REVIEW ARTICLE

REVEALING THE HIDDEN FACTS IN ULTRASOUND

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ABSTRACT:
Diagnostic ultrasound is a rapidly developing imaging technology which is widely used in both industrialized and developing countries. Since its introduction in the 1960s, ultrasound has found widespread application in anatomical imaging, blood-flow measurement, and evaluation of physiology in almost all aspects of medicine. As ultrasound instruments have become smaller, less expensive, and easier to use, diagnostic ultrasound has become increasingly popular among a wide variety of physicians. Ultrasound imaging technique has replaced or complemented a large number of radiographic and nuclear medicine procedures and has opened new areas of diagnostic investigation. Ultrasound is considered as the primary imaging modality for the detection of most gynaecological, hepatic, biliary, pancreatic, splenic, and renal diseases and for examination of the scrotal contents, bladder, and prostate. In many developing countries, diagnostic ultrasound may find an important application as an epidemiological screening and diagnostic procedure for a number of parasitic diseases, such as amoebiasis, schistosomiasis, and echinococcosis.
Key Words:-Equipment, Mechanism, Principle, Ultrasound, Uses

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INTRODUCTION

Ultrasound is like audible sound, except at a very high frequency, which means that the pitch is so high that the sound is inaudible to human beings. In diagnostic ultrasound, also known as sonography, the physician or technician places the transducer, or ultrasound probe, in or on the patient's body.[1] Pulsed ultrasound waves emitted by the transducer pass into the body and reflect off the boundaries between different types of body tissue. The transducer receives these reflections, or echoes. A computer then assembles the information from the reflected ultrasound waves into a picture on a video monitor. The frequency, density, focus and aperture of the ultrasound beam can vary. Higher frequencies produce more clarity but cannot penetrate as deeply into the body. Lower frequencies penetrate more deeply but produce lower resolution, or clarity.[2]

Ultrasound has been used to image the human body for over half a century. Dr. Karl Theo Dussik, an Austrian neurologist, was the first to apply ultrasound as a medical diagnostic tool to image the brain. Today, ultrasound (US) is one of the most widely used imaging technologies in medicine. It is portable, free of radiation risk, and relatively inexpensive when compared with other imaging modalities, such as magnetic resonance and computed tomography. Furthermore, US images are tomographic, i.e., offering a "cross-sectional" view of anatomical structures. The images can be acquired in "real time," thus providing instantaneous visual guidance for many interventional procedures including those for regional anesthesia and pain management.[3] In this manuscript, we describe some of the fundamental principles and physics underlying US technology that are relevant to the pain practitioner.

Diagnostic ultrasound is recognized as a safe, effective, and highly flexible imaging modality capable of providing clinically relevant information about most parts of the body in a rapid and cost-effective fashion. Obtaining maximum clinical benefit from diagnostic ultrasound, as well as ensuring the optimal utilization of health care resources, requires a combination of appropriate instrumentation and skills in both the performance and interpretation of examinations.[4]

The proper, safe, and effective use of diagnostic ultrasound is therefore highly dependent on the user, who has a major impact on the examination's overall benefit. In fact, the skill and training of the user are often more important than the equipment used. For this reason, standards for ultrasonography training are a prerequisite for the provision of diagnostic ultrasound services of high quality.

Equipment and techniques

WHO has published specifications for a general purpose ultrasound scanner. This is a general purpose imaging unit without Doppler or flow-imaging capability, and is recommended as suitable for a medical centre with standard X-ray equipment, such as the WHO Basic Radiological System. Such a combination is typical of most parts of the world. More sophisticated diagnostic ultrasound, including pulsed spectral Doppler and colour Doppler and specialized probes for endovaginal, endorectal, endo-oesophageal, intraoperative, laparascopic, and endoluminal applications, is available in more affluent areas of the world, usually in the hands of specialists

A Doppler ultrasound study may be part of an ultrasound examination. Doppler ultrasound is a special ultrasound technique that allows the physician to see and evaluate blood flow through arteries and veins in the abdomen, arms, legs, neck and/or brain (in infants and children) or within various body organs such as the liver or kidneys.

There are three types of Doppler ultrasound:[5]

Color Doppler uses a computer to convert Doppler measurements into an array of colors to show the speed and direction of blood flow through a blood vessel.

Power Doppler is a newer technique that is more sensitive than color Doppler and capable of providing greater detail of blood flow, especially when blood flow is little or minimal. Power Doppler, however, does not help the radiologist determine the direction of blood flow, which may be important in some situations.

Spectral Doppler displays blood flow measurements graphically, in terms of the distance traveled per unit of time, rather than as a color picture. It can also convert blood flow information into a distinctive sound that can be heard with every heartbeat.

Uses of Ultra Sound[6]

Ultrasound examinations can help to diagnose a variety of conditions and to assess organ damage following illness.

Ultrasound is used to help physicians evaluate symptoms such as:

- ✓ Pain
- ✓ Swelling
- ✓ Infection

Ultrasound is also used to:

- ✓ Guide procedures such as needle biopsies, in which needles are used to sample cells from an abnormal area for laboratory testing.
- ✓ Image the breasts and guide biopsy of breast cancer (see the Ultrasound-Guided Breast Biopsy page.
- ✓ Diagnose a variety of heart conditions, including valve problems and congestive heart failure, and to assess damage after a heart attack. Ultrasound of the heart is commonly called an “echocardiogram” or “echo” for short.

Doppler ultrasound images can help the physician to see and evaluate:

- ✓ Blockages to blood flow (such as clots)
- ✓ Narrowing of vessels
- ✓ Tumors and congenital vascular malformations
- ✓ Less than normal or absent blood flow to various organs
- ✓ Greater than normal blood flow to different areas which is sometimes seen in infections

With knowledge about the speed and volume of blood flow gained from a Doppler ultrasound image, the physician can often determine whether a patient is a good candidate for a procedure like angioplasty.

Basic Principle

Modern medical US is performed primarily using a pulse-echo approach with a brightness- mode (B-mode) display. The basic principles of B-mode imaging are much the same today as they were several decades ago. This involves transmitting small pulses of ultrasound echo from a transducer into the body.[6] As the ultrasound waves penetrate body tissues of different acoustic impedances along the path of transmission, some are reflected back to the transducer (echo signals) and some continue to penetrate deeper. The echo signals returned from many sequential coplanar pulses are processed and combined to generate an image. Thus, an ultrasound transducer works both as a speaker (generating sound waves) and a microphone (receiving sound waves). The ultrasound pulse is in fact quite short, but since it traverses in a straight path, it is often referred to as an ultrasound beam. The direction of ultrasound propagation along the beam line is called the axial direction, and the direction in the image plane perpendicular to axial is called the lateral direction. Usually only a small fraction of the ultrasound pulse returns as a reflected echo after reaching a body tissue interface, while the remainder of the pulse continues along the beam line to greater tissue depths.[3]

Mechanical Effect of Ultrasound[7]

In addition to heat, scientists have begun to learn more about the various types of mechanical effects that ultrasound can have on the body. They divide these effects into two categories. The first category is called acoustic cavitation. Cavitation can occur when sound passes through an area that contains a cavity, such as a gas bubble or other air pocket. Some tissues, most notably adult lung and intestine, do contain air bubbles, and are therefore more vulnerable to these cavitation effects. The fetal lung and intestine do not contain obvious air bubbles, because the fetus does not breathe air yet—it gets oxygen from the mother’s blood stream. However, researchers believe that tiny bubbles could potentially form in parts of the body other than the lung and intestine. More research is needed in this area.

Healing with Ultrasound

Even before ultrasound became a widespread diagnostic tool, doctors were using it as a therapeutic tool. The fact that ultrasound does have biological effects on the body is clear from its uses to promote healing and even to operate on human beings. Ultrasound speeds the healing of bone, although it is not clear why this occurs. And surgeons are using highly-focused ultrasound beams to operate on delicate areas such as the eyes. The focused beam heats up and selectively destroys a minute portion of the tissue. Studying the therapeutic effects of ultrasound could also yield clues to any possible harmful effects of diagnostic ultrasound.[8]

Working of Ultra Sound

Ultrasound imaging is based on the same principles involved in the sonar used by bats, ships and fishermen. When a sound wave strikes an object, it bounces back, or echoes. By measuring these echo waves, it is possible to determine how far away the object is as well as the object's size, shape and consistency[9] (whether the object is solid or filled with fluid).

In medicine, ultrasound is used to detect changes in appearance, size or contour of organs, tissues, and vessels or detect abnormal masses, such as tumors. In an ultrasound examination, a transducer both sends the sound waves and receives the echoing waves. When the transducer is pressed against the skin, it directs small pulses of inaudible, high-frequency sound waves into the body. As the sound waves bounce off internal organs, fluids and tissues, the sensitive microphone in the transducer records tiny changes in the sound's pitch and direction. These signature waves are instantly measured and displayed by a computer, which in turn creates a real-time picture on the monitor. One or more frames of the moving pictures are typically captured as still images. Small loops of the moving real-time images may also be saved. Doppler ultrasound, a special application of ultrasound, measures the direction and speed of blood cells as they move through vessels. The movement of blood cells causes a change in pitch of the reflected sound waves (called the Doppler effect). A computer collects and processes the sounds and creates graphs or color pictures that represent the flow of blood through the blood vessels.[10]

Recent Innovation in B – Mode Ultrasound

Some recent innovations that have become available in most ultrasound units over the past decade or so have significantly improved image resolution. Two good examples of these are tissue harmonic imaging and spatial compound imaging.

The benefits of tissue harmonic imaging were first observed in work geared toward imaging of US contrast materials. The term harmonic refers to frequencies that are integral multiples of the frequency of the transmitted pulse (which is also called the fundamental frequency or first harmonic). The second harmonic has a frequency of twice the fundamental. As an ultrasound pulse travels through tissues, the shape of the original wave is distorted from a perfect sinusoid to a “sharper,” more peaked, sawtooth shape.[3] This distorted wave in turn generates reflected echoes of several different frequencies, of many higher order harmonics. Modern ultrasound units use not only a fundamental frequency but also its second harmonic component. This often results in the reduction of artifacts and clutter in the near surface tissues. Harmonic imaging is considered to be most useful in "technically difficult" patients with thick and complicated body wall structures.

Spatial compound imaging (or multibeam imaging) refers to the electronic steering of ultrasound beams from an array transducer to image the same tissue multiple times by using parallel beams oriented along different directions.[11] The echoes from these different directions are then averaged together (compounded) into a single composite image. The use of multiple beams results in an averaging out of speckles, making the image look less "grainy" and increasing the lateral resolution. Spatial compound images often show reduced levels of "noise" and "clutter" as well as improved contrast and margin definition.[12]Because multiple ultrasound beams are used to interrogate the same tissue region, more time is required for data acquisition and the compound imaging frame rate is generally reduced compared with that of conventional B-mode imaging.

CONCLUSION

During the past decade the diagnostic capabilities and applications of ultrasound have increased dramatically. Part of the improvement in diagnostic capability is due to the higher acoustic intensity allowed for ultrasound by the US government, starting in 1991. At the same time, scientific knowledge of the biological effects of ultrasound has expanded. The medical community recognizes that they areresponsible for maintaining the excellent safety record of diagnostic ultrasound. It is up to ultrasound technicians and doctors to evaluate the risks and benefits of diagnostic ultrasound in each case. The recommendations in this report are designed to bring as much information as possible to the physicians and ultrasound technicians faced with making these decisions**.**

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