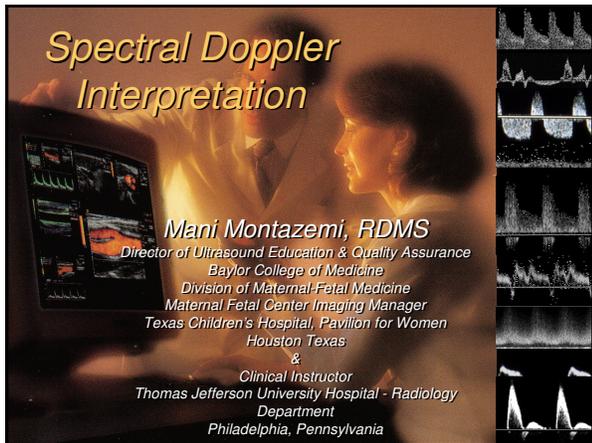
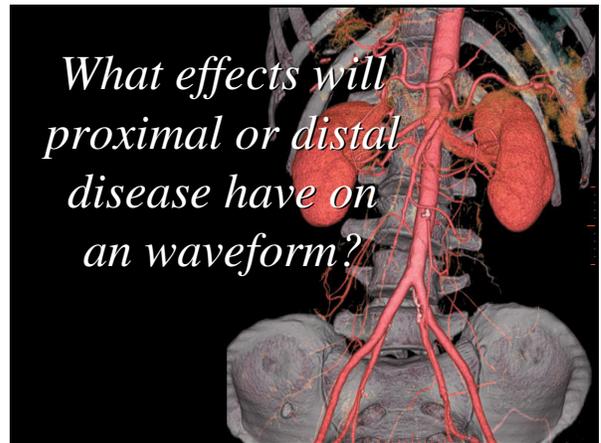


Spectral Doppler Interpretation



Mani Montazemi, RDMS
 Director of Ultrasound Education & Quality Assurance
 Baylor College of Medicine
 Division of Maternal-Fetal Medicine
 Maternal Fetal Center Imaging Manager
 Texas Children's Hospital, Pavilion for Women
 Houston Texas
 &
 Clinical Instructor
 Thomas Jefferson University Hospital - Radiology
 Department
 Philadelphia, Pennsylvania

What effects will proximal or distal disease have on an waveform?



Doppler Interpretation

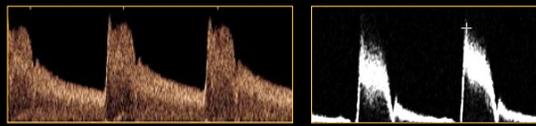
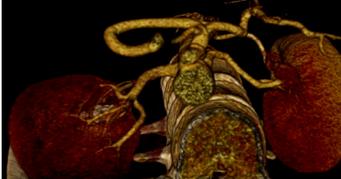
“Distal disease”
Changes the resistance

“Proximal disease”
Changes the strength of the signal

Mani Montazemi, RDMS
 Doppler Interpretation

Distal Disease

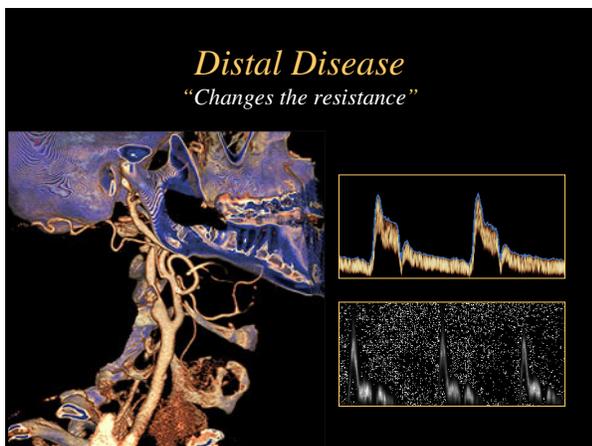
“Changes the resistance”

- Acute & chronic parenchymal disease
- Obstruction
- Renal vein thrombosis

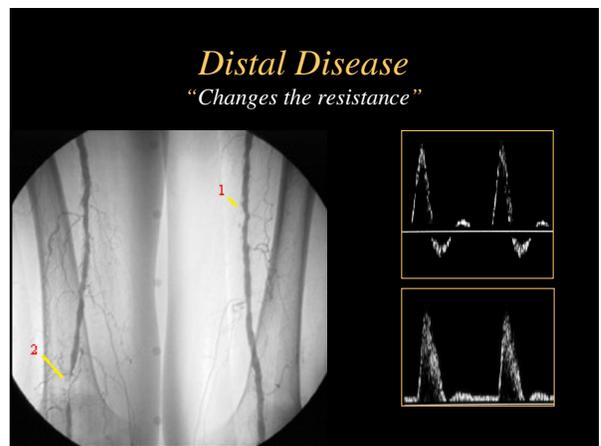
Distal Disease

“Changes the resistance”



Distal Disease

“Changes the resistance”



Distal Disease

"Changes the resistance"

Mani Montazemi, RDMS
Doppler Interpretation

Proximal Disease

Changes the strength of the signal

Mani Montazemi, RDMS
Doppler Interpretation

Caution! Increase Sweep Speed

Mani Montazemi, RDMS
Doppler Interpretation

Tardus – Parvus Waveform

Tardus

- Slow & late

Parvus

- Small & little

Mani Montazemi, RDMS
Doppler Interpretation

Tardus – Parvus Waveform

- Systolic acceleration diminished
- Acceleration time prolonged
- Waveform shape
- Diminished pulsatility

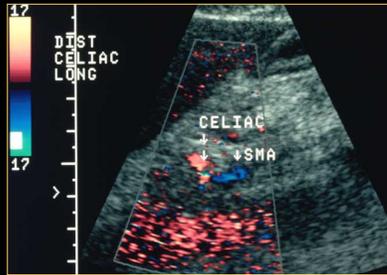
Mani Montazemi, RDMS
Doppler Interpretation

Proximal Disease

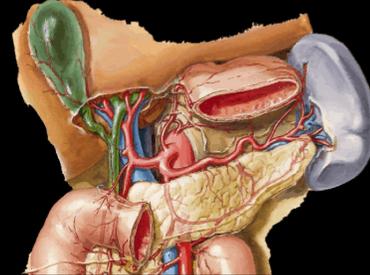
Changes the strength of the signal

Mani Montazemi, RDMS
Doppler Interpretation

Diagnostic Challenge



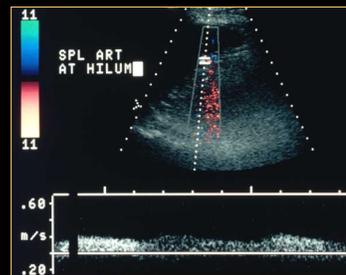
Mani Montazemi, RDMS
Doppler Interpretation



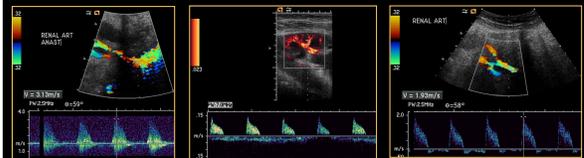
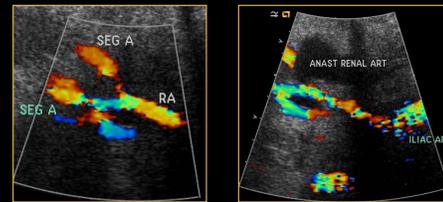
Mani Montazemi, RDMS
Doppler Interpretation

Celiac Artery Stenosis

Decreased or dampened waveform distal to stenosis



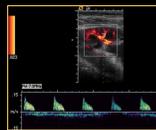
Mani Montazemi, RDMS
Doppler Interpretation



Mani Montazemi, RDMS
Doppler Interpretation

Remember!

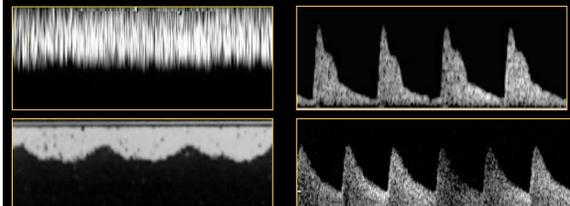
- It is more difficult to demonstrate tardus parvus in a stiff vessel
- Atherosclerotic arteries & increased distal resistance masks the post-stenotic tardus parvus



Mani Montazemi, RDMS
Doppler Interpretation

Doppler Analysis

- Qualitative
 - The visual or acoustic evaluation of Doppler wave form



Mani Montazemi, RDMS
Doppler Interpretation

Doppler Analysis

- **Qualitative**
 - The visual or acoustic evaluation of Doppler wave form
- **Quantitative** *Indirect method to evaluate blood perfusion*
 - Calculation of volume flow
 - Calculation of indices

Mani Montazemi, RDMS
Doppler Interpretation

Doppler Waveform

- Waveform is commonly described by pulsatility which can be measured
 - Peak Systolic velocity – PSV
 - Resistance Index – RI
 - Pulsatility Index – PI
 - Systolic/Diastolic Ratio – S/D
 - Acceleration Index – AI
 - Acceleration Time – AT

Mani Montazemi, RDMS
Doppler Interpretation

How to Look at a Waveform?

- Where & how was signal obtained?
- Presence of flow
- Direction of flow
- Characterization of signal
- Quality of exam

Mani Montazemi, RDMS
Doppler Interpretation

How to Look at a Waveform?

- Where & how was signal obtained?
 - 1 – Where is the sample volume
 - 2 – What is the sample volume size
 - 3 – What is the Doppler angle
 - 4 – Technical considerations

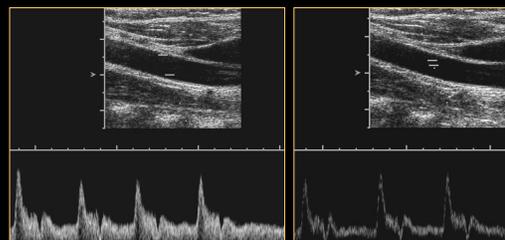
Mani Montazemi, RDMS
Doppler Interpretation

Where is the sample volume?



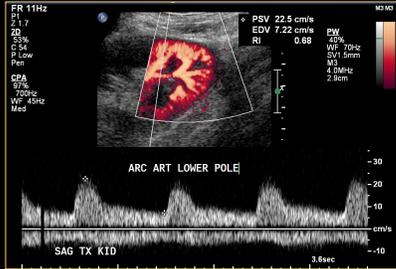
Mani Montazemi, RDMS
Doppler Interpretation

What is the Sample Volume Size?



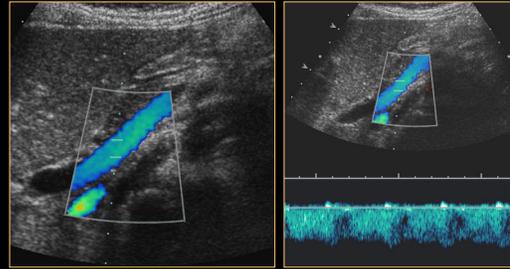
Mani Montazemi, RDMS
Doppler Interpretation

What is the Sample Volume Size?



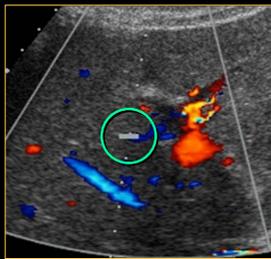
Mani Montazemi, RDMS
Doppler Interpretation

What is the Sample Volume Size?



Mani Montazemi, RDMS
Doppler Interpretation

What is the Sample Volume Size?



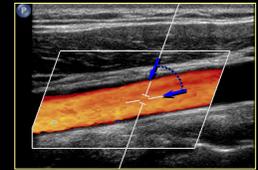
Too small a gate may give the false impression of reduced or even absent flow

Mani Montazemi, RDMS
Doppler Interpretation

What is the Doppler Angle?

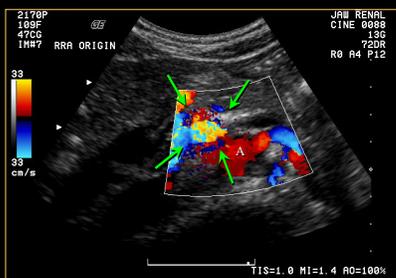
- Angle is the result of
 - Doppler line direction
 - Cursor correction
- Angle **affects** velocity accuracy

$$V = \frac{2 \cdot F_t \cdot \cos \theta \cdot F_d}{C}$$



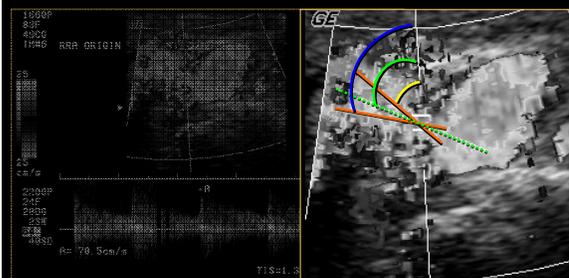
Mani Montazemi, RDMS
Doppler Interpretation

What is the Doppler Angle?



Mani Montazemi, RDMS
Doppler Interpretation

What is the Doppler Angle?



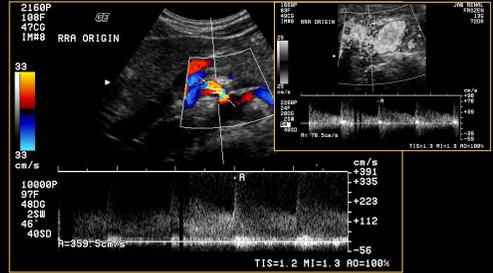
Mani Montazemi, RDMS
Doppler Interpretation

What is the Doppler Angle?



Mani Montazemi, RDMS
Doppler Interpretation

What is the Doppler Angle?



Mani Montazemi, RDMS
Doppler Interpretation

What is the Doppler Angle?

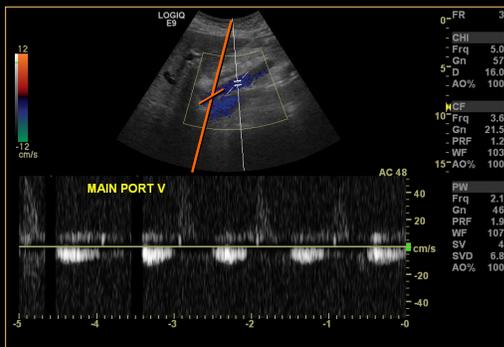


Mani Montazemi, RDMS
Doppler Interpretation

What is the Doppler Angle?

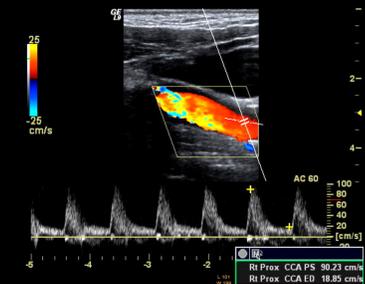


Mani Montazemi, RDMS
Doppler Interpretation

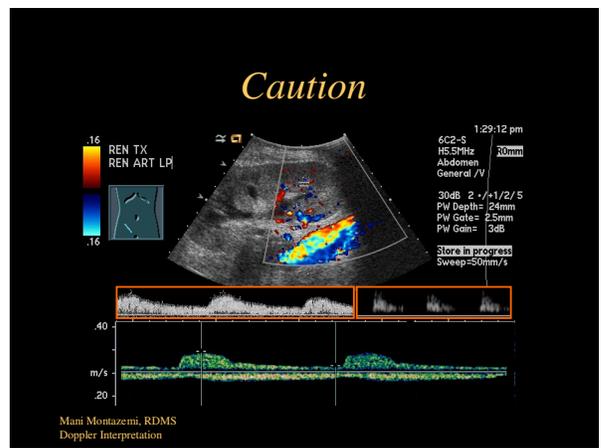
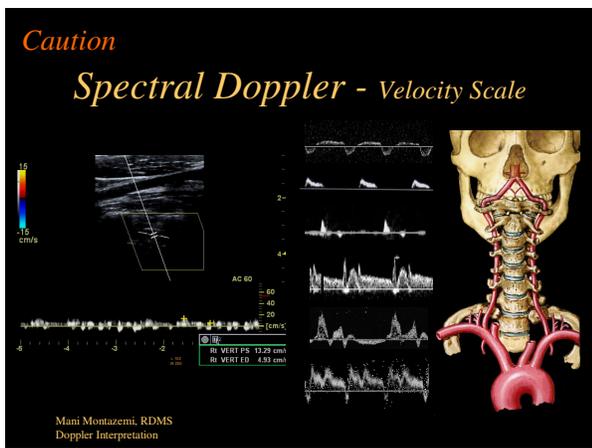
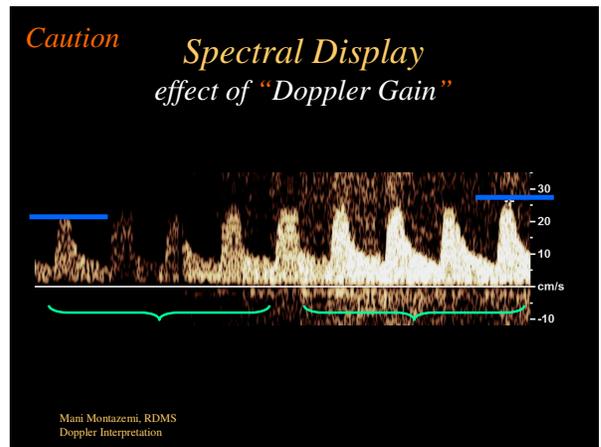
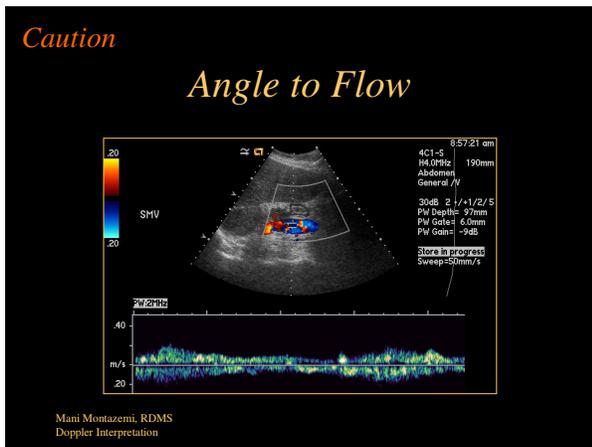
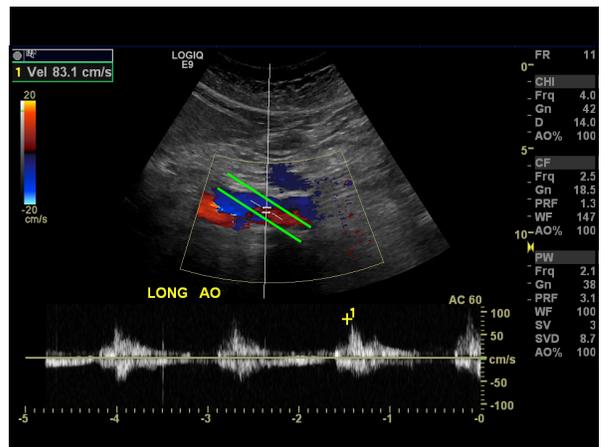
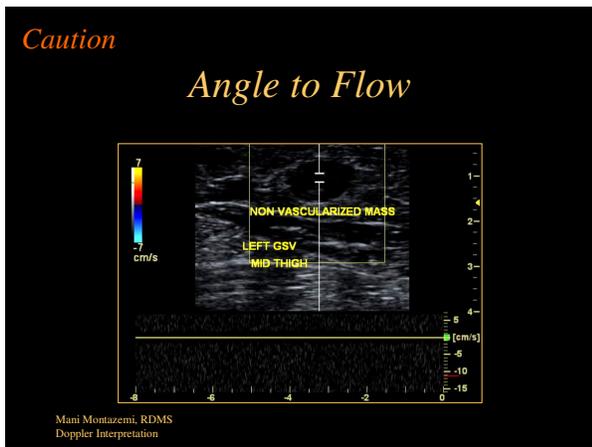


Mani Montazemi, RDMS
Doppler Interpretation

Caution Be Careful with Doppler Angle

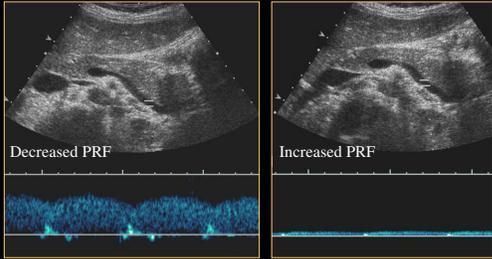


Mani Montazemi, RDMS
Doppler Interpretation



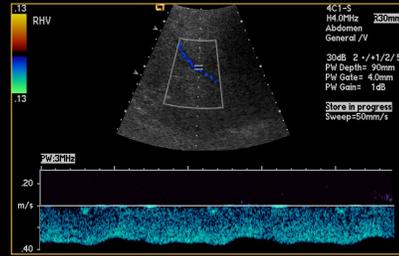
Caution

Spectral Doppler - Velocity Scale

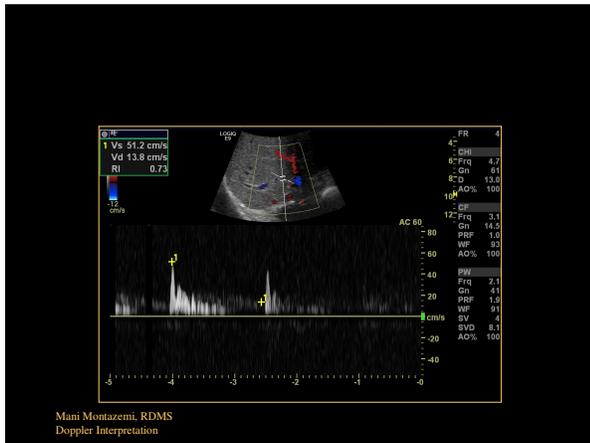


Mani Montazemi, RDMS
Doppler Interpretation

Spectral Doppler - Velocity Scale



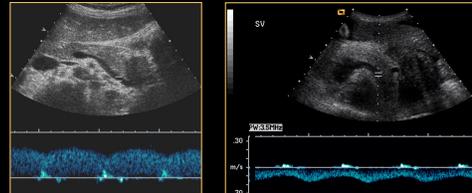
Mani Montazemi, RDMS
Doppler Interpretation



Mani Montazemi, RDMS
Doppler Interpretation

How to Look at a Waveform?

- Where & how was signal obtained?
- Flow direction



Mani Montazemi, RDMS
Doppler Interpretation

Diagnostic Challenge



Mani Montazemi, RDMS
Doppler Interpretation

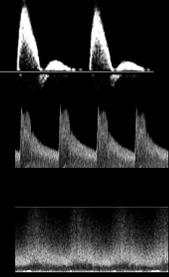
How to Look at a Waveform?

- Where & how was signal obtained?
- Flow direction
- Characterization of signal

Mani Montazemi, RDMS
Doppler Interpretation

Characterization of Signal "Spectral Analysis"

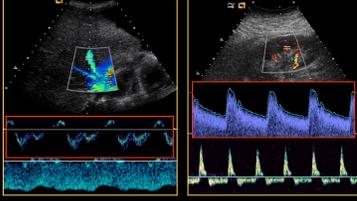
- Site of signal
 - What is normal & abnormal
- Shape (edge) of spectrum
 - Velocity of blood flow
 - Pulsatility
- Structure of spectrum
 - Distribution of blood velocities
 - Spectral broadening



Mani Montazemi, RDMS
Doppler Interpretation

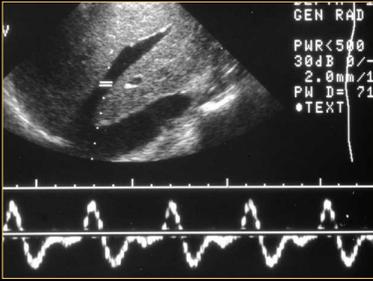
Characterization of Signal "Spectral Analysis"

- Site of signal
 - What is normal & abnormal



Mani Montazemi, RDMS
Doppler Interpretation

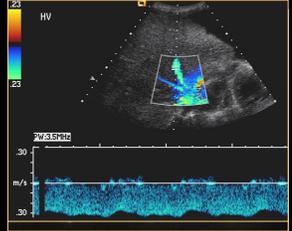
What does increased pulsatility in the hepatic veins suggest?



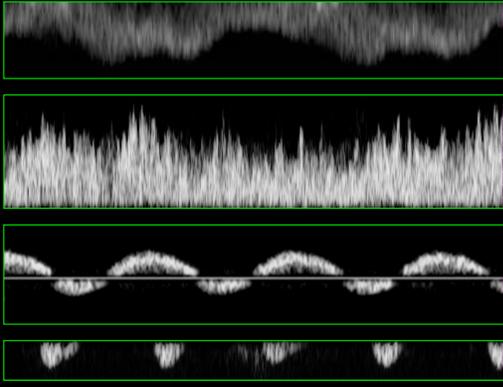
Mani Montazemi, RDMS
Doppler Interpretation

What does loss of pulsatility in the hepatic veins suggest?

1. Cirrhosis
2. Compression from mass
3. Partial thrombosis
4. Occlusion or narrowing of the IVC above the level of the hepatic veins



Mani Montazemi, RDMS
Doppler Interpretation



Mani Montazemi, RDMS
Doppler Interpretation

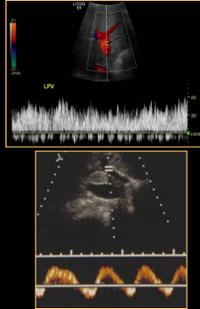
What does loss of pulsatility in the portal veins suggest?



Mani Montazemi, RDMS
Doppler Interpretation

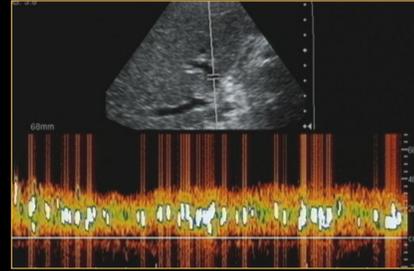
What does pulsatile portal vein suggest?

- Any communication between the systemic and portal veins, (portosystemic shunts, fistulae) may lead to a pulsatile portal vein
- Increased pulsatility of portal venous flow may also be seen with congestion of the liver, especially the passive congestion associated with right-sided cardiac failure and/or tricuspid regurgitation



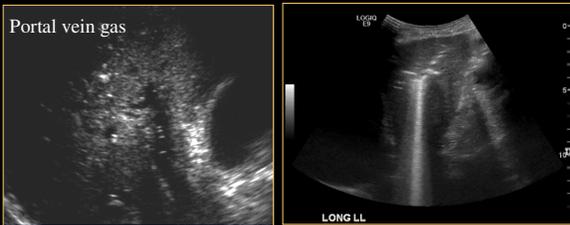
Mani Montazemi, RDMS
Doppler Interpretation

Portal Vein Gas



Mani Montazemi, RDMS
Doppler Interpretation

Portal vein gas



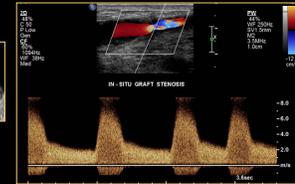
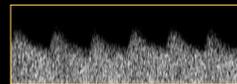
Ischemic, inflammatory, or infectious bowel diseases
Pediatric age group – Necrotizing enterocolitis

Mani Montazemi, RDMS
Doppler Interpretation

Characterization of Signal

Edge of spectral envelope

- Waveform shape & pulsatility
- Peak velocities

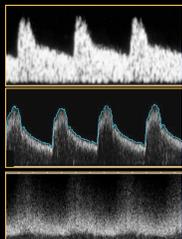


Mani Montazemi, RDMS
Doppler Interpretation

Characterization of Signal

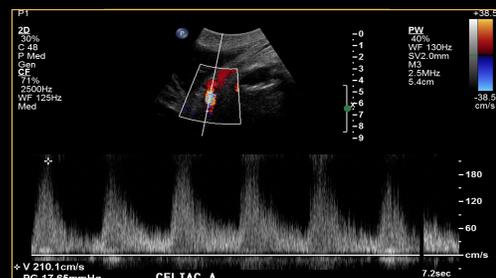
Distribution of blood velocities

- Gray scale distribution of all RBC



Mani Montazemi, RDMS
Doppler Interpretation

Celiac Artery

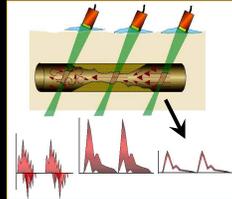


Mani Montazemi, RDMS
Doppler Interpretation

Important

Signs of Stenosis

- Proximal to stenosis
 - Change in pulsatility

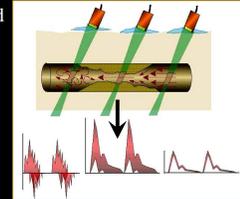


Mani Montazemi, RDMS
Doppler Interpretation

Important

Signs of Stenosis

- At the stenosis
 - Elevated velocities compared to pre-stenotic segment
 - Laminar flow

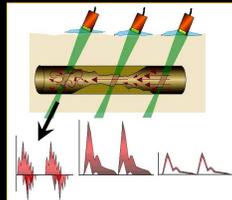


Mani Montazemi, RDMS
Doppler Interpretation

Important

Signs of Stenosis

- Beyond the stenosis
 - Post stenotic turbulence or disturb flow
 - Spectral broadening
 - Loss of well defined spectral edge

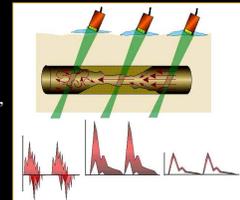


Mani Montazemi, RDMS
Doppler Interpretation

Important

Signs of Stenosis

- Distal to stenosis
 - Down stream Tardus-Parvus
 - Velocity should drop off distal to stenosis
 - Exceptions: long stenosis, near occlusive lesions



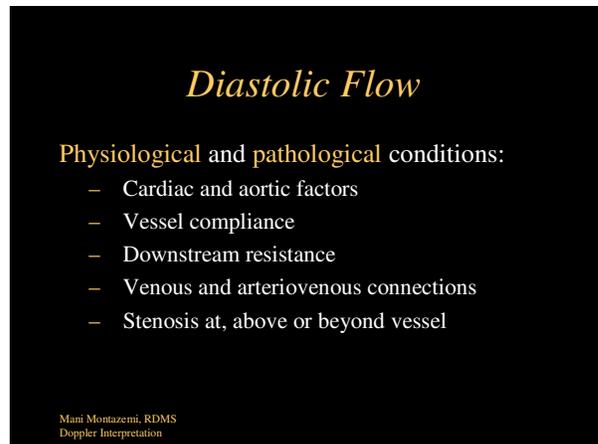
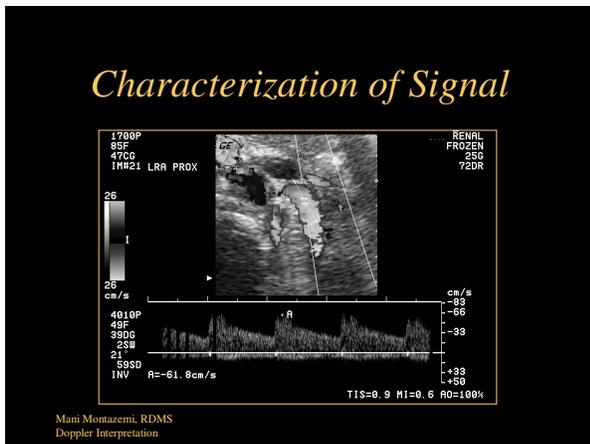
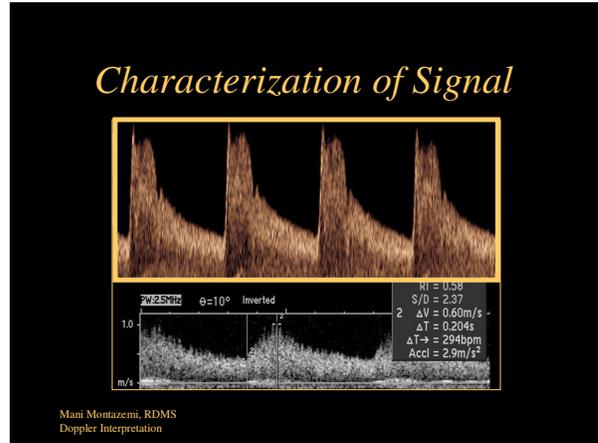
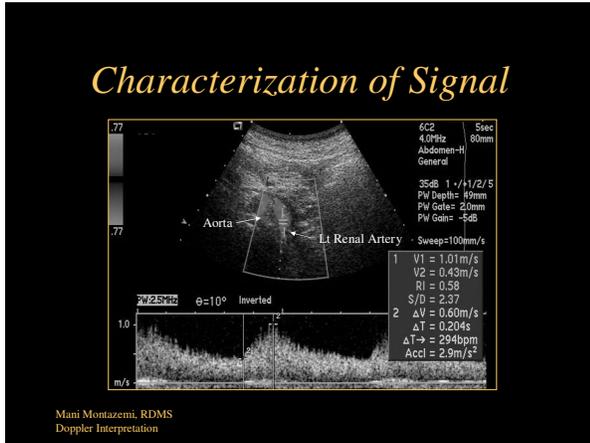
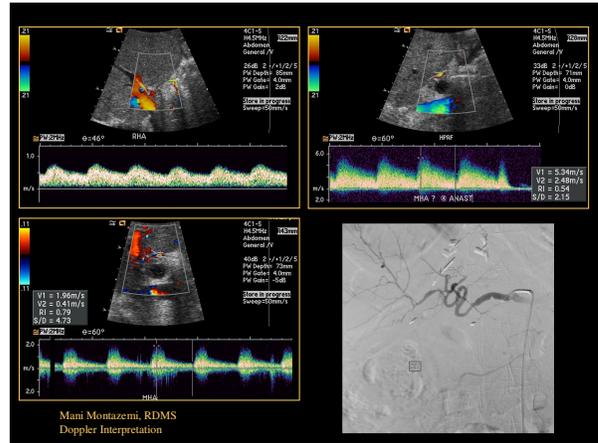
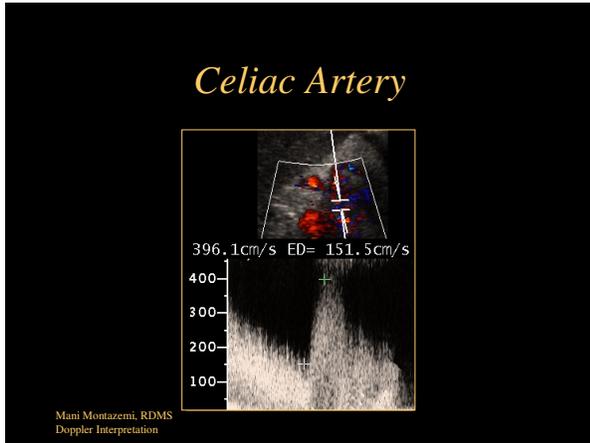
Mani Montazemi, RDMS
Doppler Interpretation

Distribution of Doppler frequencies seen in spectrum "filling of envelope"

Mani Montazemi, RDMS
Doppler Interpretation

Celiac Artery

Mani Montazemi, RDMS
Doppler Interpretation

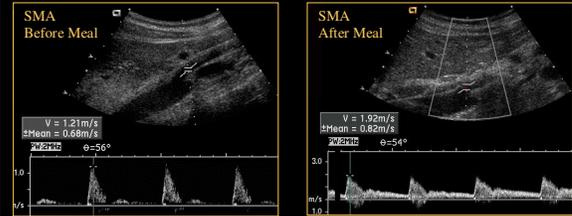


Increased Diastolic Flow

- Eating affects SMA
- Exercise affects muscles
- Neovascularity
- Inflammatory conditions
- Corpus luteum development
- Menstrual cycle on uterus
- Arteriovenous Shunting

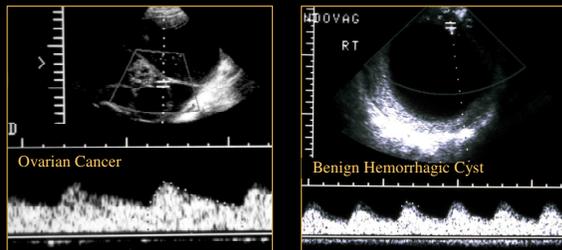
Mani Montazemi, RDMS
Doppler Interpretation

Effect of Eating on Diastole



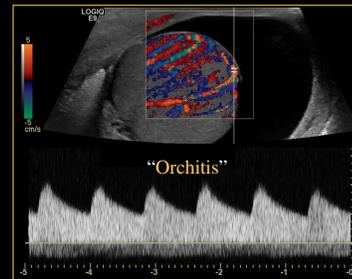
Mani Montazemi, RDMS
Doppler Interpretation

Nonspecificity of Neovascularity



Mani Montazemi, RDMS
Doppler Interpretation

Inflammatory Conditions

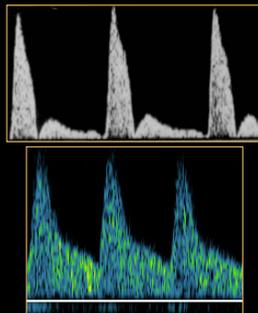


Mani Montazemi, RDMS
Doppler Interpretation

Uterine Artery Flow

Ovulatory cycles

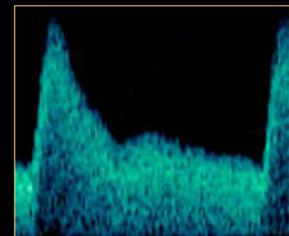
- There is an increase in end diastolic flow velocities between proliferative & secretory phases



Mani Montazemi, RDMS
Doppler Interpretation

Uterine Artery Persistent Notching

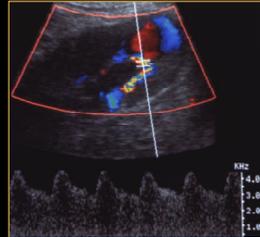
- Notch at 25 weeks implies incomplete trophoblastic invasion and is predictive of preeclampsia and/or delivering a growth restricted fetus



Mani Montazemi, RDMS
Doppler Interpretation

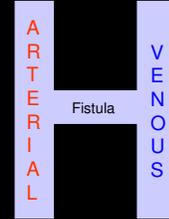
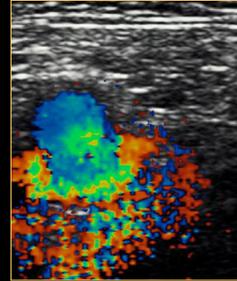
Arteriovenous Shunting

- Small connections
 - tumor vessels, arterioportal shunting in cirrhosis
- Large vessels
 - AV Malformations
 - vein of Galen aneurysm
 - uterine AVM
 - AV Fistulas
 - traumatic AVF



Mani Montazemi, RDMS
Doppler Interpretation

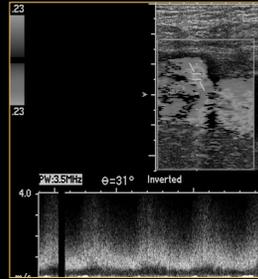
Arteriovenous Fistula



Mani Montazemi, RDMS
Doppler Interpretation

Flow Characterization-AVF

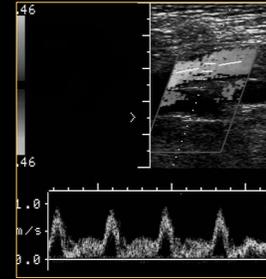
- Turbulence @ the site of fistula



Mani Montazemi, RDMS
Doppler Interpretation

Flow Characterization-AVF

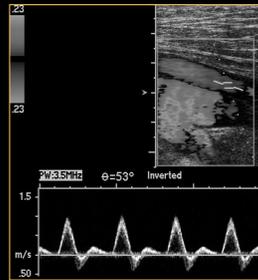
- Low resistance arterial flow proximally



Mani Montazemi, RDMS
Doppler Interpretation

Flow Characterization-AVF

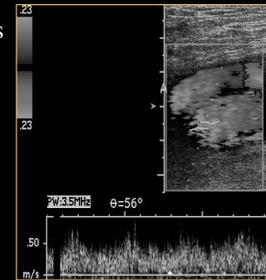
- High resistance arterial flow distally



Mani Montazemi, RDMS
Doppler Interpretation

Flow Characterization-AVF

- Arterialized venous flow



Mani Montazemi, RDMS
Doppler Interpretation

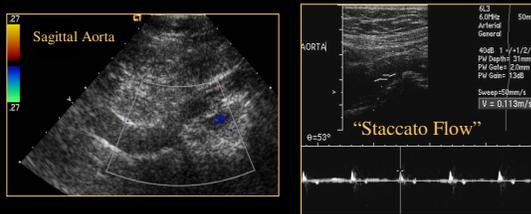
Decreased Diastolic Flow

- Change of resistance from lower to higher decreases diastolic flow
 - Frequently seen in distal stenosis or occlusive disease
 - Venous outflow obstruction

Mani Montazemi, RDMS
Doppler Interpretation



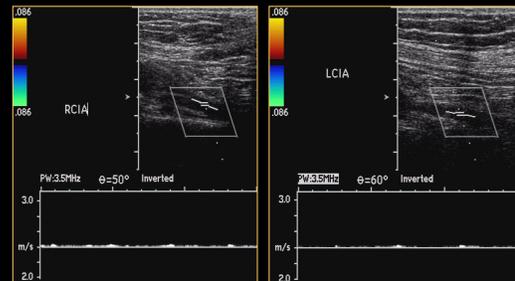
Distal Stenosis Occlusive Disease



Thrombosed Distal Aorta & Common Iliac Arteries

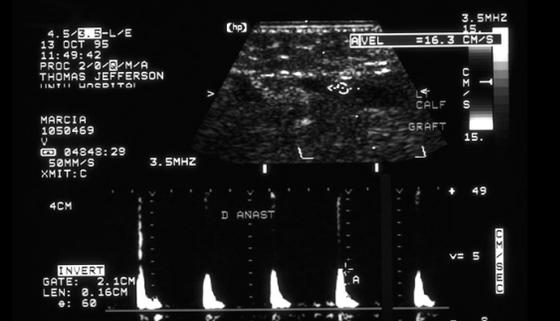
Mani Montazemi, RDMS
Doppler Interpretation

Occlusive Disease

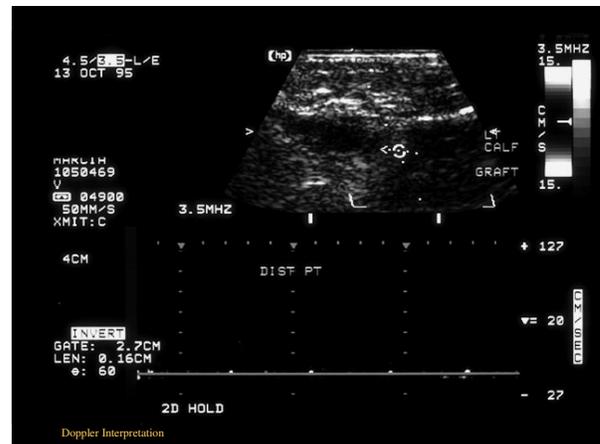


Mani Montazemi, RDMS
Doppler Interpretation

“Staccato Flow”



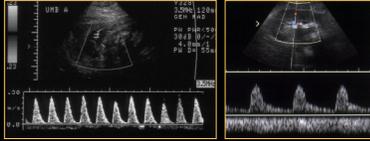
Mani Montazemi, RDMS
Doppler Interpretation



Mani Montazemi, RDMS
Doppler Interpretation

Vascular Destruction

- Capillary and vascular destruction obstructs flow → decreasing diastole
 - Common sites
 - Renal disease
 - Placental diseases



Mani Montazemi, RDMS
Doppler Interpretation

Decreased Diastolic Flow

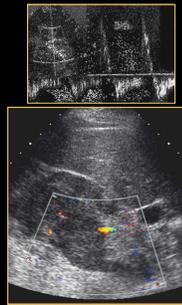
- Change of resistance from lower to higher decreases diastolic flow
 - Frequently seen in distal stenosis or occlusive disease
 - Venous outflow obstruction

Mani Montazemi, RDMS
Doppler Interpretation

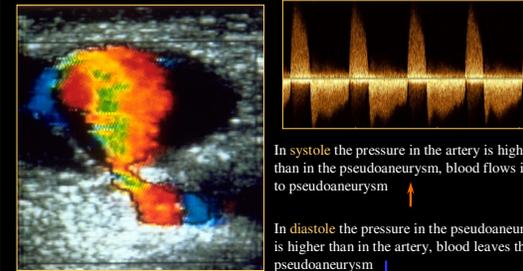
Venous Obstruction

Venous outflow affects diastole

- Physiologic
 - Erection
- Pathologic
 - Renal vein thrombosis



Mani Montazemi, RDMS
Doppler Interpretation



In systole the pressure in the artery is higher than in the pseudoaneurysm, blood flows in to pseudoaneurysm
↑
In diastole the pressure in the pseudoaneurysm is higher than in the artery, blood leaves the pseudoaneurysm
↓

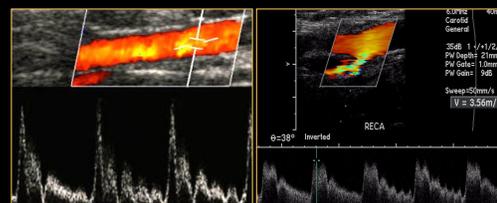
Mani Montazemi, RDMS
Doppler Interpretation

Collateral Flow

- In occlusive disease, a collateral may mimic the original vessel
 - In ICA occlusive disease, the ECA may show increased diastolic flow
 - In CCA occlusion, retrograde flow in external reconstitutes ICA and shows ICA type waveform

Mani Montazemi, RDMS
Doppler Interpretation

Flow Characterization



Mani Montazemi, RDMS
Doppler Interpretation

Conclusion

- What effects will proximal or distal disease have on an waveform?
- How to look at a waveform?
- Doppler analysis
- Stenosis profiles
- Diastolic flow

