Chapter 10

Sound Beams
foundation for a basic understanding

It’s shape

• It begins the size or diameter of the transducer
• gradually converges to a narrower point
• then begins to diverge

Anatomy of the beam

• Focus
• near zone
• focal length
• far zone
• focal zone

Focus

• Also called the focal zone
• it is the location in the sound beam in which it is at it narrowest
• the focus is one-half of the original beams diameter

Near Zone

• Also referred to as near field or Fresnel zone
• this is the region sound beam from the transducer to the to the focus point
• the beam gradually tapers to this region

Focal Length

• Focal depth or near zone length
• this is the length of the near zone
• the distance from the transducer to the focus point
Far Zone

- Far field or Fraunhofer zone
- located from the focus point and beyond
- in the far zone the beam diverges
- the divergence reaches the size of the transducer (active element) diameter when the distance is 2 times the near field length

Focal Zone

- The most important region in diagnostic imaging where the most accurate images are created.
- Half of the focal zone is in the near field the other in the far field
- an arbitrary location where the beam is narrow and imaging is at its best

How do you determine focal depth

- Two factors effect the depth on fixed focus transducers
  - transducer diameter
  - frequency of the sound beam

Transducer diameter

As long as the frequency remains unchanged
- Increased diameter results in deeper focus
- decreased diameter provides a shallow focus
*note there is a direct relationship to size and focus depth*

The imaging dilemma

- High frequency transducer create better images but have a longer focal length
- by choosing a smaller size element we can improve the near field resolution

Divergence

- Defined as the gradual widening of the sound beam in the far field
- what factors determine this widening
  - transducer diameter
  - frequency of the sound beam
Divergence

- Divergence and element diameter are inversely related.
- The smaller the element, the greater the divergence in the Fraunhofer zone.
- The larger the element, the less the divergence in the Fraunhofer zone.

Divergence frequency

- Divergence and element diameter are inversely related.
- The lower the frequency, the greater the divergence in the Fraunhofer zone.
- The higher the frequency, the less the divergence in the Fraunhofer zone, improving lateral resolution in this area.

Spherical waves

- When the source (very small) is the size of the wavelength, small “V” shaped waves are created.
- The source producing these waves are called Huygens’ sources.
- This wave is also known as diffraction patterns or Huygens’ wavelets.

Huygens’ Principle

- States that large active elements may be thought of as tiny sound sources each producing its own “V” shaped wave.
- The hourglass beam shape is the result of many of these wavelets.
- Destructive interference.

Lateral Resolution and focusing

- The ability to resolve as separate entities two objects located side by side perpendicular to the sound beam.

Lateral Resolution

- Measured in units of mm or cm with the smaller number preferred.
- Determined by the beam width.
- Synonyms include:
  - Angular, transverse and azimuthal resolution.
Lateral Resolution

- Best at the focal zone
- Lateral resolution = beam diameter

Lateral Resolution

- In clinical imaging axial imaging provides better resolution because the pulse length is shorter than the beam width
- Two objects close together appear as one if they are within the beam diameter

- The advantages of using a high frequency transducer is that the short pulse length improves axial resolution while at the same time improving lateral resolution as the result of a narrow beam

Focusing the beam

- Results in a narrower beam
- Types of focusing include
  - External
  - Internal
  - Phased array
- Fixed focusing

External focusing the lens

- Like a camera, a lens is placed between the element and the patient and is used to focus the acoustic sound wave improving the beams focus

Internal focusing curved element

- The PZT is curved concentrating its energy and creating a narrow beam improving the beams focus
- This is the most common form used
Electronic focusing phased array

- With this the electronics in the system focuses the beam
- This allows the sonographer to alter the beams focus
- Used with multi crystal transducers only

Effects of focusing

- The beam diameter in the near field as well as the focal zone is reduced
- A shallower focal depth
- The diameter of the sound beam in the Fraunhofer zone increases
- Focal zone is smaller