ULTRASOUND USE IN CARDIOLOGY

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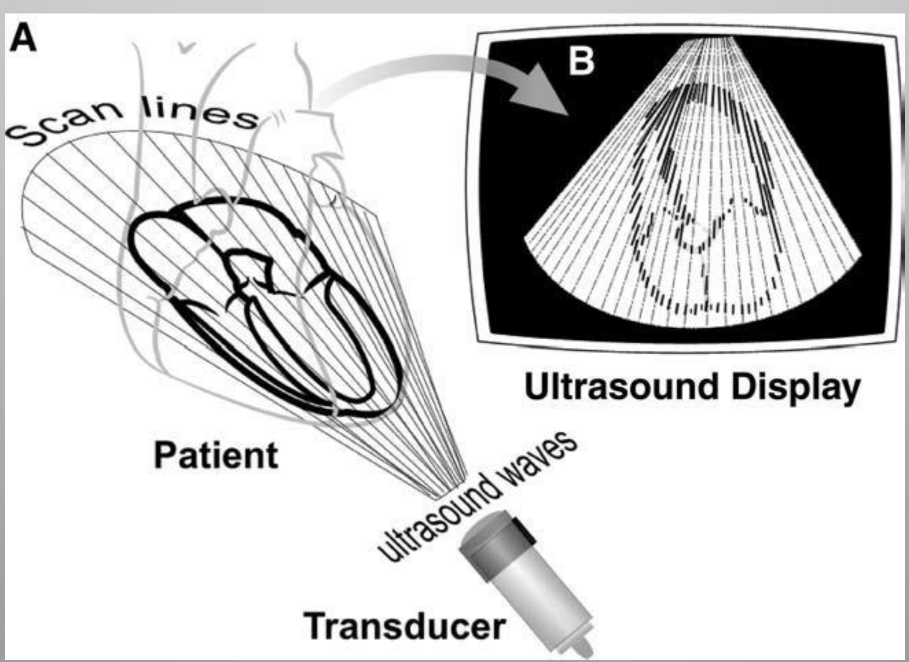
“Mother Theresa” UHC

- Echocardiography has emerged as the principal tool for noninvasive assessment of the cardiovascular system.
- The basic principles of echocardiography are no different from diagnostic ultrasound in general.
- Nevertheless, there are aspects of echocardiography that set it apart from general ultrasonography.
- Heart is a moving organ and echocardiography must additionally capture that movement.
- An understanding of echocardiography requires an understanding of both cardiac anatomy and physiology.

- Ultrasound frequencies of 2.5–10 MHz are typically utilized for normal diagnostic work.
- Although resolution can be increased by increasing the frequency of the ultrasound used, higher frequency ultrasound is less able to penetrate through tissues
- For this reason, high-frequency transducers only image well at short distances
- Pediatric imaging and transesophageal echocardiography which require less penetration, are often carried out at a frequency of 5 MHz or higher.
- Indeed, 2.5–3 MHz resolution probes have become the standard for adult imaging.


A
B
Scan lines
Ultrasound Display
Patient
ultrasound waves
Transducer

Cardiac ultrasonography has both practical and technical advantages over other cardiovascular imaging techniques (e.g., Cardiac CT, Cardiac MRI)

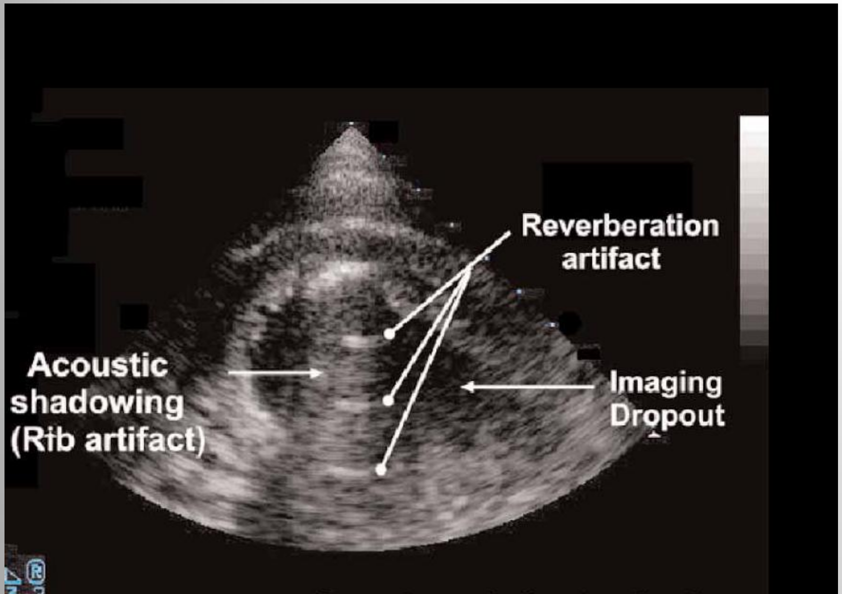
1. Good diagnostic performance
2. Excellent clinical utility
3. Widely available
4. Portable (in-hospital and point-of-care testing)
5. Immediate results
6. Safe
7. Lower cost
8. Minimal patient discomfort
9. No radiation (compare CT, angiography, and so on)
10. No special breath-holding (compare MRI)

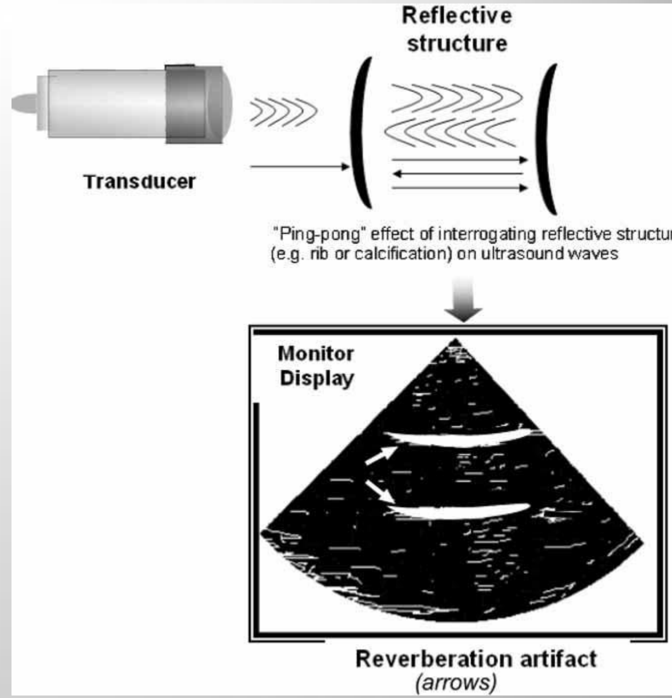
- Given its great clinical utility, there is a temptation to request echocardiography as “routine.”
- Such tendencies should be discouraged, because echocardiography, still adds to the burden of health care costs.
- Furthermore, incidental findings of no clinical significance in otherwise normal individuals can create unnecessary alarm and additional expensive testing.

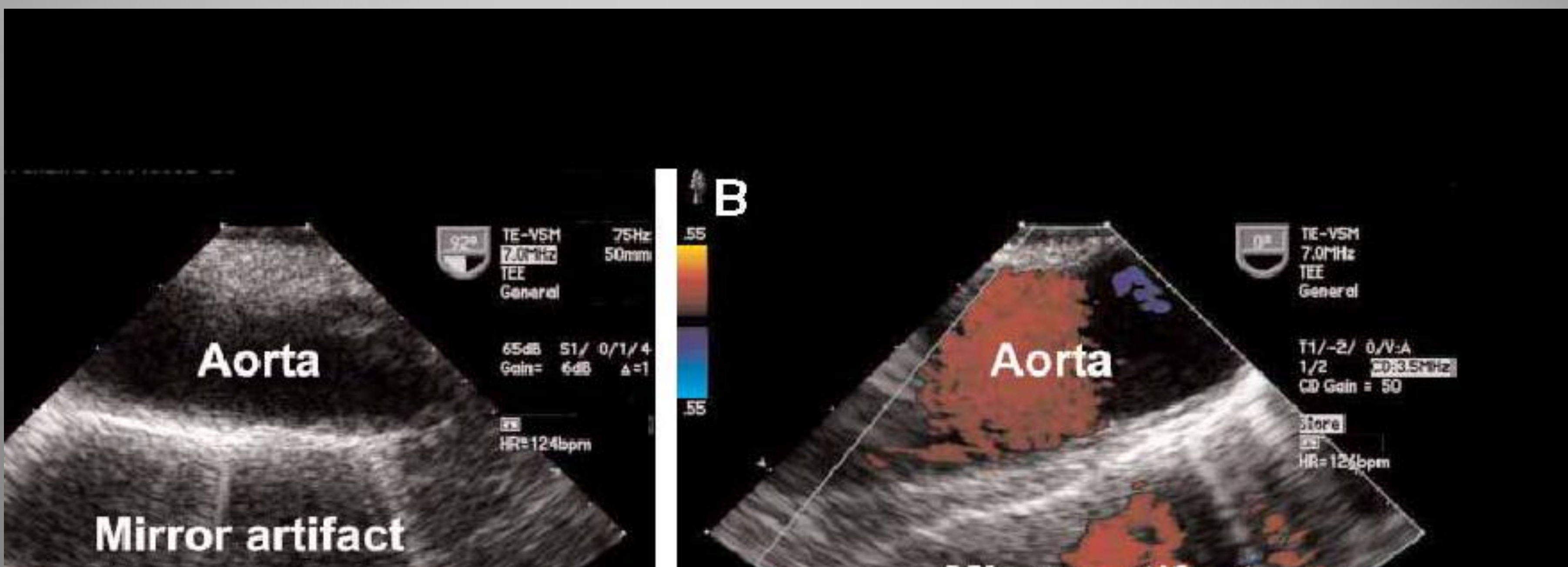
Ultrasound Artifacts

- Artifacts include both the apparent presence of structures that do not exist, or the obscuring of structures that do exist

1. **Rib artifacts** can often be distinguished from actual structures because the artifact will remain in one place relative to the transducer while the beating heart moves separately from the artifact.
2. **Reverberation artifacts** are caused by reflections that occur internally within the imaging region, usually caused by calcifications
3. **Mirror image** artifacts are frequently seen in the aorta on transesphageal echocardiography, originates from the fact that ultrasound beams can be wider than the scanline representation on the image.


Reverberation artifact
Acoustic shadowing (Rib artifact)
Imaging Dropout

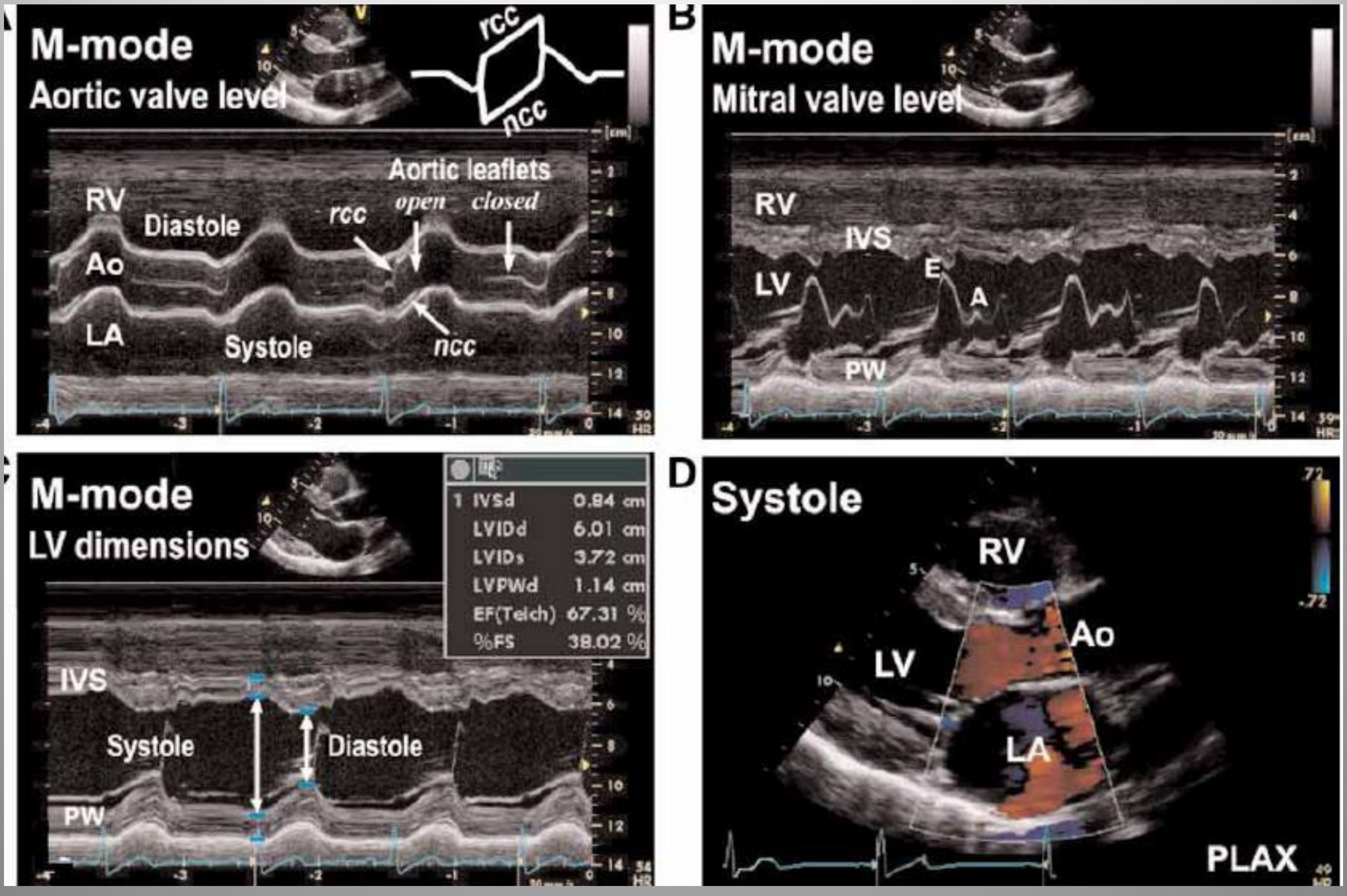

Reflective structure
Transducer
"Ping-pong" effect of interrogating reflective structure (e.g. rib or calcification) on ultrasound waves
Monitor Display
Reverberation artifact
(arrows)


B
Aorta
Mirror artifact
Aorta

M-mode echocardiography

- Most M-mode images are recorded in the parasternal long-axis and parasternal short-axis mid-ventricular level.
- The ultrasound beam is maneuvered to slice through the structure of interest, producing a high-resolution image of this slice over time.
- Is valuable to measure the left ventricle cavity dimension and wall thickness.
- Assessment of ventricular systolic function

M-mode echocardiography



Two-Dimensional echocardiography

- ***2-D* echocardiography** is performed in three orthogonal planes:
- 1. Long-axis 2. Short-axis 3. Four-chamber
- These three planes can be visualized using four basic transducer positions:

1. parasternal
2. apical
3. subcostal
4. suprasternal

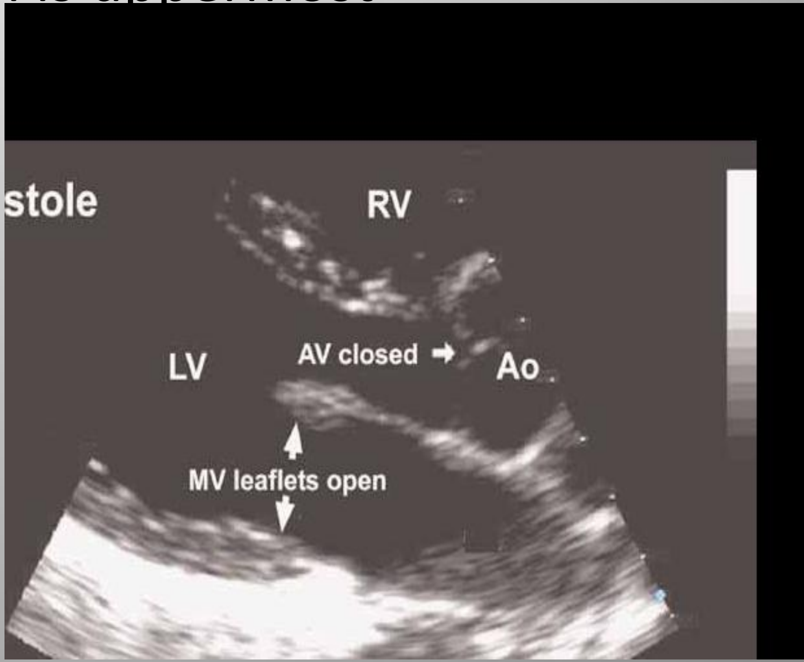
- The examination usually begins with the transducer in the left parasternal position in the long-axis view.

The Parasternal Position

- For the parasternal views, the patient lies in the left lateral decubitus position with the left arm supporting the head.
- The transducer is generally placed just left of the sternum, in the second, third, or fourth intercostal space
- From here, both **short**- and **long-axis** views of the heart can be obtained

PARASTERNAL LONG-AXIS VIEW (PLAX)

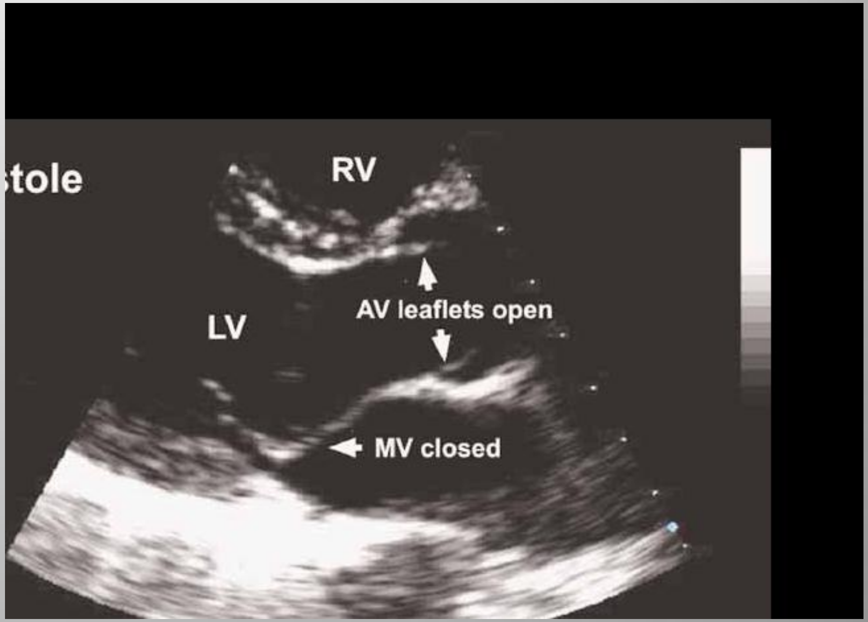
- The index is pointed toward the **patient's right shoulder**.
- The right ventricle (RV) lies anterior to the LV.
- The anterior interventricular septum is uppermost
- The posterior LV wall is below
- The LV apex to the left
- The ascending aorta is on the right of the screen
- The aortic valve: right coronary AV leaflet superiorly and noncoronary leaflet inferiorly
- The left atrium (LA) and MV are at the bottom of the screen.



PARASTERNAL LONG-AXIS VIEW (PLAX)

- It is generally **the best window** for measuring:

1. The aortic root
2. LA
3. LV chamber dimensions
4. LV wall thickness.



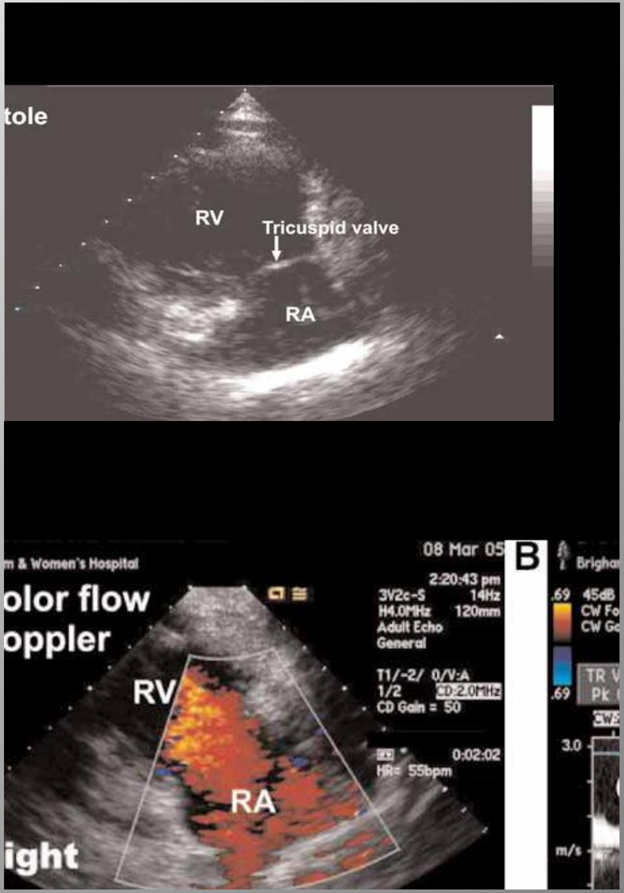
- Pericardial effusions can be visualized
- LVOT diameter
- Can reveal evidence of mitral regurgitation or aortic insufficiency

RV INFLOW VIEW

- With inferomedial tilt of the transducer a longitudinal view of the RV and right atrium (RA) can be obtained

1. RA is to the right and bottom (posterior)
2. RV is above and left (anterior)

- This view allows visualization of the tricuspid valve and assessment of tricuspid regurgitation

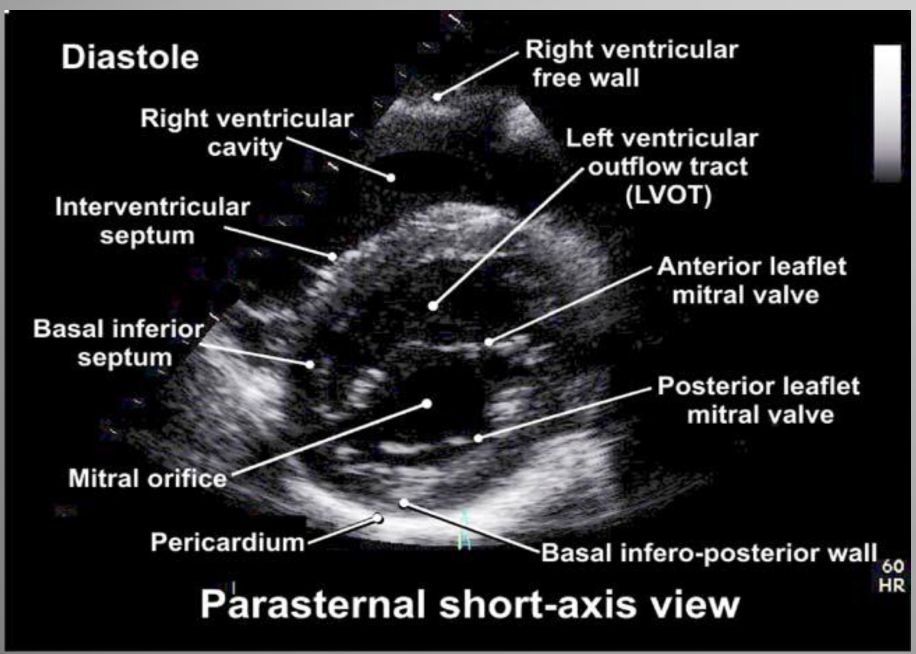


PARASTERNAL SHORT-AXIS VIEWS (PSAX)

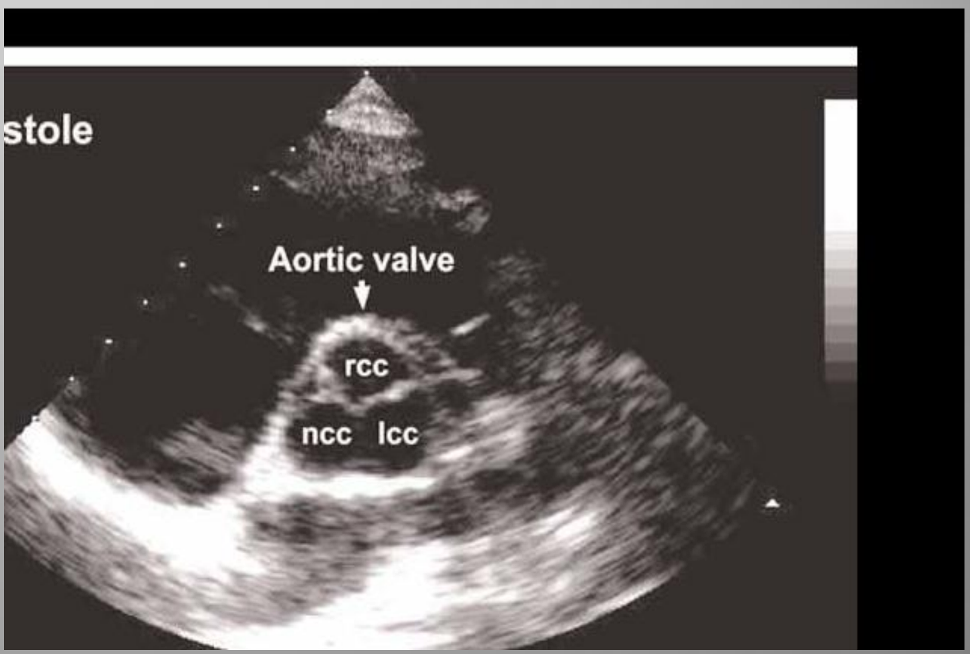
- The transducer is rotated 90° clockwise to obtain the short-axis views.
- The index is now facing the **patient's left shoulder**
- Views can be obtained at three levels:
- the base
- the midventricle
- the apex

PSAX- basal plane

- **Mitral valve level**
- By angling the transducer superiorly and rightward
- This view includes the MV leaflets and extends to the tips of the papillary muscles.



- **Aortic valve level**
- By angling the transducer slightly caudally
- Aortic valve structure (aortic insuff)
- Tricuspid valve (at 10 o’clock)
- Pulmonic valve seen at (2 o’clock)



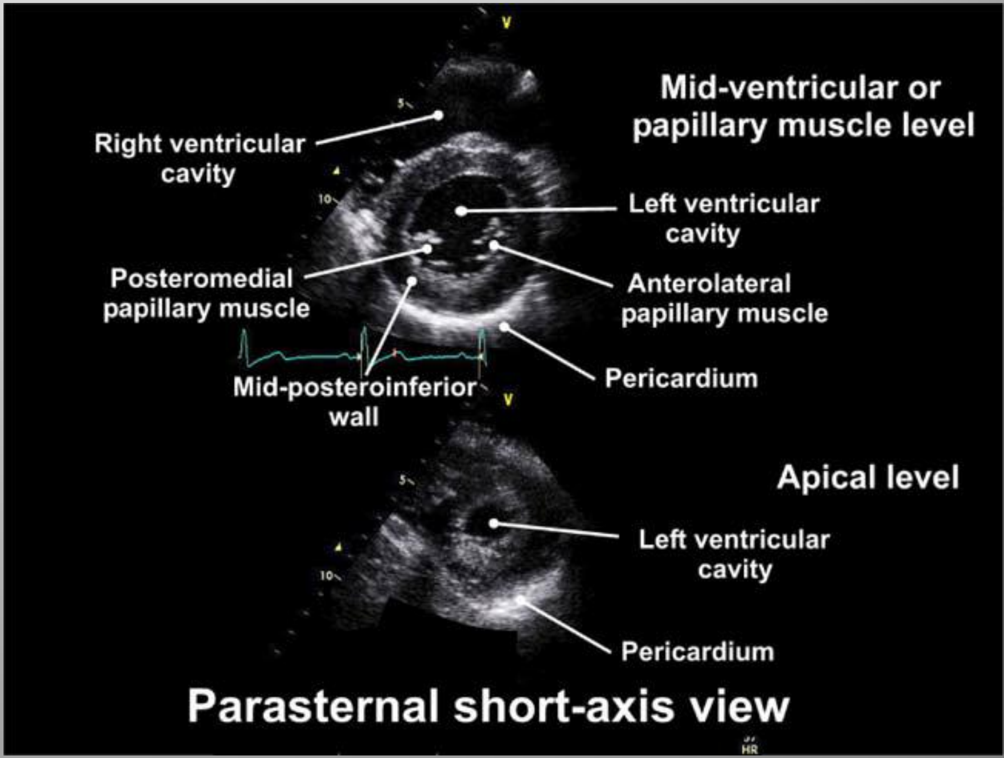
PSAX VIEWS

Mid-ventricular level (papillary muscle level)

- The transducer is perpendicular to the chest wall
- Comprises the length of the papillary muscles, from their chordal attachments to their insertion in the LV
- RV is seen at the top and to the left of the screen.
- LV should appear round (not oval)
- An excellent view for assessing global and regional LV contractility

Apical level

- Apical third of the LV can be seen with further inferior tilting of the probe.



Apical Position

- Patient still in the left lateral decubitus position
- The probe is moved to the **cardiac apex**, just lateral and caudal to the point of maximal impulse
- Is superior to the parasternal for looking at **mitral or aortic regurgitation**, because the regurgitant jets tend to be more parallel to the color
- From this position, the transducer direction is varied to obtain the:

four, five, three and **two-**chamber views of the heart

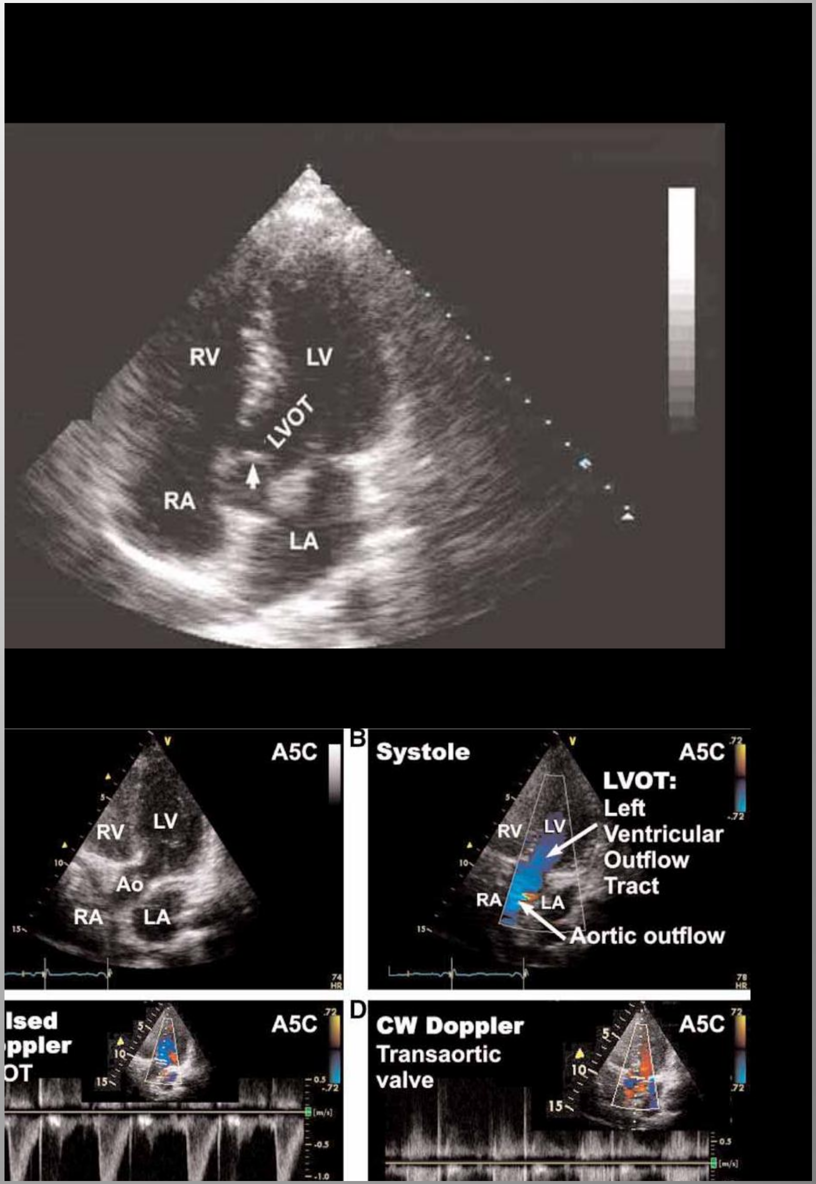
APICAL FOUR-CHAMBER VIEW

- The transducer is angled superiorly toward **the patient's right shoulder** with the index pointing down (toward the patient's left flank)
- The **apex** it is at the top of the screen; the **atria** are at the bottom.
- The LV and LA are on the right and the RV and RA on the left, divided by the interventricular septum and interatrial septum
- The attachment of the septal leaflet of the tricuspid valve is approx 5–8 mm closer to the cardiac apex than the mitral attachment
- Assessing ventricular function, particularly the motion of the i/v septum and the lateral wall.
- Color flow Doppler is used to assess possible **mitral regurgitation**, **aortic insufficiency**, and **tricuspid regurgitation**
- Spectral Doppler is used to assess mitral inflow

APICAL FOUR-CHAMBER VIEW

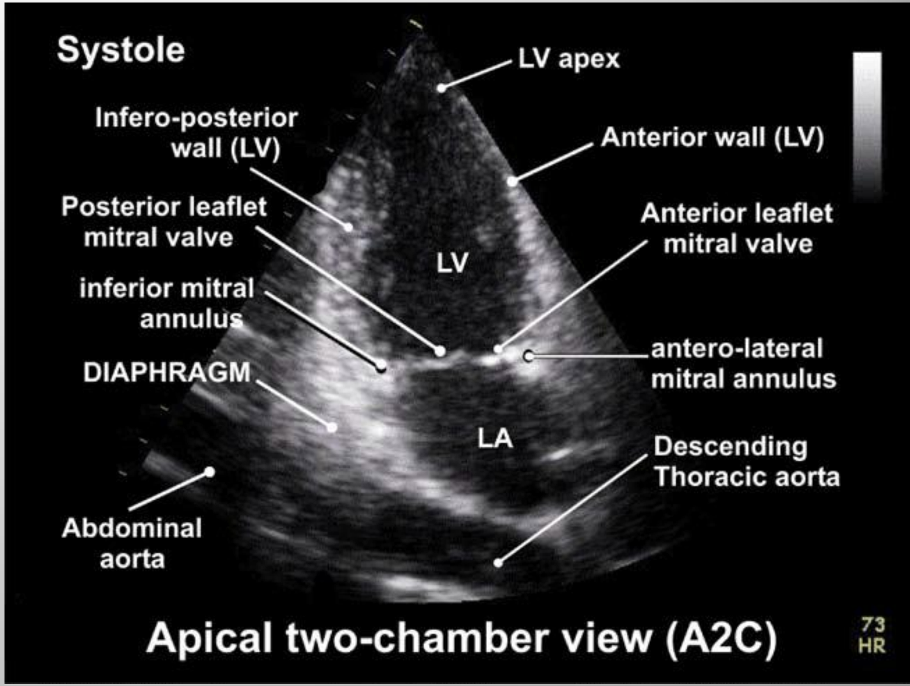
APICAL FIVE-CHAMBER VIEW

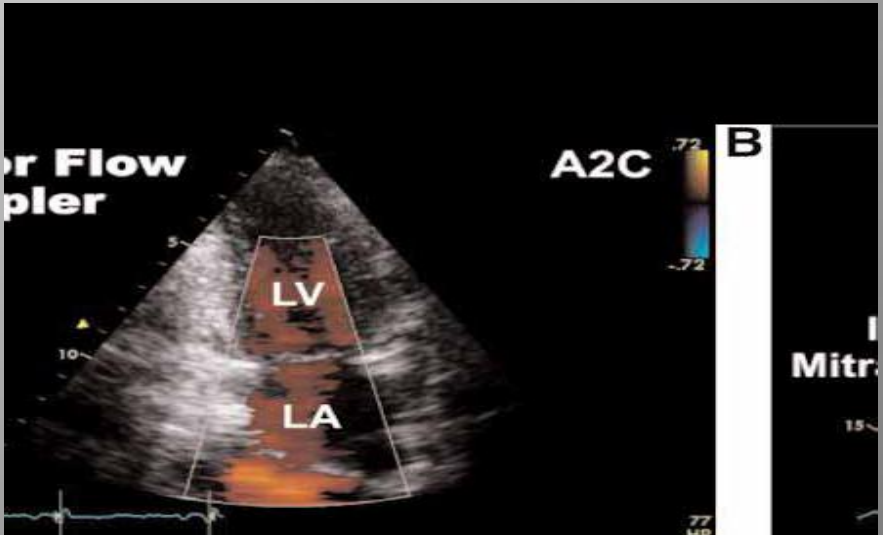
- Tilting of the scan head 10–20° anteriorly
- The best view for assessing the structure and function of the **aortic valve**
- Doppler color flow mapping and Doppler pulsed-wave images are useful in determining of **aortic regurgitation** and **aortic stenosis**



APICAL TWO-CHAMBER VIEW

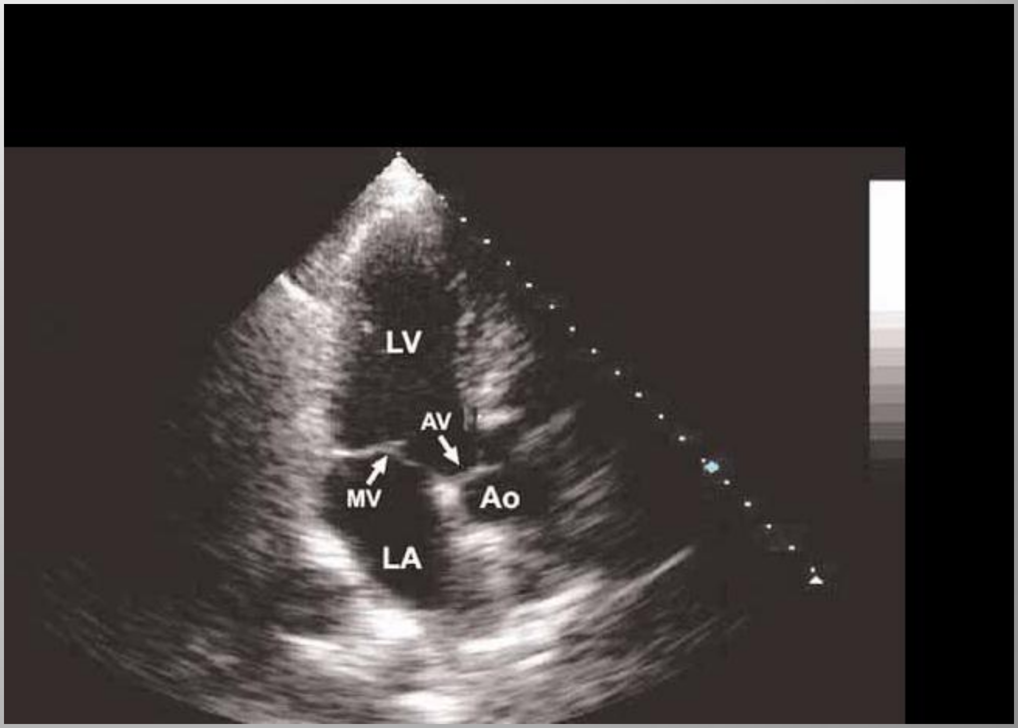
- The two chambers are the LA and LV
- Rotating the imaging plane 90° **counterclockwise** (index points to the **patient's left shoulder**)
- Regional wall motion of the **anterior** and **inferior** walls
- To view the plane of MV coaptation,
- Useful in the diagnosis of MV prolapse





APICAL THREE-CHAMBER VIEW (APICAL LONG-AXIS)

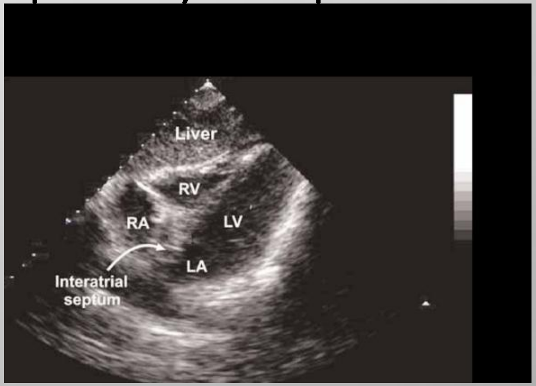
- Further **counterclockwise** rotation of the transducer head
- LV posterior wall, i/v septum, MV, and aortic valve.
- Color flow Doppler in this view can be useful to view potential **aortic insufficiency**

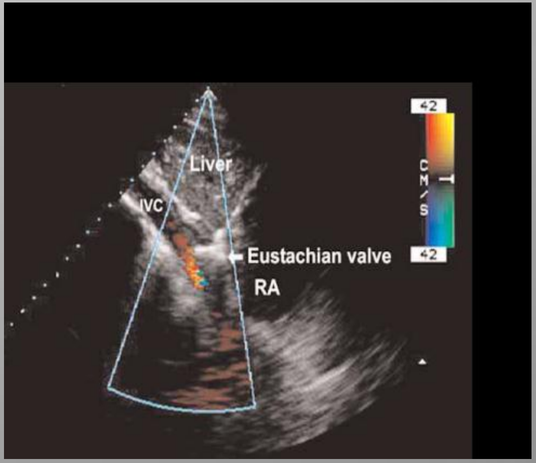


Subcostal Position

- The transducer is placed in the subxiphoid region, just to the right of center
- Emphysematous patients- the best imaging position
- The patient is placed in the supine position with knees flexed.
- Deep inspiration with breath hold.
- Angulation of the transducer head toward the left shoulder, with the index facing the patient's left flank
- The right heart structures are well visualized in this view.
- The interatrial septum can be examined for septal defects or patent foramen ovale

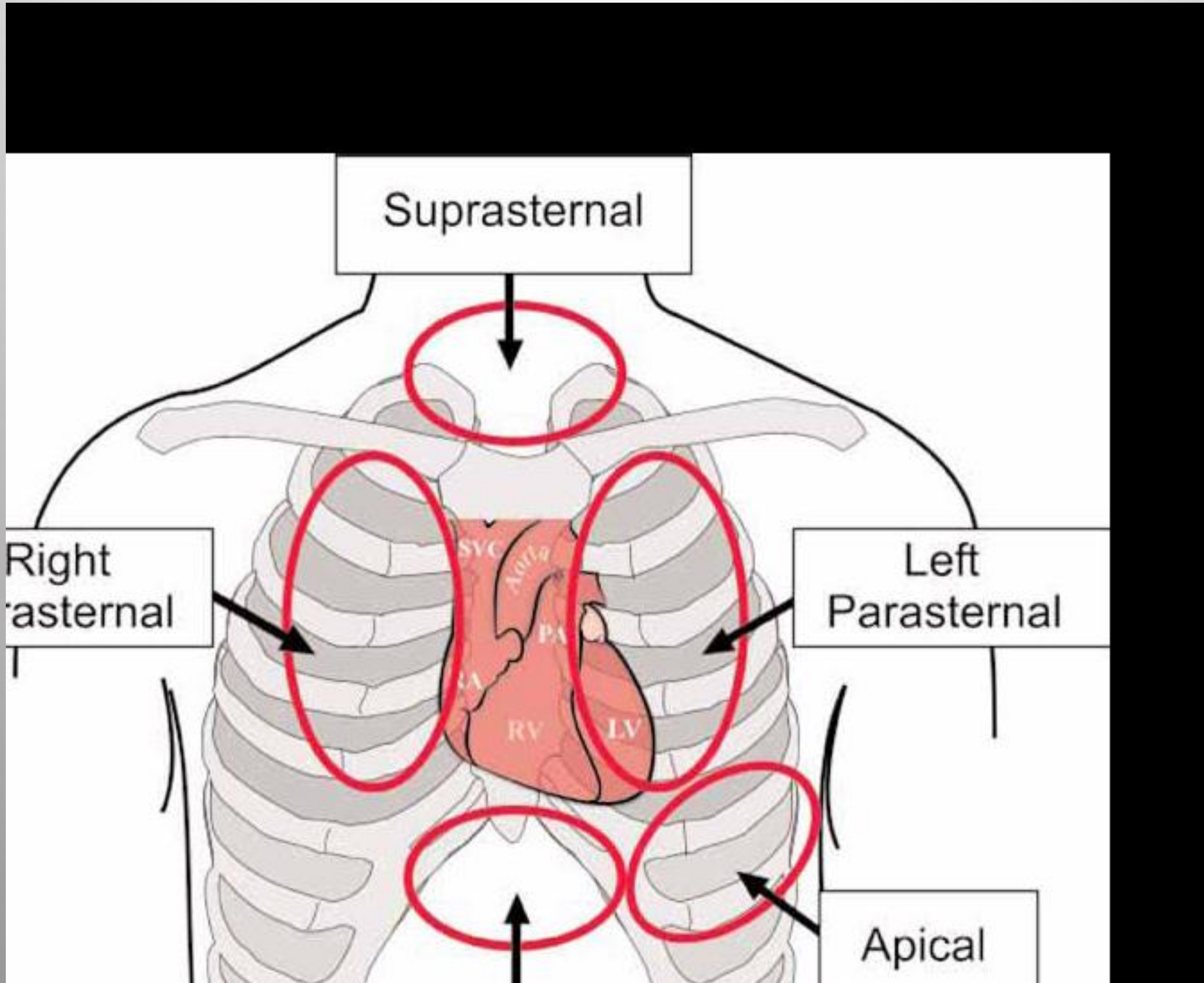
- Can be assesed inferior vena cava (IVC)
- Rlevated RA pressure may lead to IVC dilation and loss of the expected inspiratory collapse





Suprasternal Position

- Aortic arch and its major branches
- In the suprasternal notch with the index toward the patient's head and the tip angled caudally
- Diagnosis of some aortic diseases and congenital anomalies, including **severe aortic insufficiency** and **aortic coarctation**


Suprasternal
Right
rasternal
Left
Parasternal
SVC
Aorta
PA
RV
LV
Apical

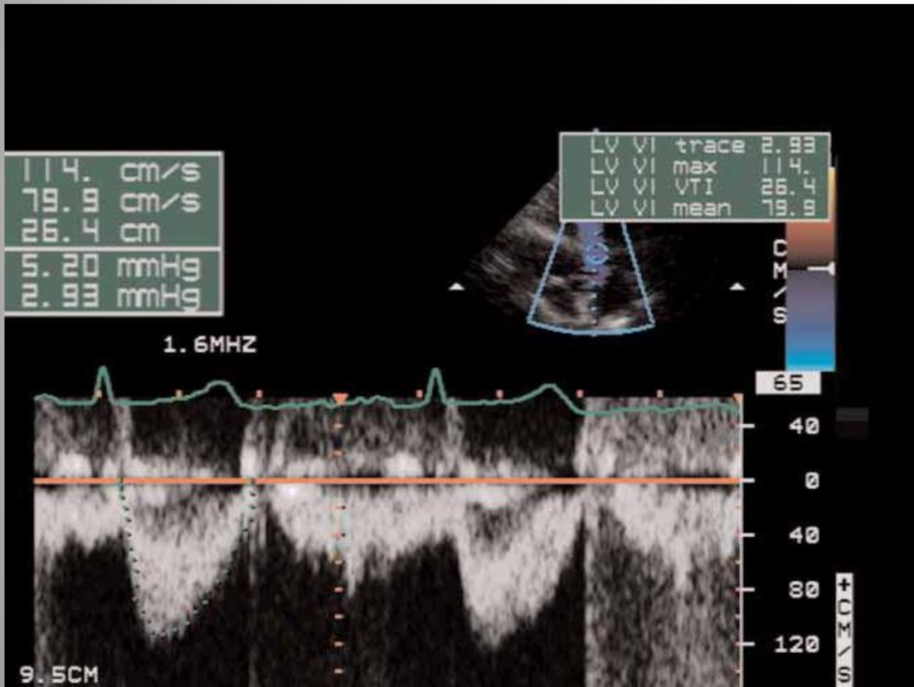
Doppler echocardiography

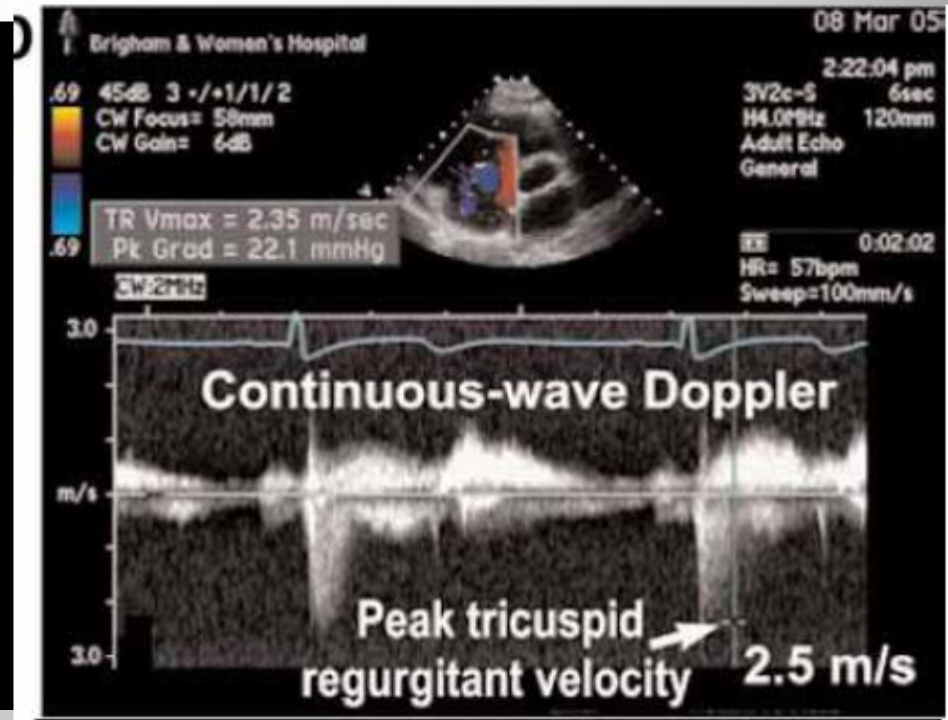
PW DOPPLER

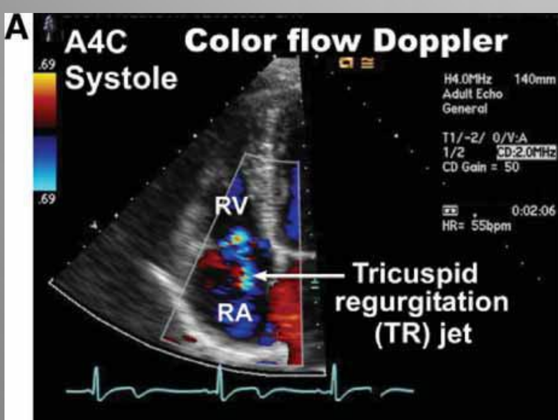
- PW Doppler is used primarily to obtain velocity information for relatively **low velocity** flows at a **specific location** within the heart or blood vessels
- 1. assessing the left ventricular outflow tract velocity
- 2. assessment of mitral inflow velocities,
- 3.assessment of pulmonary venous velocities.
- From this velocity information, it is possible to estimate pressure gradients utilizing the Bernoulli equation.

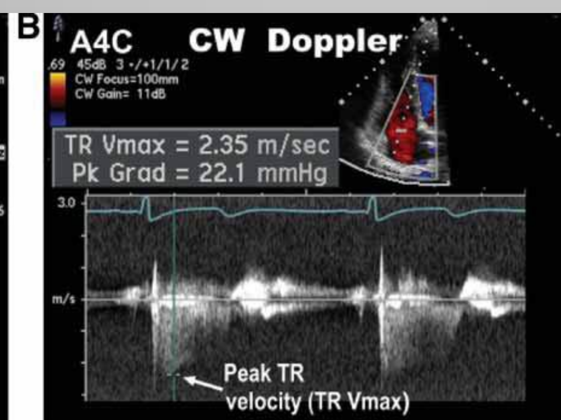
CW DOPPLER

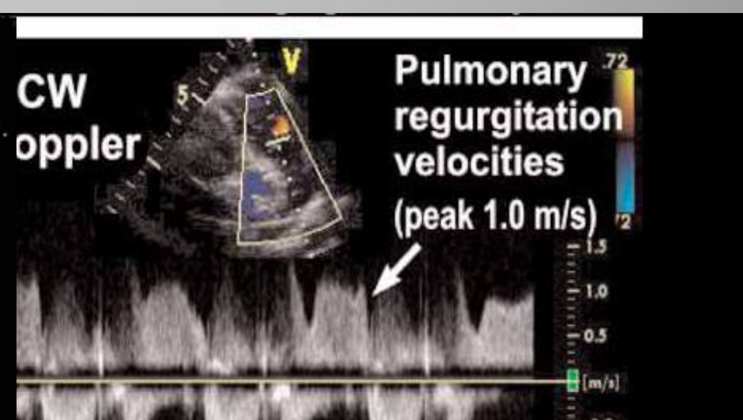
- The advantage is that it can interrogate much higher velocities than is possible with PW Doppler
- CW Doppler tells the **maximal velocity along the line** of the ultrasound beam.
- Cannot determine the location of the maximal velocity.
- 1. velocity across the aortic valve in aortic stenosis
- 2. velocity of tricuspid regurgitation.


114. cm/s
79.9 cm/s
26.4 cm
5.20 mmHg
2.93 mmHg
LV VI trace 2.93
LV VI max 114.
LV VI VTI 26.4
LV VI mean 79.9
1.6MHZ
65
40
0
40
80
120
9.5CM


Brigham & Women's Hospital
08 Mar 05
2:22:04 pm
45dB 3 -/+1/1/2
CW Focus= 58mm
CW Gain= 6dB
TR Vmax = 2.35 m/sec
Pk Grad = 22.1 mmHg
Adult Echo
General
0:02:02
HR= 57bpm
Sweep=100mm/s
CW:2MHz
3.0
Continuous-wave Doppler
m/s
Peak tricuspid
regurgitant velocity
2.5 m/s


A
A4C
Systole
Color flow Doppler
H4.0MHz 140mm
Adult Echo
General
CD Gain = 50
0:02:06
HR= 55bpm
RV
RA
Tricuspid
regurgitation
(TR) jet


B
A4C
CW Doppler
45dB 3 -/+1/1/2
CW Focus=100mm
CW Gain= 11dB
TR Vmax = 2.35 m/sec
Pk Grad = 22.1 mmHg
3.0
m/s
Peak TR
velocity (TR Vmax)

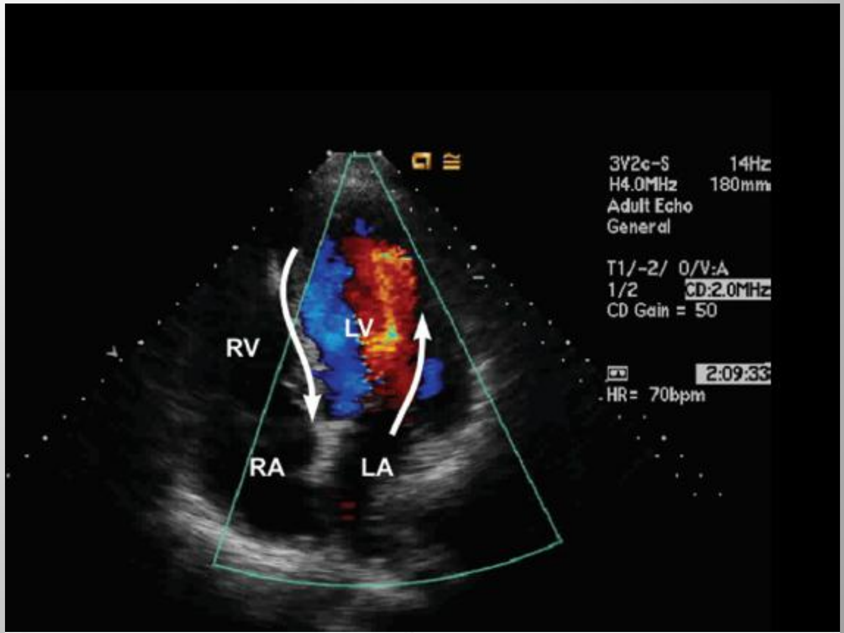

CW
oppler
Pulmonary
regurgitation
velocities
(peak 1.0 m/s)
1.5
1.0
0.5
[m/s]

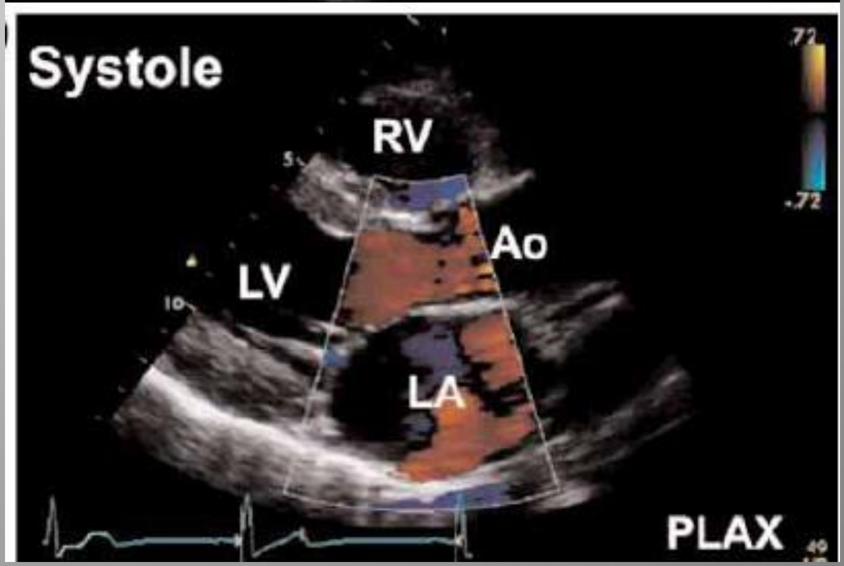
Color Flow Doppler

- Color flow Doppler samples multiple locations along a scan line simultaneously
  and determines the velocity of individual locations.
- These velocities are then "color encoded"
- Flow that is moving away

from the transducer is encoded in blue, and flow that is moving toward the transducer is encoded in red

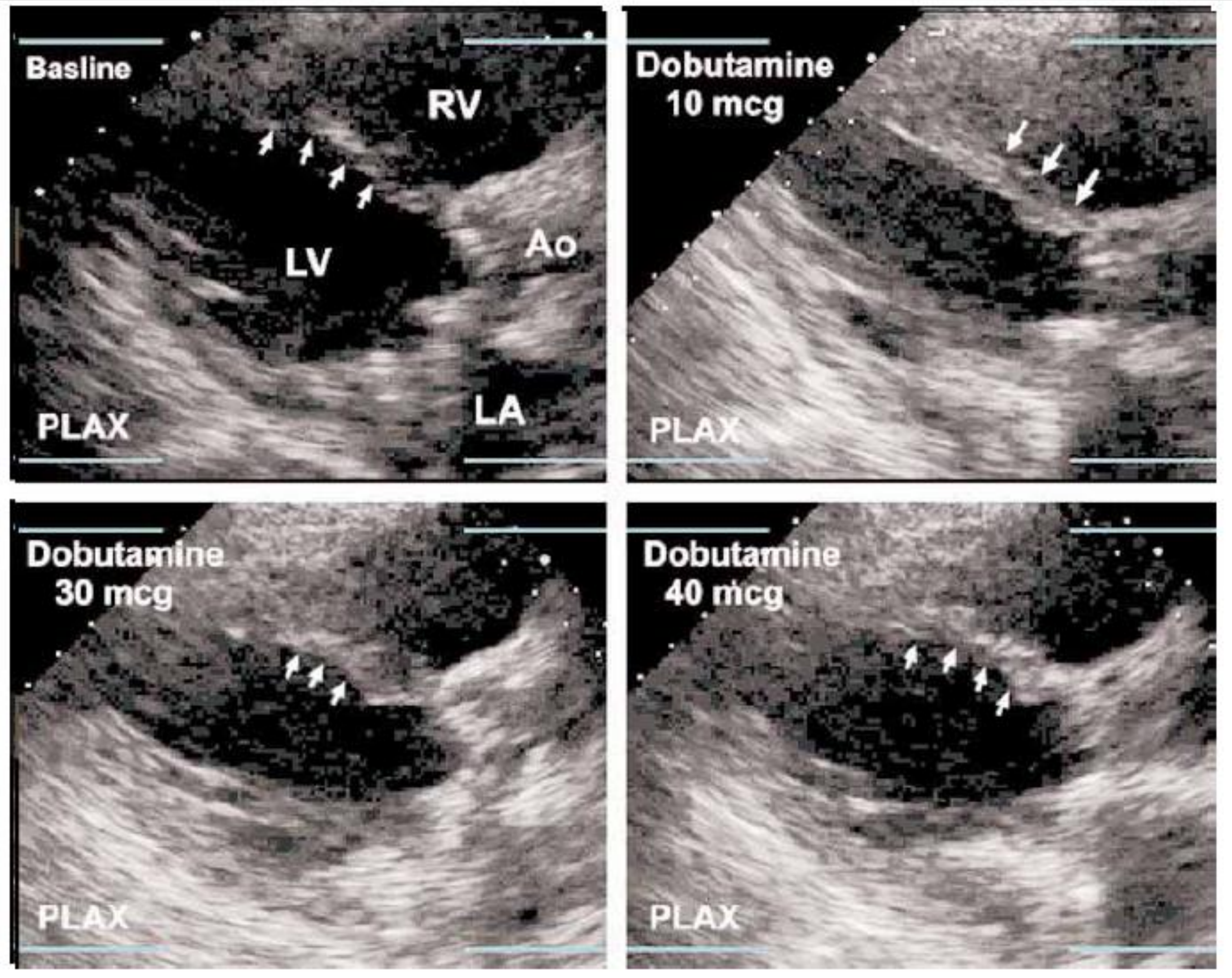
(BART)





Stress echocardiography

- Exercise-, pharmacological-, and pacing stress
- Diagnosis, risk stratification, and prognosis in coronary artery disease
- Dobutamine echocardiography can provide additional information on the LV contractile reserve
- This has value in predicting recovery of function following coronary revascularization procedures.
- A biphasic response on dobutamine stress echocardiography, however, can be a good predictor of improvement in patients scheduled to undergo coronary revascularization procedures



This patient shows augmentation of a previously poorly functioning region on low dose dobutamine (10 µg), but demonstrates ischemia (decreased contractility) at higher doses. At baseline, this region of the heart (arrows) are hypokinetic—contractility improves at the 5 µg infusion rate, is maintained at 10 µg, worsens at 40 µg. This represents an ischemic region that augmented at low doses that can benefit from revascularization

Stress Echocardiography: Utility and Indications

	Protocol	*Utility*	*Indications/comments*
Exercise stress echocardiography	Treadmill, bicycle (supine or upright)	Diagnostic	Patients with abnormal baseline ECG or limited exercise tolerance • Nonspecific ST-T-wave changes • Left bundle branch block • Left ventricular hypertrophy • Digoxin therapy • Wolff-Parkinson-White syndrome
		Prognostic	• Chronic coronary artery disease • Post-myocardial Infarction
		Risk stratification	• In heart failure: contractile reserve, mitral valve function, right ventricular function • Perioperative evaluation for noncardiac surgery
Pharmacological stress echocardiography	Sympathomimetic amines, e.g., dobutamine, dobutamine (+ atropine) —agent of choice (US)	As for exercise stress echocardiography (in patients unable to exercise)	• Indications as for exercise stress echocardiography (when patients unable to exercise) • Myocardial viability assessment (for biphasic response) • Contractile reserve in patients with heart failure and low-gradient aortic stenosis
	Vasodilators, e.g., dipyridamole, adenosine	As for exercise stress echocardiography (in patients unable to exercise)	Less sensitivity than with sympathomimetic amines (use mainly outside the US)
	Other; ergonovine–ergometrine, enoximone		Diagnostic evaluation of vasospastic coronary artery disease
Pacing stress echocardiograpy	Atrial Transesophageal atrial pacing	Diagnostic	Patients with known or suspected coronary artery disease
Stress echocardiography with Doppler		Low gradient aortic stenosis (with left ventricular dysfunction)	Assessment of contractile reserve (Dobutamine stress)
		Heart failure; assessment of systolic/diastolic dysfunction	Mitral regurgitation and Transmitral Doppler indices using exercise or pharmacological protocols

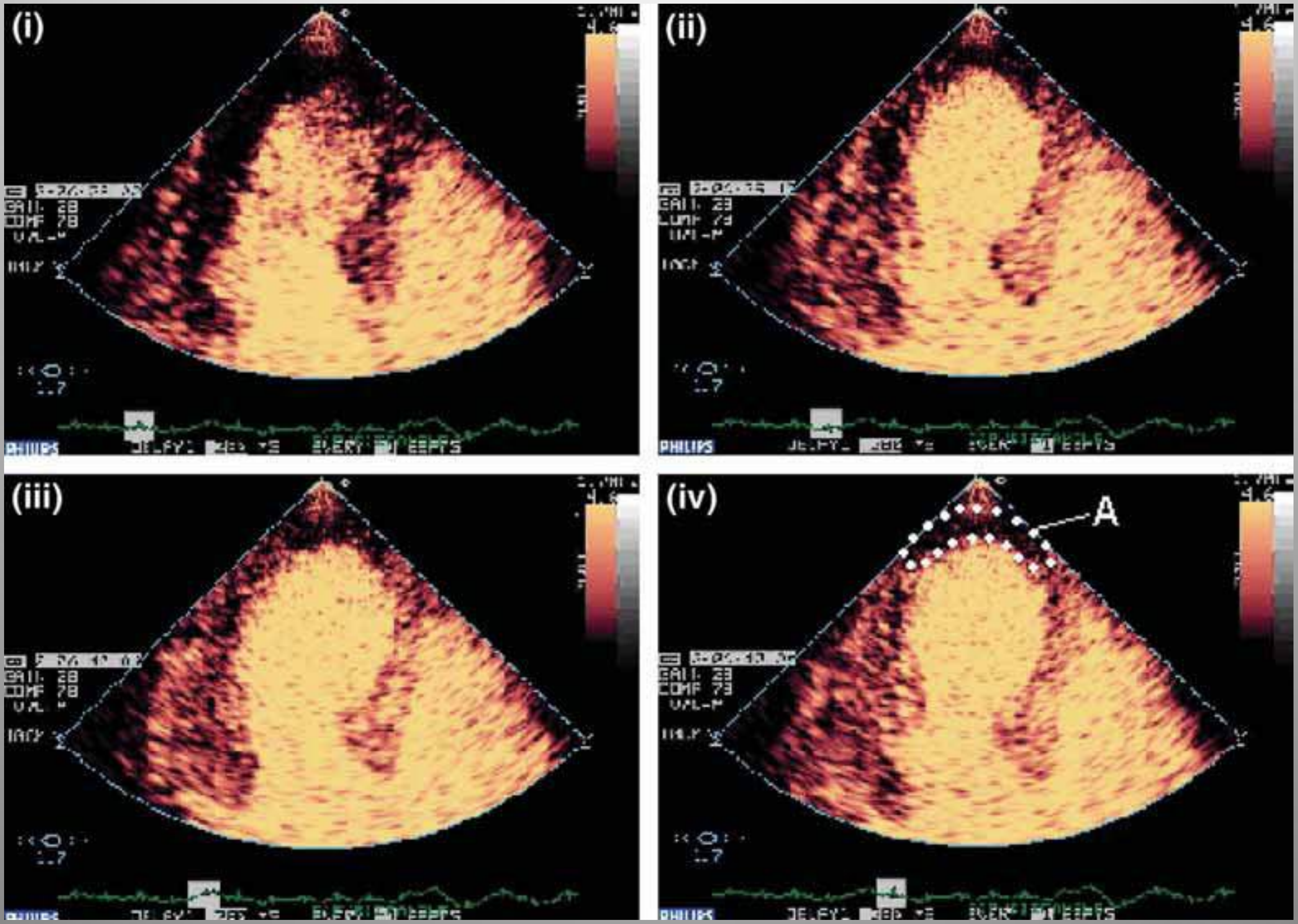
Contrast echocardiography

- **1. Right-sided contrast studies (agitated saline)**
  Right-to-left shunts

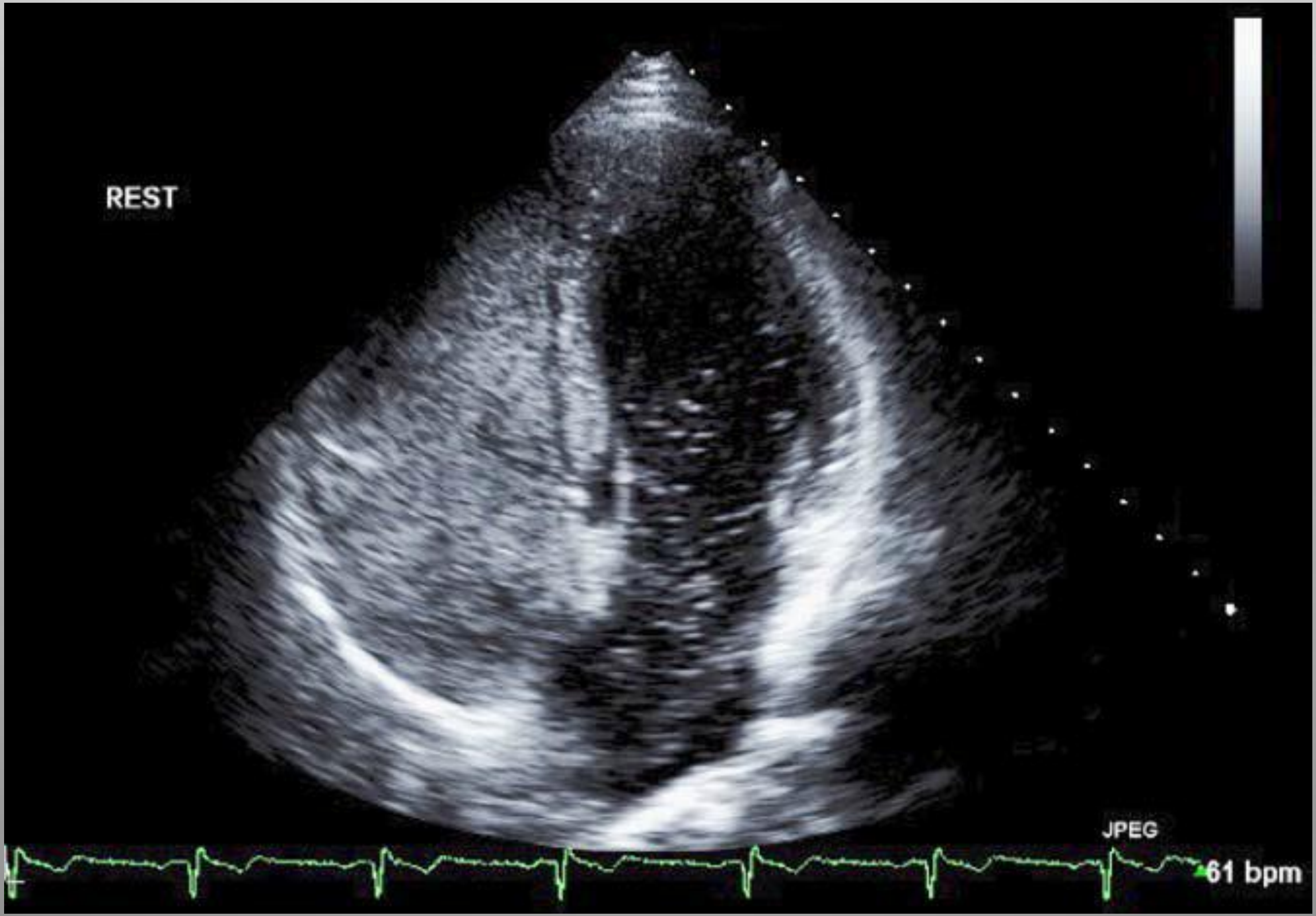
- **2. Left-sided contrast studies (micro bubbles)**
  Endocardial definition (LV opacification)

- Assessment of regional and global LV function.
- Accurate visualization of the endocardium
- By injecting microbubbles that traverse the pulmonary circulation, the LV can be opacified and endocardial definition significantly improved
- Can assist in the identification of LV thrombi

Contrast echocardiography



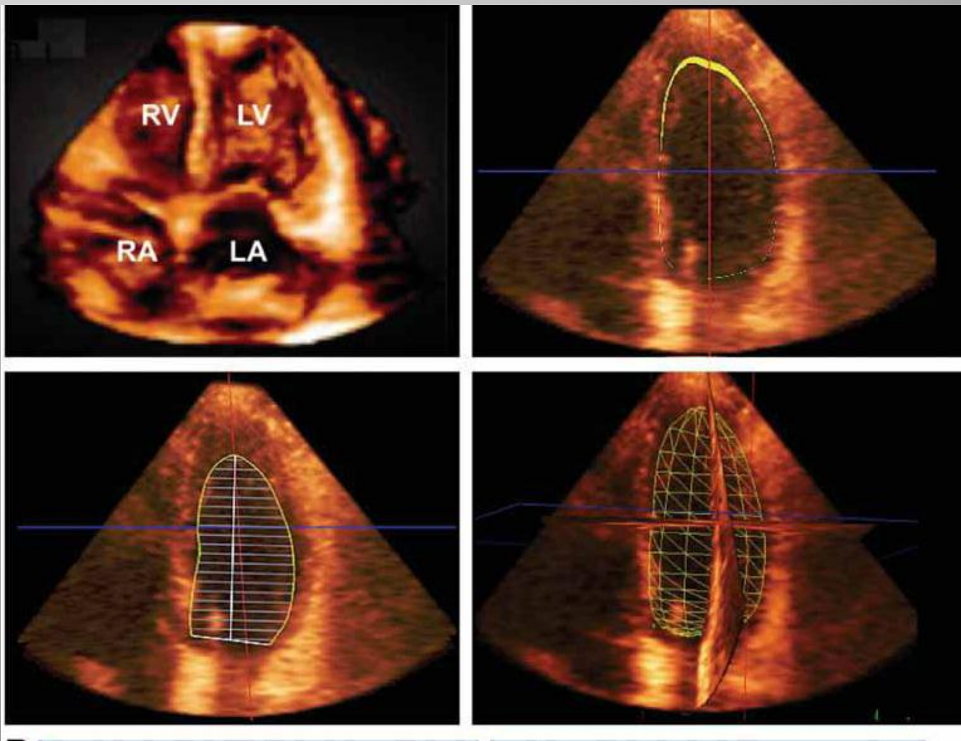
Contrast echocardiography



Three-dimensional (3D) echocardiography

Can be valuable in quantifying:

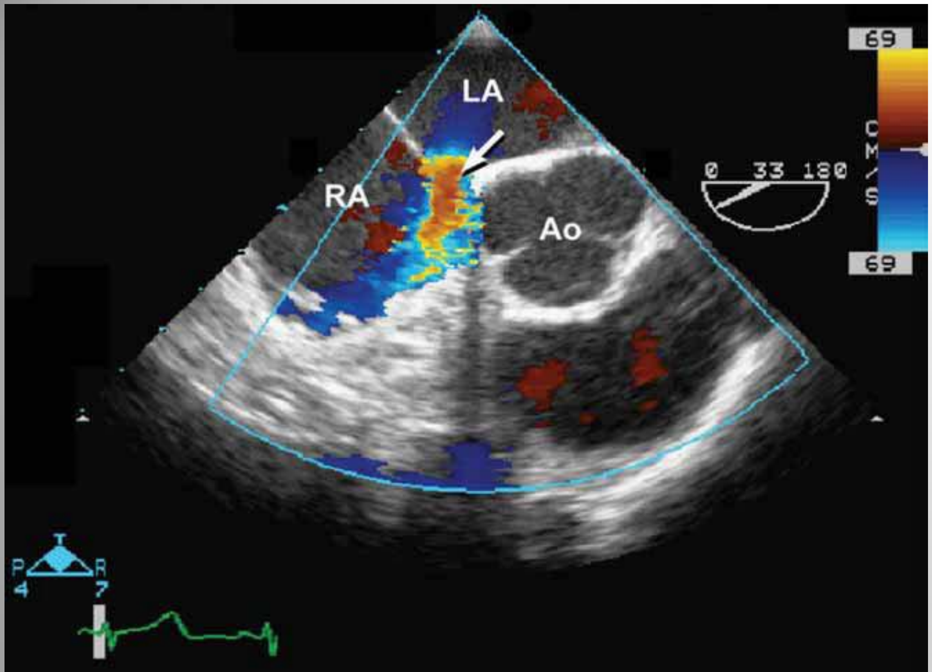
1. cardiac volumes and ejection fraction (EF),
2. assessing congenital heart disease (CHD)
3. evaluating structures of complex geometry such as the right ventricle

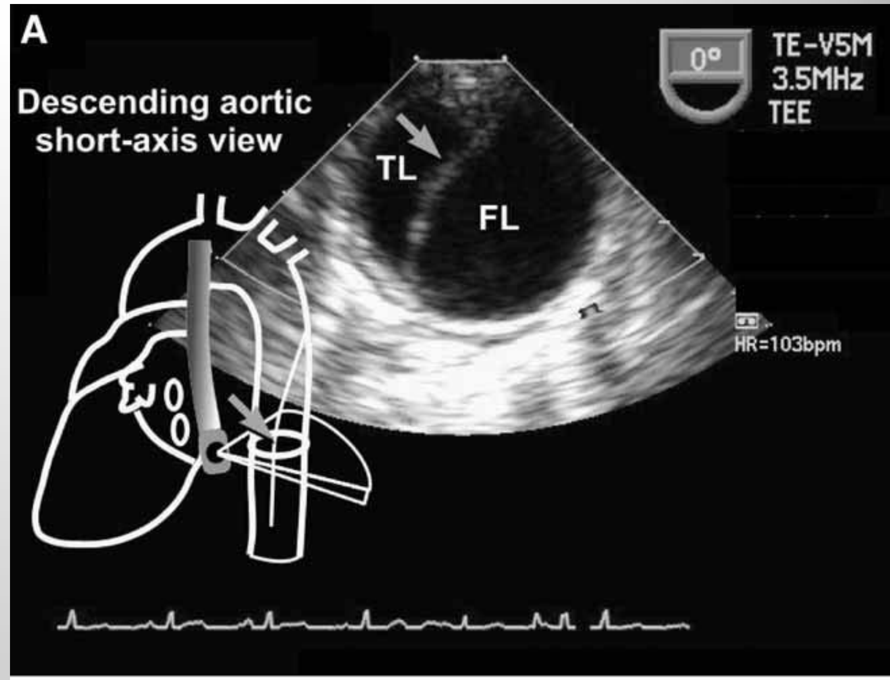


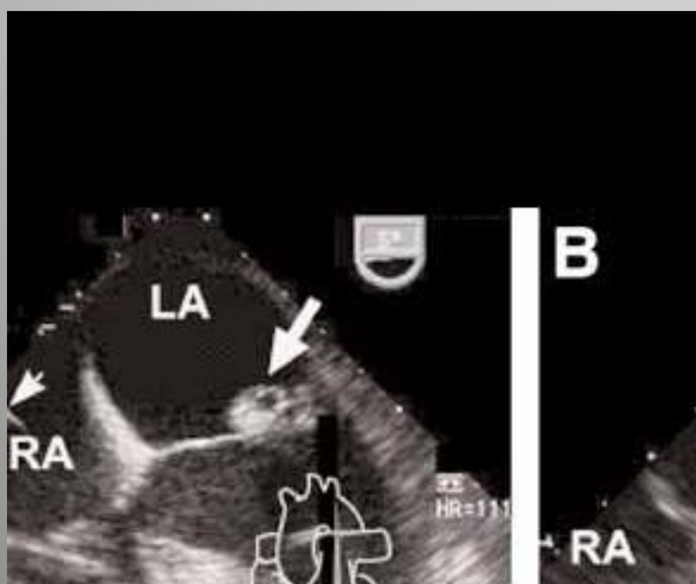
Transesophageal echocardiography (TEE)

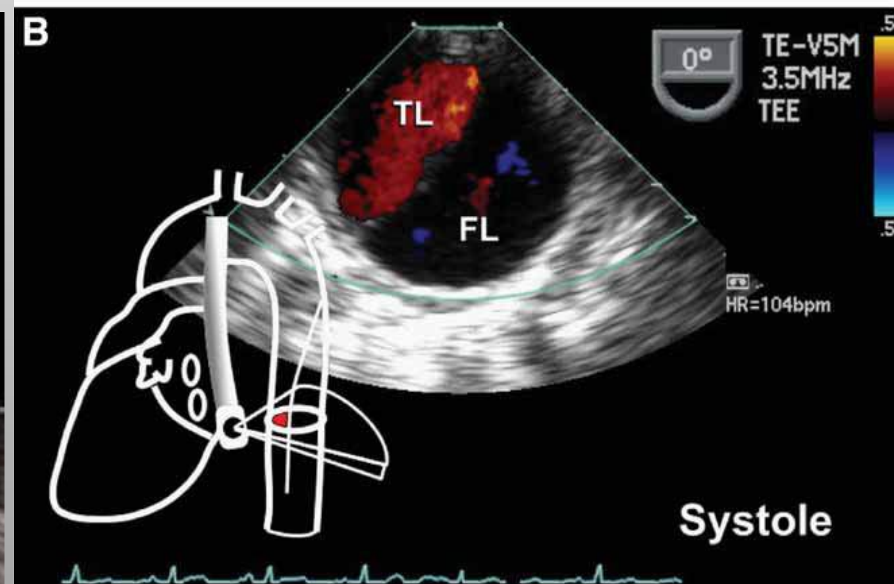
- Improved visualization when TTE is limited
- Gives detailed information especially in the evaluation of:

1. Posterior cardiac structures (left atrium, left atrial appendage, interatrial septum, aorta distal to the root),
2. Prosthetic cardiac valves
3. In the delineation of cardiac structures <3 mm in size (small vegetations or thrombi).


LA
RA
Ao
69
CM/S
69
0 33 180
P 4
R 7

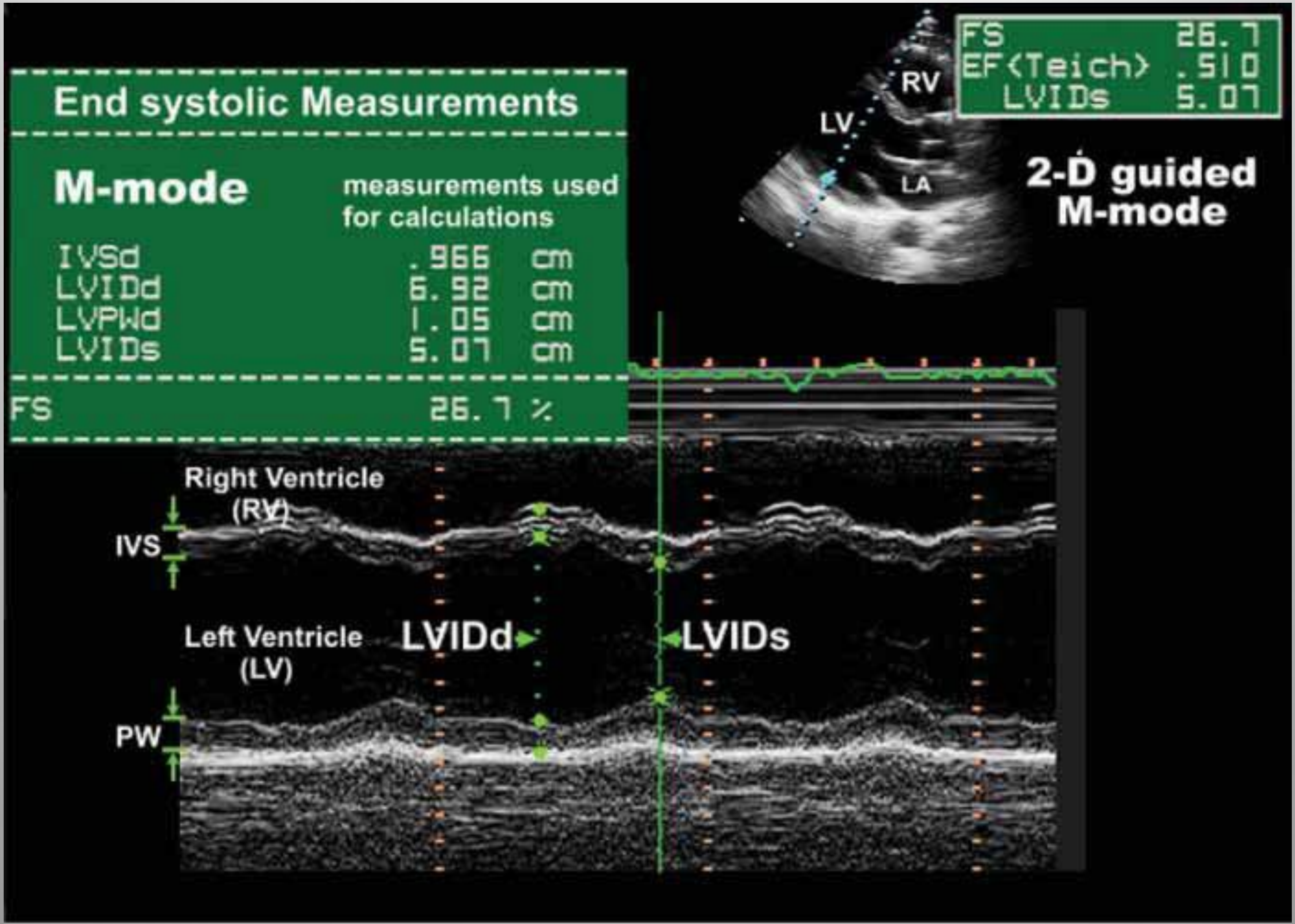

A
Descending aortic
short-axis view
TL
FL
0°
TE-V5M
3.5MHz
TEE
HR=103bpm


LA
RA
B
RA


B
TL
FL
0°
TE-V5M
3.5MHz
TEE
.55
.55
HR=104bpm
Systole

Echocardiographic Assessment of Ventricular Systolic Function

- A major clinical application of echocardiography is the assessment of ventricular systolic function
- Assessment of LV size is one of the most important components of quantitation of ventricular function
- The American Society of Echocardiography (ASE) recommends measurement of LV dimensions with the M-mode line perpendicular to the long axis of the heart and immediately distal to the tips of the mitral valve leaflets in the parasternal longaxis view
- Measurements are taken at end-diastole and at endsystole
- The diastolic measurements obtained are the interventricular septal wall thickness, the LV internal diameter at end diastole (LVIDd) and posterior wall thickness.
- In systole, the LV systolic diameter (LVIDs) is measured.
- The most important parameter: **Ejection fraction(EF)**
- **Ejection fraction(EF)= (EDV – ESV)/EDV**



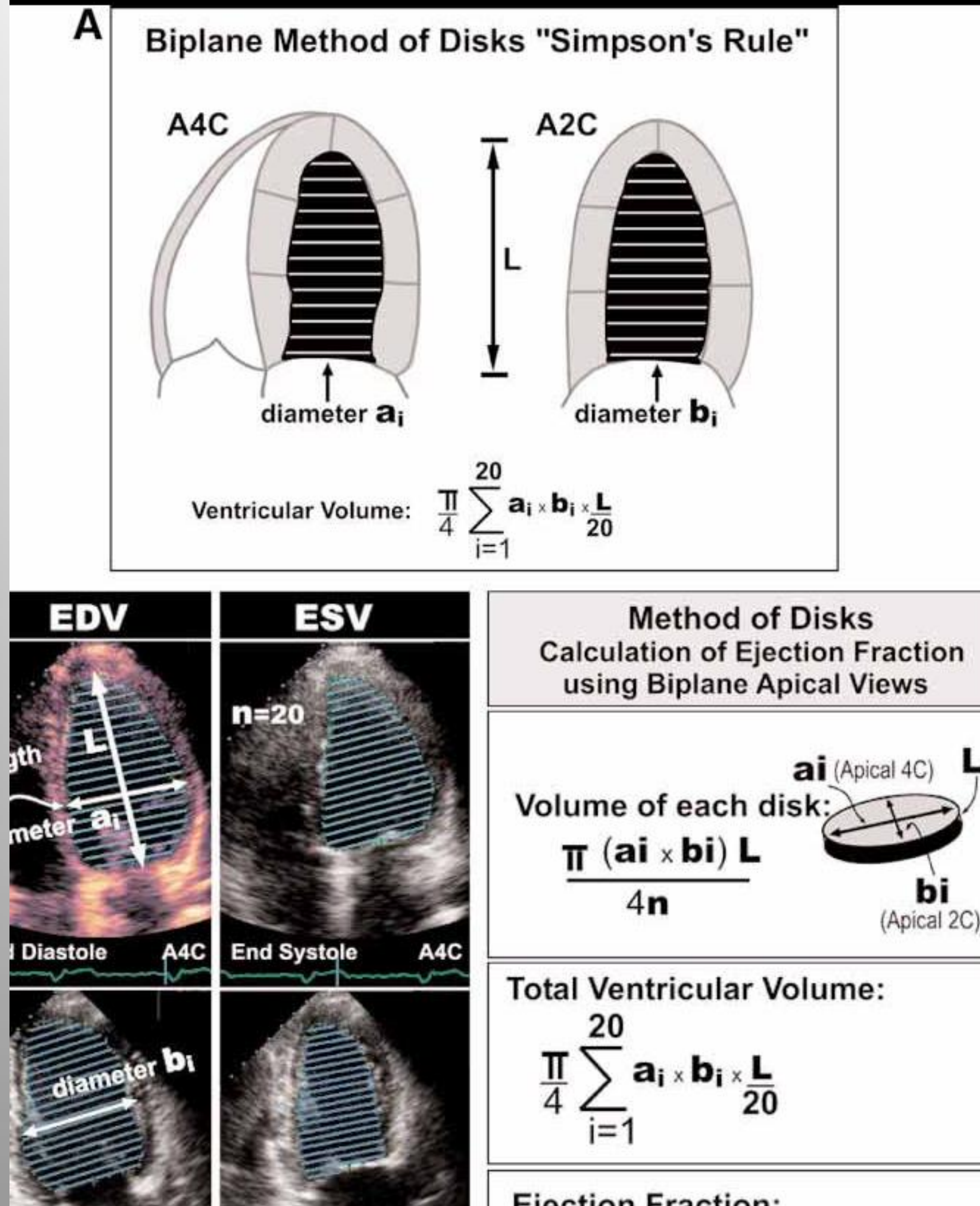
End systolic Measurements
M-mode
measurements used for calculations
IVSd .966 cm
LVIDd 6.92 cm
LVPWd 1.05 cm
LVIDs 5.07 cm
FS 26.7 %
FS 26.7
EF(Teich) .510
LVIDs 5.07
RV
LV
LA
2-D guided M-mode
Right Ventricle (RV)
IVS
Left Ventricle (LV)
LVIDd
LVIDs
PW

LIMITATIONS OF M-MODE MEASUREMENTS

1. **Nonperpendicular** alignment of the M-mode line in relation to the long axis of the LV
2. Identifing the **endocardial and epicardial borders** and avoid confusion with contiguous structures. The endocardial border is distinguished from ventricular trabeculations and chordae by its appearance as a continuous line of reflection throughout the cardiac cycle.
3. **LV geometry** should be normal. When LV geometry is abnormal, as in aneurysmal remodeling or in the presence of regional wall motion abnormality following myocardial infarction, M-mode measurements of heart size may be misleading

LV PARAMETERS BY 2D ECHOCARDIOGRAPHY

- In postmyocardial infarction and heart failure patients, 2D echo has great utility.
- The biplane method of discs (**modified Simpson's rule**) is recommended
- This method defines the LV geometry following manual tracing of the acquired LV cavity borders.
- Manual tracing of endocardial borders are made at end systole and end-diastole in apical four-chamber and two-chamber views
- The advantage of the modified Simpson's method is that it makes no assumptions about ventricular geometry
- Poor endocardial border definition, foreshortened views, and improper technique can compromise this technique
- LVEF is not the sole or a complete measure of LV function.
- Diastolic and other measures of ventricular function are needed because nearly 40% of patients with clinical heart failure have persevered systolic function (normal LVEF).


A
Biplane Method of Disks "Simpson's Rule"
A4C
A2C
L
diameter a_i
diameter b_i
Ventricular Volume: $\frac{\pi}{4}\sum_{i=1}^{20} a_i \times b_i \times \frac{L}{20}$
EDV
ESV
n=20
L
diameter a_i
diameter b_i
Diastole
A4C
End Systole
A4C
Method of Disks
Calculation of Ejection Fraction
using Biplane Apical Views
Volume of each disk:
$\frac{\pi (ai \times bi) L}{4n}$
ai (Apical 4C)
L
bi
(Apical 2C)
Total Ventricular Volume:
$\frac{\pi}{4}\sum_{i=1}^{20} a_i \times b_i \times \frac{L}{20}$
Ejection Fraction:

QUALITATIVE GRADES OF LV SYSTOLIC FUNCTION

- Normally, 60–70% of ventricular end-diastolic volume is ejected during each cardiac cycle.

1. EF > 55% is generally considered normal.
2. EF between 40 and 55% is considered mildly reduced
3. EF between 30 and 40% is considered moderately reduced
4. EF less than 30% is considered severely reduced

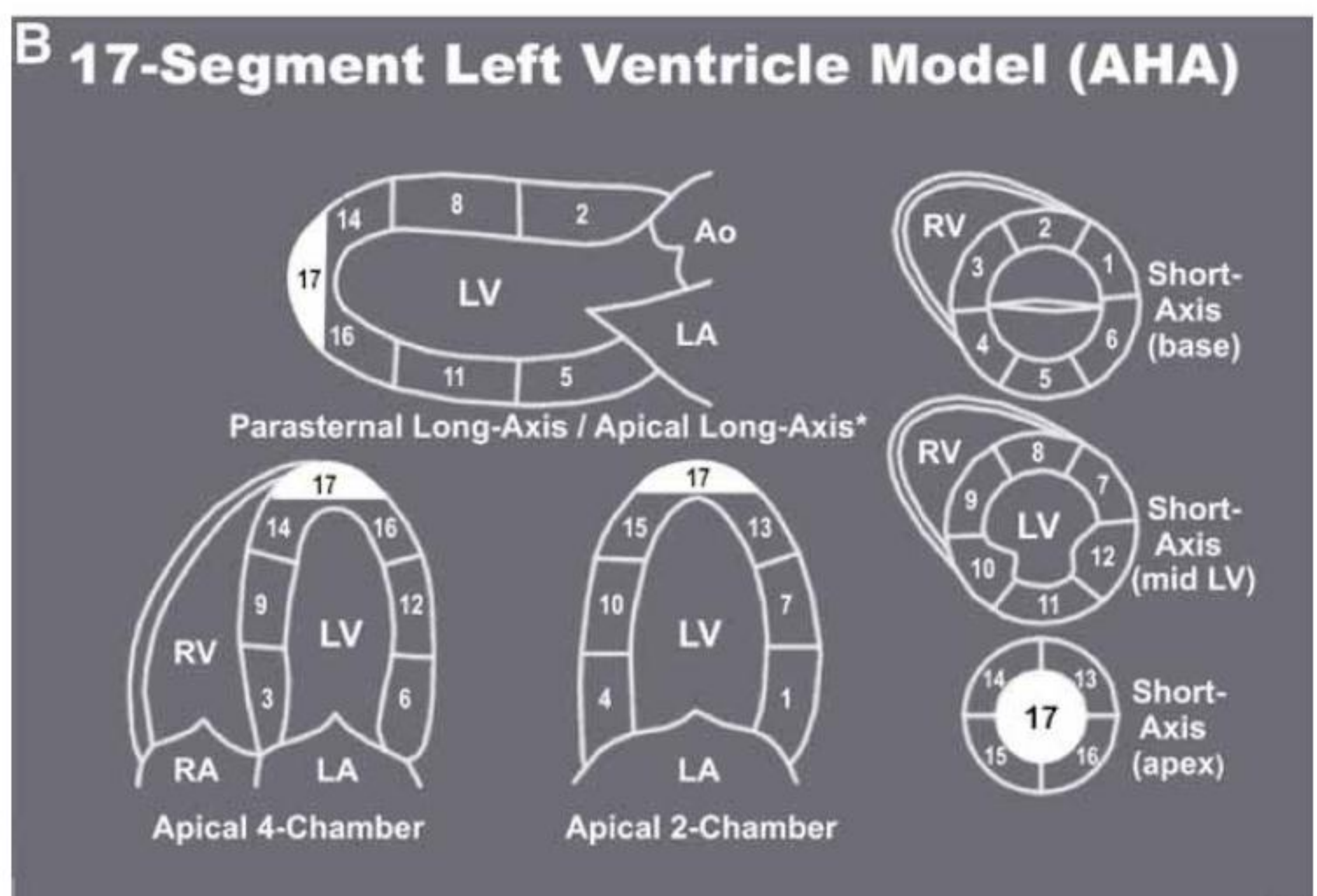
- When the EF exceeds 70%, it is considered to be “hyperdynamic.”

GRADING REGIONAL WALL MOTION

- Ventricular segment scores are assigned based on two qualitative measures of ventricular wall behavior during systole:
  (1) wall movement (contraction) and (2) wall thickening.
- Scores range from a normal score of 1 to the worst score of 5

1. **A** wall score index of 1 indicates normality
2. ***Hypokinetic*** -A segment that shows noticeable reduction in contractility (score =2).
3. ***Akinetic*** -A segment that barely moves or thickens during systole (score=3).
4. ***Dyskinetic***- myocardium moves paradoxically during systole (score=4).
5. ***Aneurysmal***- myocardium remains deformed during diastole (score=5).

- American Heart Association (2002) uses a unifying **17-segment model** to standardize myocardial segments.
- LV segments **1–6** are at the base (mitral valve level), segments **7–12** are in the middle (papillary muscle level), segments **13–16** occupy the apical region, and segment **17** represents the very tip of the apex.

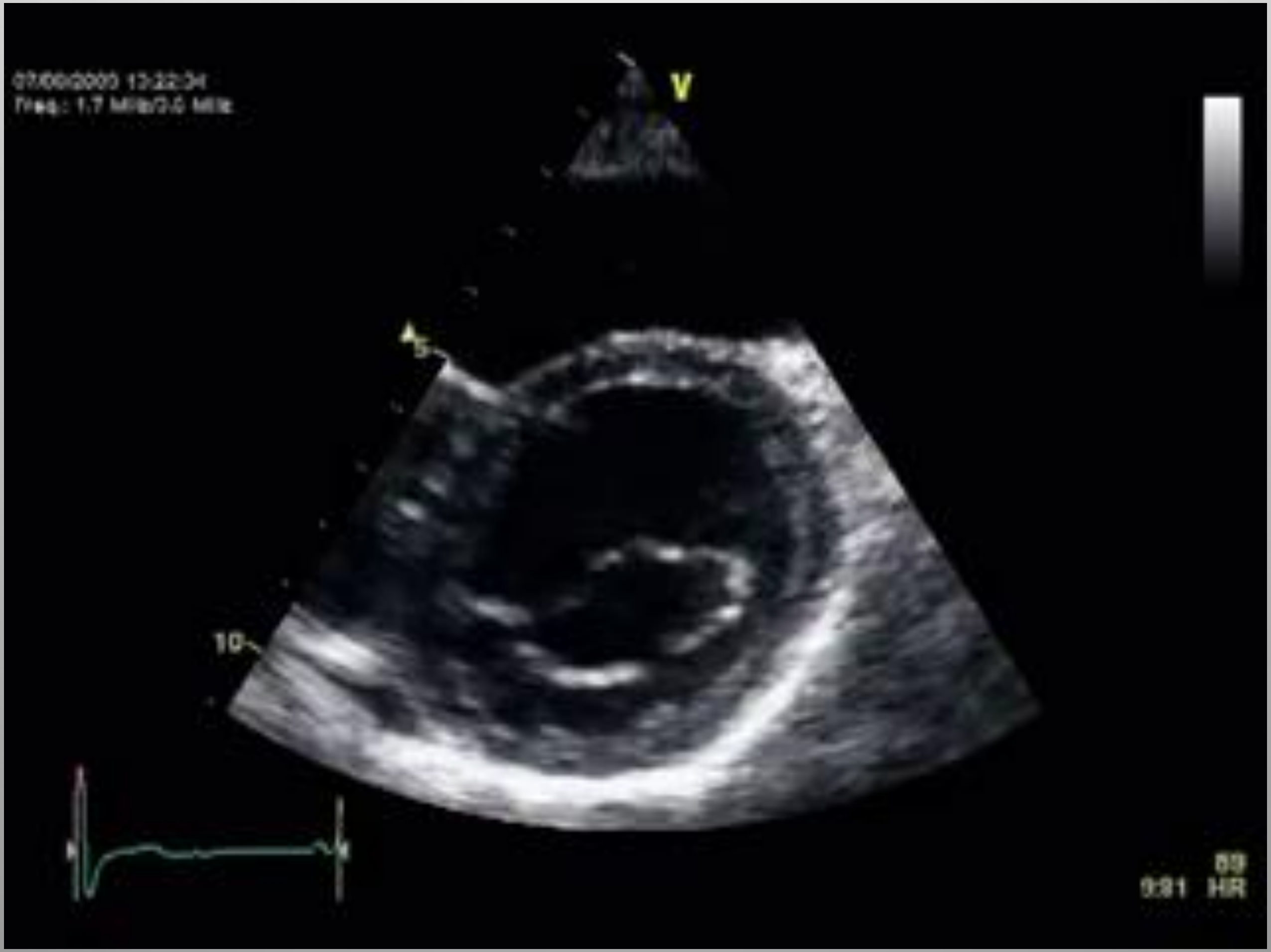

B
17-Segment Left Ventricle Model (AHA)
14
8
2
Ao
17
LV
16
LA
11
5
Parasternal Long-Axis / Apical Long-Axis*
RV
2
3
1
4
6
5
Short-Axis (base)
RV
8
9
7
LV
10
12
11
Short-Axis (mid LV)
17
14
16
9
12
RV
LV
3
6
RA
LA
Apical 4-Chamber
17
15
13
10
7
LV
4
1
LA
Apical 2-Chamber
14
13
17
15
16
Short-Axis (apex)

Normal regional wall motion Apical 4 chamber view

Hypokinetic anterior-septal wall PSAX

Akinetic LV apex
Apical 4 chamber view

Dyskinetic septum
PSAX



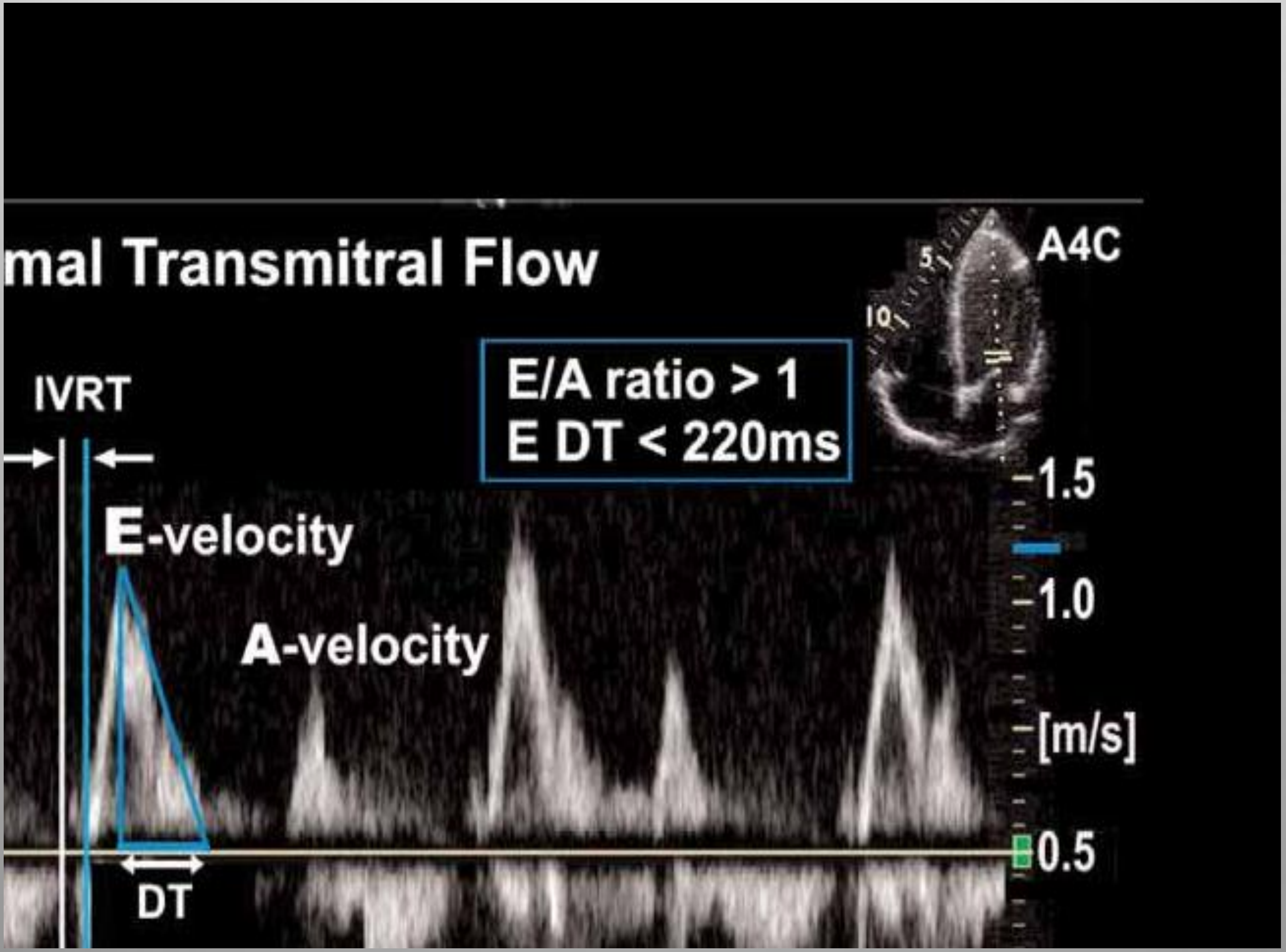
Aneurysmatic LV apex
Apical 4 chamber view

Echocardiographic Assessment of Diastolic Function

1. PW Doppler of mitral inflow
2. PV DOPPLER FLOW PATTERNS
3. ISOVOLUMIC RELAXATION TIME (IVRT)
4. *Doppler Tissue Imaging*

PW Doppler of mitral inflow

- Evaluation of spectral Doppler patterns of mitral inflow has been used to assess LV diastolic function
- This approach assumes that transmitral flow velocity is an accurate surrogate for volumetric flow.
- However, transmitral velocities reflect the *pressure gradient* between the LA and LV, rather than actual flow.
- There are two major components of normal transmitral flow:
  1. **E-wave** the rapid early filling phase.
  2. **A-wave** filling associated with atrial contraction.
- Normal transmitral flow is characterized by an **E:A ratio >1** and relatively brisk (150–220 ms) E-wave deceleration time


mal Transmitral Flow
A4C
E/A ratio > 1
E DT < 220ms
IVRT
E-velocity
A-velocity
1.5
1.0
[m/s]
0.5
DT

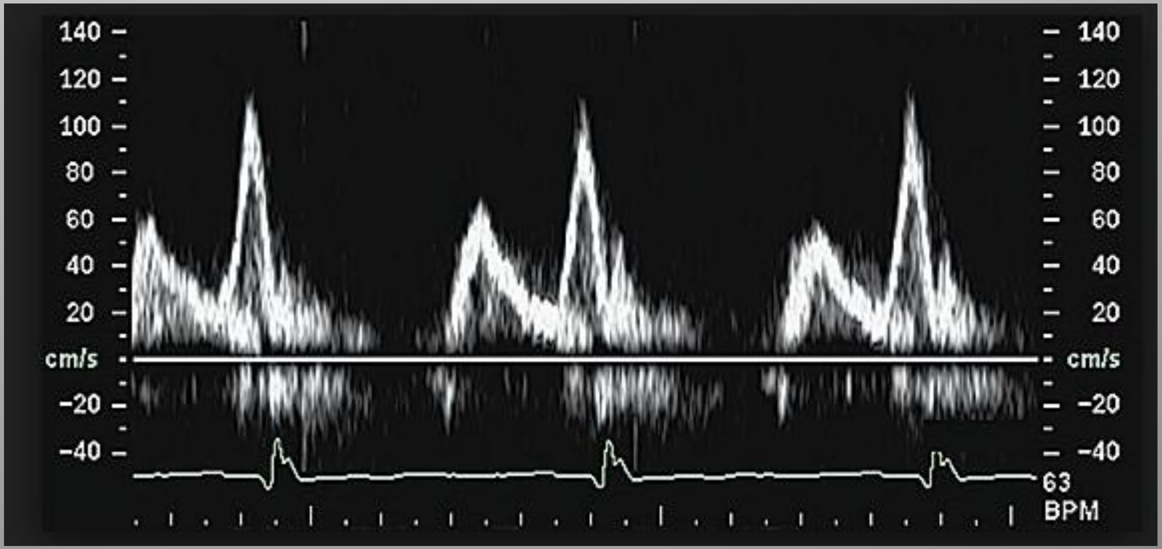
CLASSIFICATION OF MITRAL INFLOW PATTERNS

- General classification of diastolic function is based predominantly on the pattern of mitral inflow (E:A ratio), their peak velocities, and the rate of deceleration of the E-wave
- ***Impaired Relaxation***
- ***Pseudonormal MV Inflow***
- ***Restrictive Mitral Inflow***

Impaired Relaxation

- Is characterized by E- to A-wave reversal

  E:A < 1
- Prolongation of E-wave deceleration time more than 220 ms (EDT>220ms)
- This pattern has been designated as grade 1 diastolic dysfunction

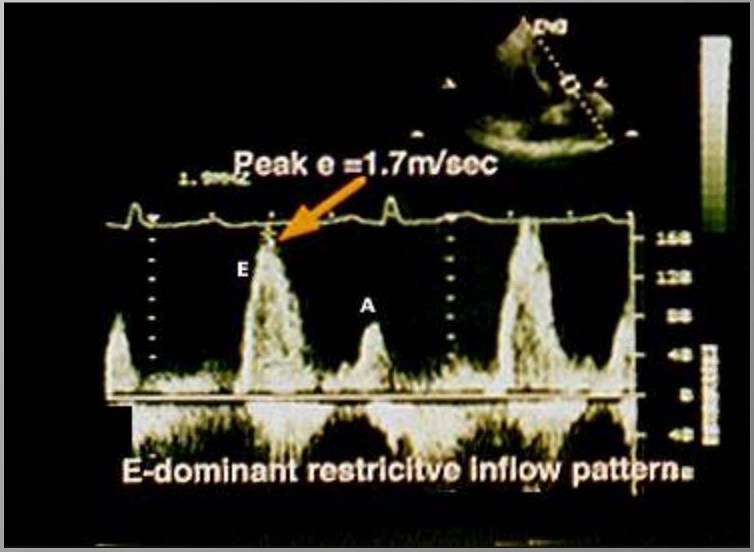


Pseudonormal MV Inflow

- 1. E:A ratio >1
- 2. Decreased E-wave deceleration time (EDT 150-200 ms)
- This occurs because increased LA pressure re-establishes a higher gradient between the LA and the LV, providing a larger pressure head to drive LV filling in early diastole
- This pattern has been designated as grade 2 diastolic dysfunction

Restrictive Mitral Inflow

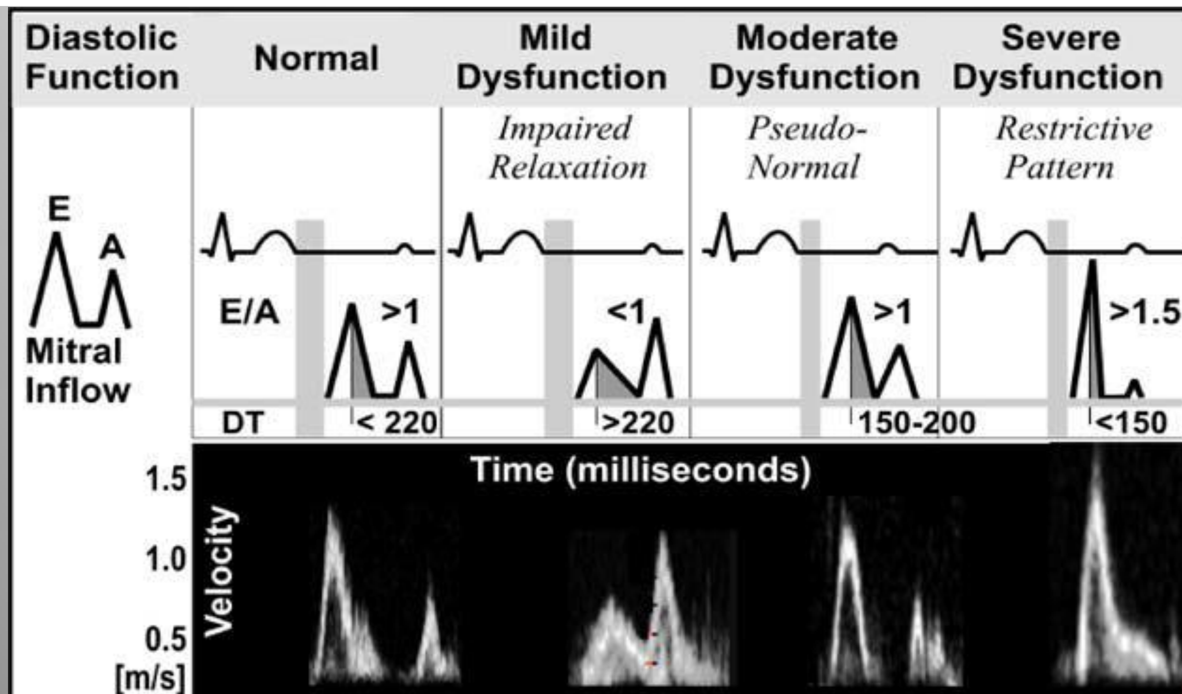
- E:A>2
- Thin E-wave and small A-wave
- Marked shortening of the Ewave deceleration time (EDT<150ms)
- This pattern has been designated as grade 3 diastolic dysfunction (if the pattern is reversible) or grade 4 (if the pattern is irreversible)



Stages of Diastolic Dysfunction

	Normal (young)	*Normal (adult)*	*Delayed relaxation grade 1*	*Pseudonormal filling grade 2*	*Restrictive filling grades 3–4*
E:A	>1	>1	<1	1–2	>2
EDT (ms)	<220	<220	>220	150–200	<150
IVRT (ms)	<100	<100	>100	60–100	<60
Pulm vein S/D	<1	≥1	≥1	<1	<1
Pulm vein AR (cm/s)	<35	<35	<35	>35[a]	≥25[a]
E_a (cm/s), lateral mitral annulus	>12	>8–10	<8	<8	<8
LV relaxation	Normal	Normal	↓	↓	↓
LV filling pressure	Normal	Normal	↑	↑	↑

Table modified from Garcia MJ, Thomas JD, Klein AL. New Doppler echocardiographic applications for the study of diastolic function. J Am Coll Cardio 1998;32:865–875.



Doppler Tissue Imaging

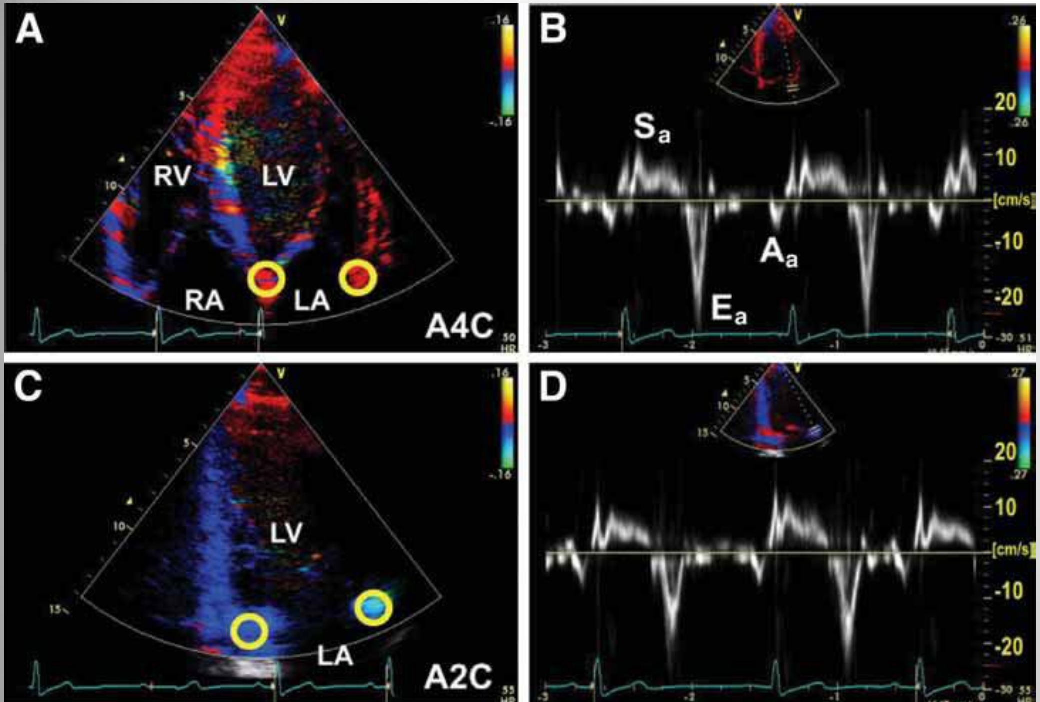
- Doppler tissue imaging (DTI), also known as tissue Doppler imaging (TDI), enables the measurement of the high amplitude, low velocity signals of myocardial motion
- The main advantage of DTI information is that it is less load-dependant than standard Doppler.
- A cardiac cycle is represented by three waveforms

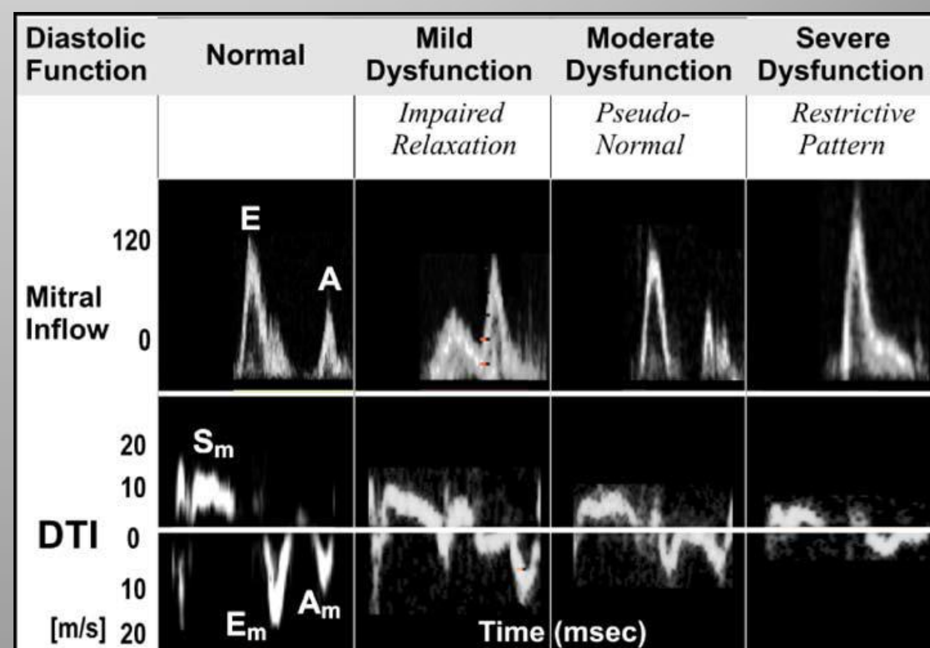
(1**) Sa**, systolic myocardial velocity above the baseline.

(2) **Ea**, early diastolic myocardial relaxation velocity below the baseline.

(3) **Aa**, myocardial velocity associated with atrial . contracation, below the baseline.

- The peak Ea velocity is used in the analysis of LV diastolic function
- Septal Ea velocities tend to be slightly lower than lateral Ea velocities.
- Reduction in lateral Ea velocity less than 8–10 cm/sec is an indication of impaired LV relaxation **(Ea< 8-10 cm/sec)**


A
RV
LV
RA
LA
A4C
B
S_a
A_a
E_a
20
10
[cm/s]
-10
-20
C
LV
LA
A2C
D
20
10
[cm/s]
-10
-20


Diastolic Function
Normal
Mild Dysfunction
Moderate Dysfunction
Severe Dysfunction
Impaired Relaxation
Pseudo-Normal
Restrictive Pattern
Mitral Inflow
120
0
E
A
DTI
20
10
0
10
[m/s] 20
S_m
E_m
A_m
Time (msec)

ECHOCARDIOGRAPHY IN CLINICAL PRACTICE: GENERAL CONSIDERATIONS

- Echocardiography assists in the diagnosis and management of patients who exhibit symptoms and signs suggestive of heart disease, as well as those with existing cardiovascular disease.
- Common requests for echocardiography include patients with murmurs, chest pain, dyspnea, palpitations, syncope, or an abnormal electrocardiogram (ECG)

Electrocardiographic Abnormalities Suggestive of Heart Disease in Asymptomatic Patients

ECG abnormality	*Possible echocardiographic finding*
Pathological Q-waves	Regional wall motion abnormalities consistent with previous infarction
Right bundle branch block, RSR′ pattern	Atrial septal defect
Left bundle branch block	Regional wall motion abnormality consistent with infarction
Atrial flutter	Pericardial effusion
Atrial fibrillation	Mitral valve abnormalities
	Left atrial dilatation
Delta wave (Wolff-Parkinson-White syndrome)	Atrial septal defect
	Ebstein's anomaly
ST-segment elevation	Acute myocardial infarction Ventricular aneurysm Acute pericarditis
Low-voltage ECG	Amyloid and infiltrative cardiomyopathies
Electrical alternans	Pericardial effusion
LVH criteria on ECG	Left Ventricular Hypertrophy Hypertrophic cardiomyopathy

ECG, electrocardiogram; LVH, left ventricular hypertrophy.

Modified from Solomon SD. Principles of Echocardiography. In: Braunwald E, Goldman L, eds. Primary Cardiology, 2nd ed. Philadelphia, Saunders-Elsevier, 2003.

Echocardiography in Acute Chest Pain and Myocardial Ischemia

- New regional wall motion abnormalities appearing in previously normal ventricular segments support the diagnosis of acute myocardial ischemia and may precede changes in the ECG
- Early and late post-myocardial infarction complications, e.g., ventricular septal defect or papillary muscle rupture can be diagnosed with echocardiography.
- In the postinfarction period, echocardiography can assist with the diagnosis, risk assessment, and prognosis

PULMONARY EMBOLISM

- Detecting right ventricular enlargement and dysfunction that result from the acute increase in pulmonary vascular resistance and right ventricular afterload
- Echocardiography is also helpful in distinguishing pulmonary embolism from other causes of acute chest pain
- Direct visualization of a large pulmonary saddle embolus in the pulmonary arteries or the right heart chambers is detectable, although seen only occasionally

DISEASES OF THE GREAT VESSELS

- Transesophageal echocardiography is the preferred modality if acute aortic dissection is suspected as it is more sensitive than the transthoracic examination
- Aortic dissection involving the ascending aorta may be accompanied by pericardial effusion, cardiac tamponade, or new onset aortic regurgitation.
- These, along with a proximal dissection flap, can be rapidly sought on a limited transthoracic study while awaiting an emergent transesophageal echocardiography examination or contrast CT sean

Echocardiography in Pericardial Disease

- In pathological states, e.g., acute pericarditis, pericardial effusion or tamponade, echocardiography is of diagnostic value, and can serve as a guide to management
- Echocardiography is the most efficient method to assess the size and hemodynamic consequences of pericardial effusion

INFECTIVE ENDOCARDITIS

- Although the diagnosis of infective endocarditis should be made clinically, the Duke classification includes positive echocardiographic findings as one of its major diagnostic criteria.
- Detection and characterization of vegetations and perivalvular structures is made possible by echocardiography

Thank you!