The Society for Vascular Technology of Great Britain and Ireland

Vascular Physics, Haemodynamics and Instrumentation

Syllabus 2015

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For review December 2015 by SVT Education Committee

A. Principles of Ultrasound, Transducers and Instrumentation (35%)

Elementary Principles of Ultrasound

- ❑ Definition of ultrasound
- ❑ Differentiation between audible sound and ultrasound
- ❑ Propagation of vibration
- ❑ Compression
- ❑ Rarefaction
- ❑ Frequency
- ❑ Wavelength
- ❑ Propagation speed
- ❑ Density
- ❑ Period
- ❑ Amplitude
- ❑ Pressure
- ❑ Power
- ❑ Intensity
- ❑ Decibels
- ❑ Units of measurement

General Physics Principles

- ❑ Voltage, current, charge
- ❑ Ohm's law
- ❑ Power
- ❑ Intensity
- ❑ Units of measurement

Propagation of Ultrasound through Tissues

- ❑ Average speed of ultrasound in tissues
- ❑ Speed of ultrasound through air, bone and specific tissues
- ❑ Reflection
- ❑ Acoustic impedance
- ❑ Refraction
- ❑ Scattering
- ❑ Attenuation
- ❑ Absorption
- ❑ Units of measurement

Ultrasound Transducers

- ❑ Piezoelectric effect
- ❑ Piezoelectric materials
- ❑ Transducer construction and characteristics
    - o Crystal thickness
    - o Speed of sound in crystal material
    - o Frequency characteristics
    - o Bandwidth
    - o Quality factor
    - o Damping
- ❑ Sound beam characteristics
    - o Interference phenomenon
    - o Huygen's principle
    - o Near field characteristics
    - o Far field characteristics

    - Beam focusing
    - Beam steering
    - Effect of transducer frequency on beam characteristics
- Lateral resolution
- Axial resolution
- Slice thickness resolution
- 3D Transducer construction and characteristics
- Electronic transducer construction and characteristics

Pulse-Echo Instruments, Storage and Display

- Continuous wave instrumentation
- Pulsed wave instrumentation
- Bi-directional Doppler instrumentation
- Uni-directional Doppler instrumentation
- Transmitter
- Receiver
    - Amplification
    - Compensation
    - Compression
    - Demodulation
    - Rejection
- Scan Converter
- Image storage
- Digital devices
    - Binary system
    - Analogue and digital converters
    - Digital memory
- Pre-processing functions
- Post-processing functions
- Display devices
- Archiving techniques

B. Principles of Ultrasound Imaging (35%)

Pulse-Echo Imaging

- A-mode, B-mode, 3-D, and M-mode definitions
- Principles of real time B-mode image formation
- Principles of 3-D image formation
- Grey scale display
- Dynamic range
- Frame rate
- Number of lines per frame
- Number of focal regions
- Field of view
- Image depth
- Gain
- Time gain control (TGC)
- Image resolution
- Temporal resolution
- Range equation
- Pulse repetition frequency
- Pulse repetition period
- Pulse duration

- ❑ Spatial pulse length
- ❑ Compound imaging
- ❑ Tissue harmonic imaging

Doppler Physics Principles

- ❑ Doppler effect
- ❑ Doppler equation
- ❑ Doppler frequency shift
- ❑ Factors affecting the magnitude of the Doppler frequency shift
- ❑ Reflector Speed
- ❑ Audible Doppler signal analysis
- ❑ Continuous wave Doppler
- ❑ Pulsed wave Doppler

Spectral Doppler Imaging

- ❑ Basic principles
- ❑ Spectral analysis
- ❑ Fast Fourier Transform spectrum analysis
- ❑ Spectral Doppler display
- ❑ Direction
- ❑ Velocity
- ❑ Duration
- ❑ Magnitude
- ❑ Sample volume size
- ❑ Zero baseline
- ❑ Pulse repetition frequency (PRF)
- ❑ Wall filter
- ❑ Doppler gain
- ❑ Spectral broadening
- ❑ Aliasing
- ❑ Diagnostic measurements
    - o Pulsatility index
    - o Resistive index
    - o Volume flow

Colour flow imaging

- ❑ Basic principles
- ❑ Sampling methods
- ❑ Reflector direction
- ❑ Average velocity
- ❑ Velocity variance
- ❑ Autocorrelation
- ❑ Time domain processing
- ❑ Colour box size
- ❑ Frame rate
- ❑ Ensemble length
- ❑ Line density
- ❑ Maximum depth
- ❑ Hue
- ❑ Saturation
- ❑ Luminance
- ❑ PRF
- ❑ Colour display baseline
- ❑ Wall filter

- Colour gain
- Colour frame rate
- Aliasing
- Power Doppler
    - Basic principles
    - Displayed information
    - Advantages and limitations
- Contrast agents and harmonic imaging

Artifacts

- Artifacts associated with resolution
- Artifacts associated with propagation
    - Reverberation
    - Comet tail
    - Mirror image
    - Multi-path side lobes
    - Grating lobes
    - Refraction
    - Speed error
    - Range ambiguity
- Artifacts associated with attenuation
    - Shadowing
    - Enhancement
    - Focal enhancement
    - Focal banding
- Artifacts associated with Doppler and colour flow imaging
    - Aliasing
    - Slice thickness
    - Reverberation
    - Mirror imaging
    - Ghosting
    - Flash
    - Registration
    - Incident beam angle
    - Clutter
- Artifacts associated with electronic noise
- Artifacts associated with equipment malfunction

C. Haemodynamics, Physiology and Fluid Dynamics (20%)

Arterial Haemodynamics

- Energy gradient
- Effects of viscosity, friction and inertia
- Pressure/flow relationships
- Velocity
- Steady flow
- Laminar flow
- Disturbed flow
- Turbulent flow
- Pulsatile flow
- Effects of stenosis on flow characteristics (direction, steal phenomenon, waveform)
- Effects of occlusion on flow characteristics (direction, steal phenomenon)
- Velocity
- Acceleration

- Entrance / exit effects
- Diameter reduction
- Area reduction (Diameter reduction and Stenosis calculation)
- Peripheral resistance
- Collateral effects
- Effects of exercise
- Hyperaemic response
- Bernoulli's equation
- Poiseuille's equation
- Reynolds Number

Venous Haemodynamics

- Venous resistance
- Hydrostatic pressure
- Pressure / volume relationship
- Effects of respiration
- Effect of oedema
- Effects of muscle pump action
    - At rest
    - Contraction
    - Relaxation

Tissue Mechanics / Pressure Transmission

- Venous occlusion by limb positioning
- Superficial venous occlusion by tourniquet
- Volume changes caused by blood inflow/outflow variation
- Arterial occlusion by tourniquet (effect of oedema, calcification)
- Arterial pressure measurements
- Venous pressure measurements

Plethysmography

- Two-wire/four-wire resistance measurements, graphical recording, calibration, AC/DC
- Coupling
- Photoplethysmography
- Impedance plethysmography
- Displacement (pneumatic cuff)
- Strain gauge
- Oculoplethysmography pressure

D. Quality Assurance and Ultrasound Safety (10%)

Instrument Performance, Evaluation, Maintenance and Safety

- Quality assurance programs
- Methods for evaluating equipment performance
- Test objects or tissue equivalent phantoms
- Doppler flow, string or belt phantoms
- Equipment parameters evaluated using test objects or phantoms
- Acoustic output quantities
    - Pressure
    - Power
    - Intensity
        - Spatial and temporal considerations
        - Average and peak intensities
        - SATA

        - SPTA
        - SPPA
        - SPTP

- Methods for determining pressure, power and intensity
- Acoustic exposure
- Acoustic output labelling
    - Thermal index
    - Mechanical index
- Maintenance of equipment
- Electrical and mechanical hazards

Biological Effects and Safety

- Primary Mechanisms of Biological Effect Production
    - Cavitation
    - Thermal

Output display standards and BMUS safety guidelines (2009) for peripheral vascular scanning