Physics of Ultrasound

Lecture9

Image Characteristics in Clinical Ultrasound

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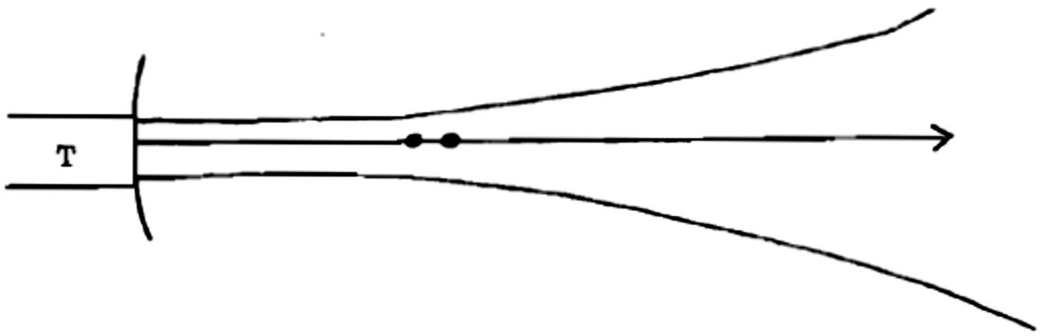
1. Introduction

- The quality of a diagnostic image is of the utmost importance III determining its usefulness.
- The overall quality of the ultrasound image is the end product of a combination of many factors originating not only from the imaging system but also from the performance of the operator.
- All the components of the imaging system, including the transducer, the electronics, image processing, display, and recording devices, impact on the ultimate quality of the ultrasound image.
- It is necessary to emphasize the multi factor nature of image quality in clinical ultrasound because experience shows that the very best of equipment used by an unskilled operator will generate poor quality images, as will unsatisfactory equipment in the hands of a highly qualified operator.
- For the ultrasound image, components of resolution include spatial resolution, temporal resolution, and contrast resolution.
- It is appropriate to consider the factors which affect resolution in some detail, because the optimum choice of these factors very often involves making compromises in the manner of give and take, an essential feature in the optimization of the ultrasonic image

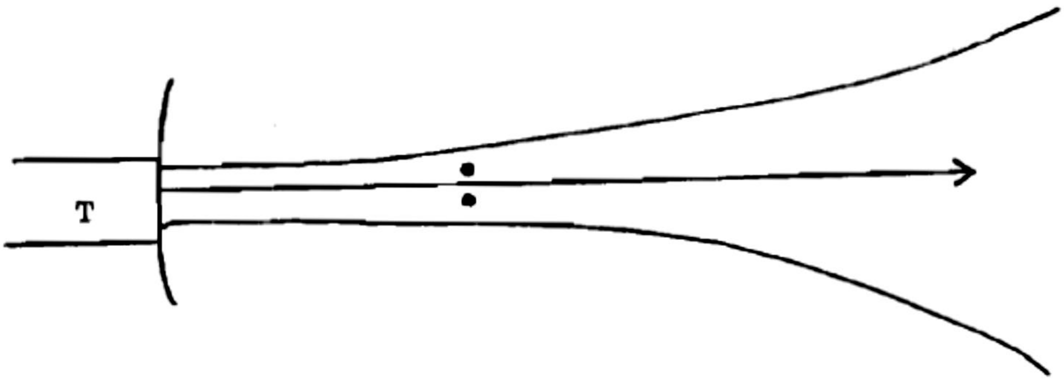
2. Spatial resolution

- Spatial resolution describes the ability to distinguish between objects located at different positions in space.
- In reference to the ultrasound image, spatial resolution is concerned with the ability to distinguish between two reflectors in space.
- It affects in a major way the capability of the imaging system to depict structural detail.

- Spatial resolution is divided into two components. Axial resolution is the ability to distinguish between echoes originating from two reflectors lying one behind the other along the axis of the ultrasound beam.



- It is sometimes referred to as depth resolution. Lateral resolution is the ability to distinguish between two reflectors situated side by side in a direction perpendicular to that of the ultrasound beam.

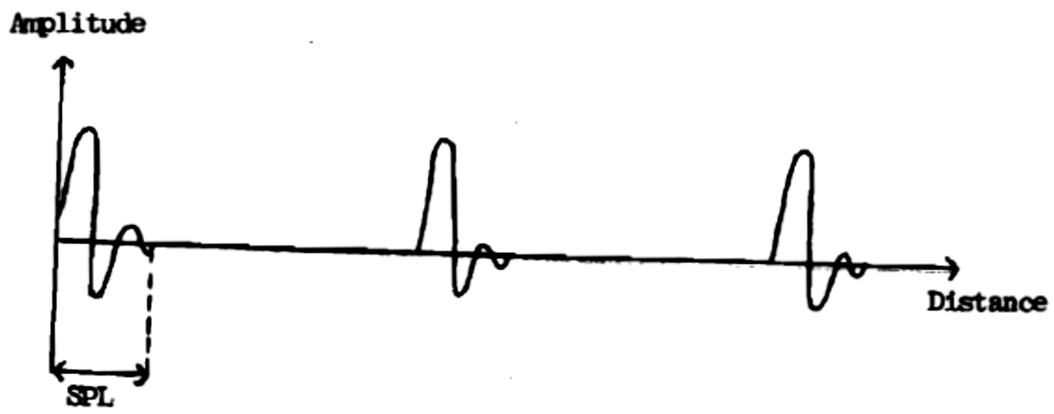


Axial resolution

Axial resolution is determined by the length of the ultrasound pulse. The variations of wave amplitude with time and distance, and the simple wave parameters of wavelength, frequency, and period, In pulsed wave (PW) ultrasound, the vibrations of the crystals which generate the ultrasound beam are effected in very short pulses, comprising just a few cycles. In between pulses, there are comparatively much longer (non-generating) intervals during which the transducer serves as a receiver. The duration of the pulse is equal to the wave period multiplied by the number of wave cycles in the pulse.

Pulse duration = Period x Number of cycles in pulse.

To achieve the short pulses, the vibrations of the crystal are deliberately damped using materials which strongly absorb ultrasound, otherwise the crystal would continue to vibrate under resonance. The damping material is placed in contact with the back face of the crystal. the variation of wave amplitude with distance for damped oscillations in PW ultrasound show in figure



The wavelength remains constant, but the amplitude decays with distance. The oscillations eventually cease altogether after a distance known as the spatial pulse length (SPL). The SPL is the product of wavelength and the number of wave cycles constituting the pulse.

Spatial pulse length = wavelength x number of cycles in pulse

Pulses with identical waveforms are repeated each time the crystal is excited, at a rate known as the pulse repetition frequency (PRF). The PRF represents the number of pulses, or bursts of ultrasonic energy, released by the transducer in one second, and is not the same thing as the vibration frequency of the transducer.