External Defibrillator

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Presentation Outline

- Introduction: What is Defibrillation?
- Brief History of Defibrillation
- Sudden Cardiac Arrest and Cardiopulmonary Resuscitation
- Defibrillation Mechanism and threshold
- Clinical Need
- Systemic Description & Diagram
- Key Features from Engineering Standards
- Manufacturers and Specifications of a few Defibrillators

Introduction: What is Defibrillation?

- According to Britannica, Defibrillation is the administration or application of electric shocks to the heart in order to reset or restore normal heart rhythm in a person experiencing cardiac arrest or whose heart function is endangered as a result of severe arrhythmia (i.e. abnormality of the heart rhythm).
- There are 2 major types of Defibrillation devices
  - Automated External Defibrillators (AEDs)
  - Automatic Implantable cardioverter Defibrillators(ICDs).

Introduction: What is Defibrillation?

Figure 1&2: AED (Rogers, 2020)

Introduction: What is Defibrillation?

- AEDs are usually used in situations involving cardiac arrest. They can be found in very crowded locations such as airports. An immediate emergency response that enables early defibrillation is essential to the successful restoration of the normal heart rhythm during a cardiac arrest.
- ICDs are used in patients with recurring or high risk of sustained arrhythmia with a potential to impair regular heart function.
  - The generator is implanted under the skin and connected to wires which are fed to through a major vein to reach the atria or ventricles of the heart.
  - When an irregular rhythm is detected by the ICD, it delivers an electric shock known as cardioversion which restores normal rhythm.

Introduction: What is Defibrillation?

- ICDs can be programmed to perform other functions including slowing heart rhythms in patients with tachycardia (i.e. abnormally fast rate) and increasing rhythm in those with bradycardia (i.e. abnormally slow heart rate.

Brief History of Defibrillation

- Defibrillation has been recognized as a life saving procedure. According to Britannica the first recorded incident was in the early 1770s when electricity was used to resuscitate an apparently dead individual. Electric shocks were applied to the thorax and a pulse was re-established.
- In the 1780s, British Surgeon Charles Kite invented a precursor of the modern defibrillation device.
- In the 1790s, Italian Physicist Luigi Galvani shed light on electrical properties of animal tissue. This was also observed in the 1840s by Italian Physicist Carlo Matteucci (he was the first to detect electrical current in the heart.

Brief History of Defibrillation

- In 1947, Claude S. Beck, an American physician reported having successfully reestablished normal heart rhythm in a patient with ventricular fibrillation (irregular and uncoordinated contraction of the ventricle muscle fibers) during heart surgery. His technique served as the prototype for modern defibrillators.
- The first ICD was implemented in a patient on Feb. 4 1980.

Sudden Cardiac Arrest and Cardiopulmonary Resuscitation(CPR)

- Ventricular Defibrillation is the most common arrhythmic cause of Sudden Cardiac Arrest (SCA).
- Other causes include coronary heart disease, myocardial infarction (heart attack), electrocution, drowning or choking.
- When SCA occurs outside the hospital, lay rescuers may perform CPR until Emergency medical services(EMS) arrives.

DEFIBRILLATION MECHANISM AND THRESHOLD

- On EMS arrival, a large current shock or countershock is administered across the victims thorax as a means of stopping fibrillation.
- Typically, electrode pads are placed in the anterolateral (situated or occurring to the front or the side) position.
- The sternum electrode is placed on the patient’s upper right chest, below the clavicle and to the right of the sternum. The apex electrode is placed on the patient’s lower left chest, over the cardiac apex and to the left of the nipple in the midaxillary line.

DEFIBRILLATION MECHANISM AND THRESHOLD

- Figure: Description of electrode placements

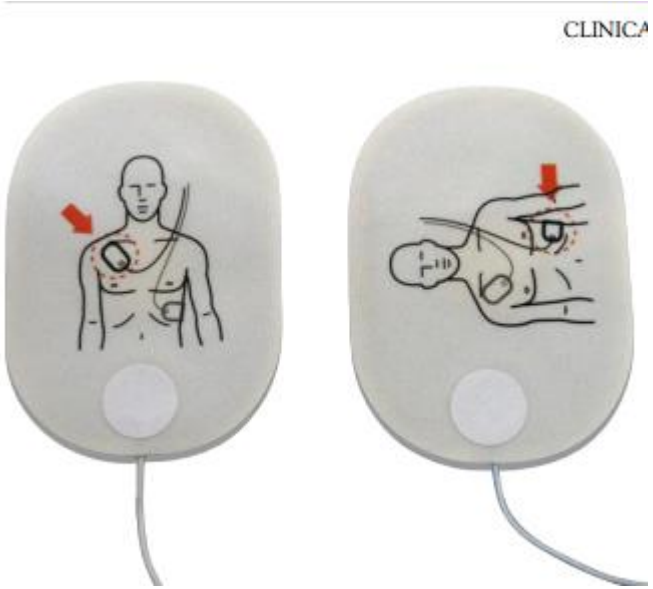

Fig 3: Electrodes (Baura (2011)

- The defibrillation threshold refers to a threshold for successful countershock .

DEFIBRILLATION MECHANISM AND THRESHOLD

- A defibrillator works by using a moderately high voltage between 200-1000 Volts. The patients heart receives 300 joules of electrical energy (about as much as a 100 watt incandescent lamp uses in 3 seconds).

Fig 4: Defibrillator (explainthatstuff.com[2019])

Clinical Need

- The countershock administered by EMS may enable a victim's heart to convert from Vfib to a perfusing rhythm
- With quicker access to defibrillation, the probability of survival increases. In general, the American Red Cross states that "each minute that defibrillation is delayed reduces the chance of survival by about 10%".

Clinical Need

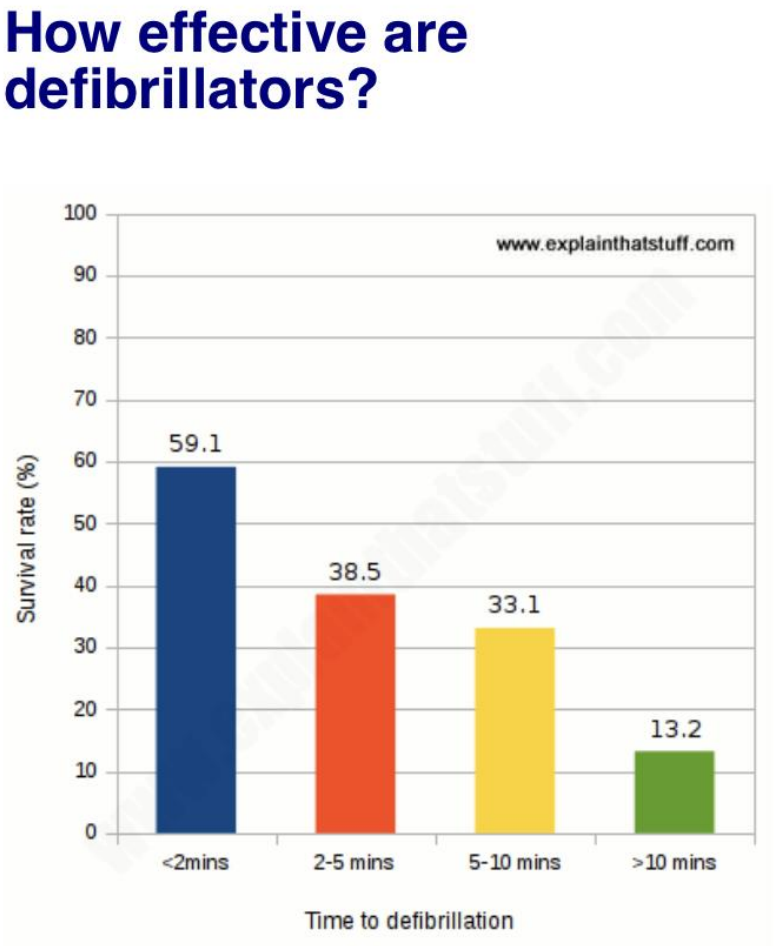

Fig 5:Explainthatstuff.com(2019)

Chart: Why we need more public defibrillators: the chance of surviving an out-of-hospital cardiac arrest increases the more quickly defibrillation is used. Data from a study of 1732 cases in North Carolina by C.M. Hansen et al, 2015.

Systemic Description and Diagram

- These days AEDs can be found anywhere (schools, airports, malls etc.)
- An AED is both an external electrical stimulator and digital instrument. The user powers on the device, which utilizes a nonrechargeable lithium ion battery. Voice prompts and an LCD screen enable the user to attach electrodes to the victim’s thorax.
- The electrocardiogram from the electrodes is digitized and analyzed by the Vfib detection module, which sends detection signals and the ECG waveform back to the processor module

Systemic Description and Diagram

- If a shockable rhythm, such as Vfib or Vtach is detected, the processor module prompts the user to depress the defibrillate button, which causes the waveform circuit, holding with a charged capacitor, to discharge across the electrodes.
- The electrode pads used are larger versions of the surface electrodes used for monitoring ECG

Systemic Description and Diagram

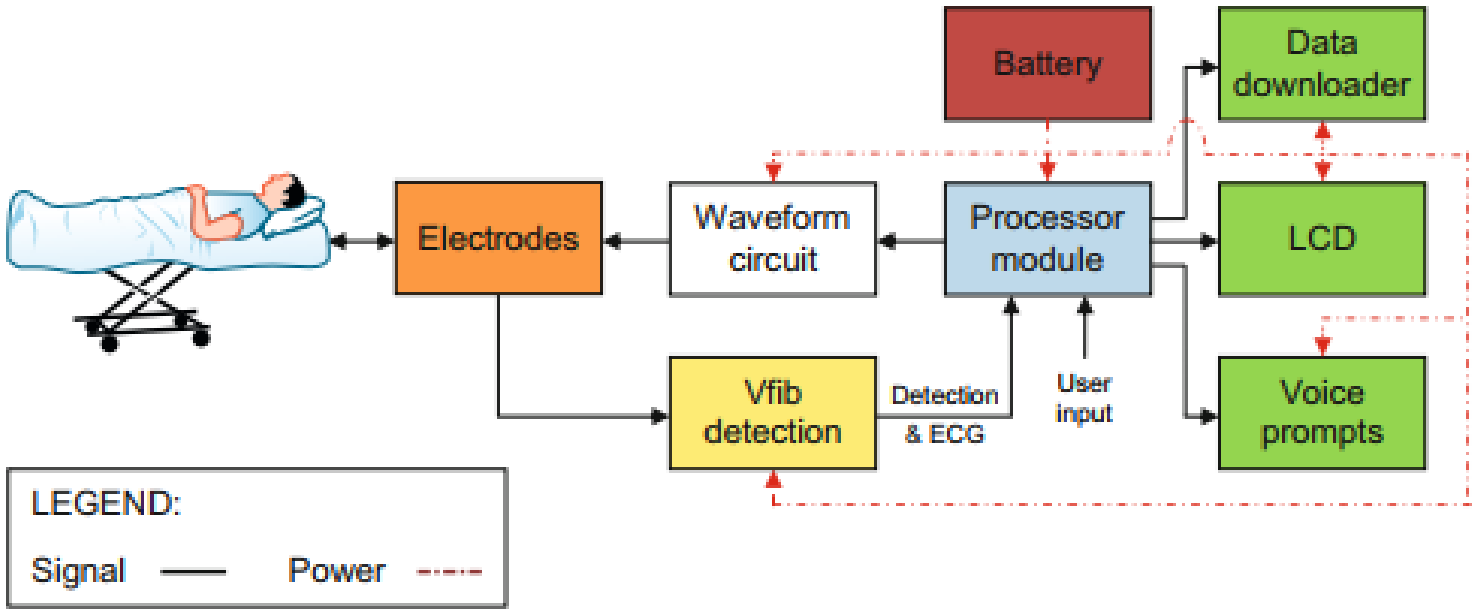

Fig 6: Systemic Description of Defibrillation

Key Features from Engineering Standards

- As of 2010, the FDA recommends the AAMI standard for external defibrillators: *ANSI/AAMI DF80:2003 Medical Electrical Equipment—Part2-4: Particular Requirements for the Safety of Cardiac Defibrillators (Including Automated External Defibrillators)*
  - Battery Charging Time
    The time until a patient is defibrillated is critical for survival. It is required that manual defibrillators be ready for discharge at maximum energy within 25-35s of being powered
  - Capacitor Discharge Accuracy
    Delivered energy is affected by patient impedance. A defibrillator energy setting assumes a patient impedance of 50 Ω

Key Features from Engineering Standards

- Synchronization
  A defibrillator may be used for external cardioversion to treat atrial flutter or atrial fibrillation. When this shock is administered, the defibrillator is placed in synchronization mode, to ensure that the shock is timed after the peak of the QRS (the series of deflection in an ECG that represent electrical activity generated by ventricular depolarization prior to contraction of the ventricles)

Manufacturers and Specifications of a few Defibrillators

- Philips Heartstart Onsite/Home Defibrillator
  - Voice Instructions
  - Daily automatic self tests to alert when device has a problem
  - AED does not shock by itself but verifies that a shock is needed then user pushes the button
  - 5 year warranty
  - Infant/child pads cartridge sold separately
- Specifications
  - Weight: 3.3 lbs (1.5kg)
  - 4 year standby battery life
  - 200 shocks minimum
  - Shocks within 8 seconds post CPR

Manufacturers and Specifications of a few Defibrillators

- Lifepak CR Plus
  - Power on Device and apply electrode pad on victim
  - Administers automatic shocks without any input from user
  - Automatic self testing occurs weekly and monthly with readiness indicator
  - Stores ECG data for up to 2 patients. Also capable of wireless transmission

- Specifications
  - Initial shock: 200J
  - Max shock: 360J
  - Total weight: 4.5lbs
  - Electrode lifespan: 2 years
  - Warranty: 1 year

Manufacturers and Specifications of a few Defibrillators

- Zoll AED plus
  - Voice instructions
  - Weekly automatic self tests
  - Option to buy fully automatic version

- Specifications
  - Weight: 6.7 lbs (3.1kg)
  - 5 year standby battery life
  - 225 shocks minimum
  - 13 hours of patient monitoring
  - Red X appears when battery is capable of 9 more shocks
  - Warranty: 7 years

Manufacturers and Specifications of a few Defibrillators

- Cardiac Science G3/G5
  - Voice instructions
  - Daily, weekly and monthly automatic self tests
  - Can shock patient automatically if automatic option is purchased

- Specifications
  - 6.6 lbs (3.1kg)
  - 4 year standby battery life
  - 7-8 year warranty

Conclusion

- An external defibrillator is an electrical stimulator that discharges electrical current across the thorax, as a treatment for ventricular fibrillation, atrial fibrillation, or atrial flutter.
- It is also a digital instrument that enables cardiac electrocardiograms to be measured, displayed, and analyzed.
- There are 2 types of Defribillators: AEDs and ICDs
- AEDs can be used by the general public.

References

- Rogers, K. (2020), *Defibrillation*, retrieved from: www.Britannica.com/science /defibrillation
- Baura, G. (2011*), Medical Device Technologies: A system based overview using engineering standards*, Oxford:Elsevier.
- Woodford, C.(2019), *Defibrillators*, explainthatstuff.com Retrieved: 5th April, 2020
- Oldani, P.(2019), *The 4 Best Portable Defibrillators in 2019,* insidefirstaid.com. Retrieved: 5th April, 2020