Physics of Medical Devices

Third lecture

Types of electrodes

Asst.Prof.Dr. Saba Abdulzahra Al-Rubaee

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Al-Mustaqbal University

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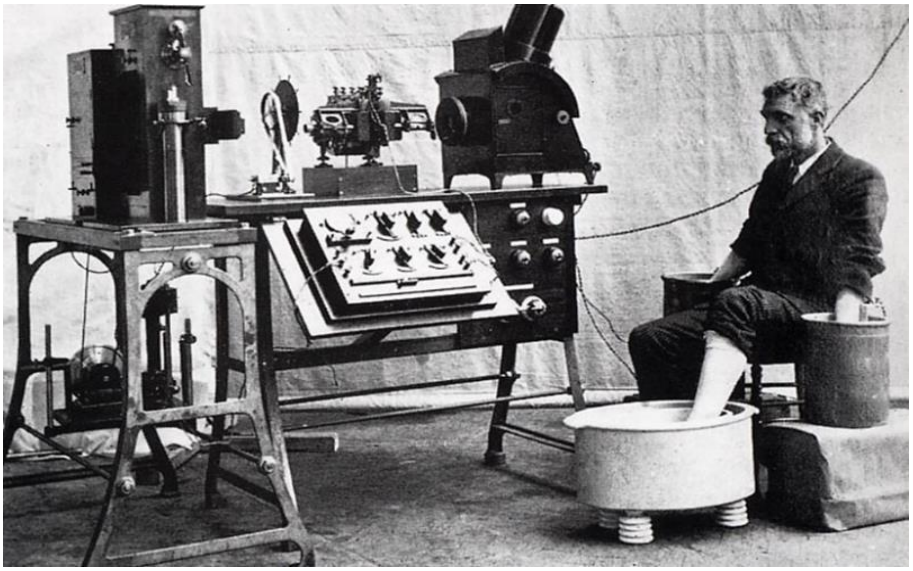
Body Surface Electrodes

- The earliest bioelectric potential measurements relied on immersion electrodes that were simply buckets of saline solution into which the patient placed a hand and a foot, as shown in Figure.

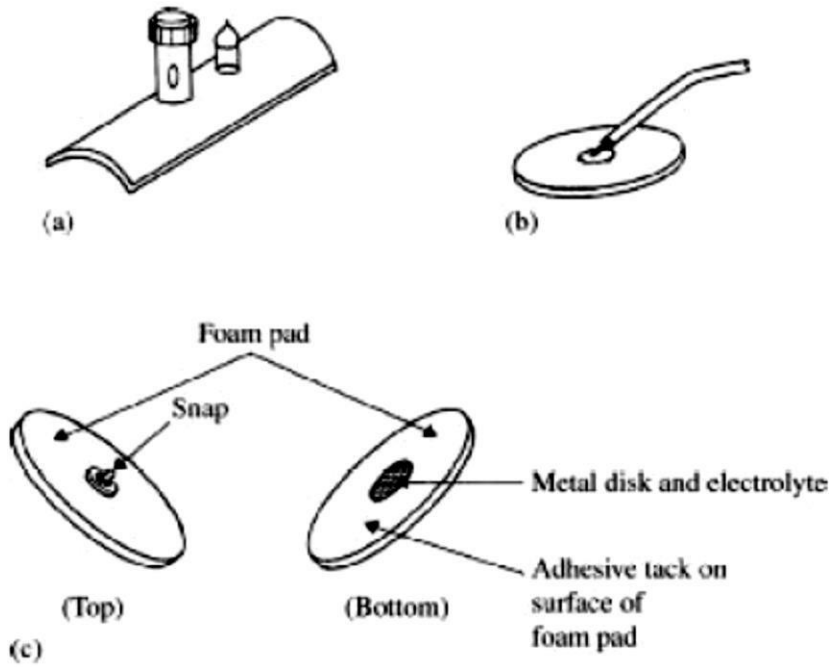


- Plate electrodes, first introduced in 1917, were a great improvement on immersion electrodes. They were originally separated from the skin by cotton pads soaked in saline to emulate the immersion electrode mechanism.
- Later, an electrolytic paste was used in place of the pad with the metal in contact with the skin.
- Electrodes that can be placed on the body surface for recording bioelectric signals. The integrity of the skin is not compromised. Can be used for short or long duration applications.

- Types of body surface electrodes:
  1. Metal Plate Electrodes
  2. Suction Electrodes
  3. Floating Electrodes
  4. Flexible Electrodes.

Metal Plate Electrodes

- It consists of a metallic conductor in contact with the skin.
- An electrolyte soaked pad or gel is used to establish and maintain the contact.



a. A limb electrode: metal-plate electrode used for application to limbs, traditionally made from German-silver (nickel-silver alloy).

b. Metal disk electrode applied with surgical tape which has lead wire soldered or welded on the back surface.

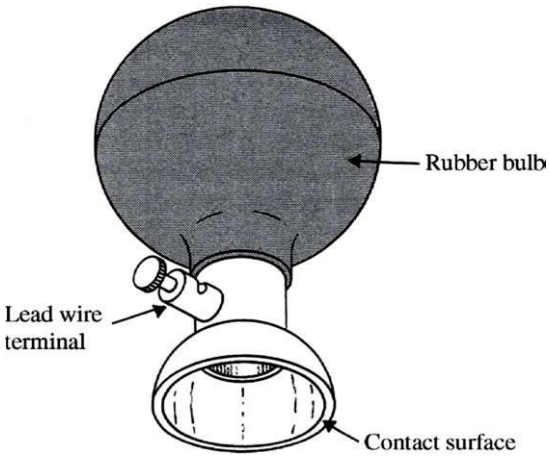
- ✓ For ECG application made form disk of Ag with electrolytically deposited layer of AgCl on its contacting surface.
- ✓ For surface EMG applications made of stainless steel, platinum or gold plated disks to minimize electrolyte chemical reaction.
- ✓ Acts as polarizable electrode, and prone to motion artifacts.

c. Disposable foam pad electrodes: often used with ECG monitoring apparatus.

- ✓ Relatively large disk of plastic foam with silver plated disk serving as electrode, coated with AgCl.
- ✓ Layer of electrolyte gel covers the disk.
- ✓ Electrode side of foam covered with adhesive material.

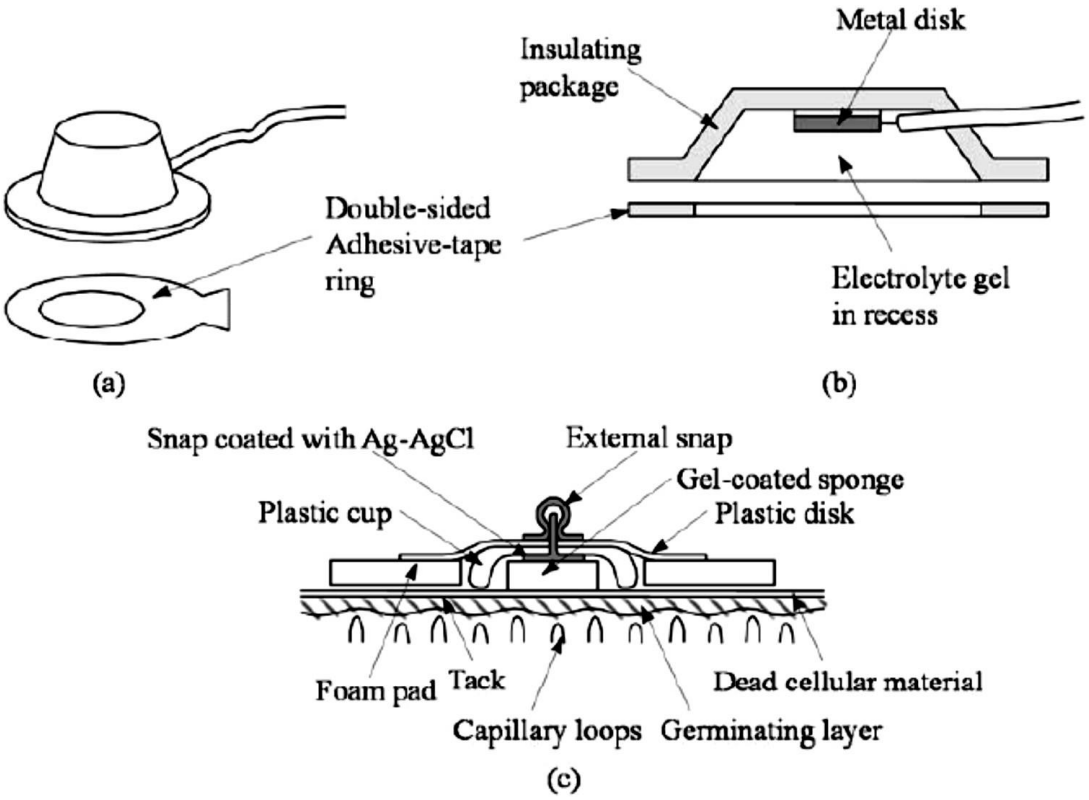
Suction Electrodes

- A metallic suction electrode is often used as a precordial (chest) electrode on clinical electrocardiographs.
- It requires no straps or adhesives for holding it in place.
- Electrolyte gel is placed on the contacting surface of electrode.
- This electrode can be used only for short periods of time.



Floating Electrodes

- Mechanical technique to reduce noise. Isolates the electrode-electrolyte interface from motion artifacts.



(a) Depicts a floating electrode known as a top-hat electrode.

(b) The internal structure of top-hat electrode.

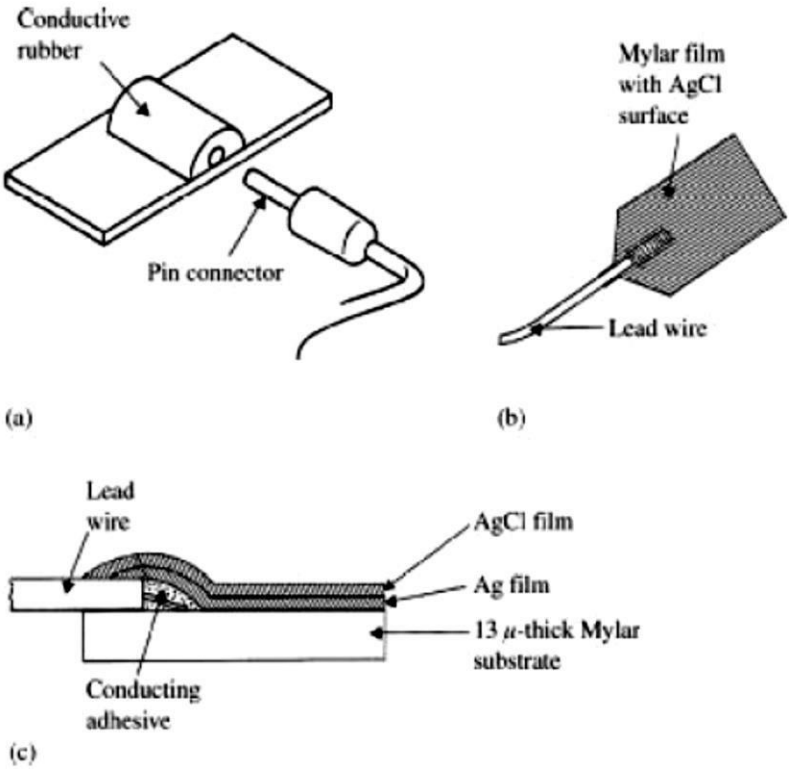
- The principal feature of the electrode metal disk (actual electrode) is recessed in a cavity.
- Floating in the electrolyte gel.
- Not directly contact with the skin.
- Reduces motion artifacts.

(c) A single use (disposable) modification of the floating electrode.

- The recess in this electrode is formed from an open foam disk, saturated with electrolyte gel and placed over the metal electrode.

Flexible Electrodes

- Solid electrodes cannot conform to body surface topology resulting additional motion artifacts.



(a) Carbon-filled silicone rubber compound (conductive) in the form of a thin strip or disk is used as the active element of an electrode.

- ✓ The carbon particles in the silicone make it an electric conductor.
- ✓ A pin connector is pushed into the lead connector hole and electrode is used like a metal plate electrode.
- ✓ Applications monitoring premature infants (2500gr) that are not suitable for using standard electrodes.

(b) Flexible thin film neonatal electrode.

- ✓ The basic electrode consists of 13 μm thick Mylar film with Ag/AgCl film deposition.

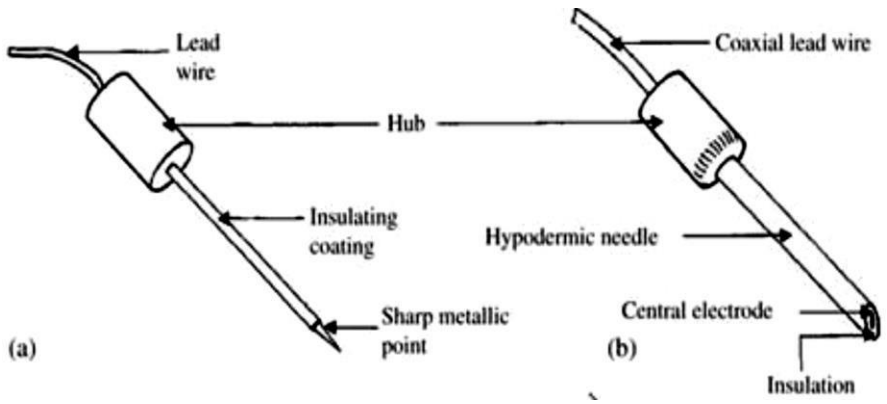
(c) Cross sectional view of the flexible thin film neonatal electrode.

- ✓ The flexible lead wire is attached to the Mylar substrate by means of a conducting adhesive.
- ✓ A silver film approximately 1 μm thick is deposited over this and Mylar.

- ✓ AgCl layer is then grown on the surface of the silver film by the electrolytic process
- ✓ Have the advantage of being flexible and conforming to the shape of newborn's chest.
- ✓ No need to be removed as they are X-ray transparent.
- ✓ Monitoring new born infants
- ✓ Drawback High electric impedance

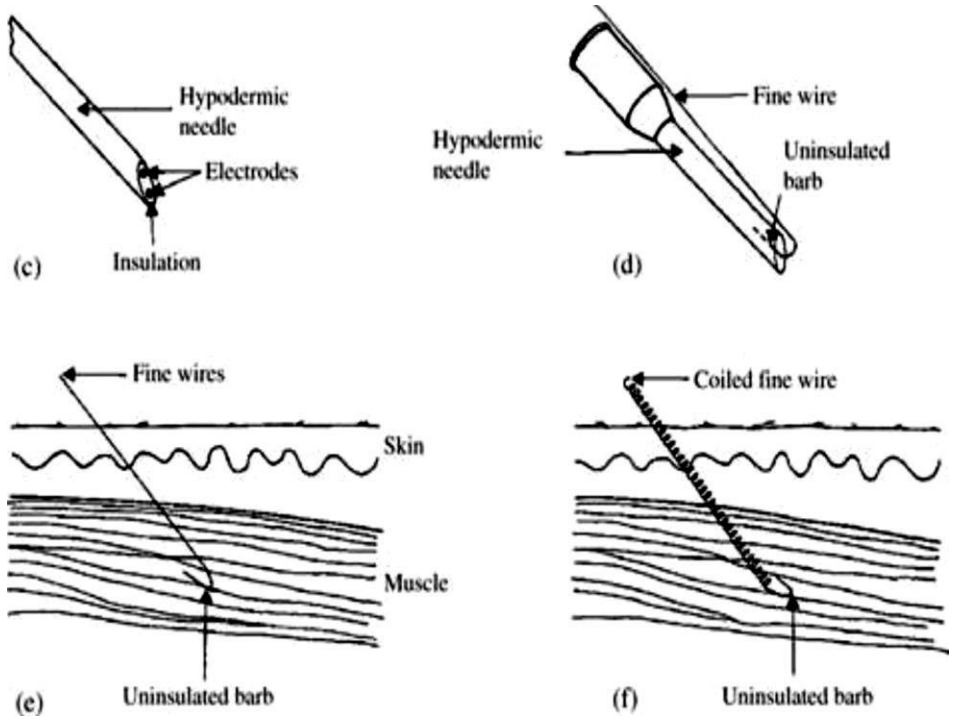
Internal Electrodes (detect biopotential within body)

- Percutaneous electrodes electrode itself or the lead wire crosses the skin.
- Entirely internal electrodes connection is to an implanted electronic circuit such as a radio-telemetry transmitter.
- No limitation due to electrolyte skin interface
- Electrode behaves in the way dictated entirely by the electrode electrolyte interface.
- No electrolyte gel is required to maintain this interface, because extracellular fluid is present.



(a) Insulated needle electrode.

(b) Coaxial needle electrode.



(c) Multiple electrodes in a single needle (Bipolar coaxial electrode).

- Chronic recordings using percutaneous wire electrodes

(d) Fine wire electrode connected to hypodermic needle, before being inserted.

(e) Cross sectional view of skin and muscle, showing fine wire electrode in place.

(f) Cross sectional view of skin and muscle, showing coiled fine wire electrode in place.

Microelectrodes

- In studying the electrophysiology of excitable cell, it is important to measure potential difference across cell membrane.
  - ✓ Small enough to be placed into cell.
  - ✓ Strong enough to penetrate cell membrane.
  - ✓ Typical tip diameter: 0.05 10 microns.

Types of microelectrodes:

- ✓ Metal Microelectrodes
- ✓ Supported-Metal Microelectrodes
- ✓ Micro-pipet Electrodes