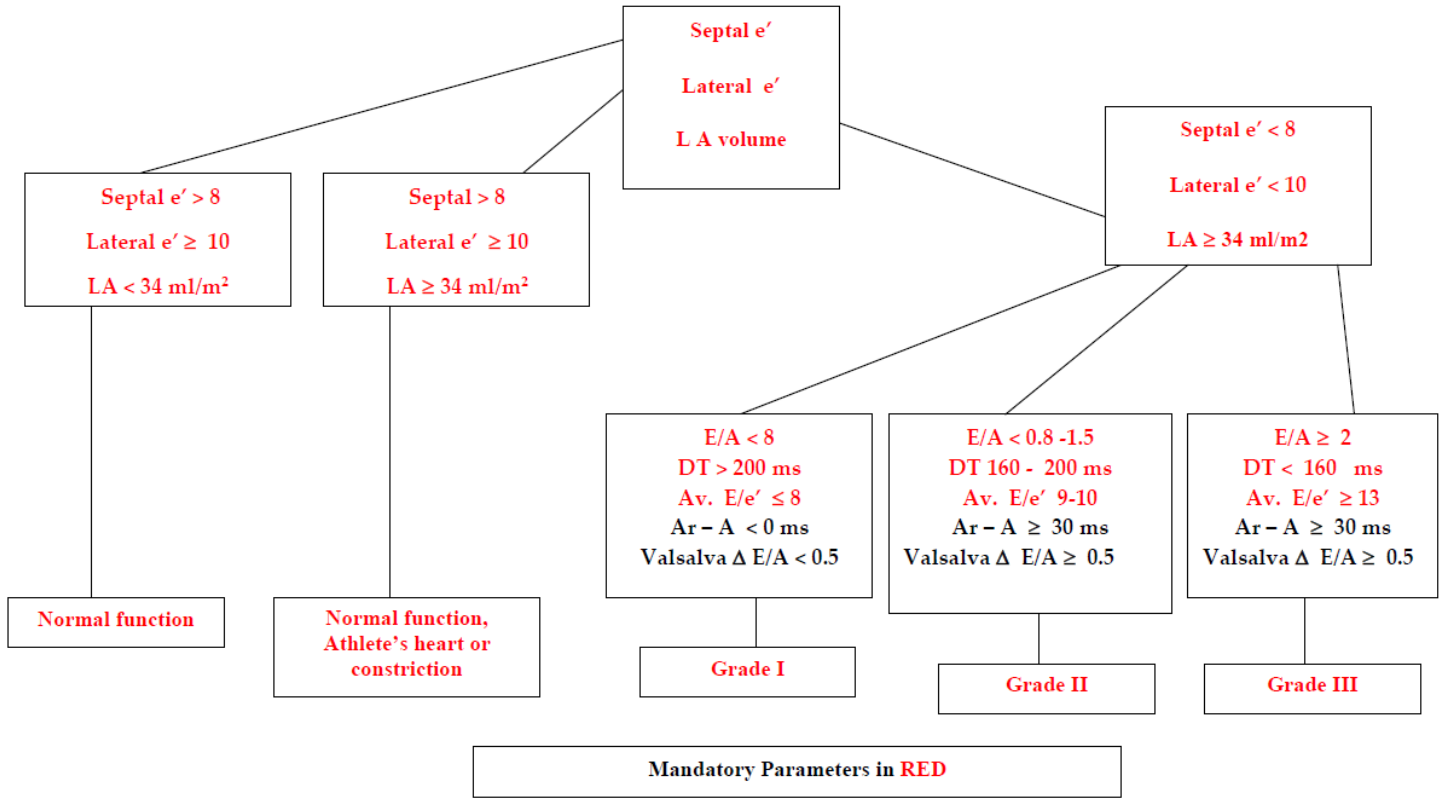
- Diastolic function will be reported as indeterminate when paced.
- In Atrial fibrillation diastolic function reported as indeterminate when Average E/e >13, increased left atrial pressure is present
- Diastolic function should be reported as indeterminate in the presence of severe mitral annular calcification (MAC) prosthetic mitral valve

Diastolic Dysfunction: Estimation of Left Ventricular Filling Pressures in Patients with Depressed EF



- Diastolic function will be reported as indeterminate when paced.
- In Atrial fibrillation diastolic function reported as indeterminate when Average E/e > 13, increased left atrial pressure is present
- Diastolic function should be reported as indeterminate in the presence of severe mitral annular calcification (MAC) prosthetic mitral valve

Practical Approach to Grade Diastolic Dysfunction



- Diastolic function will be reported as indeterminate when paced.
- In Atrial fibrillation diastolic function reported as indeterminate when Average E/e >13, increased left atrial pressure is present
- Diastolic function should be reported as indeterminate in the presence of severe mitral annular calcification (MAC) prosthetic mitral valve

8. Minimum data elements should be indicated in the final report.
 - a. Must include patient demographics, echocardiographic findings and summary. See Appendix 2 for narrative that should go in the summary
 - b. Each of the below structures should be characterized by size (volume), function and measurement
 - Left ventricle
 - Left atrium
 - Right atrium
 - Right ventricle
 - Aortic valve
 - Mitral valve
 - Tricuspid valve
 - Pulmonic valve
 - Pericardium
 - Aorta
 - Pulmonary artery
 - Inferior vena cava
 - Pulmonary veins
 - Interatrial septum
 - Interventricular septum
9. Diastolic function should be reported in all cases of suspected heart failure in patients with sinus rhythm. In Atrial fibrillation filling pressures reported as elevated when mitral DT 150 msec or $E/e' \geq 13-15$. Diastolic function should be reported as indeterminate in the presence of severe mitral annular calcification (MAC) prosthetic mitral valve.
10. Emergent/Stat final echo report ideally should be available to review within 24 hours.
11. Non-urgent/routine final echo report ideally should be available to review within 48 hours.
12. Final report should be processed and forwarded to the most responsible physician within 7 days from the time the test was interpreted.
13. Each hospital should have a policy for reporting critical values and a method to communicate these findings to the referring physician.

14. All health authorities must strive to meet the Canadian Cardiovascular Society Echocardiography accessibility recommendation guideline for:
- a. Emergent:
 - i. Defined by: a patient being: hemodynamically unstable with suspected certain cardiovascular conditions (eg, pericardial effusion with tamponade, mechanical complications, post-myocardial infarction)
 - ii. The maximum medically accepted wait time for emergent echocardiograms is <24hrs
 - b. Urgent/Semi-Urgent:
 - i. Defined by: critically ill patients who do not meet the definition of emergent and patients with a condition that could deteriorate rapidly (eg, symptomatic aortic stenosis)
 - ii. The maximum medically accepted wait time for urgent/ semi urgent echocardiogram is 7 days
 - c. Scheduled/non-Urgent:
 - i. Defined by: all patients who do not fall into the previous categories (eg, assessment of murmurs in asymptomatic individuals, assessment of left ventricle mass)
 - ii. The maximum medically accepted wait time for scheduled/non urgent echocardiogram is 30 days.

Position Statement

The Heart Failure Diagnostic Imaging Working Group believes the American Society of Echocardiography (ASE) guidelines are too complex for routine clinical practice in British Columbia [in particular the diastology protocols]. Therefore, they were adapted by Jonathan Tang and Ellamae Stadnick and the *Principles to Ensure Best Practice for Heart Failure Echocardiography Services in British Columbia* document will set the standard for Echocardiology Service in British Columbia (BC). The Heart Failure Diagnostic Imaging Group supports hospitals that are unable to meet standards because of human resource and/or equipment issues. The Imaging Group will consider setting up traveling clinics to remote locations in the province to facilitate optimum echocardiography service.

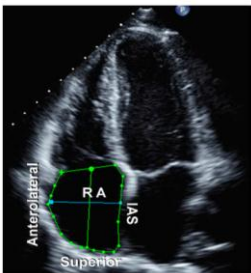
Echocardiographic Assessment of Heart Failure

Recommendations for measuring and reference values for the following:

- Right Atrium
- Right Ventricle Wall Thickness
- Right Ventricular Outflow Tract
- Right Ventricle Dimensions
- Right Ventricle Systolic Function
- Right Atrial Pressure
- Peak Systolic Pulmonary Pressure
- Left Atrial Volume
- Left Ventricle Dimensions and Mass
- Left Ventricle Ejection Fraction

Right Atrium

- How To:*
- Obtain apical-4 chamber, optimizing view of the right atrium (RA)
 - Freeze image at the end of ventricular systole when the atrial dimensions are largest, prior to tricuspid valve opening
 - Minor axis is measured from the mid- RA free wall to the interatrial septum
 - Major axis is measured from the TV annulus to the superior RA wall
 - Area is measured by tracing the RA being sure not to include the IVC



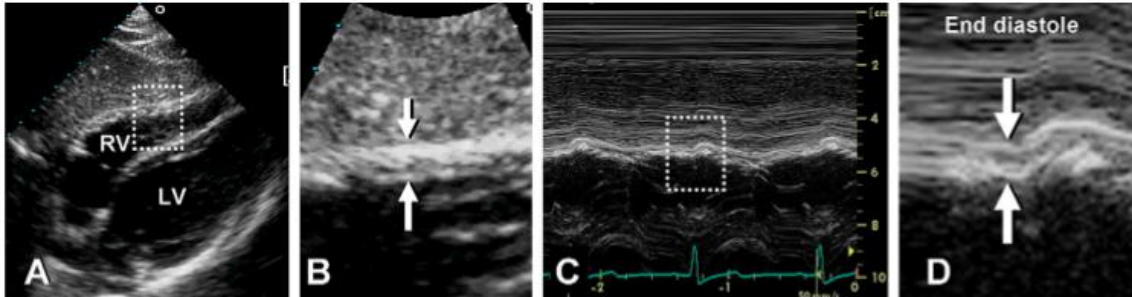
Normal Values: Minor Axis ≤ 44 mm
Major Axis ≤ 53 mm
Area ≤ 18 cm²

Pitfalls: - Normal values indexed for body surface area are not available

Right Ventricle

Right Ventricle Wall Thickness

- How To:*
- Obtain a subcostal view of the right ventricle (RV)
 - Place M-mode cursor through the RV
 - Measure RV wall thickness at end-diastole (onset of QRS) when it is the thinnest

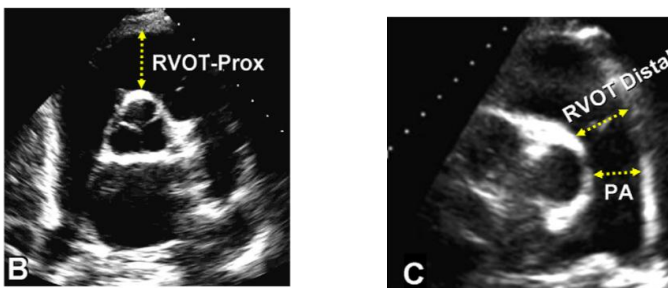


Normal Value: ≤ 5 mm

- Tips:*
- Zoom on image to decrease measurement error
 - Careful to avoid measuring epicardial fat

Right Ventricular Outflow Tract (RVOT)

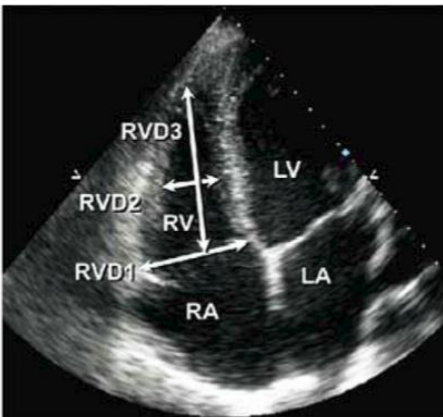
- How To:*
- Obtain a parasternal short axis view
 - Measurements are made at end diastole
 - The proximal RVOT is measured from the inner edge of the anterior RV wall to the inner edge of the aortic valve
 - The distal RVOT is measured at the level of the pulmonary valve



Normal Values: Proximal RVOT 35 mm
Distal RVOT 27 mm

Right Ventricle 2D

- How To:*
- Obtain an apical-4 chamber view focused on the RV
 - The true LV apex should be included along with the tricuspid and mitral valves
 - The left ventricular outflow tract (LVOT) should not be visible
 - Adjust transducer to obtain the largest RV dimension
 - Measurements are obtained at end-diastole
 - Measure the base of the RV from the inner edge of the interventricular septum to the inner edge of the lateral wall of the RV
 - Qualitatively the RV should not appear larger than the LV and it should not share the apex; either of these indicate either RV enlargement or an under filled LV



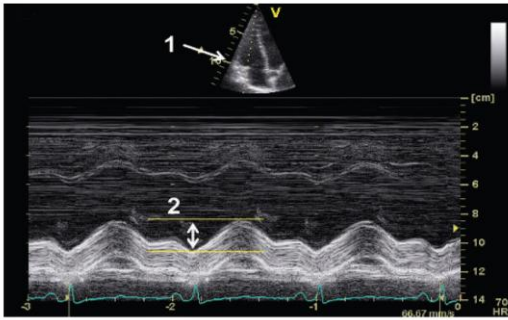
Normal Value: Basal Width ≤ 42 mm

- Pitfalls:*
- Normal values indexed for body surface area are not available
 - Large sources of error are possible if 4-chamber view is not optimized to assess the RV

Right Ventricle Systolic Function

A. Tricuspid Annular Plane Systolic Excursion (TAPSE)

- How To:*
- Obtain an apical-4 chamber view optimized to assess the RV
 - Place M-Mode cursor through the lateral tricuspid annulus
 - Measure the maximal longitudinal distance from end-diastole to peak systole

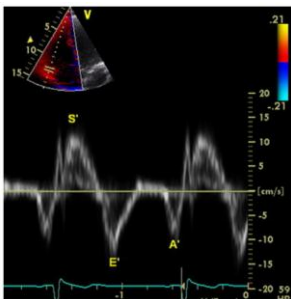


Normal Value: ≥ 16 mm

- Pitfalls:*
- TAPSE assesses longitudinal shortening and will not identify systolic dysfunction not involving the RV base

B. Pulse-Wave Tricuspid Valve Annulus Velocity

- How To:*
- Obtain an apical-4 chamber view optimized to assess the RV
 - Place PW Doppler on the basal RV free wall
 - The systolic wave is referred to as S'

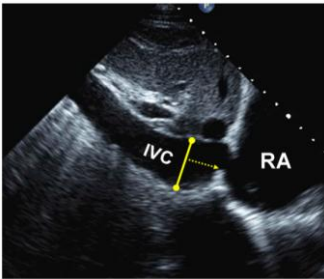


Normal Value: ≥ 10 cm/sec

- Pitfalls:*
- This measurement is not validated in the elderly

Right Atrial Pressure

- How To:*
- Obtain a sub-costal view of the inferior vena cava (IVC)
 - Measure diameter at end expiration
 - Measurements are made 0.5-3 cm proximal to the RA ostium and proximal to the junction of the hepatic veins
 - Measure collapse with patient 'sniffing' or upon deep inspiration



Normal Values:

- IVC ≤ 2.1 cm with inspiratory collapse $> 50\%$: 3 mmHg
- IVC > 2.1 cm with inspiratory collapse $< 50\%$: 15 mmHg

Tips:

- If neither category above applies estimate RAP at 8 mmHg and look for secondary indices of elevated RAP such as diastolic dominant hepatic vein flow, tricuspid E/E' > 6 or a restrictive right sided inflow pattern
- RAP measurements are not validated in ventilated patients
- IVC may be dilated in athletes (normal variant)

Pulmonary Artery Pressure

How To:

- In the absence of RVOT or pulmonary stenosis:

$$RVSP = 4v^2 + RAP$$

(v = peak tricuspid regurgitation velocity)

- Obtain the peak tricuspid regurgitation velocity by aligning Doppler signal parallel to the regurgitant jet in multiple views
- May not be accurate with severe tricuspid regurgitation
- Contrast (saline) may be used to enhance TR jet envelopes

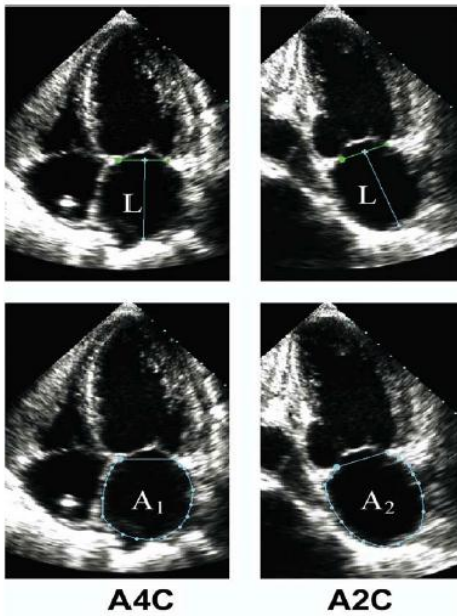
Normal Value: < 35 mmHg (assuming normal RAP)

Left Atrial Volume

- How To:*
- Area Length Method
 - Obtain apical-2 and apical-4 chamber views
 - Measure area in both views (avoid appendage and pulmonary veins)
 - Measure length in both views from back wall to level of mitral annulus

$$\text{Left Atrial Volume} = \frac{8}{3} \Pi [(A_1)(A_2)/(L)]$$

(L) is the shortest of either the A4C or A2C lengths



Normal Value: $22 \pm 6 \text{ ml/m}^2$

Left Ventricle

LV 2D Dimensions and Mass:

- How To:*
- Linear Method
 - Obtain parasternal long axis view
 - Measure the interventricular septum (SWT), posterior wall (PWT) and left ventricular internal dimension (LVID) at end diastole at the midcavitary region at the level of the chordae above the papillary muscles (level of mitral valve leaflet tips)
 - Left ventricular systolic dimension should be measured at the same
 - Either M-mode or 2D measurements have been validated (M-Mode measurements should be made perpendicular to the long axis)

$$\text{LV mass} = 0.8 \times \{ 1.04 [(LVIDd + PWTd + SWTd)^3 - (LVIDd)^3] \} + 0.6 \text{ g}$$

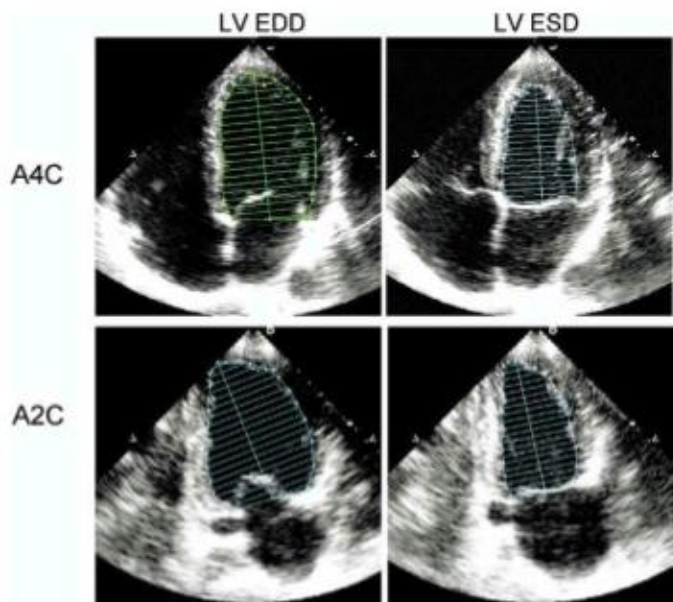
<i>Normal Values:</i>	<u>Women</u>	<u>Men</u>
Mass	< 95 g/m ²	< 115 g/m ²
LVIDd	39 – 53 mm	42-59 mm
LVIDdi	24 – 32 mm/m ²	22-31 mm/m ²

- Pitfalls:*
- The mass calculation assumes a prolate ellipse geometry for the left ventricle, and will not be accurate as the LV dilates and assumes a spherical structure
 - The mass calculation will not be accurate if there is asymmetric septal hypertrophy
 - Small discrepancies in measurements will result in large errors as the values are cubed in the calculation

LV Ejection Fraction:

- How To:*
- Quantitative assessment should correspond with qualitative visual estimate
 - Quantitative 2D Method (Modified Simpson's Rule)
 - End systolic (ESV) and diastolic (EDV) volumes are measured in both the apical 4 and 2 chamber views
 - Requires adequate visualization of the endocardium
 - Basal border should be drawn as a straight line between the lateral and septal leaflet insertion points in the mitral annulus
 - Papillary muscles should be included in the volume

$$\text{Ejection Fraction} = (\text{EDV} - \text{ESV}) / \text{EDV}$$



Reference Values of Ejection Fraction:

Normal:	≥ 55 %
Mild Dysfunction:	45 – 54 %
Moderately Dysfunction:	30 – 44 %
Severe Dysfunction:	< 30%

Appendix 2

Key Elements Required On An Echocardiology Final Report	
Patient information	
	First and Last name
	MSP # or Unique hospital #
	Date of birth
	Sex
	Height
	Weight
	Location: in patient OR out patient
	BSA
Indication for the test	
	Area for free text
Referring physician information	
Interpreting physician information	
Date and time test	
	Ordered (don't put in body of report but still collect)
	Received (don't put in body of report but still collect)
	Performed (don't put in body of report but still collect)
	Interpreted (don't put in body of report but still collect)
	Final report generated/transcribed
	Final report verified
	Final report transmitted
Site and department study performed	
Sonographer performing the exam	Initials only
Descriptor of study quality	<input type="checkbox"/> Good <input type="checkbox"/> Fair <input type="checkbox"/> Poor
Clinical findings	Their relevance to the diagnosis
	Quantitative values were applicable
	Should identify the salient findings, any abnormalities that are correlated to the reason the study was requested
	Descriptor for the values and comparison with previous echo values
	When applicable all structures should be characterized by size (volume), function and measurement <ul style="list-style-type: none"> • Left ventricle, Left atrium • Right atrium, Right ventricle • Aortic valve, Mitral valve, Tricuspid valve, Pulmonic valve • Pericardium, Aorta • Pulmonary artery (only if applicable) • Pulmonary artery systolic pressure • Inferior vena cava • Pulmonary veins (only if applicable) • Interatrial septum • Interventricular septum • Pericardial effusion (only mention if it is present)

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