Diastolic Function: What the Sonographer Needs to Know

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Echocardiographic Assessment of Diastolic Function:

Basic Concepts
Practical Hints and
Clinical Application

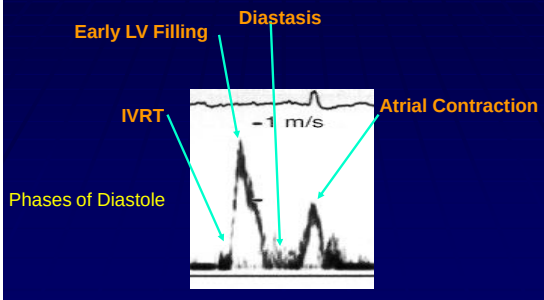
Basic Concepts

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

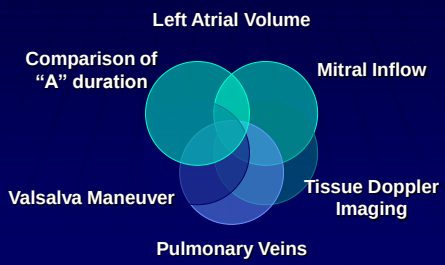
Diastolic Dysfunction

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

Assessment of Diastolic Function



Dystolic Function Exam



Left Atrial Volume

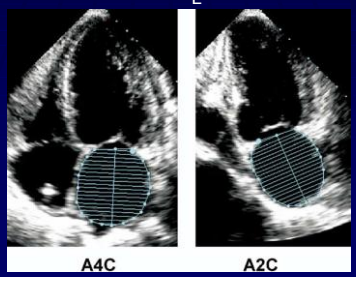
- Significant relationship to LA enlargement and diastolic function
  - Measured in apical 4-chamber and two chamber views using area/length method
  - Measure left atrial area
    - Trace volume just prior to MV opening (end systole)
    - Exclude pulmonary veins and appendage
    - Tracing up to the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

  (Index the LA Volume to body surface area)

  LA Volume (cc) / BSA(m2)=LA Volume Index

Left Atrial Volume

LA Volume = $\frac{0.85 \times A_1 \times A_2}{L}$



Mitral Inflow

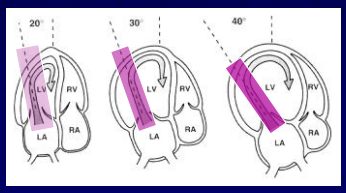
- Obtain in apical 4-chamber view
  - Technical tips:
  - Perform CW Doppler to assess peak E and A velocities before applying the PW to ensure that maximal velocities are obtained.
  - Using PW Doppler, the cursor must be parallel with the direction of blood flow.

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

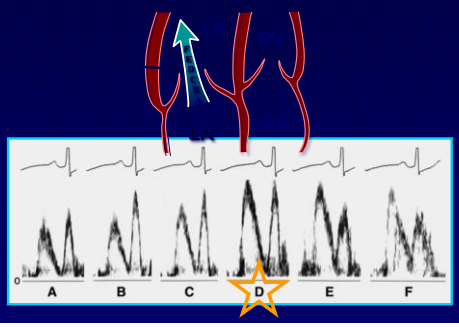
Mitral Inflow

- Align transducer parallel to flow



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

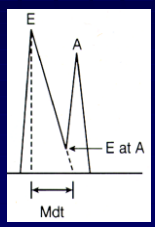
Mitral Inflow Variables

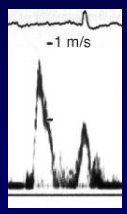


Mitral Valve Inflow

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

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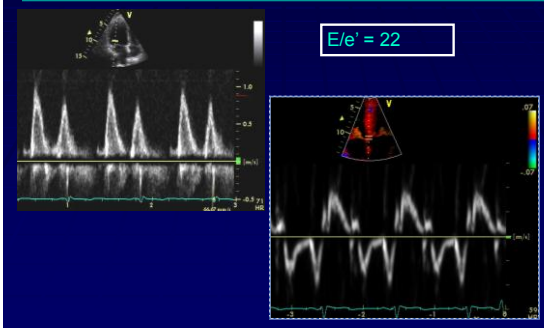
Tissue Doppler Imaging (TDI)

- 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

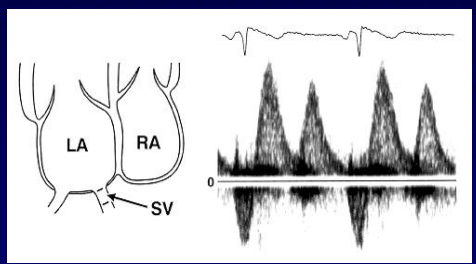
Tissue Doppler Imaging (TDI)



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

Pulmonary Venous Flow



Adapted from: The Echo Manual - Second Edition

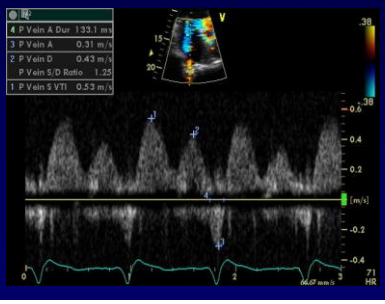
Pulmonary Veins

- 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)

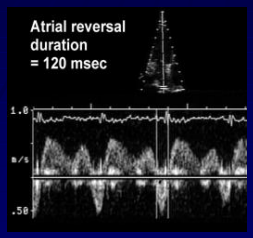
Pulmonary Veins

- 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)

Pulmonary Veins



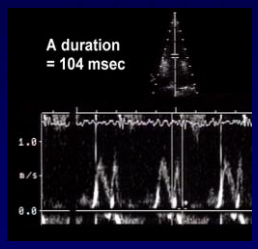
Mitral and P-Vein "A" duration comparisons

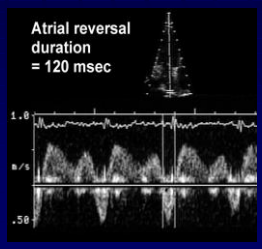


AR Duration

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

Comparison of Durations





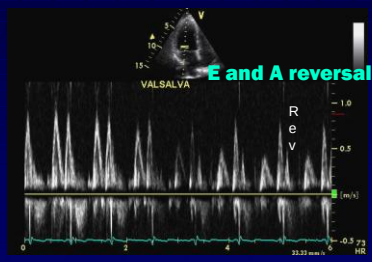
Comparison of Durations

- 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 ant 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



Valsalva Maneuver

- 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.

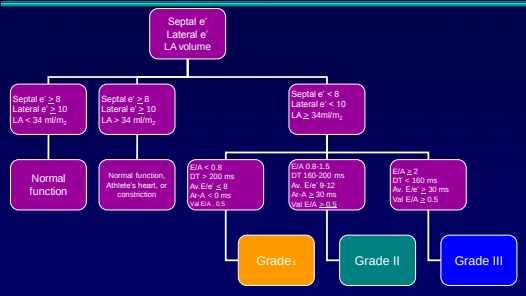
Valsalva Maneuver

- 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 Dystunction



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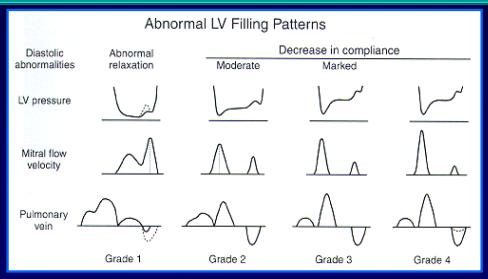
Grades of Diastolic Dysfunction

- Grade I - Abnormal relaxation
- Grade II - Pseudonormal
- Grade IIIa / IIIb - Restrictive

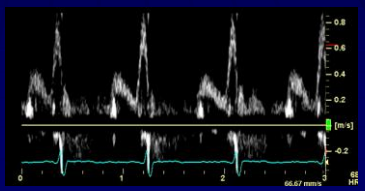
Abnormal LV Filling Patterns



Adapted from: The Echo Manual - Second Edition

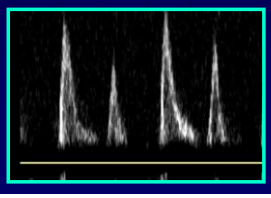
Grade I Abnormal Relaxation

- 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

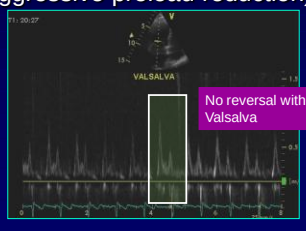
- Pseudonormal cont:
  - Pulmonary vein S/D ≤ 0.5
  - LV dysfunction (not always)
  - LA enlargement

Grade IIIa - IIIb

- LV is less compliant (Incr. filling pressure, Incr. E)
- Rapid equalizatio 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]

Grade IIIa - IIIb

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



THANK-YOU