Assessment of Left Ventricular Function

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Assessment of Left Ventricular Function

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

• 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

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

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

• 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
- LVIDd: 36-56 mm
- LVIDs: 25-41 mm
- IVSd: 6-11 mm
- Posterior Wall: 6-11 mm
M-Mode

![M-mode image showing RV, IVST, LVEDD, and LVESD measurements.]

- RV: Right Ventricular internal dimension
- IVST: Interventricular septum thickness
- LVEDD: Left Ventricular end-diastolic dimension
- LVESD: Left Ventricular end-systolic dimension
- PWT: Posterior wall thickness
LV Dimensions

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’
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

- Anterior Septum
- Posterior Wall
Parasternal Short-Axis

- Septum
- Anterior Septum
- Anterior Wall
- Lateral Wall
- Posterior Wall
- Inferior Wall
Apical 4-Chamber

- Septum
- Lateral Wall
2-Chamber

- Inferior Wall
- Anterior Wall
3-Chamber

- Posterior Wall
- Antero-Septal Wall
Qualitative Evaluation of LV Systolic Function

- Each region of the LV is observed and the degree of endocardial \textit{wall motion} and \textit{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

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

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

• 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
Echo Views for Wall Motion

Short-axis (base)

RV

1
2
3
4
5
6

LV

Short-axis (mid-LV)

RV

8
9
10
11
12

LV

Apical 4-chamber

RV

LA

9
10
14
16
17

Apical 2-chamber

LA

LV

15
13
1

Apical long-axis

LV

16
11
8

Ao

Reproduced from Textbook of Clinical Echocardiography 3rd Edition
Regional Wall Motion Abnormality

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

Anterior Wall Dyskinesis
Regional Wall Motion Abnormality

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

### Differentiation of old & new wall motion abnormalities

<table>
<thead>
<tr>
<th></th>
<th>OLD</th>
<th>NEW</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ventricular Size</strong></td>
<td>Usually Dilated</td>
<td>Usually Normal</td>
</tr>
<tr>
<td><strong>Wall motion</strong></td>
<td>Hypo-/Dyskinetic</td>
<td>Hypokinetic</td>
</tr>
<tr>
<td><strong>Wall thickening</strong></td>
<td>Reduced</td>
<td>Reduced</td>
</tr>
<tr>
<td><strong>Myocardial echo</strong></td>
<td>Bright</td>
<td>Normal</td>
</tr>
<tr>
<td><strong>Wall thickness</strong></td>
<td>Thin</td>
<td>Normal</td>
</tr>
<tr>
<td><strong>Aneurysm Formation</strong></td>
<td>Yes</td>
<td>Unusual</td>
</tr>
</tbody>
</table>
**Quantitative assessment of LV function**

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

Stroke Volume
Fractional Shortening

- The measurements LVID_d & LVID_s are made at the base of the heart
- If there are no regional wall motion abnormalities the ejection fraction can be estimated as:

\[ 2 \times \text{Fractional Shortening} = \frac{\text{LVID}_d - \text{LVID}_s}{\text{LVID}_d} \times 100\% \]

(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

‘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

- 50-70% Normal
- 40-50% Mild Impairment
- 25-40% Moderate Impairment
- <25% Severe Impairment
Stroke Volume, cardiac Output & Cardiac Index

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

(Normal 75 - 100 ml)

Cardiac Output = Stroke Volume × Heart Rate

(Normal 4 - 8 L/min)

Cardiac Index = CO / BSA

(Normal 2.4 - 4.2 L/min/m²)
Cardiac Output

\[ SV = LVOT_d \times \text{vti} \]

\[ CO = SV \times HR \]
Cardiac Arrest

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

Blaivas & Fox (Acad Emerg Med 2001)

- 169 patients presenting to ED with on-going cardiopulmonary resuscitation
- 136 patients had cardiac standstill on 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

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

- 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

• 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?