Medical ultrasound

Medical ultrasound (also known as diagnostic sonography or ultrasonography) is a diagnostic imaging technique based on the application of ultrasound. It is used to see internal body structures such as tendons, muscles, joints, vessels and internal organs. Its aim is often to find a source of a disease or to exclude any pathology. The practice of examining pregnant women using ultrasound is called obstetric ultrasound, and is widely used.

Ultrasound is sound waves with frequencies which are higher than those audible to humans (>20,000 Hz). Ultrasonic images also known as sonograms are made by sending pulses of ultrasound into tissue using a probe. The sound echoes off the tissue; with different tissues reflecting varying degrees of sound. These echoes are recorded and displayed as an image to the operator.

Many different types of images can be formed using sonographic instruments. The most well-known type is a B-mode image, which displays the acoustic impedance of a two-dimensional cross-section of tissue. Other types of image can display blood flow, motion of tissue over time, the location of blood, the presence of specific molecules, the stiffness of tissue, or the anatomy of a three-dimensional region.

Compared to other prominent methods of medical imaging, ultrasound has several advantages. It provides images in real-time, it is portable and can be brought to the bedside, it is substantially lower in cost, and it does not use harmful ionizing radiation. Drawbacks of ultrasonography include various limits on its field of view including patient cooperation and physique, difficulty imaging structures behind bone and air, and its dependence on a skilled operator.

Typical sonographic instruments operate in the frequency range of 1 to 18 megahertz, though frequencies up to 50–100 megahertz have been used experimentally in a technique known as biomicroscopy in special regions, such as the anterior chamber of the eye.[3] The choice of frequency is a trade-off between spatial resolution of the image and imaging depth: lower frequencies produce less resolution but image deeper into the body. Higher frequency sound waves have a smaller wavelength and thus are capable of reflecting or scattering from smaller structures. Higher frequency sound waves also have a larger attenuation coefficient and thus are more readily absorbed in tissue, limiting the depth of penetration of the sound wave into the body (for details, see Acoustic attenuation.)

Sonography (ultrasonography) is widely used in medicine. It is possible to perform both diagnosis and therapeutic procedures, using ultrasound to guide interventional procedures (for instance biopsies or drainage of fluid collections). Sonographers are medical professionals who perform scans which are then typically interpreted by themselves or the radiologists, physicians who specialize in the application and interpretation of a wide variety of medical imaging

modalities, or by cardiologists in the case of cardiac ultrasonography (echocardiography). Sonographers typically use a hand-held probe (called a transducer) that is placed directly on and moved over the patient. Increasingly, clinicians (physicians and other healthcare professionals who provide direct patient care) are using ultrasound in their office and hospital practices.

Sonography is effective for imaging soft tissues of the body. Superficial structures such as muscles, tendons, testes, breast, thyroid and parathyroid glands, and the neonatal brain are imaged at a higher frequency (7–18 MHz), which provides better axial and lateral resolution. Deeper structures such as liver and kidney are imaged at a lower frequency 1–6 MHz with lower axial and lateral resolution but greater penetration.

Medical sonography is used in the study of many different systems:

System/Specialty	Description
Anesthesiology	Ultrasound is commonly used by anesthesiologists to guide injecting needles when placing local anaesthetic solutions near nerves. It is also used for gaining vascular access such as central venous cannulation and difficult arterial cannulation. Transcranial Doppler is frequently used by neuroa-nesthesiologists for obtaining information about flow-velocity in the basal cerebral vessels.
Angiology	Duplex ultrasound (B Mode vessels imaging combined with Doppler flow measurement) is daily used in angiology to diagnose arterial and venous disease all over the body.
Cardiology	Echocardiography is an essential tool in cardiology, to diagnose e.g. dilatation of parts of the heart and function of heart ventricles and valves
Emergency Medicine	Point of care ultrasound has many applications in the Emergency Department, including the Focused Assessment with Sonography for Trauma (FAST) exam for assessing significant hemoperitoneum or pericardial tamponade after trauma. Ultrasound is routinely used in the Emergency Department to expedite the care of patients with right upper quadrant abdominal pain who may have gallstones or cholecystitis.
Gastroenterology/Colorectal surgery	In abdominal sonography, the solid organs of the abdomen such as the pancreas, aorta, inferior vena cava, liver, gall bladder, bile ducts, kidneys, and spleen are imaged. Sound waves are blocked by gas in the bowel and attenuated in different degree by fat, therefore there are limited diagnostic

	capabilities in this area. The appendix can sometimes be seen when inflamed (as in e.g.: appendicitis). Endoanal ultrasound is used particularly in the investigation of anorectal symptoms such as fecal incontinence or obstructed defecation. It images the immediate perianal anatomy and is able to detect occult defects such as tearing of the anal sphincter.
Head and Neck Surgery/Otolaryngology	Most structures of the neck, including the thyroid and parathryoid glands, lymph nodes, and salivary glands, are well-visualized by high-frequency ultrasound with exceptional anatomic detail. Ultrasound is the preferred imaging modality for thyroid tumors and lesions, and ultrasonography is critical in the evaluation, preoperative planning, and postoperative surveillance of patients with thyroid cancer. Many other benign and malignant conditions in the head and neck can be evaluated and managed with the help of diagnostic ultrasound and ultrasound-guided procedures.
Neonatology	for basic assessment of intracerebral structural abnormalities, bleeds, ventriculomegaly or hydrocephalus and anoxic insults (Periventricular leukomalacia). The ultrasound can be performed through the soft spots in the skull of a newborn infant (Fontanelle) until these completely close at about 1 year of age and form a virtually impenetrable acoustic barrier for the ultrasound. The most common site for cranial ultrasound is the anterior fontanelle. The smaller the fontanelle, the poorer the quality of the picture.
Neurology	for assessing blood flow and stenoses in the carotid arteries (Carotid ultrasonography) and the big intracerebral arteries
Obstetrics	Obstetrical sonography is commonly used during pregnancy to check on the development of the fetus.
Ophthalmology	Ultrasound images of the eyes, also known as ocular ultrasonography
Urology	to determine, for example, the amount of fluid retained in a patient's bladder. In a pelvic sonogram, organs of the pelvic region are imaged. This includes the uterus and ovaries or urinary bladder. Males are sometimes given a pelvic sonogram to check on the health of their bladder, the prostate, or their testicles (for example to distinguish epididymitis from testicular torsion). In young males, it is used to distinguish more benign testicular masses (varicocele or hydrocele) from testicular cancer, which is highly curable but which must be

	treated to preserve health and fertility. There are two methods of performing a pelvic sonography – externally or internally. The internal pelvic sonogram is performed either transvaginally (in a woman) or transrectally (in a man). Sonographic imaging of the pelvic floor can produce important diagnostic information regarding the precise relationship of abnormal structures with other pelvic organs and it represents a useful hint to treat patients with symptoms related to pelvic prolapse, double incontinence and obstructed defecation. It is used to diagnose and, at higher frequencies, to treat (break up) kidney stones or kidney crystals (nephrolithiasis).[5]
Musculoskeletal	tendons, muscles, nerves, ligaments, soft tissue masses, and bone surfaces.[6] Ultrasound is an alternative to x-ray imaging in detecting fractures of the wrist, elbow and shoulder for patients up to 12 years (Fracture sonography).
Cardiovascular system	To assess patency and possible obstruction of arteries Arterial sonography, diagnose deep vein thrombosis (Thrombosonography) and determine extent and severity of venous insufficiency (venosonography)

Other types of uses include:

- Interventional ultrasonography; biopsy, emptying fluids, intrauterine Blood transfusion (Hemolytic disease of the newborn)
- Contrast-enhanced ultrasound
- Quantitative ultrasound: an adjunct diagnostic test for myopathic disease in children; estimates of lean body mass in adults; proxy measures of muscle quality (i.e., tissue composition) in older adults with sarcopenia.