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Ultrasound Waves Employment in the Medical Diagnostic for Lıver and Gallbladder

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Abstract:

Ultrasound imaging is nowadays a well established imaging technique for medical diagnostics. In fact, ultrasound is the fastest, least invasive and least expensive, screening modality for imaging kidneys and other organs, therefore it is commonly used in clinical practice for assessing possible abnormalities is several parts of the human body. Through the relation between physics and medicine by employing the ultrasound waves to in medical diagnostics for liver and gallbldder appear the normal liver with gray color while gallstones appear with (hyperechoic) white color because attenuation artifact where this artifact is caused by partial or total reflection or absorption of the sound energy.

Keywords:

Ultrasonic, hepatomegaly, cholecystitis, gallstones.

1.Introduction:

Sound is a mechanical wave that travels through an elastic medium. Ultrasound (US) is sound at a frequency beyond 20000Hz, the limit of human hearing. The frequency range of diagnostic (US) is between (1-20MHz) [1,2]. Ultrasound waves are longitudinal, compressional waves, that can be periodic or pulsed, propagate at roughly 1500 m/s in water or biological tissue, can leave the medium unchanged (diagnostic ultrasound), but at higher intensities can also change it (therapeutic ultrasound) [3]. Diagnostic ultrasound is based on the pulse- echo principle and widely used in medicine[1,2]. The smallest functional units of the transducer are the piezoelectric crystals.

The crystals are embedded in the probe, and each crystal has a specific frequency. Some of the energy is absorbed in the tissue and some is reflected. The reflected energy is received by the probe, which calculates the depth of the interface by measuring the time taken to return [2]. Present medical ultrasound transducers are constructed of arrays with several piezoelectric crystals. During the transmission phase, the crystals can be activated either in groups (linear transducer) or all at the same time (phased array transducer). The linear transducer normally operates at a high frequency range (4-15 MHz), and the phased array transducer at a low frequency range (1-3 MHz). An ultrasound system can operate in several different imaging modes, providing both two- dimensional (2D) and three-dimensional (3D) images [4].

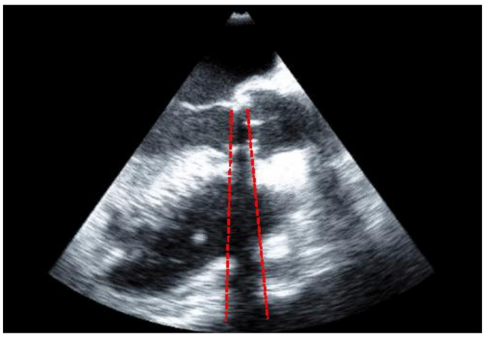
The human body is composed of three basic materials differing in acoustic impedance: gas with a very low impedance, bone with a very high impedance and soft tissue with an impedance somewhere in between. The large mismatch between air, bone and tissue causes 100%, of the sound to be reflected at air/ tissue interfaces and almost all the sound at bone/ tissue interfaces, there is a small mismatch between different soft tissue in impedances a fact that is the basis for diagnostic ultrasound [2].The sound is generated by a transducer that first acts as a loudspeaker sending out an acoustic pulse along a narrow beam in a given direction. The transducer subsequently acts as microphone in order to record the acoustic echoes generated by the tissue along the path of the emitted pulse. These echoes thus carry information about the acoustic properties of the tissue along the path. The emission of acoustic energy and the recording of the echoes normally take place at the same transducer, in contrast to CT imaging, where the emitter (the X-ray tube) and recorder (the detectors) are located on the opposite side of the patient [5].

2.Theoretical part:

Ultrasound imaging produces gray-scale images that consist of bright points of different intensities on a dark background. Darkness in the image means absence of echoes from that area, or that the emitted ultrasound has failed to reach that specific area. Consequently, brightness in the image means that a part of the emitted ultrasound wave has echoed back . the reasons for the generation of echoes /bright areas in the image are mainly two folds. Firstly, when a sound wave is propagating through a homogenous medium no energy of the sound wave is reflected back and consequently the resulting image is dark. However, if the examined volume constitutes of several media with different acoustic impedance, some of the energy is reflected back in the transition from one medium to another medium. Acoustic impedance is an important media characteristic in ultrasound imaging; it is the product of the density and the speed of sound of the media.

The border between two different medium with the same acoustic impedance cannot generate a returning echo; the ultrasound wave passes through the interface without loss of energy in the form of a returning echo. It is the returning echoes from the interface between different medium that constitute the information about the examined structure in the ultrasound image. The proportion of the energy that is reflected back depends mainly on the difference in acoustic impedance and to a lesser extent by the angle of incidence. Secondly, echoes can arise within inhomogeneous medium because of the scattering effect by very small objects in the size of the wavelength or smaller. These small objects are too small to be individually resolved in the ultrasound image. The echoes generated in this way are very weak compared to echoes from interface transitions and are undetectable. A very large number of echoes from many scatters can however be added together by constructive interference and become detectable. This phenomenon is seen in almost every tissue in the body except blood and gives rise to so-called speckles in the ultrasound image. The ultrasound image is built up from scan lines. Sound waves propagate in straight lines. If the sound waves interact with the tissue media during the propagation along the scan lines and are reflected back, an echo can be registered by the ultrasound scanner. The placement of the echo signal along a scan line depends on two factors; the time for the ultrasound to return back to the transducer and the propagation speed of the sound in the material. The travel time can always be measured accurately by the ultrasound scanner. It is however more problematic to know the propagation speed of the sound since the human body consists of many tissue types with different properties.

The speed of sound in soft tissue of the human body is ranging from about 1440 m/s in adipose tissue to 1580 m/s in muscle tissue. Therefore the manufacturers of ultrasound scanners use a fixed mean value regardless of tissue type. The mean value differs between the manufacturers, but is in the range of 1540 – 1560 m/s[6]. And the impact of structural noise on medical ultrasound images is much stronger than the influence of speckle noise, since it not only effects single pixel but whole image regions. In general, structural noise occurs in the presence of strong reflectors in the image, e.g., bone structures or air. One canonical example of structural noise is induced by insuffient covering of the US transducer with acoustic coupling gel.



(a)

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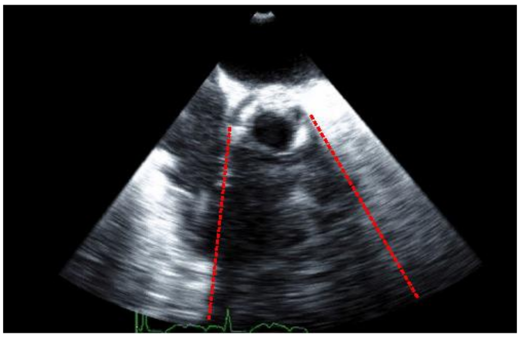

(b)

Figure(1) : a, b) Illustration of shadowing effects of different extend due to strong reflectors in two US B- mode images[7].

This causes strong reflection right at the transducer due to the presence of air bubbles, which have a significantly lower acoustic impedance. The immediate reflection of ultrasound waves leads to dropout of signal in the image regions beneath the air bubbles [7]. The most important from of structural noise within this work are so called acoustic shadowing effects. Acoustic shadowing occurs when a strong reflector (having a significantly different acoustic impedance as the surrounding tissue) blocks the transmission of ultrasound waves beyond that point [7], e.g., bones or the lungs. Similar to the shape of a shadow caused by in transparent objects in a light beam, the acoustic shadow follows the transmission path of the ultrasound waves.

This leads to the fact that a small reflector near the transducer can cause large shadowing effects to the image regions beyond. Typically, these regions appear dark with only little signal intensities, since almost no ultrasound echo is received from these regions. Figure(1) shows typical structural artifacts caused by shadowing effects in two situations with different extend. Due to the presence of a strong reflector in the upper part of the US B-mode images, one obtains images perturbed by acoustic shadowing (delineated by the red dashed lines). As can be seen, almost no information can be received from the shadowed regions.

Furthermore, the closed contour of the connected anatomical structure in fig (1a) shows gaps. Another class of structural noise artifacts is caused by reverberation. Reverberation is caused by two or more highly- reflective interfaces and leads to multiple linear high- amplitude ultrasound signals projecting the structure of the reflectors repeatedly beneath the correct image position [8]. the reason for this effect is that ultrasound waves are reflected several times between the reflectors. At each reflection a part of the ultrasound waves is transmitted back to the transducer, leading to a periodic received signal[9].

3.Experimental part:

To prepare the patient for liver examination : the patient should take nothing by mouth for 8 hours before the examination. If fluid is essential to prevent dehydration, only water should be given. If symptoms are acute, the examination should be undertaken immediately. In the case of infants, if the clinical condition of the patient permits, they should be given nothing by mouth for 3 hours before the examination. Position of the patient will performed with the patient in the supine, left - oblique and left - lateral decubitus positions. For adults, use a 3.5- MHZ transducer. For child and thin adults, use a 5- MHZ transducer, and the scanning should be in the sagittal, transverse and oblique planes, including scans through the intercostal and sub- costal spaces as in figures (2), (3), (4), (5) .

(a)

(b)

Figure (2): a) sagittal scan plane, b) the Liver and Right Kidney are visualized in this view.

(a)

(b)

Figure (3): a) costal scan plane, b) the Middle and right Hepatic Vein are visualized in this view.

(a)

(b)

Figure (4): a) sub-costal scan plane, b) Right Portal Vein is shown coursing transversely in this view.

(b)

(a)

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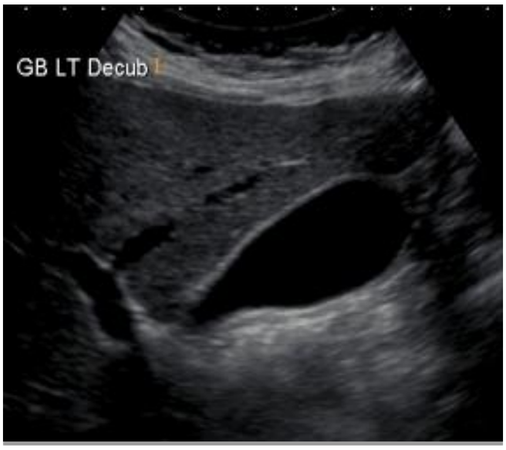
(b)

Figure (5): a) transverse scan plane, b) normal anatomy seen in the transverse view of the left lobe.

But gallbladder examination as liver examination , but the patients lying in the supine position. It may be necessary to turn patients onto the left side or to examine them in the erect position or on their hands and knees. Apply coupling agent liberally to the right upper abdomen and then to the left upper abdomen, because, whatever the symptoms, both sides should be scanned. For the scans, ask patients to hold their breath with the abdomen ″ pushed out ″ in full expiration .With scanning technique Start by placing the transducer centrally at the top of the abdomen (the xiphoid angle).

Angle the beam to the right side of the patient to image the liver and adjust the gain to obtain the best image. Start with longitudinal scans, followed by transverse; add intercostal scans if needed. Then turn the patient on the left side and make oblique scans at different angles. The best method for visualizing the proximal common duct and gallbladder is aright anterior oblique view with the patient in a left posterior oblique of left lateralecubitus position during deep inspiration figure (6).

(a)



(b)

Figure (6): a) Right anterior oblique scan, b) common bile duct and the gallbladder are visualized in this view.

The machine used in figure (7) from type “sonoscape ultrasound” consist of following parts: Transducer (probe),Central Processing Unit (CPU),Display, Transducer pulse controls, Disk storage, Printers, and Keyboard (cursor).

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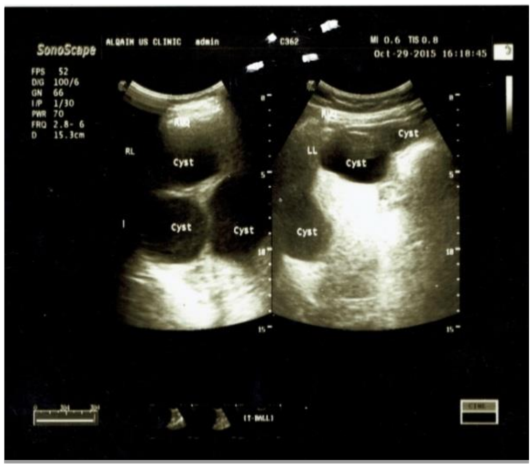
Figure (7): machine used "type Sonoscape ultrasound".



(a)

(b)

(c)

4.Discussion:

Figure (8a), the fatty changes denote to liver, and the scan is sagittal through it, liver is increase in size 170mm (hepatomegaly), no intrahepatic billiary dilatation, but there are cysts more than 6 in right and left lobes appear with black color, large one 50mmx 50mm look alike hydrated cysts (H- cyst). Figure (8b) indicates that, black colors denote to GB and CBD, and transverse scan through them, Gallbladder distended 120mm x 35mm, and increase wall thickness (picture of acute cholecystitis), no gallstone, but CBD dilated 10mm and there is a stone 4mm in CBD.

While figure (8c), sagittal scan through gallbladder, the black color denotes to GB and it contains small gallstones and sludge as shown in white (hyperechoic) colors. In figure (8d), the gray color on the left upper quadrant of image denotes to the liver, liver is normal in size , heterogeneous texture, and there are multiple different sizes hypoechoicfocal metastatic lesions, largest one about (3cm x 3.5cm) at the right lobe and Gallbladder cannot be visualized because it removed (cholecystectomy),the black color on the right lower quadrant of image denotes to portal vein about 18mm. in max. diameter where the scans are transverse and sagittal through liver.

(d)

Figure (8): shows medical diagnostic for liver

a) Liver with hydrate cysts (H- cysts).
b) Shows cholecystitis.
c) GB contain small gallstones.
d) Liver with normal size.

5.Conclusion:

1. Gallbladder can better be evaluated with fasting for at least four hours for goog distension.
2. Different position better than one position to achieve good image for each organ.
3. Linear probe with frequency 7.5MHz can use in examination of kidneys in thin adult patients and in pediatric for more resolution to curvilinear probe with frequency 3MHz.

6. Future Works:

1. Employ radioactive isotopes in diagnostic imaging that emit gamma- rays as they decay.
2. Study techniques and radiation dose in CT examinations of adults patients.
3. Develop biomedical instruments to measure highly polarized nuclei in MRI.

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