BIOE 507 Quiz - Ultrasound Terminology Due 02/16/21

1. What is piezoelectric effect in the context of ultrasound – explain the basics of ultrasound compression – when does this happen.

The piezoelectric effect is an effect that converts the mechanical energy to electrical energy due to piezoelectric element deformation.

Compression is the positive amplitude of an acoustic wave. It’s an area having high pressure and intensity of particles as the distance of particles are close. It happens when the particles are forced and pressed.

1. What is rarefraction – when does this happen – in the context of ultrasound.

Like compression, rarefraction is the negative amplitude of an acoustic wave. It’s an area having low pressure and particle density as the distance of the particles is far. It happens when the particles are given additional space and allowed to expand.

1. What are 3 main modes of Ultrasound propagation in tissues – define in 1-2 sentences.

Curved or curvilinear array probe: it has a large foot print and a sector image field with a wide deep field of view. It’s good for intra-abdominal scanning.

Linear array probe: it has a large footprint and a rectangular image field. It’s good for superficial, small parts, and vascular screening.

Phased array probe: it has a small footprint and a sector image field with a wide deep field of view. It’s good for intracostal, pediatric, abdominal, and cardiac screening.

1. What is Acoustic impedance – how is this defined

Acoustic impedance indicates how much resistance that an ultrasound beam encounters as it transmits in the tissue.

1. Explain impedance matching and why is it important in ultrasound signal propagation. What happens when there is an impedance mismatch

Impedance matching means the impedance of two mediums or tissues are close. It’s important that how much depth the ultrasound beam could reach underneath the skin surface. When the impedance is matched, it could reduce the loss and reflection during signal propagation, so the depth of signal transmission would increase. However, if the impedance is mismatched, the signal loss during transmission is large.

1. Explain the scattering equation – define the terms and state its importance.



Explain this when there is an impedance mismatch and when there is an impedance match.

P(r,q) is the scattered acoustic signal pressure received at location that has distance r to the center of the scatterer and angle q to the horizontal axis; a^3 is proportional to the volumn of the scatterer; k^2 is proportional to the frequency of the incident ultrasound; kv is the compressibility of the scatterer, k0 is the compressibility of the surrounding medium. kv-k0 is the mismatch in the compressibility; rv-r0 is the mismatch in density between surrounding medium and the scatterer.

Impedance is proportional to compressibility mismatch. Therefore, if the there is impedance mismatch, Kv-K0 is larger than 0, resulting an increasing pressure. If there is an impedance match, Kv-K0 is close to 0, resulting in little pressure.

1. What is Pulse-echo – how is an image acquired by Pulse echo
   1. Define Pulse Repetition frequency
   2. Define the concept of depth in Ultrasound and how is this obtained. What is the relationship between frame-rate and depth for a speed of sound in soft tissue.

Pulse-echo a short narrow ultrasound wave excited from the transmitter of the transducer. Then the transducer turns to receiver mode to receive the pulse signal propagated back. The received signals are used to make the image.

1. The number of ultrasound pulses emitted from the transducer over a specific period of time (usually in 1 second).

B. Depth is the distance of a particle reflecting the echo underneath the surface to the transmitter.

depth = (signal received time - signal emitted time) \* speed of the sound / 2

frame-rate = speed of sound /2\*depth\*number of channels

1. What is B-Mode imaging

B mode imaging is a two-dimensional image that is simultaneously scanned by a linear array. The amplitude of echo is converted into dots of different brightness in the B-mode imaging. The horizontal and vertical directions represent the real distances in the tissue, whereas the grayscale intensity indicates the strength of the echo. It’s the most widely used mode in ultrasound imaging.

1. Define the principle of Doppler effect – how can this be used to measure the velocity of blood flow

When a sound object moves towards the listener, the frequency of the wave increases, leading to a higher pitch. Conversely, when the sound object moves away from the listener, the frequency of the wave decreases and the pitch goes down.

Likewise, the blood moving towards the transducer produces higher frequency echo, while lower frequency echo is produced when the blood moves away from the transducer. Here is the equation to compute the velocity of blood flow:

v = f\_doppler \* c / 2 \* f0\*cosθ, where v is the velocity of blood flow, f\_doppler is the doppler shifted frequency, c is the speed of ultrasound, f0 is the transmitted frequency, θ is the angle between the ultrasound beam and the direction of blood flow.