DMS-235B: DOPPLER PRINCIPLES AND INSTRUMENTATION

Cuyahoga Community College

Viewing: DMS-235B : Doppler Principles and Instrumentation

Board of Trustees:
March 2020

Academic Term:
Fall 2021

Subject Code
DMS - Diagnostic Medical Sonography

Course Number:
235B

Title:
Doppler Principles and Instrumentation

Catalog Description:
Study of resolution, display modes, hemodynamics, Doppler principles and related instrumentation as it relates to ultrasound.

Credit Hour(s):
1

Lecture Hour(s):
1

Requisites

Prerequisite and Corequisite

DMS-1071 Concepts of Physics in Diagnostic Sonography and ENG-0995 Applied College Literacies, or appropriate score on English Placement Test.

Note: ENG-0990 Language Fundamentals II taken prior to Fall 2021 will also meet prerequisite requirements.

Outcomes

Course Outcome(s):
Evaluate the various methods and the purpose behind signal processing in the ultrasound system.

Objective(s):
1. Identify the types of artifacts encountered in diagnostic ultrasound and state their probable causes.
2. Explain the various types of ultrasound mode display forms.
3. Differentiate between the various types of resolution and indicate how to compensate for a decline in resolution.

Course Outcome(s):
Analyze the laws of hemodynamics to its effects on the circulatory system.

Objective(s):
1. Distinguish how fluid, pressure, and resistance are interrelated.
2. Identify the various kinds of flow encountered in circulation.
3. Explain how stenosis affects blood flow.

Course Outcome(s):
Distinguish and differentiate between a normal and abnormal Doppler display.

Objective(s):
1. Differentiate between the various methods of Doppler signal analysis.
2. Describe the basic principles of color flow Doppler.
3. Identify the instrumentation involved in color flow.

4. Determine whether color flow imaging, power Doppler imaging or duplex Doppler imaging is more appropriate in a given situation.
5. Explain the Doppler Effect and describe the interrelationships between the Doppler equation variables.
6. Evaluate Doppler images to provide a determination of the Doppler Effect.
7. Identify the various Doppler artifacts encountered in diagnostic ultrasound and explain probable causes.

Methods of Evaluation:

1. Weekly quizzes
2. Weekly written assignments
3. Comprehensive mid term examination
4. Comprehensive final examination

Course Content Outline:

1. Concepts
    a. Critical thinking
    b. Digital devices
    c. Instrumentation
    d. Artifacts
    e. Bioeffects
    f. Display modes
    g. Resolution
    h. Doppler
    i. Hemodynamics
2. Skills
    a. Interpret Doppler signals
    b. Interpret hemodynamic changes
    c. Manipulate machine adjustments for quality images
3. Issues
    a. Benefits
    b. Limitations
    c. Operator dependent
    d. Interpretation results
    e. Atypical studies
    f. Accuracy

Topical Outline

1. Modes of display
    a. Principal Display Modes (A-mode, B-mode, M-mode)
        i. Definition of each mode
        ii. Information displayed on each mode
        iii. Advantages and disadvantages of each mode
    b. Principles of Real-time Image Formation
        i. Relationship between echo amplitude and B-mode display
        ii. Positioning of echoes
        iii. Harmonics
        iv. 3-D and 4-D
2. Resolution
    a. Axial Resolution
        i. Dependence on spatial pulse length/ pulse duration
        ii. Numerical example
        iii. Effect of damping
        iv. Transducer frequency spectrum-relation to pulse duration
        v. Bandwidth
    b. Lateral Resolution
        i. Dependence on beam width
        ii. Frequency
        iii. Transducer size and focal characteristics
        iv. Range
    c. Slice Thickness Resolution (Elevational Resolution)

        i. Dependence on beam width
        ii. Transducer array and focal characteristics
        iii. Frequency
        iv. Lateral and axial resolution relationship
    d. Temporal
        i. Lines
        ii. Frame
        iii. Sector size
        iv. Depth
        v. Foci
        vi. Pulse repetition frequency
3. Hemodynamics
    a. Energy gradient
    b. Effects of viscosity, friction, inertia
    c. Pressure/volume/flow relationships
    d. Velocity
    e. Steady flow
        i. Laminar
        ii. Parabolic
        iii. Disturbed
        iv. Turbulence
            1. Eddies
            2. Reynold's number
    f. Pulsatile flow
    g. Stenosis
        i. Continuity Rule
        ii. Bernoulli Effect
    h. Venous resistance
    i. Hydrostatic pressure
    j. Effects of respiration (phasicity)
4. Doppler Physical Principles
    a. Doppler Effect
        i. Principle as related to sampling red blood cell movement
        ii. Doppler equation
            1. Transmitted versus received
            2. Effect of source frequency on shift
            3. Effect of the angle on shift
            4. Effect of reflector velocity
    b. Factors influencing the magnitude of the Doppler shift frequency
        i. Range of the Doppler shift frequency
        ii. Effects of beam angle, transmitted frequency, flow velocity, and flow direction
5. Doppler Instruments
    a. Pulsed wave Doppler
        i. Transducer construction
        ii. Benefits
        iii. Limitations
        iv. Nyquist limit
        v. Range ambiguity
    b. Continuous wave Doppler
        i. Transducer construction
        ii. Benefits
        iii. Limitations
        iv. Uni- and bi- directional units
    c. Instrumentation
        i. Receiver
        ii. Demodulater
        iii. Wall filter for clutter rejection
        iv. Directional devices
    d. Duplex instruments-definition and basic principles

    e. Spectral analysis
        i. Purpose
            1. Direction
            2. Velocity
            3. Duration
            4. Character
            5. Magnitude
        ii. Fast Fourier Transform (FFT)
        iii. Diagnostic measurements (indices-i.e. pulsatility, resistive)
6. Color Flow Imaging
    a. Basic Principles
        i. Sampling methods
        ii. Display of Doppler information
            1. Reflector direction
            2. Average velocity
            3. Velocity variance
        iii. Advantages and limitations
    b. Instrumentation
    c. Methods of signal analysis
        i. Fast Fourier Transform
            1. Spectral analysis
            2. Axis
            3. Turbulent vs. Laminar flow
        ii. Autocorrelation
        iii. Time domain processing
        iv. Color field size and frame rate
            1. Ensemble length (packet size, pulse packet)
            2. Line density
            3. Maximum depth
        v. Color maps, assignment, or coding
            1. Hue
            2. Saturation
            3. Luminance (significance, brightness, intensity)
        vi. Filters
    d. Artifacts Associated with Doppler and Color Flow
        i. Instrumentation (Aliasing, Slice Thickness, Reverberation, Mirror Imaging, Ghosting or Flash, Registration, Incident Beam Angle, Bleed and Clutter)
            1. Definitions
            2. Mechanisms of Production
            3. Appearance
7. Power Doppler
    a. Displayed information
    b. Advantages and limitations

Resources

Hedrick, Wayne R. *Technology for Diagnostic Sonography.* 1st ed. St. Louis, MO: Elsevier Science, 2012.

Hoskins, Peter, et al. *Diagnostic Ultrasound: Physics and Equipment*. 3rd ed. : CRC, 2019.

Kremkau, Frederick. *Diagnostic Ultrasound Principles and Instruments*. 10th ed. St. Louis: Saunders, 2020.

Miele, Frank R. *Ultrasound Physics and Instrumentation.* 5th ed. Forney, TX: Pegasus Lectures, 2013.

Hughes, Sheila. *National Certification Examination Review: Sonography Principles and Instrumentation (SPI).* 4th ed. Dallas, TX: Society of Diagnostic Medical Sonography, 2009.

Edelman, Sidney K. *Understanding Ultrasound Physics.* 4th ed. Dallas, TX: ESP, 2012.

Hoskins, Peter, Martin, Kevin and Thrush, Abigail Hoskins, Peter, et . *Diagnostic Ultrasound: Physics and Equipment*. 3rd ed. Boca Raton: Taylor & Francis Group , 2019.

Owen, Cindy A and Zagzebski, James. A. *Ultrasound Physics Review: A Review for the ARDMS SPI Exam.*. Pasadena: Davies, 2017.

Penny, Steven M., Traci B. Fox and Cathy Godwin. *Examination Review for Ultrasound: Sonography Principles & Instrumentation*. 2nd ed. Philadelphia: Lippincott Williams & Wilkins, 2017.

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