Ultrasonography

The term ultrasound refers to acoustical waves above the range of human hearing (frequencies higher than 20.000 Hz). Medical ultrasound systems operate at frequencies of up to 10 MHz or more.

An ultrasonic wave is acoustical. Ultrasonic imaging is used in medicine, engineering, geology, and other scientific areas. Radio signals are electromagnetic waves, while medical ultrasound signals are acoustical.

- Ultrasound is a non-invasive diagnostic tool used to complement other imaging modalities.
- The degree to which the ultrasound beam penetrates the patient and the image resolution obtained depend on the frequency of the transducer used.
- Artifacts can be beneficial or detrimental to image interpretation
- Ultrasonography is the use of high-frequency sound waves to generate an image. Because ultrasonography is relatively safe and non-invasive, it has become a useful diagnostic tool in veterinary medicine.[1] Veterinary technicians, especially those who wish to learn how to perform ultrasound examinations, should have a basic understanding of ultrasonography: how sound waves are produced and interact with tissue, what types of images can be obtained, howto get the best image, and how to identify common artifacts.
- Ultrasound examinations complement other imaging modalities, such as radiography, and allow more definitive diagnostic tests to be conducted. However, ultrasonography is limited by the fact that it is user dependent.
- This means that the quality of the images obtained and their accurate interpretation depend on the experience and knowledge of the sonographer

Ultrasound

Physical Properties

- Sound is a wave of energy that, unlike x-rays, must be transmitted through a medium. Sound waves can be described by their frequency, wavelength, and velocity. The frequency is the number of cycles or waves that are completed every second, and the wavelength is the distance needed to complete one wave cycle. The frequency of the sound waves used in ultrasonographyis well above the limit of the human ear (20,000 kHz) — usually in the range of 2 to 12 MHz (2to 12 million Hz).
- An inverse relationship exists between the frequency and the wavelength of a sound wave: the higher the frequency, the shorter the wavelength. This relationship affects the choice of frequency used in each patient undergoing ultrasonography. Higher-frequency ultrasound waves create higher-resolution images, but their shorter wavelength makes them unable to penetrate deeper tissues. Lower-frequency waves have better penetrating power, but because of their longer wavelengths, their resolution is lower. Weighing the need for higher resolution versus more penetrating power is always a consideration when selecting a transducer frequency.
- The velocity of an ultrasound wave is independent of the frequency. However, it changes depending on the medium through which the wave is traveling

Image Production

- Two basic principles need to be understood regarding how ultrasound is generated and an image is formed. The first is the **piezoelectric effect**, which explains how ultrasound is generated from ceramic crystals in the transducer. An electric current pass through a cable tothe transducer and is applied to the crystals, causing them to deform and vibrate. This vibration produces the ultrasound beam. The frequency of the ultrasound waves produced is predetermined by the crystals in the transducer.

- The second key principle is the **pulse-echo principle**, which explains how the image isgenerated. Ultrasound waves are produced in pulses, not continuously, because the same crystals are used to generate and receive sound waves, and they cannot do both at the same time. In the time between the pulses, the ultrasound beam enters the patient and is bounced or reflected back to the transducer. These reflected sound waves, or echoes, cause the crystals inthe transducer to deform again and produce an electrical signal that is then converted into an image displayed on the monitor. The transducer generally emits ultrasound only 1% of the time; the rest of the time is spent receiving the returning echoes

Interaction with Tissue

Ultrasound produced by the transducer interacts with different tissues in a variety of ways that may help or hinder image formation. Attenuation and refraction are the two major types of tissue interaction.

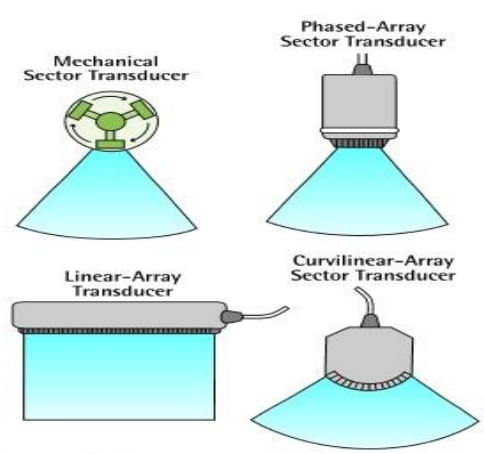
Attenuationis the gradual weakening of the ultrasound beam as it passes through tissue. Attenuation can be caused by reflection, scattering, or absorption of the sound waves and is compensated for byuse of specific controls, discussed below.

Reflectiontakes place when ultrasound waves are bounced back to the transducer for image generation. The portion of the ultrasound beam that is reflected is determined by the difference in acoustic impedance between adjacent structures.[5] Acoustic impedance is the product of a tissue's density and the velocity of the sound waves passing through it; therefore, the denser the tissue, the greater the acoustic impedance. The large differences in density and sound velocity between air, bone, and soft tissue create a correspondingly large difference in acoustic impedance, causing almost all ofthe sound waves to be reflected at soft tissue-bone and soft tissue-air interfaces. On the other hand, because there is little difference in acoustic impedance between soft tissue structures, relatively few echoes are reflected to the transducer from these areas.

Scatteringrefers to the redirection of ultrasound waves as they interact with small, rough, or uneven structures.This tissue interaction occurs in the parenchyma of organs, where there is little difference in acoustic impedance, and is responsible for producing the texture of the organ seen on the monitor. Scattering increases with higher-frequency transducers, thus providing better detail or resolution.

Absorptionoccurs when the energy of the ultrasound beam is converted to heat. This occurs at the molecular level as the beam passes through the tissues.[5]

Refractionoccurs when the ultrasound beam hits a structure at an oblique angle. The change in tissue density produces a change in velocity, and this change in velocity causes the beam to bend,or *refract*.This type of tissue interaction can also cause artifacts that need to be recognized by the sonographer.



▲ Diagrams of different transducer types.

Display Modes

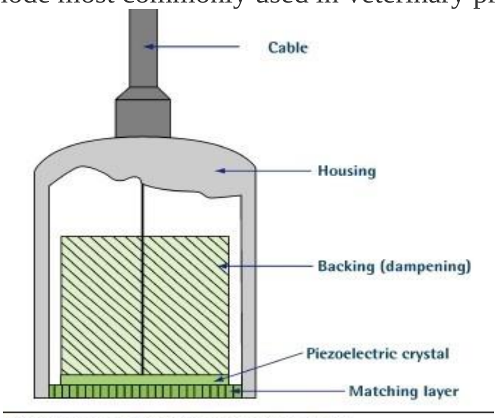
A (Amplitude) Mode

In A mode, the returning echoes are displayed on the monitor as spikes originating from a single vertical or horizontal baseline.[5] The depth of the echo is determined by the position of the spike on the axis, with the top or left side of the monitor being the most superficial and the bottom or right sidebeing farther away. The height of the spike correlates to the amplitude of the echo. This mode is not frequently used other than in ophthalmology.

B (Brightness) Mode

In B mode, echoes are represented by dots on a line that form the basis of a two-dimensional image. The brightness of each dot indicates the amplitude of the returning echo. Its location relative to the transducer is displayed along the vertical axis of the monitor, with the top of the monitor representing the transducer. The returning echo's location along the axis is based on the amount of timeit takes for the ultrasound wave to be transmitted from the transducer and reflected back. Echoes arising from structures in the near field (close to the transducer) take less time than those coming from the far field (farther away from the transducer) because they travel a shorter distance.

Real-time B mode ultrasonography allows a complete, two-dimensional, cross-sectional image to be generated by using multiple B-mode lines.[5] In real-time B mode, the transducer sweeps the ultrasound beam through the patient many times a second. With each pass of the ultrasound beam, multiple linesof dots are generated on the monitor, producing a complete image. These B-mode lines remain on the monitor until the next sweep of the ultrasound beam. Because several beam sweeps are performed per second, a moving, changing, "real-time" image is generated. This is the mode most commonly used in veterinary practice.



▲ Components of an ultrasound transducer.

M (Motion) Mode

M mode is used in echocardiography and allows the sonographer to measure the heart to assess cardiac function and chamber size. M mode uses a single B-mode line, with the amplitude of the echoes indicated by the brightness of the displayed dots. The difference is that the information obtained from that single line is constantly swept across the monitor so that the motion of the body part beinginvestigated is displayed along the horizontal axis.

Image Optimization

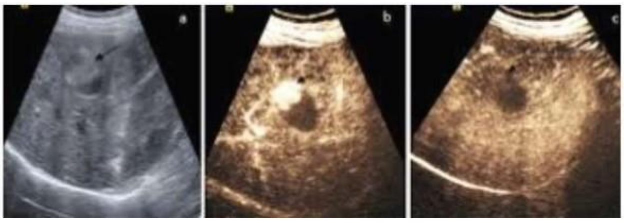
To obtain good-quality images, the sonographer must know what type and size of transducer to useand how to use the available ultrasound controls. There are many transducers or probes from which to choose, and selection of the appropriate one depends on the location of structures to be imaged and the size of the patient.

Transducers

Transducers are first classified as *linear* or *sector*, according to the arrangement (array) of the crystals and the shape of the imaging field produced on the monitor. In a linear transducer, the crystals are oriented in a straight line, producing a rectangular image in which both the near and far fields are wide. Linear transducers provide superior resolution of near-field structures and therefore are commonly used in equine reproduction and tendon examinations.[5] However, their large footprint can limit theiruse in cardiac and abdominal studies, where it may be difficult to fit the probe between the ribs.

▲ An ultrasound console showing the time gain compensation sliders and the depth and gain controls. Names and locations of ultrasound controls vary from unit to unit.

Ultrasonography of Kidney



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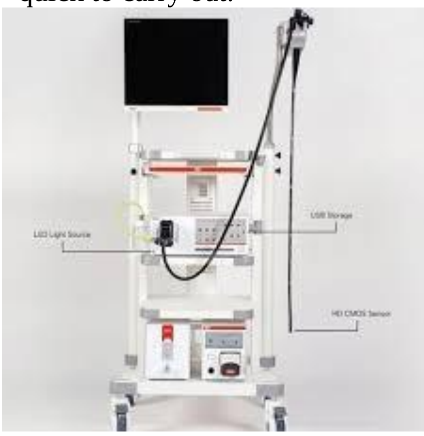
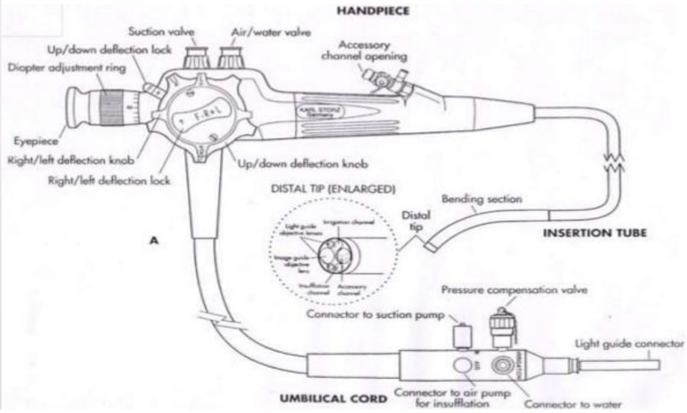
Endoscopy

- Endoscopy is a nonsurgical procedure used to examine a person's digestive tract.
- Using an endoscope, a flexible tube with a light and camera attached to it, your doctor can view pictures of your digestive tract on a colour TV monitor.
- Endoscopy is the insertion of a long, thin tube directly into the body to observe an internal organ or tissue in detail. It can also be used to carry out other tasks including imaging and minor surgery.
- Endoscopes are minimally invasive and can be inserted into the openings of the

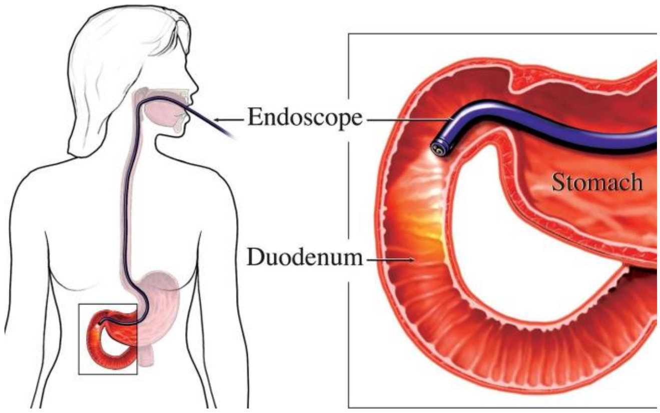
body such asthe mouth or anus.

- Alternatively, they can be inserted into small incisions, for instance, in the knee or abdomen. Surgery completed through a small incision and assisted with special instruments, such as the endoscope, is called keyhole surgery.
- Because modern endoscopy has relatively few risks, delivers detailed images, and is quick to carry out.





Endoscopymachine Parts of Endoscopy



An endoscope consist of:

- A rigid or flexible tube.
- A light delivery system to illuminate the organ or object under inspection. The light source is normally outside the body and the light is typically directed via an optical fiber system.
- A lens system transmitting the image from the objective lens to the viewer, typically a relaylens system in the case of rigid endoscopes or a bundle of fiber optics in the case of a fiberscope. an eyepiece. Modern instruments may be video scopes, with no eyepiece. A camera transmits image to a screen for image capture.
- An additional channel to allow entry of medical instruments or manipulators.

The endoscope also has a channel through which surgeons can manipulate tiny instruments, such asforceps, surgical scissors, and suction devices.
• A variety of instruments can be fitted to the endoscope for different purposes.
• A surgeon introduces the endoscope into the body either through a body opening, such as the mouthor the anus, or through a small incision in the skin

- Although fibre-optic endoscopes can be used to visualize the stomach and duodenum, they are unable to reach farther into the small intestine.

- As a result, examination of the small intestine may require the use of wireless capsule endoscopy (video capsule endoscopy), which consists of a pill-sized camera that is swallowed. The camera transmits data to sensors that are attached to the abdomen with adhesive, and a data recorder that stores image information collected by the camera is attached to a belt worn around the waist, the sensors and belt are worn for a period of eight hours, during which time the camera capsule obtains images of nearly the entire length of the small intestine. The images stored in the data recorder are downloaded onto a computer for analysis. The capsule eventually travels the length of the gastrointestinal tract and is excreted in a bowel movement.

Types

Endoscopy is useful for investigating many systems within the human body; these areas include:

- **Gastrointestinal tract**: esophagus, stomach, and duodenum (esophagogastroduodenoscopy), small intestine (enteroscopy), large intestine/colon (colonoscopy, sigmoidoscopy), bile duct, rectum (rectoscopy), and anus (anoscopy).
- **Respiratory tract**: Nose (rhinoscopy), lower respiratory tract (bronchoscopy).
- **Ear**: Otoscopy
- **Urinary tract**: Cystoscopy
- **Female reproductive tract (gynoscopy)**: Cervix (colposcopy), uterus (hysteroscopy), fallopiantubes (falloposcopy).
- **Through a small incision**: Abdominal or pelvic cavity (laparoscopy), interior of a joint(arthroscopy), organs of the chest (thoracoscopy and mediastinoscopy).

Latest techniques in endoscopy

Capsule endoscopy

- Capsule endoscopy was developed in the mid-1990s and involves a wireless camera. The camera is small enough to fit into a capsule (roughly the size of a vitamin tablet) and can, therefore, be swallowed.
- As the capsule travels through the digestive tract, it takes thousands of pictures, which are transmitted to a device attached to a wearable belt.
- Capsule endoscopy is used to image the small intestine, a region that is difficult to image using standard endoscopy. It is also very useful for examining the small intestinal mucosa and diagnosing Crohn's disease. The capsule usually passes through the digestive system within 24-48 hours.

Endoscopic retrograde cholangiopancreatography (ERCP)

ERCP combines X-rays with upper GI endoscopy to diagnose or treat problems with the bile andpancreatic ducts.

Chromoendoscopy

Chromoendoscopy is a technique that uses a specialized stain or dye on the lining of the intestine during an endoscopy procedure. The dye helps the doctor better visualize if there's anything abnormalon the intestinal lining.

Endoscopic ultrasound (EUS)

EUS uses an ultrasound in conjunction with an endoscopy. This allows doctors to see organs and other structures that aren't usually visible during a regular endoscopy. A thin needle can then be inserted into the organ or structure to retrieve some tissue for viewing under a microscope. This procedure is called fine needle aspiration.

Endoscopic mucosal resection (EMR)

EMR is a technique used to help doctors remove cancerous tissue in the digestive tract. In EMR, a needle is passed through the endoscope to inject a liquid underneath the abnormal tissue. This helps separate the cancerous tissue from the other layers so it can be more easily removed.

Narrow band imaging (NBI)

NBI uses a special filter to help create more contrast between vessels and the mucosa. The mucosa is the inner lining of the digestive tract.

There are three main reasons for carrying out an endoscopy:

- **Investigation**: If an individual is experiencing vomiting, abdominal pain, breathing disorders, stomach ulcers, difficulty swallowing, or gastrointestinal bleeding, for example an endoscope can be used to search for a cause.
- **Confirmation of a diagnosis**: Endoscopy can be used to carry out a biopsy to confirm a diagnosis of cancer or other diseases.
- **Treatment:** an endoscope can be used to treat an illness directly; for instance, endoscopy can be used to cauterize (seal using heat) a bleeding vessel or remove a polyp.

MEDICAL THERMOGRAPHY

- Thermography is the science of visualizing these patterns and determining any deviations from the normal brought about by pathological changes.
- Thermography often facilitates detection of pathological changes before any other method of investigation, and in some circumstances, is the only diagnostic aid available. Radiation hazard as with X-rays. In addition, thermography is a real-time system.

Infrared Radiation

The infrared ray is a kind of electromagnetic wave with a frequency higher than the radio frequencies and lower than visible light frequencies. There are several physical factors which affect the amount of infrared radiation from the human body. These factors are

- Emissivity
- Reflectivity
- Transmittance or absorption.

Emissivity

An object which absorbs all radiation incident upon it, at all wavelengths, is called a black body. A black body is only an idealized case and, therefore, all objects encountered in practice can be termed gray bodies. We thus define the term emissivity as representing the ratio of the radiant energy emittedper unit area by an object to the radiant energy emitted per unit area of the black body at the same temperature.

Reflection

Spectral reflectivity rl is defined as the ratio of reflected power to the incident power at a givenwavelength.

Transmittance and Absorption of Infrared Radiation

When a semi-transparent body is placed between the surface of any radiation-emitting body and a detector, it is necessary to consider the change in emissivity related to its transmittance, reflectivityand emissivity

Infrared Detectors

Infrared detectors are used to convert infrared energy into electrical signals. Basically, there are twotypes of detectors:

- Thermal detectors
- Photo-detectors.

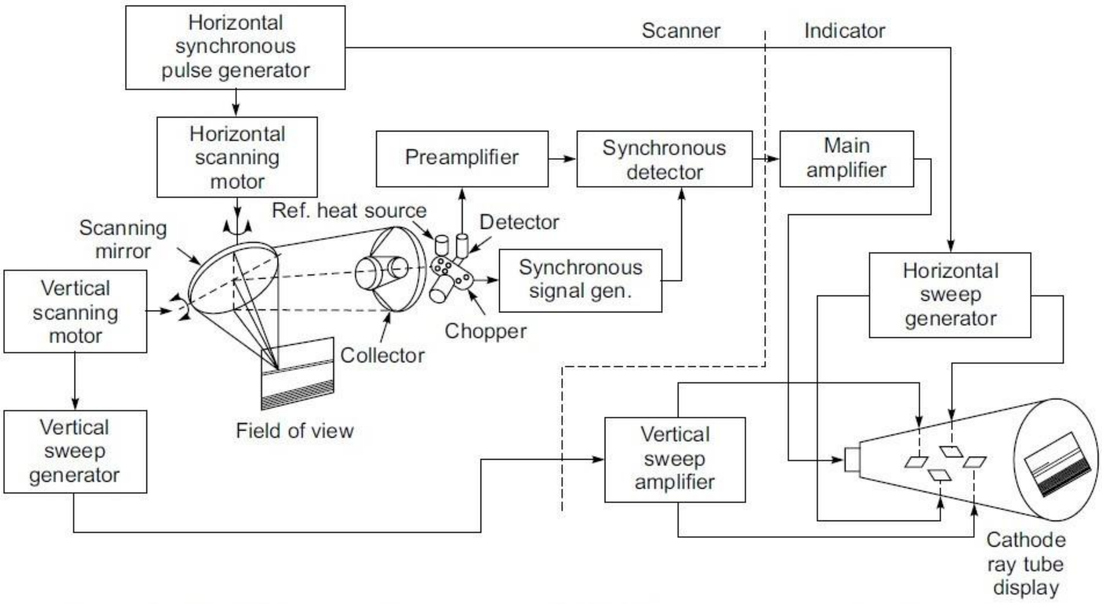
Thermal detectors include thermocouples and thermistor bolometers. They feature constant sensitivityover a long wavelength region.

Thermographic Equipment's

Thermographic cameras incorporate scanning systems which enable the infrared radiation emitted from the surface of the skin within the field of view to be focused on to an infrared detector.

The equipment used in thermography basically consists of two units: a special infrared camera thatscans the object, and a display unit for displaying the thermal picture on the screen. The camera is generally mounted on a tripod that is fitted on wheels.

The camera unit contains an optical system which scans the field of view at a very high speed and focuses the infrared radiation on a detector that converts the radiation signal into an electrical signal.The signal from the camera is amplified and processed before being used to modulate the intensity of the beam in the picture tube. The beam sweeps across the tube face in a pattern corresponding to the scanning pattern of the camera. The picture on the screen can be adjusted for contrast (temperaturerange) and brightness (temperature level) by means of controls on the display unit.



➤ Fig. 24.6 *Block diagram of the scanning and displaying arrangements for infrared imaging*

Recording Techniques

- Quantitative Medical Thermography
- Digital Analysis of Thermograms

- Medical Thermography (digital infrared thermal imaging - DITI) is used as a method of research for early pre-clinical diagnosis and control during treatment of homeostatic imbalances. There are few devices, which operate in a passive method like infrared Thermography medicine; amongst these are the ECG and EEG. The intrinsic safety of this method makes infrared Thermography free from any limitations or contra-indications.
- Thermography is a non-invasive, non-contact tool that uses the heat from your body to aid in making diagnosis of a host of health care conditions. Thermography is completely safe and uses no radiation.
- Medical Thermography equipment usually has two parts, the IR camera and a standard PC or laptop computer. These systems have only a few controls and relatively easy to use.
- Monitors are high-resolution full colour, isotherm or grey scale, and usually include image manipulation, isothermal temperature mapping, and point-by-point temperature measurement with a cursor or statistical region of interest. The systems measure temperatures ranging from10° C - 55° C to an accuracy of 0.1° C. Focus adjustment should cover small areas down to 75 x 75mm.
- These systems are PC based and therefore able to store tens of thousands of images (and these images may be retrieved for later analysis). The ability to statistically analyse the thermograms ata later date is very important in clinical work. Copies of images can easily be sent (via e-mail, floppy disk, etc.) to referring doctors or other healthcare professionals.
- The medical applications of DITI are extensive, particularly in the fields of Rheumatology, Neurology, Oncology, Physiotherapy and sports medicine. Thermal imaging systems are an economical easy-to-use tool for examining and monitoring patients quickly and accurately.
- Utilising high-speed computers and very accurate thermal imaging cameras, the heat from your body is processed and recorded in the computer into an image map which can then be analysedon screen, printed or sent via email.


- A doctor can then use the image map to determine if abnormal hot or cold areas are present. These hot and cold areas, can relate to a number of conditions for which the Food and Drug Administration, Bureau of Medical Devices has approved the thermography procedure. These include, the screening for breast cancer, extra-cranial vessel disease (head and neck vessels), neuro-Musculo-skeletal disorders and vascular disease of the lower extremities.

- The human body absorbs infrared radiation almost without reflection, and at the same time,emits part of its own thermal energy in the form of infrared radiation. The intensity of this radiantenergy corresponds to the temperature of the radiant surface. It is, therefore, possible to measurethe varying intensity of radiation at a certain distance from the body and thus determine thesurface temperature.
- In a normal healthy subject, the body temperature may vary considerably from time to time, butthe skin temperature pattern generally demonstrates characteristic features, and a remarkablyconsistent bilateral symmetry.

Applications of Thermography are in:

- Breast pathologies
- Extra-Cranial Vessel Disease
- Neuro-Musculo-Skeletal
- Vertebrae (nerve problems/arthritis)
- Lower Extremity Vessel Disease