# Lecture-8

## Topics: Needle electrodes

# Needle electrodes

- Electrodes used within the body to detect bio potentials
  - Percutaneous electrodes
  - Internal electrodes

**Percutaneous electrodes:**

- Electrode itself or the lead wire crosses the skin

**Internal electrodes:**

- The connection is to an implanted electronic circuit such as radio telemetry transmitter

**Advantages:**

- No electrolyte-skin interface and associated limitations
- Electrode behaves by the electrode-electrolyte interface
- No gel is required to maintain the interface because the extracellular fluid is present

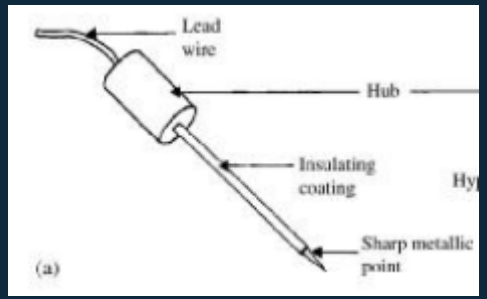
**Disadvantages:**

- It is an invasive method of acquiring the bio potentials

# Percutaneous Needle electrodes

**Basic Needle electrode:**

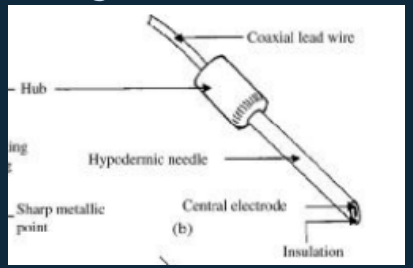
- The basic needle electrode consists of a solid needle, usually made of stainless steel with a sharp point
- The shank of the needle is insulated with a coating such as varnish and only tip is left exposed
- A lead wire is attached to the other end of the needle
- Joint is encapsulated in a plastic hub to protect it
- When place in muscle it obtains the EMG from that muscle accurately and can be removed



# Percutaneous Needle electrodes

**Shielded percutaneous electrode:**

- It consists of a small gage hypodermic needle
- It has been modified by running an insulated fine wire down the centre of its lumen
- Filling the remainder of the lumen with an insulating material
  - An epoxy resin
- When the resin has set, the tip of the needle is files to its original level exposing an oblique cross section of the central wire
  - It serves as the active electrode
- The needle itself is connected to ground through a shield of co-axial cable, there by extending the coaxial structure to its very tip



# Percutaneous Needle electrodes

**Bipolar coaxial electrode:**

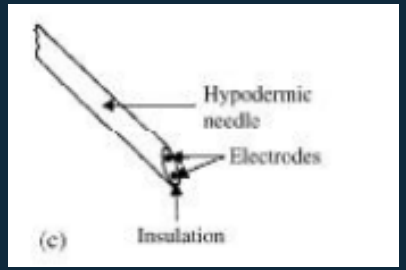
- Multiple electrodes in a single needle can be formed
- Two wires are placed within the lumen of the needle and can be connected differently
  - so as to be sensitive to electrical activity only in the immediate vicinity of the electrode tip

**Advantages of percutaneous electrodes:**

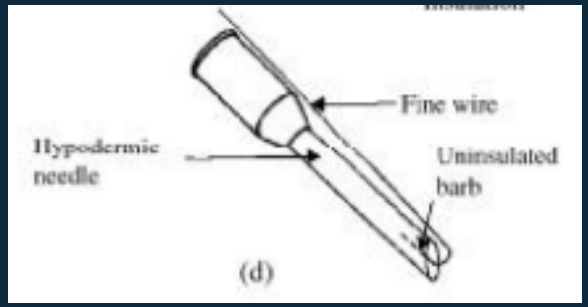
- It is used in the chronic recordings

**Disadvantages of percutaneous electrodes:**

- Can not be used for short term measurements, because of the their stiffness and size



# Needle electrodes




**Wire electrodes:**

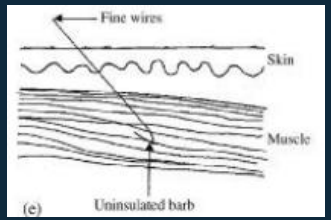
- A fine wire is made
  - Stainless steel
  - Diameter 25 to 125 micro meter
  - Insulated by varnish within a few millimetre of the tip
  - Non insulated tip is bent back to form a J-shaped structure
- The tip is introduced into the lumen of the needle

**Inserting the electrode:**

- The needle is inserted through the skin in to the muscle at the desired location desired path
- It is then withdrawn leaving the electrode in place
- The bent over portion of wire serves as a barb holding the wire in place in the muscle

**Removing the electrode:**

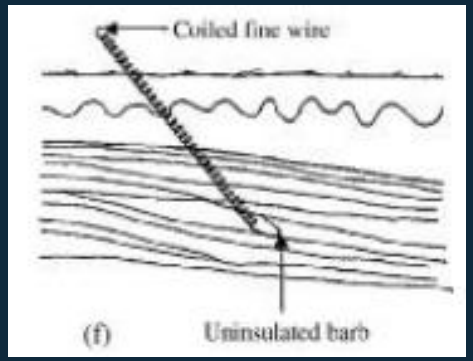
- To remove the wire a mild uniform force to straighten out the barb and pulls it out though the wires track



# Needle electrodes

**Disadvantages of wire electrode:**

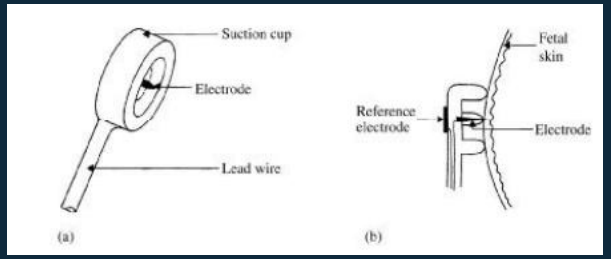
- Wire electrodes chronically implanted in the active muscles undergo a great amount of flexing as the muscle moves and it cause the
  - Wire to slip as it passes through the skin
  - Increase irritation
  - Risk of infection at this point
  - Cause wire to break




**Helical electrode or coiled fine wire electrode:**

- Made by
  - A very fine insulated wire coiled into a tight helix
  - Diameter of 150 micrometre
  - Place in the lumen of the inserting needle
- The un-insulated barb protrudes from the tip of the needle and it is bent back along the needle before insertions
  - It holds wire in the place in the tissue when the needle is removed from muscle
- External end of the electrode passes through the needle and before the electrode is connected to the recordings needle should be
  - Removed
  - Protected

# Fetal heart beat measurement

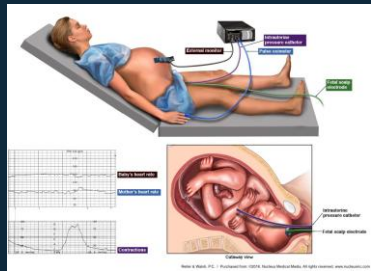




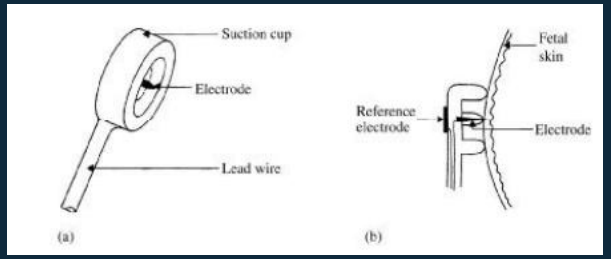
- Percutaneous electrodes are used for monitoring fetal heart beats
- ECG from fetus during labour is measured by direct connection to the presenting part through the uterine cervix
- The fetus lies in a bath of amniotic fluid contains ions and is conductive
  - Surface electrodes do not provide adequate ECG as a result of shortening effect of the amniotic acid
- Thus the electrode used to obtain fetal ECG must penetrate the skin of the fetus

**Suction Electrode:**

- A sharp pointed probe in the centre of a suction cup can be applied to the fetal presenting part
- Suction is applied after cup is placed against the fetal skin
  - Surface of the skin is drawn into the cup
  - Central electrode pierces the stratum corneum contacting the deep layers of the epidermis

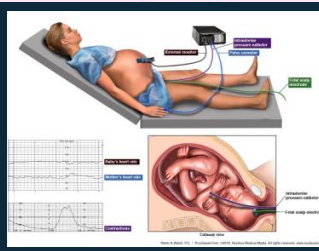


# Fetal heart beat measurement



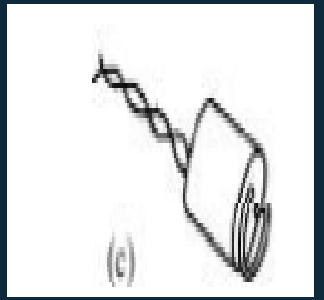

**Suction Electrode (continues):**

- Reference electrode is kept at the back of the suction electrode,
  - It contacts the fluid and
  - The signal seen between these two electrodes is the voltage drop across the resistance of the stratum corneum
- Thus although the amniotic fluid is essentially places all the body surface of the fetus at a common potential, the potentials beneath the stratum corneum can be different
- Fetal ECG
  - Peak amplitude of order 50-70 micro meter can be recorded

**Helical electrode:**

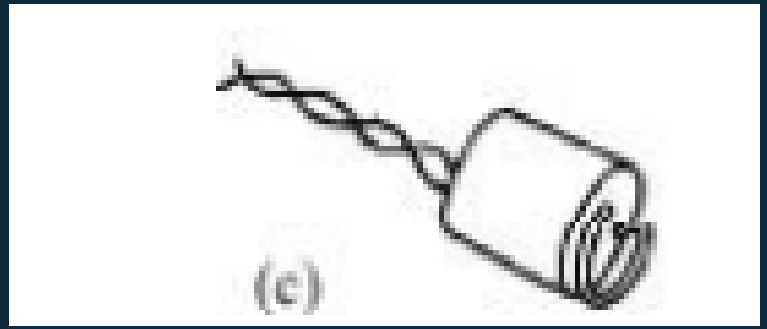
- It consists of a stainless steel needle shaped approximately like one turn of a helix mounted on a plastic hub
- Reference electrode is placed at the back surface of the hub using stainless steel



# Fetal heart beat measurement

**Helical electrode (continues):**

- When the labour has proceeded far enough
  - Electrode is attached to the fetal presenting part
  - Rotate the electrode so that the needle twists just beneath the surface of the skin
  - A corks screw shallowly penetrating a cork
  - Electrode remains firmly attached
- Because of the shortness of the helical needle it does not penetrate deep enough into the skin to cause the significant risk to fetus

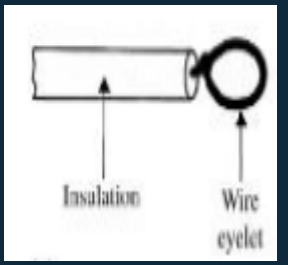


# Internal Needle electrodes

- Implantable electrodes are designed to function entirely within the body without requiring any external wires to penetrate the skin.
- Signal transmission is achieved using a radio transmitter embedded within the body, ensuring a seamless and wireless communication system.

**Wire Loop Electrodes**

- Wire loop electrodes are a specific type of implantable electrode constructed using insulated, multi-stranded wires. Materials commonly used for these electrodes include:
- **Stainless Steel**: Durable and biocompatible.
- **Platinum**: Highly conductive and corrosion-resistant.




**Construction Process:**

**1.Wire Preparation**:

1. One end of the insulated wire is stripped to expose the strands.
2. An eyelet is formed by individually twisting the strands together at the point where the insulation ends.

**2.Reinforcement**:

1. Each strand is spot-welded to the wire mass at the junction to ensure durability and electrical integrity.

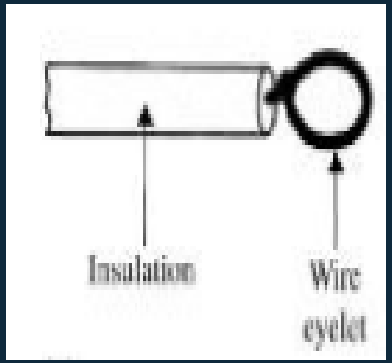
**3.Placement**:

1. The formed eyelet is sutured to the desired location in the body to establish an electric contact point.

# Internal Needle electrodes

**Wire Loop Electrode Material Considerations:**

- **Silver** should not be used for this type of electrode because:
  - Silver is toxic to surrounding tissues.
  - It can negatively impact biocompatibility and cause adverse tissue reactions.

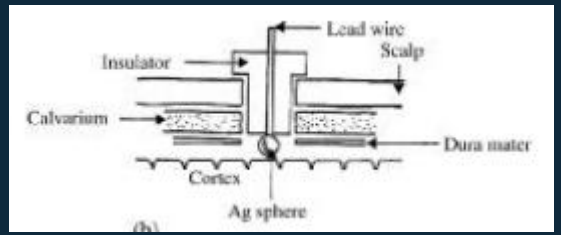


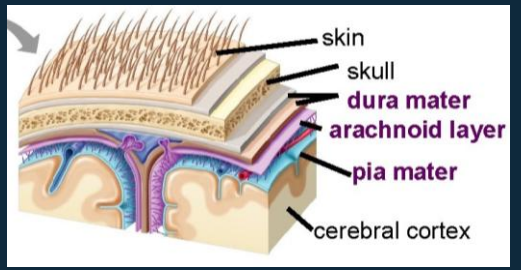

This meticulous design and material selection process ensures the electrode's effectiveness, longevity, and safety within the body.

# Internal Needle electrodes

**Platinum sphere cortical surface potential electrode:**

- It is used to measure the cortical surface potentials from brain
- The electrode consists of a
  - Metallic sphere of 2 mm diameter located at the tip of the cylindrical Teflon insulator through which the electrode wires passes
- The calvarium is exposed through an incision in the scalp and burr hole is drilled
- A small slit is made in the exposed dura and sliver sphere is introduced through this opening so that it rests on the surface of the cerebral cortex
- The assembly is then cemented in place onto the calvarium by means of a dental acrylic material



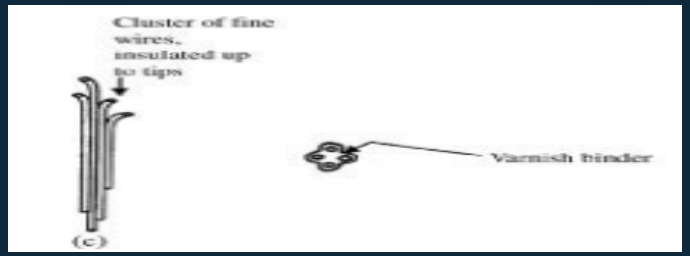
# Internal Needle electrodes

**Multi element depth electrode:**

- A cluster of fine insulated wires held together by a varnish binder
- Each wire has been cut transversely to expose an un-insulated cross section that serves as the active electrode surface
- The other end of the electrode can be attached to appropriate implantable electronic device or to a connector cemented on the skull to allow connection to an external recording apparatus

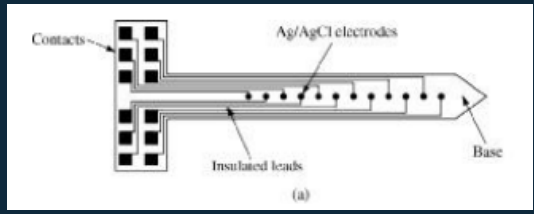
**Disadvantages:**

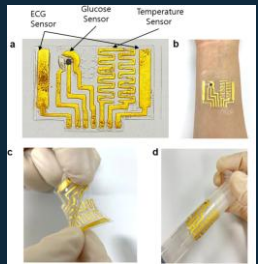
- Time consuming and expensive
- Wire clusters are made individually and each one will be different from other



# Micro fabrication electrodes

- The electrode array consist of square Ag/AgCl electrodes, each measuring **40 µm on a side**, fabricated on thin-film gold conductors.
- These components are deposited onto either a **flexible polyimide substrate** or a **more robust molybdenum substrate**, depending on the application requirements.
- To ensure proper insulation, the substrates are coated with an anodically grown oxide layer.
- The overall probe dimensions are designed for precise functionality, being: 10 mm in length, 0.5 mm in width, and 125 µm in thickness.
- Lead wires are attached to **bonding pads** located at the proximal end of the probe to facilitate electrical connectivity.
- These probes are specifically designed for **measuring transmural potential distributions** in the **beating myocardium**.
- The use of a **flexible substrate** is critical to minimize tissue damage during the contraction and relaxation of the myocardial muscle, ensuring reliable measurements and reducing potential harm to the surrounding tissue.



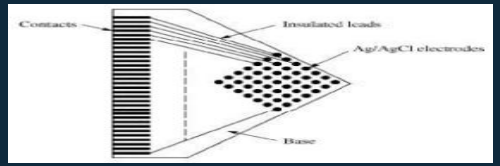
# Micro fabrication electrodes

**Two dimensional linear arrays:**

- It is used to map the electrical potential across surface of the heart
- A pattern of miniature electrode is formed on a
  - Rigid surface
  - Flexible surface
- It is connected by conductors to the associated instrumentation
  - Large arrays require more number of connections
- Silver spheres socket electrodes is used
  - Diameter is 1mm
  - Each sphere is at the tip of an insulated wire

**Disadvantages:**

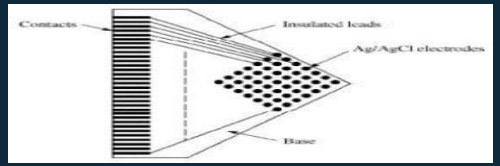
- Difficult to build an array of large number of electrodes
- Awkward to use the large number wires coming from the socket



# Micro fabrication electrodes

**Two dimensional linear arrays (continues):**

- **Difficulties can be overcome by**
  - Using a Multilayer ceramic integrated circuit package as the electrode array
  - 144 miniature Ag/AgCl electrodes can be formed on polyimide substrates
  - Thin gold film serves as conductors and base for the Ag/AgCl electrode
- Interconnection is made by ribbon cable
- Further amplifiers can also be connected to array probes
- These have been used in the extra cellular recordings of neural signals in animal study



# Micro fabrication electrodes

**Three dimensional linear arrays:**

- It is made using silicon micro fabrication technology
  - 1.5 mm long
  - Surrounded with insulating material up to the tip
  - The exposed tip serves as the electrode
- Wire connection on the base of the structure was needed to make contact with the tine electrode

**Disadvantages:**

- Require extensive fabrication
- High Costs

**Difficulties can be overcome by**

- Three dimensional electrode array can be fabricated by taking three set of one dimensional electrode array
- Micro electrode probe
- Inexpensive arrays can be build by ribbon cable can
  - It can produce 4-400 electrodes