Resolution is the ability to see or visualize.

There are two main types of resolution: Spatial and temporal.

Spatial resolution is the ability to distinguish the correct space or place of an object. There are 3 types of spatial resolution: Axial, Lateral and Elevational. Good spatial resolution means you can distinguish the correct location of a structure relative to another close structure. Spatial res involves the ability to distinguish two closely "spaced" structures as two unique distinct structures. Axial res is the ability to distinguish two structures close together front-to-back (in tandem), lateral res is the ability to distinguish two structures side-by-side, and elevational res is the ability to distinguish two structures close together along the y-axis (vertical).

Temporal resolution is the ability to correctly determine the position of a structure at a particular instant in time.

The mnemonic **LATA** helps remember the synonyms for lateral resolution: Lateral, Angular, Transverse and Azimuthal. This type of resolution is defined as the ability to distinguish two structures close together side by side as two distinct structures. It is determined by the beam width. The more narrow the beam, the smaller the numerical value for the lateral resolution and the better the lateral resolution. Axial resolution is the ability of the transducer to distinguish two objects close together in tandem (front to back) as two distinct objects. The numerical value for axial resolution is ½ SPL. The lower this numerical value, the

closer two objects in tandem can be and still be distinguished as two distinct objects and the better (more optimal) the axial res. The mnemonic used to remember the synonyms for axial resolution is: **LARD** = longitudinal, axial, radial, range, and depth resolution. Range resolution is also used to describe the ability of pulsed-ultrasound to determine the precise location of a returning echo. Pulsed-wave Doppler is said to have range resolution because the machine "listens" for returning echoes only from the location of the sample gate or sample volume. Continuous wave Doppler is said to have range ambiguity (no range resolution).

Elevational resolution is determined by the height of the ultrasound beam. It is the ability to distinguish two objects close together along the y-axis (vertical = elevational). The shorter = thinner the beam the better the elevational resolution.

Temporal resolution is the ability to correctly determine the position of a structure at a particular instant in time.

<u>Temporal resolution</u> depends on 2 main factors:

- How much the object being imaged moves.
- The *frame rate* = # frames/sec = # images/sec

The ***frame rate*** depends on several factors:

- Line density = # scan lines / image
- # of foci (focal points) / line = pulses per scan line
- Imaging depth (listening time)

Decreasing the imaging depth decreases the time the machine has to wait for echoes to return to the transducer (listening time) and thereby allows the machine to increase the # of images/sec or frame rate. This improves the Temporal Resolution = the ability to accurately locate the position of a moving structure at a particular instant in time. An increase in heart rate will increase the movement of the heart and decreases temporal resolution. An increase in line density (# scan lines / image) will decrease the frame rate (# images /sec) and thereby decrease the temporal resolution. Increasing the number of foci per scan line increases the time required to image each scan line. This will decrease the frame rate and thereby decrease temporal resolution. M-mode images only along a single scan line, so it generally has better temporal resolution than 2D and 3D ultrasound both of which have multiple scan lines.

As described above, spatial resolution is the ability to accurately locate the correct position (space = place) of an object. Spatial resolution is NOT equal to temporal resolution and beam height, width, and spatial pulse length (SPL) are not related to temporal resolution. Sector width and depth are related to temporal resolution because decreasing the area imaged and the time required to create a frame/image will improve temporal resolution.

References:

1.Understanding Ultrasound Physics by Edelman, S K 2nd ed. page 90, 121-124

2. Understanding Ultrasound Physics by Edelman, S K 3rd ed. page 148

3. Diagnostic Ultrasound, Principles Instruments and Exercises, 3rd edition by Kremkau, F.W. page 100