Spectral Analysis

The final shape of the arterial Doppler waveform is dependent on numerous factors:

- Contraction by the heart
- Presence of stenosis in the vessel
- State of the downstream circulation

Spectral Doppler Interpretation

Mani Montazemi, RDMS
Director of Ultrasound Education & Quality Assurance
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

How systolic and diastolic components of arterial waveforms appear in health and disease?

Doppler Interpretation

“Distal disease”
Changes the resistance

“Proximal disease”
Changes the strength of the signal

“Distal” Disease
“Changes the resistance”

- Acute & chronic parenchymal disease
- Obstruction
- Renal vein thrombosis
**Distal Disease**

“Changes the resistance”

**“Proximal” Disease**

Changes the strength of the signal

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**Tardus – Parvus Waveform**

*Tardus*
- Slow & late

*Parvus*
- Small & little

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- Systolic acceleration diminished
- Acceleration time prolonged
- Waveform shape
- Diminished pulsatility
Caution! Increase Sweep Speed

Proximal Disease
Changes the strength of the signal

Remember!

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

- Qualitative
- Quantitative

How to Look at a Waveform?

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

Doppler Analysis

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

Spectral Doppler
**Spectral Doppler**

**Cursor**
- is used for optimal alignment between vessel axis & Doppler scan line
- "Angle of insonation"

**Angle correction**
- only used to measure velocity

**Sample Volume**
- determines the location and area that the pulsed wave Doppler listens for a returning signal

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**How to Look at a Waveform?**

- **Where & how was signal obtained?**
  - What is the angle of insonation
  - Where is the sample volume
  - What is the sample volume size

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**What is the Doppler Angle?**

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

\[ V = \frac{2 \cdot F_t \cdot \cos \Theta \cdot F_d}{C} \]
What is the Doppler Angle?
In Straight Unbranched Vessels
Blood Flows in Layers (or Laminar)

Where is the Sample Volume?
What is the Sample Volume Size?

- Size ranges from 0.7 to 15 mm
- Larger gate to search for flow
- Smaller gate for precise information

What is the Sample Volume Size?

- What is the recommended size of the sample volume and why?

The sample volume size should be no larger than 1/3 of the size of the vessel. If larger, the sample volume is capturing slower flow that occurs near the vessel walls.

What is the Sample Volume Size?

- Too small a gate may give the false impression of reduced or even absent flow
**How to Look at a Waveform?**

- Where & how was signal obtained?
  - What is the angle of insonation
  - Where is the sample volume
  - What is the sample volume size

- Technical considerations
  - Doppler Gain
  - Velocity Scale
  - Wall Filter
  - Sweep Speed

**Spectral Doppler – Gain**

- Controls the amplification of the returning Doppler signals
- The Doppler gain should be adjusted to a level that fills in the gray scale of the spectral analysis waveform without creating noise

**Spectral Display**

Effect of “Doppler Gain”

- Angle adjustments are not necessary since the shape of the waveform, rather than velocity, is used for interpretation

**Spectral Doppler - Velocity Scale**

- Controls “PRF” (the rate at which the transducer is pulsed per second)
- Increasing the scale
  - smaller waveform size
- Decreasing the scale
  - bigger waveform size
**Spectral Doppler - Velocity Scale**

- Decreased PRF
- Increased PRF

**Spectral Doppler - Wall Filter**

- Suppress velocities associated with tissue or wall motion
- Higher setting
  - Reduce artifacts
  - Can eliminate diagnostic information

**Spectral Doppler - Sweep Speed**

- Controls how quickly the spectral information is updated
- Three sweep speeds
  - Slow
  - Moderate
  - Fast
**Spectral Doppler - Sweep Speed**

**How to Look at a Waveform?**
- Where & how was signal obtained?
- Flow direction

**Diagnostic Challenge**

**How to Look at a Waveform?**
- Where & how was signal obtained?
- Flow direction
  - Characterization of signal

**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

**Characterization of Signal**

**Spectral Analysis**
- Site of signal
  - What is normal & abnormal
What does increased pulsatility in the hepatic veins suggest?

What does loss of pulsatility in the hepatic veins suggest?

1. Cirrhosis
2. Compression from mass
3. Partial thrombosis

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

Portal Vein Gas
Portal vein gas
Ischemic, inflammatory, or infectious bowel diseases
Pediatric age group – Necrotizing enterocolitis

Characterization of Signal
Edge of spectral envelope
• Waveform shape & pulsatility
• Peak velocities

Characterization of Signal
Distribution of blood velocities
• Gray scale distribution of all RBC

Celiac Artery
V189 cm/s

Important
Signs of Stenosis
• Proximal to stenosis
  – Change in pulsatility

Important
Signs of Stenosis
• At the stenosis
  – Elevated velocities compared to pre-stenotic segment
  – Laminar flow
**Signs of Stenosis**

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

- **Distal to stenosis**
  - Downstream Tardus-Parvus
  - Velocity should drop off distal to stenosis

**Exceptions**: long stenosis, near occlusive lesions

**Celiac Artery**

Distribution of Doppler frequencies seen in spectrum “filling of envelope”
Characterization of Signal

Diastolic Flow

Physiological and Pathological conditions:
- Cardiac and aortic factors
- Vessel compliance
- Downstream resistance
- Venous and arteriovenous connections
- Stenosis at, above or beyond vessel

Increased Diastolic Flow

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

Effect of Eating on Diastole

Increased Diastolic Flow
Nonspecificity of Neovascularity

Ovarian Cancer

Benign Hemorrhagic Cyst

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Inflammatory Conditions

“Orchitis”

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Uterine Artery Flow

Ovulatory cycles
• There is an increase in end diastolic flow velocities between proliferative & secretory phases

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Uterine Artery Persistent Notching

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

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Arteriovenous Shunting

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

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Decreased Diastolic Flow

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

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**Distal Stenosis**

**Occlusive Disease**

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

**Vascular Destruction**

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

**Venous Obstruction**

- Venous outflow affects diastole
  - Physiologic
    - Erection
  - Pathologic
    - Renal vein thrombosis
Conclusion

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

Thank You