



# ASSESSMENT OF LEFT VENTRICULAR FUNCTION

THE 2ND CAMBRIDGE ADVANCED EMERGENCY ULTRASOUND COURSE

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# ASSESSMENT OF LEFT VENTRICULAR FUNCTION

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## Why

- Assessment of LV function is one of the most valuable uses of focused echocardiography in emergency medicine
- LV systolic dysfunction is a major prognostic factor in acute cardiac disease

# Left Ventricular Function

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- **Assessment of the Left Ventricle**
- Cardiogenic Shock or Hypovolaemic Shock?
- Primary aim is to assess **LV Systolic Function**
- Primary Cardiac vs Non-Cardiac
- Often sub-optimal images, *but it is often feasible to evaluate the status of left ventricular systolic function*

# ASSESSMENT OF LEFT VENTRICULAR FUNCTION

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## When

- Acute coronary syndromes
- Clinically suspected heart failure
- Unexplained hypotension
- PEA cardiac arrest
- Cardiomegaly on physical examination or CXR
- Malignant arrhythmias

# ASSESSMENT OF LEFT VENTRICULAR FUNCTION

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## How

### LV Dimensions:

Chamber Dimensions: Systolic & Diastolic  
Wall Thickness

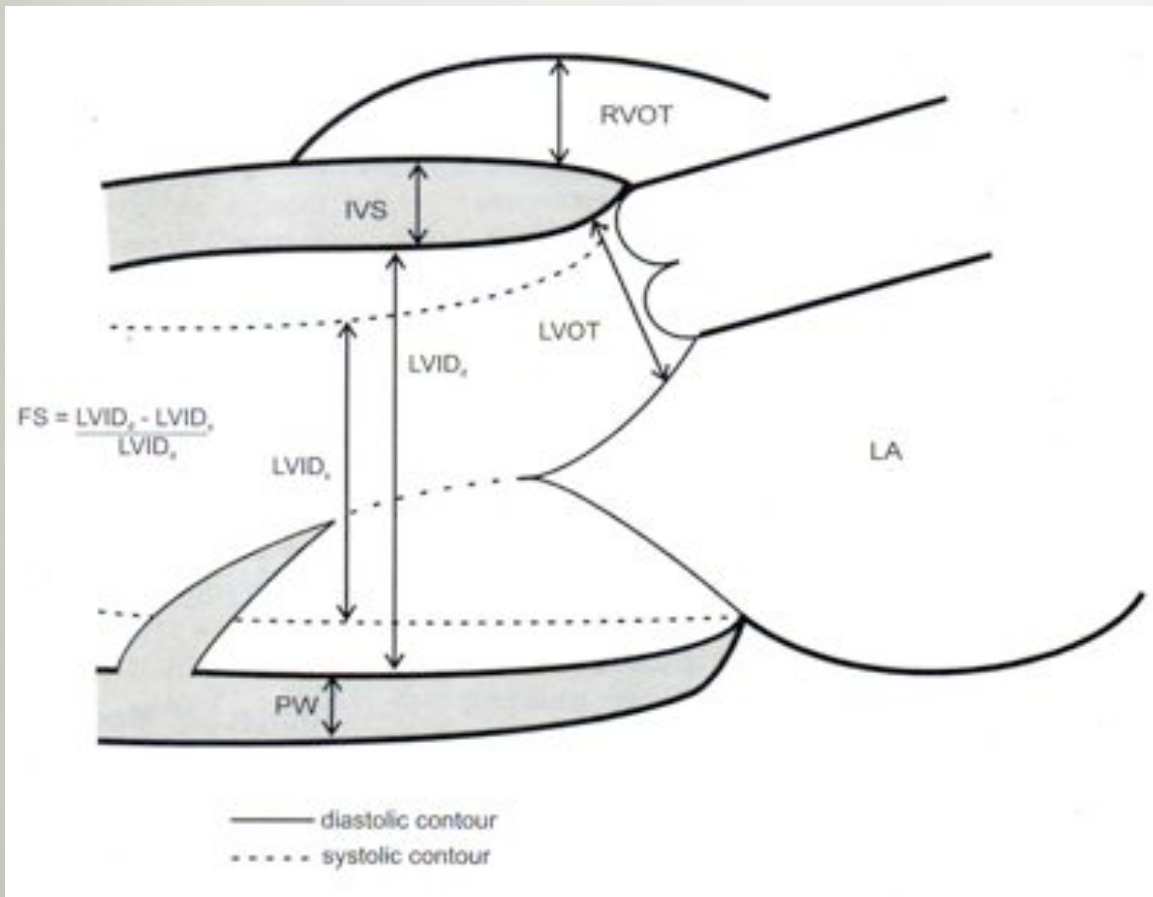
- **Systolic Function:**
  - Subjective Assessment**
  - Fractional Shortening
  - Ejection Fraction
- Regional or Global Wall Motion Abnormalities
- Evidence of Diastolic Dysfunction

# LV DIMENSIONS

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- Assess LV geometry (*both shape & size*)
- A 'big heart is a bad heart'
- LV internal dimensions are measured in end-systole (LVESD) and end-diastole (LVEDD) and are made at the level of the mitral valve tips in the parasternal long axis
- Measured using 2-D or M-mode

# LV DIMENSIONS



Left Atrium: 19-39 mm

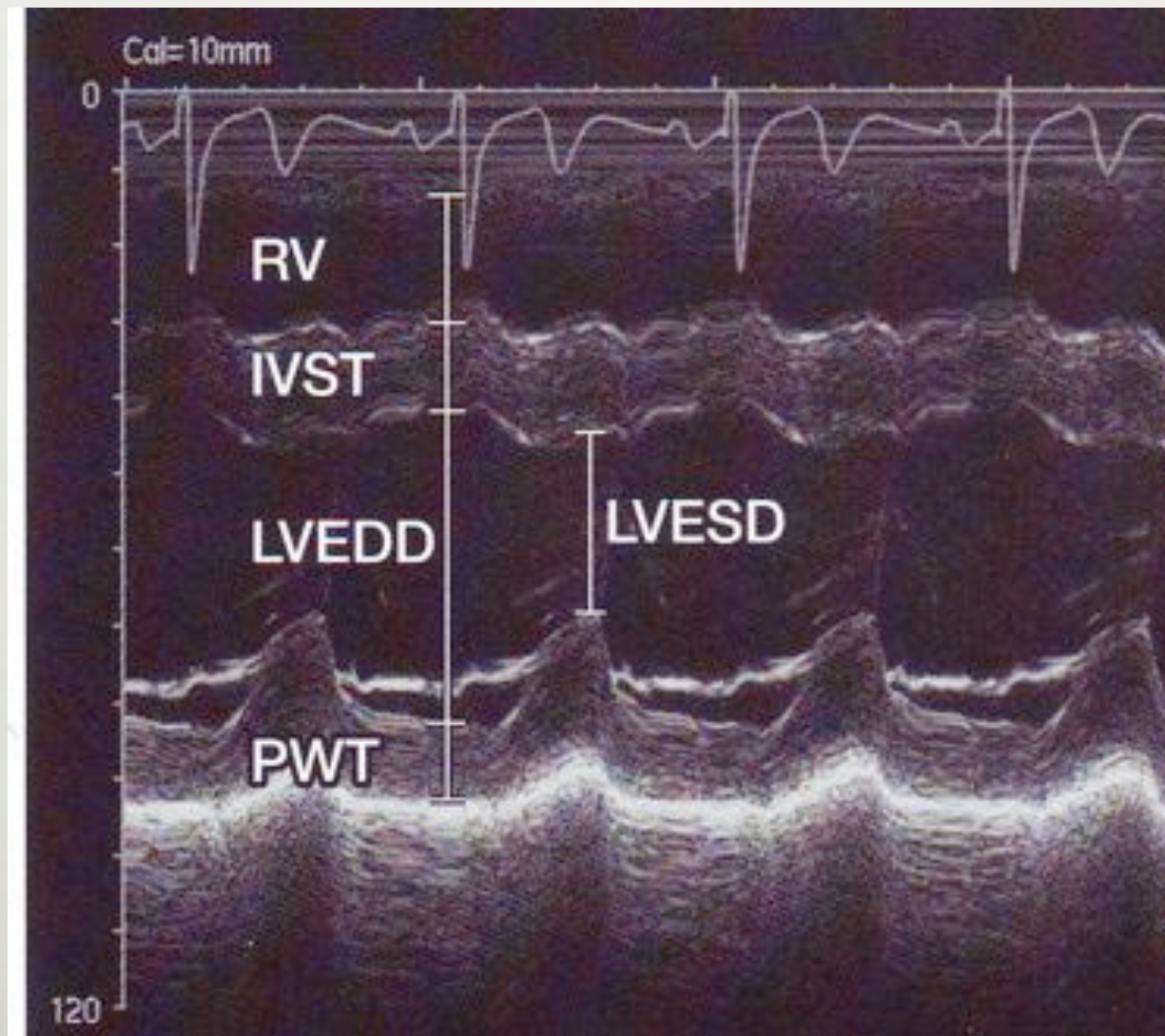
LVID<sub>d</sub>: 36-56 mm

LVID<sub>s</sub>: 25-41 mm

IVS<sub>d</sub>: 6-11 mm

Posterior Wall: 6-11 mm

# M-MODE





# LV DIMENSIONS

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## LV Shape

- Normal shape of the left ventricle is symmetrical with 2 relatively equal short axes and with the long axis running from the base (mitral annulus) to the apex
- 'Bullet-Shaped'

# QUALITATIVE EVALUATION OF LV SYSTOLIC FUNCTION

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*Both global and regional ventricular function can be evaluated with 2D echocardiography on a semi-quantitative scale*

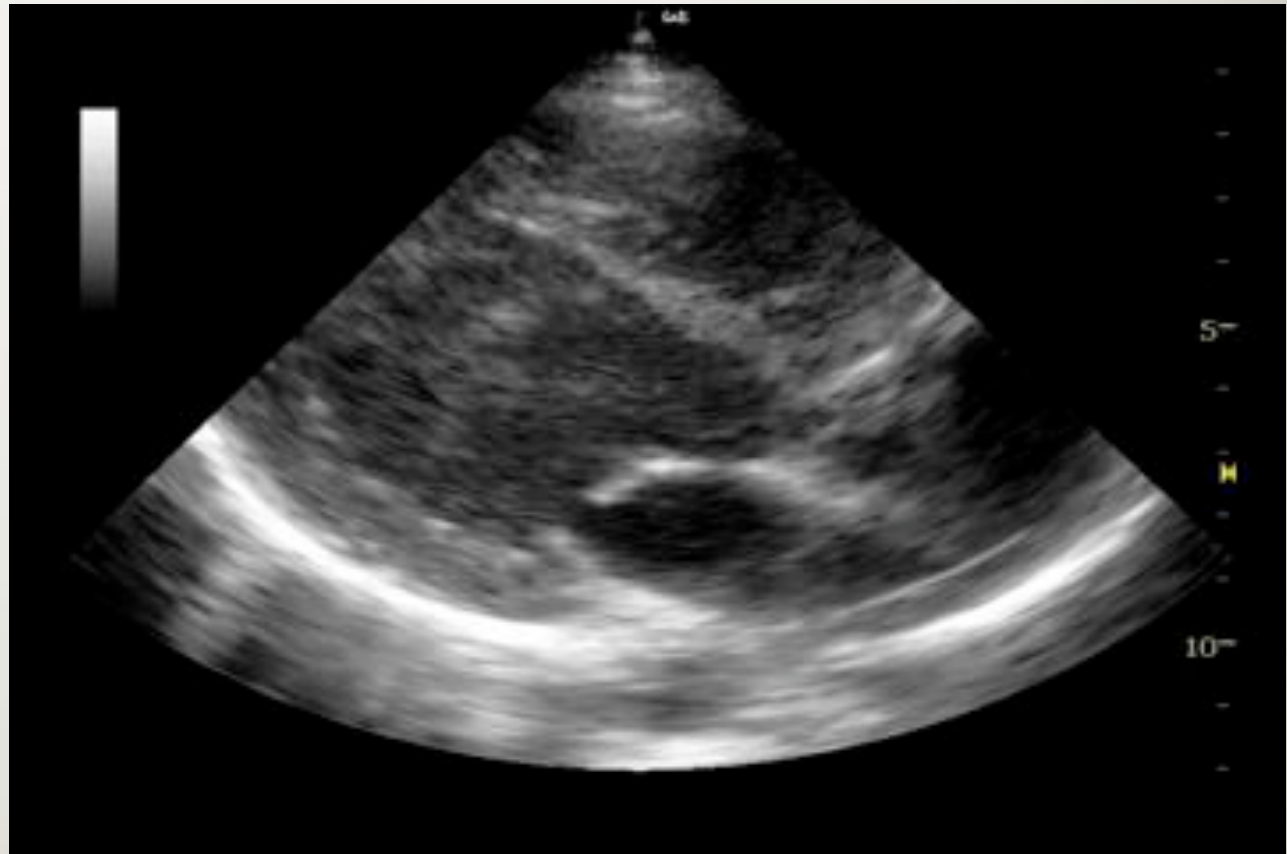
*This is best evaluated using multiple echo-windows and images:*

- Parasternal Long-Axis
- Parasternal Short-Axis
- Apical 4-Chamber
- Apical 2-Chamber
- Apical 3-Chamber

# PARASTERNAL LONG-AXIS

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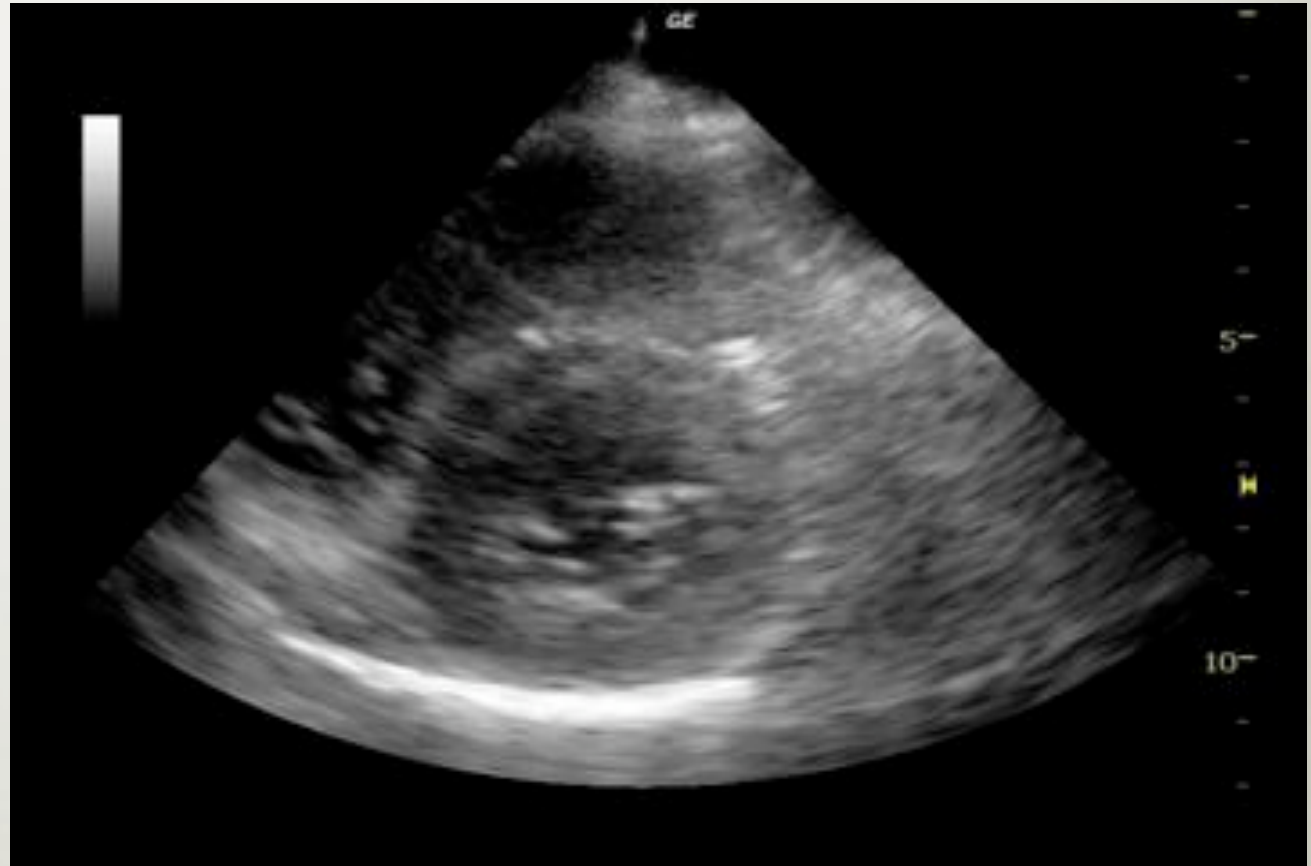
- Anterior Septum
- Posterior Wall



# PARASTERNAL SHORT-AXIS

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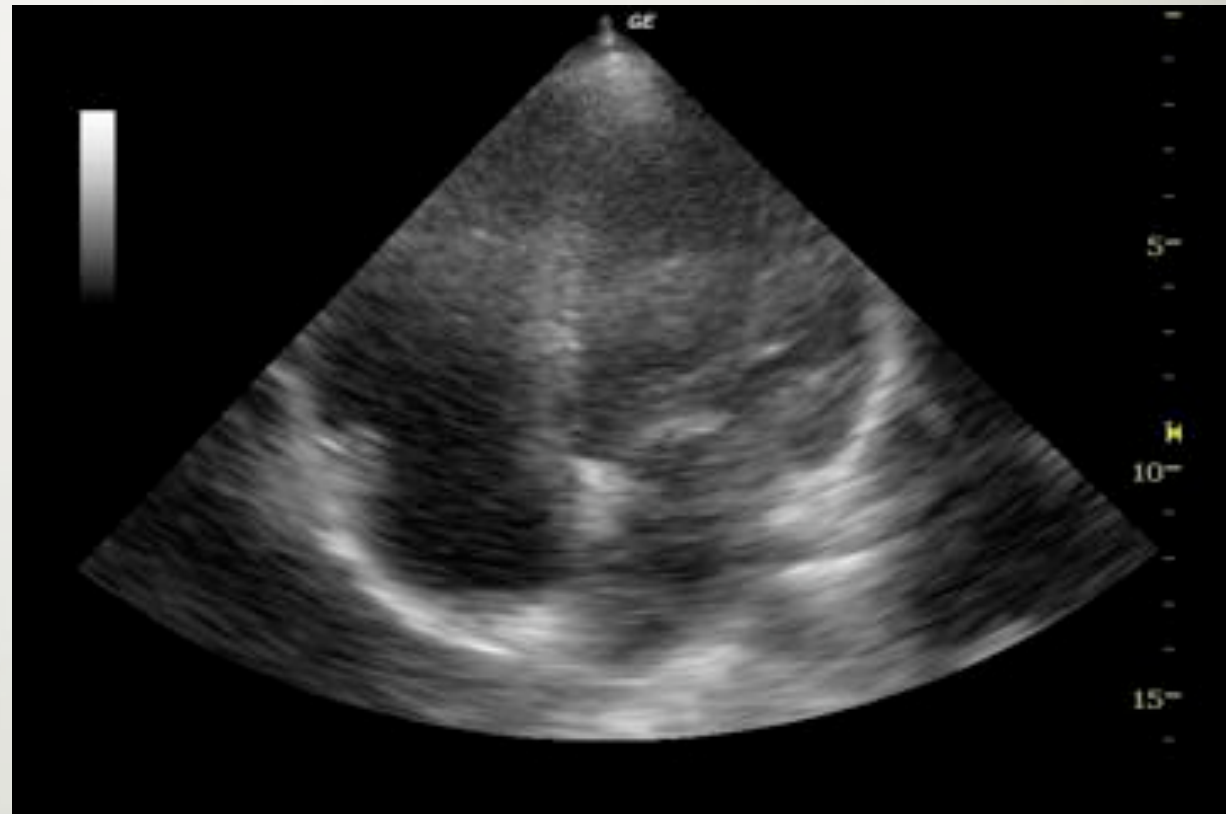
- Septum
- Anterior Septum
- Anterior Wall
- Lateral Wall
- Posterior Wall
- Inferior Wall



# APICAL 4-CHAMBER

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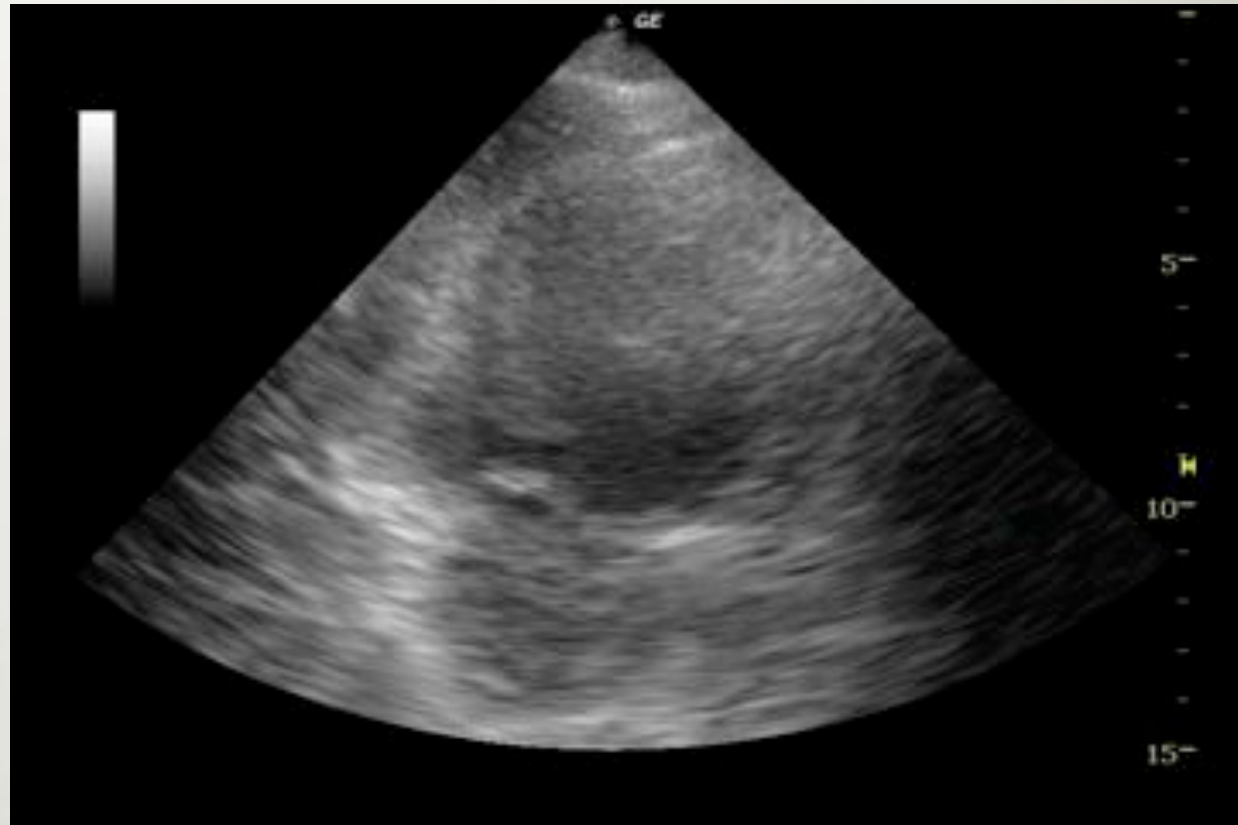
- Septum
- Lateral Wall



# 2-CHAMBER

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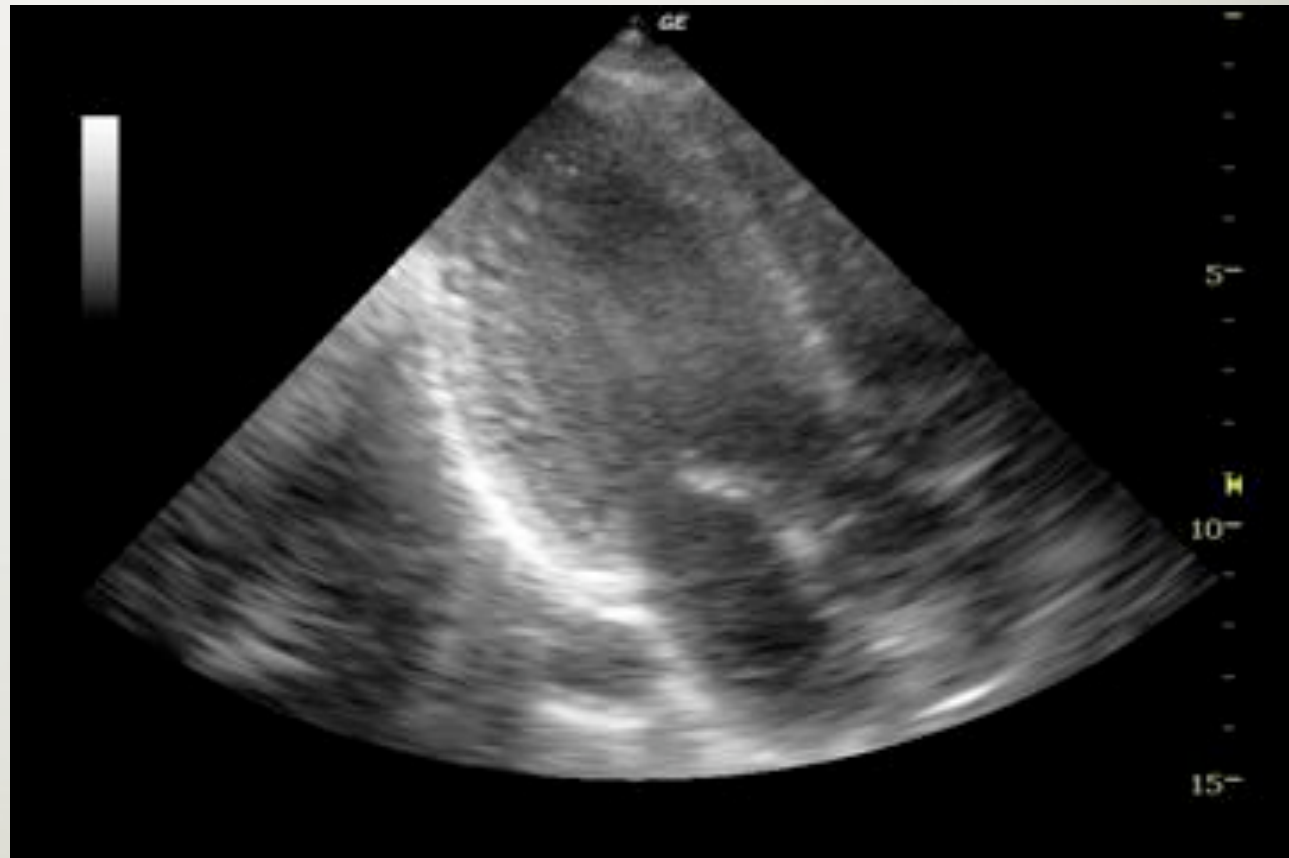
- Inferior Wall
- Anterior Wall



# 3-CHAMBER

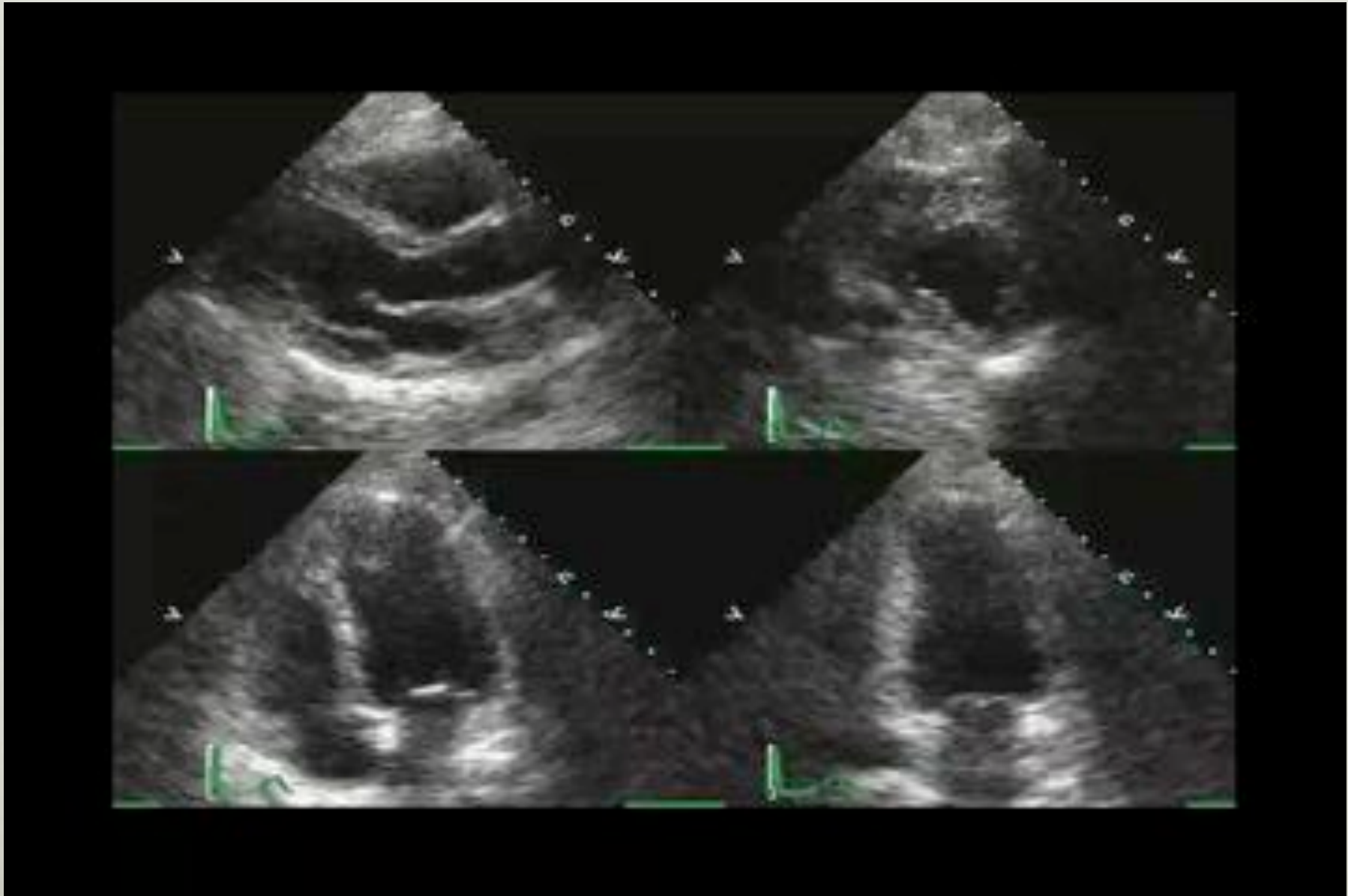
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- Posterior Wall
- Antero-Septal Wall



# QUAD SCREEN VIEW

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# QUALITATIVE EVALUATION OF LV SYSTOLIC FUNCTION

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- Each region of the LV is observed and the degree of endocardial *wall motion* and *wall thickening* is observed
- From these observations an assessment can be made of both the global and regional LV function
- Function can be classified as: *Normal*  
*Mildly Impaired*  
*Moderately Impaired*  
*Severely Impaired*

# QUALITATIVE EVALUATION OF LV SYSTOLIC FUNCTION

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## Wall (Systolic) Thickening

- During systole the normal myocardial wall thickens from its normal 9 - 11 mm to 14 - 16 mm (*35-40% increase in wall thickness*)

## Wall Motion

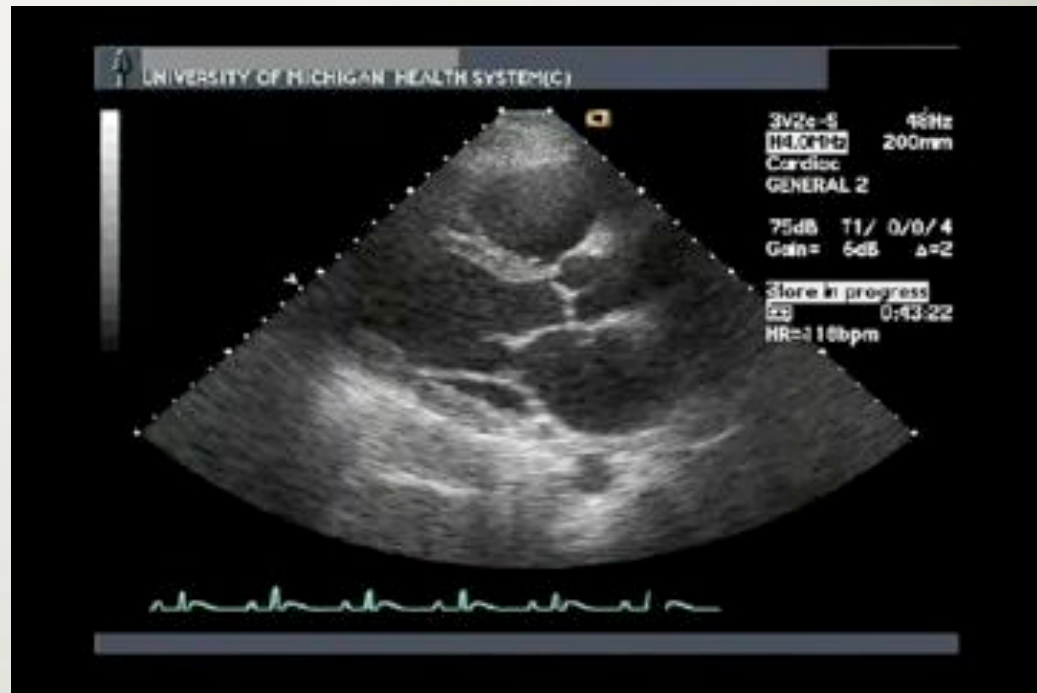
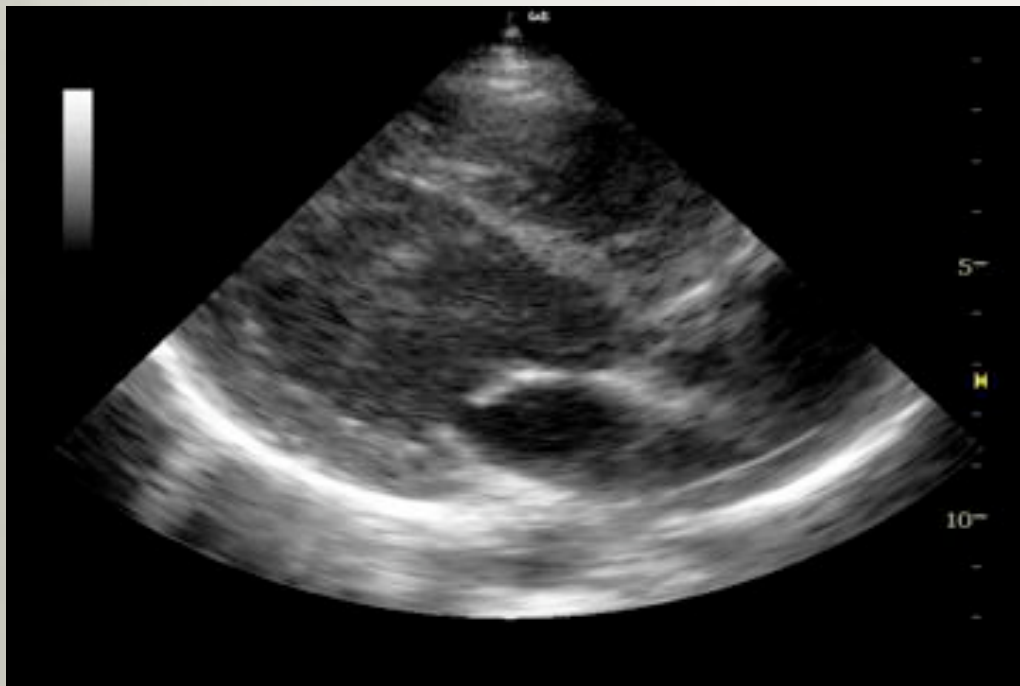
- Normal
- Hypokinetic (*reduced movement*)
- Akinetic (*absent movement*)
- Dyskinetic (*movement in the wrong direction, ie outward movement of the LV free wall during LV systole*)

# EVALUATION OF LV SYSTOLIC FUNCTION

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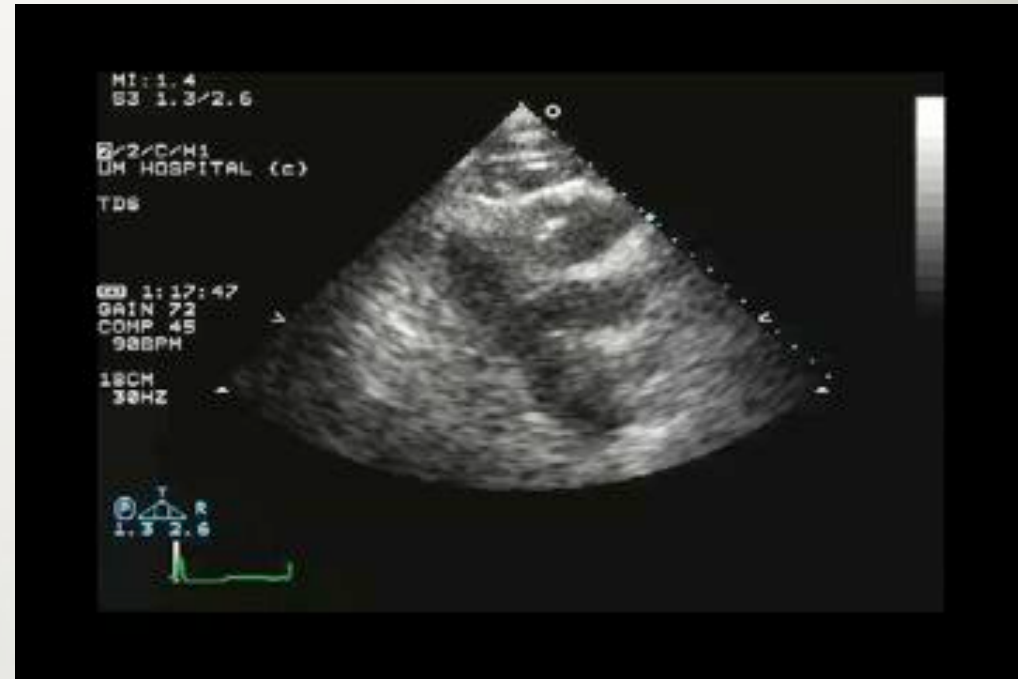
Normal

Severe Dysfunction



Cardiogenic Shock

# EVALUATION OF LV SYSTOLIC FUNCTION



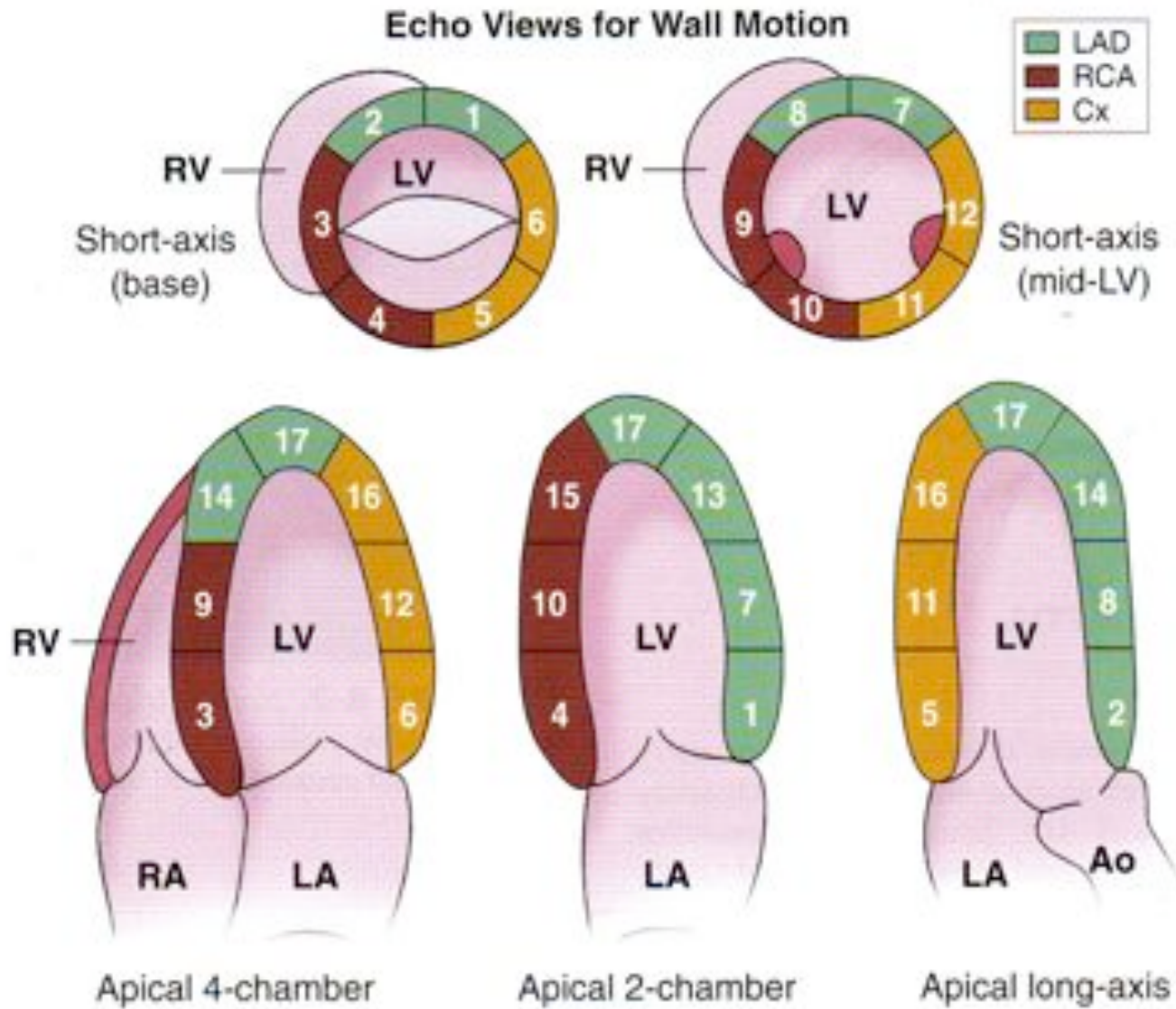
Small, under-filled left ventricles with hyperdynamic left ventricular function

**Hypovolaemic Shock**

# REGIONAL WALL MOTION ABNORMALITY

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- Most common form of acquired heart disease in the western world is coronary artery disease with its sequelae of myocardial ischaemia and infarction
- The LV can be divided into segments which can be described on the basis of coronary artery territories
- This allows the prediction of the artery involved when a regional wall motion abnormality is detected



Reproduced from Textbook of Clinical Echocardiography 3rd Edition

# REGIONAL WALL MOTION ABNORMALITY

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## LAD:

Anterior Wall

Anterior Septum

Mid & Apical Septum

Inferior & Lateral Apical Wall

## RCA:

Inferior Wall

Basal Septum

## Cx:

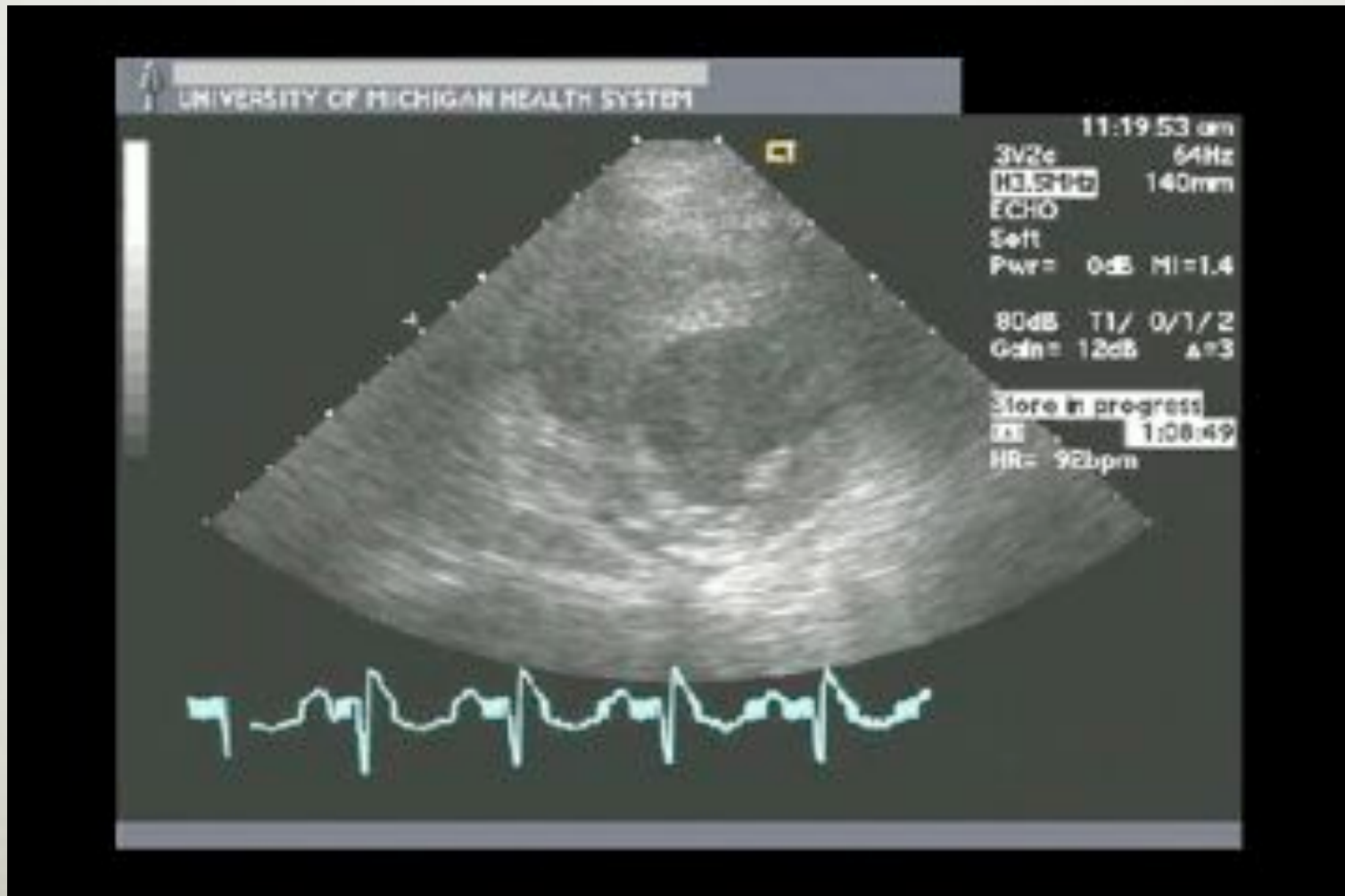
Lateral Wall

Posterior Wall

# REGIONAL WALL MOTION ABNORMALITY

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Anterior Wall Dyskinesis

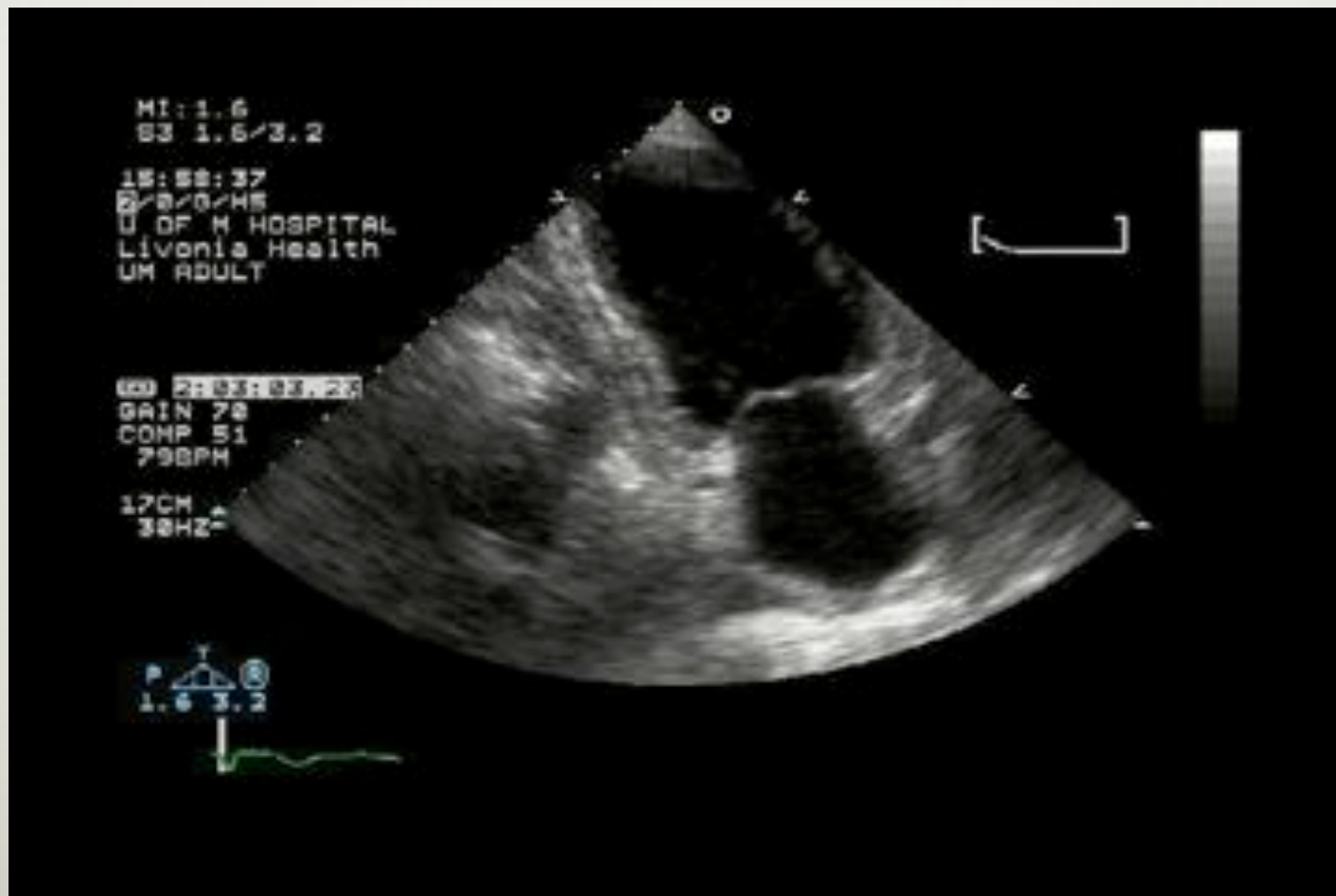




# REGIONAL WALL MOTION ABNORMALITY

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Akinesis/Dyskinesis of the Distal Inferior Wall, Apex & Anterior Wall



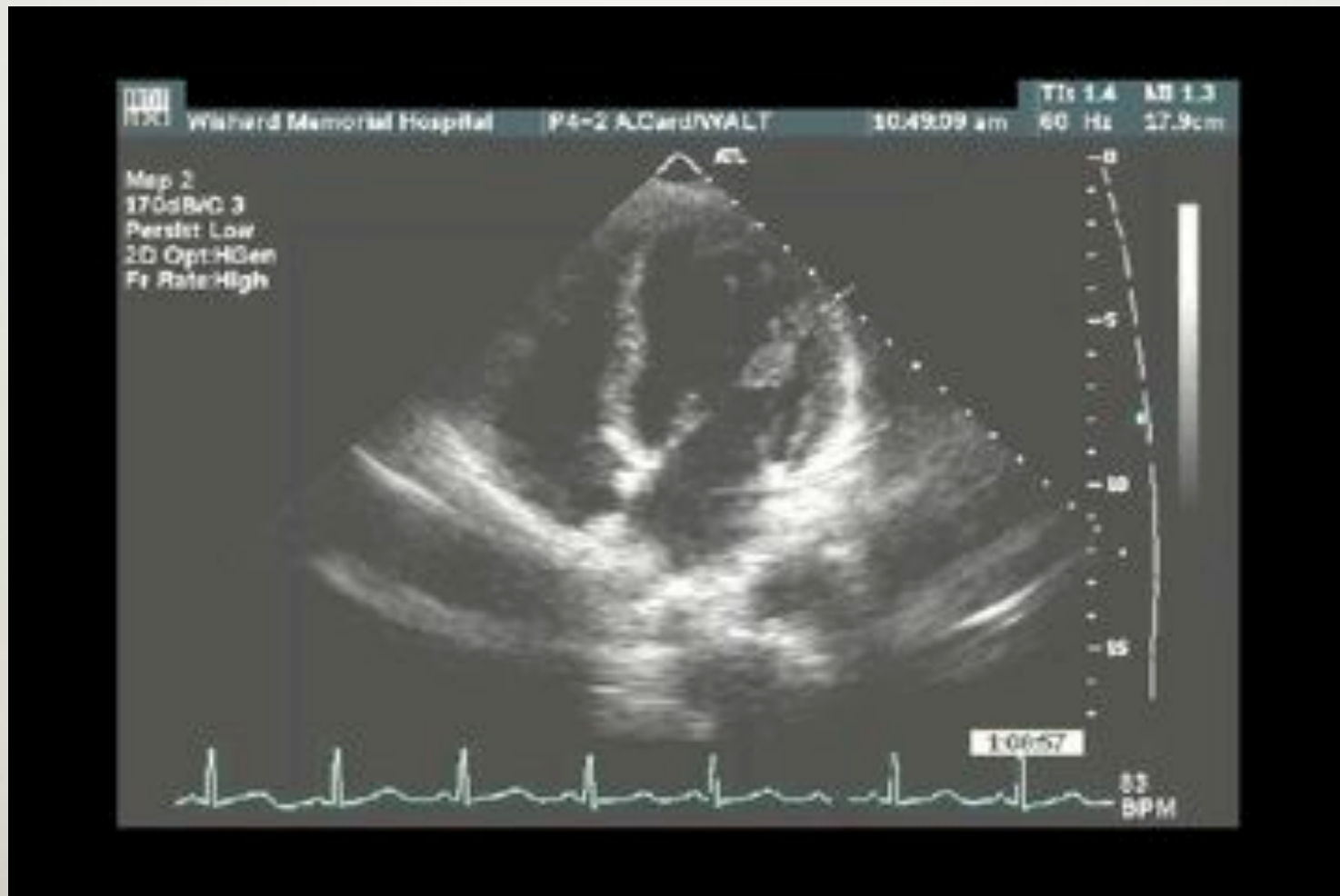
# REGIONAL WALL MOTION ABNORMALITY

Inferior Dyskinesis



# REGIONAL WALL MOTION ABNORMALITY

## Apical Dyskinesis



# REGIONAL WALL MOTION ABNORMALITY

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## Differentiation of old & new wall motion abnormalities

	OLD	NEW
Ventricular Size	Usually Dilated	Usually Normal
Wall motion	Hypo- / Dyskinetic	Hypokinetic
Wall thickening	Reduced	Reduced
Myocardial echo	Bright	Normal
Wall thickness	Thin	Normal
Aneurysm Formation	Yes	Unusual

# QUANTITATIVE ASSESSMENT OF LV FUNCTION

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Fractional shortening:

- *Percentage change in the left ventricular cavity dimension with systole*

Ejection Fraction:

- *2x fractional shortening if there are no regional wall motion abnormalities*
- *Biplane Modified Simpson's Rule*

Stroke Volume

# FRACTIONAL SHORTENING

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- The measurements LVID<sub>d</sub> & LVID<sub>s</sub> are made at the base of the heart
- If there are no regional wall motion abnormalities the ejection fraction can be estimated as:

## 2x Fractional Shortening

$$FS = \frac{LVID_d - LVID_s}{LVID_d} \times 100\%$$

(Normal Range 30-45%)

- In a patient with a regional wall motion abnormality, fractional shortening is specific only for the base of the heart

# EJECTION FRACTION

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*'The percentage of the left ventricular diastolic volume that is ejected with systole'*

- Biplane Modified Simpson's Rule
- Requires obtaining an apical 4- and 2- chamber view from which the endocardial border is outlined in end-diastole and end-systole
- Reported to the nearest 10% or as a range i.e. 40-50%
- Foreshortening of the ventricular apex will result in an inaccurate assessment of the ejection fraction, most often over-estimating it

# EJECTION FRACTION

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- 50-70% Normal
- 40-50% Mild Impairment
- 25-40% Moderate Impairment
- <25% Severe Impairment



# STROKE VOLUME, CARDIAC OUTPUT & CARDIAC INDEX

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Stroke Volume = End-Diastolic Volume - End-Systolic Volume

*(Normal 75 - 100 ml)*

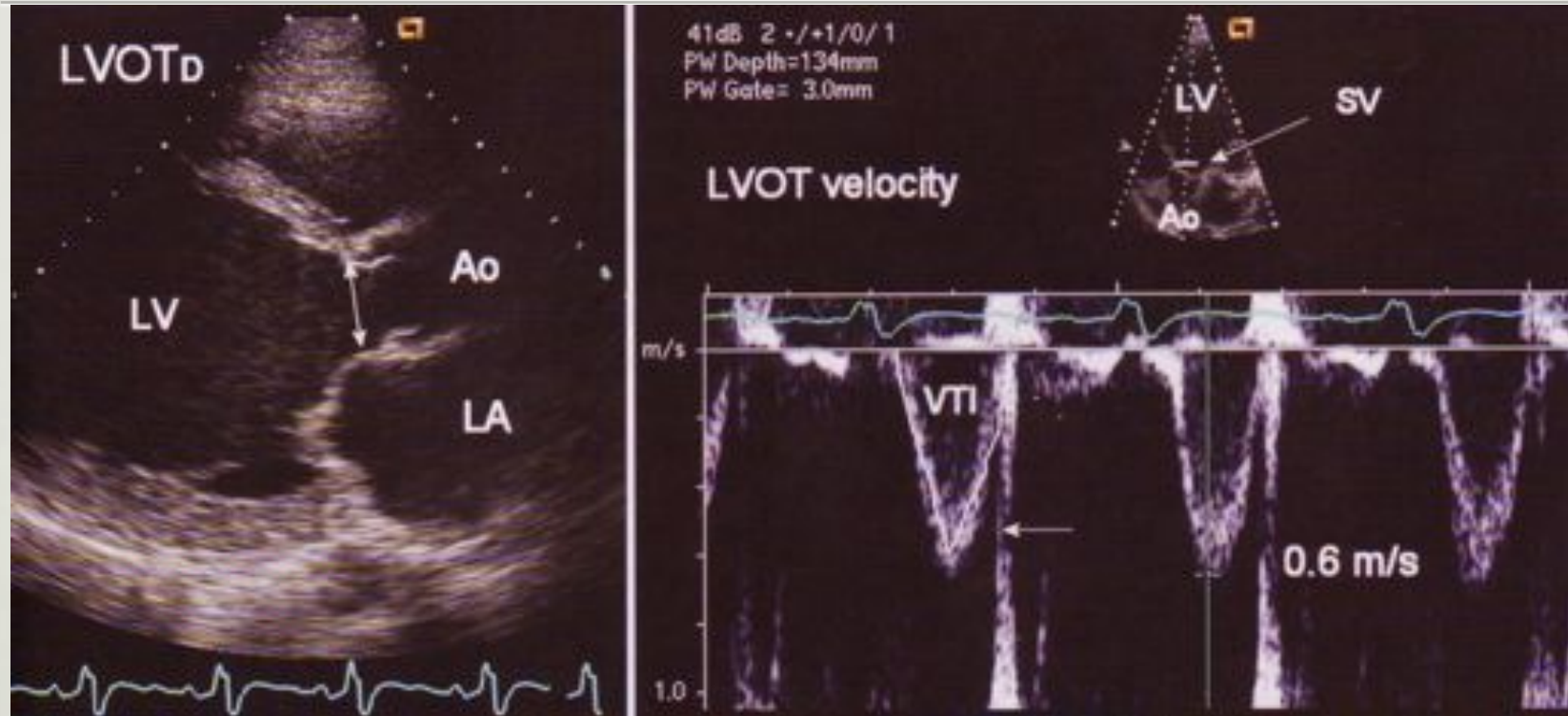
Cardiac Output = Stroke Volume x Heart Rate

*(Normal 4 -8 L/min)*

Cardiac Index = CO / BSA

*(Normal 2.4 - 4.2L/min/m<sup>2</sup>)*

# CARDIAC OUTPUT



Textbook of Clinical Echocardiography 3rd Edition

$$SV = LVOTd \times vti$$

$$CO = SV \times HR$$

# Cardiac Arrest

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- Assessment of LV activity in Cardiac Arrest
- Electrical Activity vs Mechanical Activity
- Assess for LV Activity
- Is there Ventricular Activity or Cardiac Standstill

# Cardiac Arrest

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## Prognostic Implications:

### **Blaivas & Fox (Acad Emerg Med 2001)**

- ❖ 169 patients presenting to ED with on-going cardiopulmonary resuscitation
- ❖ 136 patients had cardiac standstill on in initial echocardiographic assessment
- ❖ None of the patients with cardiac standstill on initial echocardiographic study survived to leave the ED regardless of electrical activity

# Cardiac Arrest

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## Prognostic Implications:

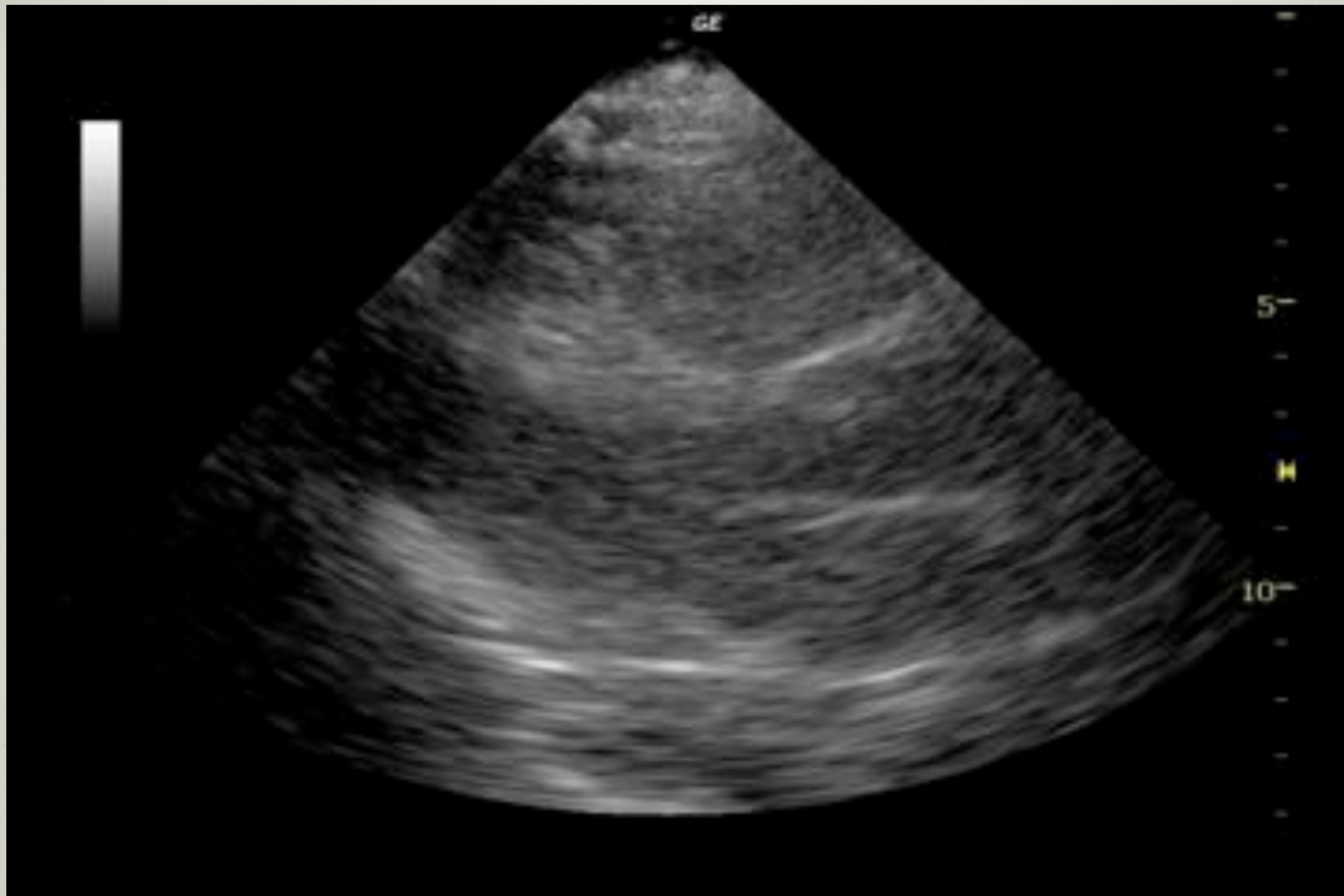
**Salen et al (Acad Emerg Med 2001)**

- ❧ 102 cardiac arrest patients
- ❧ 41 patients with identifiable electrical activity of which 11 (27%) survived to discharge (8 PEA, 2 VT, 1VF)
- ❧ 61 patients with cardiac standstill on initial presentation, none of whom survived to discharge

# Cardiac Arrest

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- Cardiac Standstill on initial presenting echocardiographic assessment has important prognostic implications
- Survival to discharge is not associated with cardiac standstill in this setting
- Evidence of cardiac standstill should be an important factor in the decision to terminate resuscitative measures



# SUMMARY

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- Evaluation of LV systolic function is one of the most valuable uses of focused echocardiography in emergency medicine
- LV systolic dysfunction is a major prognostic factor in acute cardiac disease
- Semi-quantitative assessment of regional and global LV systolic function by an experienced observer provides an accurate assessment of LV systolic function



Questions?