

“Ultrasound” As An Application Of Physics And It’s Uses In Modern Day Medicine”.

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Abstract:

Ultrasound is the term used to describe all acoustic energy with a frequency higher than human hearing (20,000 hertz or 20 kilohertz). Standard operating frequencies for diagnostic sonographic scanners vary from 2 to 18 megahertz, which is significantly over the range of human hearing. Higher frequencies can be used to create sonograms with finer details because they have shorter wavelengths. Often referred to as Ultrasonography (USG), diagnostic sonography is an ultrasound-based imaging technique for spotting anomalies or lesions in subcutaneous body parts such as tendons, muscles, joints, arteries, and internal organs. Sonography is a helpful tool to observe what is happening in your body's soft tissues. Radiologists maneuver a hand-held probe called a transducer over and around the patient (sonographers). The ultrasound is coupled between the transducer and the patient using a water-based gelly. ^(1, 2).

USG was discovered 12 years before the X-ray (1883), but it was only used in medicine much later. Detecting submarines was the first practical application of ultrasonography during World War I. Ultrasound was first used in treatment in the 1950s. It was first used in obstetrics and then in all departments of medicine (general abdominal diagnostics, pelvic diagnostics, cardiology, ophthalmology, orthopedics, and so on) (3). Ultrasound has good vision properties and is a reasonably simple and operator-dependent study from a clinical standpoint ^(4,5). Since the introduction of gray-scale signal processing in 1974, B-mode sonography has become a generally accepted approach. Better spatial resolution and imaging of highly minute structures in the abdomen (0.5-1 cm) have resulted from advancements in transducer design ⁽¹⁾.

Keywords: Ultrasound, Piezoelectric, Truma, Dynamic, Echocardiography

PHYSICS

Unlike X-rays, ultrasound requires a medium to travel through. Ultrasound waves with a frequency of 2-10 MHz are used in diagnostic ultrasound. (Audible sound frequency: 2-20,000 Hz) The pulse-echo principle underpins ultrasonography, which means that a pulse of high-frequency sound (ultrasound) is sent from the transducer and transmitted into the body. The ultrasonic vibration passes through the body until it reaches a reflecting surface, where it is reflected back to the transducer in the form of an echo. The transducer only generates pulses for less than 0.1 percent of the time, leaving it with >99.9% of the time to listen for returning echoes. The time it takes for the pulse to travel a certain distance is proportionate to that distance, allowing the position of the reflecting surface to be determined, which will be displayed as a dot on the ultrasound screen at the correct depth. The amount of the ultrasonic pulse that is reflected determines the brightness of the dot. As ultrasound travels through tissues, it grows weaker: this is called the attenuation. ⁽²⁾

Interpretation: Artifacts And Other Difficulties:

Ultrasound is a technology that is known to be operator-dependent. It is a form of study that is constantly changing. Unlike radiography, where the images are an objective document, ultrasound images must be analysed as they are taken. Hard copies are typically generated to document an observation rather than to produce something that can be interpreted afterwards. In addition to having the essential knowledge of anatomy, the operator correctly prepares the patient, selects the appropriate scanning technique and machine settings, and recognises artefacts. Because ultrasound allows for imaging anatomy in any chosen tomographic plane, the capacity to think in 3D and perceive anatomical structures such as viscera is also required. The position, size, shape, echogenicity (echo intensity: hyper-, hypo-, an-, isoechoic, or mixed) and echotexture of the structures visible during the echographic exam are frequently examined (fine, coarse, uniform or nonuniform parenchymal texture, which depends on the size, spacing and regularity of the dots that form the image). For the various organs and tissues, all of these criteria are standardised. The liver, for example, is described as having a medium amount of echogenicity, a uniform and homogeneous parenchyma, and a texture coarser than the spleen. The operator's assessment of the sonographic appearance, the machine's settings and the presence of artefacts remain relatively subjective. ^(1,2,3)

Uses Of Ultrasound In Modern Day Medicine :

As it is rightly said by the radiologists that Air is the enemy of the ultrasound as the sound waves dissociate in the air but fluid is the friend, so taking this analogy into consideration here are few important uses of ultrasonography

Skull

USG is the most practical technique to diagnose Hydrocephalus in infants up to 18 months of age. As the age advances the ultrasound can't penetrate the bone, therefore clinicians have to order other modalities of investigation like X Ray, CT-Scan or MRI.

Face

1. **Eyes** A-scan mode of ultrasound called as amplitude scan is used to measure the axial length of eyeball which is integral part of any cataract surgery while B Scan is useful in diagnosis of Retinal detachment, Retinal Tumors, Vitreous hemorrhage
2. Using USG superficial lobe of parotid gland can be seen to diagnose any pathology relating to clinical symptoms

Neck

Ultrasound is an important investigation when it comes to thyroid gland, Benign and malignant masses can be diagnosed according to the echogenicity of the mass present in thyroid USG guided Fine needle aspiration cytology is then used to confirm the malignant Nodules of thyroid.

Chest

2D echocardiography is an important ultrasound based investigation to diagnose the abnormal dynamic changes in the heart and valve motion abnormalities. Endoscopic ultrasound is also considered useful in cardiovascular evaluation in particular cases.

Ultrasound stands in the core triple assessment of the evaluation of breast/breast examination USG is the first and foremost investigation along with mammogram to evaluate a breast lump, USG gives an idea about the nature of lump and further roadmap can be drawn by the clinician about how to approach a case of breast lump.

Abdomen

Ultrasound can be considered the most important investigation as far as the abdominal cavity is considered USG is considered as the Gastroenterologist's Stethoscope. It is used in the diagnosis of liver pathologies, gallstones in gallbladder, distention of gall bladder. Endoscopic ultrasound a newer modality is used to visualize deep structures such as pancreas which are sometimes missed on CT scan Ultrasound is also very useful in the Obstetrics as it is Radiation less modality and easily accessible, Trans vaginal ultrasound as well as trans abdominal ultrasounds are performed Various Obstetric conditions like IUGR (intrauterine growth retardations), preterm baby, routine AnteNatal care, Ectopic pregnancies etc. Hydrocele, varicocele testicular torsion, epididymis orchitis are other medical conditions where ultrasound is useful.

Lower Limbs

In the Lower Limbs ultrasound doppler is the investigation for deep vein thrombosis, varicose veins, peripheral vascular disease etc.

Advantages And Disadvantages Of Usg:**1. Non Invasive Procedure**

As we are moving towards the era of ultra modern medicine, patient compliance and patient care is the utmost priority where non invasive procedures are much more preferred than an invasive procedure for example: biopsy Ultra sound is one of the best non invasive diagnostic procedures.

2. Non ionizing

As ultrasounds are not ionizing or non ionizing radiations, they are safe as far as risk of radiation is considered.

3. Easily Available

Ultrasound machines are easily available at all hospitals in the cities as well as peripheral hospitals

4. Cost effective

Ultrasounds can be performed at a minimal price as compared to the MRI and they take less time.

5. Portable

Ultrasound machines are portable and handy hence they are integral part of various lifesaving protocols where E-FAST (extended focused assessment with sonography for trauma) is used.

6. Real time

Ultrasound is a dynamic type of investigation where in you get the real time picture of the viscera eg: ultrasound of baby in the third trimester

7. Limitation of ultrasound

It is Operator dependent The operator has to undergo training and has to have a spatiovisual orientation that is the three dimensional perspective of anatomical structures, Important landmarks in our body.

Conclusion:

Considering the developmental status of our healthcare system in India, Ultrasound, which is an application of Physics is found to be widely accepted and considered to be an integral part of

various diagnostic Protocols Taking into consideration the advantages of this application it better suits our healthcare system. Further Research and modifications in this will be a next step towards ease of diagnosis for the doctors.

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