EM Field Theory Applied: Defibrillators

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History

- First Demonstration; 1899, Prevost and Batelli, Physiologists from Switzerland.
- Small charges cause ventricular fibrillation
- Large charges reverse the syndrome.
- Claude Beck, 1947, Western Reserve University
  ‘Heart too good to die”
- 14 Year Old Boy saved from congenital heart disease by defibrillation with procaine amide heart medicine.
- AC Current 110-240 V →300-1000 V; Damage to Cells; Bulky Transformers
- Dr V. Eskin and A. Klimov in Frunze, USSR 1950’s; Closed Chest Method; AC >1000V
History

- Bernard Lown; 1959 DC Capacitors to achieve ~1000V (Approx. 100-200 Joules)
- Charge through an inductance to produce heavily damped sinusoidal wave; Lown Waveform
- 1980’s BTE Lower Energy, Weight Reduction
- Modern Machines: BTE with Automatic measurement of transthoracic impedance
- Frank Pantridge, Belfast; Portable Machines
- Stephen Heilman, Alois Langer, Morton Mower, Michel Mirowski, and Mir Imran; ICD
- February 1980 at Johns Hopkins Hospital by Dr. Levi Watkins, Jr
Types

- External Manual Defibrillator

- Internal Manual Defibrillator
Types

- Automated External Defibrillator (AED)
- Implantable Cardioverter-Defibrillator
Capacitors

- Stores electric charge when voltage applied (finite charge time)
- Discharges current rapidly to load (more so than a battery)

\[ C = \frac{\varepsilon s}{d} \]

Charge \( Q = CV \)

Energy \( E = \frac{1}{2}CV^2 \)

Discharge time \( t = RC \)
Circuitry

- Capacitor stores energy for defibrillation
  - Cap charged to ~1000V
  - Delivers 100-200 J to patient
  - Discharge time ~5-10ms
- Inductor used to create a finite damped sine wave from DC (Lown waveform)
  - Monophasic vs. biphasic waveforms
- Body modeled as impedance
- Body contacts – 25 lbs. pressure required to avoid static discharge
Application

- External Units:
  - Gel
    - Lower Resistance
    - Wet vs. Dry Gel
  - Apply Paddles; 25lbs
    - Automatic vs. Manual
  - Electrodes
    - Safer, Better EKG Readings
Application

- **Internal Units:**
  - Only for those who are at severe risk;
    - Ventricular fibrillation (unproductive heartbeat), ventricular tachycardia (abnormally fast heartbeat), long QT syndrome (an inherited heart disease)
  - Placement:
    - Lead Wire from Cephalic vein to heart chamber
    - Electrode implanted lower chamber heart muscle (LV or LA)
- **Tech. Specs**
  - Li-Ion Battery
  - “Wand” Programming over RF
  - Electrodes; Platinum, Silicone
- **Treatment**
  - Pacing Regimen → Cardioversion → Defibrillation
References

- American Red Cross: Saving a Life is as Easy as A-E-D
- FDA Heart Health Online: Automated External Defibrillator (AED)
- Resuscitation Council (UK)
- History of defibrillation
- How an internal defibrillator is implanted from Children's Hospital Heart Center, Seattle.