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Review Article

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Ultrasound in Medicine

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Abstract

Ultrasound waves are longitudinal and easily penetrate through tissues in the human body. Ultrasonic sources emit ultrasonic waves of a certain frequency which are reflected from the tissue and then detected via a detector. Reflected ultrasonic waves as analog information are converted into numerical information, and they are then mathematically processed in a computer and converted back into analog information which is then obtained in the form of an image. An ultrasound device is a device that gives cross-sectional images of the inside of the human body. The ultrasound examination procedure is the procedure of creating a two-dimensional and three-dimensional cross-sectional image of the interior of the human body.

Keywords: Ultrasound; Medicine; Surgery; Health

Introduction

Ultrasound works on the principle that the ultrasound emitted as a pulse from a transducer travel at constant velocity into tissue and is reflected by varying amounts from different tissue interfaces and travels back to the receiver at the same speed [1]. The transducer is a piezoelectric crystal that both transmits and receives the ultrasound. The time required for the pulse to travel to the interface and back can be used to determine the depth of that interface. An image of the slice of the body is obtained by directing a narrow beam of high-energy sound waves into the body and recording the manner in which the sound is reflected by different structures. Sound is transmitted well through any fluid but poorly or not at all through air or bone. Returning echoes are electronically converted into a video image on a monitor, the resulting picture being a wedge-shaped slice of the area of interest.

Advantages

a) It does not employ ionizing radiation and therefore produces no biological injury in the tissues.

b) Any plane can be employed to examine the region of interest.

c) It is less expensive than CT or MRI.

d) It can be used at the bedside if the patient is too ill to be moved.

Dimensions of organs or lesions can be measured, and the volume of the bladder and the left ventricle can also be assessed. Stones cause marked changes in acoustic impedance with almost complete reflection of ultrasound, showing echogenic foci with fan-shaped acoustic shadowing. Ultrasound is non-invasive, painless, safe and cheap in comparison with CT and MRI, although it does not produce as sharp an image. Low-intensity sound waves have no effect upon the material through which they pass and can be used for the non-invasive imaging of tissues, particularly for differentiating solid and cystic masses [2]. Ultrasound is employed to identify gallstones; intra-abdominal abscesses; ovarian and thyroid masses; and to demonstrate the tissues of the growing fetus. Using ultrasonography to guide a needle, it is possible to obtain fluid for cytology and tissue for histology. The higher the frequency of the sound waves, the better the image resolution, but the less the penetration of the ultrasound beam into tissues. Thus, the greatest diagnostic precision is obtained by placing the source of the waves as close as possible to the tissues to be imaged. Pelvic tissues can be displayed using vaginal and rectal probes. Other abdominal and thoracic structures can be imaged by endoscopic and laparoscopic instrumentation. Exploiting the Doppler technique of change in frequency induced by motion, ultrasonic vibrations can be applied to measure the rate of blood flow. There are theoretical

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disadvantages. DNA may be degraded by high-intensity ultrasound, but there is no evidence that this change occurs in the range of frequencies selected for diagnostic purposes.

Technology

Healthcare technology is becoming more and more advanced and portable [3]. The process of advancement has also been applied to imaging techniques and especially to ultrasound. This constant development affected the field of ultrasound very deeply because, throughout the years, machines have undergone a "miniaturization" process in terms of dimensions with a concomitant boosting/improvement in relation to their technical effectiveness. Nowadays ultrasound machines are highly performant, portable, and light instruments, equipped with advanced settings (i.e., store and forward wireless capabilities) and long-lasting batteries that allow their use in various settings; the new maneuverable ultrasound machines can, therefore, be easily transported and used throughout the emergency rooms, in intensive care units (ICU), operating rooms (OR), and hospital wards. The technological evolution of point-of-care ultrasound has determined its rapid diffusion in different medical fields, allowing its use by a growing number of physicians like anesthesiologists, surgeons, and emergency medicine doctors that previously relied only on ultrasonographic diagnosis performed by radiologists or other specialists (cardiologists, gynecologists, urologists). Ultrasound is a simple method of assessing superficial parotid, submandibular, and sublingual masses, without the use of ionizing radiation. It is reliable at distinguishing intraglandular from extra glandular masses [4].

Ultrasound is defined as a mechanical vibration transmitted at a frequency above the upper limit of human hearing (>20 kHz) [5]. One of the main mechanisms of action for ultrasound is achieved through the process of cavitation. Cavitation involves the production and vibration of micron-sized bubbles within the coupling medium and fluids within the tissues. As the bubbles collect and condense, they are compressed before moving on to the next area. The movement and compression of the bubbles can cause changes in the cellular activities of the tissues subjected to ultrasound. Microstreaming is defined as the movement of fluids along the acoustical boundaries as a result of the mechanical pressure wave associated with the ultrasound beam. The combination of cavitation and microstreaming which are more likely to occur with kilohertz ultrasound, provide a mechanical energy capable of altering cell membrane activity.

Screening

Findings in molecular research have provided new impetus for the use of stem cells in the treatment of gastrointestinal and liver diseases [6].

Injuries

Focused abdominal sonography for trauma (FAST) is a standardized ultrasound examination that aims to identify the presence of free fluid in the pericardium and peritoneal cavity [7]. As an initial diagnostic adjunct, the ultrasound has several advantages: It is noninvasive, repeatable, accessible, portable, rapid, and cost-effective. However, ultrasound is highly operator dependent, and several patient related factors, such as subcutaneous emphysema, morbid obesity, severe chest wall injury, narrow subcostal area, and a large hemothorax, may limit adequate image acquisition. Physical examination alone is unreliable for the diagnosis of intra-abdominal injuries in patients who have sustained blunt abdominal trauma. Diagnostic imaging is therefore relied on to diagnose or rule out intra-abdominal injuries. The ideal screening examination for intra-abdominal injuries would have a high degree of sensitivity, which would allow for the safe exclusion of significant injuries while maintaining an acceptable specificity, effectively decreasing the number of patients requiring definitive imaging. The use of abdominal ultrasound for detecting the need for operative intervention in a patient who has sustained a penetrating trauma to the abdomen carries a low sensitivity and a high specificity [8]. The use of abdominal ultrasound for detecting the need for operative intervention in a patient who has sustained a penetrating trauma to the abdomen carries a low sensitivity and a high specificity.

Central Venous Access

The applications for ultrasound imaging have extended beyond the realm of diagnostic radiology to provide new treatment potential [9]. The patient's state of health may [10] require more invasive monitoring, such as arterial cannulation and central venous pressure monitoring on occasion, it may be necessary to place these before induction of anesthesia. The localization of the internal jugular vein to allow central venous cannulation is currently an area of great debate. Complications may occur in up to 10% of cases and the failure rate may be as high as 35%. There are many important surrounding structures that may be damaged; notably the carotid artery may be punctured and incidences of 1-3% have been reported. Rarely a pneumothorax may occur (although this is more common with the subclavian vein approach). Thus there has been increasing interest in the use of two-dimensional ultrasound as an aid in the placement of central venous catheters and recently the National Institute for Clinical Excellence has recommended this as the preferred method for insertion. Other complications of central venous catheterisation include infection, haematoma formation, thrombosis of the vessel, the creation of an arteriovenous fistula, cardiac tamponade, arrhythmias, brachial plexus damage and air (and catheter) embolism.

Doppler Principle

Ultrasound can be used to detect blood flow and produce images of deep structures [11]. The ultrasound is generated by exciting a piezo-electric crystal to vibrate at its resonant frequency in response to a small electric current.

Prenatal Diagnosis

The vast majority of prenatal diagnostic studies are performed to rule out a chromosomal abnormality, but cells may also be propagated for biochemical studies or molecular analyses of DNA [12].

Conclusion

The properties of a tissue can be determined based on the speed at which the ultrasound spreads in the tissue. The resistance offered by tissues to the spreads of ultrasound can be monitored on the screen by means of electronic devices by converting reflected ultrasonic waves into electrical pulses. Due to its great penetration and interaction with tissue, ultrasound is widely used in almost all branches of medicine, and, above all, in diagnostics. Weak ultrasound is used in medicine. According to previous research, ultrasound did not show any harmful biological or mechanical effects on the human body and in diagnostic doses proved to be completely safe. There is no ionizing radiation during the ultrasound, so the test or treatment can be repeated several times.

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