ADVANCED BIO MEDICAL INSTRUMENTATION

LECTURE 08: NEONATAL INSTRUMENTS

BASIC PRINCIPLES OF ECHO TECHNIQUE

Sound is created by a mechanical vibration and transmits energy through a medium. Ultrasound is sound with a pitch too high to be detected by the human ear (20000 Hz). There are several properties of ultrasound that are useful in clinical cardiology. Since ultrasound is a mechanical wave in a longitudinal direction, it is transmitted in a straight line and it can be focused. These waves obey laws of reflection and refraction. Since small objects in the human body will reflect ultrasound, it is possible to collect the reflected data and compose a picture of these objects to further characterize them. The waves are transmitted and received in an ultrasound transducer, based on piezoelectric crystals.

As ultrasound transverses tissue, its energy decreases. This is called attenuation and is more pronounced in tissue with less density (like lung).

Basically, all ultrasound imaging is performed by emitting a pulse, which is partly reflected from a boundary between two tissue structures, and partly transmitted. The reflection depends on the difference in impedance of the two tissues. Basic imaging by ultrasound does only use the amplitude information in the reflected signal. One pulse is emitted, the reflected signal, however, is sampled more or less continuously (actually multiple times). As the velocity of sound in tissue is fairly constant, the time between the emission of a pulse and the reception of a reflected signal is dependent on the distance; i.e. the depth of the reflecting structure. The reflected pulses are thus sampled at multiple time intervals (multiple range gating), corresponding to multiple depths, and displayed in the image as depth.

Different structures will reflect different amount of the emitted energy, and thus the reflected signal from different depths will have different amplitudes as shown below. The time before a new pulse is sent out, is dependent of the maximum desired depth that is desired to image.

ADVANCED BIO MEDICAL INSTRUMENTATION

Display techniques - A, B, M modes

The main parts of an ultrasound equipment are the ultrasound transducer or probe, the electrical control of the probe and the visualization system. A mode is an operational state that a system has been switched to. A normal mode occurs when all parts of a system oscillate with the same frequency.

A-mode: A-mode (amplitude mode) is the simplest type of ultrasound. A single transducer scans a line through the body with the echoes plotted on screen as a function of depth. The amplitude of reflected ultrasound is displayed on an oscilloscope screen. The A-mode is now used only in ophthalmology.

B-mode or 2D mode: In B-mode (brightness mode) ultrasound, a linear array of transducers simultaneously scans a plane through the body that can be viewed as a two-dimensional image on screen. More commonly known as 2D mode now. B-Mode is based on brightness with the absence of vertical spikes. Therefore, the brightness depends upon the amplitude or intensity of the echo. There is no y axis on B-Mode, instead, there is a z axis, which represents the echo intensity or amplitude, and a x axis, which represents depth. B-Mode will display an image of large and small dots, which represent strong and weak echoes, respectively. On a grey scale, high reflectivity (bone) is white; low reflectivity (muscle) is grey and no reflection (water) is black.

M-mode: M-Mode, or Motion Mode (also called Time Motion or TM-Mode), is the display of a one-dimensional image that is used for analyzing moving body parts commonly in cardiac and fetal cardiac imaging. This can be accomplished by recording the amplitude and rate of motion in real time by repeatedly measuring the distance of the object from the single transducer at a given moment. The single sound beam is transmitted and the reflected echoes are displayed as dots of varying intensities thus creating lines across the screen.

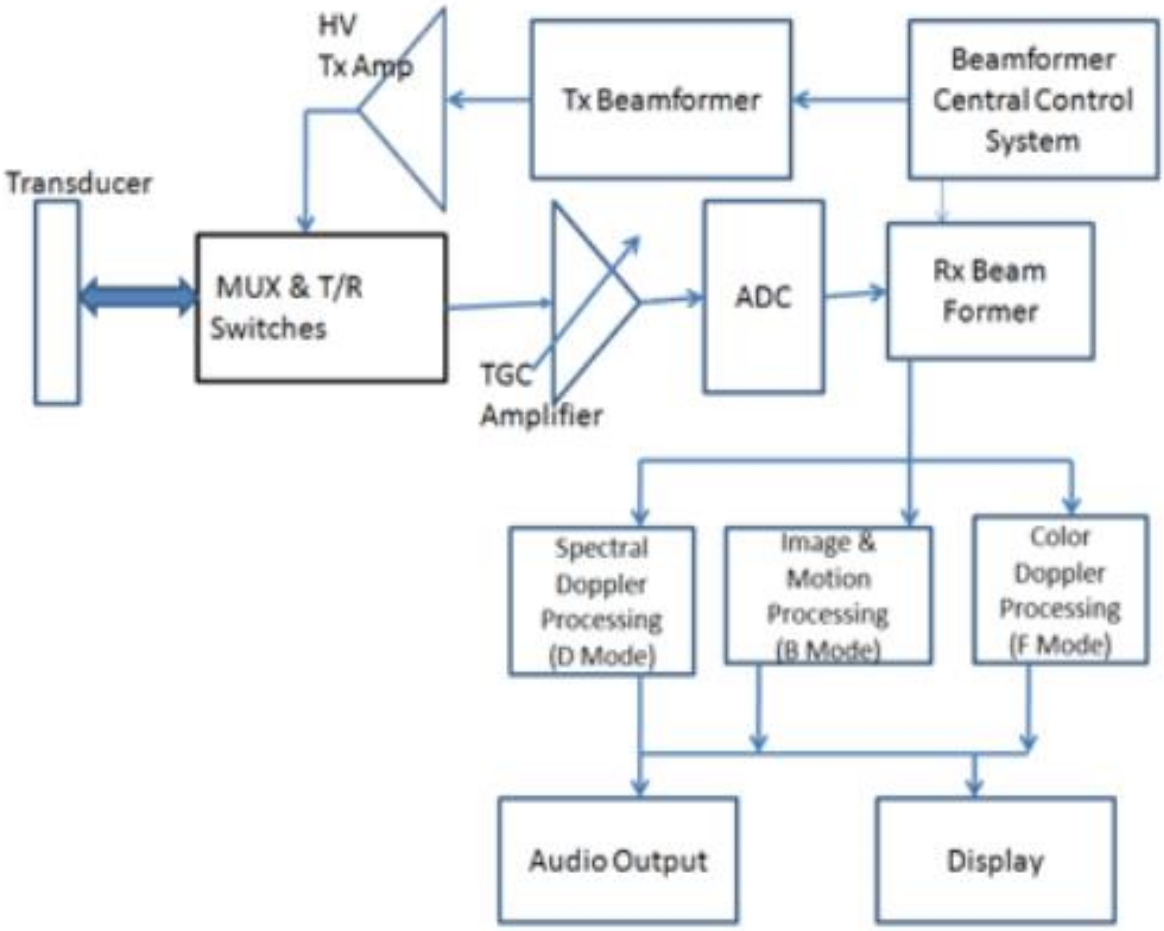
ECHO CARDIOGRAM

ADVANCED BIO MEDICAL INSTRUMENTATION

An echocardiogram (also called an echo) is a type of ultrasound test that uses high-pitched sound waves that are sent through a device called a transducer. The device picks up echoes of the sound waves as they bounce off the different parts of your heart. These echoes are turned into moving pictures of your heart that can be seen on a video screen.

Not only can an echocardiogram create ultrasound images of heart structures, but it can also produce accurate assessment of the blood flowing through the heart by Doppler echocardiography, using pulsed or continuous wave Doppler ultrasound. This allows assessment of both normal and abnormal blood flow through the heart.

An echocardiogram can also give physicians other estimates of heart function such as a calculation of the cardiac output, ejection fraction, and diastolic function.



ADVANCED BIO MEDICAL INSTRUMENTATION

The different types of echocardiograms are:

1.Transthoracic echocardiogram (TTE). This is the most common type. Views of the heart are obtained by moving the transducer to different locations on your chest or abdominal wall.

2. Stress echocardiogram. During this test, an echocardiogram is done both before and after your heart is stressed either by having you exercise or by injecting a medicine that makes your heart beat harder and faster. A stress echocardiogram is usually done to find out if you might have decreased blood flow to your heart (coronary artery disease).

3.Doppler echocardiogram. This test is used to look at how blood flows through the heart chambers, heart valves, and blood vessels. The movement of the blood reflects sound waves to a transducer. The ultrasound computer then measures the direction and speed of the blood flowing through your heart and blood vessels. Doppler measurements may be displayed in black and white or in color.

4.Transesophageal echocardiogram (TEE). For this test, the probe is passed down the esophagus instead of being moved over the outside of the chest wall. TEE shows clearer pictures of your heart, because the probe is located closer to the heart and because the lungs and bones of the chest wall do not block the sound waves produced by the probe. A sedative and an anesthetic applied to the throat are used to make you comfortable during this test.

This test is done to:

Look for the cause of abnormal heart sounds (murmurs or clicks), an enlarged heart, unexplained chest pain or pressure, shortness of breath, or irregular heartbeats, Check the thickness and movement of the heart wall, Look at the heart valves and check how well they work, See how well an artificial heart valve is working, Measure the size and shape of the heart's chambers, Check the ability of your heart chambers to pump blood (cardiac performance), During an echocardiogram, your doctor can calculate how much blood your heart is pumping during each heartbeat (ejection fraction). You might have a low ejection fraction if you have heart failure, Detect a disease that affects the heart muscle and the way it pumps, such as cardiomyopathy, Look for blood clots and tumors inside the heart.

ADVANCED BIO MEDICAL INSTRUMENTATION

ECHO ENCEPHALOGRAM

Echoencephalography is a method for detecting abnormalities within the cranial cavity, based on the reflection of high-frequency sound pulses delivered to the head through a probe held firmly to the scalp. The reflected pulses from the skin, brain ventricle, skull, and other head structures are recorded and amplified with a cathode-ray oscilloscope, giving a measure of the distance between the probe and the reflecting surfaces. The method is rapid, painless, and harmless; it is a good screening test for mass lesions causing brain shift and is well adapted for emergency examination of patients with brain hemorrhage.

ULTRASONIC APPLIED AS DIAGNOSTIC TOOL IN OPHTHALMOLOGY, OBSTETRICS AND GYNECOLOGY

Opthalmology

A major use of ocular echography is to examine the back of the eye in patients who have cloudy ocular media, such as cataract, corneal clouding, or blood in the vitreous fluid. B-scan echography uses a rapidly oscillating transducer to produce a 2 dimensional slice through the globe. The echographic images are viewed on an oscilloscope, and movements of intraocular structures can be viewed in real time. Echography utilizes high frequency sound waves at an intensity which appears to be very safe to tissues. One of the most frequent indications for ocular echography is to examine the retina in diabetic patients who have developed vitreous hemorrhage, to determine whether they have developed a potentially blinding condition called a retinal detachment.

Echography is also very useful in examining the soft tissue structures surrounding the eye. Infections, tumors, congenital abnormalities, inflammatory disease, traumatic disorders, and many other problems can be reliably diagnosed and followed using echography. In addition to standardized A-scan and B-scan instruments, a doppler instrument is also useful in examining the orbit, to listen for blood flow.

ADVANCED BIO MEDICAL INSTRUMENTATION

INFUSION PUMPS

An external infusion pump is a medical device used to deliver fluids into a patient's body in a controlled manner. There are many different types of infusion pumps, which are used for a variety of purposes and in a variety of environments.

Infusion pumps may be capable of delivering fluids in large or small amounts, and may be used to deliver nutrients or medications – such as insulin or other hormones, antibiotics, chemotherapy drugs, and pain relievers.

Types of infusion

The user interface of pumps usually requests details on the type of infusion from the technician or nurse that sets them up:

1. Continuous infusion usually consists of small pulses of infusion, usually between 500 nanoliters and 10 milliliters, depending on the pump's design, with the rate of these pulses depending on the programmed infusion speed.
2. Intermittent infusion has a high infusion rate, alternating with a low programmable infusion rate to keep the cannula open. The timings are programmable. This mode is often used to administer antibiotics, or other drugs that can irritate a blood vessel.
3. Patient-controlled is infusion on-demand, usually with a preprogrammed ceiling to avoid intoxication. The rate is controlled by a pressure pad or button that can be activated by the patient. It is the method of choice for patient-controlled analgesia (PCA), in which repeated small doses of opioid analgesics are delivered, with the device coded to stop administration before a dose that may cause hazardous respiratory depression is reached.

There are two basic classes of pumps. Large volume pumps can pump nutrient solutions large enough to feed a patient. Small-volume pumps infuse hormones, such as insulin, or other medicines, such as opiates.

Infusion pumps may be powered electrically or mechanically. Different pumps operate in different ways.

1. In a syringe pump, fluid is held in the reservoir of a syringe, and a moveable piston controls fluid delivery.
2. In an elastomeric pump, fluid is held in a stretchable balloon reservoir, and pressure from the elastic walls of the balloon drives fluid delivery.
3. In a peristaltic pump, a set of rollers pinches down on a length of flexible tubing, pushing fluid forward.
4. In a multi-channel pump, fluids can be delivered from multiple reservoirs at multiple rates.
5. A "smart pump" is equipped with safety features, such as user-alerts that activate when there is a risk of an adverse drug interaction, or when the user sets the pump's parameters outside of specified safety limits.

BABY INCUBATOR

An incubator is an apparatus used to maintain environmental conditions suitable for a neonate (newborn baby). It is used in preterm births or for some ill full-term babies.

Possible functions of a neonatal incubator are:

- Oxygenation, through oxygen supplementation by head hood or nasal cannula, or even continuous positive airway pressure (CPAP) or mechanical ventilation. Infant respiratory distress syndrome is the leading cause of death in preterm infants, and the main treatments are CPAP, in addition to administering pulmonary surfactant and stabilizing the blood sugar, blood salts, and blood pressure.
- Observation: Modern neonatal intensive care involves sophisticated measurement of temperature, respiration, cardiac function, oxygenation, and brain activity.
- Protection from cold temperature, infection, noise, drafts and excess handling:Incubators may be described as bassinets enclosed in plastic, with climate control equipment designed to keep them warm and limit their exposure to germs.
- Provision of nutrition, through intravenous catheter or NG tube.

- Administration of medications.
- Maintaining fluid balance by providing fluid and keeping a high air humidity to prevent too great a loss from skin and respiratory evaporation.

A transport incubator is an incubator in a transportable form, and is used when a sick or premature baby is moved, e.g., from one hospital to another, as from a community hospital to a larger medical facility with a proper neonatal intensive-care unit. It usually has a miniature ventilator, cardio-respiratory monitor, IV pump, pulse oximeter, and oxygen supply built into its frame