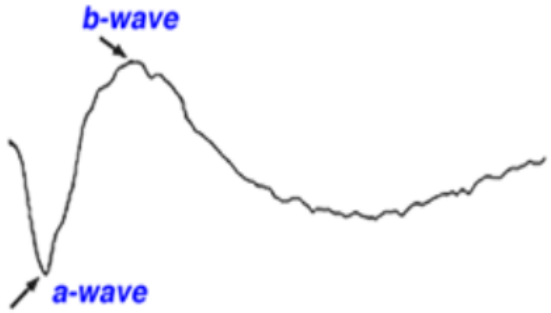
Electroretinogram/ ERG

The electroretinogram (ERG) is a diagnostic test that measures the electrical activity generated by neural and non-neuronal cells in the retina in response to a light stimulus. The light-sensitive cells of the eye, the rods and cones, and their connecting ganglion cells in the retina are examined.

Recording

The basic method of recording the electrical response known as the global or full-field ERG is by stimulating the eye with a bright light source such as a flash produced by LEDs or a strobe lamp. The flash of light elicits a biphasic waveform recordable at the cornea. The two components that are most often measured are the a- and b-waves. The a-wave is the first large negative component, followed by the b-wave which is corneal positive and usually larger in amplitude.



The a-wave, sometimes called the “late receptor potential,” reflects the general physiological health of the photoreceptors in the outer retina. In contrast, the b-wave reflects the health of the inner layers of the retina, including the ON bipolar cells and the Muller cells. Two other waveforms that are sometimes recorded in the clinic are the c-wave originating in the pigment epithelium and the d-wave indicating activity of the OFF bipolar cells. Most disorders of the retina are detected by an attenuation of amplitude.

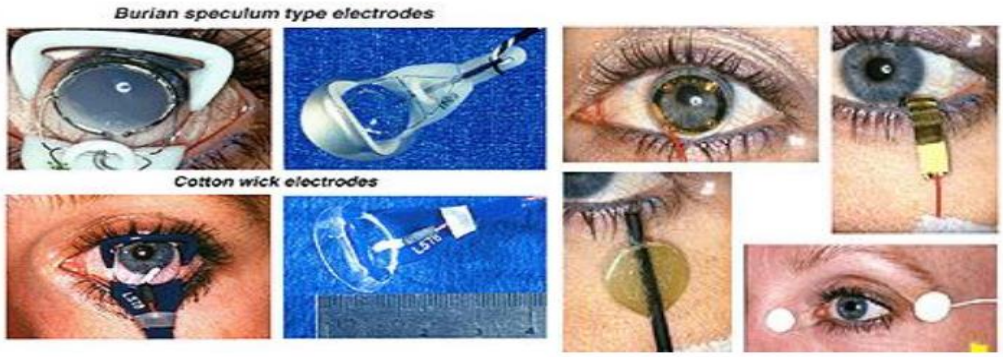
DIAGNOSTICS INSTRUMENTATION

Electrodes

Burian-Allen Electrode- (commonly used electrode for flash ERG) variable lens sizes consisting of an annular ring of stainless steel surrounding the central polymethylmethacrylate (PMMA) contact-lens core with a lid speculum

ERG-Jet Electrode- a disposable plastic lens with a gold-plated peripheral circumference

Mylar Electrode- aluminized or gold-coated Mylar



Skin Electrode- may be used as a replacement for corneal electrodes by placing an electrode on the skin over the infraorbital ridge near lower eyelid; due to decreased amplitudes and variable responses, the skin electrode is primarily used for screening purposes only

Cotton-Wick Electrode- Burian-Allen electrode shell fitted with a cotton wick which is useful for minimizing light-induced artifact.

If electrodes are to be reused, they should be sterilized with a solution that neutralizes prion-transmitted diseases.

Types

The focal ERG (fERG; also known as the foveal ERG) is used primarily to measure the functional integrity of the fovea and is therefore useful in providing information in diseases limited to the macula. Focal ERG is useful for assessing macular function in conditions such as age-related macular degeneration, however requires good fixation from the subject.

The full-field ERG (ffERG) measures the stimulation of the entire retina with a flashlight source under dark-adapted (scotopic) and light-adapted (photopic) types of retinal adaptation.This is useful in detecting disease with widespread generalized retinal dysfunction i.e. cancer associated retinopathy, toxic retinopathies, and cone-rod dysfunction. Due to the massed retinal electrical response, small retinal lesions may not be revealed in ffERG recordings.

The multifocal ERG (mfERG) simultaneously measures local retinal responses from up to 250 retinal locations within the central 30 degrees mapped topographically.

The pattern ERG (PERG) uses pattern-reversal stimuli similar to VEP testing and captures retinal ganglion cell activity predominantly in the N95 waveform component. The PERG is used to detect subtle optic neuropathies. In demyelinating optic neuropathy, the PERG is relatively normal, while it may be abnormal in ischemic optic neuropathies.

Electrooculogram/ EOG

Electrooculography (EOG) is a technique for measuring the corneo-retinal standing potential that exists between the front and the back of the human eye. The resulting signal is called the electrooculogram.

Principle

The eye acts as a dipole in which the anterior pole is positive and the posterior pole is negative.

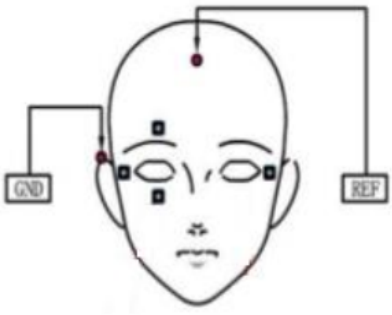
1. Left gaze: the cornea approaches the electrode near the outer canthus of the left eye, resulting in a negative-trending change in the recorded potential difference.
2. Right gaze: the cornea approaches the electrode near the inner canthus of the left eye, resulting in a positive-trending change in the recorded potential difference.

Electrodes

Measurement of eye movements is done by placing pairs of electrodes either above and below the eye or to the left and right of the eye.

If the eye moves from the centre position towards one of the two electrodes, this electrode sees the positive side of the retina and the opposite electrode sees the negative side of the retina. Potential difference occurs between the electrodes. The recorded potential is the measure of the eye position.

The EOG ranges from 0.05 to 3.5 mV and is linearly proportional to eye displacement.



The EOG makes an indirect measurement of the minimum amplitude of the standing potential in the dark and then again at its peak after the light rise. This is expressed as Arden ratio which is the light to dark peak trough.

Advantages

Application of surface electrodes is easy, noninvasive, without discomfort for the patient, and does not limit the field of view. In contrast to most other methods, EOG can be used with the subject wearing glasses and is applicable to children, poorly cooperative patients, or patients with ophthalmic disease. Further, it is possible to record eye movements with eyes closed.

Disadvantages

The amplitude of the corneo- retinal potential changes with the amount of ambient light, so illumination has to be kept constant as much as possible. Further EOG and ENG is often contaminated by electrical, electroencephalographic, and electromyographic artifacts, by lid and blink artifacts, and by slow baseline drifts, caused by changes of skin resistance.

Phonocardiography/PCG

The technique of listening to sounds produced by the organs and vessels of the body is called auscultation. The areas at which the heart sounds are heard better are called auscultation area.

The graphic recording of the sounds connected with the pumping action of the heart is called phonocardiogram. These sounds are produced by vibrations set up in the blood inside the heart by the sudden closure of valves,

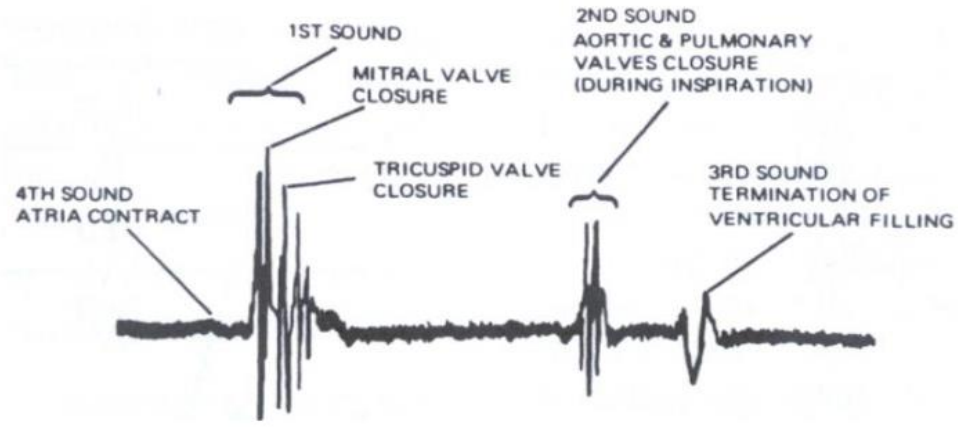
movement of heart wall, closure of walls and turbulence and leakage of blood flow.

Phonocardiography is a diagnostic technique that creates a graphic record of the heart sounds.

The phonocardiogram is obtained either with a chest microphone or with a miniature sensor in the tip of a small tubular instrument that is introduced via the blood vessels into one of the heart chambers.

Heart sounds

Heart sounds are vibrations or sounds due to the acceleration or deceleration of blood during heart muscle contractions, whereas murmurs (a type of heart sounds) are considered vibrations or sounds due to blood turbulence.



S. No	Heart sound	Occurence	Frequency	Time duration	Ausculatory area
1	First heart sound (Lub)	Occur at the end of the atrial	30-45Hz(loud deep pitch and is	50 to 100msec	Occurs approximately 0.05 second

		contraction and at beginning of the ventricular contraction. Due to closure of mitral and tricuspid valves	booming in character)(longer in duration, lower in frequency and greater in intensity than the second sound)		after the onset of QRS complex and just before ventricular systole. Best heard at the apex of mid pericardium.
2	Second heart sound(Dub)	Occurs at the end of ventricular systole due to closure of semilunar valves (aortic and pulmonary aortic valves)in the arteries leading out of the ventricles	50 -70 Hz (higher pitch than the first sound)	25 to 50msec	occurs at 0.03-0.05 second after the end of T wave. Best heard in the aortic and pulmonary areas.
3	Third heart sound	Cessation of ventricular filling. heard in children and patient	below 30Hz.	0.1to 0.2sec	Starts 0.12 – 0.18 second after the onset of second heart sound. The

		with left ventricular failure due to rapid inflow of blood from the atria into the ventricles			asculatory area is at the apex
4	Fourth heart sound or atrial heart sound	contraction of the atria	10-50Hz	0.03 to 0.06 second	Occurs immediately before the first heart sound. It starts 0.12 –0.18 second after the onset of P wave

The third and fourth sounds are called diastolic sounds and are generally inaudible in the normal adult but are commonly heard among children.

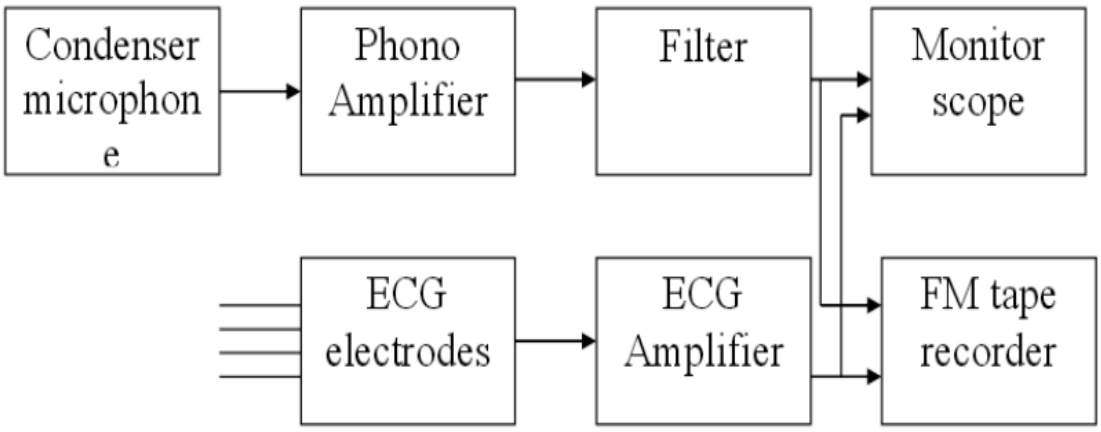
Murmurs.

It occurs in abnormal hearts between normal heart sounds. They are higher pitched sounds in 100-600Hz range and are longer in duration compared to normal heart sounds.

The causes of murmurs are

1. High velocity blood flow that occurs through small opening when there is improper opening of valves.
2. Regurgitation which results when the valves do not close completely and allow some backward flow of blood.
3. Small opening in the septum that separates the left and right sides of the heart. This forces the blood through the opening from the left ventricle into right ventricle by passing the systemic circulation.

Block Diagram



Microphone:

It has a microphone e.g. piezoelectric crystal microphone , condenser, moving coil, carbon and dynamic microphones with frequency response from below 5Hz to above 1000Hz , fastened to the chest wall by an adhesive strip, converts the heart sounds into electrical signals.

The microphones commonly used in PCG are air coupled microphone and contact microphone. In the former, the movement of chest is transferred through an air cushion and presents low mechanical impedance to the chest. But the second one is directly coupled to the chest wall and presents a higher impedance, high sensitivity, low noise and light weight. Sometimes special microphones are placed at the tips of catheters to pick up heart sounds from within the chambers of the heart or from the major blood vessels

near the heart.

Preamplifier:

The electrical signals from the microphone are amplified by a phonocardiographic preamplifier.

Filter:

The high pass filters are used to separate the louder low frequency components from the medically interesting soft high frequency murmurs.

For heart sounds, high pass filters with gradual slope are required and for murmurs, high pass filters with sharper slopes are required.

Recorders

Galvanometer recorders and direct writing recordes(ink jet, theral) are used.

Applications

1. Detection of Rheumatic valvular lesions:

Occurs due to Rheumatic fever which is an autoimmune or allergic disease in which the heart valves are likely to be damaged or destroyed.

2. Murmur of Aortic stenosis:

The blood is ejected from the left ventricle through a small opening of the aortic valve. Because of the resistance to the ejection, the pressure in the left ventricle rises sometimes to as high as 350mm of Hg. This causes turbulent blood flow. This turbulent blood impinging the aortic valve causes intense vibration it produces loud murmur. This sound can be heard several feet away from the patient.

3. Murmur of Mitral regurgitation:

The blood flows backward through the mitral valve during systole.

4. Murmur of Aortic regurgitation:

In aortic regurgitation, the blood flows backward from the aorta into the left ventricle causing "blowing murmur", during diastole.

5. Murmur of mitral stenosis:

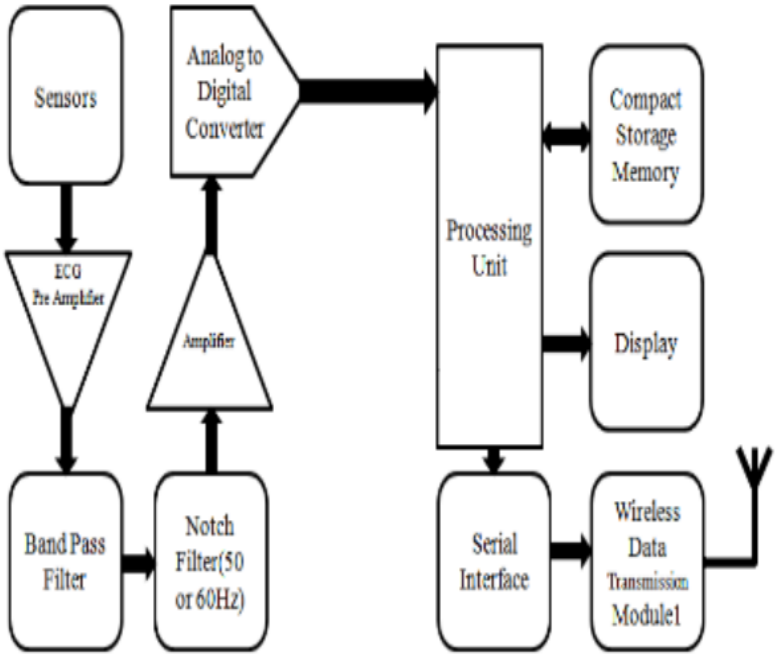
The blood passes with difficulty from the left atrium into the left ventricle due to the pressure difference.

Holter Monitoring

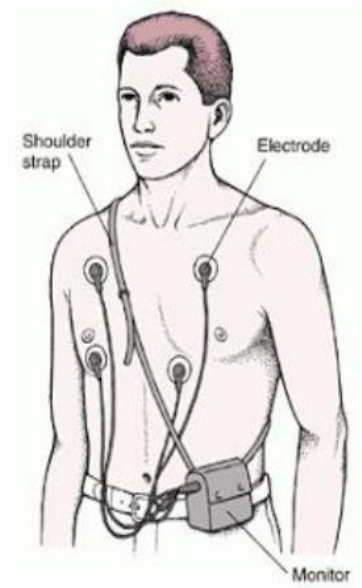
A Holter monitor is a battery-operated portable device that measures and tape records the various electrical activity of the cardiovascular system continuously for 24 to 48 hours or longer depending on the type of monitoring used.

The Holter monitor is named after physicist Norman J. Holter, who invented telemetric cardiac monitoring.

The Holter monitor is small. It is the size of a small camera. Several leads, or wires, are attached to the monitor. The leads connect to electrodes(silver dollar-sized electrodes) that are placed on the skin of the chest with a glue-like gel.



Electrodes are placed over bones to minimize artifacts from muscular activity. The metal electrodes conduct the heart's activity through the wires and into the Holter monitor. The monitor is s attached to the patient's belt or hung around the neck, and is responsible for keeping a log of the heart's electrical activity throughout the recording period.



There are 2 types of Holter monitoring:

Continuous recording - The ECG is recorded continuously during the entire testing period.
Event monitor, or loop recording - The ECG is recorded only when the patient starts the recording, when symptoms are felt.

Components

Each Holter system consists of two basic parts – the hardware (called monitor or recorder) for recording the signal, and software for review and analysis of the record.

Recorder

It records the ECG signals. The average size is 110x70x30 mm but some are only 61x46x20 mm. The devices operate with two AA batteries. Most of the Holters monitor the ECG just in two or three channels. Recently 12 channel Holters have appeared. Recordings from these 12-lead monitors are of a significantly lower resolution than those from a standard 12-lead ECG.

Some modern devices also have the ability to record a vocal patient diary entry that can be later listened to by the doctor.

Software

The physician performs the signal analysis when the recording of ECG signal is finished (usually after 24 or 48 hours. An integrated automatic analysis process in each Holter software, automatically determines different sorts of heart beats, rhythms, etc. But the analysis depends on the signal quality. The quality itself mainly depends on the attachment of the electrodes to the patient body. If these are not properly attached, electromagnetic disturbance can influence the ECG signal resulting in a very noisy record. If the patient moves rapidly, the distortion will be even bigger. Such record is then very difficult to process. Besides the attachment and quality of electrodes, there are other factors affecting the signal quality, such as muscle tremors, sampling rate and resolution of the digitized signal (high quality devices offer higher sampling frequency).

The automatic analysis commonly provides the physician with information about heart beat morphology, beat interval measurement, heart rate variability, rhythm overview and patient diary (moments when the patient pressed the patient button).

Applications

Holter Monitor study is generally ordered by a physician for a patient that has symptoms or suspected activity that is not detected in the 12 Lead resting EKG test performed in the office. These symptoms can include chest pain, shortness of breath, palpitations, syncope or light headedness, dizziness, or skipped beats. The Holter Monitor is an effective diagnostic tools for physicians because it can provide a direct correlation between these symptoms and the behavior of your heart.

A Holter Monitor is also useful in patients that have documented Coronary Artery Disease. The physician will often order the study to look for asymptomatic events or those abnormalities that

cannot be felt by the patient. The detection of these abnormalities can be a predictor of future adverse events.

The other use for a Holter Monitoring study is for patients that already have diagnosed ECG arrhythmias. The continual monitoring of patients with these types of rhythms is useful for physicians to adjust medication and keep a pulse on any changes in these ECG rhythm abnormalities.