Cardiovascular Instrumentation

1.BIOTENTIALS OF THE HEART

Movements of ions into muscle fibers (cells) of the heart cause action potentials, which produce the contraction. Ion movements in heart muscle cells constitute a current flow, which results in potential differences in the tissue outside the fibers and on the surface of the body (Fig. 1).

لا يمكن عرض هذه الصورة حاليًا.

This current only flows while the action potential is propagating (mainly during the QRS wave of the ECG) or during the recovery period (T wave). At the peak of the R wave, the potentials on the surface of the body are as shown in Fig. 2

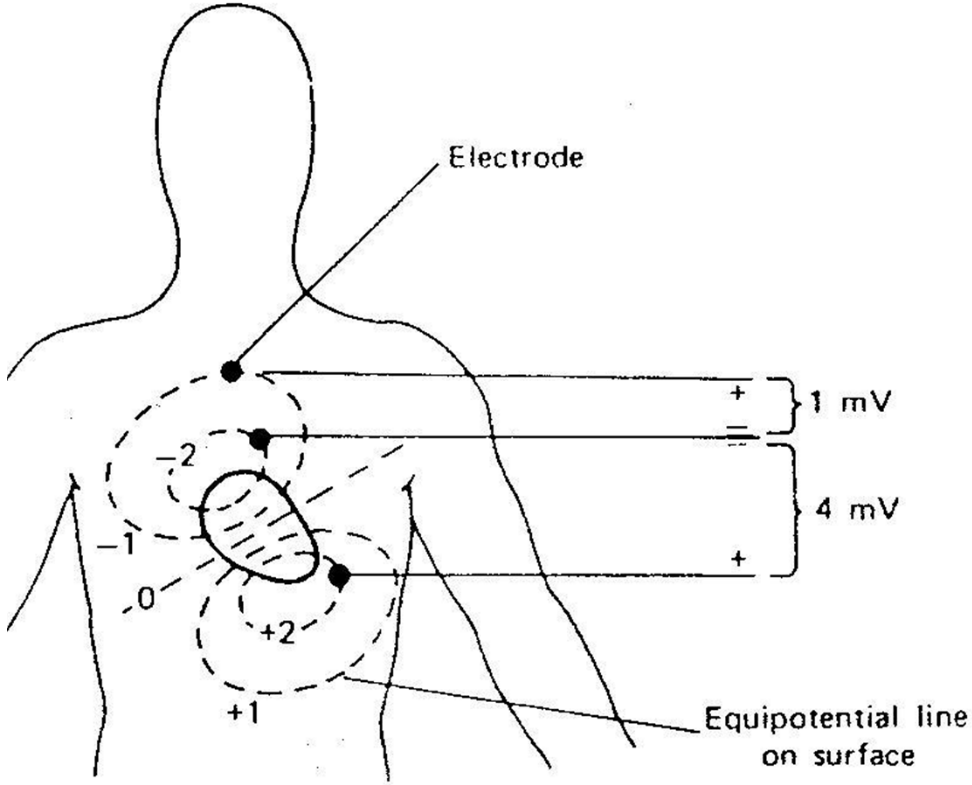


Fig.2. The dashed lines show the resulting surface potentials. The difference in the measured potentials caused by using different electrode locations. Both voltage and polarity my change with electrode position

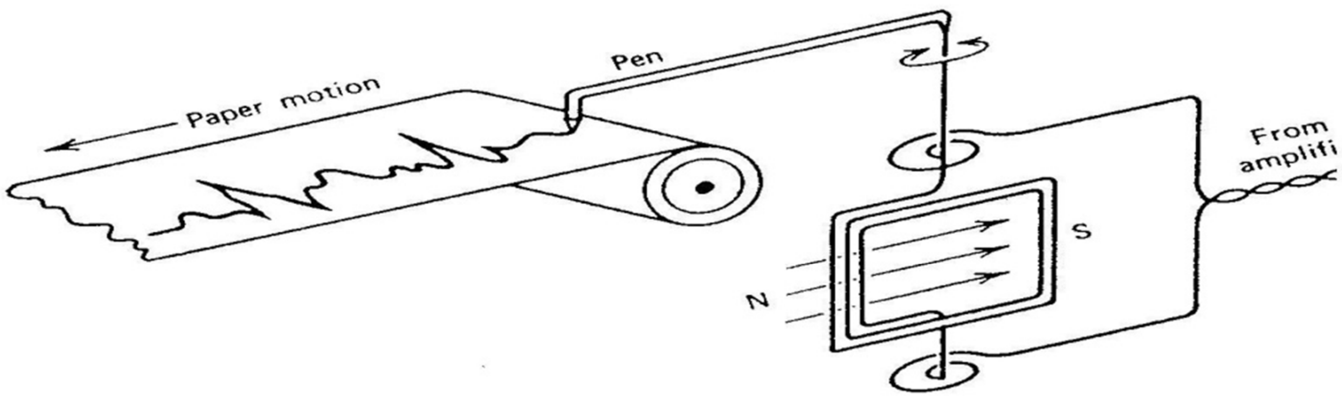
2.ELECTRODES

At the interface between the body and a mental, ion flow must be converted to electron flow through a chemical reaction.

3.AMPLIFIERS

The amplitude of the typical ECG signal is only about 1 mV . However, in a typical building the current capacitively coupled into the body from the 120 V power lines can produce a much larger potential. The amplifier used to record the ECG must be able to eliminate interference from voltages induced in the body from such external sources.

4. PATIENT MONITORING

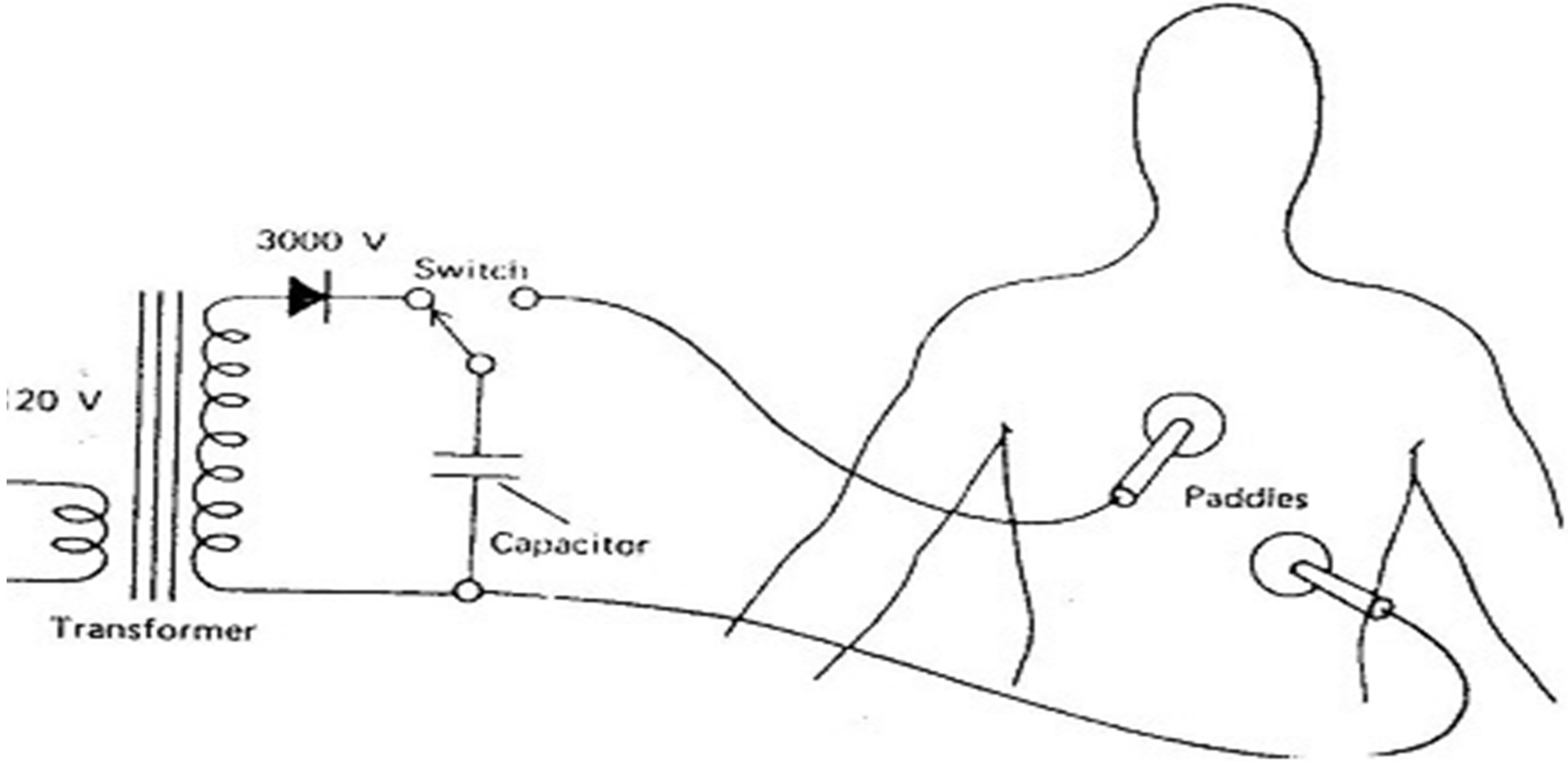


After amplification, the ECG signal must be displayed. When a routine diagnostic ECG is taken, a permanent record is required for analysis and a pen recorder is usually used (Fig.3). In a pen recorder, the amplifier output passes through a coil of wire suspended in a magnetic field. In the same way that a galvanometer twists when current passes through it, the pen twists to write on a moving strip of paper.

5.DEFIBRILLATORS

The reason for continuously monitoring the ECG is that problems arise, prompt therapeutic action can be taken to save the patient's life. Many heart attack patients undergo sudden changes in rhythm. The orderly heart muscle contractions associated with normal heart pumping change to the uncoordinated twitching of ventricular fibrillation, which halts the heart pumping action. Death follows within minutes unless the heart can be defibrillated.

Defibrillation is accomplished as shown in Fig. 4. The paddles are mental electrodes 7.5 cm in diameter that are coated with conductive paste and placed above and below the heart. The paddle handles are made of plastic and are electrically insulated to prevent accident shock to the operation. When the switch is thrown, a current of about 20 A flows through the heart for about 5 mill second. This current contracts every muscle fiber in the heart at the same time. All muscle fibers then recover at about the same time, and the heart can initiate normal rhythm again.

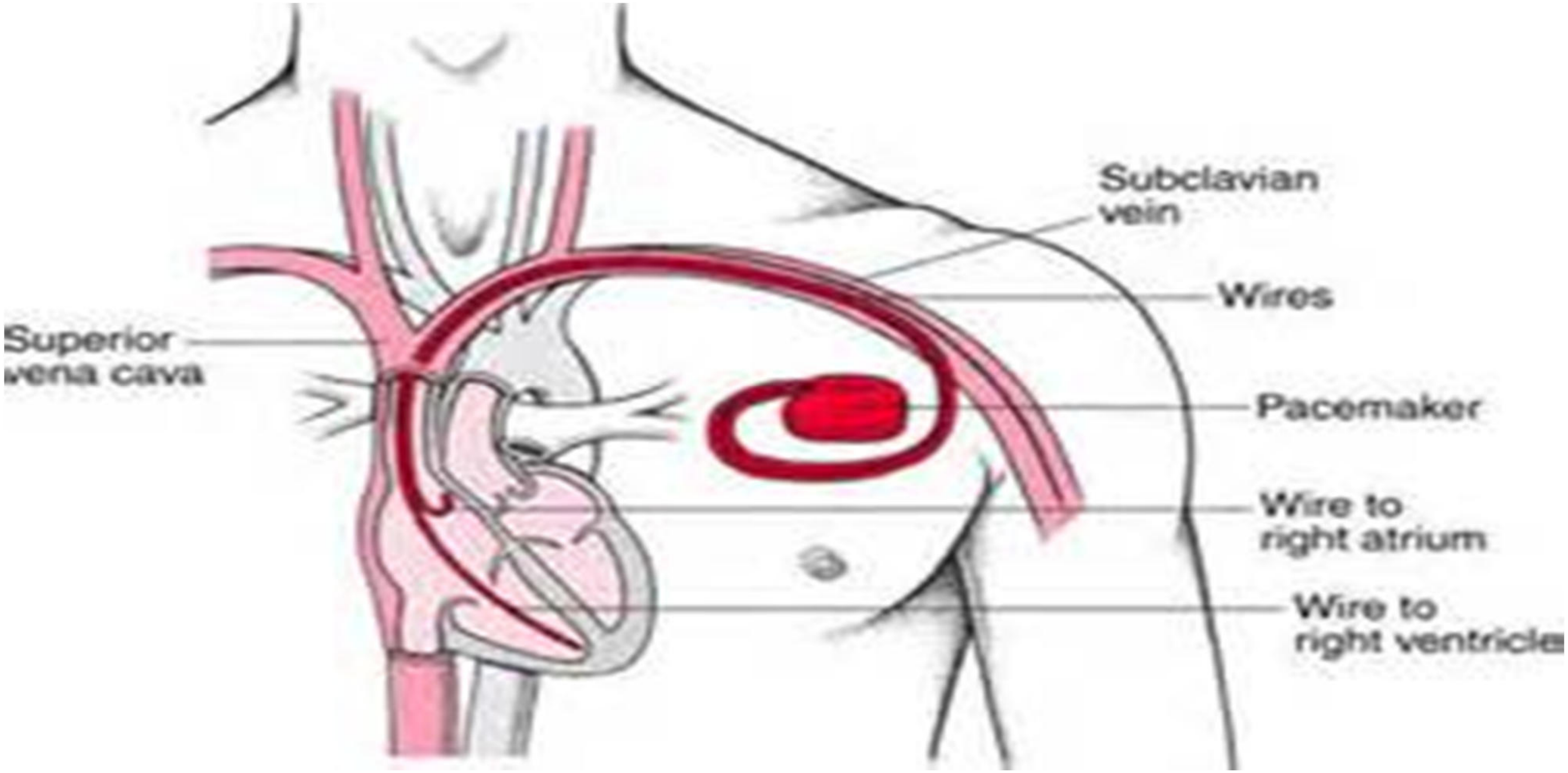


(Fig. 4). A simple defibrillator. The line voltage is stepped up to several thousand volts by a transformer. A diode rectifies the alternating current into direct current to charge up the capacitor. When the switch is thrown. The capacitor discharge through the paddles and the heart.

6. PACEMAKERS

The atria of the heart are separated from the ventricles by a fatty layer that does not conduct electricity or propagate nerve impulses. At a single location, the atrioventricular node, impulses from the atria are conducted to the ventricles, which perform the heart's pumping action. If this node is damaged, the ventricles receive no signals from the atria. However, the ventricles do not stop pumping; there are natural pacing centers in the ventricle a pulse if none has been received from the atria for 2 seconds. The resulting heart rate, 30 beats/min, will sustain life, but the patient may have to live a life of semi-invalidism.

To improve the quality of life for patients with faulty atrioventricular nodes, artificial pacemakers have been developed. The pacemaker contains a pulse generator that puts out 72 pulses/min. The pacing wire is fed through a slit in the shoulder vein and advanced under fluoroscopic control until the tip is imbedded in the wall of the right ventricle (Fig. 5).



- (Fig.5). Pacemakers provide electrical pulses to the heart in order to produce a normal heart rate.

Applications of Electricity and Magnetism in Medicine

1. ELECTRICAL SHOCK

When an electrode is connected to each hand and 60 Hz currents of different levels are passed through the body. The amount of current depends on the resistance of body between two points due to Ohms law

$$V = I \times R$$

As the current is increased from zero, the level at which we can just feel the current- the perception level is reached. About 50% of adult men fell a 60 Hz current of about 1 mA. For women about one third lower than those fell. The perception level is frequency dependent; it rise as the frequency increases above 100 Hz.

As a 60 Hz current is increased above the perception level it causes a tingling sensation in the hands.

1. At current of 10 to 20 mA.

A sustained muscular contraction takes place in hands and many subjects cannot let go of the electrodes. (Note that this current is higher at both low and high frequency) in (Fig. 6). As the current increased still further, pain and some cases fainting occur.

2. Near the 100 mA level the portion of the 60 Hz current passing through the heart is sufficient to cause ventricular fibrillation. (rapid, irregular, and ineffectual contraction of the ventricles).

3. For a 60 Hz shock, the estimated maximum current that will not induce fibrillation in man is given by $(116/t^{1/2})$ mA, where t is the time (in seconds) the shock tests.

For example: if t = 1 s the safe current is 116 mA

If t = 4 s the safe current is 58 mA

4. Current levels of 6 A and above cause sustained muscular contraction of the heart similar to the (cannot let go) behavior of the hands. Defibrillators make use of such current levels. If a potential has ventricular defibrillation, a brief shock from a defibrillator usually restores normal coordinated pumping in the heart. The defibrillator uses a brief pulse of up to 10 Kv. A defibrillator can also be used to synchronize the heart to its normal rhythm when a patient has atrial fibrillation, in this case the electrical pulse is applied after R wave but before T wave .