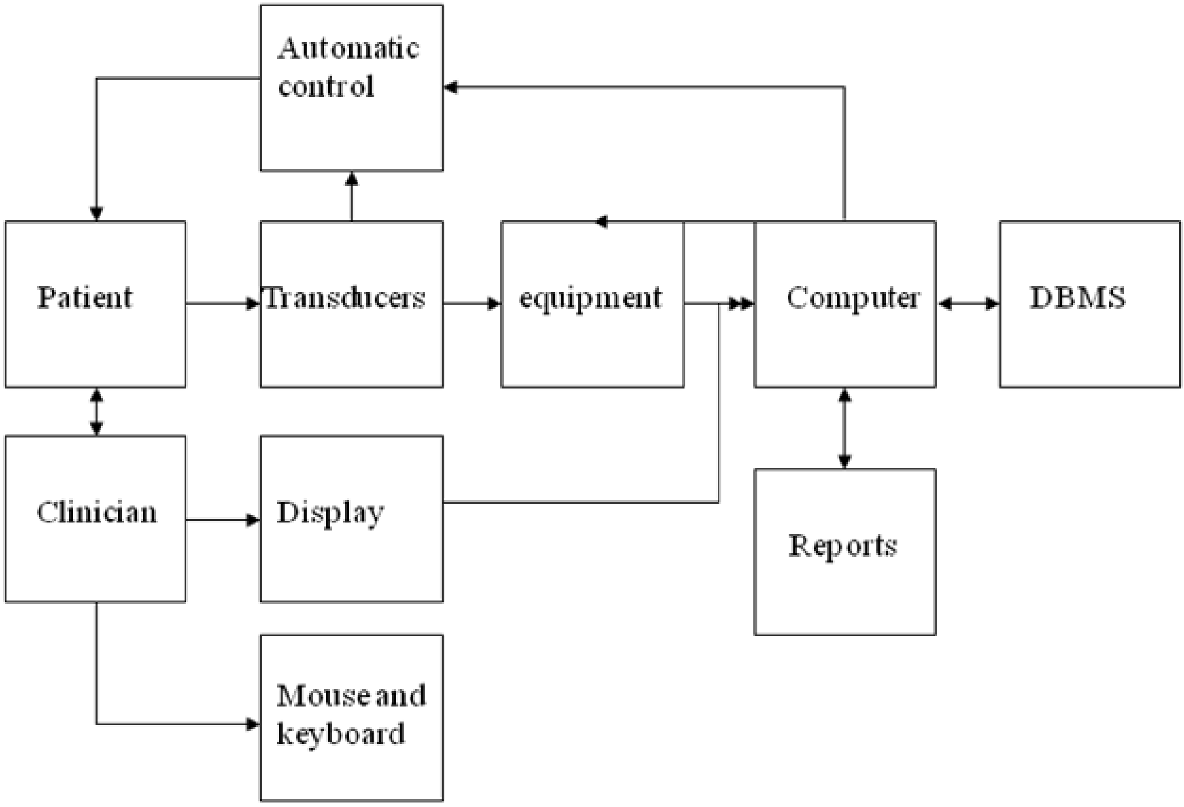
UNIT - 4

PATIENT CARE & MONITORING

Patients are monitored because they have an unbalance in their body systems. This can be caused by a heart attack or stroke, for example, or it may be the result of a surgical operation, which can drastically disturb these systems. By continual monitoring, the patient problems can be detected as they occur and remedies taken before these problems get out of hand.

The Elements of Intensive-Care Monitoring

The need for intensive-care and patient monitoring has been recognized for centuries. The 24-hour nurse for the critically ill patient has, over the years, become a familiar part of the hospital scene. The basic block diagram which shows the elements of patient monitoring system is indicated below.



Although patient-monitoring systems vary greatly in size and configuration, certain basic elements are common to nearly all of them. A cardiac-care unit, for example, generally includes the following components:

- **Skin electrodes to pick up the ECG potentials**
- **Amplification equipment**
- **A cathode-ray-tube (CRT) display**
- **Rate meter**
- **Alarming Systems**
- **Recording Equipment**

- **CCTV Camera’s**

The purpose of body electrodes is to extract the biopotentials from the body with the help of help of sensing element and transduction element.

The potential we pick up from the human being is not in a suitable form so it has to be amplified and processed to a suitable format to see on a display. This can be done with the help of amplification equipment.

For visual representation of the biopotentials we generally use CRT displays. Some times we also prefer non fade displays and bouncing ball displays depend on the application (ECG, EMG, and EEG).

Rate meters are used to obtain the pulse rate, heart beat rate, respiration rate with the help of Electrocardiograph, Electroencephalograph etc….

Alarming systems plays a major role in ICU’s to monitor and alert the physician or nurse whenever there is an abnormality found with the patient. These systems may use some sort of beeping sounds or flash light mechanisms to alert the authorized person.

Recording equipment are used to store the data either on a physical media like strip chart recorders, cylindrical drum recorder or on a virtual media like CD, DVD’s for future purpose.

To monitor the patient 24/7 in an ICU we use closed circuit TV cameras which are available at a bearable cost. Usually in every hospital there is central nurses monitoring station which contains 8 to 10 computers to maintain a continuous coverage of the ICU.

Patient Monitoring Displays

An important feature of any patient-monitoring system is its ability to display the physiological waveforms being monitored. Clear, faithful reproductions of the ECG, blood pressure, and other variables enable the medical staff to periodically check a patient's progress and make vital decisions at times of crisis. Although paper-chart recordings are often used to provide a permanent record of the data, the principal display device for patient monitoring is the cathode-ray tube (CRT).

There are three types of patient monitoring displays used in the bed side of the patient for parameter observations. They are

a) CRT displays
b) Bouncing ball displays
c) Non fade displays

CRT displays:

Most monitors (computer screens) use cathode ray tubetis (or CRT for short), which are glass vacuum tubes into which an electron gun emits a flow of electrons guided by an electrical field towards a screen covered in small phosphorescent elements.

The electron gun is made up of a cathode, a negatively charged metallic electrode, and one or more anodes (positively charged electrodes). The cathode emits the electrons attracted by the anode. The anode acts as an accelerator and concentrator for the electrons, forming a flow of electrons aimed at the screen. A magnetic field guides the electrons from left to right and from top to bottom. It is created with two electrified X and Y plates (called *deflectors*) which send the flow horizontally and vertically, respectively.

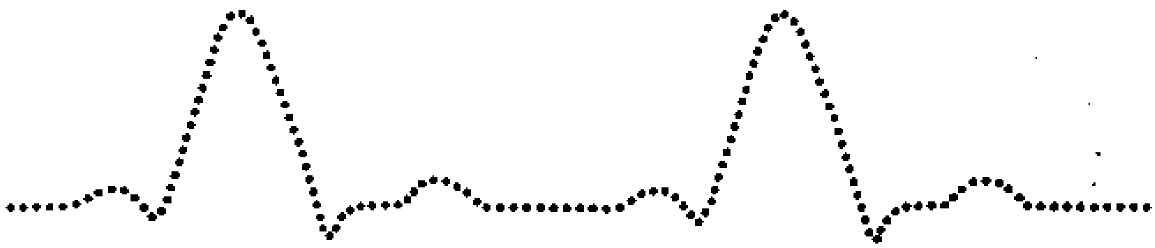
Bouncing ball displays:

The bouncing ball displays are similar to the conventional CRT displays but difference is in terms of sweep rate. The sweep rates of ordinary CRT display vary from 20 to 25 mm/sec. whereas the sweep rates of bouncing ball display vary from 35 to 40 mm/sec.Due to high sweep rates they appeared to be continuous but usually not.

Non - fade displays:

Nonfade displays also use the cathode-ray tube, but in an entirely different way. In the Nonfade method, the electron beam rapidly scans the entire surface of the CRT screen in a television-like raster pattern, but with the brightness level so low that the background raster is not visible.

The beam is brightened only when a brightening signal is applied to the CRT by a method called Z-axis modulation. This brightening signal is applied only when the electron beam passes a location that is to contain a part of the displayed waveform, at which time it produces a dot on the screen. Each time the entire screen is scanned, each of the traces appears as a series of dots similar to the ECG pattern shown in Figure.



Equipments required for the patient monitoring

Surgical Equipment:

The equipments like scissors, knives and other equipment required for the surgery or any operation in an ICU is called Surgical Equipment.

Non surgical Equipment:

The equipment like Rate meters, ECG, EEG machines and respiratory therapy equipment like inhalators, aspirators, and emergency equipment like pacemakers and defibrillators are called as Non surgical Equipment.

PACEMAKERS

The rhythmic action of the heart is initiated by regularly recurring action potentials (electrochemical impulses) originating at the natural cardiac pacemaker, located at the sinoatrial (SA) node.

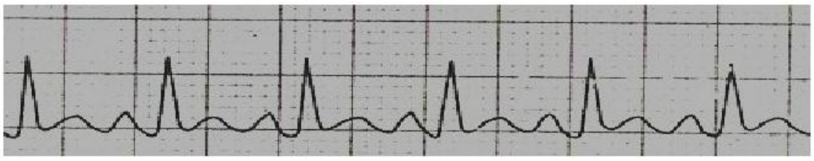
A **natural pacemaker** is an organ which maintains heart rhythm to beat at regular intervals. Failure of this pacemaker in the body leads to uneven rhythm of the heart beat which further leads to failure of the heart functioning.

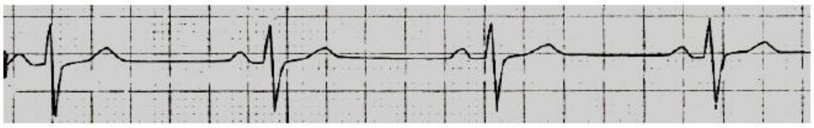
(Or)

A device capable of generating artificial pacing impulses and delivering them to the heart is known as a pacemaker system (commonly called a pacemaker) and consists of a pulse generator and appropriate electrodes.

Heart block occurs whenever the conduction system fails to transmit the pacing impulses from the atria to the ventricles properly.

If the speed of the heart rate is increased beyond the natural pace, then that condition is called as **"TACHYCARDIA"**. Similarly if the speed of the heart rate is below the natural pace, the situation is called as **"BARDYCARDIA".** Below diagram shows the difference between the natural rhythm and deviated rhythm.



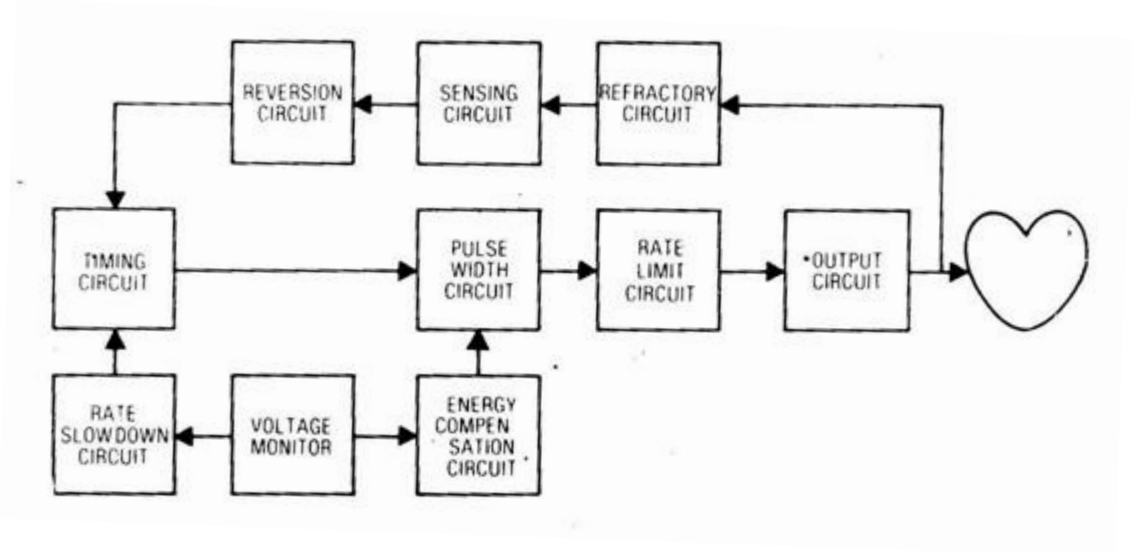


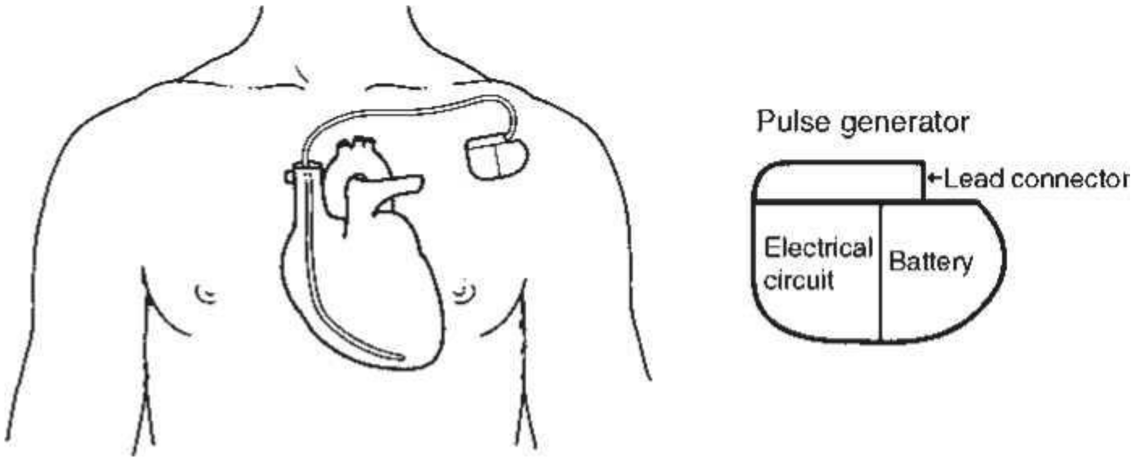
Types of Pacemakers:

a) Internal pacemakers
b) External pacemakers

Internal pacemakers:

- Pacemakers are available in a variety of forms. Internal pacemakers may be permanently implanted in patients whose SA nodes have failed to function properly or who suffer from permanent heart block because of a heart attack.
- An internal pacemaker is defined as one in which the entire system is inside the body. It can be seen from the figure below.

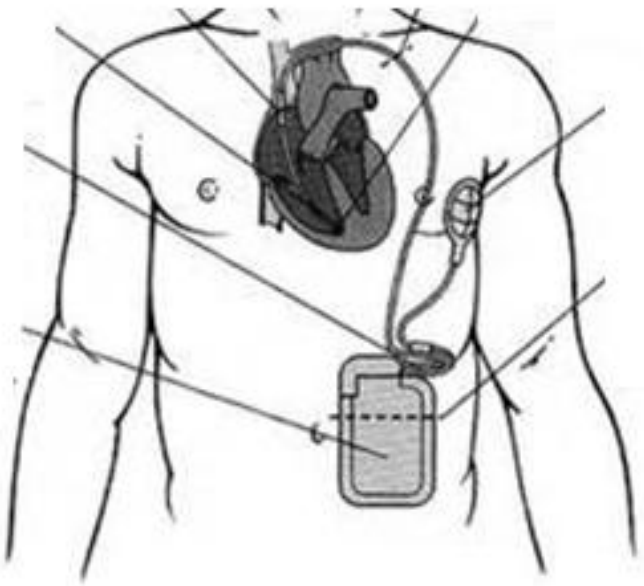




- Internal pacemaker systems are implanted with the pulse generator placed in a surgically formed pocket below the right or left clavicle, in the left sub costal area.
- Internal leads connect to electrodes that directly contact the inside of the right ventricle or the surface of the myocardium.
- The exact location of the pulse generator depends primarily on the type of electrode used, the nature of the cardiac dysfunction, and the method of pacing that may be prescribed.
- Since there are no external connections for applying power, the pulse generator must be completely self-contained, with a power source capable of continuously operating the unit for a period of years.
- The battery life is up to 5 years and it is usually made up of lithium iodide.
- The persons who are implanted with internal pacemakers should be stay away from the microwave ovens and devices which emit high electromagnetic field radiation.

External pacemakers:

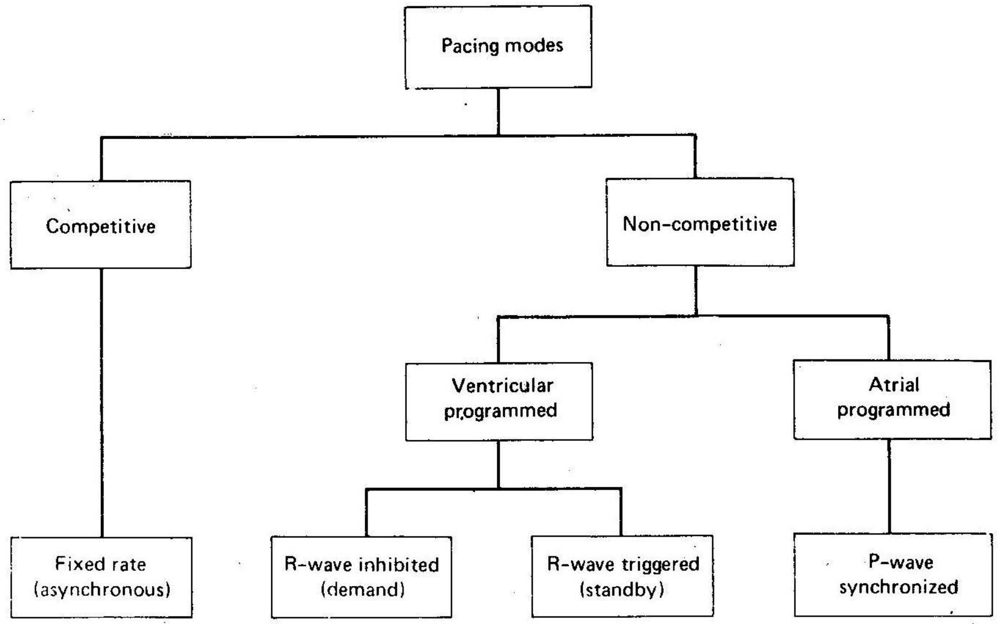
- An external pacemaker usually consists of an externally worn pulse generator connected to electrodes located on or within the myocardium. We can see the external pacemaker from the below figure.



- External pacemakers are used on patients with temporary heart irregularities, such as those encountered in the coronary patient, including heart blocks.
- They are also used for temporary management of certain arrhythmias that may occur in patients during cardiac surgery, especially if the surgery involves the valves or septum.
- External pacemakers, which include all types of pulse generators located outside the body, are normally connected through wires introduced into the right ventricle via a cardiac catheter, as shown in Figure.
- The pulse generator may be strapped to the lower arm of a patient who is confined to bed, or worn at the midsection of an ambulatory patient.

Pacing Modes in pacemakers

- Several pacing techniques are possible with both internal and external pacemakers. They can be classed as either competitive or noncompetitive pacing modes as shown in Figure.



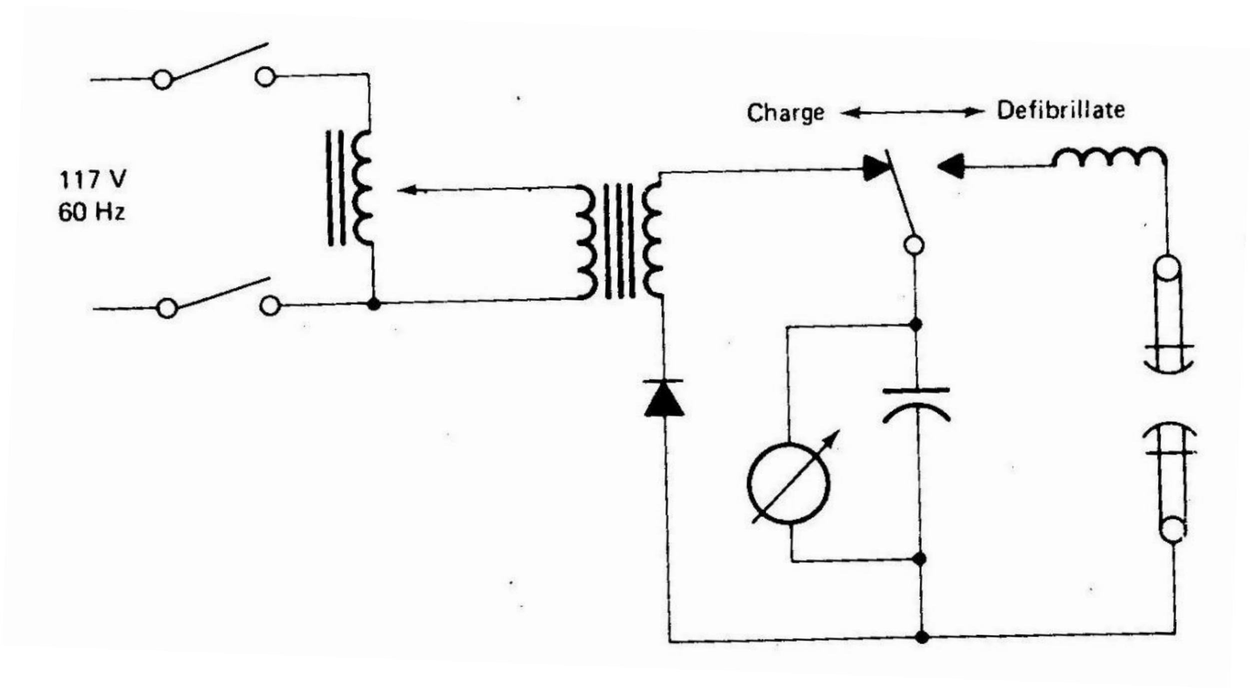
- The noncompetitive method, which uses pulse generators that are either ventricular programmed or programmed by the atria, is more popular.
- Ventricular-programmed pacemakers are designed to operate either in a demand (R-wave-inhibited) or standby (R-wave-triggered) mode, whereas atrial-programmed pacers are always synchronized with the P wave of the ECG.
- The first (and simplest) pulse generators were fixed-rate or asynchronous (not synchronized) devices that produced pulses at a fixed rate (set by the physician or nurse) and were independent of any natural cardiac activity.
- Asynchronous pacing is called competitive pacing because the fixed-rate impulses may occur along with natural pacing impulses generated by the heart and would therefore be in competition with them in controlling the heartbeat.
- Fixed-rate pacers are sometimes installed in elderly patients whose SA nodes cannot provide proper stimuli.

DEFIBRILLATORS

- The heart is able to perform its important pumping function only through precisely synchronized action of the heart muscle fibers. The rapid spread of action potentials over the surface of the atria causes these two chambers of the heart to contract together and pump blood through the two ventricles. After a critical time delay, the powerful ventricular muscles are synchronously activated to pump blood through the pulmonary and systemic circulatory systems. A condition in which this necessary synchronism is lost is known as fibrillation.
- During fibrillation the normal rhythmic contractions of either the atria or the ventricles are replaced by rapid irregular twitching of the muscular wall. Fibrillation of atrial muscles is called atrial fibrillation; fibrillation of the ventricles is known as ventricular fibrillation.
- Ventricular fibrillation is far more dangerous, for under this condition the ventricles are unable to pump blood; and if the fibrillation is not corrected, death will usually occur within a few minutes.
- Unfortunately, fibrillation, once begun, is not self-correcting. Hence, a patient susceptible to ventricular fibrillation must be watched continuously so that the medical staff can respond immediately if an emergency occurs.
- Although mechanical methods (heart massage) for defibrillating patients have been tried over the years, the most successful method of defibrillation is the application of an electric shock to the area of the heart.
- If sufficient current to stimulate all musculature of the heart simultaneously is applied for a brief period and then released, all the heart muscle fibers enter their refractory periods together, after which normal heart action may resume.
- This application of an electrical shock to resynchronize the heart is sometimes called counter shock. If the patient does not respond, the burst is repeated until defibrillation occurs. This method of counter shock was known as ac defibrillation.
- There are a number of disadvantages in using ac defibrillation, however. Successive attempts to correct ventricular fibrillation are often required. Moreover, ac defibrillation cannot be successfully used to correct atrial defibrillation.
- In fact, attempts to correct atrial fibrillation by this method often result in the more serious ventricular fibrillation. Thus, ac defibrillation is no longer used.

DC Defibrillator

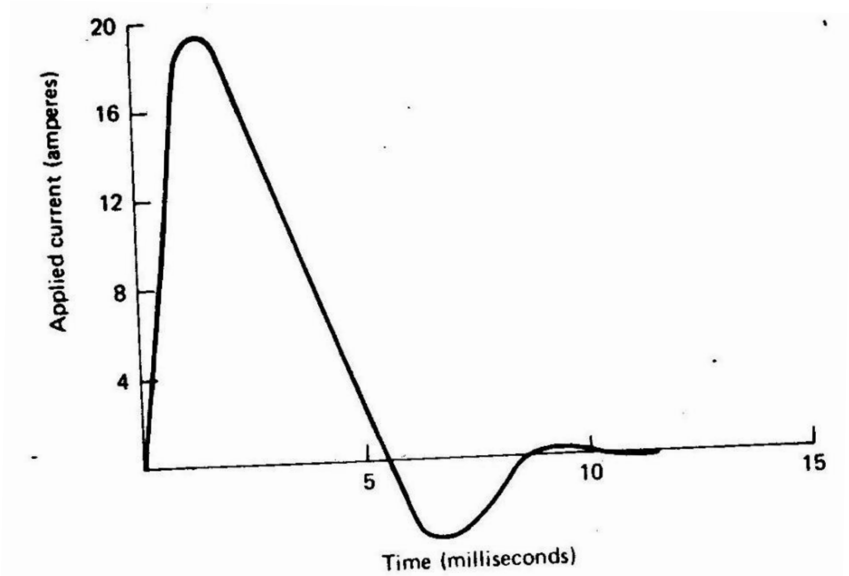
A new method of dc defibrillation that has found common use today. In this method, a capacitor is charged to a high dc voltage and then rapidly discharged through electrodes across the chest of the patient. A dc defibrillator is shown in Figure with a typical dc defibrillator circuit shown in Figure.



It was found that dc defibrillation is not only more successful than the ac method in correcting ventricular fibrillation, but it can also be used successfully for correcting atrial fibrillation and other types of arrhythmias.

Depending on the defibrillator energy setting, the amount of electrical energy discharged by the capacitor may range between 100 and 400 W-sec, or joules.

The duration of the effective portion of the discharge is approximately 5 msec. The energy delivered is represented by the typical waveform shown in Figure as a time plot of the current forced to flow through the thoracic cavity.

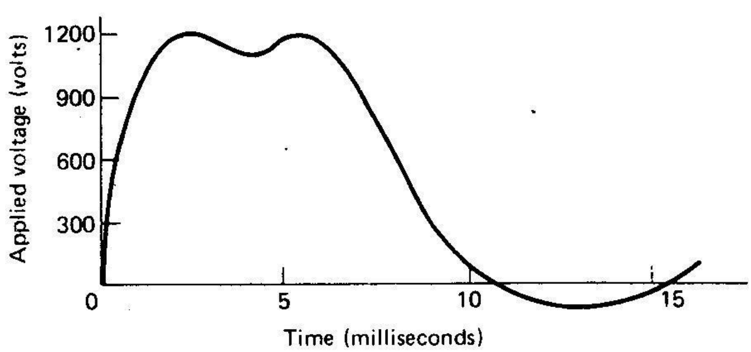


The area under the curve is proportional to the energy delivered. It can be seen that the peak value of current is nearly 20 A and that the wave is essentially monophasic, since most of its excursion is above the baseline.

An inductor in the defibrillator is used to shape the wave in order to eliminate a sharp, undesirable current spike that would otherwise occur at the beginning of the discharge.

Even with dc defibrillation, there is danger of damage to the myocardium and the chest walls because peak voltages as high as 6000 V may be used.

To reduce this risk, some defibrillators produce dual-peak waveforms of longer duration (approximately 10 msec) at a much lower voltage. When this type of waveform is used, effective defibrillation can be achieved with lower levels of delivered energy (between 50 and 200 W-sec). A typical dual-peak waveform is shown in Figure.



To protect the person applying the electrodes from accidental electric shock, special insulated handles are provided. A thumb switch, located in one (or both) of the handles, is generally used to discharge the defibrillator when the paddles are properly positioned.

The two defibrillator electrodes applied to the thoracic walls are called either anterior-anterior or anterior-posterior paddles.

With anterior-anterior paddles, both paddles are applied to the chest. Anterior-posterior paddles are applied to both the patient's chest wall and back so that the energy is delivered through the heart. This method of paddle application offers better control over arrhythmias that occur as a result of atrial activity.