**Lecture 14:** **Cardiovascular instrumentation**

Lecture Objectives:

* Physical principles of different parts of ECG machine.
* Physics of defibrillator and pacemakers.

People have been dying of heart diseases for years. If you have heart attack in 1960, you put to bed and your physician hoped for the best, now patient are monitored with ECG which is continuously displayed on oscilloscope.

**Electrodes:**

A major problem of ECG is the metal electrode; assume the body as a bag of salt water & current flows by moving ions. In wire and metals from which the electrode is made, its current flows by moving electrons. So at the interface between the body and a metal electrode, the ion flow must be converted to electron flow through a chemical reaction.

If ordinary metal are used for electrodes, polarization results from chemical reaction. At electrode, gas bubbles form due to electrolysis and this become unstable, this instability produces electrical noise, and these problems may be avoided by using silver–silver chloride electrode.

**Amplifier:**

The amplitude of ECG signal is about 1 mv. The amplifier used to record ECG must be able to eliminate interference from voltages induced in the body from such external sources. If there is problem in amplifier, oscilloscope is used to observe ECG, since oscilloscope requires power about 1 μA current flow to ground through B

 Voltage is 10 times ˃ ECG

To avoid this interference voltage we may use differential amplifier on some oscilloscopes.



**Figure 1:** **Differential amplifier**

Another cause of interference in ECG is illustrated in Figure 2 changing magnetic field produced by alternating current flow through wires and strong near motors and transformers since the induced voltage is proportional to the loop, this interference minimized by keeping the area of the loop small.

 The wires can be either twisted or run parallel and close together in a bundle.



**Figure 2:** **The effect of wire twisting on the formation**

 **of interference in the ECG recording**

**Patient monitoring:**

ECG recording using pen recorder is a permanent record and it’s impractical for continuous monitoring of heart attack.

A more convenient approach is enough for doctors or nurses to assess the patient condition using modern monitors which use microcomputers to store ECG information.

It is very difficult to maintain vigilance while watching ECG tracing on scope, so automatic alarm devices have been used to measure the time between successive R waves.



**Figure 3:** **The use automatic detection of heart rate**

**Defibrillator:**

Many heart attack patients undergo sudden change in rhythm. Death flow within minutes unless the can be defibrillated, defibrillator shown in the fig. (3).

The paddles are metal electrodes 7.5 cm in diameter coated with conductive paste placed above and below the heart. When switch thrown a current, about 20 A flows through heart for about 5 msec. This current contracts every muscle fiber in the heart at the same time; the heart can initiate normal rhythm.

**Pacemaker:**

The atria of heart are separated from ventricles by fatty layer that doesn’t conduct electricity, at single location the atrioventricular node impulses are conducted from atria to the ventricles. If this node is damaged, the ventricles receives no signal from the atria however the ventricles does not stop pumping. There are natural pacing centers in the ventricles that provide pulse if none has been received from atria for 2 sec. The resulting heart rate 30 beats /min. will sustain life but the patient may have to live semi-invalidism, artificial pacemakers have been developed about 72 pulse/ min.

 

 **Figure 4: Pacemaker device**

**Small Group Session Discussion:**

Q1/ What are Korotkoff sounds?

Q2/ What is the approximate velocity of blood in the capillaries?

Q3/Why can arteries with small diameters have thinner walls than arteries with large diameters carrying blood at the same pressure?

Q4/ How does the venous blood get from the feet to the heart of a standing person?

Q5/ Why do differential amplifiers used for ECG recording have a large input resistance?

Q6/ Explain why cardiac muscle contraction need more time than other muscle

Q7/ Discuss the total work done by the normal heart to pump the blood from left

ventricle to aorta

Q8/ Discuss the effect of turbulent flow on pressure, velocity, viscosity,

and heart sound.