Diagnosis of Cardiac Disease: Transthoracic Echocardiography: 2D and Doppler Imaging

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Abstract:

Transthoracic echocardiography is a noninvasive method, cost-effective, portable, and undeniable which use to determine the cardiac function and disease from the critically ill patients. The ability of echocardiography to yields an accurate hemodynamic Doppler gating signal data (blood flow velocity, direction and flow patterns). The spatial temporal resolution, suboptimal quality image are extremely useful in the ICU setting and expertise in ICU is a time-consuming and challenging to their potential findings. The study of transthoracic echocardiography is depends on the handling of transducer or probe and the knowledge about the augmentation of the ultrasound settings using specialized ultrasound doppler machines. Transthoracic echocardiography is achieved by using different acoustic cardiac windows - parasternal long- axis views and short-axis views, apical four chamber views, apical five chamber views, and subcostal view), Doppler have the different modes Such as continuous wave, pulse wave, Single angle, and vector are apply to acquired the cineloops and acoustic cardiac window of doppler spectrum. The standardized views are characterized by specific cardiac structures and their positioning in the scanning sector. Every standardized orientation is highly mimeo graphically documented. So, those cardiac structures can be visualized in a specific manner by transthoracic echocardiography.

Key words: *Transthoracic echocardiography, parasternal long- axis views and short-axis views, apical four chamber views, apical five chamber views, subcostal view and ultrasound doppler machines.*

Introduction

Echocardiogram:

An echocardiogram (echo=sound + card=heart + gram=drawing) is a ultrasound test, uses sound waves that can appraise the architecture of the heart, in addition to the direction of blood flow within it. The heart is a double pump that circulates blood throughout the body. The anatomy includes four chambers two at the top (the atria) and two at the bottom (the ventricles) and four valves (The mitral valve and tricuspid valve, also known as atrioventricular valves, which controls the blood flow from atria to ventricles. The aortic valve and pulmonary valve also known as semilunar valves, which controls the blood flow out of ventricles). The heart works normally; these structures are essentially required to integrate with involuntary muscle and striated muscle of cardiac to beat in a coordinated configuration, so that blood flows in and out of particular chamber in the appropriate direction. The echocardiography ultrasound images and videos are taken by using a special probe- standard 8 MHz probe or transducer that is placed in various places on the chest wall, to view the heart from different orientation by specially trained technicians. Cardiologists or heart specialists are appraising these images to assess heart function and provide a report of the results.

Types of echocardiograms:

Transthoracic echocardiogram:

The echocardiographer places the standard 8 MHz probe or transducer, on the chest wall and bounces the ultra sound waves off the structures of the heart. The return wave signals are received by the same transducer converts the digital signals in to images seen on the screen by computer software –Cardio Report ware or EchoPAC-3D software. It is a painless test and does not use ionizing radiation. There are no risk factors linked with a transthoracic echocardiogram.

Transesophageal echocardiogram:

In critical situations, a proper and clearer view of the heart ultrasound echocardiography image is required and instead of placing the standard 8 MHz probe or transducers on the chest wall, a cardiologist will directs the probe through the mouth into the esophagus. The esophagus is a straight muscular thin hollow tube, about 8 inches long, which travels behind the trachea and heart and the ultrasound waves can travel to the heart without any hindrance of the ribs and muscles of the chest wall. This test regularly requires intravenous treatments to lay back the patient. Because of the sedation, proper observation will also be used to detect the blood pressure and oxygen levels from the blood.

Doppler echocardiogram:

In extension to high-frequency ultrasound waves bouncing off the solid structures of the heart, they also bounce off the red blood cells as they circulate through the heart chambers. Doppler ultrasonography technology, which used to measuring the speed and analyze of blood flow direction, supporting the increased amounts of quality information available from the test (heart size, heart beats, heart valve and pumping mechanisms, displaying a cross-sectional view of the chambers, valves- four valves for leaks and other abnormalities and the major blood vessels, measures the speed and direction of the blood flow within the heart). The 2D Echo Reporting Software can added the Color flow Doppler mappings to allow the abnormal blood flow was elucidated by the cardiologist.

Doppler echocardiogram

Stress echocardiogram:

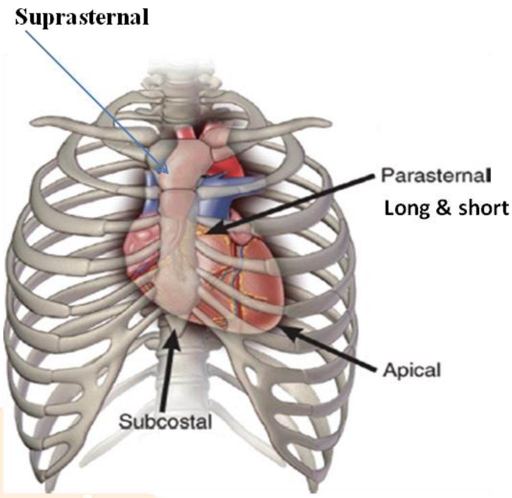
An echocardiography stress test is otherwise known as stress echo is a technique, to help uncovered abnormalities and variation from the heart wall, cardiac muscle function, Blood clots, Bulging arteries and

Narrowing of an artery. The patient may be asked to exercise on a treadmill; stress can be triggered and monitors your blood pressure and heart rhythm.

Methods:

Transthoracic Echocardiography:

The basic five transthoracic echocardiography views



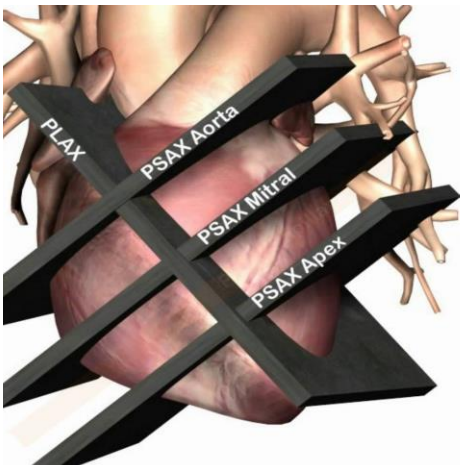
The transducer or probe is placed in various multiple areas of the chest. These areas are commonly referred to as windows. There are five standard views used in transthoracic echocardiography (parasternal long- and short-axis views, apical four chamber views, apical five chamber views, and subcostal view of the heart and observation of the inferior vena cava. The suprasternal view is occasionally used in emergency cardiac patient). The order, structure or number of views /contour may change, however, depending upon the resources of the echocardiogram. For example, during invigoration, only the subcostal view may be observed in order to further chest compressions. The clinical situation allows the patient roll to the left and if possible put their left hand up behind their head. These drop the heart away from behind the sternum and opens up the rib spaces.

Parasternal Long Axis View (PLAX):

The parasternal long axis (PLAX) view is achieved by placing the transducer or probe in the 3rd and 5th intercostal spaces with the marker orientated towards the right clavicle (patients right shoulder approximately 11 o'clock) rotate the probe until the heart comes in to view. A structured approach is required to investigate the pericardial space; if there is pericardial fluid (5-15ml above) demonstrated the tamponade physiology, pericardial fluid lies anterior to descending aorta-pleural effusion dorsal. The parasternal long axis is an excellent overview image of the heart. This parasternal window commonly used for calculating the aortic root and LA, LV chamber dimensions LV wall thickness, mitral , aortic valves and anterior structures, such as the RV pericardial effusions and Systole.

Parasternal Short Axis View (PSAX):

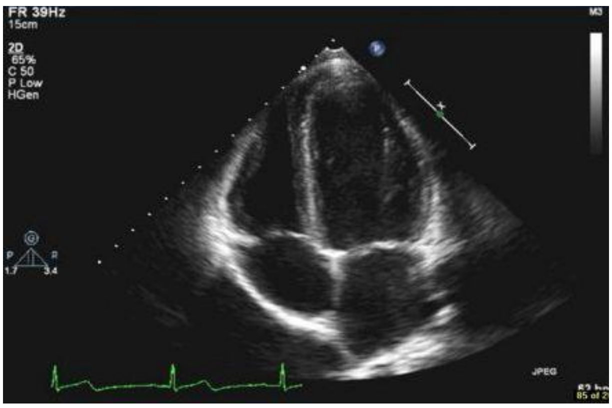
Parasternal Short Axis View is achieved by placing the transducer or probe in the 90 degrees (it is perpendicular to the long axis of the LV) from PLAX in counterclockwise direction you will obtain a short-axis (PSAX) view. This orientation cross-sectional view of the chambers slices through the heart on a long axis from base to apex.

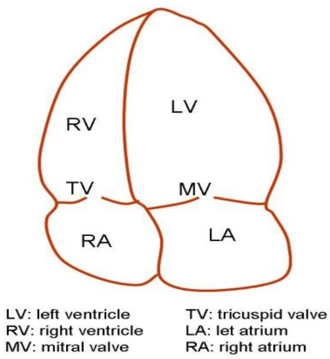


The principal applications of this sight view in basic echo are to determine the relative shapes and sizes of the two ventricles in suspected pulmonary embolism (PE) and to visually appraise the LV function, Echocardiography Correlates the Global and Segmental Wall Motion Abnormalities. It’s also useful for confirming suspected pericardial effusion. The shapes and sizes of the ventricles are investigated; the LV must be bigger than the RV. The LV should be round in shape and symmetric, the left ventricle should be in the middle of the screen and the RV is crescent shaped, this relationship is contrariwise in acute cor pulmonale due to pulmonary embolism. Parasternal Short Axis View used to observe the 3 main levels of imaging: aortic valve, mitral valve, papillary muscle and mid-ventricle.

Apical Four Chamber View (A4C):

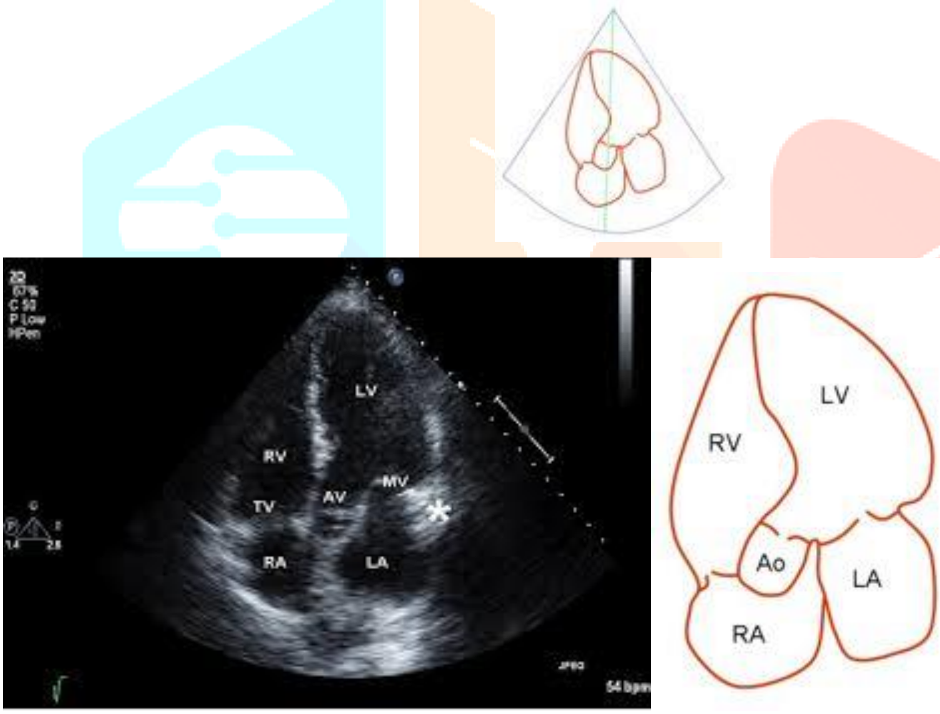
The transducer or probe is placed at the point of palpable apical beat region; otherwise it is placed in the 5th intercostal space near the anterior axillary (left) line. The beam is directed up towards the patient’s head, rotated the transducer and the marker is at around 3 o’clock. this orientation is helpful for the identification circumferential pericardial effusions and explaining the tamponade physiology (right sided diastolic chamber collapse) by examine the pericardial space and pericardial fluid, as well as RV dilation in massive (RV/LV ratio <0.6 indicates normal RV size, a RV/LV ratio of 0.6 to 1.0 indicates moderate RV dilatation and an RV/LV ratio >1.0 indicates severe dilation) and submassive pulmonary embolism. LV apex must be at the top of the screen with the atria visualized directly below a normal size .MV annulus moving up and down, suggesting good long axis function of the LV Measure the IVC and assess its collapsibility.





Apical 5 chamber view:

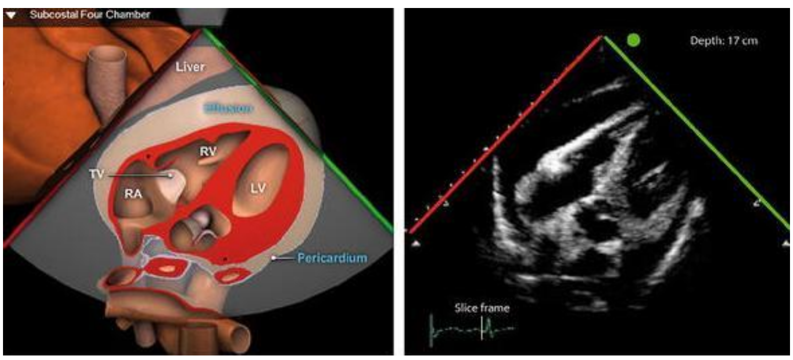
The apical 5 chamber view is achieved by placing transducer or probe slightly move towards upwards (angle up direction): the tricuspid valve and RA will go out of the imaging plane; the aorta will appear in the middle of the screen. Sometimes transducer placed higher in the first intercostal space, lateral to have improved positioning of your ultrasound beam with the LV out flow tract. You should have a good apical 4 chamber view and objective to visualize the 5th chamber: aorta. Since the aorta is the most anterior. Apical 5 chamber view is a good view to assess only the aortic valve, LVOT and their relations to the interventricular septum and mitral valve-Ao: left ventricle outflow tract and initial aorta. Apical 5 chamber view is not very good views to look at the structure of the aortic valve, parasternal views are better. In apical 5 chamber view, you will be ideally located to assess aortic regurgitation and/or aortic stenosis. In this view you can quantitate the severity of aortic stenosis with CW-Doppler since your Doppler beam should be well aligned with the LVOT.



Sub costal View:

The transducer or probe is placed below and hardly noticeable to the right of the xiphisternum. The side marker is in the 3 o'clock position. In this view anterior structures such as the RA and RV are at the top of the image.

Sub costal View

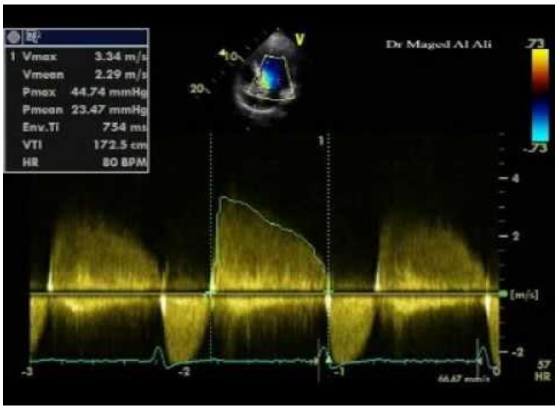


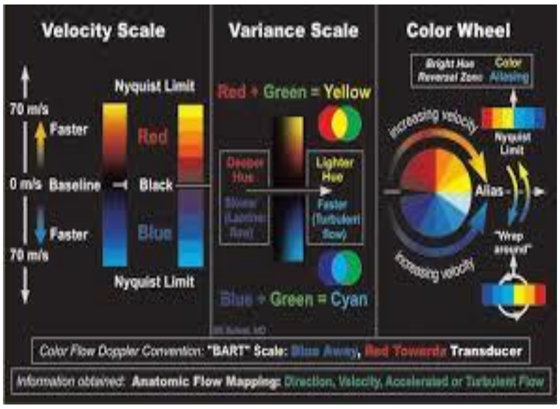
Posterior structures such as the LA and LV are seen toward the bottom of the screen. You can evaluate the 4 chambers, septum, mitral and tricuspid valves. This subcostal short axis otherwise known as subcostal saggital view is an excellent view to profile the superior vena cava (SVC), (Counterclockwise rotation will open up the inferior vena cava) IVC and atrial septum (The vessel has to be visualized in a true long axis together with the inferior vena cava/right atrial junction), detect the pericardial effusion from this view. This window may contribute the attainable view in professionally difficult, patients who are accepting mechanical ventilation or with chronic obstructive pulmonary disease.

Color Doppler in Apical Five chamber:

With color Doppler, 2-D echocardiogram shows regurgitation or acceleration around the aortic out flow tract and left ventricular enlargement. An aortic regurgitation will appear as a red (going toward the probe) flow, in diastole, from the aorta to the left ventricle. An aortic or sub-aortic stenosis will be suspected if there is acceleration (mosaic flow or aliasing) in this area. For example: the degenerative aortic cusps with aortic stenosis.

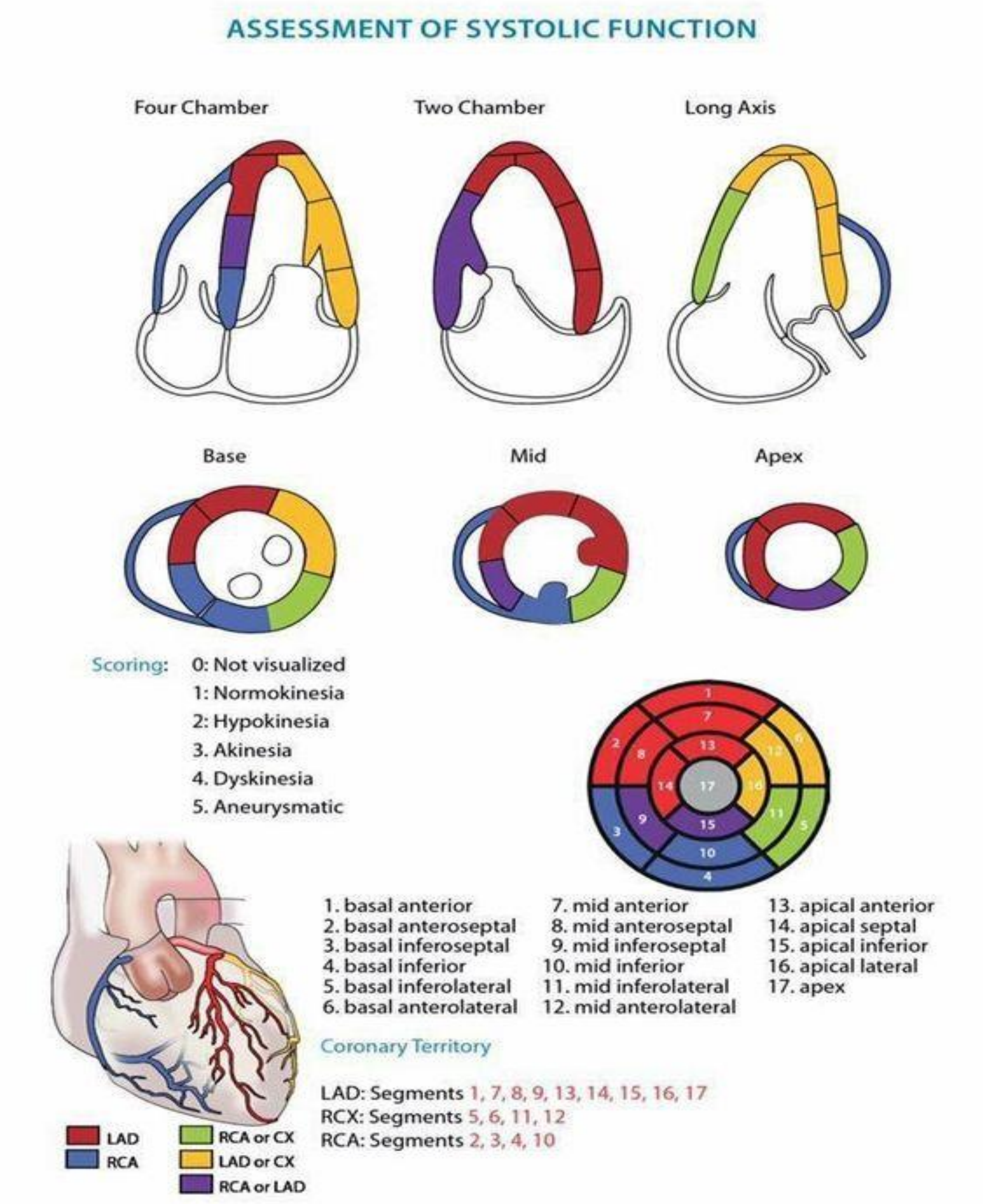
Aortic regurgitation **BART scale**





Assessment of Systolic Function:

A large number of ECHO cardiography systolic function parameter assessments were published. Most of them are more complicated for the everyday clinical practice but only have scientific value. The traditional systolic functional ECHO measurements are M-mode, two dimensional (2D), derived volume changes, cardiac output (CO), Systolic index, Global longitudinal strain (GLS) with speckle tracking echocardiography (STE) and Color Doppler derived ejection such as fractional shortening (FS) and ejection fraction (EF), shortening of velocity circumferential fibre (Vcf), variation in peak and mean pressure and time intervals of systolic .



Normal cardiac chamber sizes and the wall thickness (adult):

Internal diameter LV (in diastole) 3.5-5.7cm (4-6cm roughly), Internal diameter RV diameter (in diastole) 0.9-2.6cm (1-3cm roughly),RV diameter < 0.6 x LV diameter, LV wall / IV septum in diastole <1.1cm (note that walls should thicken by about 50% in systole), RV free wall < 0.6cm in diastole, Internal diameter of LA, RA & Ao root each < 4cm.

Reference ranges from 2D and M-mode echocardiography: Lang et al 2005

Parameter	Female	Male
Left atrium (mm)	27–38	30–40
Left ventricle diastolic diameter (mm)	39–53	42–59
Interventricular septum (mm)	6–12	6–13
Left ventricle posterior wall (mm)	6–12	6–13
Left ventricle diastolic volume (ml)	56–104	67–155
Left ventricle systolic volume (ml)	19–49	22–58
Left ventricle ejection fraction (%)	>55	>55
Right ventricle diameter (base) (mm)	20–28	20–28
Right ventricle diameter (mid) (mm)	27–33	27–33

Reference ranges for Doppler parameters: Rakowski et al 1996, †Bonow et al 2006

Mitral valve E wave/A wave ratio*	1–2
Mitral valve E deceleration time (milliseconds)*	100–200
Aortic valve peak velocity (metres/second)†	<1.7
Pulmonary valve peak velocity (metres/second)†	<1.6

Reference ranges: Mitral valve

Age	35–44	45–54	55–64	65–75	*P* -value (ANOVA)
E (cm/s)	75.0 ± 15.3	72.5 ± 14.7	74.1 ± 16.7	64.7 ± 14.8	0.01
A (cm/s)	57.5 ± 12.4	63.1 ± 13.9	72.0 ± 17.9	71.8 ± 16.7	<0.001

Reference ranges: Pulmonary valve

	Mild	Moderate	Severe
Peak velocity (m/s)	<3	3-4	>4
Peakgradient (mmHg)	<36	36-64	>64

Reference ranges: Aortic valve

	Aortic sclerosis	Mild	Moderate	Severe
Aortic jet velocity (m/s)	≤2.5 m/s	2.6-2.9	3.0-4.0	>4.0
Mean gradient (mmHg)	-	<20 (<30^a)	20-40^b (30-50^a)	>40^b (>50^a)

Reference ranges: Tricuspid valve

	Mild	Moderate	Severe
Peak velocity (m/s)	<3	3-4	>4
Peak gradient (mmHg)	19.3±4	36-64	>64

Result and discussions:

Presenting Complaints:

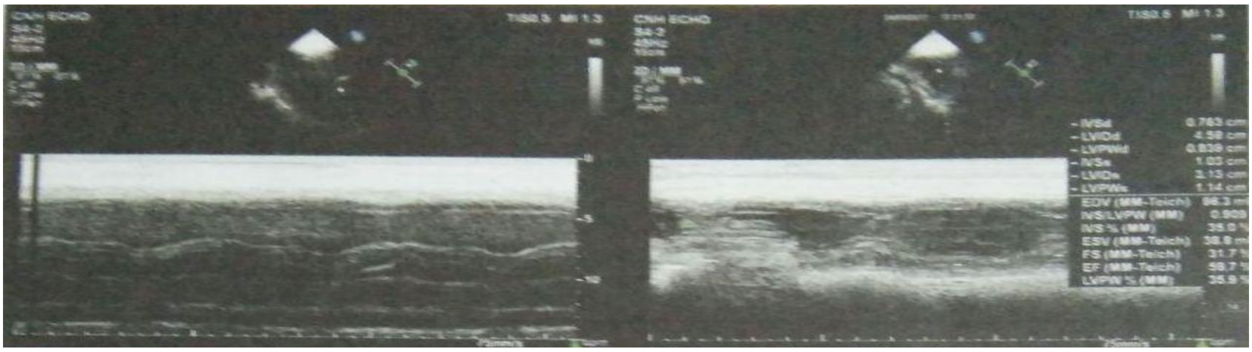
69 years old male, known diabetic, presented with complained of chest pain. Troponin I high sensitivity: 2911, ECG taken revealed acute inferior wall myocardial infarction. Echo done revealed minimal minimal hypokinesia apical inferior wall of LV, normal systolic function, LV EF: 59%, Grade I LV Diastolic dysfunction, No mitral regurgitation, aortic valve sclerosis (+), No aortic regurgitation/ aortic stenosis, No LV clot, No pulmonary hyper tension.

Physical & Systematic Examination:

BP: 130/90 mm Hg, pulse: 62/min,Temp:98.6 ºF ,SPO$_2$: 98% in room air, CVS:S1 S2(+), RS : BAE(+), NVBS,P/A: SOFT,BS (+),CNS: NFND.

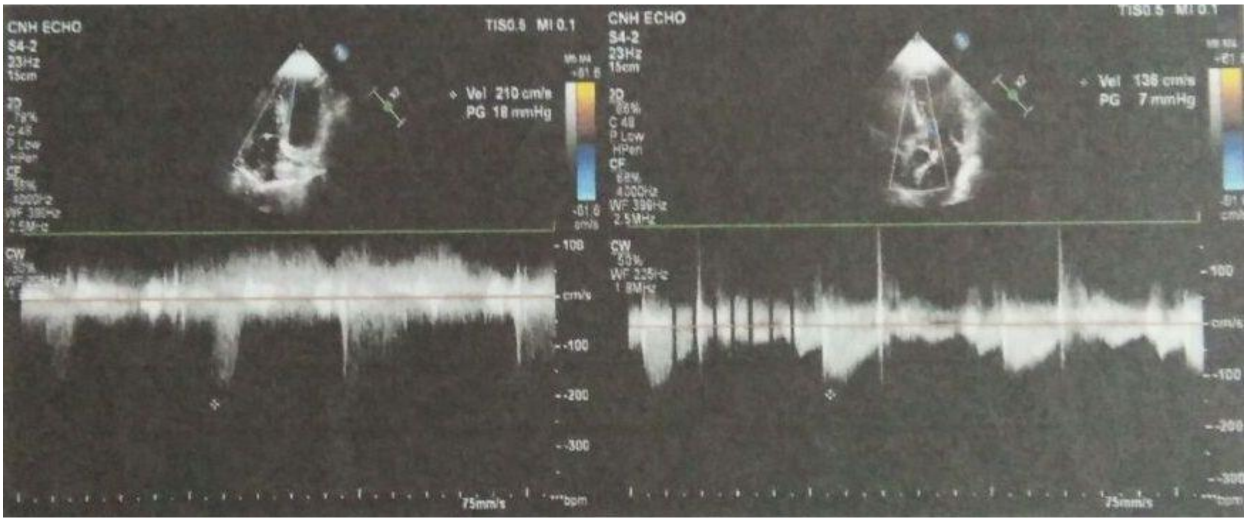
ECHO cardiogram:

M-Mode LV-M-Mode



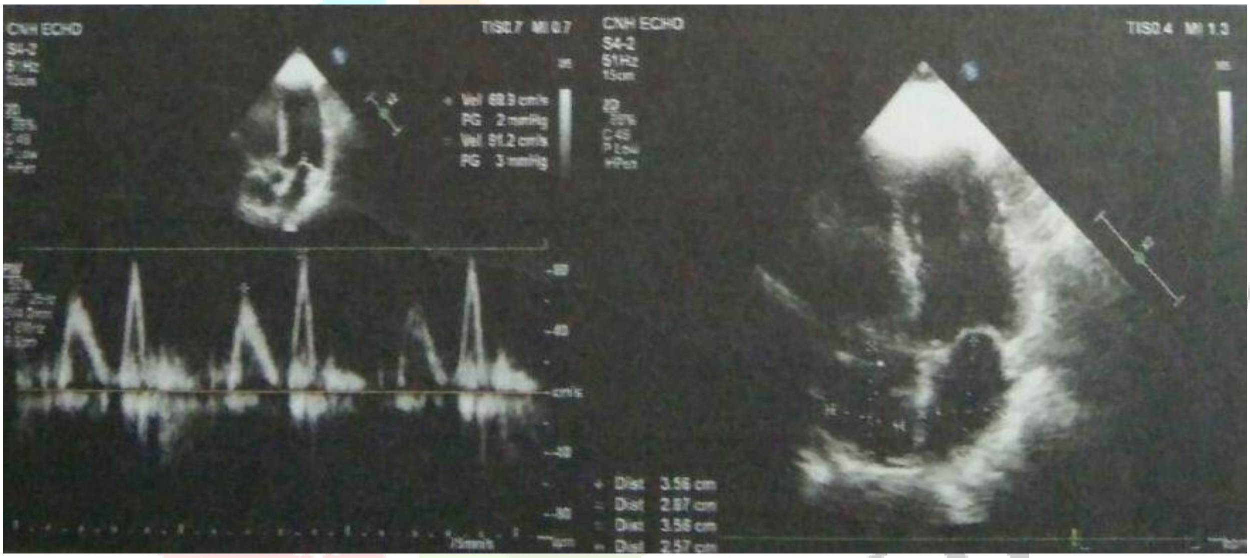
Tricuspid valve: Aortic valve:

(E Peak velocity &A Peak gradient) (E Peak velocity &A Peak gradient)



Mitral valve: 2D measurement

(E Peak velocity &A Peak gradient)



M-Mode	Ranges
RV	1.92cm
AO	2.44cm
LA	2.82cm
2D-Mode	LA: 3.56cm × 2.87cm RA:3.56cm × 2.57cm

LV-M-Mode	Diastole	Systole
IVS	0.763cm	1.03cm
LV	4.58cm	3.13cm
LVPW	0.839cm	1.14cm
EDV & ESV	96.3 ml	38.8cm
LV EF & FS	59%	31%

Doppler:

Mitral	E :68.9 cm/s	A : 91.2 cm/s
Pulmonary	Peak velocity: 99.1 cm/s	Peak Gradient :4 mmhg
Aortic	Peak velocity: 136cm/s	Peak Gradient :7mmhg
Tricuspid	Peak velocity:210 cm/s	Peak Gradient : 18mmhg

Conclusion:

Transthoracic echocardiography is a noninvasive method, cost-effective, portable, and undeniable which use to determine the cardiac function and cardiac disease. The spatial temporal resolution, suboptimal quality image are extremely useful in the ICU setting and expertise in ICU is a time-consuming and challenging to their potential findings. Stress echo cardiography and SPECT myocardial perfusion imaging (MPI) are considered an equivalent diagnostic test.

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