The Society for Vascular Technology of
Great Britain and Ireland

Vascular Physics, Haemodynamics and Instrumentation

Syllabus 2013

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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 ○ Crystal thickness ○ Speed of sound in crystal material
  - ○ Frequency characteristics
    - ○ Bandwidth ○
      Quality factor ○
      Damping

- ❑ Sound beam characteristics ○ Interference phenomenon ○ Huygen's principle ○ Near field characteristics
    - ○ Far field characteristics ○ Beam focusing
    - ○ Beam steering
    - ○ Effect of transducer frequency on beam characteristics
- ❑ Lateral resolution
- ❑ Axial resolution
- ❑ Slice thickness resolution
- ❑ Mechanical 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
- ❑ Recording and archiving techniques ○ Video format ○ Digital format
    - ○ PACS (picture archiving communication system)

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 ○ Pulsatility index ○ Resistive index ○ 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)
- Effects of occlusion on flow characteristics (direction, steal phenomenon)
- Velocity
- Acceleration
- Entrance / exit effects
- Diameter reduction
- 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

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  - 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