**Diastolic Function: What the Sonographer Needs to Know**

Pat Bailey, RDCS, FASE  
Technical Director  
Beaumont Health System

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**Echocardiographic Assessment of Diastolic Function:**

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**Basic Concepts**

- Optimal Diastolic Function occurs when a **compliant** left ventricle allows filling from **low** pressure left atrium.
Diastolic Dysfunction

- **Elevated filling pressures** are the main physiologic consequence of diastolic dysfunction.

Assessment of Diastolic Function

- Early LV Filling
- Diastasis
- IVRT
- Atrial Contraction
- Phases of Diastole

Dystolic Function Exam

- Left Atrial Volume
- Comparison of “A” duration
- Mitral Inflow
- Valsalva Maneuver
- Tissue Doppler Imaging
- Pulmonary Veins
Left Atrial Volume

- Significant relationship to LA enlargement and diastolic function
  - Measured in apical 4-chamber and two chamber views using area/length method
  - Measure left atrial area
    - Trace volume just prior to MV opening (end systole)
    - Exclude pulmonary veins and appendage
    - Tracing up to the level of the mitral annulus (Index the LA Volume to body surface area)
  - LA Volume (cc) / BSA(m2) = LA Volume Index

![Diagram of Left Atrial Volume](https://www.asecho.org)

Left Atrial Volume

\[ \text{LA Volume} = 0.85 \times A_1 \times A_2 \]

![Images of A1C and A2C views](https://www.asecho.org)

Mitral Inflow

- Obtain in apical 4-chamber view
  - Technical tips:
    - Perform CW Doppler to assess peak E and A velocities before applying the PW to ensure that maximal velocities are obtained.
    - Using PW Doppler, the cursor must be parallel with the direction of blood flow.
Mitral Inflow

- Technical tips cont:
  - A 1-mm to 3-mm sample volume is then placed between the mitral leaflet tips during diastole to record a crisp velocity profile.
  - Optimize gain and wall filter settings to ensure optimal spectral display.
  - Begin with sweep speeds of 25 to 50 mm/s for the evaluation of respiratory variation. If no variation is seen, increase to 100 mm/sec.

Mitral Inflow

- Align transducer parallel to flow

Adapted from: Appleton, Jensen, Iwane Oh. Doppler Evaluation of Left and Right Ventricular Ejection Function: Technical Guide

Mitral Inflow Variables

- LA
- RA
- RV
- LV
- A
- B
- C
- D
- E
- F
Mitral Valve Inflow

Measurements
- E velocity
- A velocity
- E at A velocity
- E/A ratio
- Deceleration time
- A duration

Caveats:
E & A Velocities may become fused with Tachycardia or first-degree A-V block

Adapted from: Appleton, Jensen, Hatle Oh. Doppler Evaluation of Left and Right Ventricular Diastolic Function: Technical Guide

Tissue Doppler Imaging (TDI)

- Used to acquire mitral annular velocities and estimate LV filling pressures
- Preload independent
  - Technical tips:
    - Use pulsed wave Doppler
    - Position sample volume at or 1cm within the septal and lateral insertion sites of the mitral leaflets
    - Sample size usually (5-10mm) to cover the longitudinal excursion of the mitral annulus in both systole and diastole.

Tissue Doppler Imaging (TDI)

- Use Doppler pre-set (DTI) if available
- If not available, set velocity scale at 20 cm/s above and below the zero-velocity baseline. (Lower settings may be necessary when there is severe LV dysfunction and annular velocities are reduced.
- Decrease power, filter & gain
- Increase reject & compress
- Best viewed at a sweep speed of 50 mm/sec
Tissue Doppler Imaging (TDI)

- Measurements:
  - Mitral annular e′ velocity (m/sec)
  - Mitral annular a′ velocity (m/sec)
    - Limitation for septal annulus:
      - Regional wall motion abnormalities
      - Prosthetic valves
      - Severe mitral valve disease
      - Constrictive pericarditis

Adapted from: The Echo Manual - Second Edition

Pulmonary Venous Flow

Adapted from: The Echo Manual - Second Edition
Technical tips:
- Performed in apical 4-chamber view
- Color flow imaging is useful for the proper location of the sample volume in the RUPV.
- Angle transducer superiorly with aortic valve in view.
- Use a 2-mm to 3-mm sample volume, placed >5 cm into the pulmonary vein.
- Optimize scale/baseline
- Increase sample volume size if Doppler signal is weak (4-5mm)

Measurements:
- Systolic flow velocity \([S_1, S_2]\) (m/sec)
- Diastolic flow velocity (m/sec)
- Atrial reversal duration (msec)

Limitations:
- Wall noise (ensure the atrial reversal flow signal intensity matches that of the systolic and diastolic flow)
**Mitral and P-Vein “A” duration comparisons**

AR Duration
- Optimize atrial reversal Doppler signal
- Requires sharp distinct signals
- Measure close to baseline
- Difference in durations must be > 30 msec

**Comparison of Durations**

- MV A duration > P vein AR duration in hearts with normal filling pressure
- As LVEDP increases, the P vein AR duration lengthens
- Difference in durations must be > 30 msec to be significant
- Longer P vein AR duration (> 30 msec) indicates increased LVEDP
Valsalva Maneuver

- The Valsalva maneuver is used to differentiate the grades (II, III) of diastolic dysfunction.
- Performance of valsalva maneuver:
  - Ask patient to suspend their breath at the end of a normal inspiration and strain down without breathing. By increasing the intra-thoracic pressures and thereby reducing the venous return to the heart, a decreased pre-load (left atrial pressure) potentially unveils any underlying grade of diastolic dysfunction.

Mitral inflow with Valsalva

- An adequate Valsalva maneuver is defined as a 10% reduction in the maximal E velocity from baseline.
- A reduction of the E/A ratio by 0.5 or more demonstrates increased filling pressure (ex. 1.2 to 0.7)
Valsalva Maneuver

- Technical tips:
  - Obtain apical 4-chamber view
  - Align sample volume at leaflet tips
  - Begin Valsalva maneuver, while maintaining sample volume alignment
  - After 12 seconds, turn to live Doppler to capture the signal.

Valsalva Maneuver

- Measurements:
  - MV “E” velocity (m/sec)
  - MV “A” velocity (m/sec)
  - E at A velocity (m/sec)
  - E/A ratio
  - Deceleration time (msec)

Valsalva Maneuver

- Limitations:
  - Not everyone is able to perform this maneuver adequately
Practical Approach to Grade Diastolic Dysfunction

Septal e' > 8
Lateral e' > 10
LA volume < 34 ml/m

Septal e' > 8
Lateral e' > 10
LA volume > 34 ml/m

E/A < 0.8
DT > 200 ms
Av.E/e' < 8
Ar - A < 0 ms
Val E/A , 0.5

E/A 0.8 - 1.5
DT 160 - 200 ms
Av. E/e' 9 - 12
Ar - A > 30 ms
Val E/A > 0.5

E/A > 2
DT < 160 ms
Av. E/e' > 30 ms
Val E/A > 0.5

Grade I
Abnormal relaxation

Grade II
Pseudonormal

Grade IIIa / IIIb
Restrictive

Abnormal LV Filling Patterns

Adapted from: The Echo Manual - Second Edition
Grade I Abnormal Relaxation

- Cont:
  - LA contraction (A wave) contributes up to 35% of filling
    - E/A ratio ≤ 0.8 (If E at A is < 0.2 m/sec)
    - DT > 240

Grade II Pseudo-normal

- Impaired myocardial relaxation with mild to moderate elevation of LV filling pressures.
- Symptoms of heart failure at rest or with minimal exertion (NYHA II-III)
  - E/A 0.8-1.5
  - DT 160-200 ms
  - Av. E/e' 9-12
  - Ar-A ≥ 30 ms
  - Val E/A > 0.5

Grade II Pseudo-normal

- Pseudonormal cont:
  - Pulmonary vein S/D ≤ 0.5
  - LV dysfunction (not always)
  - LA enlargement
Grade IIIa - IIIb

- LV is less compliant (Incr. filling pressure, Incr. E)
- Rapid equalization of pressure (decr. DT)
- Late diastolic LA-LV pressure gradient is limited (decr. A)
- Symptoms of heart failure at rest or with minimal exertion (NYHA III-IV)
- Reversible mitral inflow pattern upon preload reduction with Valsalva, nitroglycerin or diuretic administration [Grade IIIa]

Cont:
- Eventually irreversibly restrictive (no response to aggressive preload reduction) [Grade IIIb]