Quizzes are only ultrasound, final includes NUC med and ultrasound

Week 1 – Intro to Ultrasound Physics

- Uses 1 to 20 MHz frequencies, which is way above the sound wave range for human ears
- Higher frequency is better detail but less penetration
- Images created by interpreting sound reflections
- Each dot in the image represents an echo that is returned to the probe
- Ultrasound is performed in real time and some images are taken throughout
- Images are poorly understood, can't compare to the real time images so sonographers usually fill out a sheet of what they saw
- High degree of decisional latitude with sonographers, radiologist relies heavily on the sonographer's observations
- Advantages: no radiation, mobile equipment that is quick and cost effective, real time can see motion, accurate measurement of structures, good soft tissue information and can be used for intervention (blood studies)
- Disadvantages: not suitable for bone, lungs, abdominal structures covered by bowel, adult cranium and the GIT (most of these surfaces can't be penetrated). Hand held transducer leads to high degree of scan plane variability between sonographers making comparison images difficult. Interpretation is difficult.
- Scan planes → must understand the orientation of the image of the screen. Remember it is a two dimensional slices of anatomy in of the scan planes
- **Transverse plane**: divides the body into superior and inferior segments. Transducer on the anterior surface of the patient with the bottom being the posterior section. Left and right are reversed. Posterior is not necessarily the very back of the patient but just as far as the beam goes.
- Note that the transducer is ALWAYS at the top of the screen
- You can image in the transverse plane from a multitude of angles, it doesn't have to be midline. Might do this to avoid artefacts
- **Sagittal plane**: divides the body into left and right segments. Probe located up and down the patient. Image is always viewed with the patient's head (superior) to the left of the screen
- Can go from a midsagittal plane to a para-sagittal plane (parallel to the plane), some image orientation
- **Coronal plane**: probe coming in from the side with lateral aspect at the top of the image and the medial at the bottom. Superior is still on the left and inferior on the right. A coronal can be obtained from either side of the patient.
- **Longitudinal**: plane that divides the body into section along its axis. Sagittal and coronal planes are both longitudinal planes. About aligning to the long axis of the anatomy
- **Oblique**: any plane through the body or organ other than the planes already described

- These last two relate to the anatomy present rather than the approach to the scan like the first three
- **Echogenicity**: relates to the brightness of the structure, how intense the echoes are
- **Anechoic**: Under the banner of echogenicity. Used to describe an area that has no echoes and appears completely black on the image. Structures such as blood, bile or urine usually appear anechoic because there is no interface within the fluid to return an echo. May also hear the word echolucent or sonolucent which mean the same.
- **Hypoechoic**: an area where the echo is of low intensity, where it is dark on the screen. Not anechoic as some echos are returning. Echopenic is also used to mean the same
- **Echogenic**: an area where the echoses are more intense and bright on the screen, high number of echos returning to the probe. For example, gas will do this. Also called hyperechoic
- Echogenicity is a relatively subjective term, may also use terms such as mid/ moderate level echogenicity
- Is useful to use these terms to describe one structure relative to another
- **Echotexture**: relates to the pattern of the image, a description of the pattern of the echoes
- It could be described as fine (can't identify individual pixels), coarse, homogeneous (even pattern/gray scales) or heterogeneous
- **Acoustic Windows**: an anatomical structure or configuration that allows anatomy to be visualized deeper because they naturally cause little attenuation. Suitable windows are used to view anatomy from as many angles as possible
- Examples include a full urinary bladder to help see the prostate or uterus and ovaries
- Liver and spleen are also acoustic windows
- Amniotic fluids in pregnancy act as an acoustic window to help visualize the developing foetus
- Aqueous and vitreous humour help visualize eye structures
- Intercostal spaces and sternal notch allows visualization of the heart and thorax as the bones will attenuate the beam too much
- Fontaelles of neonatal heads also act as an acoustic window

PHYSICS

- Lower frequencies penetrate deeper into the tissue
- Ultrasound started by having patient emerged in water (which doesn't attenuate the beam)
- Used to be considered more therapeutically rather than diagnosis
- Somascope was the original, followed by water bath scanner
- Contact scanners was the first precursor to modern technology but not in real time
- Modern equipment consists of: transducer, monitor for display, housing with electronics/controls and a recording device
- Wave physics determine how ultrasound works
- Electromagetic waves are xray and require no medium for propagation
- Mechanical wave are ultrasound, defined as the propagation of energy trhough a medium which often needs to be a deformable elastic medium
- Transverse waves (e.g. water) the waves move longitudinal and particles up and down
- Longitudinal waves both move longitudinal

- Sound propagates through a medium in the form of compression waves
- As you compress the wave, the area directly behind it gets a bit more relax and lengthened
- Velocity variation → with heavy molecules the sound transmits at a lower velocity because it take more energy to move
- With more compressible materials (e.g. air) the sounds transmits with lower velocity. Weaker intermolecular forces and more compressible
- Less compressible and stiffer materials such as bone transmit with higher velocity
- Gain is the overall brightness of an image, can be overall or TGC
- Overall gain = overall brightness of the entire image
- TGC = time gain compensation which increases gain (attenuation) as you get deeper. So deep structures may appear slightly different normally than the superficial structures. Used to compensate for this loss of attenuation by amplifying structures that are deeper
- The electrical power from machine passed to transducer crystal and converted to the sound wave
- Can manipulate the beam, which is divergent or shaped and not necessarily constant to help focus and show the depth of anatomy better
- Narrow and tighter beam has greater intensity as its focused into a small area, beams intensity effects echo strength and therefore brightness
- Intensity is the preferred unit to measure the power of the ultrasound beam
- Dynamic range is the range of grey scales that can be shown in the image
- The range of echoes on the image range from the high level before saturation to the lowest level
- Soft tissue interactions are important to image formaition, gain and production of artifacts
- Refractions or attenuation may occur (may be absorption, divergence, scattering or reflecting)
- Refraction: change in direction of ultrasound beam when it crosses as tissue boundary at an angle. Depends on the difference in sound velocity of the two structures
- Reflection and refraction interaction are the primary causes of artefact in ultrasound
- **Attenuation**: reduction of intensity of the beam as it passes through medium. Degree depends on the material, the distance travelled from the source and the frequency of the beam
- Attenuation co-efficients in deciebel, water is very low and so can't attenuate the beam whereas lung has a very high co-efficient and reflects back a lot of echoes
- Absorption → result from internal frictional forces that directly remove energy from the beam that is converted to heat. Decreases the penetration of the beam
- This depends on the viscosity of the material itself (more viscous means less can penetrate)
- Depends on materials molecule relaxation time, if they are slow they are still returning when the next compression wave hits
- Also depends on the depth of the tissue because obviously more leads to more beam absorption
- Divergence (diffraction) → spreading of the ultrasound beam as it moves further from the source. Increased diffraction causes increased attenuation
- Occurs in far field (non focused) or beyond the focal zone (focussed) of a transducer
- Also occurs after reflection from a convert or curved interface, creating artefact

- Scattering → the dispersion of the ultrasound beam in many directions when the wave strike a very small object. Scatter pattern depends on size of interface
- Only a very small portion of the scatter actually returns to the transducers to creater the image
- Reflection can be non-specular (diffuse, small portion of beam only returns due to irregular surface) or specular (smooth surface where amount of return depends on angle of incidence. Greatest when probe and surface are at 90 degrees)
- Therefore try and get probe and area of interest at a 90 degree angle to get the maximum return of echoes
- **% of beam returned depends on: angle of incidence, surface texture and acoustic property difference**
- Near gain represents the amount of gain applied to the closest echoes. Shape of this graph depends on the tissue type you're passing through
- Use delay control to regulate the time at therefore depth at which the TGC begins to be applied

Revision

1. What is a sonographer and the role they play?
   A sonographer is a trained professional that perform ultrasound, which uses sound waves from 1 to 20 MHz (outside of human hearing) to create images as they propagate through the medium. Commonly 3 to 10 MHz is used. They have any important role in making written observations and have a high degree of decisional latitude because they are seeing the images in real time.

2. Advantages and Disadvantages of Ultrasound
   Advantages: does not use ionizing radiation, produces real time images, mobile equipment that is cost effective and quick to use, produces good soft tissue information, is generally well tolerated by patients and can also be used for intervention such as blood studies.
   Disadvantages: many areas not suitable for imaging with US especially gas filled areas such as the GIT, abdominal structures or lungs that will return very little signal, hand held transducer that makes it highly operator independent and leads to scan plane variability, can be hard to interpret.

3. Imaging planes
   Transverse plane → a scan plane that divides the body into superior and inferior portions. On the image presented, the top will be the anterior portion where the transducer sits, the bottom will be posterior and left and right will be reversed (like a CT slice). You can achieve this plane from a multitude of angles.
   Sagittal plane → divides the body into left and right segments, with the transducer still placed on the anterior portion of the body. The anterior portion is at the top of the screen, the posterior at the bottom, the superior at the left and the inferior at the right. When this is in the midline it is the sagittal plane, anywhere else it is the parasagittal plane.
   Coronal plane → the transducer is placed on the side of the patient to divide the body into anterior and posterior sections. The top of the image will be the lateral aspect and