

***The Society for Vascular Technology of  
Great Britain and Ireland***



**Vascular Physics, Haemodynamics and  
Instrumentation**

**Syllabus 2012**

## 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
- ❑ 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