IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 1, September 2024

A Review on Application of Ultrasound in Biomedical Field

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Abstract: *Sound waves that have frequencies greater than the upper limit of human hearing typically above 20 kHz are referred to as ultrasonic waves. It can detect, measure, and manipulate materials with great precision and without causing harm, ultrasonic technology is widely employed in many engineering domains. Ultrasonic biophysics is the study of mechanisms responsible for how ultrasound and biological materials interact. These high-frequency waves may enter tissues without harming them, they are frequently utilized in the biomedical area for imaging and therapeutic applications. This review summarizes the effects, and potential biomedical applications.*

Keywords: Ultrasonic

I. INTRODUCTION

The study of the mechanisms behind the interactions between biological materials and ultrasound is known as ultrasonic biophysics[1-2].Ultrasonic is a non-destructive testing (NDT) technique that measures thickness, examines material properties, and checks materials and structures for internal faults using high-frequency sound waves. In the biomedical industry, ultrasound technology is essential because it provides a variety of therapeutic and diagnostic uses that improve patient care and medical research. Ultrasonic investigation based on following principles.

1. **Sound Wave Propagation:** The body's tissues absorb ultrasonic waves at varying rates, depending t upon the tissue's composition and density. For example, sound waves pass through bone more quickly than they do through soft tissues like fat or muscles. A portion of the ultrasonic wave travels deeper and is reflected back to the transducer when it passes through various bodily tissues or structures. The tissues' acoustic impedance is determined by their density and flexibility, which in turn determines the quantity of reflection.
2. **Detection of Reflected Waves:** In addition to producing ultrasonic waves, the transducer also picks up echoes reflected waves. The transducer receives these echoes back and transforms them into electrical signals. It is measured how long it takes for the echoes to return to the transducer. An image of the internal structure can be created by calculating the distance between the transducer and the reflecting structure using the time-of-flight data.
3. **Image Formation**
   - **Amplitude Mode:** The simplest form of ultrasound imaging, where the strength of the echo is displayed as a function of depth. It's primarily used in ophthalmology.
   - **Brightness Mode:** The most common type of ultrasound imaging. Here, the amplitude of the reflected signals is converted into pixel brightness on the screen, creating a two-dimensional cross-sectional image of the tissues.
   - **Motion Mode:** Used to represent moving structures, such as the beating heart. It displays the motion of structures over time, providing a dynamic view.
   - **Doppler Mode:** This mode utilizes the Doppler effect to measure and visualize blood flow. By detecting changes in frequency of the reflected waves due to motion (e.g., blood moving towards or away from the transducer), it can provide information about the speed and direction of blood flow.

Within the field of biomedicine ultrasonic investigation also referred to as ultrasonography or ultrasound scanning is a crucial diagnostic technique. It uses high-frequency sound waves to project images of the body's internal structures[3].

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With ultrasound examination, medical professionals can examine the internal structures of the body and guide therapeutic and diagnostic procedures in a flexible, safe, and efficient manner. This is a thorough summary of how ultrasound is used in the biomedical profession.

II. APPLICATION OF ULTRASOUND IN BIOMEDICINE

1. **Obstetrics and Gynecology:** Throughout pregnancy, ultrasound is frequently used to track the growth and well-being of the fetus. It assists in monitoring the placenta's location, assessing fetal growth, detecting congenital anomalies, and determining the gestational age. It aids in the diagnosis of diseases such ovarian cysts, fibroids, and ectopic pregnancies by evaluating the uterus, ovaries, and other pelvic organs.
2. **Cardiology**: A specialized type of ultrasound called echocardiography is used to evaluate the anatomy and physiology of the heart. It helps in the identification of illnesses like cardiomyopathy, congenital heart disease, and problems of the heart valves by providing an image of the heart chambers, valves, and blood flow. Echocardiography for stress This test assesses the heart's stress response during exercise or pharmacological stress, aiding in the diagnosis of coronary artery disease.
3. **Abdominal Imaging**: Gallstones, liver abnormalities (such as fatty liver, cirrhosis, or tumors), and pancreatic disorders can all be found with ultrasound imaging. In cases of stomach discomfort, it's frequently the first imaging method used.In addition to directing the evaluation of urinary tract infections, it aids in the detection of kidney stones, cancers, and anatomical anomalies in the kidneys and bladder.
4. **Vascular Ultrasound**: Doppler Ultrasoundmeasures blood flow in arteries and veins. It is used to diagnose conditions such as deep vein thrombosis (DVT), carotid artery disease, and peripheral artery disease (PAD).Ultrasound is used to screen for and monitor abdominal aortic aneurysms, a potentially life-threatening condition where the abdominal aorta becomes enlarged.
5. **Musculoskeletal Imaging:**Ultrasound is used to evaluate soft tissues like muscles, tendons, and ligaments. It helps diagnose conditions such as tendonitis, bursitis, muscle tears, and joint effusions.Ultrasound is often used to guide the precise injection of medications into joints or soft tissues, such as corticosteroids for inflammation.
6. **Breast Imaging:** Breast ultrasoundis used as a complementary tool to mammography for breast cancer screening, particularly in women with dense breast tissue. It helps differentiate between solid masses (which may be cancerous) and fluid-filled cysts.Ultrasound is also used to guide needle biopsies of breast tissue, allowing for accurate sampling of suspicious areas.
7. **Thyroid and Neck Ultrasound:**Ultrasound helps assess the thyroid gland for nodules, cysts, and other abnormalities. It's commonly used in the evaluation of thyroid disorders such as goiters and thyroid cancer.Ultrasound is used to examine lymph nodes in the neck for signs of enlargement or abnormality, which may indicate infection, inflammation, or malignancy.
8. **Emergency Medicine**: Ultrasound is used in emergency settings to quickly assess trauma patients for internal bleeding, particularly in the abdomen and chest.In emergency rooms and critical care units, ultrasound is used at the bedside to rapidly assess conditions like pneumothorax, pericardial effusion, and deep vein thrombosis.
9. **Pediatric Ultrasound**: Ultrasound is used to evaluate the brains of newborns, particularly premature infants, for conditions like intracranial hemorrhage or hydrocephalus.Ultrasound is employed to screen for developmental dysplasia of the hip (DDH) in infants, allowing for early intervention.
10. **Oncology:** Ultrasound is used to characterize tumors in various organs, helping to differentiate between benign and malignant masses.It's used to assess lymph nodes for metastatic spread of cancer, guiding staging and treatment decisions.
11. **Therapeutic Guidance**: Ultrasound guides procedures like needle biopsies, abscess drainage, and catheter placements, ensuring accuracy and reducing the risk of complications.In procedures like radiofrequency ablation (RFA), ultrasound helps guide the treatment of tumors by delivering focused energy to destroy cancerous tissue.
12. **Research and Advanced Applications**: Electrography is advanced ultrasound technique measures tissue stiffness, which can help in the diagnosis of liver fibrosis, breast cancer, and other conditions.Contrast-

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Enhanced Ultrasound (CEUS) involves the use of contrast agents (microbubbles) to improve the visibility of blood flow and tissue perfusion, enhancing the detection of tumors and vascular diseases.

III. CONCLUSION

There are various advantages of ultrasound investigations in biomedical field as, Ultrasound is a non-invasive imaging technique, making it safer and more comfortable for patients, it provides immediate, real-time images, which is crucial for guiding procedures and assessing dynamic processes. Unlike X-rays and CT scans, ultrasound does not use ionizing radiation, making it safer for repeated use, especially in sensitive populations like pregnant women and children. Ultrasound machines setup are often portable, allowing for use in a variety of settings, including clinics, hospitals, and even in remote or field locations.

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