Ultrasound and surgeon
เรียบเรียงโดย พญ.ฑิชกร พานิช
อาจารย์ที่ปรึกษา อ.นพ.ปัญญา ทวีปวรเดช

Ultrasound and surgeon and principle of ultrasound

OUTLINES

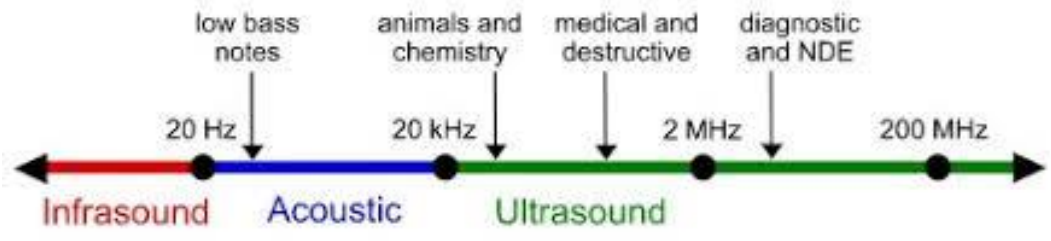
- Definition of ultrasound
- Basic physics
- Creation of images
- US artifacts
- US machine and probes
- Advanced US

Ultrasound

- Non-ionizing radiation
- Sound wave at higher frequency than can be detected by human hearing (> 20kHz), Humans can hear from 20 Hz to 20 kHz.
- Medical US - 1-20MHZ
- High frequencies give greater definition, but tissue penetration depth is reduced

| material | Speed(m/sec) |
|---|---|
| Air | 330 |
| Soft tissue | 1540 |
| Bone | 5160 |

$$C = f\lambda$$



Ultrasound interaction

Reflection

- Occurs at boundary between materials of different acoustic impedance
- Unique, depending on density of the medium times the velocity of US wave transmitted through it
- Acoustic impedance Z = **ρ**C

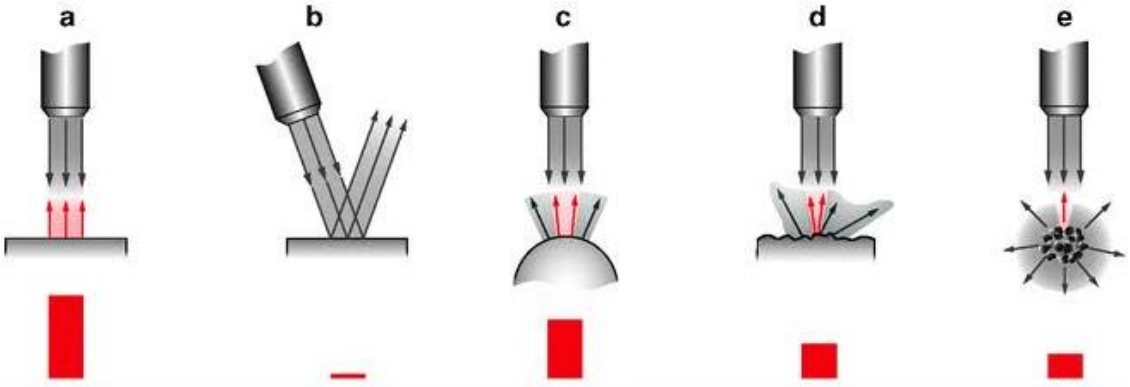
**ρ**-density, C = speed of sound

| Interface | % reflection |
|---|---|
| Gas-tissue | 99.9 |
| Bone-muscle | 30 |
| Fat-muscle | 1 |
| Blood-muscle | 0.1 |
| Liver-muscle | 0.01 |
| Soft tissue-PZT | 80 |
| Plastic-soft tissue | 10 |

- The greater differences in acoustic impedance between 2 adjacent tissues, more waves are reflected back It is individual acoustic impedance but relative difference of among adjacent tissues that control the amount of energy reflected back!

Scatter

- When reflecting object is about the size of a wavelength, reflection occurs in all direction (scatter)
- Some energy reflected back at detector, some reaches detector after multiple scatter
- Shorter wavelength (higher f), smaller objects will cause scatter



Refraction

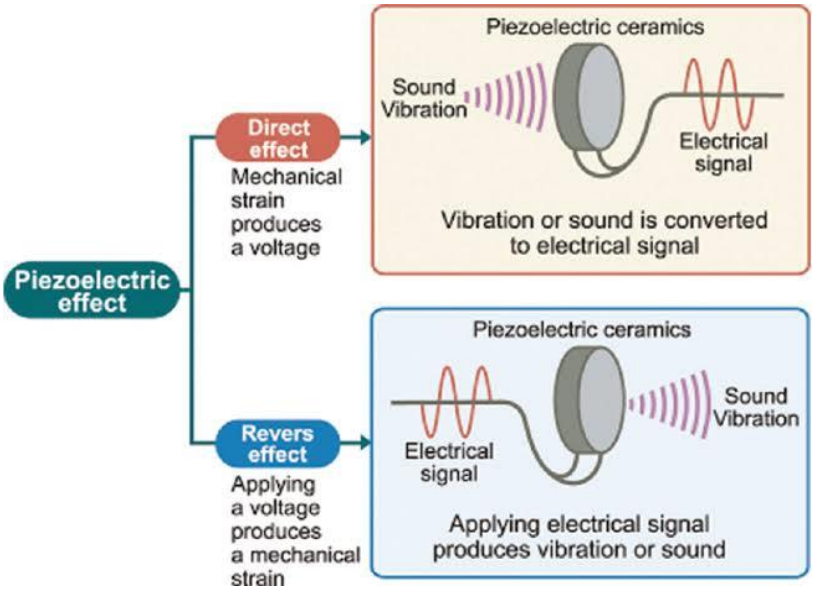
- Occurs across the boundary between materials in which the speed of sound is different
- Resulting in changing direction of US wave
- When captured by transducer, producing artefacts

Absorption

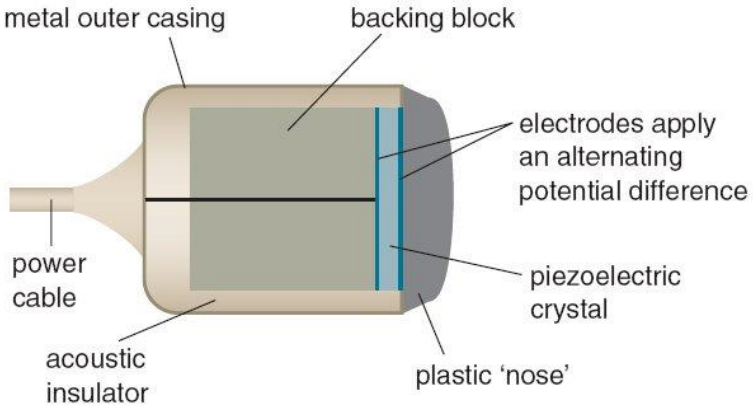
- Attenuation / absorption = loss of energy as the sound waves travel through increasing depth
- High f signal attenuated > low f signal
- High frequency probe cannot well visualize deeper structures
- Signal from greater depth arrive later
- To compensate, gain of amplifier is increased with time "Time gain compensation"

Piezo-electric effect

- Distortion of crystal (PZT) produces a voltage
- Application of a voltage to a Crystal produces distortion
- US probes acts as transmitter and receiver using both version of PZT

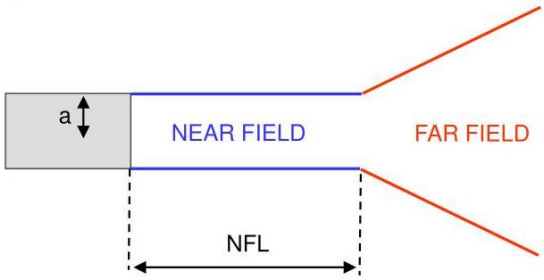


Transduction probe




Thickness = half wavelength

$t = \lambda/2$




**Near Field Length, NFL = $a^2 / \lambda$**

a = radius of transducer
λ = Wavelength

Frequency

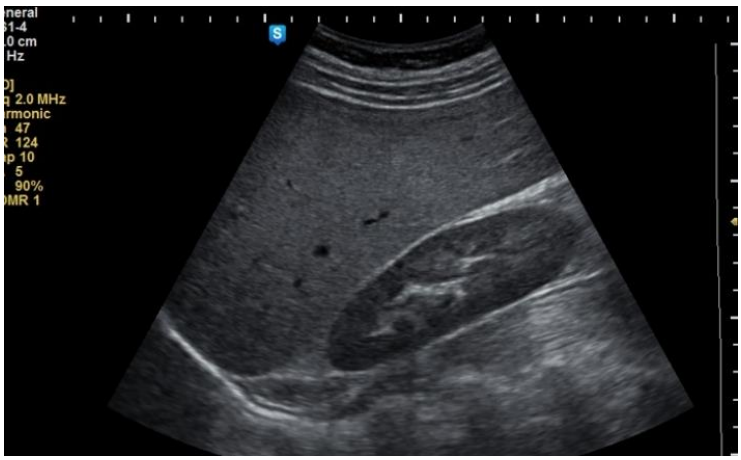
- Increasing the frequency
  - Increases length of near field
  - Improves axial resolution
  - Decreases penetration (reduces depth of measurement)

B – mode (brightness scan)

- 2-dimension sector scan for display spatial information
- Represents amplitude by pixel brightness

C – mode (color Doppler)

- Helps to detect structure with movement; blood flow
- Structure moving from probe = BLUE
- Structure moving toward the probe = RED



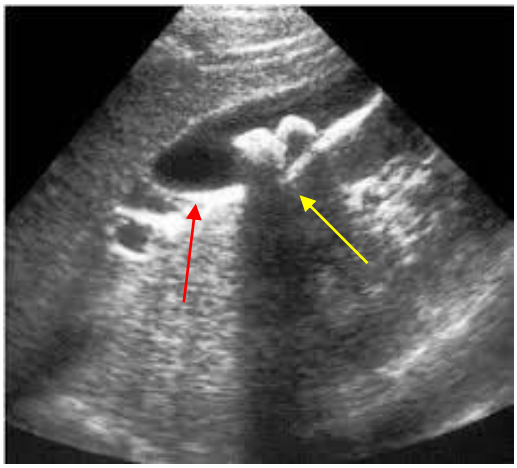

M mode

- Pericardium, heart valve, cardiac imaging
- Diaphragm

Ultrasound artifacts

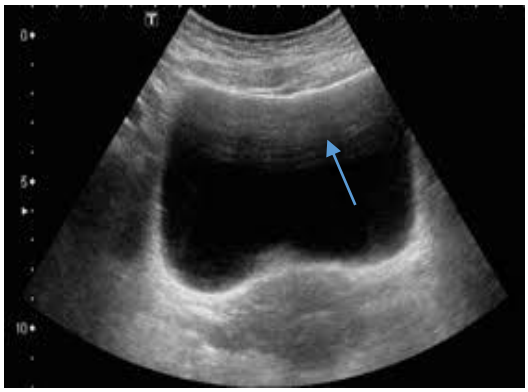
Shadowing

- Signal loss behind reflective surface
- Try a different scanning plane
- Fill the gas space with fluid
- Move anatomy, get the patient to inhale



Flaring

- Bright area behind region of low absorption: fluid, cystic
- Try a different part
- Alter the time gain control

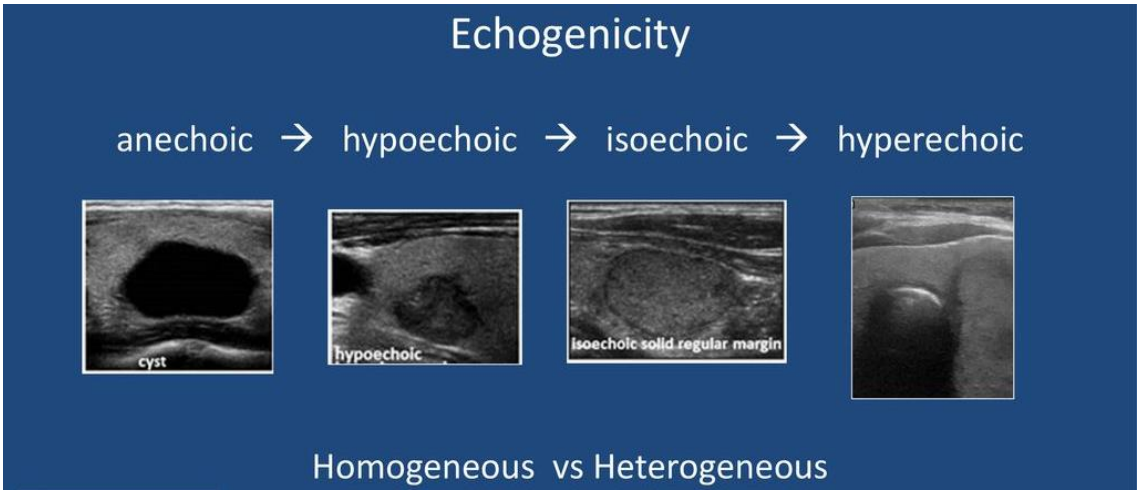


Reverberation

- Multiple reflections from 2 highly reflective boundaries
- Parallel highly reflective surface, the echo generated from US beam repeated reflected back and forth before returning to probe for detection
- Decreased TGC at near field, change angle

US Glossary

- Anechoic: no echo
- Isoechoic: echo equal to adjacent soft tissue
- Hypoechoic: less echo than adjacent soft tissue
- Hyperechoic: moor echo than adjacent soft tissue




Ultrasound machine and probe

GAIN

- Refers to the strength of signal
- Brightness of signal to signal strength received by transducer
- GAIN control uniformly alter brightness of all echos in themonitor
- Time gain compensation control(TGC) - adjust amplification at various depth


Depth control

- Control depth of image
- Place the structure of interested in the middle of monitor optimization

Focus

- The sound waves converge to a point called "focal zone" and then diverge
- Divergence beyond focal zone can allow missed information in a horizontal plane

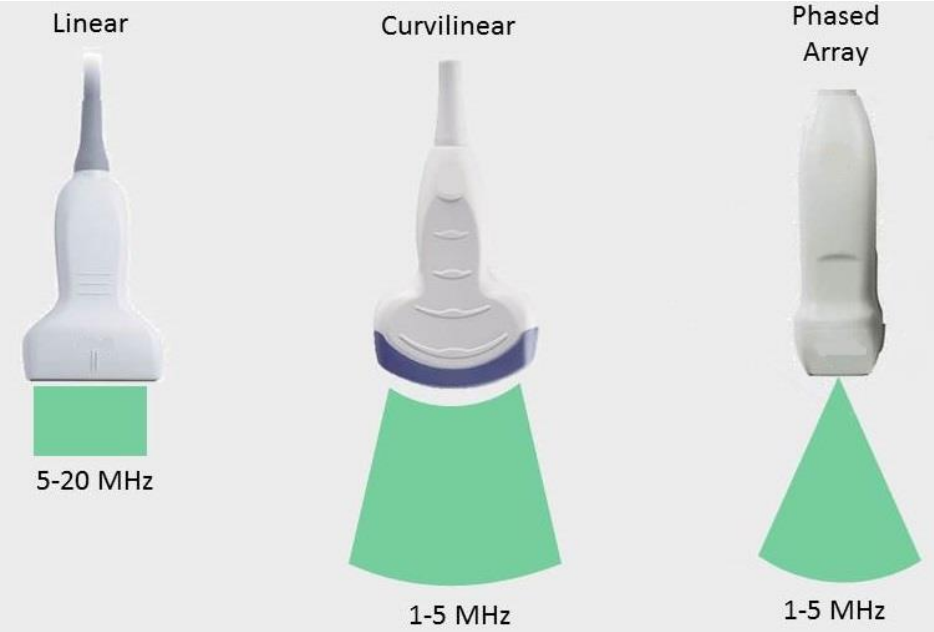
Frequency

- High frequency wave are more attenuated.
- High frequency probe for superficial structures
- Low frequency probe for deep structure

Advance Ultrasound

Strain elastrography

- Breast mass, thyroid mass
- Compare before and after compression
- Parallel




Shear wave elastrography

- Hepatic fibrosis, hepatitis
- Acoustic radiation force impuse (ARFI)
- Perpendicular, shear wave