Review Article

Interpretation Of Ultrasound Image

Islam MS [1], Mostafa MG [2]

Slogan of 21st century is "Ultrasonography is second to stethoscope of a clinician"

Abstract

An ultrasound system constructs an image by a series of sound waves produced by its transducer elements from different tissues at different depths of the body. Normal B (Brightness) mode Ultrasonography displays an image at grey scales from bright to black according to the tissue characters and nature of sound wave transmission. M(Motion) mode produced a wavy line taking B-mode waves which is applicable in moving structure like heart.Doppler sonography is a special technique to evaluate blood flow through a blood vessel using Doppler shift equation. Color Doppler uses for direction and speed of blood flow, where as, power Doppler can detect even a very low flow state of a blood vessel. Combined uses of B-mode and color denotes either Duplex or Triplex sonography according to numbe of images used.

Key words: *B-mode, M-mode, Doppler sonography, Duplex/Triplex sonography.*

Introduction

Ultrasound is the most common investigation requested by a physician. It is non invasive, less expensive and most reliable among the myriads of investigation done. Unfortunately, our physicians have a little exposure to Ultrasound room. They cannot interpret the supplied image themselves, so they have to rely upon the sonologist for the interpretation of ultrasound image. The supplied images are a few and too small to see in detail. So we have attempted here to introduce the basic principle of ultrasound imaging technique and explain the characteristics of the images supplied along with the report.

A standard ultrasound machine

Transducers of different frequency and shape

What is Ultrasound?

Sound is a series of alternating waves of compression and rarefaction and ultrasound consists of sound at frequencies that are greater than 20,000 cycles per second (20,000 Hertz) and are above human hearing levels. As Ultraviolet ray is invisible to human eyes.

What is Ultrasonography?

It essentially an echography, that is, recording of echoes returned from the various tissue planes. If it records the echoes coming from the chambers of the heart, it is called echocardiography.

1.Dr. Md. Saidul Islam , MBBS; DCH, ADMU; Sonologist,Department of Radiology and Imaging, KYAMCH.
2.Dr. Md. Gulam Mostafa, MBBS; DTM&H; Ph.D; DMU; Sonologist,Department of Radiology and Imaging, KYAMCH.

If it records the echoes returning from the liver tissue, it is echo-hepatography, but it is not called as such but simply sonography. Why 'ultra'sonography , because it records the sound in the range of 2.5 -15 million hertz (beyond the range of human hearing). It records the strength and returning time of the echoes and represents as graphs on the computer monitor. If no echo returns it is represented as black spot, if returns weakly it is represented as gray spot and if most of the echoes return it is recorded as bright spot. This is called gray scale and we will have to identify the various tissues by observing the scale.

Speed of sound

The speed of sound varies for different biological media but the average value is assumed to be 1,540 m/sec (constant) for most human soft tissues. The speed of sound (c) can be calculated by multiplying wavelength (?) x frequency (f). Thus sound with a high frequency has a short wavelength and vice versa. For example, the wavelength of a 2 MHz ultrasound wave = 0.77 mm and that of a 15 MHz wave = 0.10 mm.[1]

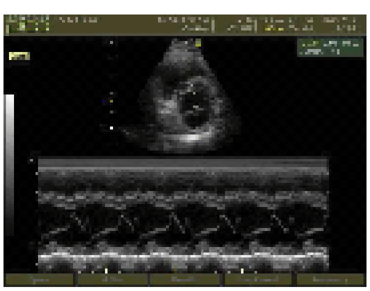
Medium	Ultrasound Speed (m/sec)	Medium	Ultrasound Speed (m/sec)
Air	300	Kidney	1,560
Lung	500	Brain	1,560
Fat	1,450	Soft Tissue	1,540
Brain	1,520	Bone	4,000
Muscle	1,580	Liver	1,550

Air is a bad medium for sound transmission. So, coupling agents like, Ultrasound gel, Spirit, Hexisol, etc are used to dislodge the air between the probe and skin.

Types of ultrasound imaging [2]

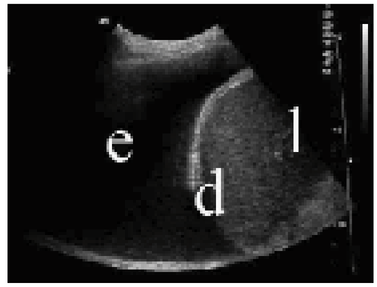
1. Conventional (2D) Ultrasound -Also called gray scale imaging, displays the images in a thin, flat sections of the body.

I. B-mode (Brightness mode) - Brightness mode is the most basic grey scale imaging mode. It consists of a two dimensional image where the brightness of an area is stronger in places where the echo returns most strongly



M-mode ultrasound image of the heart (lower image). Upper image is a B-mode image of heart

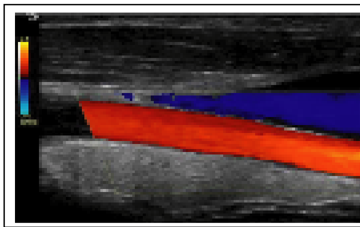
II. M-mode (Motion mode) - M-Mode is based upon B-mode but is used to track motion, such as the beating of a heart. Short movies are taken in M-mode and can usually be exported to a computer system to be viewed.



A typical B-mode image, showing Liver, diaphragm and right pleural effusion.

2. Doppler Ultrasound -
It is a special ultrasound technique that evaluates blood flow through a blood vessel, including the body's major arteries and veins in the abdomen, arms, legs and neck. There are three types of Doppler ultrasound:

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

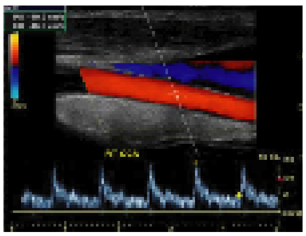


A typical Color-mode image, showing Carotid artery (red) and Jugular veins (blue)

II. 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 to determine the direction of blood flow, which may be important in some situations.

A typical power Doppler mode image, showing renal artery.

III. Spectral Doppler. Instead of displaying Doppler measurements visually, Spectral Doppler displays blood flow measurements graphically, in terms of the distance traveled per unit of time.



A typical Spectral Doppler mode superimposed on Color-mode image, showing Carotid artery (red) and Jugular veins (blue). Spectral wave of carotid artery (lower tracing).

This is a duplex ultrasound imaging mode, as spectral Doppler mode is super imposed on color mode

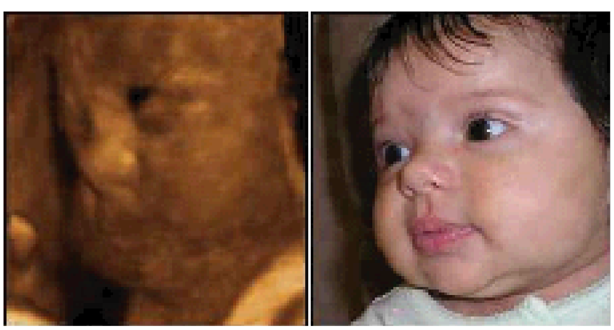
** **Duplex / Triplex -** When two ultrasound modes are used simultaneously it is called duplex scan and when three modes of ultrasound are used simultaneously it is called triplex scan.

** Often color Doppler is used superimposed on B-mode and Spectral Doppler is used superimposed on B-mode or color-mode.

3. Advanced Ultrasound technology [3,4]

I. Three-dimensional (3-D) ultrasound that formats the sound wave data into 3-D images.

II. Four-dimensional (4-D) ultrasound is 3-D ultrasound in motion.



3 D ultrasound of a baby in utero and after

Tissue Echogenicity

When an echo returns to the transducer, its amplitude is represented by the degree of brightness (i.e. echogenicity) of a dot on the display. Combination of all the dots forms the final image. Strong specular reflections give rise to bright dots (hyperechoic) e.g., diaphragm, gallstone, bone, pericardium. Weaker diffuse reflections produce grey dots (hypoechoic) e.g., solid organs. No reflection produces dark dots (anechoic) e.g., fluid and blood filled structures because the beam passes easily through these structures without significant reflection. Also, deep structures often appear hypoechoic because attenuation limits beam transmission to reach the structures, resulting in a weak returning echo.[5]

Echogenicity of various tissue - Example-
The blood in the aorta is anechoic; Spinal column distal to the aorta is bright; Liver is echopoor; peritoneum, in front of liver is echogenic; Muscle below the skin is mildly echogenic.

Terms used to describe the tissue echogenicity

I. Echogenic - It indicates that the echo is being produced , whatever might be the intensity. Usually it is used to mean mid level echoes, as returning from liver, spleen, prostate etc.

II. Anechoic or echolucent - No echoes, black.

III. Hyperechoic - It means increased echo intensity, producing bright images (e.g. Renal sinus, mesenteric fat, diaphragm, etc).

IV. Hypoechoic / Echopoor- Decreased brightness. It is a relative term use to compare echogenicity between two echogenic structures.

V. Homogeneous or uniform - Echogenicity is same throughout the organ or portion of an organ; Such as liver, spleen, etc.

VI. Heterogeneous or non uniform - Echogenicity is different at different areas of same organ. Such as kidneys, tumours etc.

VII. Cystic - Any structure containing encysted fluid , e.g. hepatic , renal cyst , chocolate cyst, Hydatid cyst, etc

VIII. Accentuation /Enhancement of sound - As the sound pass through the cystic structure, there is little reflection of sound, causing increase in intensity of echo distal to it. It is seen beyond GB, Hepatic cyst, ovarian cyst, etc.

IX. Complex - Mixture of cystic and solid components ; such as, Hydatid cyst, Adenomatous ovarian cyst, Hydatidiform mole, etc.

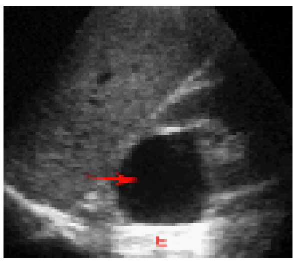
X. Attenuation of sound - Decrease in intensity of sound /echo as it travels through the media / tissue. It may be found in fatty liver, large fibroid uterus, etc.

XI. Acoustic shadow - When anything completely reflects or absorbs sound, there is no sound transmission beyond that point. As no echo returns distal to it, it appears anechoic or black. Such as stone, bones, bowel gas, etc.

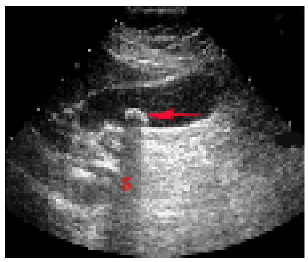
XII. Target shaped lesion - An echogenic or isoechoic lesion , which is surrounded by relatively echopoor rim or band of tissue is called target shaped lesion. It is mainly seen in the liver , uterus or spleen, as primary or metastatic neoplasm.

XIII. Internal echoes - Speckles of echoes scattered in the cystic structures are called internal echoes. These are tiny particles such as blood clots, pus, inspissated biles, etc. They are also called debris. In GB this may represent biliary sludge or sands. They may differ in densities and the heavier particles may settle in the dependent part forming a thick layer. Sometime it may create fluid / fluid level of different densities.

Images of various types of tissue echogenicity.



Renal cyst (arrow) having distal enhancement (E)



GB stone (arrow) having acoustic shadow (S)

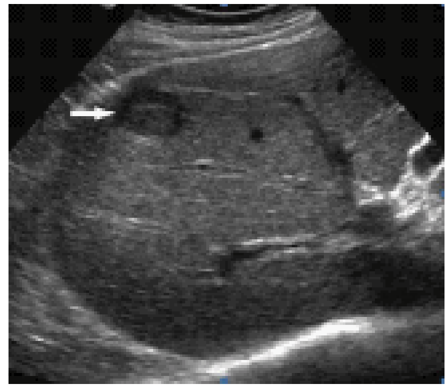
Liver hemangioma is highly echogenic (hyperechoic)

Necrotic metastasis is complex in echogenicity.

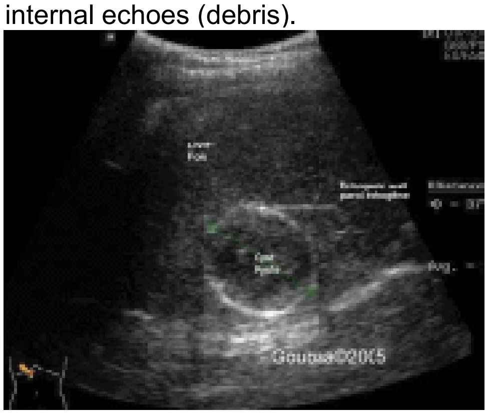
Ultrasound image character of different tissues :

Blood, bile,urine, ascites, cysts.	Anechoic
Fat	Hypoechoic with irregular hyperechoic line.
Muscles	Heterogeneous (mixture of hyperechoic lines within a hypoechoic tissue background).
Tendons	Predominantly hyperechoic technical artifact (hypoechoic).
Bones , Stone	Markedly hyperechoic with a hypoechoic shadow.
Nerves	Hyperechoic / hypoechoic technical artifact (hypoechoic).
Liver	Mid level echogenicity.
Pancreas, Spleen	Mid level echogenicity (less echogenic than liver).
Renal cortex	Mid level echogenicity (less echogenic than Spleen).
Renal medullae	Echopoor (less echogenic than cortex).
Bowel gas	Markedly hyperechoic (or bright) , casting dirty shadow or reverberation artifact.
Tissue	Ultrasound image character.
Veins	Anechoic (compressible).
Arteries	Anechoic (pulsatile).
Fat	Hypoechoic with irregular hyperechoic lines.
Muscles	Heterogeneous (mixture of hyperechoic lines within a hypoechoic tissue background).
Tendons	Predominantly hyperechoic technical artifact (hypoechoic).
Bone	Hyperechoic lines with a hypoechoic shadow.
Nerves	Hyperechoic / hypoechoic technical artifact (hypoechoic).

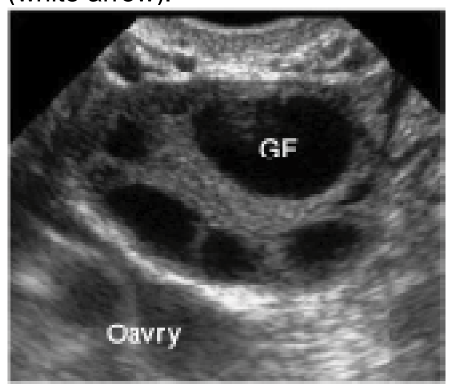
Chocolate cysts is filled with uniform internal echoes (debris).



Liver shows a target shaped lesion (white arrow).



Liver shows an egg shell shaped calcified lesion (old hydatid cyst) .



Ovary shows a large Graffian follicle and many other small growing follicles.

Scope of ultrasound examination [6]

Almost whole body except skeleton and gas containing organs, like Lungs and GIT
(Including brain of neonate and infant up to six month; till the fontanels are open)

Preparation of the patient

- Fasting for 6-8 hours - to see GB function (overnight fasting is preferable) .
- Full bladder - to see pelvic organs (UB & Prostate; the female genital organs- Uterus & Ovaries).
- Bowel preparation - If you have time, send the patient after bowel preparation, i.e., Laxative and Ultracarbon for one or two days. It will help to reduce the bowel gas, which hampers ultrasound transmission.

l TVS (Transvaginal Ultrasound)- needs empty bladder.

References

1.Fikri M, Abu-Zidan, Asraf F Hefny and Peter Corr: J Emerg Trauma Shock. CLINICAL ULTRASOUND PHYSICS. 2011 Oct-Dec, 4(4):501-503

2.Hangiandreou NJ: A PHYSICS TUTORIAL FOR RESIDENTS. RADIOGRAPHICS. 2003 Jul-Aug 23(4)1019-33

3.Sandra L. Ansert; Textbook of diagnostic ultrasonogrpahy; University of California; San diego, Calfornia (fifth ediotion).

4.Carol M. Rumak; Stephen R. Wilson; Jo-Ann M. Johnson: DIAGNOSTIC ULTRASOUND ; Third Edition

5.Roger C. Sanders; Tom Winer; CLINICAL SONOGRAPHY : Fourth Edition.

6.P.E.S. Palmer (Editor); MANUAL OF DIAGNOSTIC ULTRASOUND; Published by WHO.