Chapter 1

Introduction to Ultrasound

Learning Outcomes

While studying this chapter, you will learn about:

- History of Ultrasound
- Introduction of Ultrasound in India
- Classification of Ultrasound—Based on Types, Modes, Frequency, and Clinical Applications

INTRODUCTION TO ULTRASOUND

Ultrasound, also known as sonography, is a widely practiced, versatile diagnostic imaging method that uses high-frequency sound waves to create real-time images of internal body structures. It is recognized for being non-invasive, radiation-free, and suitable for various medical applications, including cardiology, gastroenterology, obstetrics, and musculoskeletal diagnostics. For the medical field, it is considered a breakthrough that has made significant progress. Scientific advancements and technological development have transformed it from a theoretical idea into an essential clinical tool.

HISTORY OF ULTRASOUND (Fig. 1.1)

The Acoustic Era

Ancient times: Our understanding of sound traces back to ancient philosophers (mainly Greek) like Aristotle in the 4th century BCE, and Pythagoras in the 6th century BCE. Their initial experiments, ideas, and discoveries laid the foundation for acoustics and explained how sound waves function.

Early interventions: Lazzaro Spallanzani, an Italian physiologist, discovered in 1794 that bats navigate through echoes. This phenomenon clarified that sound waves can be used to detect the position of objects by reflecting off them. This concept laid the groundwork for modern ultrasound technology and is now known as **Echolocation**.

Doppler effect: Christian Doppler, an Austrian physicist, proposed the phenomenon of shifting in sound waves in 1842, depending on the movement of the observer or the source; this idea is termed the "Doppler effect", the core of Doppler ultrasound. This technique is used to assess heart function and measure blood flow through the heart.

Piezoelectric principle: In 1880, Pierre and Jacques Curie confirmed the piezoelectric effect, demonstrating that certain crystals produce electrical charges when subjected to mechanical stress. This phenomenon remains essential to modern ultrasound transducer technology.

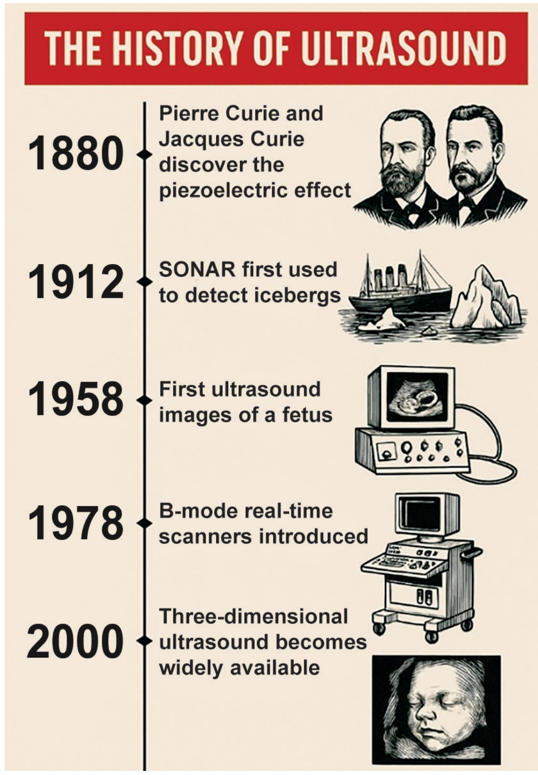

Fig. 1.1: History of ultrasound

Early Medical Applications

SONAR and technological basis: The emergence of SONAR (sound navigation and ranging) during World War II, intended initially for submarine detection, laid the critical technical foundation for modern ultrasound. This development was laid out by the Russian engineer Constantin Chilowski and the French physicist Paul Langevin, using piezoelectric crystals.

Initial medical applications: In the late 1940s, Austrian neurologist Karl Dussik was the first to use ultrasound for the medical purpose of visualizing brain structures, paving the way for the clinical adoption of ultrasound.

Pioneers in medical ultrasound in the 1950s (Fig. 1.2)***:*** A Scottish physician, Dr Ian Donald, made unprecedented advancements in ultrasound technique by applying it to evaluate fetal development and detect abdominal masses, revolutionizing prenatal care. He is regarded as the "father of modern ultrasound."

An American radiologist, Douglas Howry, developed water-bath imaging for soft tissues, laying the groundwork for the concept of two-dimensional (2D) imaging. Their experimental design involved submerging body parts in a water tank. This provided a consistent medium for the sound waves to propagate and transmit without any artefacts, ensuring the clarity of images.

Dr John Wild, a physicist, is recognized as one of the pioneers of medical ultrasound. His work focused on detecting and visualizing tumors, differentiating between normal and cancerous tissue. The technique was considered groundbreaking for early cancer detection. He also applied the method to analyze and measure the thickness of the bowel wall.

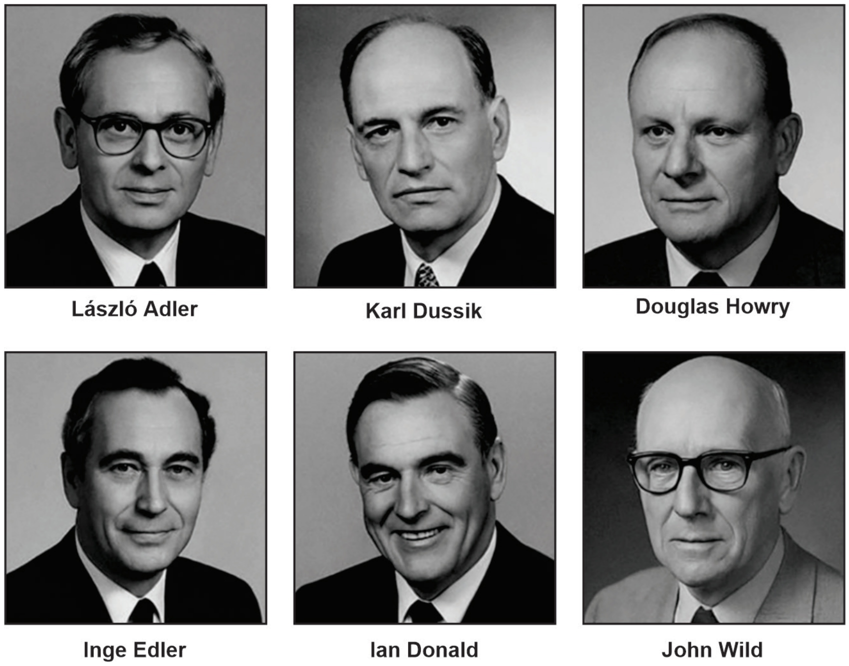

Fig. 1.2: Contributors of ultrasound

Innovations by Wild and Howry together formed the strong backbone of modern diagnostic ultrasound, making it a non-invasive, powerful technique for visualizing internal organs, tissues, pathologies, and more.

Advances in Doppler technology: The 1960s marked the emergence of Doppler ultrasound, a transformative innovation that enabled the real-time measurement of blood flow, significantly expanding the clinical applications of ultrasound.

INTRODUCTION OF ULTRASOUND IN INDIA

X-rays and CT scans were predominant in India during the 1970s. Ultrasound gradually developed, gaining popularity during this period. Its introduction dates back to the late 1970s and early 1980s. It was established in many medical centers for detecting abnormalities related to the abdomen and obstetrics. The widespread use of ultrasound accelerated during the 1980s and 1990s.

Dr Pai at Bombay Port Trust Hospital was one of the first to experiment with ultrasound, setting up a machine and becoming the first known practitioner in India to use it for routine clinical practice.

Near about the same time, **Dr Amrish Dalal** returned to India in the early 1980s after completing his training in the United States. He established a private ultrasound practice, becoming one of the earliest dedicated ultrasound practitioners in Mumbai.

Institutional Support

Jaslok Hospital in Mumbai established India's first state-of-the-art ultrasound department in 1983. This foundation was led by Dr Mukund Joshi, who gained significant support from the hospital management and colleagues like Dr Keshav and Dr GN Mansukhani (gynecologist).

AIIMS in Delhi also set up a well-equipped ultrasound unit, making it one of the first centers for ultrasound clinical practice and research in India.

Technological Advancements and Training Expansions

Dr Joshi made significant contributions to the expansion of ultrasound technology across India, introducing advanced techniques such as the automated breast volume scanner (ABVS) for breast imaging and acoustic radiation force impulse (ARFI) imaging for cancer diagnosis. The Indian Radiological and Imaging Association (IRIA) played a crucial role in regulating and standardizing official ultrasound training programs.

History of Musculoskeletal Ultrasound

Musculoskeletal (MSK) ultrasound has advanced considerably over the past decades, becoming a widely used, safer, non-invasive, and versatile imaging method. Its development began in the 1940s and 1950s, mainly for obstetric and industrial purposes. However, it was not immediately suitable for musculoskeletal applications due to various limitations and the primitive technology of the transducer. By the 1960s and 1970s, enough efforts had been made to image muscles, soft tissues, and fluids, especially in sports settings. In the 1980s, ultrasound took a significant step forward with the introduction of B-mode imaging and high-frequency linear probes, which allowed for more precise visualization of soft tissues, tendons, joints, and ligaments.

In the 1990s, notable progress was made in image quality and Doppler capabilities, enabling detailed assessment of inflammation and vascularity (beneficial for rheumatology). The 2000s saw the introduction of formal training and the standardization of guidelines by leading professional organizations, including EULAR, AIUM, and OMERACT, which established musculoskeletal ultrasound as a dependable imaging tool for diagnosing bursitis, arthritis, and enthesitis, as well as guiding interventions.

Over the past few decades, the rise of portable devices and the emergence of artificial intelligence have made MSK ultrasound more precise and accessible, backing up its growth in point-of-care diagnostic monitoring.

Musculoskeletal ultrasound (MSK-USG) in rheumatology in India traces its origins to the pioneering efforts of Dr Ved Chaturvedi, who introduced it for the very first time in 2003 at the prestigious Army Hospital (Research and Referral), New Delhi (Fig. 1.3). His vision and commitment not only established MSK-USG as a vital diagnostic and monitoring tool in

Fig. 1.3: In India, rheumatology ultrasound was first initiated by Dr Ved Chaturvedi at Army Hospital (R & R), New Delhi

rheumatology practice but also laid the foundation for its widespread adoption across the country. In recognition of his contributions, Dr Chaturvedi was appointed as the Vice-President of the Musculoskeletal Society, underscoring his leadership role in advancing this transformative modality within Indian rheumatology.

Key features of MSK ultrasound:

1. **1940s–1970s:** Early medical use, imaging of muscles and fluid collection.
2. **1980s:** Real-time B-mode imaging and high-frequency linear probes.
3. **1990s:** Doppler imaging-guided assessments of inflammation and vascularity.
4. **2000s:** Standardized international training and guidelines.
5. **2010s–present:** Point-of-care diagnostic devices and artificial integration improved accuracy and accessibility.

CLASSIFICATION OF ULTRASOUND

Ultrasound imaging can be broadly classified by mode of image acquisition, functions, dimensions, and applications. In clinical practice, particularly in fields such as cardiology, rheumatology, radiology, and obstetrics, various types of ultrasound imaging are used to visualize strictures, evaluate function, and guide interventions as needed (*refer* to Table 1.2).

Classification Based on Imaging Mode

Imaging can be performed using various ultrasound modes (Fig. 1.4), each offering unique in-sights into body functions and structures. Selecting the appropriate mode is essential for accurate diagnosis and efficient treatment planning.

A-mode Ultrasound

- Referred to as amplitude mode ultrasound.
- This is the earliest and simplest type of ultrasound.
- The graph in this represents depth on the X-axis and amplitude on the Y-axis.
- It displays signal strength when vertical, and there is a spike on a graph.
- A single beam of ultrasound is sent into the body, and returning echoes are plotted as spikes depending upon their depth and amplitude.
- This kind of ultrasound is mainly used in ophthalmic studies, brain, and breast imaging.

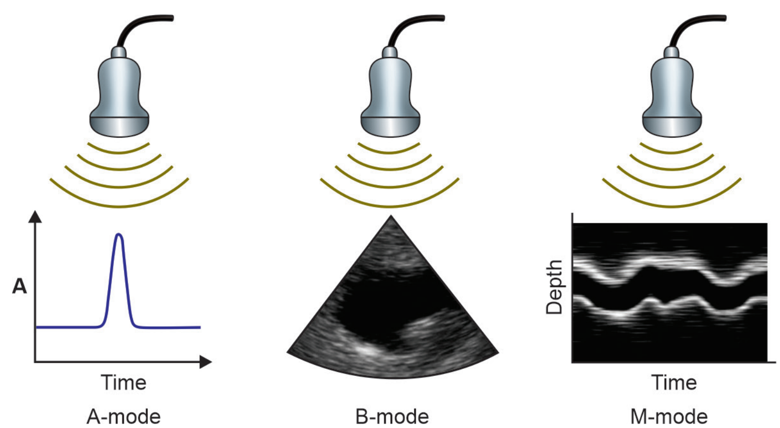

Fig. 1.4: Different modes of ultrasound

B-mode Ultrasound

- Termed brightness mode ultrasound.
- It mainly converts the amplitude of echoes into grayscale pixels to create 2D cross-sectional images.
- Works on, weak echoes = darker pixels and strong echoes = bright pixels.
- B-mode ultrasound uses multiple scan lines to generate a 2D real-time image.
- This is one of the most widely used forms of ultrasound nowadays.
- Mainly used for musculoskeletal imaging, abdominal imaging, and thyroid, breast, and soft tissue imaging. It is also prominently used in obstetric imaging (placenta, fetus).

M-mode Ultrasound

- Referred to as motion mode or time-motion mode ultrasound.
- It is one of the earliest modes of ultrasound and is still explicitly used in cardiac imaging.
- It is a combination of both A-mode and B-mode ultrasound.
- It is appreciated to visualize and record moving structures over time.
- It repeatedly transmits a single line of ultrasound, which is received at a fixed location.
- The reflected echoes received from the moving structures are plotted over time. As a structure moves, a wave-like pattern is created on a graph. The vertical axis represents depth of the tissue, whereas the horizontal axis represents time.
- It provides precise measurements of movement and time. Also, it can easily track the fast-moving structures.
- It is predominantly used in fields like cardiology, neonatology, and pediatrics.

Doppler Mode Ultrasound

Doppler mode ultrasound depends entirely on the Doppler effect, which reveals how the frequency of a wave changes when an observer moves relative to its source. The Doppler frequency shift is measured as the difference between the observed and transmitted frequencies. Suppose the object being imaged moves away from the transducer (causing a negative shift). In that case, its motion causes the reflected waves to stretch and return with a delay, resulting in a longer wavelength and a lower frequency. Conversely, if the object moves towards the transducer (causing a positive shift), the reflected waves are compressed, producing a shorter wavelength and a higher frequency. Doppler imaging displays flow directionality through color mapping—red indicating flow towards the probe and blue indicating flow away. The positive and negative shifts help determine the direction, velocity, and pattern of blood flow.

The Doppler shift frequency is also related to the cosine of the angle between the probe and the vessel being imaged:

$$\text{Frequency (original)} - \text{frequency (final)}/f = 2\,(v/c)\cos\theta$$

where f = original frequency

The change in frequency is directly proportional to the velocity of the moving interface.

$$\text{Change in frequency/original frequency} = 2 \times \text{velocity of the interface (v)/velocity of the sound (c)}$$

Types of Doppler ultrasound

1. **Power Doppler:** This type is more sensitive to detecting small-volume or low-velocity blood flow. It does not display the direction of blood flow and uses color intensity to indicate flow strength. This Doppler ultrasound method is mainly useful for assessing organ perfusion, tumors, and torsion of the ovary or testis.

2. **Color Doppler:** This technique involves adding color mapping to standard ultrasound imaging. Blood flow is easily detectable on B-mode imaging, with red color indicating flow towards the probe and blue color indicating flow away from the probe. It is useful in identifying normal versus abnormal blood flow patterns, reversed flow, or blockages. The only limitation of the technique is its lower precision in measuring flow velocity.
3. **Spectral Doppler (pulse wave):** It provides a waveform graph that represents the velocity of blood flow over time. This type of Doppler ultrasound enables the detailed analysis of heart valves, venous insufficiency, or arterial stenosis. It is further divided into two subtypes:
   a. *Pulsed wave (PW) Doppler* measures the flow at a particular point, but only with lower velocities.
   b. *Continuous wave (CW) Doppler* cannot localize the flow at a single point, but can measure the flow with high velocity.

3D-Mode Ultrasound

It is an advanced imaging technique that creates three-dimensional (3D) images by combining 2D ultrasound scans taken from different angles. The method records the echoes returned from the ultrasound probes, which are processed by computer software to generate a 3D image.

3D ultrasound provides information related to the depth, height, and width of the structure and offers more lifelike images.

4D-Mode Ultrasound

4D images refer to "time" which means you can observe live motion of internal organs or the fetus as it happens. This allows clinicians to visualize movements, such as smiling, stretching, or yawning, of the baby.

This technique uses the same amount of data as a 3D ultrasound. The benefit is the ability to view live images that show the continuous movement of internal organs. It needs advanced computers and transducers to produce and display real-time 3D moving data (Table 1.1).

TABLE 1.1: Comparison of 3D and 4D ultrasound

Feature	*3D ultrasound*	*4D ultrasound*
Number of dimensions	3 (length, width, depth)	4 (3D + time)
Output	Static image	Live video
Use	Detailed imaging of anatomy	Observation of real-time motion
Processing time	Post-processing required	Real-time processing
Equipment complexity	Standard 3D probe with image reconstruction	High-speed transducers and processors

Elastography

- Also known as the strain and shear wave mode.
- It is used to measure tissue stiffness by evaluating how a tissue deforms under pressure, as it is believed that different tissues deform differently under pressure.
- Soft and inflamed tissue is more elastic and exhibits greater displacement, whereas stiff and fibrotic tissue is less flexible and deforms less. Figure 1.5 describes the softness and hardness of the tissue encountered in elastography. By analyzing and quantifying these differences, elastography helps distinguish between permanent fibrotic changes and active inflammation.

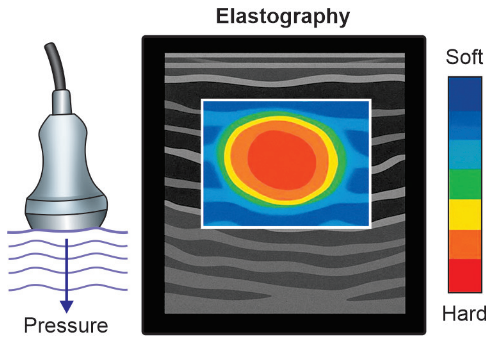

Fig. 1.5: Elastography technique

- It is a non-invasive, radiation-free, real-time evaluation technique that helps in the detection of fibrosis earlier than clinical symptoms.
- It allows quantification for tracking measures over time. Also, an exemplary method for customized treatment, e.g. whether to increase anti-inflammatory drugs or improve the management of fibrosis.
- The only limitations of this technique are poor image quality in obese patients and deep structures. It requires standardized protocols for regularities across devices and centers.

Each mode of ultrasound modality has its unique features and is used for specific purposes. The differentiation of each and its utility depend on the skill and experience of the operator. Table 1.2 provides summary of different modes of ultrasound imaging.

TABLE 1.2: Modes of ultrasound imaging

Mode	*Function*	*Common use*
A-Mode	1D echo amplitude display	Eye measurements
B-Mode	2D grayscale image	Standard imaging in rheumatology
M-Mode	Motion tracking along a scan line	Cardiology (valves, walls)
Color Doppler	Blood flow direction and speed	Inflammation, vascular flow
Power Doppler	Sensitivity to low-velocity flow	Synovitis, tenosynovitis
Spectral Doppler	Flow velocity over time (graph)	Arterial/venous blood flow
3D/4D	3D/real-time 3D imaging	Emerging in musculoskeletal imaging
Elastography	Tissue stiffness	Fibrosis assessment

Based on Frequency

Ultrasound imaging uses different frequencies of sound waves to create images of anatomies present inside the body. The correct choice of frequency (which depends on the depth of the tissue) while scanning is essential, as it is necessary for optimal image resolution.

Higher frequencies provide less depth but better resolution; lower frequencies penetrate much deeper but with lower resolution (Table 1.3).

- **High-frequency ultrasound** ranges from 10 to 20 MHz and is excellent for very detailed imaging, such as small erosions in joints, inflammation, or tendon tears.
  - Although this type of frequency is limited to the visualization of superficial structures only. Higher-frequency waves correspond to a loss of strength and attenuate quickly in tissues.

TABLE 1.3: Different Frequency range and their clinical relevance				
Type	*Frequency range*	*Penetration*	*Resolution*	*Common use*
High-frequency	10–20 MHz	Low (superficial)	High	Skin, tendons, and small joints
Mid-frequency	5–10 MHz	Medium	Moderate	Muscles, medium joints, and abdominal organs
Low-frequency	2–5 MHz	High (deep tissues)	Low	Pelvis, abdomen, deep joints (e.g. hips)

- **Mid-frequency ultrasound** corresponds to 5–10 MHz of range. This frequency provides a balance between depth and resolution. These frequencies enable moderate tissue penetration and are typically used for musculoskeletal imaging (muscles, joints, such as the shoulder, elbow, and knee), as well as abdominal imaging (including the liver, kidneys, and gallbladder).
  - In rheumatology, mid-range frequencies are used for evaluating effusion in larger joints, deep-seated synovitis, and edema.
- **Low-frequency ultrasound** ranges from 2 to 5 MHz and is useful for deep tissue penetration. It provides lower image resolution compared to high- or mid-frequency ultrasound. These frequencies are ideal for targeting deep-seated structures, including pelvic organs, hip joints, deep abdominal organs, and retroperitoneal structures. They are also helpful in scanning obese patients.

Based on Clinical Applications

There are various types of ultrasounds, each with its own unique application and clinical relevance, as summarized in Table 1.4.

- **Musculoskeletal ultrasound (MSK-US),** predominantly used in rheumatology, sports medicine, and orthopedic streams of medical sciences. MSK-US helps assess synovitis and effusion in joints, tears and tendinitis in tendons, sprains and ruptures of ligaments, bursitis, and enthesitis in spondyloarthritis.
  - It allows dynamic assessment and versatile movement during scanning. It provides real-time, high-resolution imaging of superficial structures.

TABLE 1.4: Types of ultrasounds and their clinical applications	
Type of ultrasound	*Clinical application*
Musculoskeletal ultrasound (MSK US)	Assessment of joints, tendons, ligaments, and soft tissues in rheumatology and orthopaedics.
Obstetric ultrasound	Monitoring pregnancy, foetal development, and detecting complications.
Cardiac ultrasound (echocardiography)	Evaluating heart structure, function, valves, and chambers.
Abdominal ultrasound	Imaging liver, gallbladder, pancreas, kidneys, spleen, and bladder.
Vascular ultrasound	Assessing arteries and veins for clots, stenosis, aneurysms, and blood flow.
Pelvic ultrasound	Evaluating reproductive organs (uterus, ovaries, prostate) and bladder health.
Thoracic ultrasound	Detecting pleural effusion, pneumothorax, lung consolidation, and pericardial effusion.
Cranial ultrasound	Used in neonates to assess brain structures, haemorrhage, and hydrocephalus.
Interventional ultrasound	Guiding procedures like biopsy, aspiration, and joint injections.

- **Cardiac ultrasound** imaging technique is specialized for evaluating the heart and its activity. It grants the assessments of heart wall motion, ejection fraction, and pericardial effusions. It also allows the identification of congenital heart defects.
  - This application of ultrasound imaging can be transesophageal or transthoracic and uses Doppler, M-mode, and color flow imaging.
- **Obstetric ultrasound** imaging is used mainly during pregnancy to monitor fetal development and maternal health. This application of ultrasound is non-invasive and safe for mother and fetus, and is often conducted in 2D, 3D, and 4D imaging.
  - This technique is frequently used for estimating gestational age, observing fetal growth and anatomy, assessing fetal location and heart rate, and identifying multiple pregnancies.
- **Vascular ultrasound,** a specialized form of imaging that evaluates blood vessels, particularly veins and arteries, using the Doppler ultrasound mode. A highly effective technique for assessing stenosis, aneurysms, deep vein thrombosis, and the direction of blood flow, facilitating the identification of peripheral arterial disease.
  - It is non-invasive and a proven alternative to angiography, and includes carotid and venous Doppler. Generally, a reliable method to evaluate and detect blood clots or blockages.
- **Thoracic ultrasound** imaging helps evaluate the chest cavity, also known as the non-lung areas, and critical chest conditions. It is primarily used in emergency and intensive care unit (ICU) settings, providing point-of-care capabilities. It is generally regarded as a safe alternative to chest X-rays in specific situations. One of its main applications is to detect pleural effusion; it not only identifies the presence of fluid but also determines its nature.
  - Additionally, atelectasis (where part of the lung becomes airless and deflates) and lung consolidation can also be identified. It is a sensitive imaging tool for diagnosing pneumothorax. Ultrasound can quickly detect the absence of normal lung sliding or the presence of a lung point, which are key indicators of pneumothorax.
- **Cranial ultrasound** is a valuable imaging method, mainly used in neonates through open fontanelles, which are soft spots between the skull bones that have not yet fused. Open fontanelles are natural acoustic windows that permit ultrasound waves to pass and produce a clear image of the brain.
  - Major primary uses of cranial ultrasound include the evaluation of hydrocephalus and intracranial hemorrhages. It can identify cystic changes or infections, primarily signs of meningitis or abscesses. Overall, it is a safe, bedside-friendly imaging technique that plays a crucial role in the early diagnosis and management of neurological conditions.
- **Pelvic ultrasound** is a non-invasive imaging technique primarily used to evaluate the bladder and reproductive organs in both men and women. In males, the scan examines the prostate gland to help detect tumors or inflammation. It also assesses bladder wall thickening, post-void residual urine, and the presence of stones.
  - In females, pelvic ultrasound plays a vital role in monitoring the uterus, aiding in the detection of conditions like fibroids, estimating endometrial thickness, visualizing cysts, polycystic ovary syndrome (PCOS), and ovarian tumors. It can also confirm pregnancy, monitor fetal development, and identify potential complications.
  - It is a crucial diagnostic tool that enables the assessment of a wide range of urological and reproductive health conditions. This procedure can be performed transvaginally in women, transrectally in men, and transabdominally in both genders.
- **Abdominal ultrasound** is a widely used method for imaging internal organs within the abdominal cavity. It is a painless, radiation-free technique that produces real-time images,

making it suitable for both routine and emergency diagnosis. One of its primary uses is to detect fatty liver, liver tumors, and cirrhosis.
  - It is highly effective for evaluating the gallbladder, particularly for detecting gallstones and signs of cholecystitis. Additionally, it helps visualize cysts, kidney stones, and hydronephrosis. The spleen and bladder are also assessed for any enlargement, infection, or injury.
- **Interventional ultrasound** is a specialized use of ultrasound imaging that provides real-time guidance for minimally invasive medical procedures. One of its most common applications includes performing needle biopsies, joint injections, or aspirations.
  - It can also be used to perform drainage in abscesses and assist with nerve blocks. Interventional ultrasound improves precision, effectiveness, and patient safety by enabling a wide range of diagnostic and therapeutic procedures.

Based on Technology

Each ultrasound technology platform offers various advantages, depending on the clinical needs and settings. From comprehensive diagnostic imaging to portable solutions, modern ultrasound technology continues to evolve and strengthen its role in clinical practice and patient care (Table 1.5).

Conventional Ultrasound

Refers to standard and traditional imaging modalities that mainly provide 2D B-mode (brightness mode) imaging. In this method, grayscale images of the body are generated. These are usually large, cart-based devices equipped with various transducers tailored to the operator's clinical needs.

They can easily support M-mode and Doppler mode imaging, which are used in radiology departments, hospitals, and diagnostic centers. They offer versatile applications, a wide range of functionalities, and high-quality images.

Therapeutic Ultrasound

Therapeutic ultrasound imaging is a technique that utilizes high-frequency sound waves primarily for therapeutic purposes rather than general imaging. It is often used in physical therapy to promote healing of soft tissue injuries, reduce inflammation, and boost local blood flow.

Additionally, it is used in lithotripsy (breaking kidney stones), destroying tumors with high-intensity focused ultrasound, and is even helpful in treating uterine fibroids or critical prostate conditions. They provide a precise targeting and energy delivery system.

TABLE 1.5: Technology-based different ultrasound techniques

Type	*Details*
Conventional ultrasound	Traditional machines with 2D B-mode imaging.
Portable/handheld ultrasound	Compact, often wireless devices for bedside use or field work.
Point-of-care ultrasound (POCUS)	Performed at the bedside by clinicians for immediate diagnosis.
Therapeutic ultrasound	Uses high-frequency waves for physical therapy or to break down tissues (e.g. kidney stones, tumors).
Contrast-enhanced ultrasound (CEUS)	Uses microbubble contrast agents to enhance vascular or tumor imaging.

Contrast-enhanced Ultrasound (CEUS)

The use of microbubbles as contrast agents is a crucial aspect of the CEUS imaging technique. These agents are injected into the bloodstream to improve ultrasound imaging, especially for vascular studies and tumor detection. They are considered safer than MRI or CT contrasts, particularly for patients with kidney problems, and they do not require ionizing radiation.

CEUS enhances the visualization of blood flow in organs, aiding in the differentiation between benign and malignant lesions.

Portable or Handheld Ultrasound

These devices are lightweight and compact, usually about the size of a tablet or smaller. Some of these devices are wireless for this imaging method. They are often connected via Bluetooth or Wi-Fi to a smartphone, tablet, or laptop, providing a quick, efficient, and convenient way to perform a scan.

They are designed to conduct basic diagnostic imaging, making them ideal for bedside assessments, rural healthcare, emergencies, resource-limited settings, and field visits. This offers the operator versatility and flexibility while assessing the patient.

Point-of-Care Ultrasound

This imaging technique is a clinical method, not a machine, and is primarily used in intensive care units, emergency rooms, outpatient clinics, or occasionally in ambulances. The devices are usually portable or handheld. This technique is typically performed by the treating physician rather than a radiologist, providing immediate diagnosis and supporting quick decision-making. Commonly used for conditions such as pleural effusion, monitoring cardiac activity, and guiding procedures like injections or catheter placement.

Glossary of the Chapter

Abbreviation	Full form	Description
IRIA	Indian Radiological and Imaging Association	Organisations that standardise and regulate radiology and ultrasound practices in India.
ABVS	Automated breast volume scanner	Ultrasound tool for volumetric breast imaging.
ARFI	Acoustic radiation force impulse	Ultrasound-based technique for assessing tissue stiffness, especially useful in liver and cancer imaging.
EULAR	European League against Rheumatism	A body that contributed to standardised MSK ultrasound guidelines.
AIUM	American Institute of Ultrasound in Medicine	Organization providing education and setting practice guidelines for ultrasound in the US.
OMERACT	Outcome measures in rheumatology	International initiative that develops and standardizes outcome measures, including MSK ultrasound.
CW	Continuous wave (Doppler)	A Doppler ultrasound subtype that measures high-velocity flow but without spatial specificity.
CT	Computed tomography	Imaging modality using X-rays for cross-sectional imaging (mentioned in the historical context).
DVT	Deep vein thrombosis	A blood clot in the deep veins, commonly in the legs, is evaluated using vascular ultrasound.
CEUS	Contrast-enhanced ultrasound	To visualise blood flow and lesions, ultrasound enhanced with microbubble contrast is used.
EF	Ejection fraction	Percentage of blood leaving the heart during each beat.

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