Left Ventricular Systolic Function: Global and Regional Assessment

Ankur R. Gosalia, M.D.
Assistant Professor of Anesthesiology
Western Pennsylvania Hospital

Learning Objectives:
1. Identify normal and abnormal global left ventricular systolic function
2. Understand how to perform basic qualitative and quantitative assessments of global left ventricular systolic function
3. Recognize left ventricular regional wall motion abnormalities and their corresponding coronary distributions

Assessment of left ventricular systolic function is a primary component of every echocardiographic examination. The degree of systolic dysfunction is a powerful predictor of clinical outcome in a multitude of clinical settings. Echocardiographic evaluation of global and regional LV performance is accomplished by assessing LV muscle contractile function and the size and shape of the LV cavity. Utilization of both qualitative (i.e. visual estimations of EF) and quantitative techniques (i.e. cavity volumes, ejection phase indexes) is helpful in determining the degree of LV dysfunction, possible etiologies, and methods to improve LV performance.

Echocardiographic Assessment of Global Left Ventricular Function

Ventricular systolic function is most commonly assessed by “load-dependent” indices. These measurements, although practical in the clinical setting, are subject to change when preload and/or afterload are altered and should be used only with consideration of current loading conditions.

Common “Load-Dependent” echocardiographic techniques utilized in the evaluation of global LV function include:

1. **2D & 3D Left Ventricular Anatomy and Wall Function Imaging**
   a. Imaging planes used to describe & quantitate LV function:
      i. ME 4 Chamber
      ii. ME 2 Chamber
      iii. ME LAX
      iv. TG MidPap SAX
      v. TG Basal SAX
      vi. TG LAX

2. **Fractional Shortening (%FS)**
   a. Ventricular diameters from M-Mode measurements
      i. \( \%FS = \left[ \frac{(LVEDd - LVESd)}{LVEDd} \right] \times 100 \)
3. Fractional Area Change (%FAC)
   i. \( \% \text{FAC} = \left( \frac{\text{LVEDA} - \text{LVESA}}{\text{LVEDA}} \right) \times 100 \)

4. Ejection Fraction (%EF)
   a. Modified Simpson’s Method of Discs from ME 4C and ME 2C LV end-systolic and end-diastolic images
      i. \( \% \text{EF} = \left( \frac{\text{EDV} - \text{ESV}}{\text{EDV}} \right) \times 100 \)

5. Stroke Volume (SV) & Cardiac Output (CO)
   a. \( \text{SV} = \text{Area} \times \text{VTI} \)
      i. May be performed at multiple sites (i.e. LVOT, RVOT, MV)
      ii. \( \text{Area} = \left( \frac{D}{2} \right)^2 \times \pi \) (requires accurate diameter measurement)
      iii. \( \text{VTI} = \) calculated by tracing outline of velocity spectral display
   b. \( \text{CO} = \text{SV} \times \text{HR} \)
   c. Stroke Volume Index (SVI) = \( \frac{\text{SV}}{\text{BSA}} \)

6. Preload (Left Ventricular End-Diastolic Area/Volume)
   a. LV EDA as a surrogate for preload
      i. \( \text{EDA index} = \frac{\text{LVEDA}}{\text{BMI}} \)
   b. LVEDV
7. Afterload (Wall Stress)
   a. Measure of LV function:
      i. Forces acting “in” the wall balance the forces acting “on” the wall
   b. Meridional Wall Stress: Longitudinal Axis LV
   c. Circumferential Wall Stress: Short Axis LV
   d. Radial Wall Stress: LV Shape

8. Rate of Ventricular Pressure Rise or Systolic Index of Contractility (dP/dt)
   a. Most load insensitive of the “Load-dependent” indicies
   b. Initial acceleration of the mitral regurgitation jet represents contractile force generated during IVCT
      i. dP/dt requires that a measureable MR jet be present
      ii. dP/dt > 1200 mmHg/s (dt < 26ms) is normal
      iii. dP/dt < 800 mmHg/s (dt > 40ms) is depressed systolic function

9. Myocardial Performance Index (MPI)
   a. Ratio of total LV isovolemic time to ejection time
   b. MPI = (IVRT + IVCT) / Systolic Ejection Period
      i. Normal MPI = 0.4
      ii. MPI > 0.6 implies either Systolic or Diastolic dysfunction

“Load-INDependent” measurements remove the need to take into account the changing preload and afterload states, but due to their cumbersome nature they have not been widely adopted in the operating room setting.

Load-independent echocardiographic techniques that may be utilized in the evaluation of global LV function include:

1. Left Ventricular Mass, Geometry, and Relative Wall Thickness (RWT)
   a. LV Mass = 1.05 (Total LV volume – LV Chamber volume)
      i. Normally indexed to BSA (women = 44-88 g/m², men = 50-102 g/m²)
   b. RWT = 2 x (Inferolateral Wall Thickness) / LV Internal Diameter
      i. Performed in diastole
      ii. Normal RWT <0.42
   c. Normal Geometry = Normal LV mass and RWT
   d. Concentric Hypertrophy = ↑ LV mass and ↑ RWT
   e. Eccentric Hypertrophy = ↑ LV mass with Normal RWT
   f. Concentric Remodeling = Normal LV mass and ↑ RWT
2. **Tissue Doppler Imaging (TDI)**
   a. Doppler imaging of movement of cardiac structures
      i. TDI velocity is commonly sampled from the septal mitral annulus to assess descent of the mitral annulus toward the apex (velocity > 5.4 cm/sec = EF >50%)
      ii. 10x slower than cardiac blood flow
      iii. Multiple limitations (i.e. angle dependent)

3. **Speckle Tracking**
   a. Angle – INDEPENDENT
   b. Myocardial shortening and strain can be calculated by measuring the changing distance between speckles during systole and diastole

4. **Mean Velocity of Fiber Shortening**

*Echocardiographic Assessment of Regional Left Ventricular Function*

TEE is highly sensitive when evaluating regional myocardial ischemia of the LV. Most often, LV regional wall motion assessment is made by 2D imaging focusing on visually observed changes of inward radial motion and systolic wall thickening of specific segments of the LV. The LV is divided into 17 segments, according to guidelines established by the ASE and the SCA. The basal and mid levels of the ventricle are each divided into six segments, the apex is divided into four segments, and the apical cap is segment 17.

<table>
<thead>
<tr>
<th>REGIONAL FUNCTION</th>
<th>GRADE</th>
<th>INWARD RADIAL MOTION</th>
<th>SYSTOLIC WALL THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>1</td>
<td>&gt; 30%</td>
<td>Marked</td>
</tr>
<tr>
<td>Hypokinetic</td>
<td>2</td>
<td>&lt;10% to &lt;30%</td>
<td>Reduced</td>
</tr>
<tr>
<td>Akinetic</td>
<td>3</td>
<td>&lt;10%</td>
<td>Negligible</td>
</tr>
<tr>
<td>Dyskinetic</td>
<td>4</td>
<td>Paradoxial Systolic motion</td>
<td>Systolic Thinning</td>
</tr>
<tr>
<td>Aneurysmal</td>
<td>5</td>
<td>Diastolic Deformation</td>
<td></td>
</tr>
</tbody>
</table>
Note: The TG MidPap SAX view of the LV is easy to obtain and provides a relatively good indicator of overall coronary perfusion and regional wall motion, but remember that the basal and apical segments are not identified in this view. All LV imaging planes should be used to thoroughly assess LV regional wall function.

Precise localization of coronary artery pathology requires accurate identification of regional wall motion abnormalities (RWMA). The zone of RWMA directly correlates with its coronary artery distribution.

**Coronary Artery Distribution**

![Diagram showing different imaging planes and coronary artery distribution](Image)

**Further Reading:**

3. Lang RM, Bierig M, Devereux RB et al: Recommendations for chamber quantification: a report from the American Society of Echocardiography’s Guidelines and Standards Committee and the Chamber Quantification Writing Group, developed in conjunction with the European Association of Echocardiography, a branch of the European Society of Cardiology. JASE 17: 1086-1119, 2005.