Major Aspects for Ultrasound Equipment in Medical Applications

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Abstract: this medical device is one of the most important radiology devices used to diagnose patients. This machine is utilized to generate an image of interior body structures and endeavor to discover a cause of an illness or to eliminate pathology. Compared to other prevalent processes of medical imaging, ultrasound has a key advantage which is providing images in real-time.

Keywords: Echo, Sound Wave, Ultrasound and Transducer.

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1. Introduction

Before the middle of the last century, specifically in 1940, the American scientist Floyd was able to invent the first ultrasonic echo imaging equipment [1]. It was first used to reveal interior flaws in the mineral casting. Shortly thereafter, this technique entered the medical field [2]. The first physician who used the ultrasound waves in diagnosing human structures was John Wild. He used the ultrasound waves to estimate the density of bowel tissue. Not only this, but he was also known as the father of medical ultrasound [3].

The working principle for the ultrasound equipment is represented in 3 phenomena. The first step is generating a sound wave, then drawing the echoes and the last step is interpreting the echoes.

i. Generating a sound wave: A piezoelectric transducer is a chip responsible for producing a sound wave. This transducer is masked in a plastic covering. Then, electrical pulses lead the transducer at the required frequency. Moreover, modern approaches of transducers utilize phased array technologies to qualify the equipment to alter the tendency and depth of focus. Here, the sound wave is converged by two techniques. The first technique is the form of the transducer. The other technique is the complicated series of control pulses from the scanner. In fact, the sound waves move to the structure of the body and focuses on a required depth [4].

ii. Drawing the echoes: In this step, the returning sound wave from the body vibrates the transducer. This will generate electrical pulses that move into the scanner which will be responsible for processing and converting the electrical pulses into a digital image [5].

iii. Interpreting the echoes: In this stage, two principles should be determined by the ultrasound scanner. The first principle is determining the time that requires the sound wave to be produced and returned as an echo wave. The second principle is determining the strength of the echo wave. After determining these two principles, then, the ultrasonic scanner enables to determine the location of the pixel in the image to ignite as well as its intensity [6].

2. Working Principle

Indeed, the density depth depends highly on the media that the electrical pulses pass through. However, if the electrical pulses strike either gases or solids, then, the density difference will be considerable. Hence, a large amount of acoustic energy is reflected which will lead to difficulty on discovering deeper. The promptness of sound waves differs when it moves through various media. This velocity depends mainly on the acoustical impedance of the media. Besides, the sonographic tool proposes that the acoustic speed is fixed at 1540 meter per second. This proposition affects the body with non-uniform structures where the ray turns into a little de-focused as well as the resolution of the image is decreased [7, 8].

For producing a two-dimensional image, the ultrasonic waves are swept. There are two approaches to sweep the transducer which is either mechanically or electronically. The obtained data is addressed and utilized to structure the image. This image is after that a two-dimensional performance of the interior structure of the real body. In fact, three-dimensional images might be produced via obtaining a sequence of contiguous two-dimensional images.

Besides two-dimensional images and three-dimensional images, there is also Doppler ultrasounds which are utilized to address the flowing of blood and the movement of muscles. Here, the various received velocities are performed in color owing to easiness of performance. Colors might alternately be utilized to illustrate the capacities of the received echoes.

3. Modes of Ultrasound

There are different modes of ultrasound utilized in medical imaging such as

i. A-mode: The letter "A" here is the abbreviation of amplitude. In fact, the amplitude of the reflected wave is demonstrated on an oscilloscope display. This mode is considered the plainest kind of ultrasounds. Here, a singular transducer scans a line over the body with the waves represented on screen as a representation of depth. An example of this mode is the therapeutic ultrasound that targeted at a precise tumor [9, 10]. Figure (1) below illustrates the A-mode

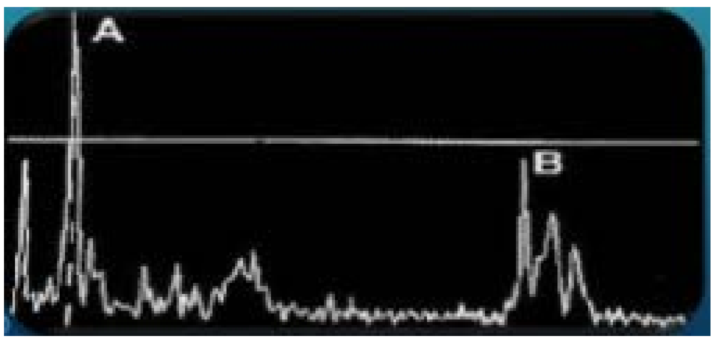

Fig1: A-Mode

ii. B-Mode: The letter "B" here is the abbreviation of brightness. Indeed, a linear array of transducers altogether scans a scale over the body which can be examined as a two-dimensional image on the monitor. So, it is sometimes called a 2D-mode. This mode is considered an important imaging modality in the diagnostic ultrasound. An amplitude of the received ultrasound signal is transformed into a gray scale image [11, 12]. Figure (2) below shows the B-mode.

Fig (2): B-Mode

iii. D-Mode: The letter "D" here is the abbreviation of Doppler. This type of modes is based on Doppler's effect. The modification in frequency is triggered by the mutual activities of sound generator and the observer. There are different types of this mode such as color Doppler, Continuous Wave (CW) Doppler and Pulsed Wave (PW) Doppler [12]. Figure (3) below illustrates the D-mode

Fig 3: D-Mode

iv. M-Mode: The letter "M" here is the abbreviation of motion. This mode imitates the movement of the organ's structure such as the heart over time because of its outstanding chronological resolution. It is considered the most precise mode among all. After a while, this is equivalent to recording a video in ultrasound [13]. Figure (4) illustrates the M-mode

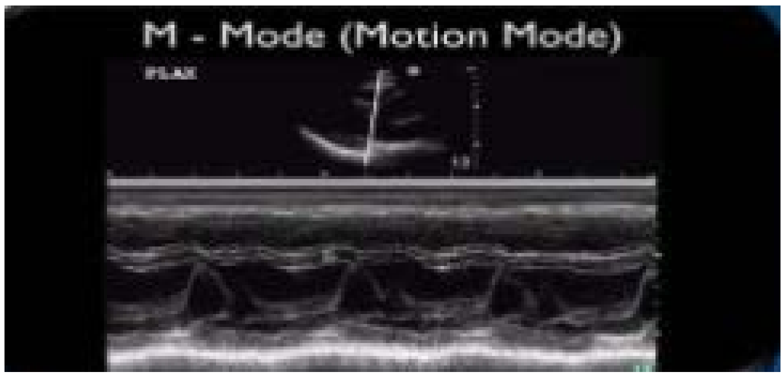

Fig (4): M-Mode

4. Maintenance, Safety and Precautions

Many biomedical engineers' advice physicians that frequently use ultrasound machines to properly calibrate the equipment after every six months. They also requesting from them to clean all external surfaces and filters. Besides, they also inform the technicians and the operators to frequently check system and power supply fans. They also advice technicians to look over system controls, power cords and cables for crack, cuts and wear [14].

Having considered some rules in preventive maintenance of ultrasound machines, it is also reasonable to look at some steps associated with safety and precautions. One of the important rules in this manner is the aim of reducing the potential of adverse events, so that the operator has to utilize least exposure to accomplish anticipated reimbursements. Moreover, the physician should care about the transducer position. It should be at an angel of 90' during use and has to gradually transfer with the purpose of reducing the hazard of triggering hot spots [15].

Another advice associated with ultrasound is to disconnect the probe when the patient feel of any pain during diagnosing. The reason behind this cause is that the overheat of tissue.

5. Conclusions

The ultrasound machine is considered a safe and painless equipment. It can image muscles, soft tissues and bone surfaces perfectly and is predominantly convenient for allocating the boundaries among hard and fluid-filled spaces. Ultrasound machine extracts "live" images, where the physician enables to animatedly chose the most valuable subdivision for identifying and authenticating variations, frequently permitting prompt diagnoses. Live images similarly permit ultrasoundchannelled operations or injections, that might be burdensome with other imaging modalities. Moreover, ultrasound machines can illustrate the composition of organs.

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