

Q14 Describe the basic principles of ultrasound imaging including the Doppler effect (March 2010)

Ultrasound – utilization of sound waves with a frequency 2-20MHz and the echoes produced by application of those sound waves to tissue for diagnostic purposes

Sound energy is attenuated as it passes through tissue because of:

- **Reflection** → a reflection (echo) occurs at the boundary between two materials if the acoustic impedance of the materials (the property of density and propagation speed) is different.
- **Scattering** → not all echoes are reflected back to the probe. Some of it is scattered in all directions in a non-uniform manner.
- **Refraction** → the change in the direction of a sound wave on being incident upon a tissue interface at an oblique angle. Determined by Snell's law. The amplitude of the reflected echo is a function of the acoustic mismatch of the tissues and the angle of incidence
- **Absorption** → tissue absorption of sound energy contributes most to the attenuation of an ultrasound wave in tissues.

Doppler effect → a phenomenon whereby there is an apparent change in the frequency of the sound wave observed when the sound moves towards (frequency higher) or away (frequency lower) from the observer. Used to assess characteristics of blood flow.

Probes → a number of probes exist (linear, curvilinear, phased array). They each utilize piezoelectric crystals to generate ultrasound by changing shape in response to a changing electrical field. 2000-4000 pulses (the Pulse Repetition Factor) are emitted per second, with the transducer 'listening' for echoes between emitted pulses. Use of longer wavelengths allows better tissue penetration but at the expense of poorer image quality.

Modes → Several modes can be selected

- B mode → brightness mode, the standard 2D mode
- M mode → captures returning echoes in only one line of the B-mode image but displays them over a time axis.
- Colour doppler may be used to show blood flow or tissue motion in a selected 2D area. Direction and velocity of tissue motion and blood flow are color coded and superimposed on the corresponding B-mode image

Multiple artefacts occur in USS imaging (reverberation, ring down, mirror images, reflection, enhancement, attenuation) which are sometimes useful in diagnostic purposes.