Left Ventricular Diastology

Presented By
Lara Williams, BS, ACS, RCCS, RDCS, RVT, RDMS, FASE

1

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2

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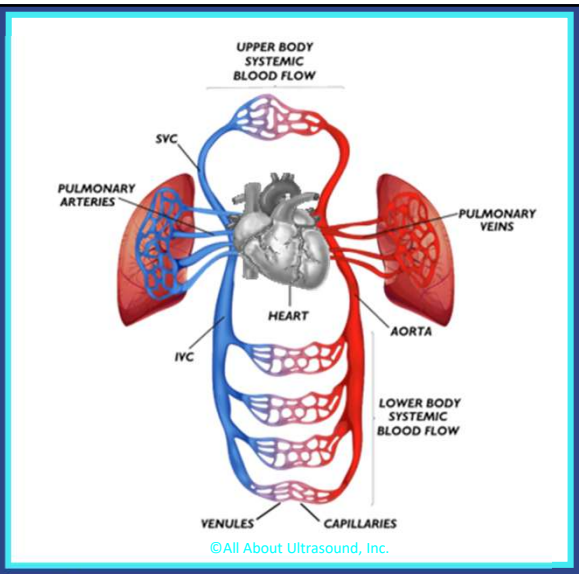
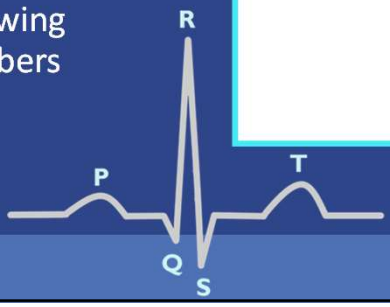
3

Cardiac Cycle

- Cardiovascular Hemodynamics
- Hemodynamic blood flow to the peripheral vasculature is primarily influenced by the cardiac cycle
- Systole – Heart actively pumping, ejecting blood out through the aorta
- Diastole – Heart at rest, allowing filling within the atrial chambers





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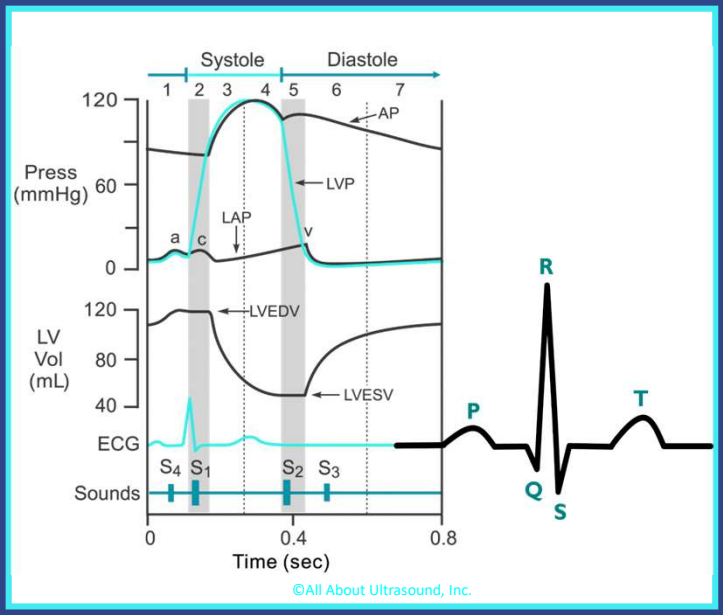
Cardiac Cycle

Phases of Cardiac Cycle:

- 1. Atrial Contraction
- 2. Isovolumetric Contraction
- 3. Rapid Ejection
- 4. Reduced Ejection
- 5. Isovolumetric Relaxation
- 6. Rapid Filling
- 7. Reduced Filling (Diastasis)



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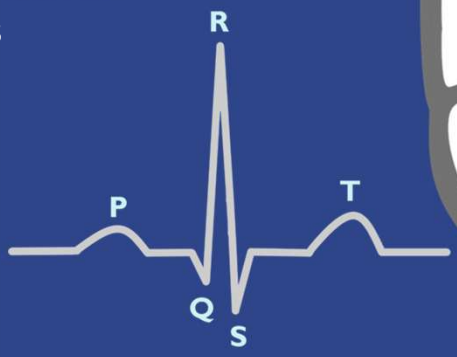
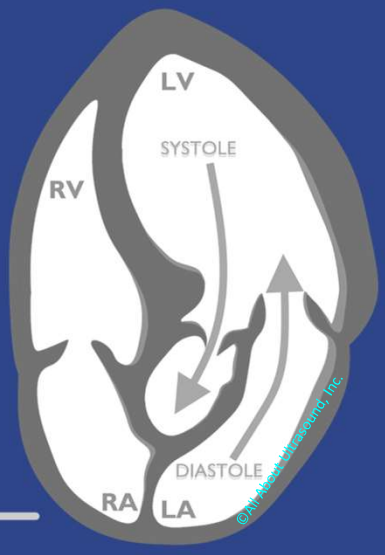
Cardiac Cycle

Systole:

- Heart actively pumping, ejecting blood out through the aorta
- Begins with ventricular contraction
- Ends when ejection ceases
- Includes:
  - Isovolumetric Contraction
  - Rapid Ejection
  - Reduced Ejection





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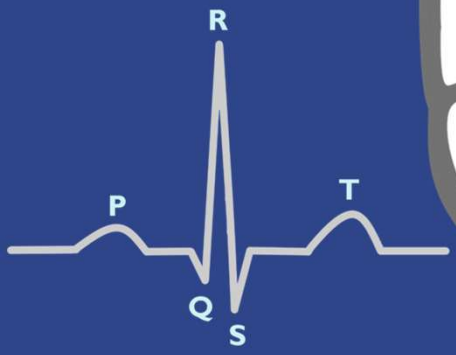
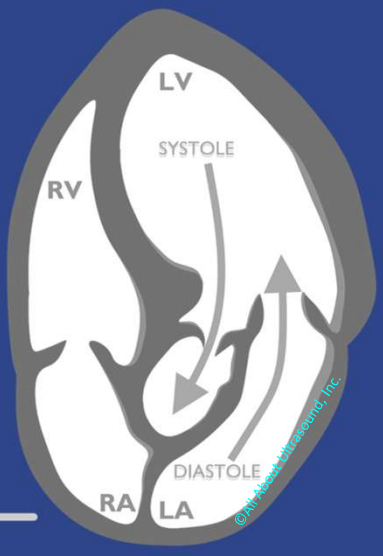
Cardiac Cycle

Diastole:

- Heart at rest, allowing filling within the atrial chambers
- Begins when cardiac ejection ceases
- Includes:
  - Isovolumetric Relaxation
  - Rapid Filling
  - Reduced Filling
  - Atrial Contraction

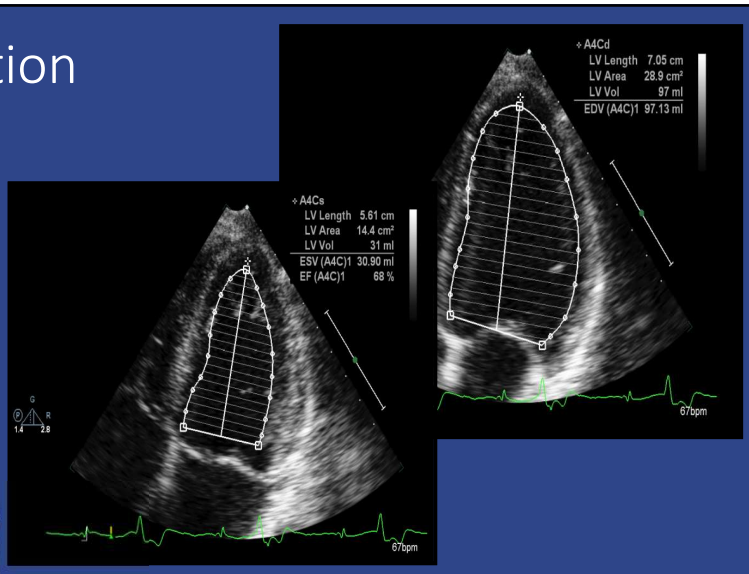


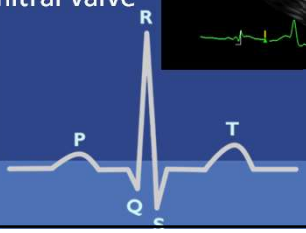


7

Left Ventricular Function

- Diastolic Function
  - Relaxation of the heart and myocardium which occurs during diastole. LVIDd and ED volume is measured immediately after mitral valve closure.
- Systolic Function
  - Squeezing action of the ventricle which occurs during systole. LVIDs and ES volume is measured immediately before mitral valve opening.

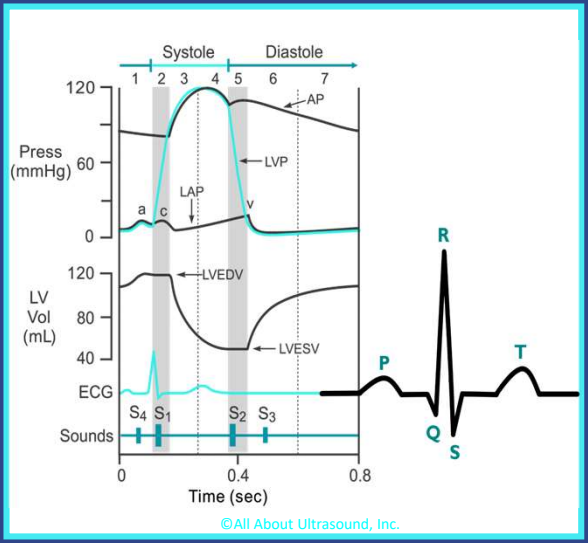




8

Left Ventricular Diastolic Function

- The ventricular myocardium relaxes and creates a vacuum to assist with left ventricular filling
- Diastolic filling from the left atrium into the left ventricle
  - Rapid Filling Phase - Ventricles continue to relax at the end of isovolumetric relaxation, the intraventricular pressures fall below their respective atrial pressures. When this occurs, the AV valves rapidly open and passive ventricular filling begins.
  - Reduced Filling Phase - In normal, resting hearts, the ventricle is about 90% filled by the end of this phase.



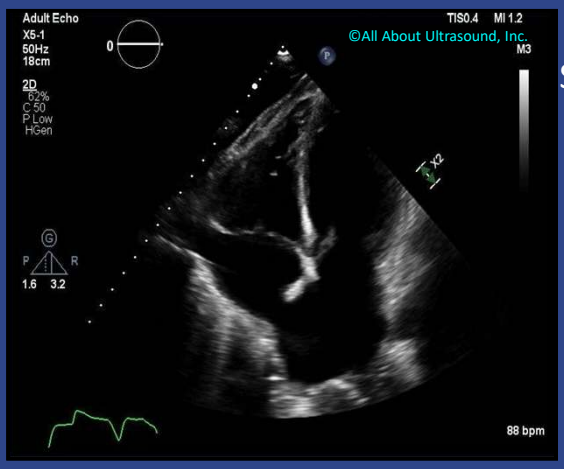
9

Sonographic Evaluation **of Diastology**

- 2D Left Ventricular Morphology/Systolic Function
- PW Mitral Inflow Pattern
- Tissue Doppler Velocity Mitral Annular Motion
- Left Atrial Volume Index
- Pulmonary Vein Doppler
- TR Velocity

10

Sonographic Evaluation of Diastology



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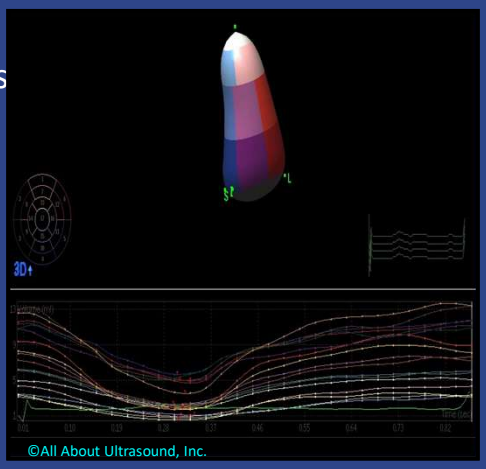

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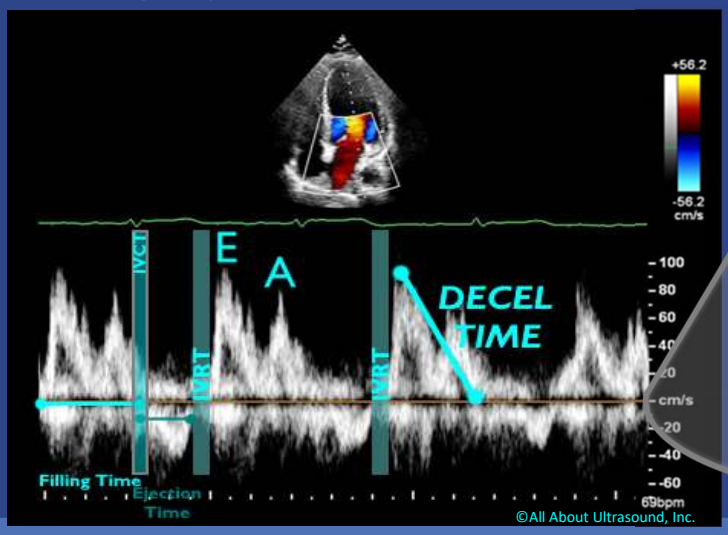
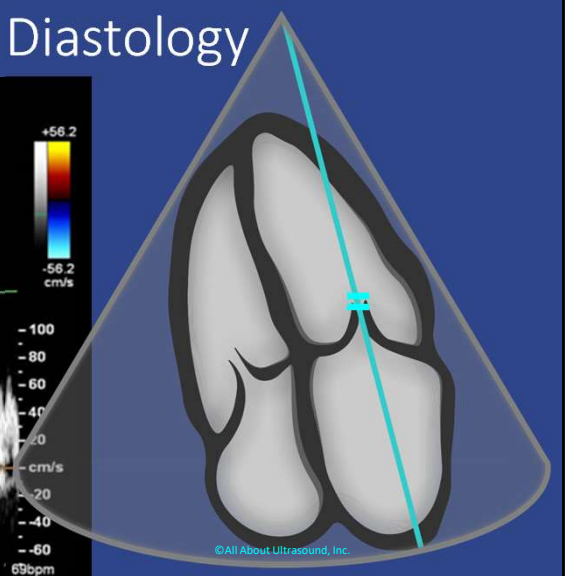
Sonographic Evaluation of Diastology



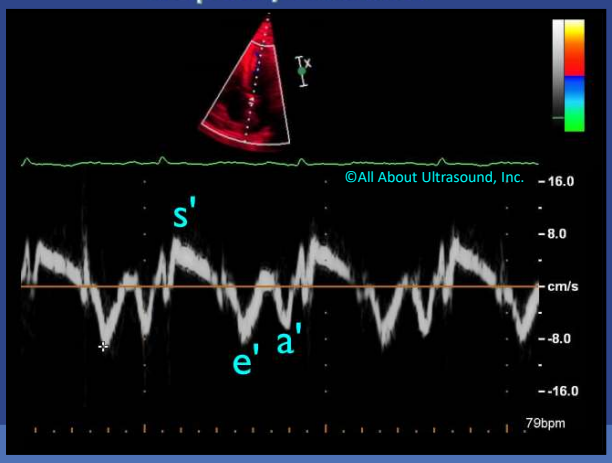


12

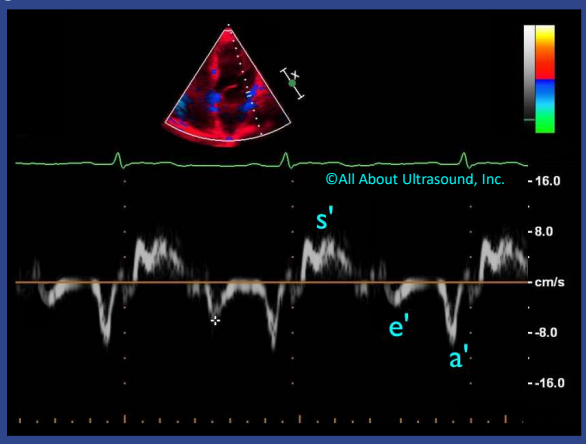
Sonographic Evaluation of Diastology

- Tissue Doppler Velocity at Mitral Annulus

Septal/Medial



Lateral



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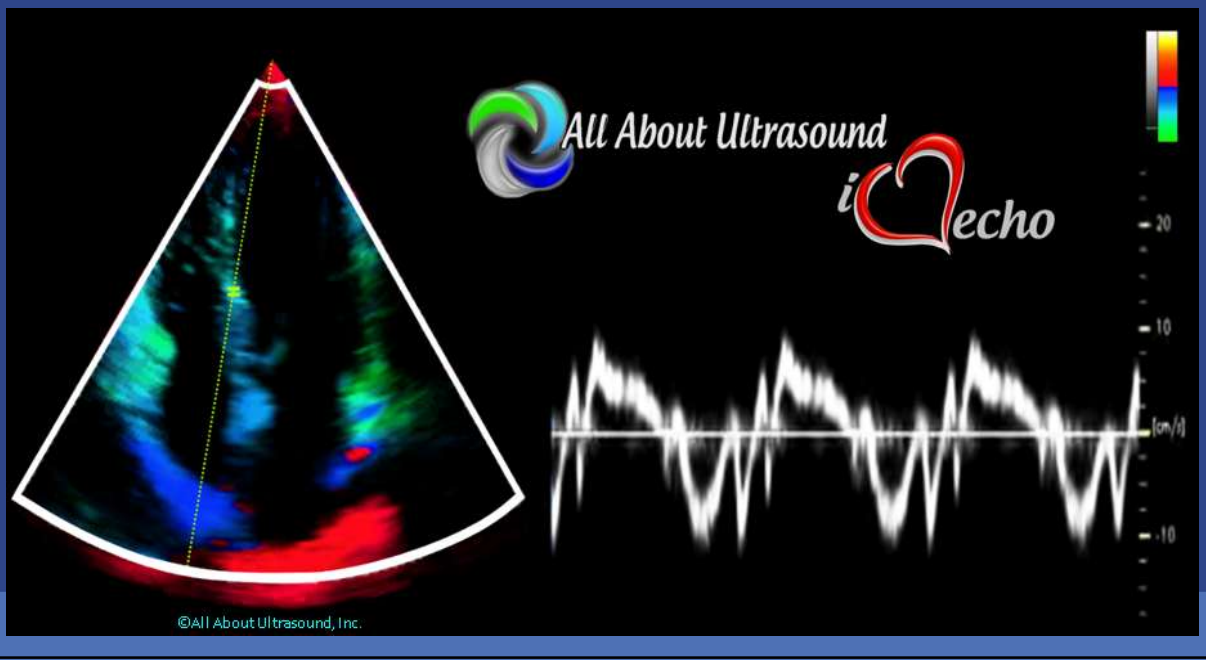

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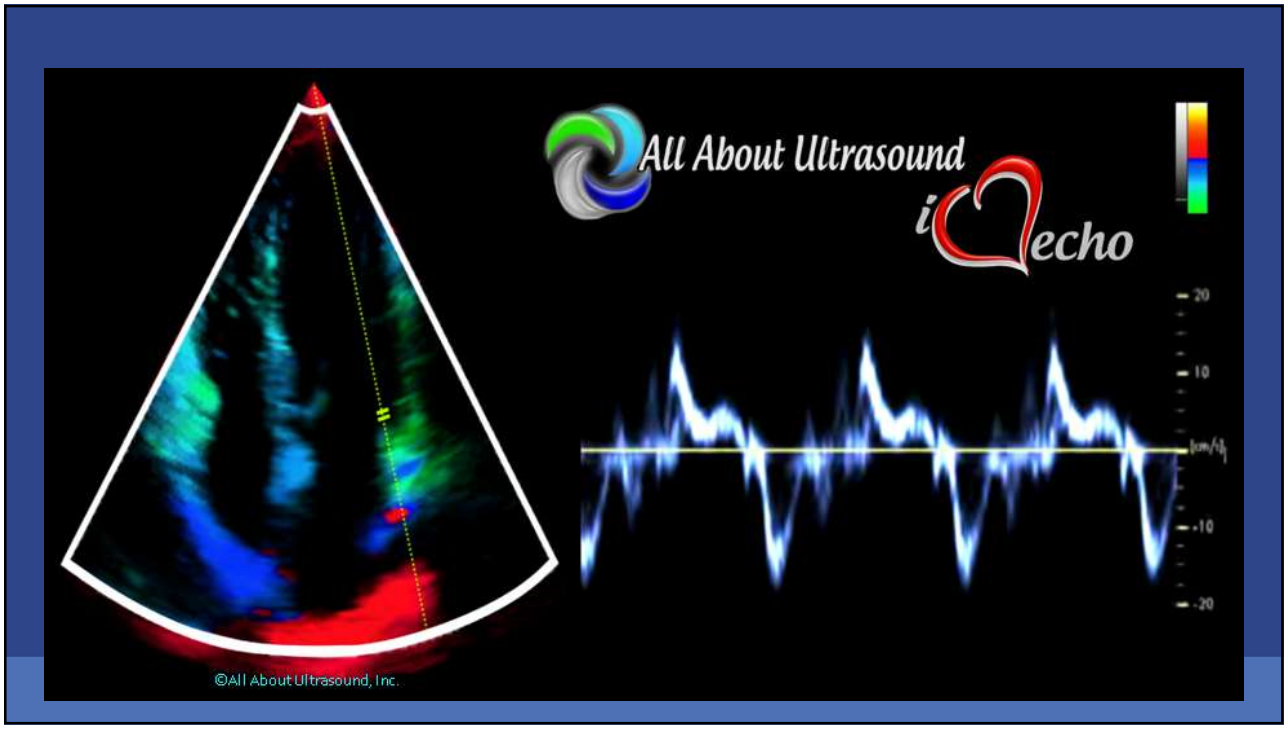

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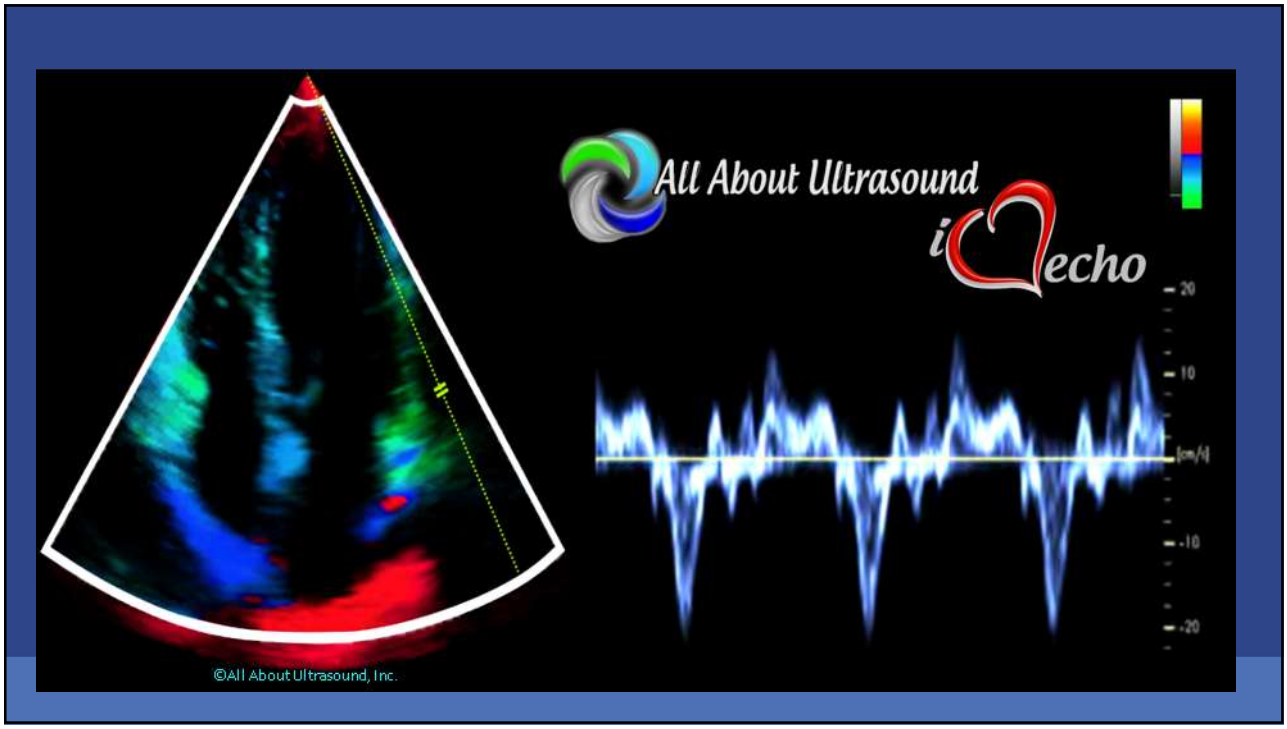

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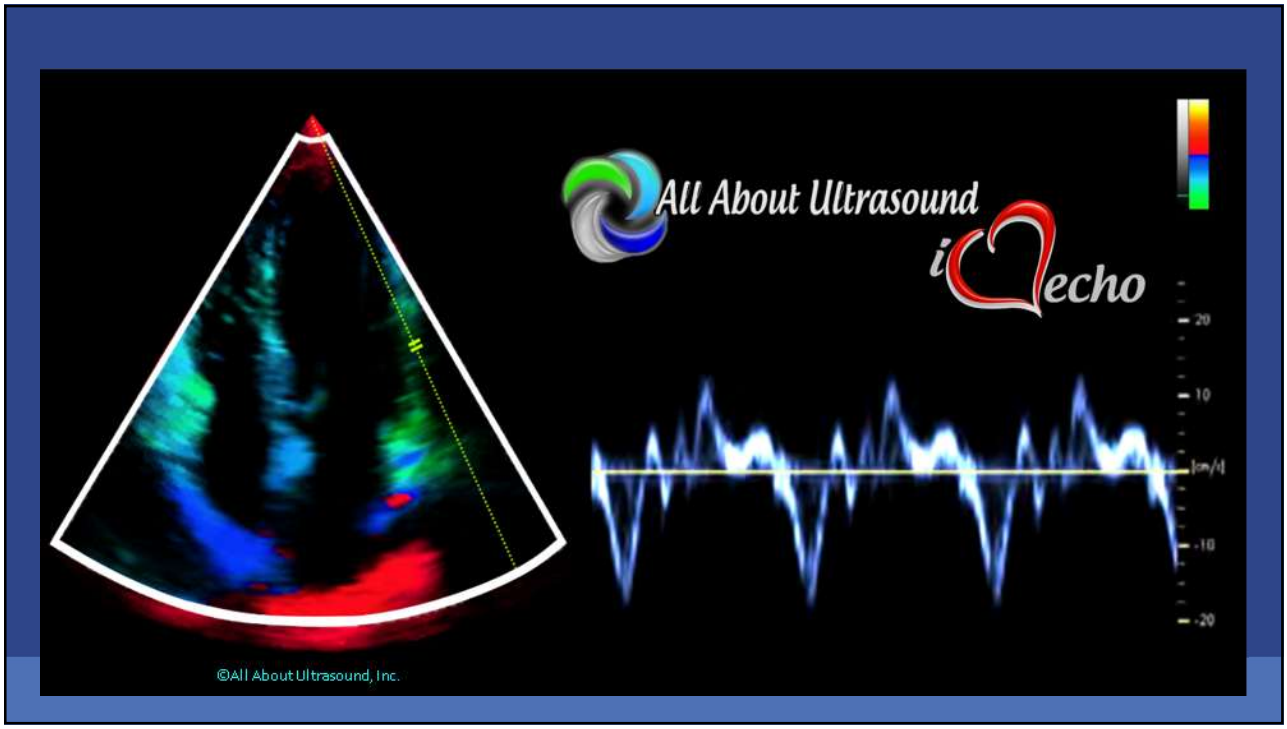

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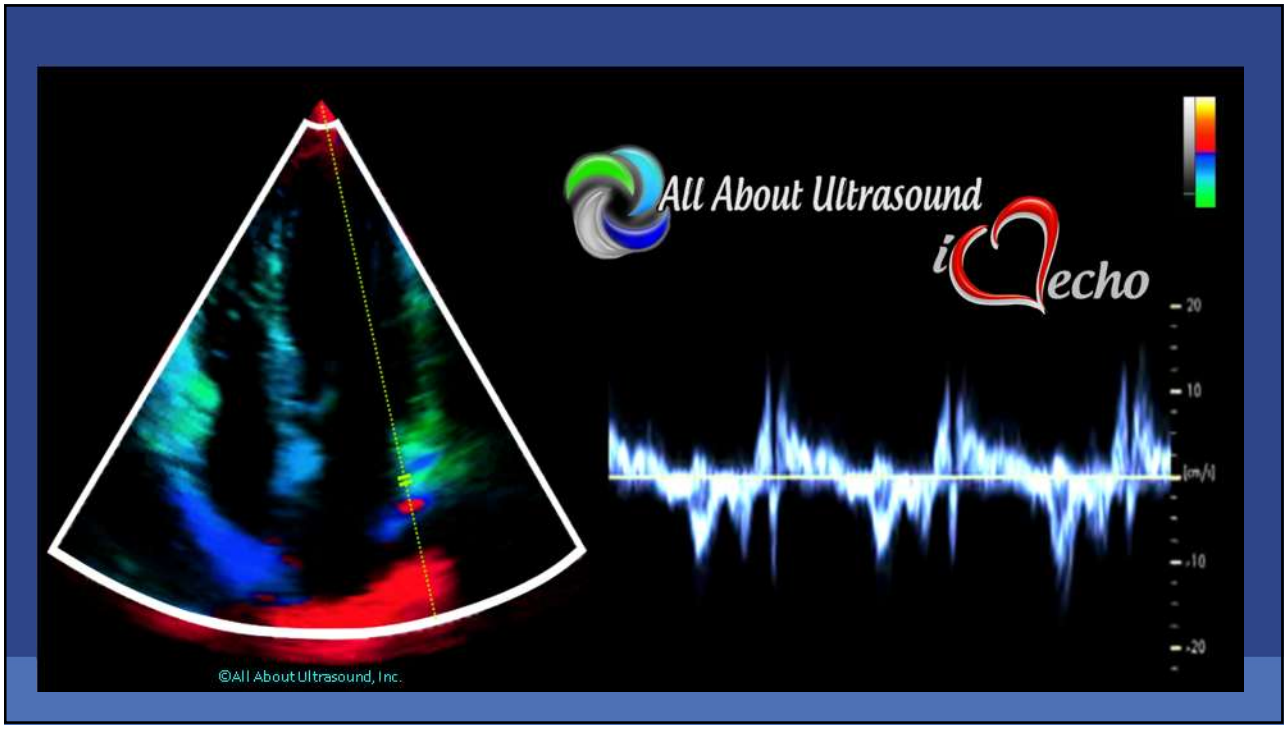

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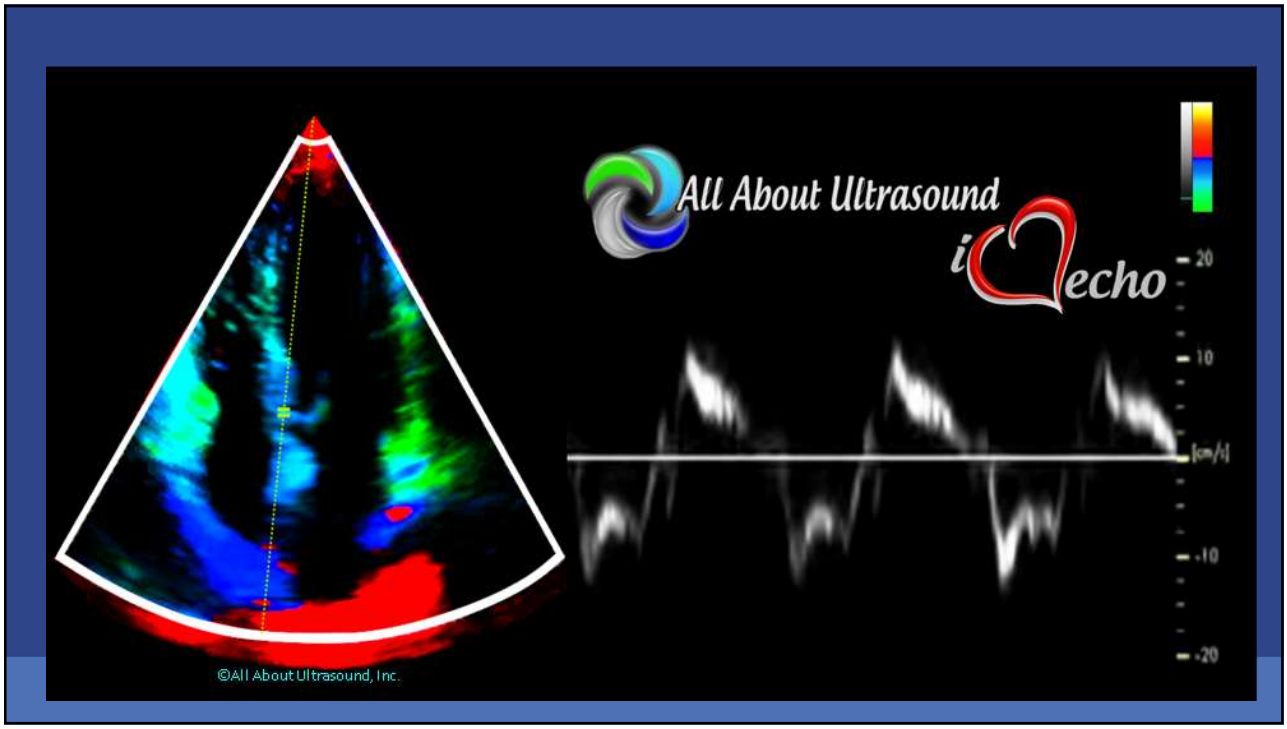

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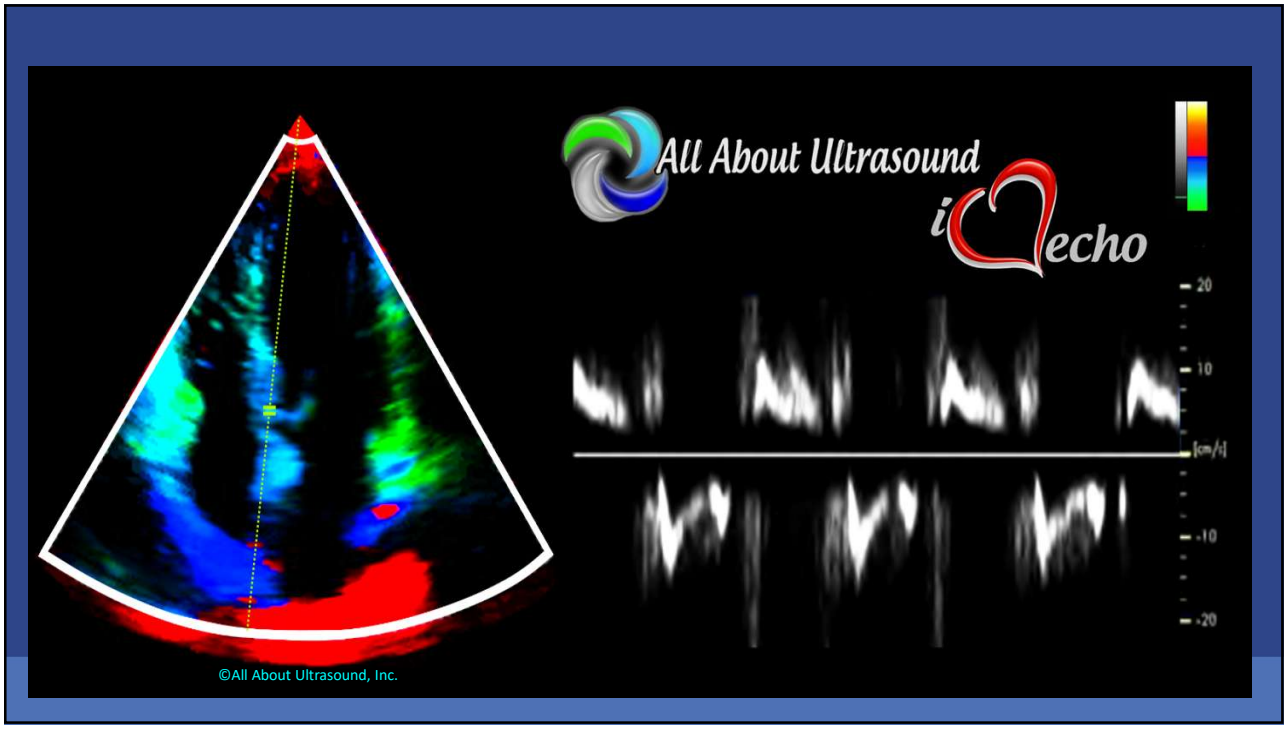
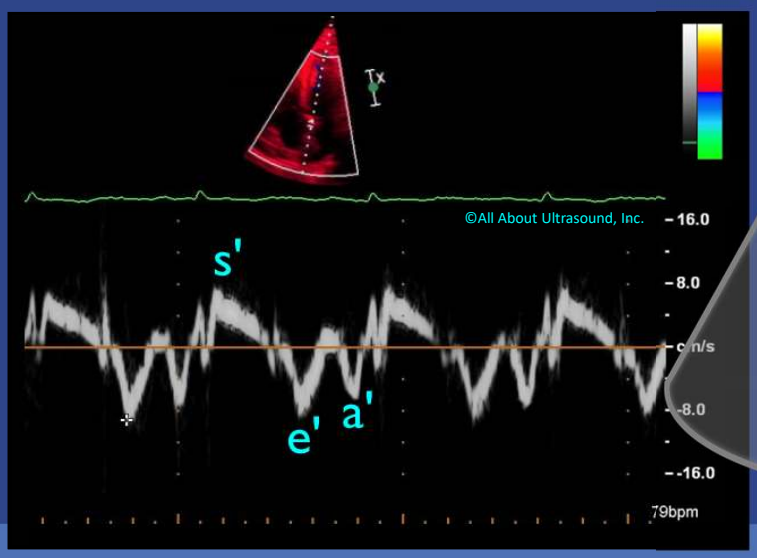
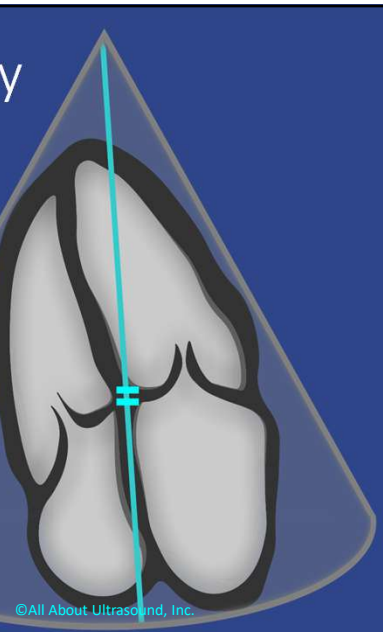


20

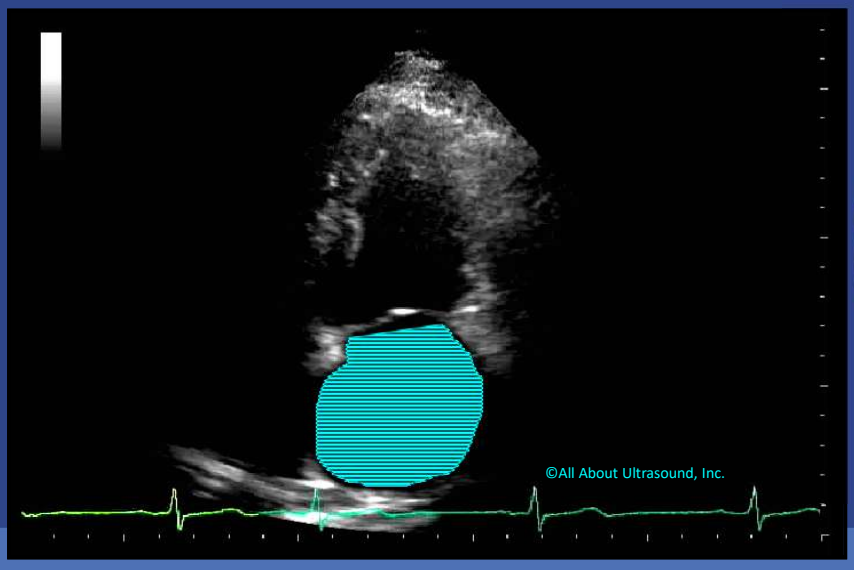
Sonographic Evaluation of Diastology

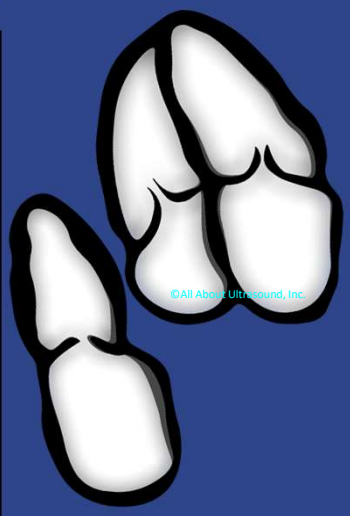




21

Sonographic Evaluation of Diastology





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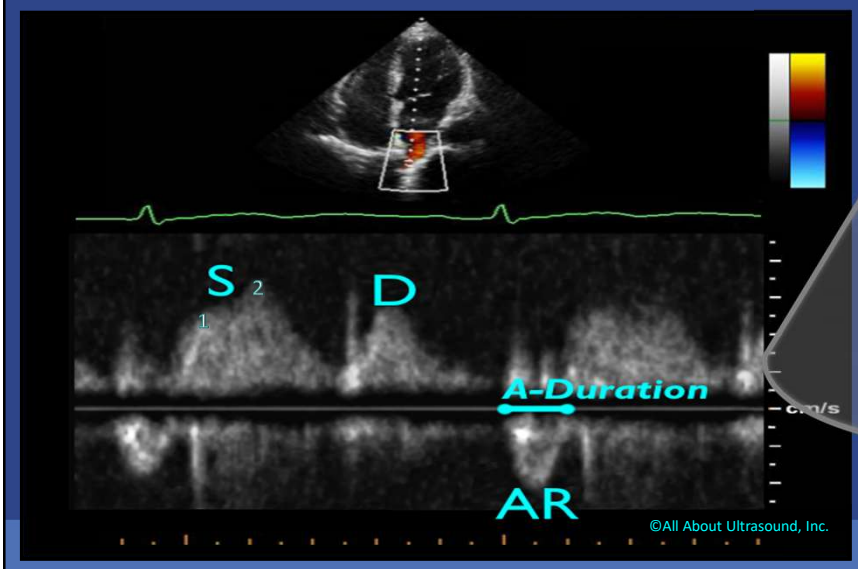
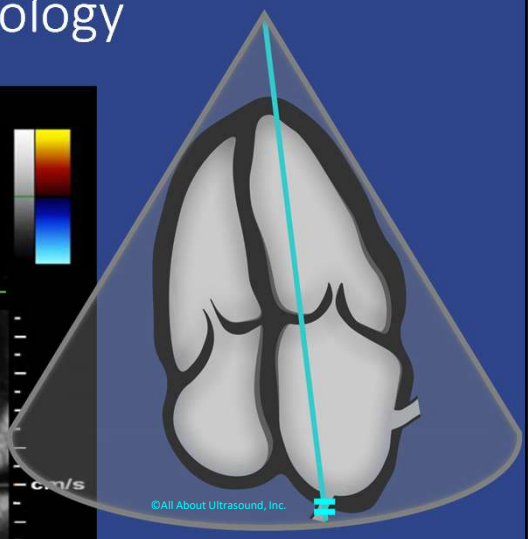
Sonographic Evaluation of Diastology

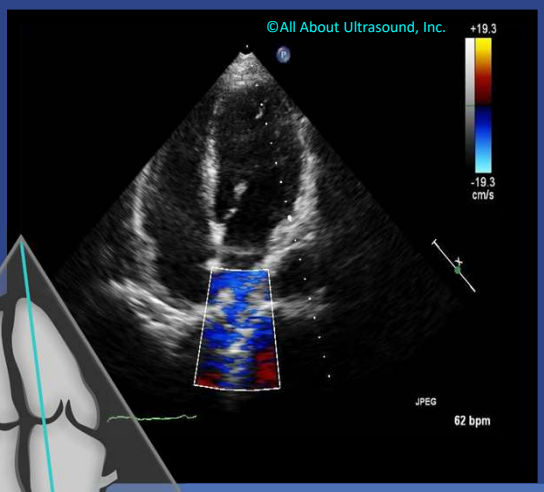


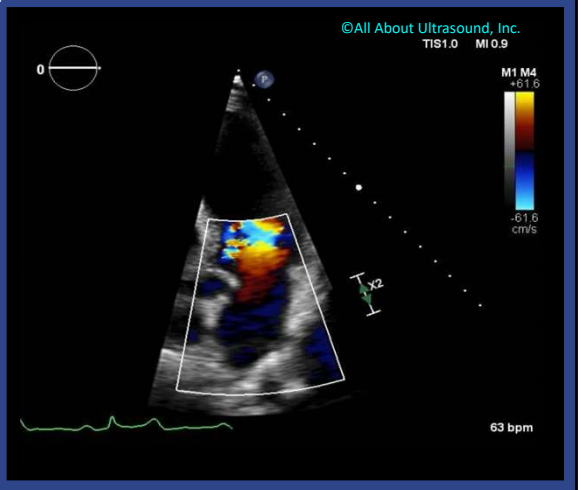


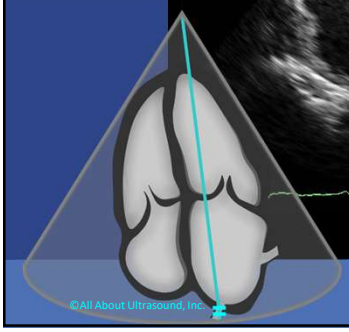
23

Sonographic Evaluation of Diastology

- Pulmonary Venous Doppler – Color Guided

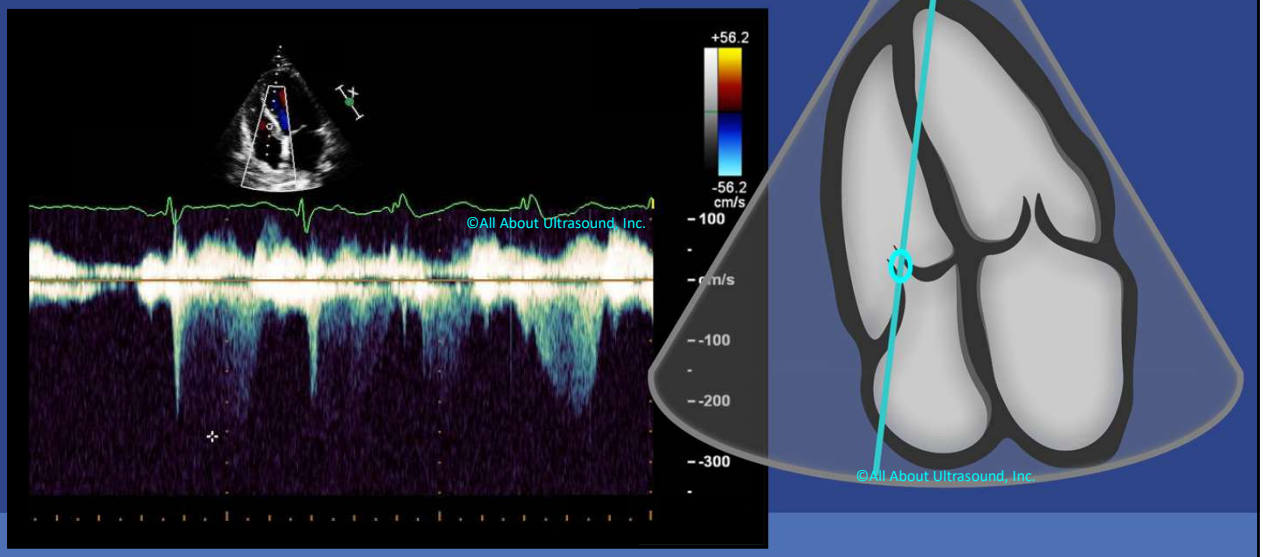






24

Sonographic Evaluation of Diastology



25

Additional Echo Parameters & Considerations of Diastology

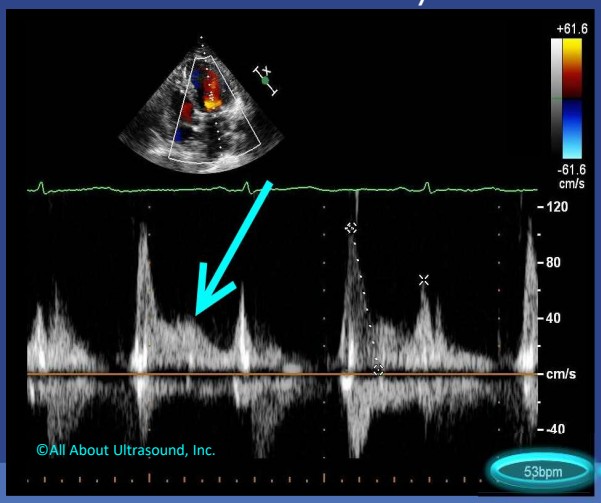
- Mitral Inflow L Wave
- Mitral Inflow E/A Fusion
- Changes to E velocity during valsalva
- Color M-Mode Flow Propagation
- Pulmonary Regurgitation End Diastolic Velocity
- Left Ventricular Strain (GLS)
- Left Atrial Reservoir Strain

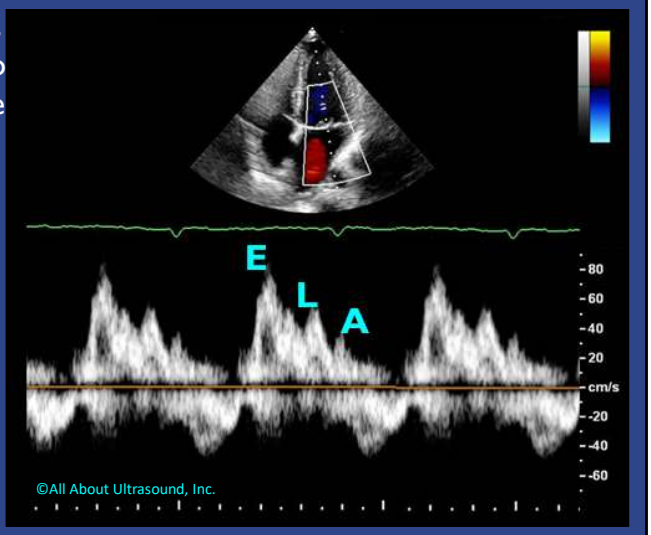
26

Additional Echo Considerations • Presence of L Wave

Sinus Bradycardia

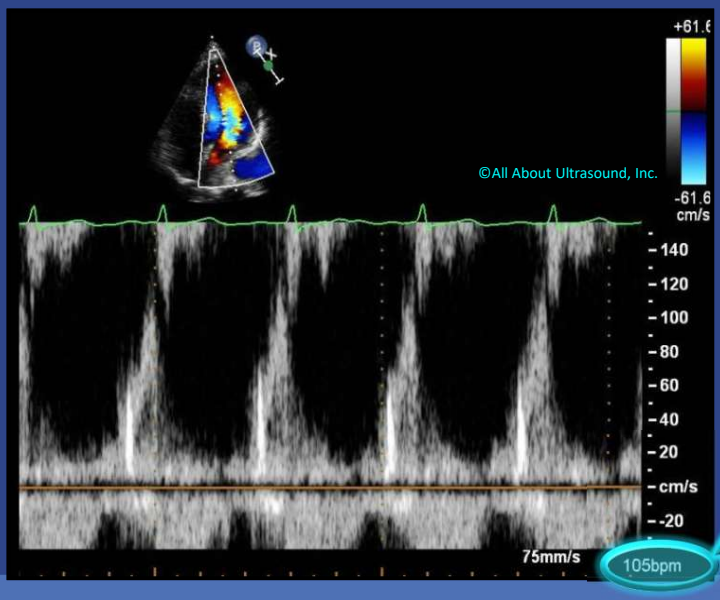
- Increases E/A ratio
- May induce L-wave





27

Additional Echo Considerations • E/A Fusion

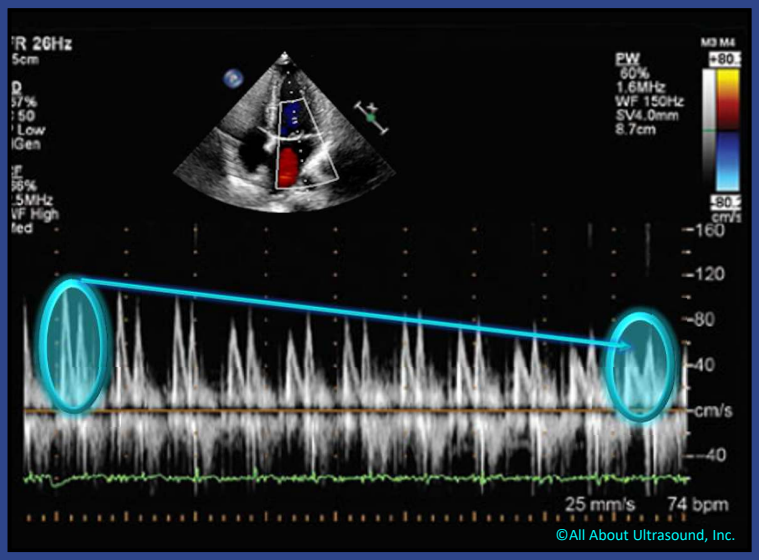


Sinus Tachycardia

- Fusion of E and A waves
- Reduces E/A ratio
- E/E' most useful

28

Additional Considerations • E Velocity Valsalva Changes



Decreased E Wave

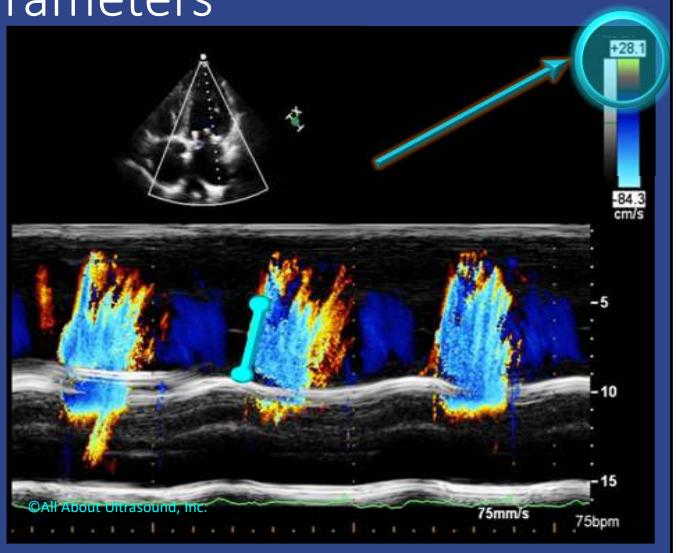
- E-wave reduction
- Reduces E/A ratio
- Reveals impaired relaxation

29

Additional Assessment Parameters

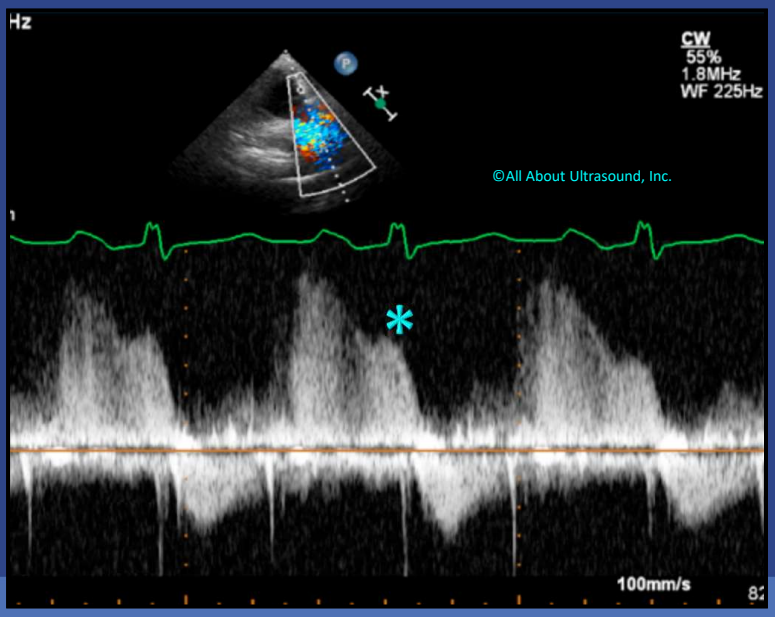
Color M-Mode Flow Propagation

- Early diastolic inflow
- Blood reaches the apical region before early flow at the level of the mitral valve has stopped.
- In the presence of diastolic dysfunction the slope will decrease and flow might not even reach the apical regions.



30

Additional Echo Considerations • PR End Diastolic Velocity



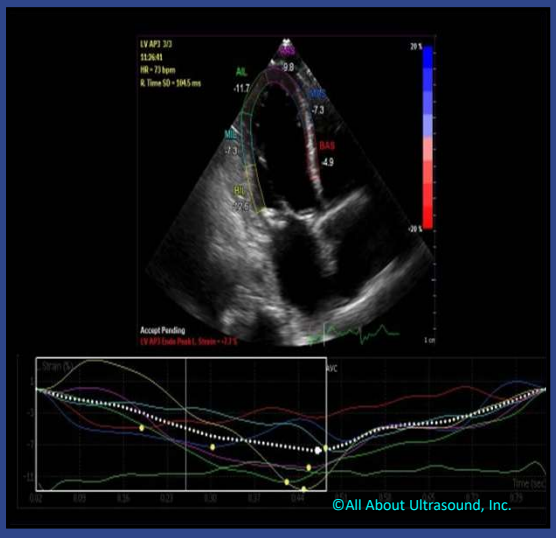
Indicates PADP

- <1.5m/s – Normal PADP
- ≥1.5m/s – Elevated PADP
- Elevated PADP indicates elevated LV Filling Pressures

31

Additional Assessment Parameters

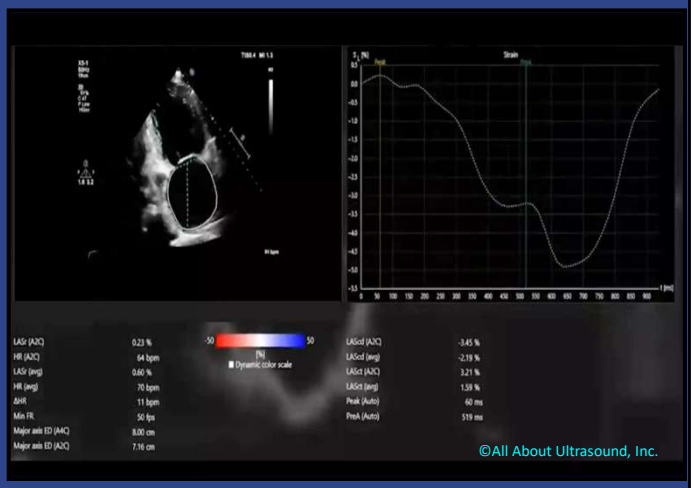
- LV global longitudinal diastolic strain measurements during the isovolumic relaxation period and during early diastole.
- The timing of peak untwisting rate can be of value in diagnosing patients with diastolic dysfunction and normal LV volumes and EF.



32

Advanced Assessment Parameters

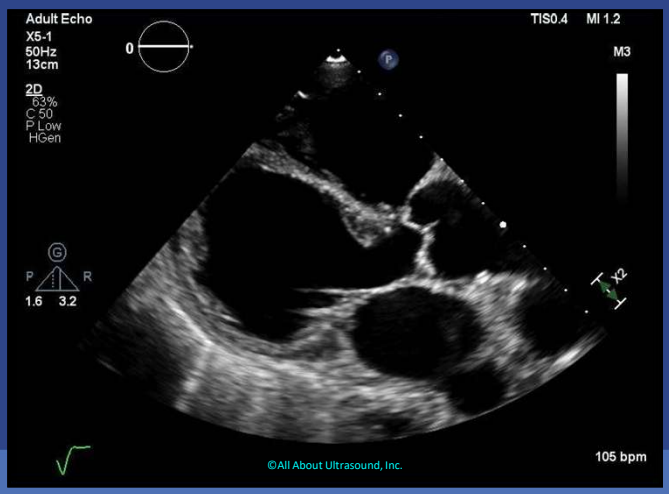
- LA reservoir strain(LARS)
- Normal values are typically >35% (vendor dependent)
- An inverse correlation is present between LARS and mean wedge pressure.



33

Grading of Diastolic Function

- Diastolic Dysfunction - Normal LVEF
- Diastolic Dysfunction/Left Atrial Pressure Grading



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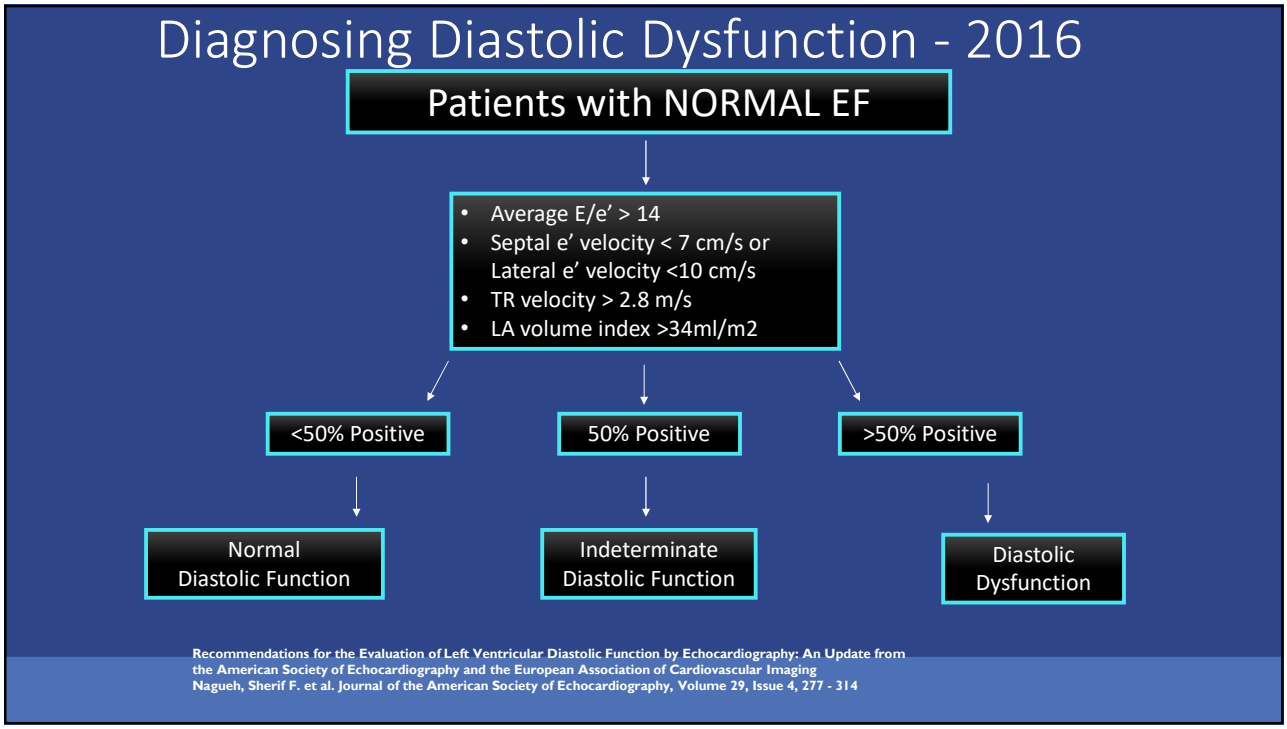

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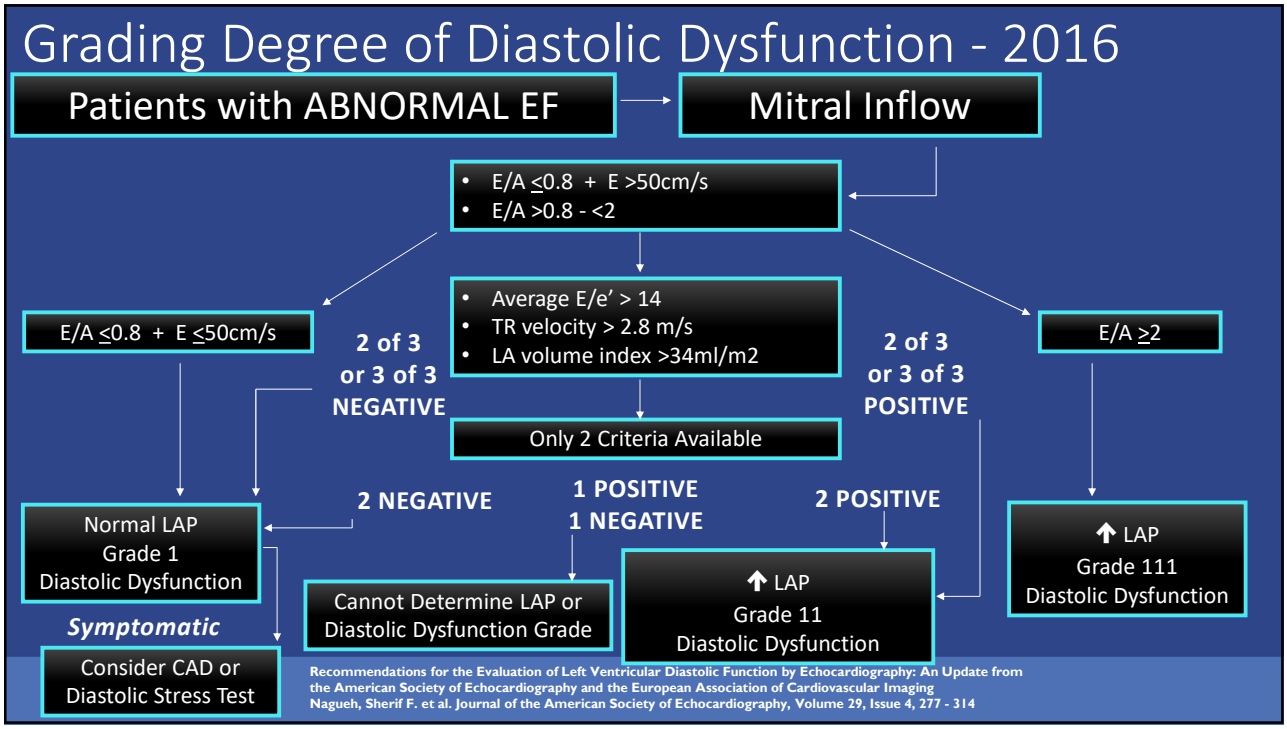


36

Grading of Diastolic Dysfunction - 2016

Table 4 LV relaxation, filling pressures and 2D and Doppler findings according to LV diastolic function

	Normal	Grade I	Grade II	Grade III
LV relaxation	Normal	Impaired	Impaired	Impaired
LAP	Normal	Low or normal	Elevated	Elevated
Mitral E/A ratio	≥0.8	≤0.8	>0.8 to <2	>2
Average E/e′ ratio	<10	<10	10–14	>14
Peak TR velocity (m/sec)	<2.8	<2.8	>2.8	>2.8
LA volume index	Normal	Normal or increased	Increased	Increased

Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging
Nagueh, Sherif F. et al. Journal of the American Society of Echocardiography, Volume 29, Issue 4, 277 - 314

37

Diagnosing Diastolic Dysfunction - 2025

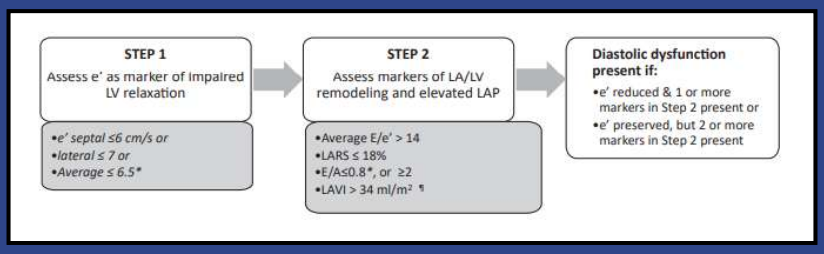
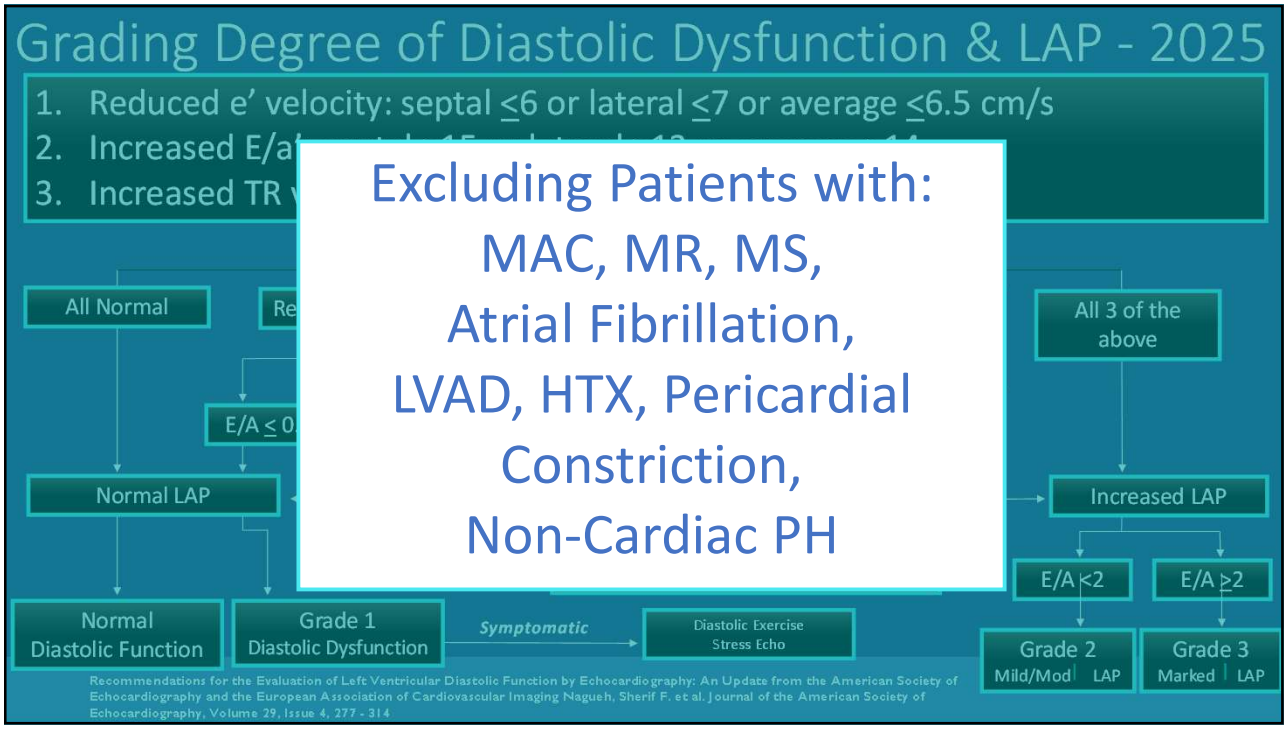


Table 6 Mitral annular e′ velocity values for diagnosis of impaired LV relaxation

	20-39 y	40-65 y	>65 y
1. Septal e′, cm/s	<7	<6	<6
2. Lateral e′, cm/s	<10	<8	<7
3. Average e′, cm/s	<9	<7	<6.5

Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography and for Heart Failure With Preserved Ejection Fraction Diagnosis: An Update From the American Society of Echocardiography
Nagueh, Sherif F. et al. Journal of the American Society of Echocardiography, Volume 38, Issue 7, 537 - 569.

38

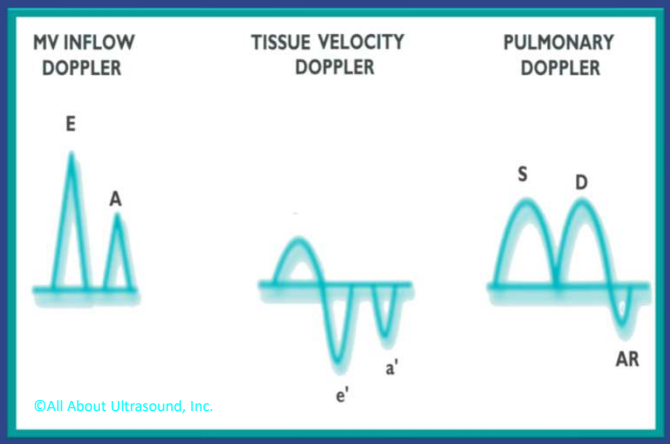


39

Grading of Diastolic Function

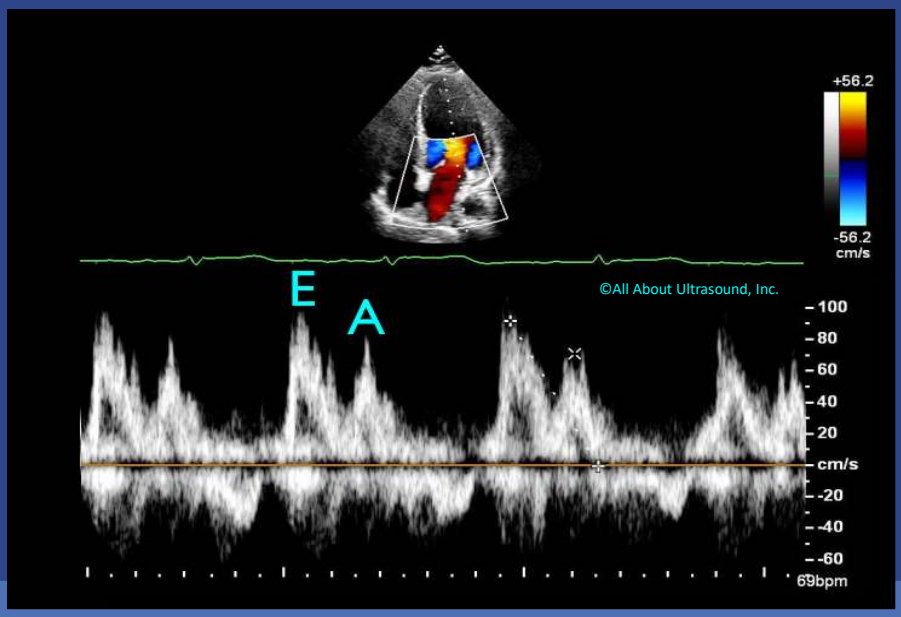
Normal – with NORMAL Ejection Fraction

- No evidence of Diastolic Dysfunction
- Normal E/A ratio between 1-2
- Normal Deceleration Time (160-240ms)



40

Normal Diastolic Function



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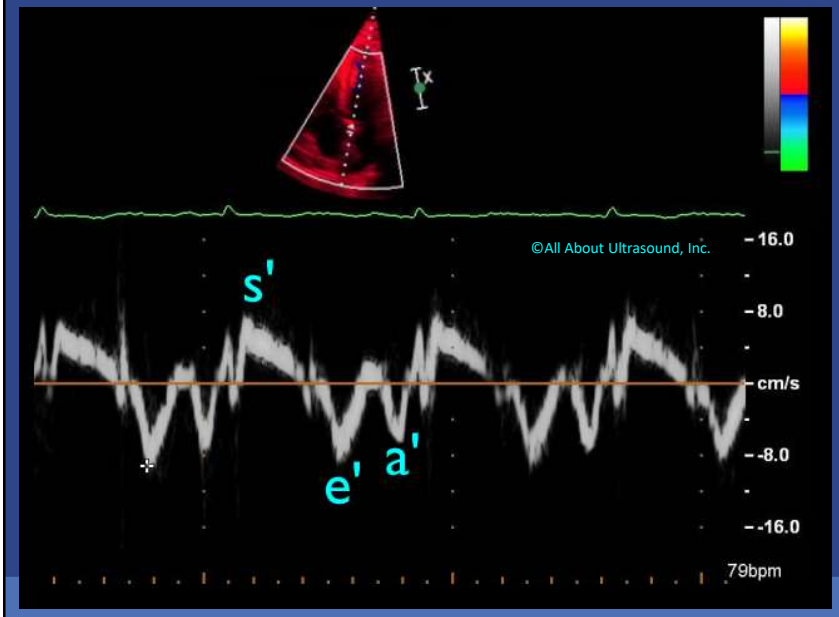
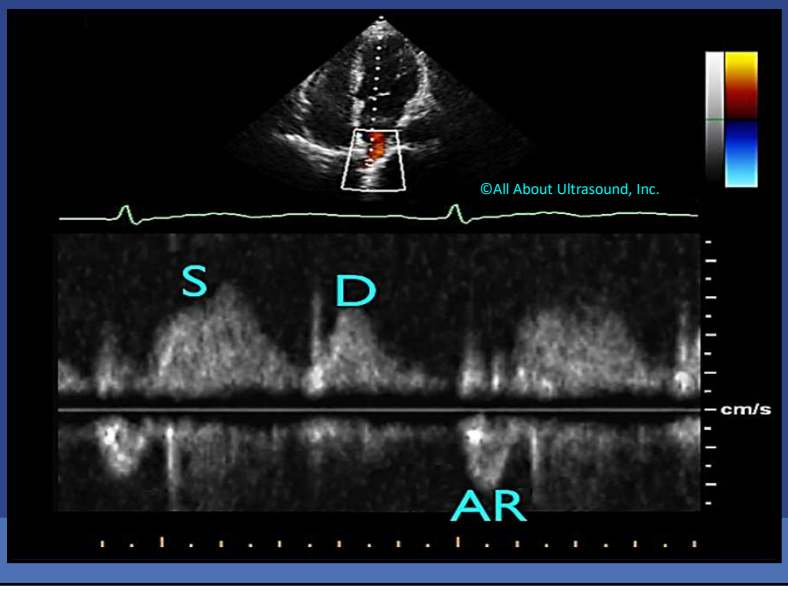
Normal Diastolic Function



42

Normal Diastolic Function

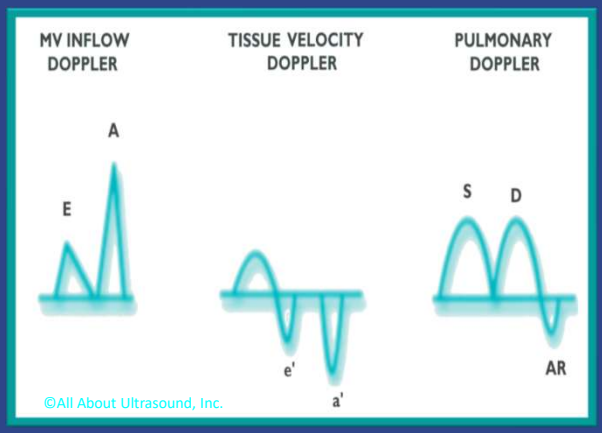


43

Grading of Diastolic Function

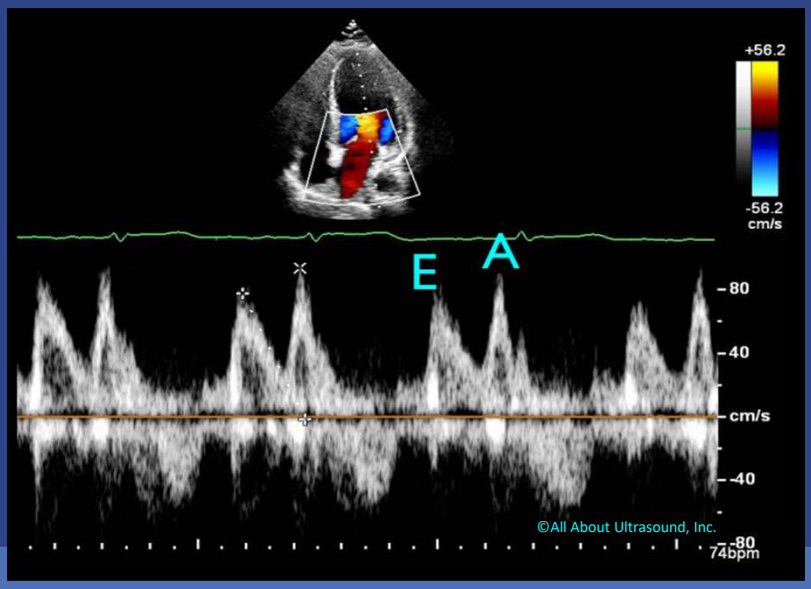
Grade 1 – Normal Filling Pressures

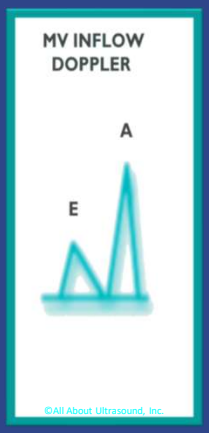
- The E/A ratio is < 1
- Reduced e' velocity
- Prolonged Deceleration Time (>240ms)
- D < S wave
- AR wave is normal



44

Grade 1 Diastolic Dysfunction





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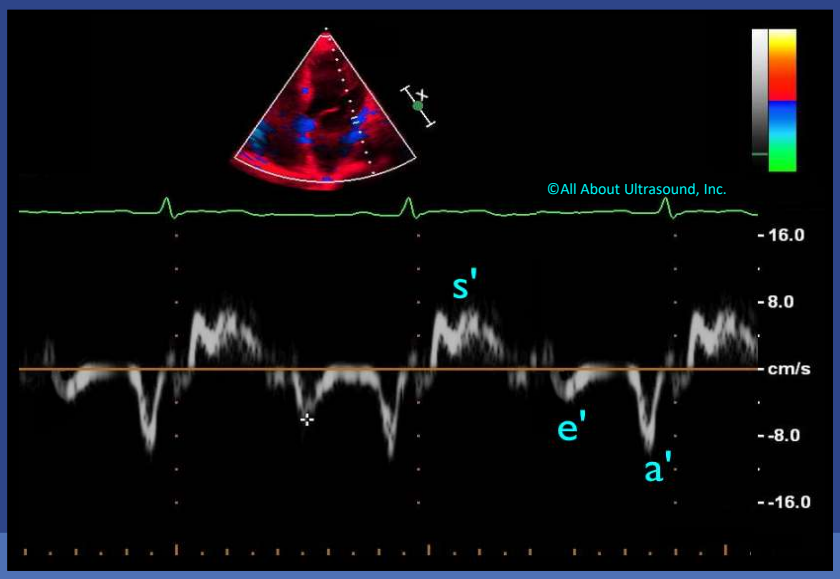
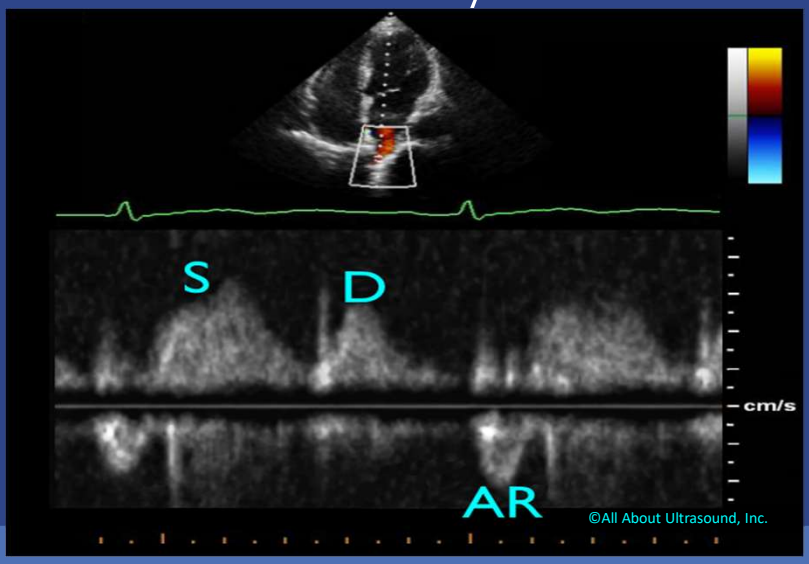
Grade 1 Diastolic Dysfunction



46

Grade 1 Diastolic Dysfunction

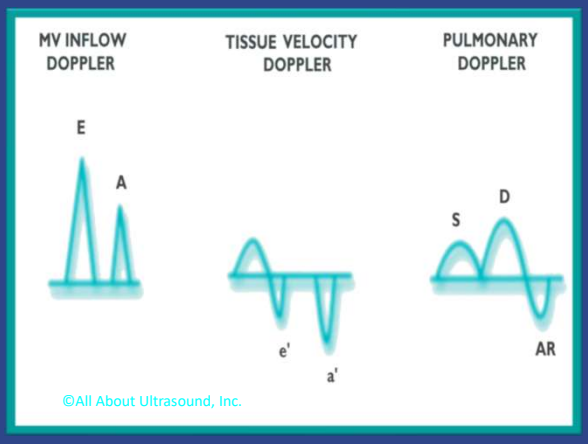


47

Grading of Diastolic Function

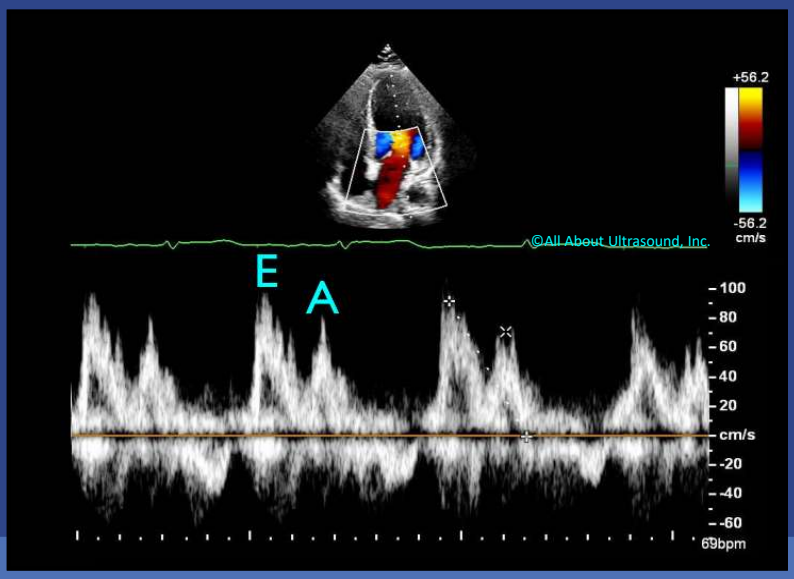
Grade 2 – Elevated Filling Pressures

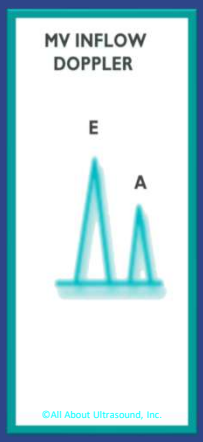
- The E/A ratio is psuedonormal
  - Valsalva will alter inflow
- Reduced e' velocity
- Prolonged Deceleration Time (>240ms)
- Increased D velocities
- AR wave is (>35cm/s)



48

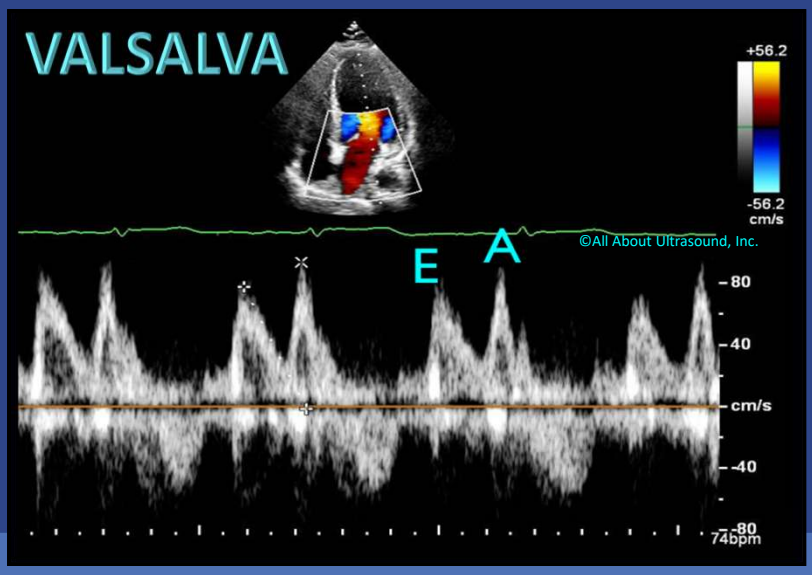
Grade 2 Diastolic Dysfunction

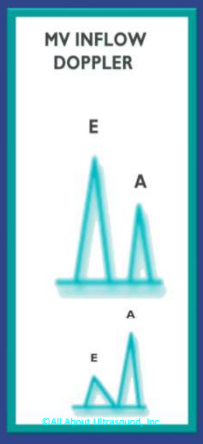




49

Grade 2 Diastolic Dysfunction





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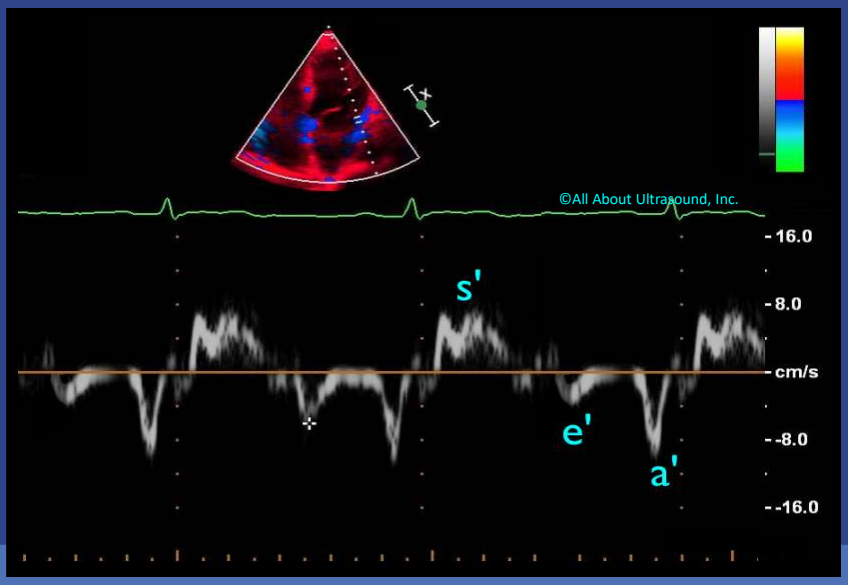
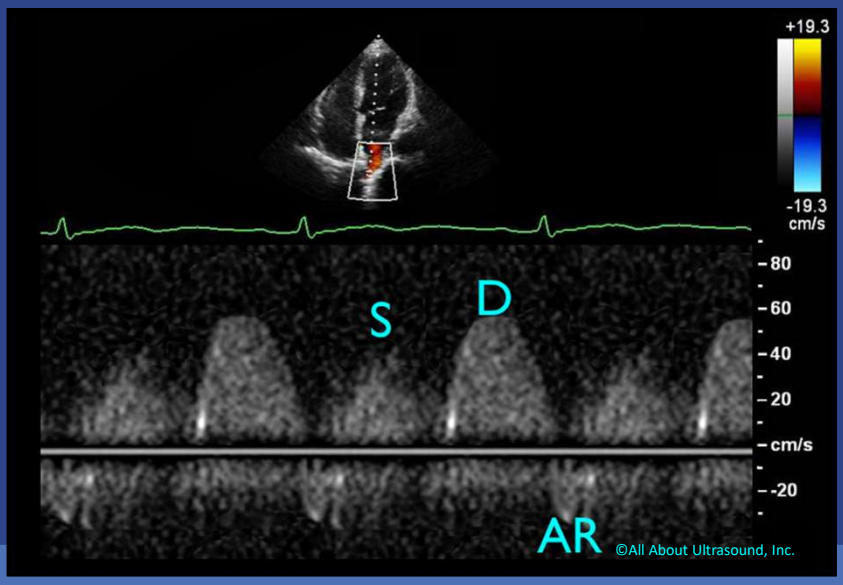
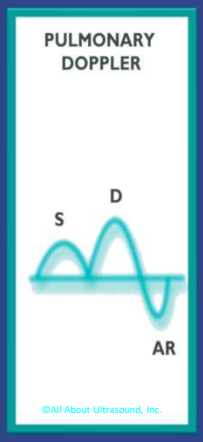
Grade 2 Diastolic Dysfunction



51

Grade 2 Diastolic Dysfunction



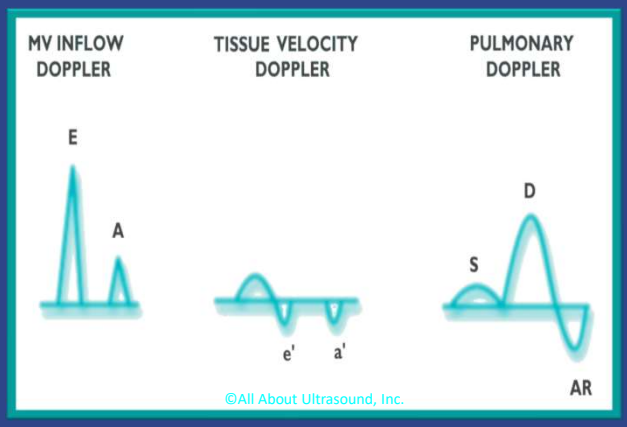


52

Grading of Diastolic Function

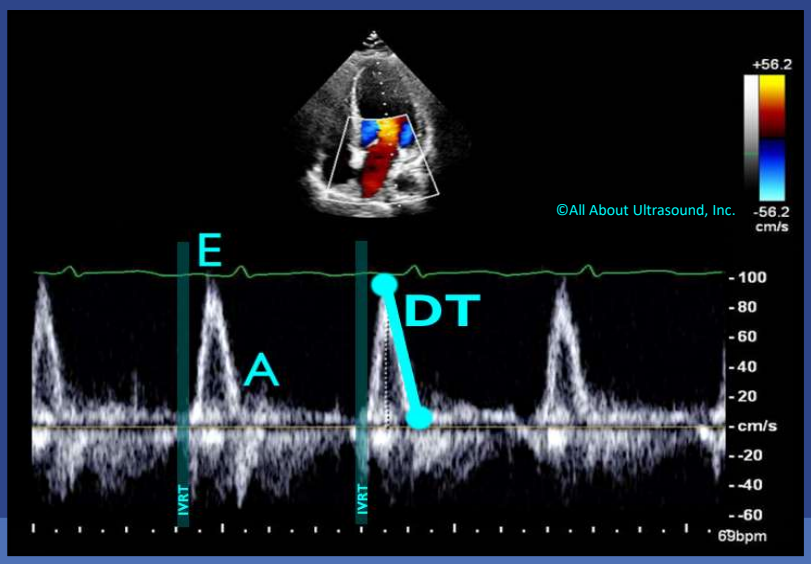
Grade 3 – Elevated Filling Pressures

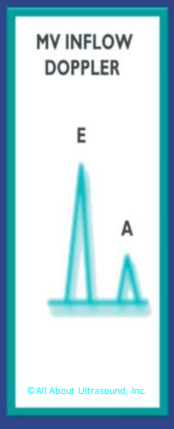
- The E/A ratio is restrictive (>2)
- Reduced e' and a' velocities
- Decreased S wave and increased D velocities
- Presence of LA Enlargement
-



53

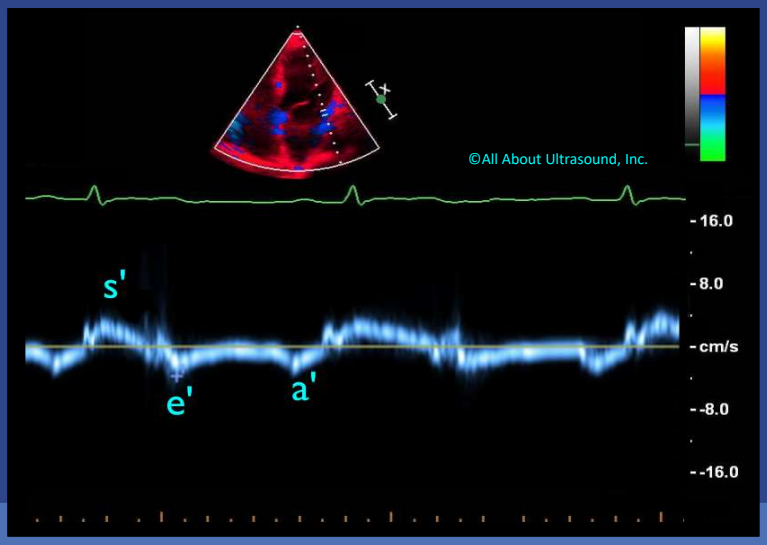
Grade 3 Diastolic Dysfunction





54

Grade 3 Diastolic Dysfunction



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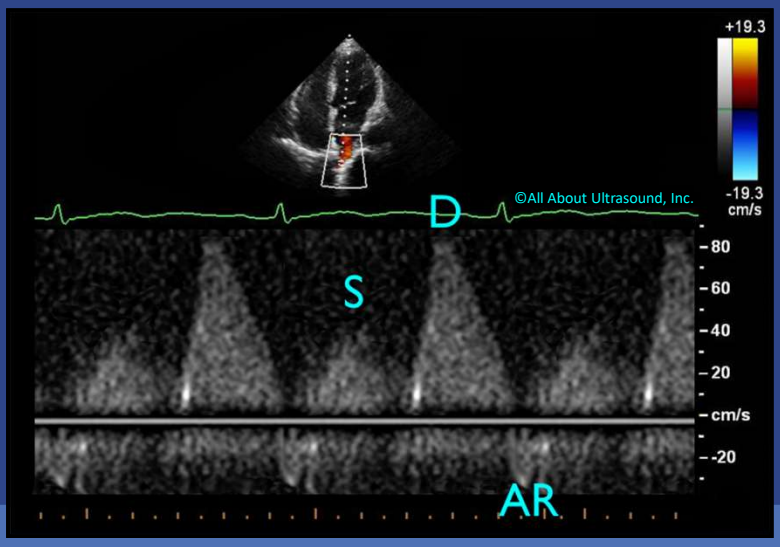
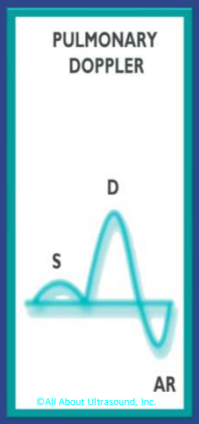
Grade 3 Diastolic Dysfunction



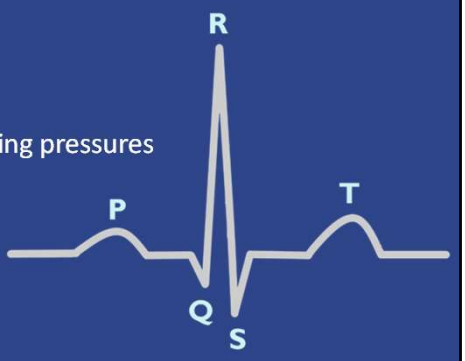


56

Additional Considerations

Atrial Fibrillation

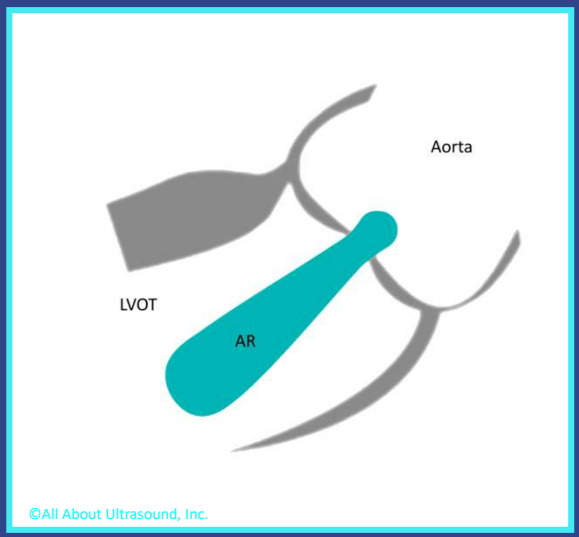
- Absence of mitral A wave and beat to beat variability
- Measure average of several beats for accuracy*
- Dual Doppler Transducer
- Mitral Inflow Decel Time
  - ➢A short deceleration time (<130ms) indicates elevated filling pressures
- Atrial contraction is absent
  - ➢Measurements independent of atrial influence are used:
    - Decel Time
    - IRP
    - E/e' ratio
    - S wave



57

Additional Considerations

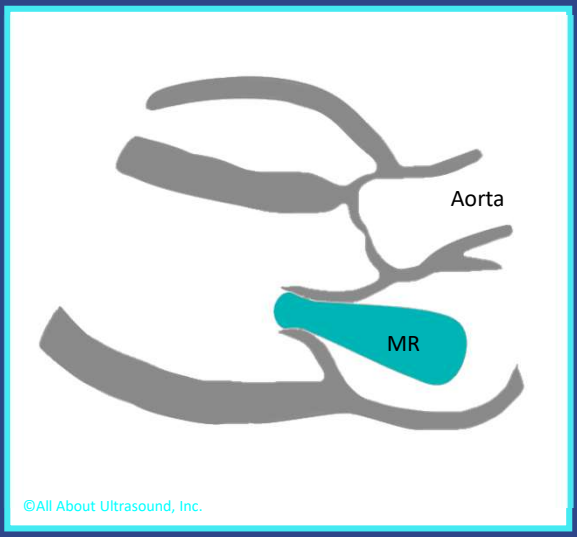
- Paced Rhythms
  - Dissociated E and A waves
  - Asynchronous
  - Prolonged LV relaxation, ↓ E velocity
- Aortic Regurgitation
  - Increased LAP
  - E velocity, ↓A velocity , ↓Decel Time



58

Additional Considerations

- Mitral Stenosis
  - Normal or low LVEDP, LA pressure (LAP)
  - Mitral inflow represents the valve disease, not DD
  - Short IVRT and E velocity = early LAP
- Mitral Regurgitation
  - Increased LA & LV compliance
  - Severe E velocity >1.5 m/sec
  - PV systolic blunting



59

Additional Considerations

- Decreased Preload
  - ↓ LAP and Transmitral Gradient
  - ↓ E velocity, variable A velocity, ↓E/A ratio
  - ↓ PV D velocity and AR velocity
- Increased Afterload
  - Reduced active relaxation
  - ↓ E velocity, ↑ A velocity and DT

60

Thank you!