

Medical Equipment I

(BIS 402)

Defibrillator & Pacemaker

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Outline

- Introduction
- History
- Uniphasic vs. Biphasic Defibrillation
- Defibrillation Types
- Pacemaker





Defibrillator

Defibrillator is a device that delivers a therapeutic dose of electrical energy to the affected heart.

This depolarizes a critical mass of the heart muscle and allows normal sinus rhythm to be reestablished by the body's natural pacemaker of the heart.



Defibrillator

History

- Defibrillation was first demonstrated in **1899** by Prevost and Batelli, two physiologists from University of Geneva, Switzerland. They discovered that small electric shocks could induce ventricular fibrillation in dogs, and that larger charges would reverse the condition.
- The first successful human defibrillation was performed in 1947 by Dr. Claude Beck on a 14 year old boy.
- These early defibrillators used the **alternating current** from a power socket, transformed from the 110-240 volts available in the line, up to between 300 and 1000 volts, to **the exposed heart** by way of 'paddle' type electrodes. The nature of the AC machine with a large transformer also made these units **very hard to transport**, and they tended to be large units on wheels.



Cont.

Defibrillator

History

- Defibrillation was initially performed directly on the heart only during surgery. Until the early 1950s, defibrillation of the heart was possible only when the chest cavity was open during surgery.
- The closed-chest defibrillator device which applied **an alternating current of greater than 1000 volts**, conducted by means of externally applied electrodes through the chest cage to the heart, was pioneered by Dr V. Eskin with assistance by A. Klimov in Frunze, USSR in mid 1950s.
- The early defibrillation machines all employed alternating current until the transition to direct current.



Cont.

Defibrillator

History

- In **1959** Bernard Lown charged a bank of capacitors to approximately 1000 volts with an energy content of 100-200 joules then delivering the charge to the heart by way of 'paddle' electrodes.
- The direct current defibrillators delivered an uniphasic (one way or monophasic) current from one paddle to the other. This was standard for nearly 30 years until the introduction of the biphasic waveform.
- A major breakthrough was the introduction of portable defibrillators used out of the hospital. This was pioneered in the **early 1960s** by Prof. Frank Pantridge in Belfast.



Defibrillator

Uniphasic Defibrillation

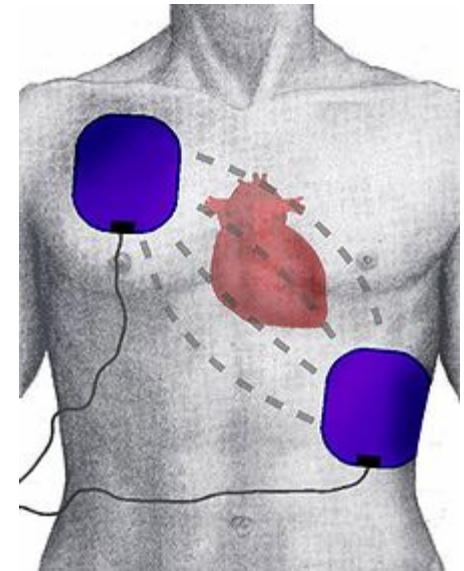
- The uniphasic defibrillator called for a single burst of current between 200 and 360 joules to be passed through the heart from one paddle to the other for a fraction of a second; i.e. electrical pulses are sent rapidly from one electrode to the other, in a single direction.
- Despite being the standard for several decades, uniphasic defibrillation was not an ideal solution.
- Although this method could restore a normal rhythm, it could also take several shocks to restore the rhythm.
- The repetition of shocks and higher energy shocks could cause skin burns and inflict damage to the heart muscle.



Defibrillator

Biphasic Defibrillation

- In biphasic defibrillation, current travels in one direction from paddle to paddle and then in the other direction; i.e. the direction of the pulses alternates.
- It takes slightly longer than in uniphasic defibrillators, but still completing one cycle in approximately 10 milliseconds.
- The advantages of the biphasic procedure are that it requires **less energy** to restore a normal heart rhythm, even in high impedance (resistance to current) individuals.
- There is some evidence that this **lowers the risks of burns and cellular damage** to the heart.





Defibrillator

Manual external defibrillator

- The units are used in conjunction with **ECG** which the healthcare provider uses to diagnose a cardiac condition.
- The healthcare **provider** will then **decide** what charge (in joules) to use, based on proven guidelines and experience, and **will deliver the shock** through pads on the patient's chest.
- As they require detailed medical knowledge, these units are generally only found **in hospitals** and **on some ambulances**.



Defibrillator

Manual internal defibrillator

- They are virtually identical to the external version, except that the charge is delivered through internal paddles in **direct contact with the heart**.
- These are almost exclusively found in **operating theatres**, where the chest is likely to be open, or can be opened quickly by a surgeon.



Defibrillator

Automated external defibrillator (AED)

- These simple-to-use units are based on computer technology which is designed to analyze the heart rhythm itself, and then advise the user whether a shock is required.
- They are designed to be used by persons, who require little training to operate them correctly.





Defibrillator

Semi-automated external defibrillator

- These units are a compromise between a full manual unit and an automated unit.
- They are mostly used by pre-hospital care professionals such as emergency medical technicians.
- These units have the automated capabilities of the **AED** but also feature an **ECG** display, and a **manual override**, where the clinician can make their own decision, either before or instead of the computer.





Defibrillator

Wearable cardiac defibrillator

- It is a portable external defibrillator that is worn like a vest.
- The unit monitors the patient 24 hours a day and will automatically deliver a biphasic shock if needed.
- This device is mainly indicated in patients awaiting an implantable defibrillator.

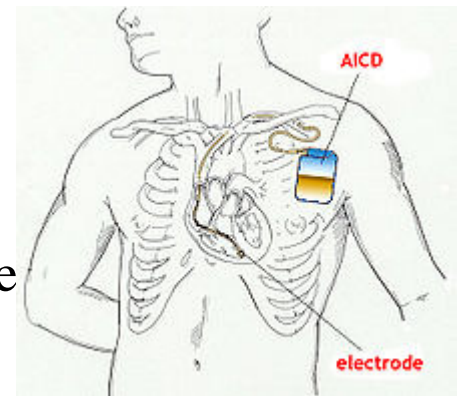




Defibrillator

Implantable cardioverter-defibrillator (ICD)

- It is a small battery-powered electrical impulse generator which is surgically implanted in the chest of patients who are at risk of sudden cardiac death due to fibrillation.
- Also known as automatic internal cardiac defibrillator (AICD).
- These devices are similar to pacemakers (and many can also perform the pacemaking function).
- They constantly monitor the patient's heart rhythm and automatically administer shocks for various life threatening arrhythmias, according to the device's programming.
- In the event of such fibrillation, the ICD will deliver a **biphasic** current in an attempt to stop the abnormal rhythm.





Defibrillator

Interface with the patient

- The most well-known type of electrode is the traditional metal **paddle** with an insulated (usually plastic) handle.
- This type must be held in place on the patient's skin while a shock or a series of shocks is delivered.
- Before the paddle is used, a gel must be applied to the patient's skin, in order to ensure a good connection and to minimize electrical resistance. These are generally only found on the manual external units.
- Newer types of resuscitation electrodes are designed as an **adhesive pad**. These are peeled off their backing and applied to the patient's chest when deemed necessary, much the same as any other sticker.





Cont.

Defibrillator

Interface with the patient

- These adhesive pads are found on most automated and semi-automated units, and are gradually replacing paddles entirely in non-hospital settings.
- Both **solid-** and **wet-gel adhesive** electrodes are available.
- Solid-gel electrodes are more convenient, because there is no need to clean the patient's skin after removing the electrodes.
- However, the use of solid-gel electrodes presents a higher risk of burns during defibrillation, since wet-gel electrodes more evenly conduct electricity into the body.
- In a hospital setting, paddles are generally preferred to pads, due to the inherent speed with which they can be placed and used.



Cont.

Defibrillator

Interface with the patient

- There are cases where the patient's ICD may fire constantly or inappropriately. This is considered a medical emergency, as it depletes the device's battery life, causes significant discomfort and anxiety to the patient, and in some cases may actually trigger life threatening arrhythmias.
- Some emergency medical services personnel are now equipped with a ring magnet to place over the device, which effectively disables the shock function of the device while still allowing the pacemaker to function (if the device is so equipped).



Pacemaker

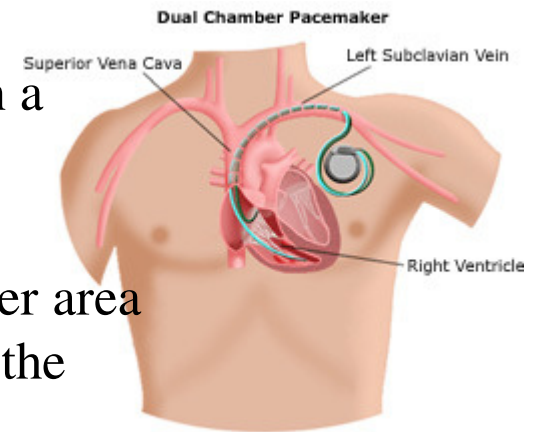
- A **pacemaker** is an **artificial pacemaker**, so as not to be confused with the heart's natural pacemaker.
- It is a medical device which uses electrical impulses, delivered by electrodes contacting the heart muscles, to regulate the beating of the heart.
- The primary purpose of a pacemaker is to maintain an adequate heart rate, either because the heart's native pacemaker is not fast enough, or there is a block in the heart's electrical conduction system.
- Modern pacemakers are externally programmable and allow the cardiologist to select the optimum pacing modes for individual patients.
- Some combine a pacemaker and defibrillator in a single implantable device.
- Others have multiple electrodes stimulating differing positions within the heart.



Insertion

Pacemaker

- A pacemaker is typically inserted into the patient through a simple surgery using either local anesthetic or a general anesthetic.
- In most cases the pacemaker is inserted in the left shoulder area where an incision is made creating a small pocket where the pacemaker is actually housed in the patient's body.
- The lead or leads (the number of leads varies depending on the type of pacemaker) are fed into the heart through a large vein using a **fluoroscope** to monitor the progress of lead insertion.
- The actual surgery may take about an hour.
- The outer casing of pacemakers is so designed that it will rarely be rejected by the body's immune system. It is usually made of **titanium**.





Pacemaker

Replacement

- Since a pacemaker uses batteries, the device itself will need replacement as the batteries lose power.
- Device replacement is usually a simpler procedure than the original insertion as it does not normally require leads to be implanted.
- The typical replacement requires a surgery in which an incision is made to remove the existing device, the leads are removed from the existing device, the leads are attached to the new device, and the new device is inserted into the patient's body replacing the previous device.
- With advances in technology, artificial pacemakers today generally last **seven to ten years** (depending upon the type of heart condition)



Pacemaker

Testing

At the time of in-office follow-up, the device will be tested according to the **FDA's Good Guidance Practices, GGP's**. These tests include:

Sensing:

The ability of the device to "see" intrinsic cardiac activity.

Impedance:

A test to measure lead integrity. Large and/or sudden increases in impedance can be indicative of a lead fracture while large and/or sudden decreases in impedance can signify a breach in lead insulation.

Threshold:

This test confirms the minimum amount of energy (Both volts and pulse width) required to reliably depolarize (capture) the chamber being tested. Determining the threshold allows the Allied Professional, Representative, or Physician to program an output that recognizes an appropriate safety margin while optimizing device longevity.



Cont.

Testing

Pacemaker

- An additional aspect of the in-office check is to examine any events that were stored since the last follow-up.
- These are typically stored based on specific criteria set by the physician and specific to the patient.
- Some devices have the availability to display intracardiac electrograms of the onset of the event as well as the event itself. This is especially helpful in diagnosing the cause or origin of the event and making any necessary programming changes.



Questions ?

