SECTION

1

Theory Component

- Principles of Basic Physics: Types of Currents used in Electrotherapy
- Physiology of Nerve and Muscle
- Electrical Stimulation of Nerve and Muscle
- Faradic Currents
- Galvanic Currents and HVGS
- Nerve Injuries and Electrodiagnosis
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CHAPTER

1

Principles of Basic Physics

Types of Currents used in Electrotherapy

Learning Objectives: At the end of this chapter, students will be able to

- Define electricity and discuss the states of matter
- Enumerate the types of currents used in physiotherapy
- Discuss the fundamental principles of electricity and electric components
- Demonstrate the knowledge gained on the safety measures used in electrotherapy.

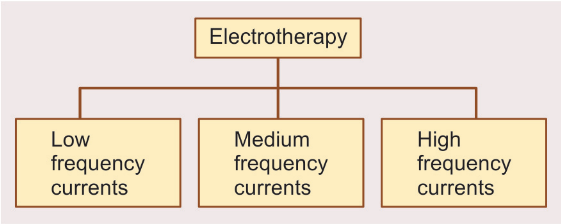
INTRODUCTION

Electrotherapy is the therapeutic application of various physical agents like heat, cold, water, pressure, sound, electromagnetic radiations and electrical currents to patients for therapeutic purposes.

In electrotherapy, the currents are classified based on frequency.

The number of times, electric impulses come in a particular time (second) is regarded as frequency.

Usually it is expressed in cycles per second, hertz, kilohertz, megahertz, etc.



Low Frequency Currents

1. These are therapeutically used currents whose frequency is 0 to 100 cycles per second.
2. The primary use of low frequency currents is stimulation of nerve and muscle, pain relief, muscle re-education, reduction of oedema.

LOW FREQUENCY CURRENTS

Frequency=0–100 cycles/sec. Used for:

1. Nerve and muscle stimulation
2. Pain relief
3. Muscle re-education
4. Oedema reduction

Types of low frequency currents

1. Direct currents
2. Interrupted direct current
3. Sinusoidal current

4. Diadynamic currents
5. High voltage pulsed galvanic current
6. Micro amperage electrical nerve stimulation
7. Transcutaneous electrical nerve stimulation (TENS)

Medium Frequency Currents

1. These are therapeutically used currents whose frequency is in the range of 1000–10,000 cycles per second.
2. These are used to stimulate deeply situated muscles and nerves.

> **MEDIUM FREQUENCY CURRENTS**
>
> Frequency = 1000 – 10,000 cycles/sec. Used for:
> 1. Prevent muscle atrophy
> 2. Pain relief
> 3. Muscle re-education
> 4. Oedema reduction

3. Clinically they are used for:
   a. Muscle re-education
   b. To prevent muscle atrophy
   c. Reduction of oedema
   d. Pain relief
4. Various currents in this category are:
   a. Interferential currents
   b. Russian currents
   c. Rebox currents

High Frequency Currents

1. These are currents used therapeutically, whose frequency is more than 10,000 cycles per second
2. They are mainly used for deep tissue heating for therapeutic purposes
3. Various modalities which work on these currents are:
   a. Microwave diathermy
   b. Shortwave diathermy
   c. Longwave diathermy
   d. Therapeutic ultrasound

> **HIGH FREQUENCY CURRENTS**
>
> Frequency = >10,000 cycles/sec. Used for
> 1. Prevent muscle spasm
> 2. Pain relief

The currents that are used therapeutically are also classified on other parameters as follows:

Parameter on basis of	Type of current
Direction	• Alternating currents • Unidirectional currents
Voltage	• Low voltage (less than 100 volts) • High voltage (higher voltage)
Amperage	• Low amperage (1–30 milliamp) • High amperage (500–2000 milliamp)
Biophysical effects	• Currents causing ionic changes • Currents causing thermal changes

Basic Structure of Atom

Atom is the basic structure of matter. It is the basis of everything in the universe. There are three states of matter existing.

- Solids: Where the atoms are densely packed
- Liquids: Where the atoms are closely packed
- Gases: Where the atoms are spread out.

Each atom is made up of three tiny particles:

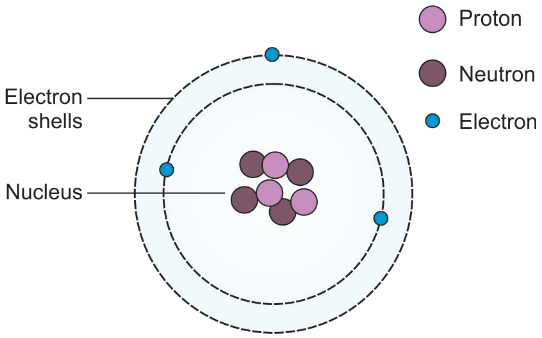
- *Electrons:* These are negatively charged and are revolving round the nucleus of the atom in orbits.
- *Protons:* These are positively charged particles present in the nucleus
- *Neutrons:* These are neutrally charged particles present in the nucleus.

Atoms are usually neutrally charged particles. An ion is a charged particle. Usually a charge is attained by addition or subtracting an electron.

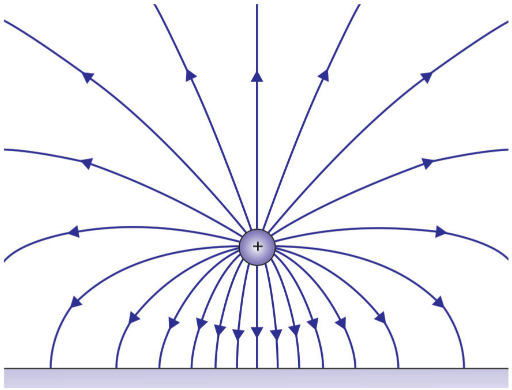
Anion is a negatively charged ion and cation is a positively charged ion.

Atomic number indicates the number of electrons present in the atom

- Electricity: The flow of electric charges through a conductor is called electricity.



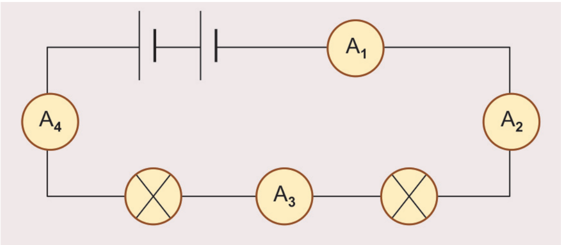
- Electric current: The movement of electric charges is called electric current and is usually measured in amperes.



- Electric field: An electric field is created by a charged body in the space that surrounds it, and results in a force exerted on any other charges placed within the field. Simply it is the area around the electrically charged particle/object where its effect is felt.

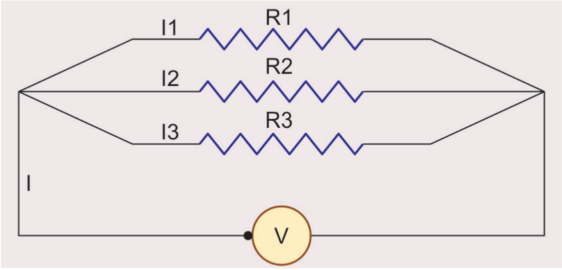
Electric Circuit in Series

A circuit composed solely of components connected in a single path, so that same current flows through all the components is said to be in "SERIES".



ELECTRIC CIRCUIT IN PARALLEL

A circuit connected to all components in parallel to each other, so that same voltage is applied to each component is called an electric circuit in parallel.



Static electricity: It is an imbalance of electric charges within or on the surface of a material. The charge remains until it is able to move away by means of an electric charge. The best examples of a static electricity are lightning and rubbing your hand on the carpet and then touching a doorknob.

- Current electricity: It is just contrast to static electricity. It is produced by constant flow of electrons. There are two types of current electricity
  - *Direct current:* Where the electrons move in one direction
  - *Alternating current:* Where the electrons flow in both directions

Electromagnetic Induction and Radiations

Definition: It is the production of an electromotive force across a conductor when it is exposed to a varying magnetic field.

Electromagnetic induction (EMI) was first discovered by Michael Faraday.

He observed that when a permanent magnet is moved in and out of a coil or single loop of wire, it is induced and EMF (electromotive force/voltage) and therefore a current is produced.

- Faraday's law of conduction: A voltage is induced in a circuit whenever relative motion exists between a conductor and a magnetic field and that magnitude of this voltage is proportional to the rate of change of flux.

Factors affecting EMF by electromagnetic induction:

A. *Number of turns of wire in the coil:* When number of turns in the coil increases, EMF increases.

B. *Speed of the relative motion between coil and magnet:* When the speed of the relative motion between the coil and magnet increases, there will be an increased EMF.

C. *Strength of the magnetic field:* Increased strength of the magnetic field increases EMF.

- Lenz's law: The direction of an induced EMF is such that it always opposes the change of motion that is causing it.

ELECTROMAGNETIC RADIATIONS

It is the energy that is propagated through free space or through a material medium in the form of electromagnetic waves such as radiowaves, visible light and gamma rays.

Scottish scientist and physicist James Clerk Maxwell was the first to predict existence of electromagnetic waves.

If an electric charge is accelerated, it causes the production of electromagnetic radiation.

This radiation moves away from moving charge and once generated is independent of the charge.

If the electric currents are made to oscillate, the rapid acceleration of charges causes the production of electromagnetic radiations whose wavelength and frequency are related to frequency of oscillation.

All electromagnetic radiations have the same velocity of 3×10^8 m/s and differ in wavelength and frequency.

These waves are transverse waves, and is the variation occurs at right angles to the direction of travel.

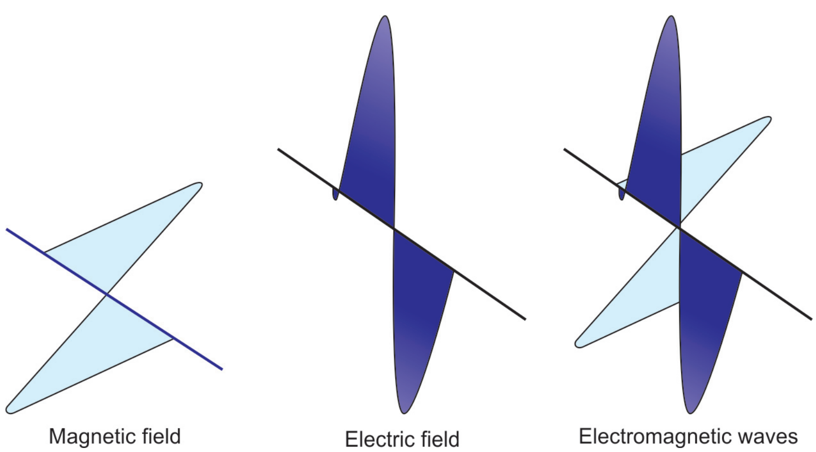
PROPERTIES OF ELECTROMAGNETIC RADIATION

1. They always travel in straight lines in space.
2. They obey inverse square law "The intensity of radiation from a point source is inversely propotional to the square of the distance from source".
3. Radiations are emitted out from space in all directions so that if the source is small, the radiations will spread out equally in all directions with the result that the energy passing through a unit area per unit time will decrease the distance.

Electromagnetic induction discoverer—Michael Faraday

Laws governing EMI are:

Faraday's Law and **Lenz's Law**



4. Phase difference and coherence: Radiations emitted from a source consist of bursts of radiation because each atom or molecule of the source acts independently.
   - The varying electric and magnetic fields are not in time or in step.
   - It is possible to make all the emitting atoms radiate in phases by stimulating the emission.
   - When this occurs, the radiation is said to be coherent, e.g. LASER.
5. Obeys Groutthu's law: Electromagnetic radiations can pass unaffected through a material, they are said to be transmitted. When they pass into a material they are said to be penetrated and when may not be able to enter the material, they are said to be "reflected".

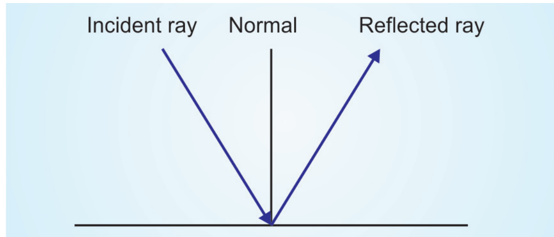
   In all the above cases, there is "no energy loss" to the material and there is no effect.

   Groutthu's law states: Radiation must be absorbed in order to have effect on the material and the effects are produced at the point they are absorbed.
6. Reflection of radiation: When a beam of light enters a different medium from the one it is travelling, the rays may be absorbed, reflected or refracted.
   - *Reflection:* When an electromagnetic radiation changes a medium of travelling, it has to change its velocity.
   - When a ray strikes a new medium, it may turn back from surface and is called reflection.

   The amount of reflection depends on:
   1. Nature of radiation
   2. Angle of incidence
   3. Nature of surface

   The angle of incident ray to normal is equal to the angle of reflected ray to normal.

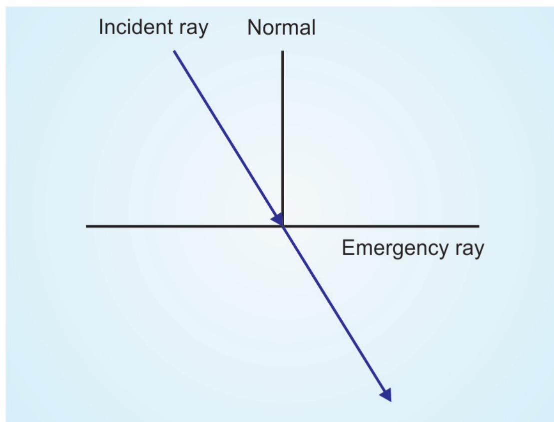
Note: "Normal" is the perpendicular line to the surface.



Cosine law: The intensity of radiation falling on a surface is directly propotional to the cosine of angle (θ) between the direction of incident light and surface normal.

If the radiations occur at 45°, then cos 45°=0.7, so the intensity will be 70% of maximum.

Refraction: When a beam of light passes through a different medium from the one it is travelling, it may bend, the bending of rays is called refraction.



Note: Shorter rays are refracted more than longer rays.

Refraction will not occur if the incident ray is parallel to normal.

The greater the difference between the densities of medium, the greater is the refraction.

Absorption and Penetration

Absorption of electromagnetic radiations depends on depth of penetration "the greater the penetration the lesser the absorption".

- Penetration depth: The depth at which 63% of the original radiation is absorbed.
- Half-value depth: The depth at which 50% is absorbed.

Scattering

In non-homogenous materials, radiations may alter their directions effectively reducing the depth of penetration. This is called scattering.

Radiations with shorter wavelengths are scattered in the skin decreasing their penetrations, e.g. UVR rays.

PHYSICS AND BASIC ELECTRICAL COMPONENTS

Conductors: These are elements whose atoms have a few electrons in their outer orbit. They allow the heat and electricity to pass through them, e.g. copper.

Non-conductors: (1) They are materials made of atoms in which the electrons in the outer shell are firmly held in their orbits. (2) They will not allow the current to pass through them. They are also called insulators, e.g. wood.

Transmission of Heat

Heat is transmitted by three methods.

a. Conduction
b. Convention
c. Radiation

a. Conduction: (1) It is the transmission of heat from one particle of a conductor to another from area of higher temperature to area of lower temperature. (2) It is due to increased vibration of molecules.
   For example, when a rod is heated at one end, the other end becomes hot after sometime.
b. Convection: (1) This is the process of transmission of heat by means of displacing kinetic energy from one part to the another. (2) It is usually observed in a liquid or a gas.
c. Radiation: Heat may be transmitted by means of radiation. When an atom is heated, it causes an electron to move to a higher energy electron shell. As it returns to its normal shell, the energy is radiated.

Physical Effects of Heat

a. Expansion: When an object is heated, it expands in size.
b. Change of state: (1) Heat alters the change in the state of matter. (2) When solids are heated they are converted to liquids and on further heating become gases.
c. Acceleration of chemical action: According to van't Hoff's law that any chemical action is accelerated by a raise in temperature.
d. Production of a PD: If two different metals are heated at the junction, a potential difference is produced between their free ends.
e. Production of electromagnetic waves: When a substance is heated, they produce electromagnetic radiations.
f. Thermionic emission: When a substance is heated, e.g. tungsten, molecular agitation occurs, but later they reach a point where the rate of loss of electrons equal to the rate of return and a cloud of electrons exists as a 'charge' around the object. This principle is called thermionic emission.
g. Reduced viscosity of fluids: When heated, the kinetic energy of molecules in fluids increases and the mutual attraction reduces, thus reducing the viscosity of fluids.

Static Electricity

When two suitable materials are rubbed together, a static electric charge is produced. This type of electricity gained by the objects is called static electricity.

Electrical Components

Transformers

These are commonly used in applications which require the conversion of AC voltage from one voltage level to another.

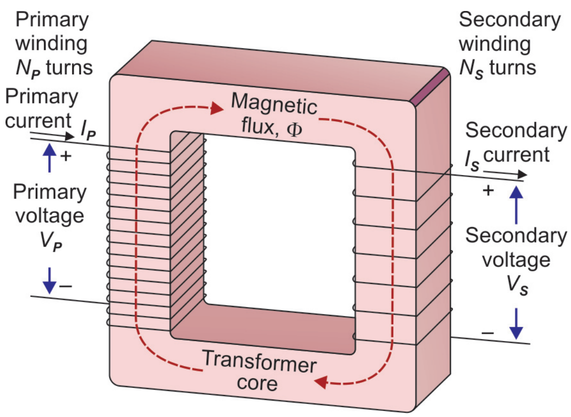
There are two broad categories of transformers

a. Electronic: Which operate at very low power levels
b. Power: Which operate at high power levels.

Definition: A transformer with the help of mutual induction between two windings, transforms power from one circuit to another without changing its frequency but changing voltage level. Mutual induction is the process by which a coil of wire magnetically induce a voltage into another.

Parts of a Transformer

1. Primary winding: Which produce magnetic flux when connected to electrical source.
2. Magnetic core: They create a closed magnetic circuit.
3. Secondary winding: This gives a desired output of the transformer.



Step-up transformer: When a transformer is used to increase the voltage on its secondary winding, it is called step-up transformer.

Step-down transformer: When a transformer is used to decrease the voltage on secondary winding, it is called step-down transformer.

The difference in voltage between primary and secondary is brought by changing the number of coil turns in the primary winding (Np) and secondary windings (Ns). "A transformer works on Farday's laws of induction".

Capacitor: It is an electrical component which has the ability or capacity to store energy in the form of an electrical charge producing a potential difference (static voltage) across its plates.

- Capacitors sometimes referred to as condensers.
- It acts as a small rechargeable battery.

Components and Construction of a Capacitor

- A capacitor consists of two or more parallel conductive plates which are to connected or touch each other.
- They are separated electrically by a good insulating material, e.g. air, waxed paper, mica ceramic, plastic or liquid gel.
- This insulating layer is called Dielectric.

Capacitance of a Capacitor

It is the measure of ability to store an electrical charge onto its two plates of capacitor

The unit is "farad" and abbreviated as "F".

"Capacitance is defined as being that a capacitor has the capacitance of 1 farad. When a charge of 1 coulomb is stored on the plates by a voltage of 1 volt."

The subunits of capacitance are microfarad, nanofarad, picofarad.

Capacitance depends upon:

- Surface area of plates
- Distance between two plates
- Dielectric material used.

Diode: It is an electric component that controls the direction of flow of current:

1. Current can pass through diode in only one direction.
2. They are like "one-way valve" of electronics.
3. Diode always allow current in forward direction.
4. If the voltage across the diode is negative, no current can flow, and act as a open cirucuit, in such a case, the diode is said to be of "OFF" or "reverse biased".
5. If the voltage across a diode is positive, it will conduct current and act as a "short circuit", in such case, the diode is said to be "on" or "forward biased".

Types of Diodes

Type	Function
Normal (standard signal diode)	Forward voltage drop
Rectifier or power diode	High voltage forward drop
LED (light emitting diode)	Forward voltage and they light up
Photo diodes (solar diodes)	Special diodes which capture energy from photons of light to generate electrical current

Uses of Diodes

a. As rectifier: It converts AC to DC.

b. Reverse current protection: It allows only positive current in a circuit.

c. Voltage spike protection: These protect and limit potential damage from unexpected large spikes in voltage.

Valves: In electronics, vacuum tube, electronic tube or valve is a devise that controls electric current through a vacuum in a sealed container.

They allow current to flow in one direction or used in tunring on and off current.

Common valves are diode, triodes and transistors, in Britain, these are called valves and in North America Vacuume tubes or electronic tubes.

It consists of two main parts:

a. Heated filament

b. Metal plate

These are enclosed in a vacuume container or a glass tube filled with inert gas.

ELECTRIC SHOCK

Definition: A shock is a painful stimulation of sensory nerves caused by a sudden flow, cessation or variation in the current passing through the body.

Effects of electric shock

1. The victim may be frightened and distressed
2. If the victim faces a major shock, he may become unconscious.
3. In extreme cases, respiratory cessation (apnoea) will occur.
4. Cardiac arrest
5. Absence of pulse in carotid artery.
6. Dilated pupils.

Treatment of electric shock

1. Immediately after shock, disconnect the victim from source of supply of current.
2. Following a minor shock, the patient is reassured and allowed to rest.
3. Allow the patient to drink cool water.
4. In severe shocks, victim is laid flat
5. Loosen the tight clothing.
6. Clear the airways
7. In case of respiratory failure, artificial respiration is given (mouth to mouth)
8. In case of cardiac arrest, external cardiac massage

Check the machine condition before setting up for therapy

1. It is always advisable to have wooden flooring for the electrotherapy department.
2. It is also advisable to have inverter and stabiliser facility for electrotherapy department.
3. Never allow any wires or leads to come in contact with the skin of the patient.
4. Do not suddenly raise the intensity to maximum.
5. Strictly tell the patient not to touch the apparatus.
6. All the machines should be serviced regularly by a qualified engineer.

Earth shock: When a shock is due to a connection between the live wire of the main and earth, it is known as earth shock.

Example: A patient who is receiving treatment with a current that is not earth free may rest his hand on a water pipe may lead to a shock.

Precautions against earth shock

1. Water pipes and gaspipes should be out of reach of the apparatus and of patients receiving treatment.

2. The flooring should be of insulating material and should be kept dry.
3. All equipment should have intact working fuses.
4. The metal caring of all apparatus must be connected to earth.
5. Patients should not be permitted to touch the apparatus during treatment.
6. Special care is taken in case of baths. The bath must be of insulating material.
7. Never add water to the bath during treatment.

Differences between low frequency and high frequency currents.

Low frequency	High frequency
1. Currents having frequency up to 1 kHz are called low frequency currents	1. Alternating electric currents having a frequency of 10,000 Hz.
2. Stimulates muscle and produces contraction	2. Cannot stimulate muscle for contraction.
3. Stimulates nerves	3. Cannot stimulate nerve
4. Does not produce thermal effect.	4. Produces deep heating of tissues.

Safety issues by using electrical stimulation/basic guidelines for application of electrotherapy:

1. Explanation to the Patient: An explanation to the treatment is an essential precursor of application. The type of sensation to be expereinced is explained, and the patient is warned of any effects that should be reported.
2. Examination and Testing: Specific examination of the part to be treated for possible dangers and contraindications + any relevant tests are done, e.g. checking the sensitivity of the patient skin.
3. Assembly of Apparatus: All the apparatus and equipment needed should be assembled and suitably positioned.
4. Safety and Working of Apparatus: Check all the knobs are pointing neutral or zero.
   - Check all the wires from mains to the machine are properly insulated.
   - Check all the leads for break or abrations in the insulation.
   - Switch on the machine and test the apparatus before application.
   - Insulate the couch by placing resin or machintosh.
5. Preparation of the Part to be Treated: This involves any preparatory procedure, e.g. skin cleaning to reduce resistance, positioning of the patient, comfortably and appropriately.
6. Setting Up: The parameters are set on the machine to the optimum therapeutic effects and safety.
7. Instruction and Warnings: Before the treatment commences, it is important to instruct the patients in what he/she must and must not do.

   Strictly instruct the patient not to touch any apparatus while working.
8. Application: The patient must be observed throughout to ensure that the treatment is progressing satisfactorily.
9. Termination Of/Winding-Up/Weaning Off Treatment: At the termination of the treatment, the part treated should be examined to ensure that the desired effects have occurred if visible. If any undesired effects, e.g. skin burn or excessive redness, then give first aid and seek for medical consultation in emergency.
10. Recording: An accurate record of the parameter of treatment including the region treated, techniques, dosage and resultant effect must be recorded for evidenced-based practice.
11. Electrotherapy Design and Maintenance:
    - The department should be ideally on ground floor easily accessible from parking area.
    - A ramp should be provided if the ground floor is on a height.

- The flooring of the electrotherapy department must be made up of wooden or with a carpet.
- The wiring of the department must be earthed and insulation must be checked regularly.
- A voltage stabilizer and inverter is advised for all the machines.
- Fire extinguishers and first aid kit must be provided.
- There should be a provison of cubicles for privacy.

MULTIPLE CHOICE QUESTIONS

1. **Which of the following is NOT a substructure of atom?**
   A. Proton
   B. Electron
   C. Neutron
   D. Ion

2. **What is the electricity produced when you rub your feet on the carpet?**
   A. Static electricity is produced
   B. Current electricity is produced
   C. Feel shock like sensation
   D. Nothing happens

3. **If the frequency is more than 10,000 cycles/sec, then these are called ____ currents**
   A. High frequency
   B. Medium frequency
   C. Low frequency
   D. Russian

4. **Low frequency currents therapeutically mainly used for**
   A. Muscle stimulation
   B. Heating the tissues
   C. Cooling the tissues
   D. All of the above

STATE TRUE or FALSE

1. **Ions are charged particles.**
2. **Direct current electricity means flow of electrons in both directions.**
3. **Radiation must be absorbed to have the effect.**
4. **James Clerk Maxwell was the first to predict existence of electromagnetic waves.**

FILL IN THE BLANKS

1. **Low frequency currents are of ______________ frequency.**
2. **Rebox current is an example of ______________ currents.**
3. **Electromagnetic induction was first discovered by ______________ .**
4. **______________ frequency currents are used for deep tissue heating.**

Answers MCQs 1. D 2. A 3. A 4. A

CHAPTER 2

Physiology of Nerve and Muscle

Learning Objectives: At the end of this chapter, students will be able to learn

1. Definition of muscles
2. Parts of muscle
3. Classification of muscles
4. Structure of skeletal muscles
5. Properties of skeletal muscles
6. Mechanism of muscle contraction
7. Structure of neuron
8. Neuromuscular junction
9. Transmission of nerve impulses to muscle
10. Motor unit

INTRODUCTION

It was discovered in the late 18th century that the electrical current produces muscle contraction and hence used to stimulate the innervated muscles and is called *neuromuscular electrical stimulation* (NMES).

Definition

In Latin word *'Mus'* means Mouse (most of the muscles resembles mouse-shaped with their tendon representing tail).

A muscle is soft contractile bundle of fibrous tissues that has ability to contract, to bring about movements and to maintain the position of body parts.

- Muscles considered as 'motors of the body'.
- Myology: The study of muscles.

Parts of muscle

- Two ends
  a. *Origin:* The fixed end of muscle during contraction.
  b. *Insertion:* The movable end of muscle during contraction.
- Two parts
  a. *Belly:* The fleshy and contractile part of muscle.
  b. *Tendon:* The fibrous, noncontractile and cord-like structure and when flattened it is called *Aponeurosis.*

Classification of muscles

The muscles are classified as follows:

1. Voluntary muscles: Striated (e.g. skeletal muscle)
2. Involuntary muscles:
   a. Striated (e.g. cardiac muscle)
   b. Nonstriated (e.g. smooth)

Structure of Skeletal Muscle (Fig. 2.1)

- These are also known as striped, striated, somatic or voluntary muscles.
- Under microscope they exhibit cross-striations and respond quickly to stimuli.
- When examined, each muscle is composed of numerous fasciculi separated by fibrous septa passing between fasciculi from the covering fascia.
- The fascicule are made up of number of fibres.
- Each muscle fibre is a multinucleated, cross–striated cylindrical cell 1–300 mm long.
- There are 3 types of muscle fibres:
  a. Type I (slow oxidative fibres produce tonic contraction characteristics for postural muscles).
  b. Type II (fast glycolytic fibres produce phasic contraction required for large scale movement of body segments) and
  c. Intermediate fibres (fast oxidative—glycolytic fibres).
- It has limiting cell membrane known as sarcolemma and is enclosed by sarcoplasm.
- The sarcoplasm contains several hundred nuclei and evenly distributed longitudinal threads called myofibrils which contain dark and light bands.
- Dark bands are known as 'A' bands (anisotrophic) and light bands as 'I' bands (isotrophic).
- In middle of A band there is H band with M band which is dark in middle and in the middle of I band there is a dark Z disc.

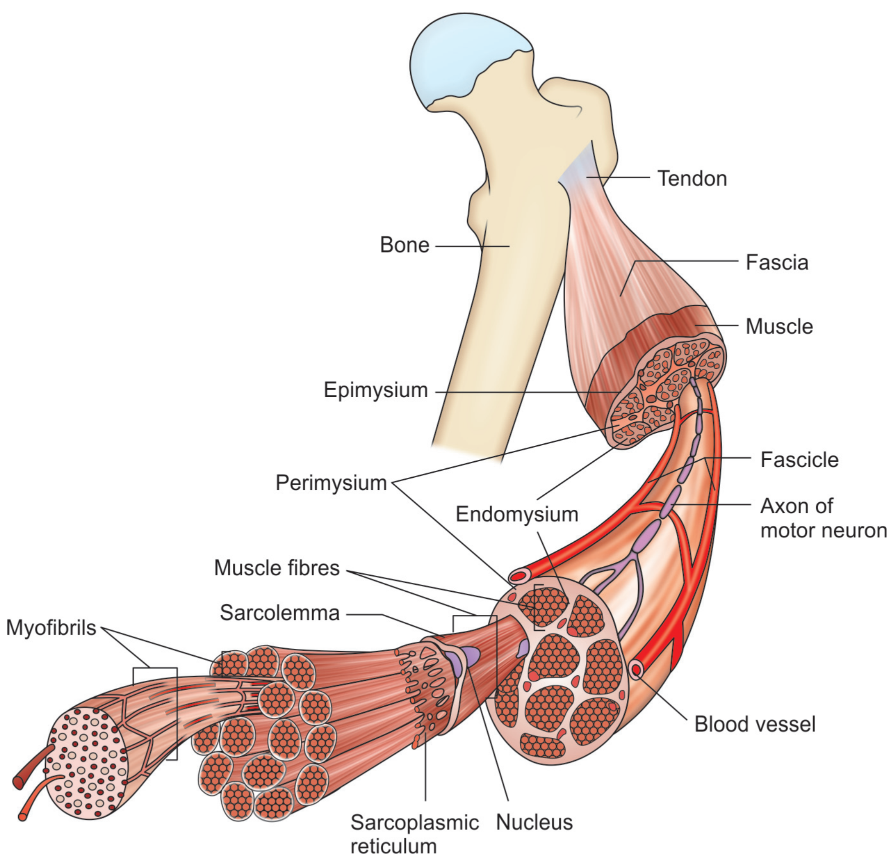


Fig. 2.1: Skeletal muscle

- The segment of myofibrils between two Z discs is called sarcomere which is a unit of muscle contraction.
- Each myofibril contains contractile protein called actin (thin filaments) and myosin (thick filaments).
- During muscular contraction actin filaments at each end slides over the myosin filaments, as a result Z disc brought closer together and sarcomere shortens.

Supporting tissues

It helps in organization of muscle.

The connective tissue of muscle becomes continuous with the tendon.

- Epimysium: Surround entire muscle
- Perimysium: Surround bundle of muscle fibres (fasciculi)
- Endomysium: Surround individual muscle fibres.

Properties of Skeletal Muscles

The skeletal muscle shows the following physiological properties:

1. Excitability
2. Contractility
3. Refractory period
4. Tone
5. Conductivity
6. Fatigue.

Excitability: It is the property by which the skeletal muscle responds to threshold stimulus.

Contractility: It is the property which refers to the internal events of the muscles which are manifested externally either in the form of shortening of muscle fibres or increase in the tension of muscles.

There are two types of contractions in the muscles:

1. Isometric contraction (*Iso* = same; *Metric* = measurement): An increase in the intramuscular tension without any change in the length of muscle.
2. Isotonic contraction (*Iso* = same; *Tonic* = tension): An increase in the intramuscular tension with change in the length of muscle.
3. Concentric contraction: The contraction of muscle against gravity.
4. Eccentric contraction: The contraction of muscle towards the gravity.

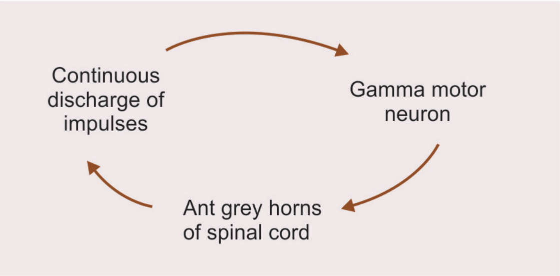
Refractory period: Altered state of excitability. It is of two types:

1. *Absolute refractory period:* It is the first part of refractory period in which the muscle remains inexcitable to any stimulus strength.
2. *Relative refractory period:* It is the second part of refractory period in which muscle is less excitable but responds to stronger stimulus.

Tone

The state of minimal contraction with certain degree of vigor and tension in a muscle.

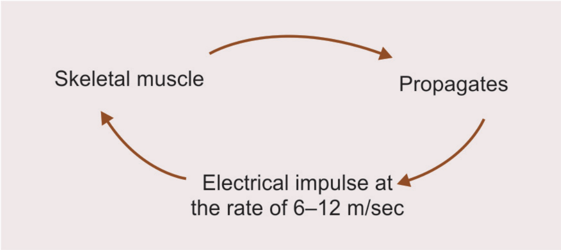
- If motor nerve is cut, tone is lost.
- Maintenance of skeletal muscle tone: Gamma motor neuron



- Maintenance of cardiac muscle tone: Muscles themselves control the tone—purely myogenic.
- Maintenance of Smooth muscle tone: Depends upon: (a) Calcium level, (b) number of cross bridges.
- In LMN lesion—tone decreased: Flaccidity.
- In UMN lesion—tone increased: Spasticity.

Conductivity

The property of transferring or propogating an impulse is called conductivity.



All-or-None Law

- If there is adequate strength of stimulus: Maximum response.
- If there is inadequate strength of stimulus: No response.

Smooth muscle

- These are plain, unstriped, non-striated, visceral or involuntary muscles.
- Length of relaxed smooth muscle fibres 30–200 µm.
- Thickest in middle (3–8 µm); tapers at the ends
- These muscles often circle or surround the viscera.
- They do not exhibit cross-striations and respond slowly to stimuli.
- Individual muscle fibre is an elongated, spindle-shaped cell.
- Each fibre is single, oval and with centrally located nucleus.
- Each cell is limited by a cell membrane, the plasma lemma.
- The sarcoplasm of smooth muscles contains thick, thin and intermediate filaments (attached to dense bodies).
- They are supplied by sympathetic and parasympathetic division of autonomic nervous system.
- During contraction, tension develops within the thick and thin filament, which in turn transmitted to intermediate filament that pull the dense bodies and causes lengthwise shortening of muscle fibres.
- The smooth muscles line the respiratory, alimentary, urinary systems, etc.
- Their capacity of regeneration is considerable when compared with other muscle tissues.

For example, *muscle of blood vessels, errector pili muscles of skin, iris, etc.*

Cardiac muscles

- These muscles are striated and involuntary.
- The cardiac muscles form the myocardium of the heart.
- It resembles the skeletal muscles to some extent only.
- Each fibre contains single centrally placed nucleus, branches and anastomoses with another fibres.
- This gives rise to the branching and anastomosing system of cylinders.
- The unique feature of cardiac muscle fibre is the presence of their intercalated disc (intercal = to insert between) that are made up of plasma membrane.
- It remains contracted for about 10–15 times longer than the skeletal muscle fibres in response to stimulus.
- The perimysium layer encloses blood vessels, nerves and group of muscle fibres.
- They contain both gap junction and desmosomes.
- They are supplied by both sympathetic and parasympathetic division of autonomic nervous system.

Group action of skeletal muscles and classification

According to their chief role in movement, the muscles are classified as:

a. Agonist or prime movers.
b. Antagonist or opponents.
c. Synergist
d. Fixators.

Agonist/prime movers: The muscles which bring about the desired movement.

Antagonist/opponents: The muscles which opponent the prime movers. They help the prime movers by active controlled relaxation.

Synergist: These are the group of muscles which support or help agonists in bringing about the desired movements.

Fixators: These are the group of muscles which stabilizes the proximal joints of a limb so that the desired movements at the distal joint may occur on a fixed base.

Mechanism of contraction

Steps in contraction cycle.

- Nerve impulses in motor neuron release acetylcholine into synaptic cleft.
- ACh binds receptors on motor end plate, depolarization occurs.
- Sarcoplasmic reticulum releases calcium and binds to troponin.
- Formation of troponin–tropomyosin complex.
- Hydrolysis of ATP into ADP and phosphate group (sources glycolysis, phosphocreatinine and oxidative phosphorylation)
- Myosin head energized.
- Energized myosin head attaches myosin to actin.
- Crossbridge formation occurs (released hydrolysed phosphate group)
- Stronger bond formation due to ADP attachment to myosin results in power stroke, i.e. sliding of actin filament between the myosin (ADP released) towards the centre of sarcomere.
- Z disc comes closer together.
- Shortening of contractile unit.
- Another ATP binds to the myosin head
- Link between myosin head and actin weakens
- Myosin head detaches.

The contraction cycle will repeat as long as there is availability of ATP and calcium ions.

Structure of neuron

- Neuron: Structural and functional unit of nervous system.
- It divides into three parts:
  1. The cell body
  2. Dendrites
  3. An axon
  4. Myelin sheath

1. The cell body: It contains nucleus which is surrounded by cytoplasm and includes mitochondria, Golgi complex and lysosymes. It also contains endoplasmic reticulum (Nissl bodies—for protein synthesis).
2. Dendrites: These are short and highly branched receiving portion of neuron.
3. Axon
   - It is long, thin and cylindrical and joins the cell body at the cone-shaped elevation called axon hillocks.
   - It propagates nerve impulse to other neuron and muscle fibre.
   - The first part of axon is called initial segment and the junction between axon hillock and initial segment is called trigger zone.
   - It contains axoplasm, axolemma.
4. Myelin sheath
   - The covering of multilayered lipid and protein on axon.
   - Function: It acts as an insulator to axon.

     It increases speed of nerve impulse conduction.
   - Unmyelinated: Axon without covering of myelin sheath.
   - Myelinated: Axon with covering of myelin sheath.
   - Neuroglia producing myelin sheath: (1) Schwann cells (PNS) which during fetal development forms myelin sheath around axon. (2) Oligodendrocytes (CNS)
   - Nodes of Ranvier: The gap between the myelin sheath.

Properties of Nerve Fibres

The nerve fibre shows the following physiological properties:

1. Excitability
2. Conductivity
3. Refractory period
4. Summation
5. Adaptation
6. Infatigability
7. All-or-none law

- Excitability: Due to application of stimulus the physiochemical changes which occur in a tissue.
- Conductivity: Propagation of action potential through nerve impulse.
- Refractory period: A period in which nerve does not respond to stimuli.
- Summation:
  - *Action of one subliminal stimulus:* No response in the nerve fibres.
  - *Action of one or more subliminal stimulus within short interval:* Response is produced.
  - The phenomena in which stimuli are summed up together is called summation.
- Adaptation: When the nerve fibre is stimulated
  - *At the beginning:* Maximum response (excitability) can be seen in nerve fibres.
  - *At the later stages:* Response decreases.
  - *At the final stage:* No response. This phenomena is called adaptation/accommodation.
- Infatigability: The nerve fibre does not fatigue if stimulation is given for a longer period of time because it conducts only one action potential at a time.
- All-or-none law:
  - If there is subthreshold strength of stimulus—action potential does not develop.
  - If there is above subthreshold strength of stimulus—action potential amplitude remains the same.

Neuromuscular junction

- The junction of synaptic contact between somatic motor neuron and a skeletal muscle fibre.
- *Synapse:* A region where communication occurs between two neurons or between neuron and target cell.
- *Neurotransmitter:* The chemical substance that acts as a mediator for propogation of nerve impulse from one neuron to another through synapse.
- The skeletal muscle fibres innervates motor nerve fibres each of which divides into many terminal branches and each terminal branch is supplied by one muscle fibre.
- Terminal branch of nerve fibre is called axon terminal and it contains mitochondria and synaptic vesicles.
- The synaptic vesicles contain neurotransmitter acetylcholine which is synthesized by mitochondria by formation of ATP energy.
- The axon loses its myelin sheath as the impulses travel down to muscle fibre as a result there is exposure of axis cylinder.
- The terminal end portion of axis cylinder looks like a bulb called motor end plate.
- Presynaptic membrane—membrane of the nerve endings.
- Postsynaptic membrane—membrane of the muscle fibre and contains nicotinic acetyl choline receptors.
- Synaptic cleft—the space between the presynaptic and postsynaptic membrane.

Transmission of nerve impulse to muscle: A series of events takes place when nerve impulses travel to muscle.

1. Release of acetylcholine to synaptic cleft.
2. ACh diffuse between motor neuron and motor end plate.
3. ACh binds with nicotinic receptors.
4. Opening of ligand gated channel and inflow of sodium ions into the muscle fibre produces electrical potential (end plate potential).
5. Action potential is generated.
6. Propagation of action potential to sarcolemma and T-tubules
7. The ACh activity is terminated by breaking down into acetyl and choline due to enzyme acetylcholinesterase.
8. The muscle action potential and calcium release mechanism into sarcoplasmic reticulum stops.
9. This signifies that the excitation stops and muscle relaxes.

10. If another nerve impulse release again, this cycle continues.

Motor point

- A point where the motor nerve enters the muscle.
- Electrical stimulation at this point is very effective.
- It varies in number.

Motor unit

- The single alpha motor neuron along with axon terminal and all the skeletal muscle fibre it stimulates is called a motor unit.
- The muscle fibre varies in each motor unit.
- Small motor units consist of 5–10 muscle fibre, e.g. extraocular muscles.
- Large motor unit consists of 100–2000 muscle fibre, e.g. proximal limb muscles.

MULTIPLE CHOICE QUESTIONS

1. Electrical stimulation is very effective over

A. Motor point **B.** Synapse
C. Neuromuscular junction **D.** None

2. Membrane of nerve endings is known as

A. Presynaptic membrane **B.** Postsynaptic membrane
C. Axolemma **D.** Meninges

3. Actin filament has 3 molecules, namely

A. Troponin **B.** Tropomyosin
C. F-Actin **D.** None

4. Agonist, antagonist, fixators, synergist are types of

A. Smooth muscle **B.** Skeletal muscle
C. Cardiac muscle **D.** None

STATE TRUE or FALSE

1. The junction of synaptic contact between somatic motor neuron and a skeletal muscle fibre is termed synapse.
2. Postsynaptic membrane contains nicotinic acetylcholine receptors.
3. Myelin sheath increases speed of nerve impulse conduction.
4. Dendrite propagates nerve impulse to other neuron and muscle fibre.

FILL IN THE BLANKS

1. A point where the motor nerve enters the muscle is called ______________.
2. ______________ is chemical substance that acts as a mediator for propagation of nerve impulse from one neuron to another through synapse.
3. The study of muscles is known as ______________.
4. LMN lesion leads to ______________ in tone.

Answers MCQs	1. A	2. A	3. D	4. B

CHAPTER

3

Electrical Stimulation of Nerve and Muscle

Learning Objectives: At the end of this chapter, students will be able to learn

1. Definition of electrical stimulation of nerve and muscle
2. Various currents used for electrical stimulation of nerves and muscles
3. Types of electrodes used in the electrotherapy department and their uses
4. The basic guidelines for application of electrical nerve stimulation to patients

INTRODUCTION

1. Electrical muscle stimulation is the elicitation of a muscle contraction in a skeletal muscle by using electrical impulses.
2. It can be used as a strength training tool for healthy subjects and athletes.
3. It can be used as a rehabilitation and preventive tool for partially or totally immobilized patients.
4. It can be used as a testing tool for evaluating the neural and/or muscular function *in vivo*, a post-exercise recovery tool for athletes.
5. The impulses are generated by a device and delivered through electrodes on the skin in direct proximity to the muscles to be stimulated.
6. The impulses mimic the action potential coming from the central nervous system, causing the muscles to contract.

Fig. 3.1: Electric nerve muscle stimulator (Pocket size)

HISTORY OF DEVELOPMENT

1. *Luigi Galvani* provided the first evidence that current can activate muscle.
2. During the 19th and 20th centuries researchers studied and documented the exact

electrical properties that generate muscle movement.

3. In 1960s and 1970s Soviet sport specialists applied EMS in training of elite athletes.
4. Recent medical physiology researches pinpointed the mechanisms by which electrical stimulation causes adaptation of cells of muscles, blood vessels and nerves.

Types of Currents Used for Electrical Stimulation

- Faradic currents
- Galvanic currents

1. A current which varies sufficiently in magnitude can stimulate a motor nerve and so produce contraction of the muscle which it supplies.
2. Impulses with duration of less than 10 ms may be classed as having a short duration and said to be **Faradic** type currents.
3. Impulses with duration of more than 10 ms may be long duration and known as **Galvanic** type currents.

Types of Electrodes Used for Electrical Stimulation

1. Plate electrodes

> Muscle and nerve stimulation when hand in hand work with manual therapy shows better result

2. Carbon electrodes
3. Karraya rubber electrodes (self-adhesive)
4. Pen electrodes
5. Button electrodes

> Electrode, specially plate, is wrapped with gauze piece or cotton layer, soaked in water for better conduction of the current to tissue layer.

BASIC GUIDELINES FOR APPLICATION OF ELECTRICAL MUSCLE NERVE STIMULATION

1. An explanation of the treatment is an essential precursor of application. The type of sensation to be expereinced is explained, and the patient is warned of any effects that should be reported.
2. Examination and testing: Specific examination of the part to be treated for possible dangers and contraindications plus any relavent tests are done, e.g. checking the sensitivity of the skin.
3. All the apparatus and equipment needed should be assembled and suitably positioned.
4. Preparation and testing of apparatus: This includes setting up the apparatus and any necessary testing prior to its application.
5. Preparation of the part to be treated: This involves any preparatory procedure, e.g. washing the area and positioning the patient, and in particular the part to be treated, comfortably and appropriately, so that he or she is relaxed and unnecessary movement is avoided.
6. Setting up: The apparatus is set up to the optimum therapeutic effects and safety.
7. Instructions and warnings: Before the treatment commences it is mandatory to instruct the patient in what he or she must and must not do.
8. Application: The patient must be observed throughout to ensure that treatment is progressing satisfactorily.
9. Termination of treatment: At the termination of treatment the part treated should be examined to ensure that the desired effects have occurred if visible.
10. Recording: An accurate record of the parameters of treatment including region treated, technique, dosage and the resultant effect must be recorded for evidenced-based practice.

SHORT ESSAY QUESTIONS

1. What are the types of currents used for electrical muscle nerve stimulation?
2. What are the various benefits of electrical nerve stimulation?
3. List out various electrodes used in the electrical stimulation of nerve and muscle.

LONG ESSAY QUESTION

1. Discuss briefly the principles and guidelines of application of electrical stimulation of nerve and muscle.

MULTIPLE CHOICE QUESTIONS

1. Who first provided scientifically that current can produce a response in muscles?
   A. Luigi Galvani **B.** Faraday
   C. Newton **D.** Curie
2. What are the electrical impulses less than 10 millisec duration known as?
   A. IFT
   B. Faradic currents
   C. Galvanic currents
   D. None
3. What are the electrical impulses more than 10 millisec duration known as?
   A. IFT
   B. Faradic currents
   C. Galvanic currents
   D. None
4. How can we avoid the danger of shock while giving electrical stimulation?
   A. Proper examination of apparatus
   B. Examination of pateint
   C. Proper insulation
   D. All of the above
5. Which of the following are self-adhesive electrodes?
   A. Karayya rubber
   B. Pen
   C. Plate
   D. Carbon

STATE TRUE or FALSE

1. The impulses used for electrical muscle nerve stimulation mimic the action potential coming from the central nervous system, causing the muscles to contract.
2. Sensitivity of the skin does not matter in electrical muscle nerve stimulation.
3. Carbon electrodes are self-adhesive electrode.
4. Electrical stimulation causes adaptation of cells of muscles, blood vessels and nerves.

Answers MCQs	1. A	2. B	3. C	4. D	5. A

FILL IN THE BLANKS

1. ____________ provided the first evidence that current can activate muscle.
2. Faradic type currents have duration of _________ 10 millisecond.
3. Long duration impulses are known as ___________ current.
4. Electrical stimulation of nerve and muscle can be used as a ___________ training tool for atheletes.

CHAPTER

4

Faradic Currents

Learning Objectives: At the end of this chapter, students will be able to learn

1. Definition and types of faradic currents.
2. Physiological and therapeutic effects of faradic currents.
3. Indications and contraindications of various faradic type currents.
4. Methods of application of faradic currents.

INTRODUCTION

A current which varies sufficiently in magnitude can stimulate a motor nerve and so produce contraction of the muscle which it supplies.

Impulses with duration of less than 10 ms may be classed as having a short duration and said to be faradic type.

The term Faradism was originally used to signify the type of current produced by a faradic coil.

Today electronic stimulators are being used for therapeutic purposes which produce same physiological effects as the original faradic current.

DEFINITION

A faradic type current is a short duration interrupted direct current with pulse duration of 0.1 millisecond and a frequency of 50–100 Hz

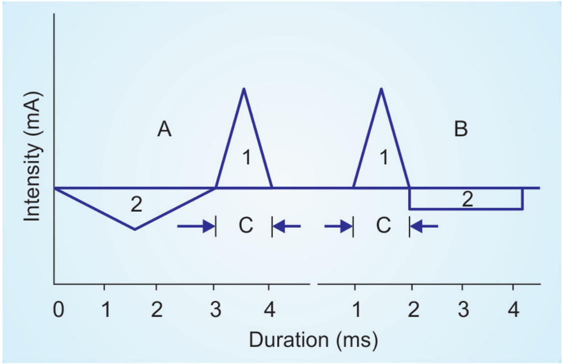


Fig. 4.1: Faradic currents

Modified Faradic Currents

1. Faradic type of currents is always surged for the treatment purposes to produce a near normal like contraction and relaxation of muscles.
2. The current is surged so that the intensity of successive impulses increases gradually and falls suddenly or gradually.

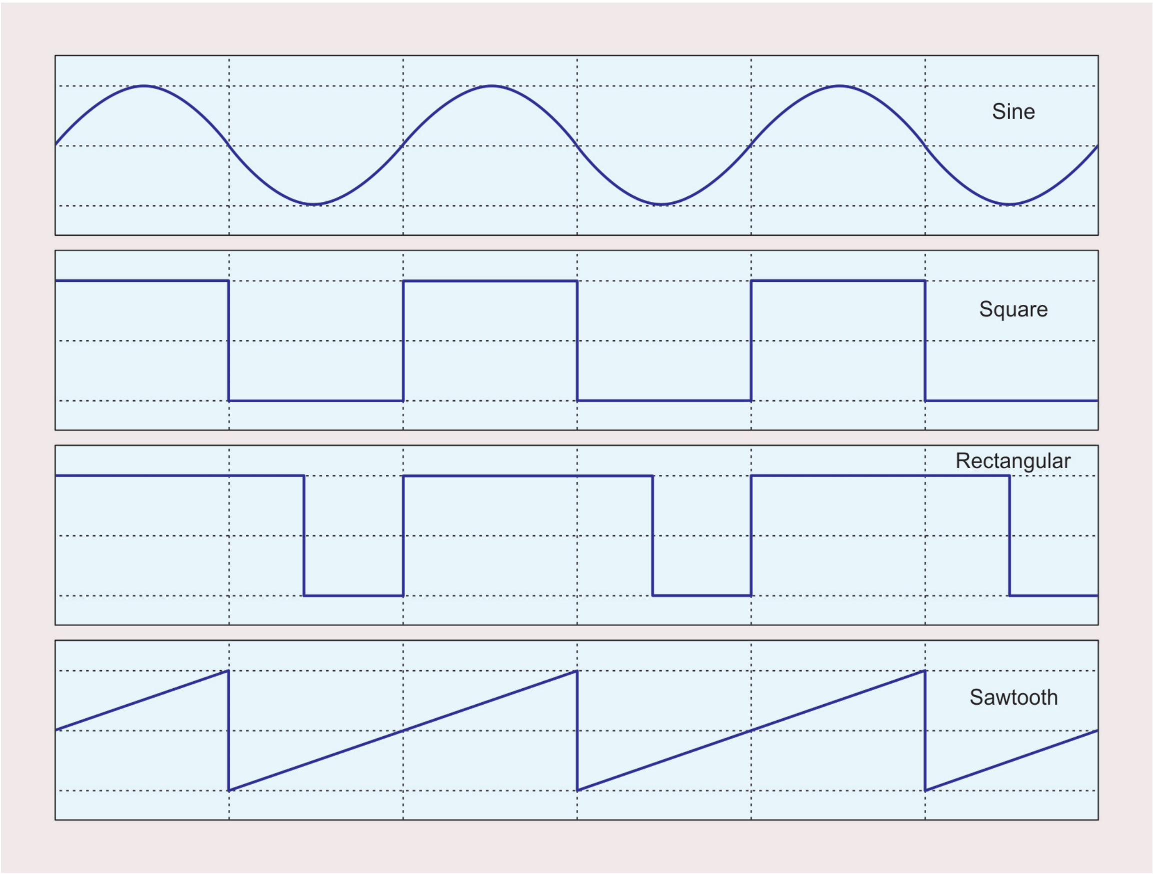


Fig. 4.2: Surged faradic currents

3. In the modern stimulators, an electronic device is used to surge the current.
4. The circuit can be modified to give surges of various durations, frequencies and wave-forms.
5. Various types of surges are trapezoidal, triangular and sawtooth impulses.

Important Points to Remember

1. The tissues of the body are capable of transmitting an electric current because of the ions present in the tissue fluid. Hence they are considered as conductors.
2. The conductivity differs with type of tissue.
3. Muscle is a good conductor and fat is a poor conductor.
4. Always the current travels through tissues of low resistance. Epidermis has a high resistance.

Surging

Surging means the gradual increase in peak intensity and decreasing types of trapezoidal surging—rectangular, triangular and saw-tooth.

PHYSIOLOGICAL EFFECTS OF FARADIC CURRENTS

A. Stimulation of Sensory Nerves

i. When a faradic current is applied to the body, a mild prickling sensation is experienced.

ii. This sensory stimulation causes a reflex vasodilatation of superficial blood vessels.
iii. Erythema is formed (Redness of skin).

B. Stimulation of Motor Nerves

i. Faradic current stimulates motor nerves.
ii. If there is threshold intensity, it causes contraction of the muscles applied.
iii. Because the stimuli are repeated 50 times per second or more than the type of contraction seen is tetanic.
iv. If tetanic contraction is allowed for more than short period of time, the muscle will undergo fatigue.
v. If the current is surged, then the contraction gradually increases and decreases in strength similar to voluntary contraction.

C. Metabolic Effects

When a muscle contracts as a result of electrical stimulation, the changes taking place within the muscles are similar to those associated with voluntary contraction. The changes are as follows:

i. Increased metabolism
ii. Increased output of waste products

> Physiological effects of faradic currents
> - Sensory and motor nerve stimulation
> - Metabolic effects
> - Stimulation of denervated muscle

iii. Increased oxygen demand
iv. Increased in the blood supply to the muscle.
v. Increased in venous and lymphatic return.

D. Stimulation of Denervated Muscles

To produce a contraction of denervated muscles by faradic current is unsatisfactory because the current required to produce a contraction with an impulse lasting for 1 millisecond is intolerable by patients.

CHEMICAL EFFECTS OF FARADIC CURRENT

- When a direct current is passed through an electrolyte, chemical changes take place at the electrodes.
- If the chemicals formed come in contact with the tissues, there is danger of electric burns.

INDICATIONS OF FARADIC–TYPE CURRENTS

- *Facilitation of muscle contraction:* When a patient is unable to produce a muscle contraction or finds difficulty in doing so, electrical stimulation is used in assisting voluntary contraction.
- *Re-education of muscle action:* In prolonged disuse, or of incorrect use, there may be disability to contract a muscle voluntarily. In such cases faradic stimulation may be used to produce contractions and so help to restore the sense of movement.
- *Training a new muscle action:* After tendon transplantation or other reconstruction surgeries, a muscle may be required to perform a new action. Faradic currents are given to stimulate and train the muscle for a new action.
- *In treating neuropraxia of a motor nerve:* In this case the impulses from brain are unable to reach the muscles across the site of lesion through the affected nerve. As a result, the voluntary power to contract a muscle is reduced or loosed. Faradic current is useful to bring back normal condition.

  Note: After somedays, if the contraction becomes weaker when stimulated by faradic current, then modified direct current is used.
- *To improve venous and lymphatic drainage:* *"Faradism under pressure"* increases the venous and lymphatic drainage by means of effective pumping action of alternate muscle contraction and relaxation. It is best used in treatment of oedema and gravitational ulcers.
- *Prevention and loosening of adhesions:* When there is effusion into the tissues, adhesions are liable to form, but these can be prevented

by keeping structures moving with each other. If active movement is not possible, faradic stimulation will be of great benefit in such conditions, e.g. scar tissue binding muscles and tendons.

CONTRAINDICATIONS

A. Cannot be used over—cardiac pacemakers, electrical implants, metal implants, carotid sinus, epiglottis, abdomen
B. Acute injury—diagnostics of the problem must be performed before treatment
C. Active bleeding—haemorrhaging may increase with stimulation
D. High fever—a secondary problem may exist that needs treatment
E. Infection—potential for spreading a localized infection because of increased blood flow
F. Blood clots—therapy may dislodge clots due to increased circulation
G. Dislocation and subluxations—can cause disruption and increased inflammatory fluids around the joint
H. Pregnancy—therapy applied close to uterus may initiate contractions
I. Cancer—therapy may break loose bits of cancer cells and increase spread throughout the body
J. Mentally unstable patients

SHORT ESSAY QUESTIONS

1. **Define faradic type currents. Describe briefly with the help of neat labeled diagrams about modified faradic currents.**
2. **List out indications and contraindications of faradic type currents.**
3. **Enumerate the physiological effects of faradic currents.**

LONG ESSAY QUESTIONS

1. **Describe the procedure for stimulation of muscles by faradic type currents.**
2. **Explain briefly how faradism under pressure is performed on a oedematous limb due to lack of muscle activity.**
3. **Describe the technique of giving faradic foot bath.**

MULTIPLE CHOICE QUESTIONS

1. **Which of the following is a short duration current?**
   A. Faradic **B.** Galvanic
   C. Russian **D.** IFT
2. **Which of the following is known as long duration current?**
   A. Faradic **B.** Galvanic
   C. Russian **D.** IFT
3. **What is frequency of the faradic currents?**
   A. 50–100 Hz **B.** 500–1000 Hz
   C. 4000 Hz **D.** 20,000 Hz

4. Which of the following is a good conductor of the electricity?

A. Epidermis **B.** Fat
C. Muscle **D.** None

5. What is the type of sensation felt while applying faradic current to the body?

A. Mild prickling
B. Pins and needles
C. Heat
D. Cold

6. Which of the following is a therapeutic effect of faradic currents?

A. Stimulation of motor nerves
B. Increases blood pressure
C. Decreases metabolism
D. Increases tidal volume

7. What is the purpose of faradic reeducation?

A. To train a muscle new action
B. To stimulate a denervated muscle
C. To stimulate innervated muscle
D. All of the above

8. Which of the following technique is used for improving the lymphatic and venous drainage?

A. Faradic foot bath
B. Faradism under pressure
C. Faradic reeducation
D. None

9. What is the point where the motor nerve enters a muscle fiber is known as?

A. Dermatome **B.** Myotome
C. Motor point **D.** All of the above

10. Which of the muscles are stimulated when there is neuropraxia of axillary nerve?

A. Trapezius
B. Sternocleidomastoid
C. Deltoid
D. Quadriceps

11. The accumulation of fluid in the tissue spaces is called

A. Oedema
B. Inflammation
C. Necrosis
D. All of the above

12. The main reasons for the accumulation of fluid in the tissue spaces are

A. Lack of muscle activity
B. Inflammation
C. Necrosis
D. Both A and B

13. Which current is used for reduction of oedema due to lack of muscle activity?

A. Surged faradic
B. Plain faradic
C. Galvanic
D. TENS

14. Which current is used for reduction of oedema due to inflammation?

A. Surged faradic
B. Plain faradic
C. Galvanic
D. TENS

15. The duration of treatment for faradism under pressure is

A. 30 min/day **B.** 50 min TDS
C. 40 min BDS **D.** All of the above

16. The affected limb should be elevated to _______ degrees for reduction of oedema

A. 90 **B.** 60
C. 50 **D.** 30

17. What is the type of pulse used for reduction of oedema in faradism under pressure?

A. Triangular **B.** Rectangular
C. Trapezoidal **D.** None

18. The ON-OFF time for faradism under pressure for reduction of oedema because of lack of muscle activity

A. 1 : 1 B. 4 : 1
C. 5 : 1 D. 1 : 5

19. The bandaging is done from metatarsel head until _______ for oedema reduction due to muscle activity in lower limb

A. Calf
B. Patella
C. Femoral traingle
D. Hip joint

20. The main aim of faradism under pressure is

A. Reduction of oedema
B. Improve venous drainage
C. Improve lymph drainage
D. All of the above

21. The procedure to bring about arches of foot is

A. Faradic foot bath
B. Faradism under pressure
C. Stimulation
D. TENS

22. The current used for faradic foot bath is

A. Surged faradic
B. Plain faradic
C. Galvanic
D. All of the above

23. The indifferent electrode at heel and active at base of metatarsal heads is placed for stimulation of

A. Lumbricals
B. Interossei
C. Abductor hallusis longus
D. All of the above

24. One electorde at medial side of the foot and one electrode at lateral aspect of foot is placed for stimulation of

A. Lumbricals
B. Interossei
C. Thenar
D. Hypothenar

25. The frequency used for faradic foot bath is

A. 50–100 Hz
B. 200–250 Hz
C. 20–20,000 Hz
D. None

26. The on-off time for faradic foot bath is

A. 1 : 4 B. 2 : 3
C. 3 : 5 D. 4 : 5

27. The duration of treatment for faradic foot bath is

A. 20–30 min B. 40–50 min
C. 50–60 min D. 2–3 hr

28. The duration of pulse used for faradic foot bath is

A. 0.1–1 ms B. 1–2 ms
C. 4–5 ms D. 10–20 ms

29. What is the type of pulse used for faradic foot bath?

A. Triangular
B. Trapezoidal
C. Rectangular
D. Sawtooth

Answers MCQs	1. A	2. B	3. A	4. C	5. A	6. A	7. A	8. B	9. C	10. C
11. A	12. D	13. A	14. B	15. A	16. B	17. A	18. A	19. C	20. D	21. A
22. A	23. A	24. B	25. A	26. A	27. A	28. A	29. A			

MODEL OSPE QUESTIONS

1. A 30-year-old female patient came with left wrist drop after an injection palsy. She is non-diabetic, but hypertensive. On performing FG test, the results showed Faradic +ve. Perform the faradic stimulation for wrist extensors.
2. A male patient with age 35 who is athlete has come with chief complaint that he cannot run fast. On examination, you have found that his lumbricals are weak. Give faradic foot bath to stimulate the lumbricals.
3. A post-appendicectomy female patient of age 40 was referred to physiotherapist in the post-surgical ward for gravitational oedema. Perform faradism under pressure for her right lower limb.
4. A 20-year-old male patient referred to physiotherapy for reduction of oedema on left foot due to acute inflammation. Perform faradism under pressure.

STATE TRUE or FALSE

1. "Faradism under pressure" increases the venous and lymphatic drainage.
2. Faradic currents can be used over cardiac pacemaker.
3. TENS is used for reduction of oedema due to inflammation.
4. The accumulation of fluid in the tissue spaces is known as necrosis.

FILL IN THE BLANKS

1. Faradic type currents have frequency of __________.
2. The current always travels through tissues of __________ resistance.
3. On application of faradic current a ___________ sensation is experienced.
4. Faradic currents are used to stimulate _____________ muscles.

CHAPTER 5

Galvanic Currents and HVGS

Learning Objectives: At the end of this chapter, students will be able to learn

1. Definition, indications and contraindications of galvanic currents
2. Physiological and therapeutic effects of galvanic currents
3. Methods of iontophoresis
4. Techniques of application of galvanic currents

DEFINITION

These are long duration interrupted or modified direct currents with duration of more than 10 milliseconds.

PHYSIOLOGICAL EFFECTS

- With adequate intensity and duration of impulse, a contraction of denervated muscle can be initiated

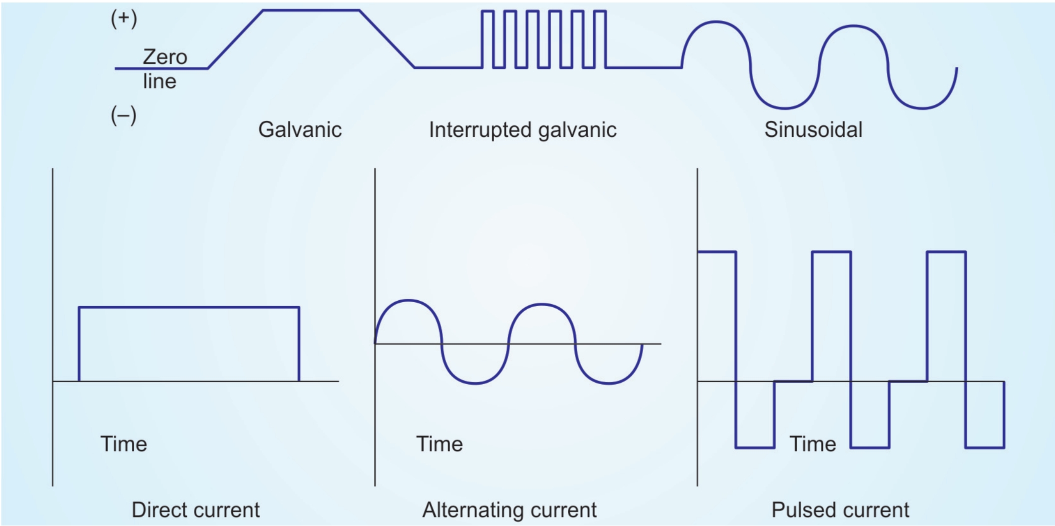
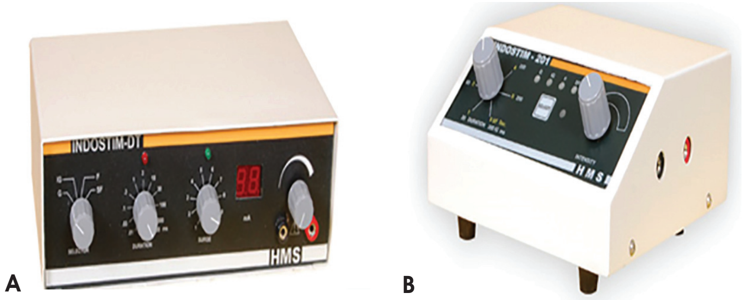


Fig. 5.1: Types of current forms



Figs 5.2A and B: Electrical nerve muscle stimulator

- When interrupted direct current is applied to the body, there is stimulation of sensory nerves
- With application of direct current, there is reflex dilatation of superficial blood vessels and results in erythema of skin
- Stimulation of motor nerves with interrupted direct current produces contraction of the muscles supplied.

TYPES OF INTERMITTENT GALVANIC CURRENTS

1. Rectangular: In these types of currents there is a sudden rise, short stay at peak intensity and sudden fall in the impulse.
2. Triangular: In this type, there is a sudden rise in and a sudden fall of the impulse.
3. Trapezoidal: In this type of current, there is a gradual rise and fall of impulse with a short stay at the peak.

   These currents are also called *selective currents.*
4. Sawtooth: In this type of currents there is a very gradual rise and sudden fall of the impulses.
5. Depolarised: In this type, the polarity is reversed between the intervals.

INDICATIONS

- To stimulate denervated muscles
- To maintain muscle properties of denervated muscles
- To send medicated ions through biological membranes like skin by iontophoresis
- Can be used in electrodiagnosis by plotting SD curves and FG tests

CONTRAINDICATIONS

- Phobia for electrical currents
- Hyposensitivity/hypersensitivity
- Open, unhealed wounds
- Recent unhealed fractures
- Boils and abscess

IONTOPHORESIS

DEFINITION

The process of introduction of medicated ions across biological membranes by means of direct current for therapeutic purposes is called iontophoresis.

Principles of Iontophoresis

- "Like charges repel each other". Based on this principle, ions are placed under an electrode with the same charge, e.g. a negative ion is placed under a cathode.
- The electrode where the ion is placed is an active electrode. The passive electrode is placed to connect the circuit.

Formula for Administration of Iontophoresis

- Number of ions entering the tissues from and given area of active electrode is

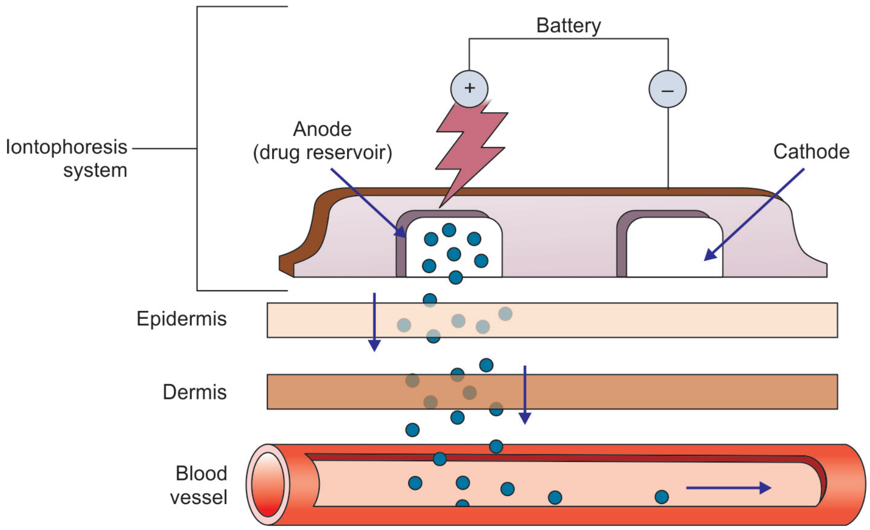
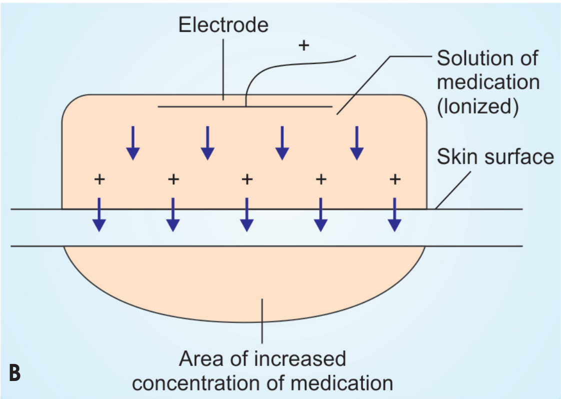
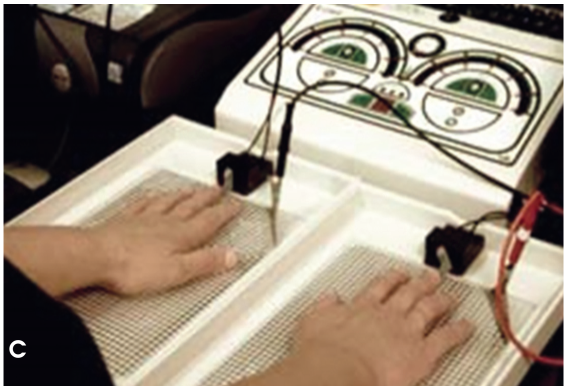


Fig. 5.3A: Principle of iontophoresis





Figs 5.3B and C: Procedure of iontophoresis

proportional to both current density and time of application

- I × T × ECE = Grams of substance introduced
- I = Intensity in milliamp
- T = Time in min
- ECE = Refers to standard figure for ionic transfer with known currents and time factor

Common Drugs Used in Iontophoresis

Ion	Indications	Polarity	Concentration (%)
Acetate Source: Acetic acid	Calcium deposits like calcified tendinitis	Negative	2.5–5
Chloride Source: NaCl	To soften the scars and adhesions	Negative	2
Iodine Source: Iodine	To soften scars and adhesions	Negative	5

Contd...

Ion	Indications	Polarity	Concentration (%)
Dexamethasone *Source:* Dexamethasone phosphate	Musculoskeletal inflammations	Negative	0.4
Copper *Source:* Copper sulphate	Fungal infections	Positive	2
Salicylate *Source:* Sodium salicylate	Myalgia, inflammations	Negative	2
Magnesium *Source:* Derived from Epsom salts, magnesium sulphate	Muscle relaxant, antispasmodic, vasodilator	Positive	2
Lidocaine *Source:* Lidocaine	Positive	Local anaesthetic	5
Tap water	Negative/positive	Hyperhydrosis	—
Zinc *Source:* Zinc oxide	Positive	Dermal ulcers, wounds	—

Points to Remember

- The therapist must have thorough knowledge on present pathology
- Must identify the correct ion for treating pathology
- Must identify the polarity of the ion choice
- Must select an electric generator that gives continuous direct current
- Must determine whether the patient is allergic to the treatment ions
- Must inspect the body part to be treated to determine the cuts, aberrations scar tissue, new skin, inflammation.
- Must check the patients skin sensation in the area to be treated.

High Voltage Galvanic Current (HVGC)

High-voltage galvanic stimulation (HVGS) produces a high-voltage current with a high-peak intensity of a maximum of 300 to 400 ma but with a low-frequency current and a very short duration, ranging between 50 and 100 msec.

Characteristics

- The high-peak intensity produced is of a twin-pulsed shape.
- It is safer and more comfortable (less painful) to the patient than faradic current because of its short duration.
- It penetrates deeper than that of low-voltage currents.
- Direct stimulation of deep nerves and muscles can be effective.
- It can stimulate either an isolated muscle or muscle group according to the appropriate technique.
- High-voltage galvanic current does not produce contraction in the denervated muscle as the pulse duration is too short to depolarize the muscle membrane.
- Partially innervated or totally innervated muscle will respond well to high-voltage galvanic current.

Physiological Effects of HVGC

- *Pain reduction:* It is accomplished either through decreasing pain by using two small electrodes closely-spaced in a narrow area or minimizing pain fibre stimulation by using two widely-spaced large electrodes. Both of these methods can stimulate the release of opiate substance; β-endorphins in the central nervous system in order to suppress pain.
- *Increase of joint mobility:* This occurs due to reduction of pain through the direct effect of the current on blood vessels, which leads to improvement of circulation. So, HVGC is effective after fractures, menisectomy, osteoarthritis and frozen shoulder. Reduction of post-traumatic oedema is evident immediately after treatment.
- *Improvement of peripheral circulation:* This is due to the stimulation of muscle pumping effect on the venous circulation and stimulation of sympathetic neurons, which subsequently cause vasodilatation.
- *Healing of ulcers:* It is accomplished through electrical stimulation with the positive electrode, which increases the repair process. Furthermore, electrical stimulation with the negative pole destroys bacteria.
- *Relief of muscle spasm:* It is accomplished due to reduction of pain through strong muscle contraction, which produces relaxation.

INDICATIONS

As a low-frequency current, with the exception of treating the denervated muscles, it may be used for:

- Facilitation of muscle contraction inhibited by pain.
- Re-education of weak muscles.
- Reduction of post-traumatic oedema.
- Mobilization of joint stiffness.
- Reduction of pain and muscle spasm (arthritis, sprain and strain).
- Improvement of peripheral circulation.
- Healing of ulcers.

Contraindications

They are similar to those of the other low frequency currents, including:

- Skin lesions.
- Acute infections and inflammations.
- Thrombosis.
- Loss of sensation.
- Cardiac pacemakers.
- Superficial metal.

Dose

It is adjusted according to the patient's tolerances. In cases of oedema, muscle spasm and stiff joint, the dose must be high enough to produce muscle contraction:

- *Pulse rate:* 80 pulses/sec.
- *Treatment duration:* 20–30 minutes.

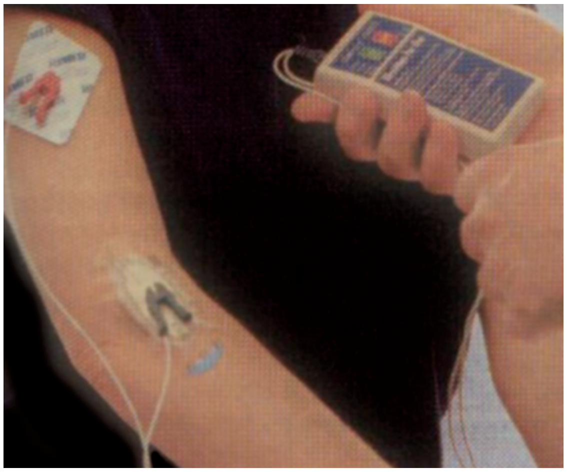


Fig. 5.4: Application of HVGS

SHORT ESSAY QUESTIONS

1. Define galvanic currents. Describe the physiological effects of galvanic currents.
2. Enumerate the indications and contraindications of galvanic currents.
3. Define iontophoresis. Explain the principle behind the iontophoresis.

LONG ESSAY QUESTIONS

1. Describe the technique of stimulation of facial muscles for a Bell's palsy patient with IG currents.
2. Describe the procedure for administration of dexamethasone iontophoresis for tennis elbow.

MULTIPLE CHOICE QUESTIONS

1. **The long duration interrupted or modified direct currents with duration more than 10 millisec are known as**
   A. Faradic **B.** Galvanic
   C. Russian **D.** Interferential
2. **Which current with adequate intensity and duration can produce contraction of denervative muscle**
   A. Galvanic **B.** Faradic
   C. Russian **D.** All of the above
3. **The erythema seen on the skin with application of direct current is due to**
   A. Reflex vasodilatation
   B. Reflex vasoconstriction
   C. Inflammation
   D. Adverse effect
4. **The lower motor neuron palsy of facial nerve is known as**
   A. Bell's palsy
   B. Erb's palsy
   C. Klumpke's palsy
   D. All of the above
5. **Which of the following current is used for SD curve in electrodiagnosis?**
   A. Faradic
   B. Galvanic
   C. Interferential
   D. All of the above
6. **Which of the following is a contra-indication of galvonic currents?**
   A. Phobia **B.** Open wounds
   C. Boils **D.** All of the above
7. **What is the chief purpose of stimulation of denervated muscles by galvanic currents?**
   A. Maintain muscle properties
   B. To maintain nerve properties
   C. To improve circulation
   D. To enhance regeneration
8. **The complete transection of nerve is known as**
   A. Neurotemesis
   B. Neuropraxia
   C. Axonotemesis
   D. None
9. **Which degeneration is seen in the transection of axon in PNS?**
   A. Wallerian **B.** Axonal
   C. Both **D.** None

10. The process of introduction of medicated ions by direct current is

A. Phonophoresis
B. Iontophoresis
C. PWB
D. SWD

11. The number of ions entering the tissues from given area of active electrode is proportional to

A. Current density
B. Type of current
C. Type of ion
D. All of the above

12. Which of the following formula is TRUE about grams of substance (G) introduced by iontophoresis

A. G = I × T × ECE
B. G = I/T
C. G = I/ECE × T
D. G = I × ECE

13. Which ion is used for treating calcified deposits in tendons?

A. Acetate **B.** Chloride
C. Iodine **D.** All of the above

14. Which ion is used for reduction of inflammation?

A. Diclofenac
B. Acetate
C. Chloride
D. Sodium

15. Which current is used in the iontophoresis?

A. Interrupted galvanic
B. Surged faradic
C. Plain galvanic
D. TENS

16. What is the principle behind iontophoresis?

A. Like repels like
B. Unlike charges attracts
C. Like charges attract
D. None

17. When cathode is used as active electrode in iontophoresis, the current density should not exceed

A. 1.0 mA/cm^2
B. 0.5 mA/cm^2
C. 5 mA/cm^2
D. 10 mA/cm^2

18. When anode is used as active electrode in iontophoresis, the drug might be _______ ion.

A. Cation **B.** Anion
C. Both **D.** None

19. Which of the following ion is used in iontophoresis for reduction of myalgia?

A. Tapwater
B. Salicylate
C. Copper
D. Zinc

Answers MCQs 1. B 2. A 3. A 4. A 5. B 6. D 7. A 8. A 9. A 10. B 11. D 12. A 13. A 14. A 15. C 16. A 17. B 18. A 19. B

MODEL OSPE QUESTIONS

1. A 24-year-old male patient nondiabetic and nonhypertensive, nonsmoker and nonalcoholic has been referred to physiotherapy department for treatment and advice for left side Bell's palsy. Perform the galvanic muscle stimulation.
2. A tennis player was referred to the physiotherapy department with diagnosis left tennis elbow. He is nonhypertensive and nondiabetic. Perform Iontophoresis for him.

STATE TRUE or FALSE

1. Faradic currents are used for iontophoresis.
2. Dexamethasone is used for gouty deposits.
3. Galvanic currents are used to stimulate denervated muscles.
4. Neuropraxia term denotes complete transection of nerve.

FILL IN THE BLANKS

1. The place in a muscle where electrical stimulation will produce the greatest contraction with the least amount of electricity is known as ____________.
2. The time taken by the current amplitude to increase from zero is termed ____________.
3. The number of cycles or impulses per second is termed ______________.
4. The principle that states the greater the load placed on a muscle and the higher force contraction it produces, the more strength that muscle will gain is known as ______________ principle.

CHAPTER

6

Nerve Injuries and Electrodiagnosis

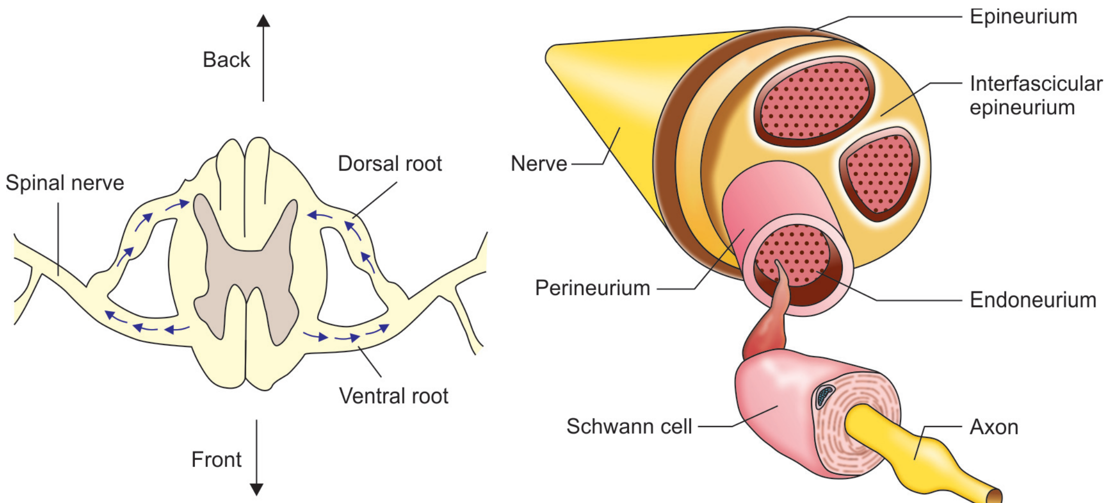
Learning Objectives: At the end of this chapter, students will be able to learn

1. Anatomy of a peripheral nerve
2. Type of nerve injuries
3. Pathological basis of nerve degeneration
4. Strength duration curves—interpretation and procedure
5. Principles of electromyography
6. Principles of nerve conduction velocity
7. Principles and interpretation of FG test

INTRODUCTION

Anatomy of Peripheral Nerve

- A spinal nerve is formed by the union of ventral root and dorsal nerve root.
- After emerging from the intervertebral foramen, it is divided into a dorsal ramus and a ventral ramus.
- Because of their position ventral ramus is usually affected by injuries.



Structure of peripheral nerve

- Each peripheral nerve enveloped by myelin sheath called myelinated nerves
- Peripheral nerves consist of nerve bundles or fasciculi, each bundle consists of several nerve fibers.
- Each large nerve is surrounded by epineurium.
- Each nerve bundle is covered by perineurium
- Each nerve fibre is covered by endoneurium.
- The myelin sheath is deficient at certain positions, such points are called nodes of Ranvier.

Types of Nerve Injuries

- The peripheral nerve injuries are classified depending upon the severity of injuries.
  - Neuropraxia
  - Axonotomesis
  - Neurotmesis

Neuropraxia

- It is compression of nerve
- There is no Wallerian degeneration
- Partial paralysis is seen
- Complete recovery is possible

> Person who performs the EMG technique is called **Electromayographer.**

Axonotmesis

- Wallerian degenaration is present
- Partial paralysis to complete paralysis is seen.
- Recovery is better than neurotmesis, but incomplete.

Neurotmesis

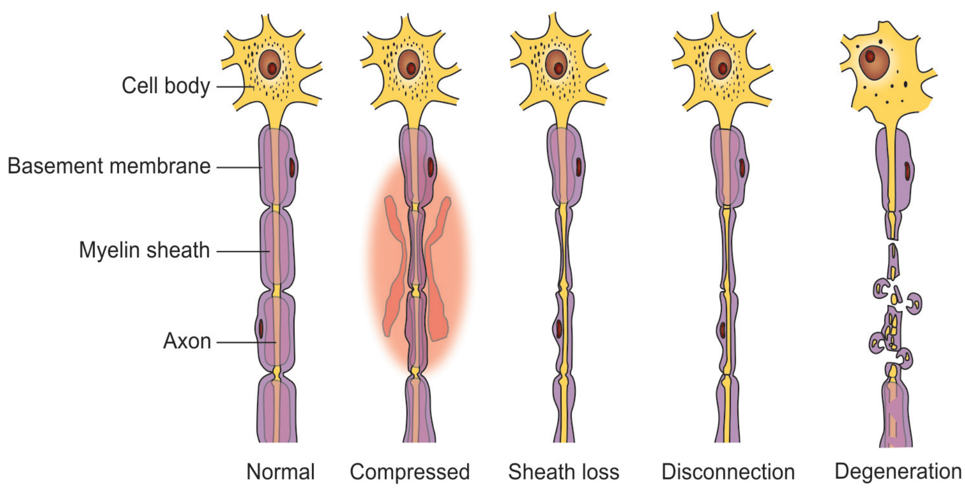
- It is the total discontinuity in the nerve trunk.
- Complete paralysis of involved muscles is seen
- Recovery is poor.

Types of Degeneration

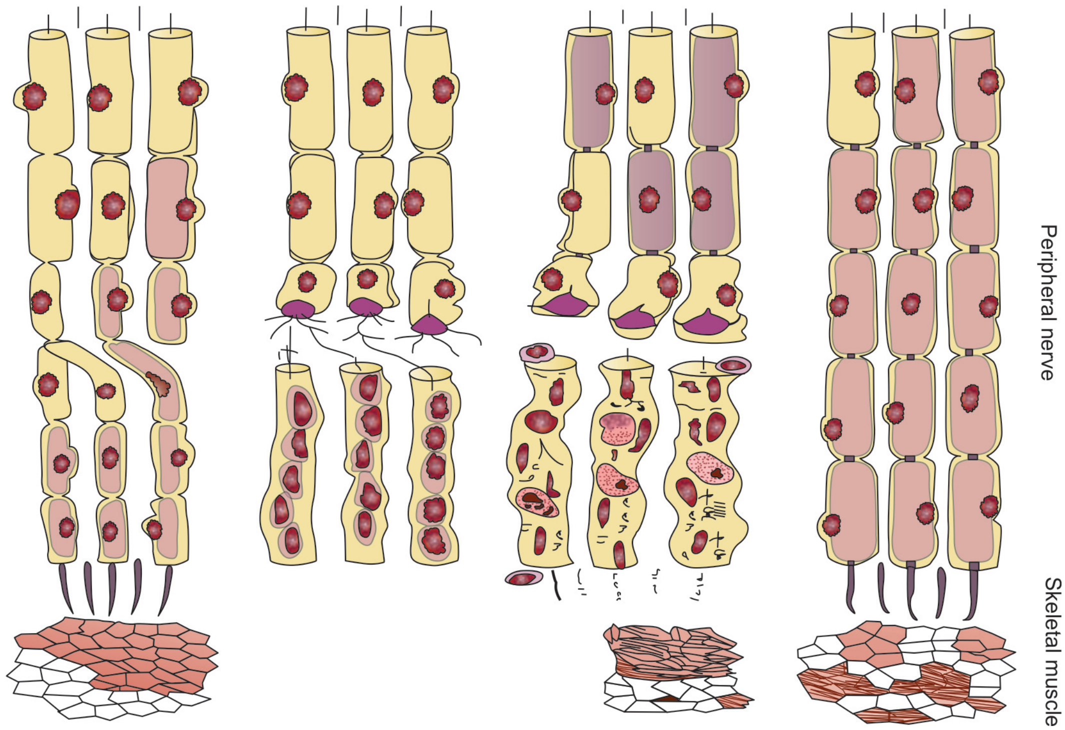
The types of degeneration seen in neural tissue are:
- Wallerian degeneration
- Axonal degeneration

Wallerian Degeneration

- This type of degeneration is seen in peripheral nervous system.
- It occurs after transection of the axon.
- The reasons for this is knife wounds, compression, traction and ischaemia.
- Following transection, initially there is accumulation of organelles in proximal and distal ends of transection sites.



Wallerian degeneration



Wallerian degeneration

- Later, the axon and myelin sheath distal to transection site undergo disintegration up to next node of Ranvier, followed by phagocytosis.
- The regeneration occurs by sprouting of axons and proliferation of Schwann cells from proximal end.

Axonal Degeneration

- In axonal degeneration, degeneration of axon begins towards the nerve cell.
- The cell body often undergoes chromatolysis.
- All other changes are similar to Wallerian degeneration, but the regeneration reaction is limited or absent.

ELECTRODIAGNOSIS

INTRODUCTION

It is the process whereby electrical impulses are used to identify the problem/condition, existing in a muscle, nerve or both. Thereby helps in analysis by methods of recording, display and measurement.

Electrical impulses are used for the diagnostic purpose.

Types of Electrodiagnostic test in interest of physiotherapist are:

1. Strength duration curve (SDC)
2. Nerve conduction velocity test (NCVT)
3. Electromyography (EMG)
4. FG test

SD CURVES—ELECTRODIAGNOSIS

INTRODUCTION

The amount of electrical current required to produce an action potential (AP) in a specific type of nerve varies and can be represented by the nerve's strength–duration curve.

DEFINITION

It is the graphic representation of the minimum combination of current strength (amplitude) and pulse duration needed to depolarize a nerve.

HYPOTHESIS

In general, lower current amplitudes and shorter pulse durations can depolarize sensory nerves.

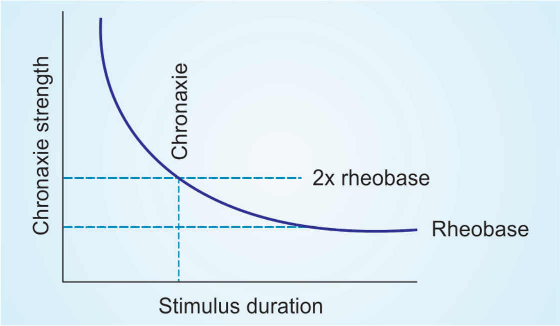
Higher amplitudes and longer pulse durations are needed for depolarizing motor nerves.

Even higher amplitudes or longer pulses are required for depolarizing pain transmitting c fibres.

Characteristics of SD Curves

Normal innervations: When all the nerve fibres supplying a muscle are intact, the SD curve has a shape characteristic of normally innervated muscle.

The curve is of typical shape because the same strength of stimulus is required to produce a response with all the impulses of longer duration, while those of shorter duration require an increase in the strength of the stimulus each time, the duration is reduced.



Chronaxie and rheobase

Complete Denervation

- When all fibres supplying a muscle have degenerated, the strength duration curve produced is characteristic of complete denervation.
- For all impulses with a duration of 300 ms or less, the intensity of stimulus is increased each time, the duration is reduced and no response is obtained to impulses of very short duration.
- So the curve rises steeply and is further to right than that of normally innervated muscle.

Partial Denervation

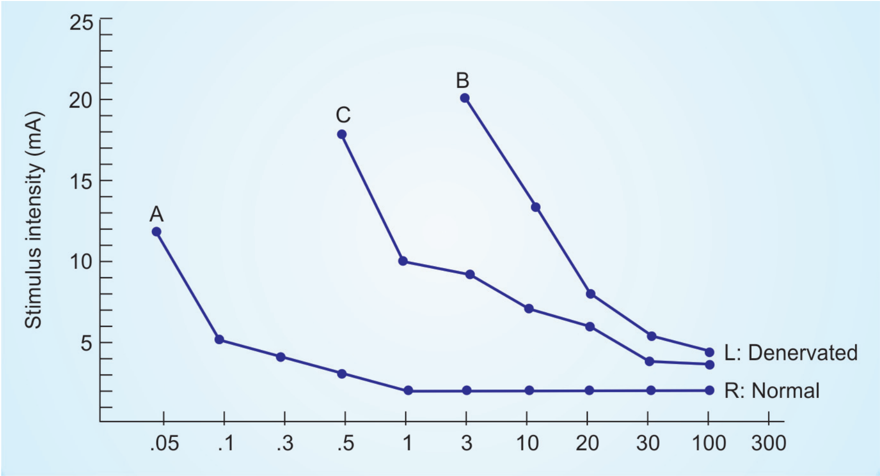
- When some of the nerve fibres supplying a muscle have degenerated, while others are intact, the characteristic curve obtained clearly indicates partial denervation.
- The impulses of longer duration stimulate both innervated and denervated muscle fibres, so a contraction is obtained with a stimulus of low intensity.
- As the impulses are shortened, the denervated fibres do not respond, so a stronger stimulus is required.
- Thus, the right-handed part of the curve resembles that of denervated muscle, the left-hand part that of innervated muscle.
- A kink is seen at the point where the two sections meet.
- The shape of the curve indicates the proportion of denervation.

Chronaxie and Rheobase

Rheobase: The rheobase is the smallest current that will produce a muscle contraction.

Chronaxie: It is the duration of the shortest impulse that will produce a response with a current of double the rheobase.

Normal innervation	Complete denervation	Partial denervation
Initial straight line Kink absent Smooth appearance of graph	Incomplete graphline Kink absent Graph line steep in appearance	Initial and final curve is smooth Kink present



SD curves

ELECTROMYOGRAPHY

Definition

It is the study of electrical activity of muscle by the way of needle or surface electrodes which are either inserted in or placed over the skin.

This technique consists of observation, analysis and interpretation of electrical activity of muscles or nerves, so also known as **electroneuromyography** (ENMG) and the instrument used for the technique is called **electromyograph** and the produced record is called **electromyogram.**

Uses

Conditions like

- Spinal muscular atrophy

> Needle electrodes provide error-free recording than the surface electrodes

- Syringomyelia
- Poliomyelitis
- Postpolio syndrome
- Inflammatory muscle disease like
  - Polymyositis
  - Viral myositis

Myopathies like

- Metabolic myopathies
- Congenital myopathies
- Myotonic dystrophy

Dystrophies like

- Duchenne muscular dystrophy
- Becker muscular dystrophy
- Limb girdle muscular dystrophy
- Myotonic dystrophy
- Facioscapulohumeral muscular dystrophy

Lesions of anterior horn cells

Lesions of nerves and muscles

Apparatus

1. Electrodes:
   - *Needle*
     a. Concentric
     b. Monopolar
     c. Single fibre
     d. Macro needle

- *Surface* electrodes are in the form of disk, cup, ring

2. EMG unit
3. Filters
4. Amplifier
5. Display unit
6. Averager
7. Cotton swab
8. Spirit

Guideline

Apparatus preparation

- Check for any cut, break in the power cable.
- Prepare procedure trolly with cotton swabs.

Patient preparation

- Clean the skin with cotton swab soaked in spirit.
- Select the electrode and place it over the desired area.
- Knowledge of muscle anatomy is a must to perform this procedure.

Techniques

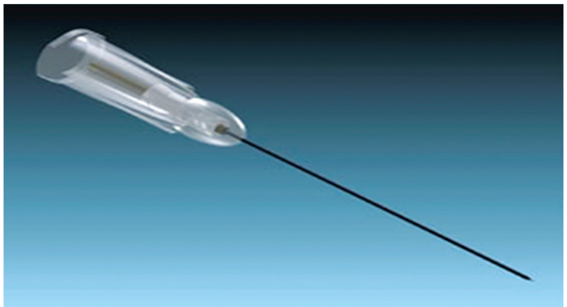
Two types of techniques are:

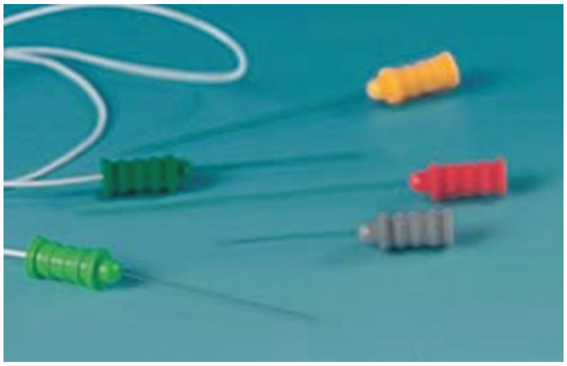
a. Surface EMG
  - Records muscle activity from the surface of the muscle underlying the skin.
  - Provide only a limited assessment of the muscle activity.
  - Limitations: Recordings are restricted to superficial muscles
  - Fatty patients have weaker EMG signals.

b. Intramuscular EMG
  - Simple approach performed by a monopolar needle electrode.
  - Fine wire inserted into a muscle with a surface electrode as a reference or two fine wires inserted into muscle referenced to each other.

Use for research or kinesiology studies

- To see maximum muscle contraction
- To indicate amount of muscle fatigue
- Diagnostic monopolar EMG electrodes are stiff so that these can penetrate the skin and insulated, with its tip exposed using a surface electrode for reference.
- Concentric needle electrode:
  - complex in design
  - made of fine wire, insulated, shaft is exposed, and serve as the reference electrode.
- Exposed tip of the fine wire serves as the active electrode.





Needle electrodes

Advantages

- Small signals
- Reduced electrical artifacts from tissue
- Reliable measures
- Monopolar needle

Procedure

1. Patient skin preparation is done.
2. Monopolar or concentric needle electrode is inserted through the skin into the muscular tissue.

Needle electrodes in EMG

3. Needle is then moved to multiple spots in a relaxed muscle and to insertional and resting activity of the muscle are evaluated.
4. Normal muscles exhibit a brief burst of muscle fibre activity which lasts for 100 ms.
5. Resting and insertional activities are evaluated by the electromyographer.
6. Activity is analyzed by retracting the electrode a few millimetres and is repeated.
7. Due to difference in the internal structure of skeletal muscle, the electrode is placed at several points so that an accurate study can be performed.

Contraindications

- Pacemakers
- Lymphoedema
- Cellulitis

Limitations

It is less informative for patients who are:

- Not willing or not co-operative
- Children and infants
- Paralytic
- Obesity

NERVE CONDUCTION VELOCITY

- It is a rate of acceleration through which impulses travel down the neuronal pathway.
- It depends upon the fibre diameter and intermodal distance.
- The larger the axon, thicker the myelin sheath, longer the intermodal distance and faster the nerve conduction velocity.

Conduction velocity: It is a measurement made by the stimulating and recording electrodes from the two different sites along the course of nerve.

$$\text{Conduction velocity} = \frac{\text{Distance between two sites}}{\text{Distance in conduction times between two sites}}$$

Factors affecting nerve conduction velocity:

- Age
- Sex
- Height
- Pathological delays occur with various medical conditions (carpal tunnel syndrome, nerve injuries, demyelinating neuropathies, etc.)
- Temperature
- The upper limb nerve conduction velocity is higher compared to lower limb nerve conduction velocity.

Principles of motor nerve conduction:

- It is performed by electrical stimulation of a peripheral nerve and recording from the muscle supplied by this nerve.
- For prevention of hyperpolarisation effect of anodal conduction block, supramaximal stimulation is done keeping cathode close to active recording electrode.
- The surface recording electrodes are placed in belly tendon keeping active electrode closer to motor point and reference to the tendon.

- The ground electrodes are kept between stimulating and recording electrodes.
- The healthy nerve requires surface stimulation of: Square wave pulse –0.1 ms and intensity –5–40 mA.

Formula of motor nerve conduction $= \frac{D}{PL-DL}$ m/sec.

Where, PL = proximal latency
DL = Distal latency
D = Distance between proximal and distal stimulation in mm

- The measurement of motor nerve conduction includes:
  a. Onset latency: The time it takes for the electrical impulse to travel from stimulation to the recording site is measured and this value is called the latency and is measured in milliseconds.
  b. Duration: The time of response
  c. Amplitude of compound muscle action potential. The size of the response.
  d. Nerve conduction velocity

Principles of sensory nerve conduction

- It is performed by electrical stimulation of a peripheral nerve and recording from the sensory portion of the nerve.
- The sensory receptors are innervated by different types of nerve fibres.

Proprioceptors: Type IA, IB and type II sensory fibres

Mechanoreceptors: Type II and type III sensory fibres.

Nociceptors: Type III and type IV sensory fibres.

It can be measured by 2 types
a. Orthodromically
b. Antidromically

- In orthodromic conduction distal nerve is stimulated and nerve action potential is recorded at the proximal nerve.
- In antidromically conduction proximal nerve is stimulated and nerve action potential is recorded distally.
- The measurement of sensory nerve conduction includes:
  a. Onset latency
  b. Duration
  c. Amplitude of sensory nerve action potential.
  d. Nerve conduction velocity.

Procedure of nerve conduction velocity

- It is used to determine the severity of nerve damage.
- Place the 2 electrodes on the nerve to be tested on the patient's skin surface.
- The one electrode is stimulated and the other will record the impulse travel through the nerve.
- The distance between stimulating and receiving electrodes is divided by the impulse latency and conduction velocities.

Electrode placement with distance and time in motor conduction velocity (motor nerve) and sensory conduction velocity (ulnar nerve).

Normal values for motor and sensory conduction of various nerves.

Motor	Sensory
Ulnar and median nerve = 50–60 m/s	Ulnar and median nerve = 60–70 m/s
Common peroneal nerve = 45–55 m/s	Common peroneal nerve = 50–70 m/s

FARADIC-GALVONIC TESTS (FG TEST)

Faradic-Galvonic test also known as regeneration test is a simple test to know whether the muscle is innervated or denervated.

Principle: The faradic current applied to a normal muscle or motor nerve elicits a continuous contraction during stimulation.

The galvanic current applied to a normal muscle or motor nerve does not elicit any contraction, but it causes a brisk single clonic contraction.

This test can be used to differentiate the innervated muscle from denervated muscle.

(For detailed application and technique refer FG test in practical session)

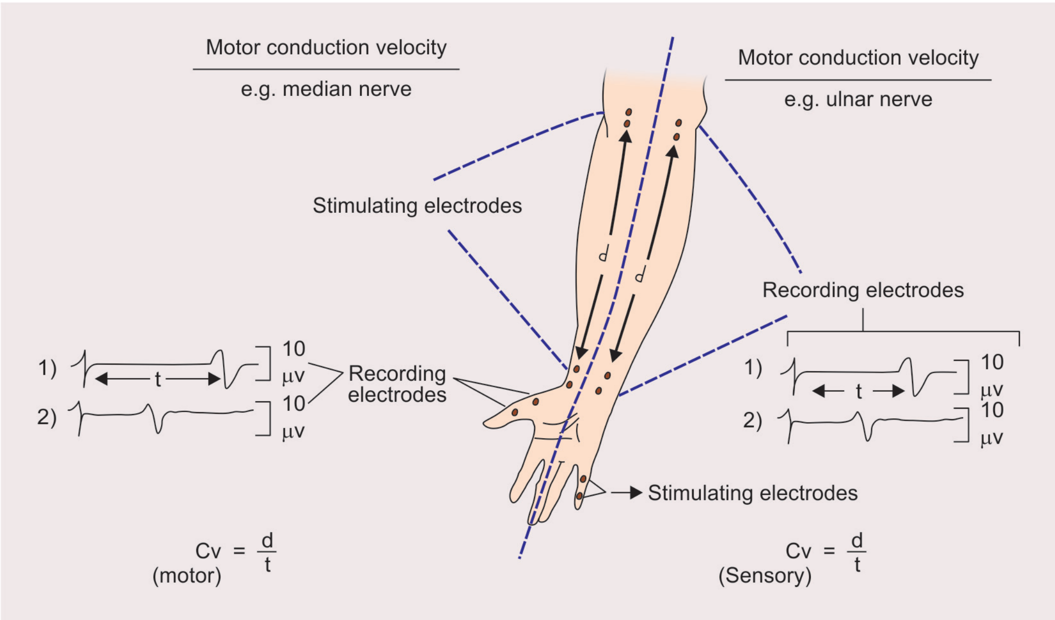


Fig. 6.1: Electrode placement with distance and time in motor conduction velocity (motor nerve) and sensory conduction velocity (ulnar nerve)

SHORT ESSAY QUESTIONS

1. **Describe briefly the anatomy of peripheral nerve with the help of a neat labeled diagram.**
2. **Enumerate the various types of nerve injuries.**
3. **Discuss briefly axonal and Wallerian degeneration of peripheral nerves.**

LONG ESSAY QUESTIONS

1. **Discuss the procedure to draw SD curves for radial nerve injuries.**
2. **Explain briefly the characteristics of innervated, denervated, partially innervated–denervated muscles.**

MULTIPLE CHOICE QUESTIONS

1. **The process of declining from a higher to a lower level of vitality is known as**
   A. Inflammation
   B. Degeneration
   C. Disuse
   D. Shock

2. **The type of degeneration seen in PNS after transection of axon is known as**
   A. Wallerian
   B. Axonal
   C. Disuse
   D. Atropic

3. In axonal degeneration, the cell body often undergoes

A. Heamolysis **B.** Cloning
C. Chromatolysis **D.** Disintegration

4. The regeneration reaction is limited or absent in ______degeneration

A. Wallerian **B.** Axonal
C. Both **D.** None

5. The compression of a nerve without Wallerian degeneration is known as

A. Neuropraxia
B. Neurotmesis
C. Axonotmesis
D. None

6. The bend seen in the SD curve which indicates partially innervated muscle is known as

A. Hair pin bend **B.** Kink
C. Curve **D.** None

7. Which current is used for the plotting of SD curves?

A. IG **B.** SF
C. Russian **D.** IFT

8. Which type of degeneration, the degeneration of axon begins towards the nerve cell?

A. Axonal **B.** Wallerian
C. Neuropraxia **D.** All of the above

MODEL OSPE QUESTIONS

1. A 50-year-old female patient came with a chief complaint that she cannot do the dorsiflexion of right foot. Perform SD curve for common peroneal nerve. She is nondiabetic and non-hypertensive.

Answers MCQs	1. B	2. A	3. C	4. B	5. A	6. B	7. A	8. B

CHAPTER

7

Pain Gate Theory

Learning Objectives: At the end of this chapter, students will be able to learn

1. Definition and types of pain
2. Physiology behind pain
3. Pain gate theory

WHAT IS PAIN?

- Pain is an unpleasant sensory experience. It can be elicited by the application of noxious stimulus.
- It is symptom for many diseases
- It is the warning signal of tissue damage
- It causes the individual to react to the pain to withdraw from noxious stimulus

UNDERSTANDING PAIN

- **Fast pain:** It is also called acute pain. First pain, sharp pain, etc.
  For example, when a needle is stuck or skin is cut with knife
- **Slow pain:** It is also called chronic pain, second pain, throbbing pain, burning pain
- It is associated with tissue destruction.

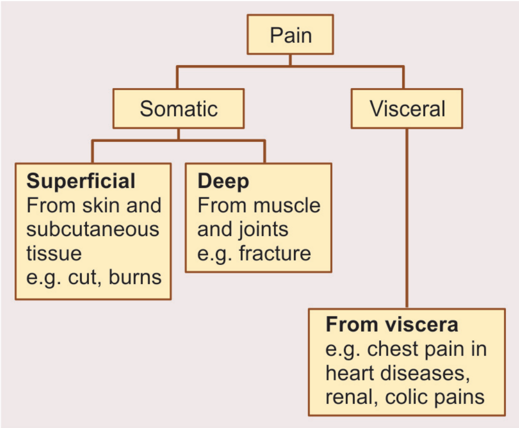
Types of pain sensations

Mild irritation through burning and prickling sensations.

More intense stabbing and throbbing sensations.

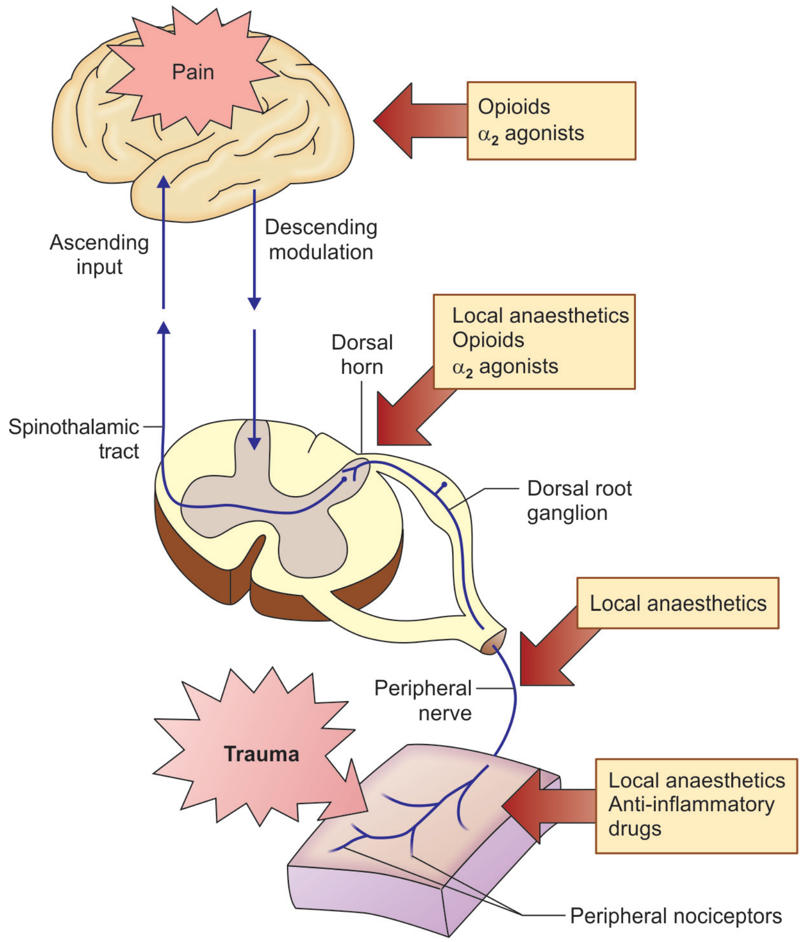
Agonising and intractable pain sensations

Classification of Pain



Characteristics of pain

- Threshold and intensity: Subthreshold stimulus does not produce pain, increasing strength of stimulus causes increased intensity of pain
- Adaptation: Pain receptors do not adopt. This is beneficial. This makes us to put effort for removal of injurious agent.



Pain pathway

- Localization: Superficial pain is better localized than deep pain. Visceral pains are usually referred.
- Emotion: Pain is associated with uncomfortable emotion.
- Extent of pain: Higher the tissue damage, the more severe is the pain.

Pain Pathway

- The pain is carried by two types of fibres
- Aδ fibres and C fibres
- Aδ fibres carry fast pain and C fibres carry slow pain
- These fibres from receptors carry to the dorsal or posterior horn of spinal cord and from there they are carried to the thalamus and then to the cerebrum.

Types of Nerve Fibres

Table 7.1 gives types of nerve fibres.

PAIN GATE THEORY

- This theory was first proposed by Melzack and Wall.
- When touch sensation receptors are also stimulated along with pain sensation, then pain sensation is less felt.
- The posterior horn of the spinal cord is viewed as a gate through which touch, pain,

Table 7.1: Types of nerve fibres

Fibre type		Functions	Fibre diameter μm	Conduction velocity m/sec
A	α	Proprioception	12–20	7–20
	β	Touch pressure	05–12	30–70
	γ	Motor fibres	03–06	15–30
	δ	Acute pain, cold, touch	02–05	12–30
B		Preganglionic autonomic	<3	03–15
C		Chronic pain, temperature	0.1–1.2	0.5–2.0
Sympathetic		Postganglionic	0.3–1.3	0.7–2.3

temperature and other sensory impulses are entering.

- When pain alone is entering, it can enter very well and the person feels pain.
- But when there is touch sensation also accompanying the pain sensation, the touch sensation may block the entry of pain sensation, resulting in reduction of pain.
- Thus, when a high diameter fibres carrying sensations are passed through the posterior horn, it will block the pain sensation.

SHORT ESSAY QUESTIONS

1. Define pain. Classify pain with examples.
2. Enumerate the various types of pain nerve fibres.
3. Discuss briefly the characteristics of pain.

LONG ESSAY QUESTION

1. Explain briefly how pain gate theory works.

MULTIPLE CHOICE QUESTIONS

1. An unpleasant sensory experience, which can be elicited by the application of noxious stimulus is called
   A. Pain **B.** Inflammation
   C. Spasm **D.** None
2. Acute pain is also called
   A. Fast pain
   B. Slow pain
   C. Visceral pain
   D. All of the above

3. **Pain gate theory is proposed by**
   A. Newton
   B. Melzack and Wall
   C. Edison
   D. Dena Gardener

4. **Which nerve fibre carries acute pain?**
   A. A delta
   B. A beta
   C. C fibres
   D. All of the above

5. **Which type of pains are usually referred?**
   A. Fast pain
   B. Slow pain
   C. Visceral pain
   D. All of the above

STATE TRUE or FALSE

1. **Pain gate theory was first proposed by Melzack and Wall.**
2. **The pain is carried by Aδ fibres and C fibres.**
3. **Pain can be elicited by the application of noxious stimulus.**
4. **When touch sensation receptors are also stimulated along with pain sensation, then pain sensation is less felt.**

FILL IN THE BLANKS

1. **Pain is an ____________ sensory experience.**
2. **Chronic pain and temperature sensation is carried by _________ nerve fibres.**
3. **Pain is the ____________ signal of tissue damage.**
4. **The ___________ horn of the spinal cord is viewed as a gate in pain gate theory.**

Answers MCQs	1. A	2. A	3. B	4. A	5. C

CHAPTER

8

TENS

Learning Objectives: At the end of this chapter, students will be able to learn

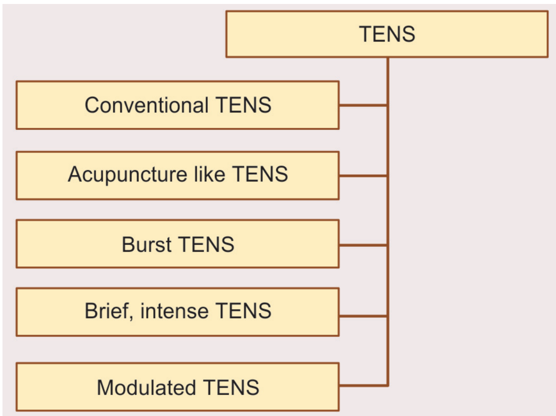
1. Definition of TENS
2. Therapeutic classification of TENS
3. Characteristics and parameters of various types of TENS
4. Indications and contraindications of TENS
5. Methods of application of TENS

INTRODUCTION

1. TENS is an acronym for "Transcutaneous Electrical Nerve Stimulation".
2. It was developed by Melzack and Wall.
3. It is a low intensity, short impulses current applied largely for pain relief.
4. Transcutaneous means 'through the skin'. **TENS** machines deliver small electrical pulses to the body via electrodes placed on the skin.
5. Transcutaneous electrical nerve stimulation is a method of producing pain relief, by the application of a pulsed biphasic rectangular wave currents via surface electrodes on the skin.
6. This current is often generated by small battery operated machines in which circuits modifies the battery's output in such a way that it will have stimulating effect.

Fig. 8.1: Pocket TENS machine

TYPES OF TENS



Conventional TENS: It is a high frequency, short pulse duration and low intensity TENS.

Acupuncture like TENS: It is a low frequency, long pulse duration and high intensity TENS.

Burst TENS: It is a low frequency TENS consisting short, high frequency pulse duration and high intensity TENS.

Brief intense TENS: High frequency, long pulse duration maximum tolerable intensity applied for limited periods.

Modulated TENS: Continuously varying frequency, pulse duration. In modulated TENS the pulse width, frequency and intensity are automatically varied and the benefits of both conventional and acupuncture TENS are obtained.

HIGH TENS

Characteristic Features of High TENS

a. Frequency: 50–100 Hertz
b. Pulse width: 100–500 microseconds
c. Intensity: 12–30 mA, patient should feel a tingling sensation.

Duration of Treatment

- Treatment duration varies from 30 to 60 min once or twice daily, continuously for a minimum of 8 hrs/day to even full 24 hrs/day.
- Acute pain, superficial pain like causalgia responds better for high TENS.

Effects

- When TENS is applied in this way, the stimulation will cause impulses to be carried along larger diameter afferent neurons A-β. This can produce presynaptic inhibition of transmission of nociceptive impulses through A delta and C fibres at substantia gelatinosa of the pain gate.
- The patient is aware of strong tingling sensation but pain sensation is reduced.

> *Do not use TENS over the front of the neck due to the risk of acute hypotension through a vasovagal reflex or even a laryngospasm.*

LOW TENS

Characteristic Features of Low TENS

a. Frequency varies between 1 and 5 Hz
b. Pulse width varies between 100 and 150 microsec
c. Intensity more than 30 mA

Duration of Treatment

- It is applied once/day for 20–30 minutes

> *Do not use the TENS unit in children, during pregnancy, epilepsy, except with medical advice.*

- Longstanding, deep pain responds better for low frequency TENS.

Effects

- This low TENS gives a sharp nociceptive stimulus and a muscle twitch.
- Nociceptive stimulus is carried towards the cerebrum. Its passage through the midbrain will cause the periacquductal area of grey (PAG) matter and RAPHE nucleus to interact to cause the release of opiate like substances at the cord level.

BURST TENS

Burst TENS have series of pulses, this is repeated 1–5 times/second, normally 2 times/second.

Each burst TENS last about for 70 ms and consists of number of individual pulses at the usual conventional frequencies of 50–100 Hz.

Effects

- The effect of burst TENS combines both conventional and acupuncture tens.
- Therefore, pain relief by both modes.

MODULATED TENS

- In modulated TENS the pulse width, frequency and intensity are automatically varied and the benefits of both conventional and acupuncture TENS are obtained.
- Modulated TENS prevent adaptation of the nerves to the current.

Effects

It is widely used for the relief of acute pain including post-operative and obstetric pain, chronic and neurogenic pain.

PARAMETERS FOR THE APPLICATION OF TENS

Energy source: All the portable TENS machines are powered by an alkaline 1.5 volt battery.

Amplitude: This is adjustable from 0 to 5 MA into an electrode impedance of 1 kΩ

Waveform: The most commonly used waveform is a biphasic, asymmetrical balanced square wave with zero net DC component.

Pulse frequency or rate: Variable from 1 to 50 pulses per second or Hz.

PHYSIOLOGICAL EFFECTS

The physiological effects of TENS can be best explained under the following theories.

Gate Theory

The gate theory of pain perception, proposed by Melzak and Wall in 1965, is that there is a "gate" through which nerves send pain messages to the brain. TENS treatment based on this theory sends electrical impulses flooding along larger nerve pathways and close the gate so the brain never receives the pain messages from the smaller nerves in the affected part of the body.

Endorphin Theory

Some of the researches into the physiological effects of TENS relates to stimulation of endorphins. Endorphins are the natural pain-relieving hormones secreted by the pituitary gland. The theory holds that the electrical stimulation from the TENS machine encourages the brain to secrete more endorphins, reducing the perception of pain.

Ischaemic Theory

Ischaemia is a reduction of blood flow to a particular area of the body. TENS proponents say it helps increase the blood flow for some patients through vasodilatation, or widening of the blood vessels. The theory is that electrical stimulation from TENS causes the blood vessels to dilate and reduce pain.

Stimulation of Acupuncture Points Causes a Sensory Analgesia Effect (Melzack, 1988)

Acupuncture background: Acupuncture is based on energy lines (meridian) and entry points (acupuncture points).

Melzack theorizes that stimulation of these points using TENS causes a sensory analgesia effect by inhibiting or changing the pain evoked nerve impulses at several levels in the nervous system.

THERAPEUTIC EFFECTS

The therapeutic effects of TENS is

a. To reduce pain perception
b. To reduce spasticity
c. To reduce nausea and vomiting (cancer patients or post-operative)

Indications

- Long standing severe pain
- Postherpetic neuralgia
- Stump neuroma and phantom limb pain
- Trigeminal neuralgia
- Chronic neck pain
- Chronic back pain
- Chronic leg pain
- During labour pain
- Cancer pain
- Post-operative pain, e.g. cholecystectomy
- Rheumatoid arthritis

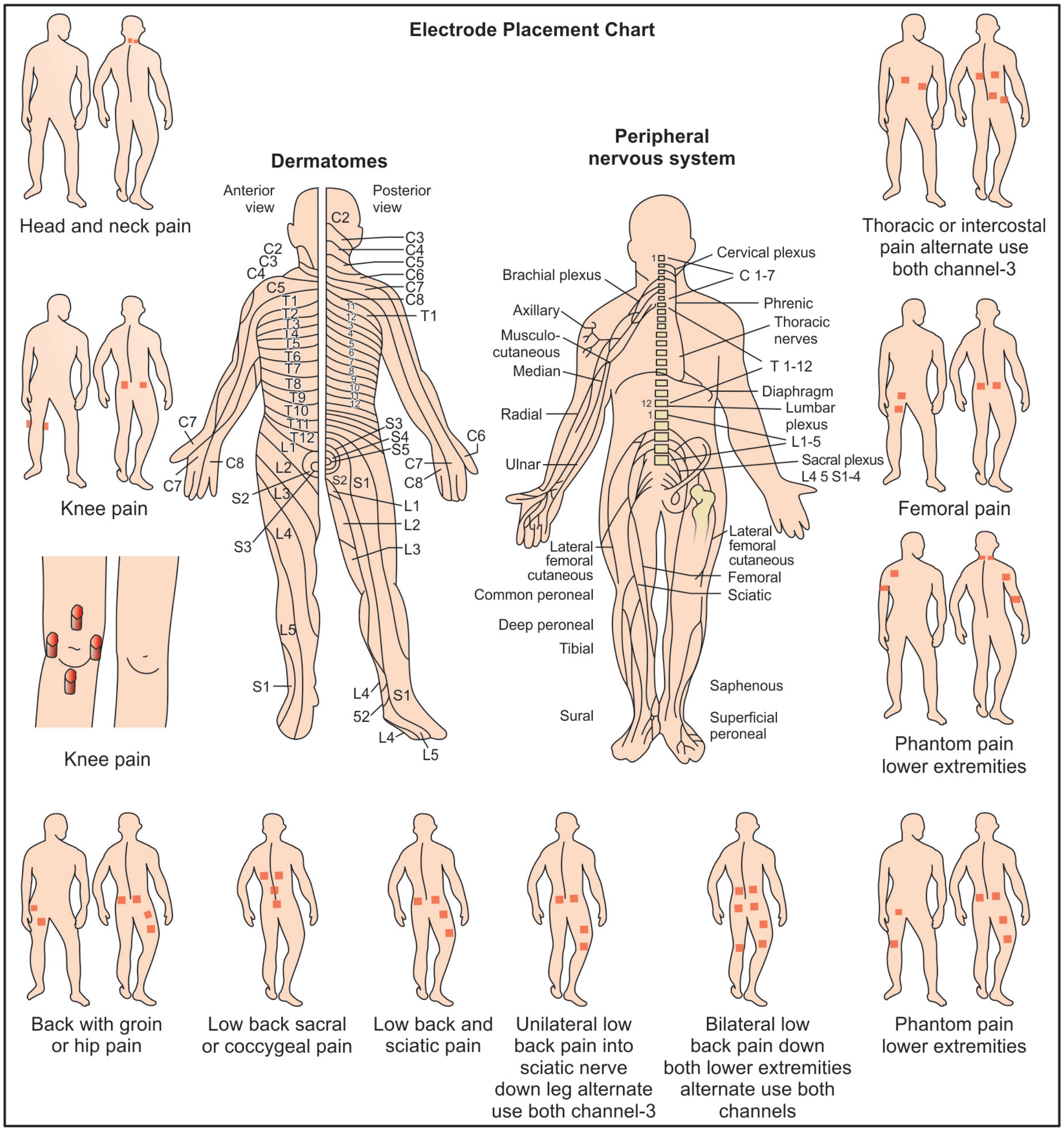


Fig. 8.2: Electrode placement for TENS

Fig. 8.3: Pocket TENS and its operational instructions

- Osteoarthritis
- To reduce spasticity
- To reduce nausea and vomiting

Contraindications

a. Someone with a pacemaker
b. Patients with undiagnosed pain.
c. Patients with a heart condition
d. On head or neck of someone with epilepsy
e. Patients with venous or arterial thrombosis or thrombophlebitis
f. Patients with indwelling phrenic nerve or urinary bladder stimulators
g. Near operating diathermy device
h. Around the head
i. On the eyes
j. Over mucosal surfaces
k. Using electrodes on infected (inflamed) skin
l. Electrodes across the chest of a patient with cardiac disease
m. Electrodes should not be placed near carotid artery (sinus) in the anterolateral region of the neck. There is a potential risk that stimulation at this site might cause heart block by exciting the vagus nerve.

Precautions

a. Areas of skin irritation, damage or lesions
b. Areas with impaired sensation

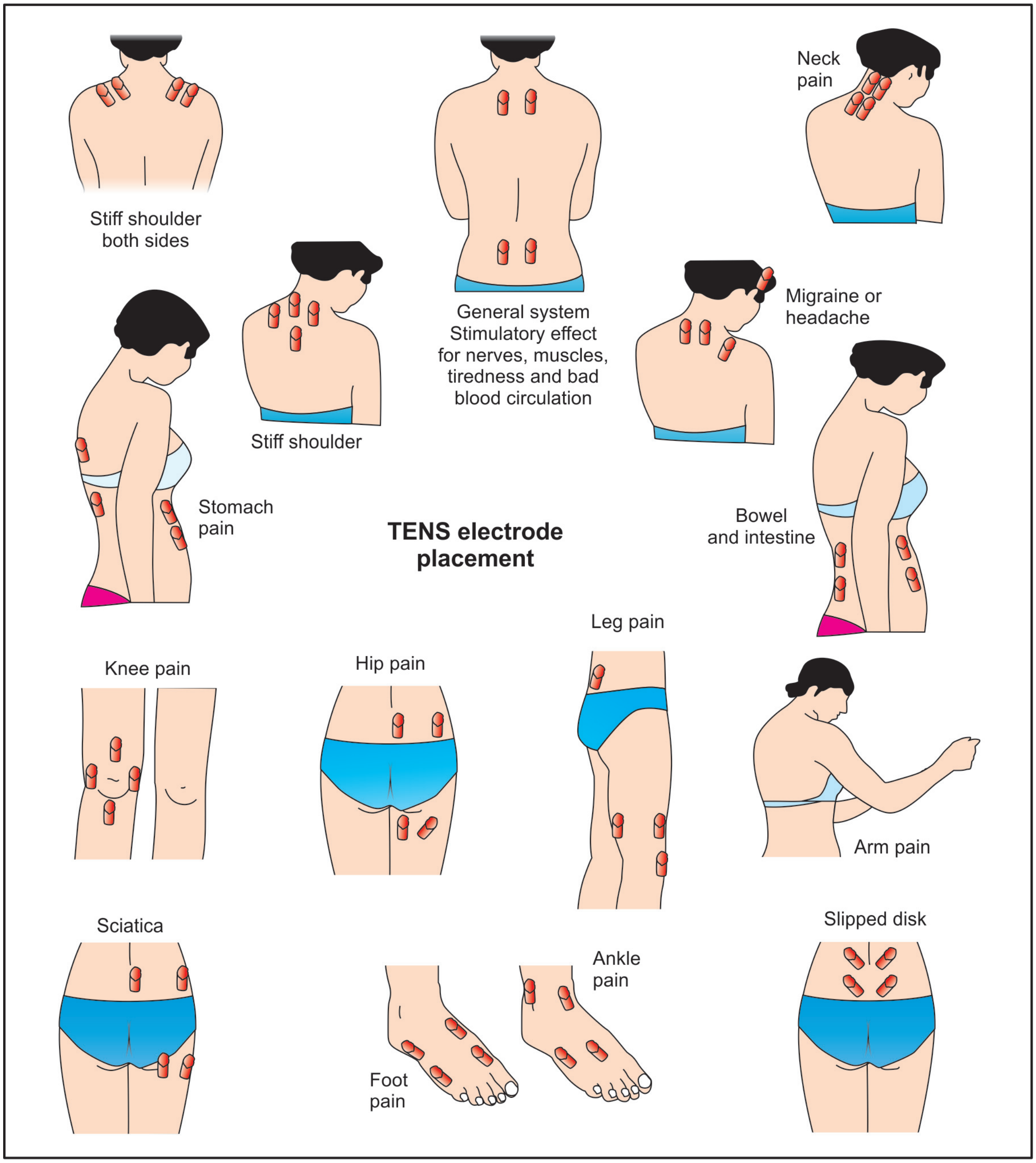


Fig. 8.4: TENS electrode placement

c. Over abdominal, lumbosacral or pelvic regions during pregnancy other than for labour/delivery

d. Tissues vulnerable to haemorrhage or haematoma

e. Athletes should not be permitted to participate in sports while under the influence of TENS analgesia
f. Extreme caution is needed with patients taking narcotic medication or who are known to have hyposensitive areas.
g. Incompetent patients may not be able to manage the device and it must be kept out of reach of children.
h. For patients with diagnosed malignancies that have been diagnosed as terminal, TENS can be used for pain control with informed consent of the patient.

Otherwise, TENS should not be used when malignancies are present.

Basic Safety Principles

a. Keep TENS appliances out of reach of children
b. Do not use TENS while operating vehicles or potentially hazardous equipment
c. Switch the appliance off before applying and removing the electrodes
d. After prolonged application, local skin irritation or allergic rash can occur beneath or around the electrodes and skin after stimulation. Care of the skin can be assured if the application site and electrodes are washed after stimulation to prevent skin rash and the rubber electrode from perishing.

SHORT ESSAY QUESTIONS

1. **Define TENS, classify TENS with parameters.**
2. **List out the indications and contraindications of TENS.**
3. **Enumerate the precautions and basic safety principles for the application of TENS.**

LONG ESSAY QUESTION

1. **Describe the procedure for application of TENS therapy.**

MULTIPLE CHOICE QUESTIONS

1. **Who proposed the pain gate theory?**
   A. Melzeck
   B. Madam curie
   C. Roentzen
   D. Newton

2. **Which fibres carry pain impulses in our body?**
   A. C
   B. Aβ
   C. Aδ
   D. Both A and C

3. **What is the full form of TENS?**
   A. Transcutaneous electrical nerve stimulation
   B. Transcutaneous electroneuron synapse
   C. Both A and B
   D. None

4. **What type of impulse TENS uses?**
   A. Rectangular
   B. Biphasic
   C. Both A and B
   D. Trapezoidal

5. **What is the frequency of high TENS?**
   A. 50–100 Hz
   B. 40–100 Hz
   C. 1–5 Hz
   D. 30–35 Hz

6. **What is the frequency of low TENS?**
   A. 30–35 Hz
   B. 60–65 Hz
   C. 70–100 Hz
   D. 1–5 Hz

7. **What type of sensation patient would feel with the application of high TENS?**
   A. Tingling
   B. Burning
   C. Throbbing
   D. No sense

8. **Which type of TENS is widely used for postoperative and obstetric pains?**
   A. Burst TENS
   B. High TENS
   C. Low TENS
   D. Modulated

MODEL OSPE QUESTIONS

1. **A 30-year-old male lorry driver has been referred to physiotherapy with acute lumbago. Perform TENS for lumbar region.**
2. **A male patient of age 40, nondiabetic, has been suffering from cervical spondylosis with acute radiculopathy of left upper limb with median nerve involvement. The patient chief complaint is acute radiating pain from neck until the thumb of left upper limb. Demonstrate the procedure for application of TENS (high).**

Answers MCQs	1. A	2. D	3. A	4. C	5. A	6. D	7. A	8. D

STATE TRUE or FALSE

1. Electrically stimulated action potentials in sensory or motor nerves can control pain.
2. Conventional TENS uses short duration, high frequency pulses to reduce the pain sensation by the gate control theory.
3. Burst mode TENS has a mechanism of action similar to that of low-rate TENS.
4. TENS can be used safely over carotid sinus.

FILL IN THE BLANKS

1. Low-rate TENS is also known as ____________.
2. The time between bursts is termed ____________.
3. Low-rate TENS stimulates the release of ____________________ to mediate pain.
4. Three types of TENS are available: ___________ , _____________ and __________.

CHAPTER 9

Interferential Therapy

Learning Objectives: At the end of this chapter, students will be able to learn

1. Definition and principles of interferential current
2. Types of Interference
3. Indications and contraindications
4. Physiological effects of IFT
5. Principles of application

DEFINITION

Developed by Dr Hans Nemec of Vienna Austria in the early 1950.

It may be described as transcutaneous application of alternating medium frequency electrical currents, amplitude modulated at low frequency for therapeutic purposes.

WHY IFT?

- Medium frequency currents are associated with lower skin resistance (impedance)
- More comfortable than low frequency currents
- More tolerable penetration of current through skin is possible
- Medium frequency current spread uniformly in tissues when compared with low frequency currents
- The effects of IFT are deep when compared to low frequency currents

SKIN IMPEDANCE

- The word impedance comes from Latin word *impedire* meaning to prevent, to stop from going on.
- Conventionally speaking, the term resistance refers to the obstacle to direct current, and is represented by letter 'R'.
- The term impedance refers to the obstacle to the alternating current and is represented by letter 'Z'.

Impedance expressed as Z
$Z = 1/2\ \pi FC$

- Both 'R' and 'Z' are expressed in Ohms
- Skin impedance is calculated as
  $Z = 1/2\ \pi fc$

Where, Z = skin resistance
f = frequency in Hz
C = capacitance of skin in microfarads

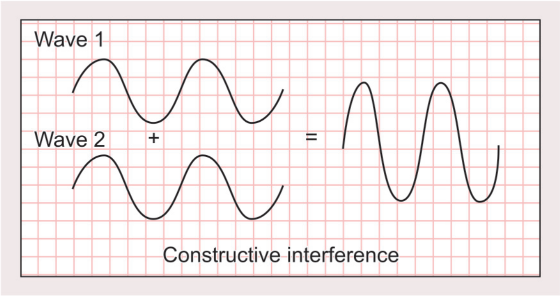
- From above formula, skin impedance is inversely proportional to frequency and capacitance of the skin.
- Capacitance of the skin cannot be changed, hence by increasing the frequency the skin impedance can be lowered.

PRINCIPLE OF IFT

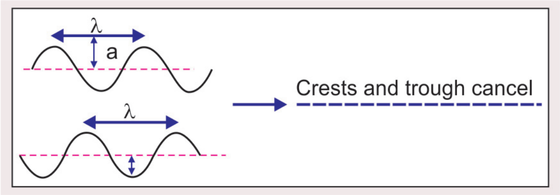
The principle of IFT is to pass two medium frequency alternating currents which are slightly out of phase, through the tissues, where the currents intersect to produce a low frequency effect.

Principles of wave interference: Combined effects.

Constructive interference: When two sinusoidal waves those are exactly in phase, the waves supplement each other in constructive interference.



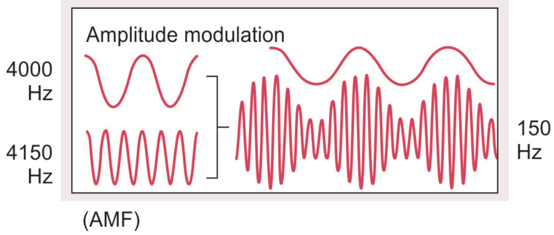
Destructive interference: When two waves are having different wavelength, the result is cancellation of both waves.



Continuous interference: Two waves slightly out of phase collide and form a single wave with progressively increasing and decreasing amplitude.

Principle of Working

- In the IFT method, two medium frequency alternating currents that interact with each other are used.
- One of the alternating currents has a fixed frequency of 4000 Hz while the frequency of the other alternating current can be set between 4000 and 4250 Hz
- The superimposition of one alternating current on the other is called interference.
- The frequency of the new medium frequency alternating current can be caluculated as f1 + f2/2,
- Example: f1= 4000 Hz
  f2 = 4150 Hz



- Then the resultant frequency after interference is 4075 Hz
- The frequency with which the amplitude varies is referred to as amplitude modulation frequency (AMF)
- In IFT the AMF (treatment frequency) corresponds to frequencies which are used in low-frequency
- The AMF has a value of f1–f2 or vice versa
- The difference between the two frequencies is called beat frequency

Physiological effects
- Relief of pain
- Muscle stimulation
- Increased blood flow
- Decrease in oedema

Sweep: The principle of using the sweep is that the machine is set to automatically vary the effective stimulation frequency using preset or user set sweep ranges.

- Such sweep prevents accommodation of nerves
- An AMF of 20 Hz is set and a 50 Hz spectrum is added
- The current begins with an AMF of 20 Hz and passes successively through all the frequencies up to 70 Hz, after which it decreases gradually to 20 Hz, the process is repeated automatically.

Parameters

- *AMF parameter:* To choose the basic value of the low frequency (LF) modulation that is desired
- *Spectrum parameter:* To set the range of variation in the AMF value that is desired. For example: AMF at 100 Hz and spectrum at 50 Hz will give an AMF variation from 100 Hz up to 150 Hz and back to 100 Hz.
- *Sweep time parameter:* Sets the time period for the AMF to change from base to peak frequency. Faster sweep is used for less painful stimulation and for strong muscle contraction or sensory input, sweep must be slow, to ensure aggressive stimulation.
- *Contour parameter:* Sets the rate of change of the AMF from base to peak frequency
- *Rotation parameter:* It is applicable in case of vector currents only and sets the rate of rotation and the direction change of the AMF field within the tissues

Physiological Effects

The physiological effects of interferential therapy depend upon:

1. Magnitude of the current
2. Type of mode used: Rhythmic or constant
3. The frequency range used
4. Accuracy of the electrode positioning

Effects

- *Relief of pain:* Believed that this may be achieved by stimulation of the reticular formation at frequencies of 10–25 Hz or by blocking 'C' fiber transmission at >50 Hz
- *Muscle stimulation:* For patients who cannot generate useful voluntary contraction, IFT may be beneficial. Most effective motor nerve stimulation range is between 10–25 Hz. When employing IFT it is not possible to continue to stimulate the muscle beyond its point of fatigue, some machines employ 'surged' mode to overcome this

Increased local blood flow:

- Experimentation demonstrated vascular changes at a frequency of 10–25 Hz
- Effects of increased blood flow is believed to be due to
  1. Effects of suction electrodes on tissues
  2. Effects of muscle stimulation on circulation
  3. Deep tissue penetration stimulates parasympathetic nerve fibres for increased blood flow.

Reduction of oedema

- Local muscle contraction combined with its local vascular changes encourages the reabsorption of tissue fluid
- The use of suction electrodes may also be beneficial

Indications

- Pain relief in acute and chronic conditions
- Stress incontinence
- Placebo effects

> IFT plays an important role in stress incontinence and strengthening of weak pelvic floor muscles of pregnant ladies and old age patients.

Low back pain

- Muscle spasms and strains
- Ligament sprains
- Cervical and lumbar spondylosis
- Periarthritis of shoulder
- Sacroiliitis

Contraindications

- Cardiac pacemaker
- Advanced cardiac diseases
- Uncontrolled hypertension
- Thrombosis
- Haemorrhage
- Pregnancy
- Neoplasia
- Tuberculosis
- Infections
- Over the eyes
- Skin disorders
- Epiphyseal region in children

Precautions

- IFT apparatus must be at least 6 metres away from SWD machine
- Epileptic patients
- Over the anterior chest wall
- Position suction electrode below the level of damage or discomfort

MODEL OSPE QUESTION

1. **A female patient, diabetic and hypertensive of age 45, was referred to the physiotherapy for assessment and treatment for right shoulder pain. On examination, there was restriction of movement for abduction and external rotation. Demonstrate the procedure for application of IFT.**

MULTIPLE CHOICE QUESTIONS

1. **Medium frequency currents are associated with**
   A. Impedance
   B. Inheritance
   C. Coherence
   D. None

2. **Impedance is represented by**
   A. Z **B.** S
   C. F **D.** A

3. **For production of interferential currents, type of currents used is**
   A. Low frequency currents
   B. Medium frequency currents
   C. High frequency currents
   D. None

4. **Indication of IFT is**
   A. Stress incontinence
   B. Cardiac pacemaker
   C. Thrombosis
   D. Pregnancy

5. **Physiological effects of IFT depend upon**
   A. Magnitude of current
   B. Accuracy of electrode positioning
   C. Frequency
   D. All of the above

Answers MCQs 1. A 2. A 3. B 4. A 5. D

STATE TRUE or FALSE

1. Low Frequency currents are used for the production of IFT.
2. Beat frequency means the difference between 2 medium frequency currents.
3. Clove leaf pattern is seen in IFT.
4. IFT is a pain relieving modality.

FILL IN THE BLANKS

1. IFT is ______________ in case of recent haemorrhage.
2. ______________ frequency currents are produced in the body tissue.
3. Beat frequency is usually between ______________ and ______________ Hz.
4. IFT can stimulate ______________ and ______________ muscle.

CHAPTER 10

Russian and Rebox Currents

Learning Objectives: At the end of this chapter, students will be able to learn

1. Definition of Rebox currents
2. Various physiological effects of Rebox and Russian currents
3. Indications and contraindications of Rebox and Russian currents
4. Methods of application for various patients

INTRODUCTION

These currents are also known as KOTZ current

- Followed by the name of scientist who first used Russian currents for strengthening the muscles of Russian athletes
- KOTZ currents are medium-frequency currents, which in comparison with those of low frequency, can cause an extraordinary strengthening of the muscle
- This is a 2.5 kHz alternating current delivered in rectangular burst frequency of 50 Hz
- Due to their potent tetanization effect—minimal muscular fatigue for relatively long stimulation periods.
- This current can be used to rebuilding muscle, restoring the muscle's tone, strength and flexibility.
- The result is a true remodeling of the body.
- When current is applied, the command for the muscle to contract does not come from the brain, but from localized stimulation.
- The electric stimulator becomes the "command centre" of the muscle.

MANNER OF CONTRACTION

- The manner of the contraction, that is
  - the speed of the contraction,
  - the duration of maximum stress and
  - the period of relaxation and rest between one stimulus and another.
- The operator's job is simply to regulate the intensity of the stimuli for the best possible contraction.
- Rebox method is different from classic Transcutaneous Electric Nerve Stimulations (TENS) in many basic characteristics.
- Specific impulses (frequency 24 kHz, pulse width 100–300 μs) of weak electric currents (100–200 μA) are introduced transcuta-

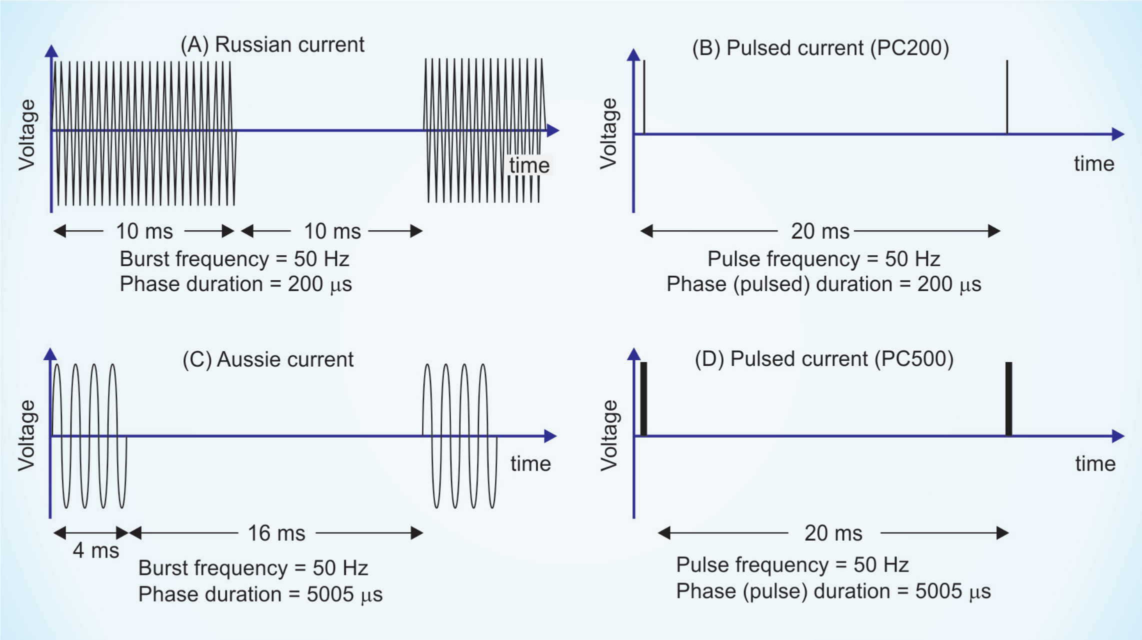


Fig. 10.1: Various currents and their waveforms

neously to the affected region with a touch of a small non-invasive treatment electrode (cathode).

- While the patient holds a second reference electrode (anode) in a hand to complete electric circuit.
- The treatment electrode (active surface 1.5 mm^2) is applied for 2–3 seconds in one spot.
- Then proceeding approx. 1.5 cm to another point.
- About 20 points are treated per one session.
- Frequency of treatment sessions depends on individual needs for each patient.

Indications

The most frequent applications include:

- Back pain
- Epicondylitis
- Sprained ankle
- Torticollis
- Knee ligament damage
- Acute and chronic pain
- Immobility or hypertonia
- Oedema
- Neurological disorders
- Healing process

Contraindications

The Rebox should not be used in these cases:

Local Contraindications

- Disruption in continuity of the skin (open wound, etc.)
- Skin ulcer
- Acute inflammation of the skin or subcutaneous tissue
- Thrombosis

General Contraindications

- Cardio stimulator
- Pregnancy
- Epilepsy
- Tumours (diagnosed or suspected)
- Shock

Types of Treatment

Cathode Stimulation

- This type is used most often (95% of all applications). Positive tissue ions (K^+, Na^+, Ca^{2+}) are attracted to the treatment electrode (cathode).
- The local ion concentration changes lead to analgesic and anti-oedematic effect, muscle relaxation and correction of local acidosis.

Anode Stimulation

- This stimulation is applied rarely in the situations, when the cathode stimulation irritates the patient. For example: Post-hepatic neuralgia, some conditions after neurosurgery.

Fig. 10.2: Rebox machine

Treatment Modes

1. **Gentle:** Recommended for a new patient (first few sessions).
2. **Standard:** The most frequent mode when patient is used to the treatment.
3. **Strong:** For patients who do not respond to normal stimulation amplitude.

MULTIPLE CHOICE QUESTIONS

1. Rebox currents are also known as

A. Russian **B.** KOTZ
C. IFT **D.** None

2. KOTZ currents are ____ frequency currents

A. High **B.** Low
C. Medium **D.** None

3. General contraindications for rebox currents are

A. Pregnancy
B. Metal implant
C. Neurological disorder
D. All of the above

Answers MCQs 1. B 2. C 3. A

CHAPTER

11

Thermotherapy

Learning Objectives: At the end of this chapter, students will be able to learn

1. Physiological effects of heat
2. Methods of application of dry and moist heat
3. Indications and contraindications of heat therapy
4. Technique of application of various heat therapy modalities

INTRODUCTION

- The therapeutic application of heat is called thermotherapy.
- It is used primarily to control pain, increase soft tissue extensibility and circulation and accelerate healing.
- Heat plays a very important role in many therapeutic methods used in physiotherapy
- The amount of energy that tissue will gain or loose during treatment depends on the nature of tissue, agent involved and duration of exposure.

Physiological Effects

The physiological effects of heat depend upon the following factors

1. Method of application
2. Intensity of heat
3. Length of time exposed to the heat
4. Thermal conductivity, density and specific heat characteristics of the tissue
5. In order to achieve therapeutic level of heating, the temperature attained in the tissues should be between 40° and 45°C
6. Above 50°C of heating results in burning and below 40°C of heating does not provide any effects

Vasodilatation: Heat causes vasodilatation and thus increase the rate of blood flow. As a result of increased blood supply there is abundant O_2 supply to the tissues along with increased supply of nutrients.

Changes in nerve conduction velocity: Increased temperature increases nerve conduction velocity and decreases the conduction latency of the sensory and motor nerves. Nerve conduction velocity increases at a rate of 2 m/sec for every 1°C rise of temperature.

Nerve firing rate: The nerve firing rate has been found to change in response to change in temperature. With increase in temperature around 42°C can cause decrease in nerve firing and thus reduces muscle spasm.

Increased pain threshold: With increase in temperature the pain threshold increases. It can also decrease pain because of ischaemia by increasing blood supply to the area.

Changes in Muscle Strength

Muscle strength decreases for the initial application of heat for first 30 min and then in next two hours, the muscle power and endurance shall increase.

Increased metabolic rate: The metabolic rate and enzymatic actions are increased with increase in heat.

Altered tissue extensibility: Increasing the temperature of soft tissue increases its extensibility.

Promotes muscle relaxation: Rise in temperature induces muscle relaxation and increases the efficiency of muscle contraction.

Increased activity of sweat glands: There is reflex stimulation of sweat glands in the area exposed to heat leading to increased activity of sweat glands.

METHODS OF APPLICATION OF HEAT (SUPERFICIAL)

- Hot packs
- Paraffin wax
- Fluidotherapy
- Infrared lamps
- Hydrocollator packs

Paraffin Wax Bath

Definition

Treatment of various body parts with melting paraffin wax whose temperature is maintained at 40–44°C is known as paraffin wax bath therapy.

The actual melting point of wax is 51–54°C. If this melted wax is directly poured on the surface of the body, it may cause thermal injury and hence to avoid this, melting point of wax is lowered by an addition of an impurity in form of oil in the ratio of 6:1 or 7:1 of paraffin: oil.

The heat transferred during wax bath treatment occurs through conduction from the layer of solid paraffin wax into skin.

Therapeutic Effects

> *The heat and cold application can reduce the pain; therefore while applying it, patientís preference can be taken into consideration.*

Fig. 11.1: Paraffin wax bath

1. Paraffin wax bath therapy can reduce muscular skeletal pain
2. Reduce stiffness
3. Increase the local temperature
4. Increase sweating
5. Increase local circulation and
6. Increase the local permeability of the skin

Indications

Clinically paraffin wax bath is used for the treatment of the following conditions

1. Osteoarthritis
2. Rheumatoid arthritis
3. Synovitis
4. Sudek's dystrophy
5. Various soft tissue contractures
6. Low back pain
7. A pre-requisite for post-traumatic mobilization of joints
8. To facilitate finer movements
9. To accelerate healing especially in superficial injuries
10. To lengthen the scar tissue

Contraindications

1. Open wounds
2. Infective conditions
3. Allergic rashes
4. Deep vein thrombosis
5. Skin conditions like acute dermatitis

Advantages

1. Maintains good contact with highly contoured areas
2. Easy to use and inexpensive
3. Oil lubricates and conditioners the skin
4. Self-administration is possible

Disadvantages

1. Messy and time consuming to apply
2. Cannot be used over an open skin lesion
3. Risk of cross contamination if the paraffin is reused

Precautions and Principles

1. Always before starting the treatment, check the skin sensitivity of the patient.
2. Before pouring the wax, check the temperature of the wax
3. Explain the entire procedure to the patient
4. After the treatment, the wax is discarded, cleaned in a purifier and reused
5. Wax is highly inflammable if it becomes overheated, so it is advisable to have a fire blanket or fire extinguisher.

Hot Packs

Hot packs is one of the superficial heating agents used for thermo therapy.

Physiological Effects

Increased local temperature: Rise in local body temperature occurs following hot pack application.

1. It is due to the conduction of heat from hot packs to the skin and the superficial tissues.
2. The increase of temperature should not exceed 45°C, otherwise tissue burn can occur.

Increased connective tissue extensibility: Increases the extensibility of connective tissues. It is due to effect of heat on the elastic tissues.

Increased circulation of blood: Increase in tissue temperature is associated with vasodilatation. As a result of it local increase in the blood supply especially in the superficial tissues occur.

1. *Relief of pain*: Hot packs can be used to obtain analgesia.
2. Pain relief following hot packs may occur due to decreased nerve conduction velocity.
3. There may be sedation or counter irritant effect by heat.
4. Pain relief may be due to decrease in muscle spasm.

Types of Hot Packs

1. Hydrocollator packs
2. Kenny's packs

Fig. 11.2: Hydrocollator packs

3. Chemical hot packs
4. Electrical heating pads

Hydrocollator packs

1. Provides superficial heating
2. Consists of canvas bag filled with silicates gel or other hydrophilic substance
3. Stored in thermostatically controlled water bath inside container
4. Available in variety of shapes and sizes
5. Temperature should be 65°celsius
6. The increased blood flow helps to minimize pain and stimulate healing.

Hot water bags

1. Contains water
2. Used as a same fashion as hydrocollateral bags
3. These bags are advised for home use

Kenny's pack

1. Named after sister Kenny
2. Consists of a wool cloth
3. Surplus water is removed by spinning

Fig. 11.3: Hot water bags

4. Relatively dried packs are quickly applied to the surface, temperature quickly drops to normal within 5 minutes

Chemical hot packs

1. Less commonly used
2. Substance inside it is allowed to mix and heat is generated by a chemical reaction

Fig. 11.4: Kenny's packs

Electrical heating pads

1. Best for home treatment
2. Patient can use it by himself
3. Cheaper
4. Flexible
5. Patient can control heat through the knob

Advantages of hot packs

- Easy to use
- Inexpensive materials
- Short use of clinician's time

Fig. 11.5: Chemical hot pack

Fig. 11.6: Electrical heating pack

- Low level of skill needed for application
- Can be used to cover moderate to large area
- Safe because packs start cooling on removal from the water cabinet
- Readily available for patient purchase and home use.

Disadvantages

- Hot packs must be moved to observe the treatment area during treatment
- Patient may not tolerate the weight of the hot pack
- Pack may not be able to maintain good contact with small or contoured areas
- Active motion not practical during treatment
- Moderately expensive equipment.

Infrared Radiations

Definition

Infrared radiations are rays whose wavelength are from 760 nm to 1 mm. Their wavelength is longer than visible red light.

Classification

Type	*Wavelength*
IRA	760–1400 nm
IRB	1400–3000 nm
IRC	3000 nm–1 mm (not used for therapy)

Production

1. Any heated material will produce infrared radiations.
2. There are two main groups of infrared radiation generators used clinically for therapeutic uses.
   - Non-luminous generators
   - Luminous generators

Non-luminous generators

1. They consist of simple coil of wire wound on a cylinder of insulating material like fireclay or porcelain
2. An electric current is passed through the wire and produces heat.
3. Infrared rays are emitted from the hot wire
4. Some visible rays are also produced
5. The entire setup is connected by screw-cap device and placed at a focal point of gentle curved spherical reflector
6. The reflector is mounted on an adjustable stand
7. All non-luminous generators require some time to heat up and hence they are switched on soon before they are required

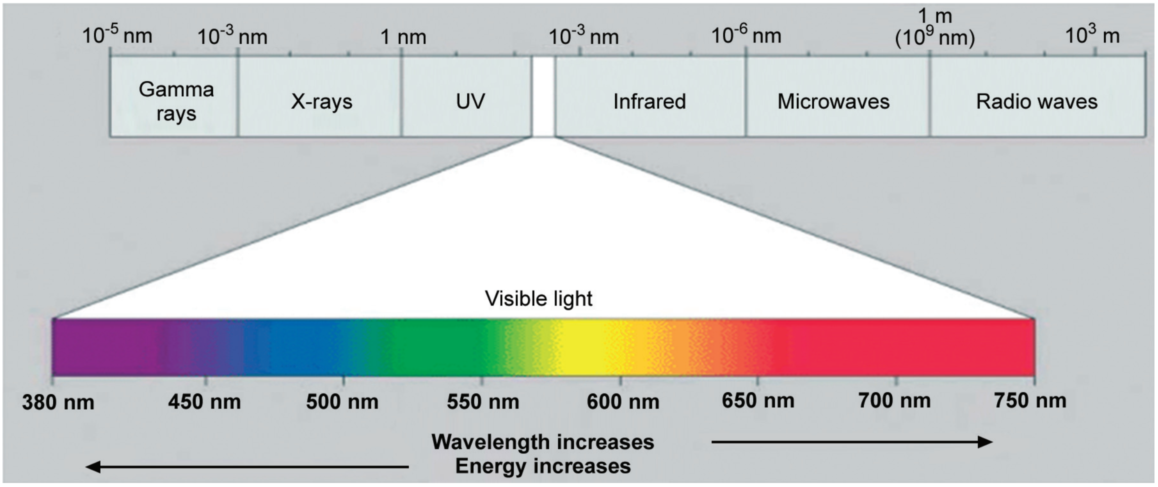


Fig. 11.7: Infrared radiations

Fig. 11.8: IRR generator

8. Non-luminous elements produce infrared rays with wavelength from 1500 nm down to 750 nm, the maximum emission is in the region of 4000 nm

Luminous generators

1. They consist of an incandescent lamp consisting of a wire filament in a bulb.
2. The bulb may be evacuated or may contain inert gas at a low pressure
3. The filament is made up of tungsten
4. The passage of electric current through the filament produces heat
5. Infrared visible and a few ultraviolet rays are emitted
6. In front of the bulb is painted red to filter ultraviolet rays
7. The luminous generators produce infrared rays with wavelengths from 350 to 4000 nm, the maximum emission is in the region of 1000 nm.

Physiological effects

1. Local cutaneous vasodilatation leading to local increased blood supply
2. Erythema formation
3. Increased activity of sweat glands
4. Stimulates thermal heat receptors
5. Increased metabolism
6. Increased collagen extensibility

Principles of Treatment with IRR Therapy

Choice of Apparatus

The choice of luminous and non-luminous generators depends upon the condition treated and effect needed

Choice	*Effects and uses*
Luminous	Chronic conditions counter-irritation effect
Non-luminous	Acute conditions sedative effect

Preparation of Patient

a. Explain briefly the type of sensation the patient would feel.
b. Instruct the patient strictly that he/she should feel comfortable warmth only and should report to the therapist if it is excessive.
c. Instruct the patient not to touch any apparatus.
d. Remove the clothing from the affected part. Cover the part with a towel to cover the ears and occipital region.
e. Check and ensure normal skin sensations
f. Check for all contraindications
g. Make the patient assume supportive, suitable and comfortable treatment
h. Advice the patient not to move until the therapist give command
i. Ask the patient to wear protective eye goggles

Treatment Procedure

a. The lamp is positioned so that the area to be treated and the rays strike at 90°
b. The lamp is maintained at a distance of 50–75 cm from the treatment area, according to the output of the generator
c. After sometime if patient complains of over heat, the lamp is moved still far from the patient
d. The physiotherapist should be present throughout the treatment time

Treatment Protocol

a. For acute inflammation and treatment of wounds = 10–15 min
b. For chronic inflammation = 20 min

Note: At the termination of treatment, there should be an erythema over the treatment area

Indications

1. Pain relief
2. Reduction of muscle spasm
3. Accelerates of healing and repair
4. Promotes tissue flexibility and reduce stiffness
5. To treat certain skin conditions
6. Increases vascularity of the skin

Contraindications

1. Areas of defective arterial blood supply
2. Area at the risk of haemorrhage
3. Defective skin sensation
4. Boils and abscess

Dangers of IRR

1. Burns
2. Damage to eyes
3. Precipitates occipital headache
4. Gangrene
5. Electric shock
6. Low blood pressure

SHORT ESSAY QUESTIONS

1. **List out the various types of hot packs with examples.**
2. **Enumerate the physiological effects of heat.**
3. **List out the indications and contraindications of heat therapy.**
4. **What are the uses of paraffin wax bath?**
5. **Explain briefly the production of IRR by luminous and non-luminous generators.**

LONG ESSAY QUESTIONS

1. Describe the technique of application of PWB for low back pain.
2. Explain the procedure of application of IRR therapy for acute conditions.
3. Explain the procedure of application of moist heat to hamstrings muscle.

MULTIPLE CHOICE QUESTIONS

1. **Which of the following is a type of hot pack?**
   A. Hydrocollateral
   B. Kenny's
   C. Chemical
   D. All of the above

2. **What is the desired temperature for therapeutic usage of hydrocollateral packs?**
   A. 65°C **B.** 45°C
   C. 35°C **D.** 50°C

3. **What substance is used in the hydro-collateral packs?**
   A. Silicates gel **B.** Oxalates
   C. Salts **D.** None

4. **What is the name of the hot pack which is made up of wool cloth?**
   A. Curie pack **B.** Kenny's pack
   C. Six pack **D.** Electric pack

5. **Which of the following hot pack uses mixture of various chemicals to produce heat?**
   A. Kenny's pack
   B. Moist heat
   C. Chemical pack
   D. All of the above

6. **Which of the following is NOT an advantage of hot pack?**
   A. Easy to use
   B. Inexpensive
   C. Saves time
   D. Patient cannot tolerate the weight of pack

7. **Which of the following is an indication for hot pack?**
   A. Open wound
   B. Cancer
   C. Appendicitis
   D. Muscle spasm

8. **What is analgesia?**
   A. Reduce in pain
   B. Reduce in swelling
   C. Reduce in sensation
   D. All of the above

9. **Which of the following is a contra-indication for the use of hot packs?**
   A. Muscle spasm
   B. Tightness of muscle
   C. Pain
   D. Open wound

10. **What is the time required to get a therapeutic effect for hydrocollateral packs?**
    A. 5 min **B.** 40 min
    C. 3 min **D.** 20 min

11. **What is the therapeutic application of heat is known as?**
    A. Thermotherapy
    B. Cryotherapy
    C. US therapy
    D. None

12. Which of the following is the primary role of heat in therapeutics?

A. Control pain
B. Improve circulation
C. Accelerate healing
D. All of the above

13. How much increase is seen in nerve conduction velocity for every 1 degree raise of temperature?

A. 2 cm/sec
B. 2 m/sec
C. 2 km/sec
D. 2 mm/sec

14. At what degree in celsius temperature, the heat can reduce muscle spasm?

A. 44 **B.** 45
C. 42 **D.** 40

15. Which of the following is a superficial heating agent?

A. Hot packs
B. Paraffin wax
C. Infrared lamp
D. All of the above

16. What is ratio of paraffin and oil mixture used in paraffin wax bath?

A. 6 : 1 **B.** 8 : 1
C. 10 : 1 **D.** 1 : 1

17. Which of the following is an indication for paraffin wax bath therapy?

A. Osteoarthritis
B. Synovitis
C. Low back pain
D. All of the above

18. Which of the following is a contra-indication for Paraffin wax bath?

A. Open wounds
B. Infections
C. Allergy
D. All of the above

19. Which of the following is NOT a suitable technique for giving paraffin for low back pain?

A. Paint
B. Dip-wrap
C. Both A and B
D. None

20. What is the suitable temperature required for giving paraffin wax bath?

A. 55–54°C
B. 40–44°C
C. 30–40°C
D. 100°C

MODEL OSPE QUESTIONS

1. **A 20-year-old female athlete came for improving her muscle pliability. Perform moist heat for left quadriceps as a prerequisite procedure for stretching.**
2. **A 40-year-old male patient is suffering from chronic rheumatoid arthritis. Perform paraffin wax bath dip and wrap technique for PIP and DIP joints of right hand.**

Answers MCQs	1. D	2. A	3. A	4. B	5. C	6. D	7. D	8. A	9. D	10. D
11. A	12. D	13. B	14. C	15. D	16. A	17. D	18. D	19. B	20. B	

3. A 30-year-old male lorry driver has been referred to physiotherapy with acute lumbago. Perform PWB paint technique for lumbar region.
4. A 50-year-old female patient who is non-hypertensive and non-diabetic has been referred to physiotherapy for paraffin wax bath treatment for right rheumatoid hand. Perform dip immersion procedure for right PIP and DIP joints.

STATE TRUE or FALSE

1. Heat causes vasoconstriction.
2. Thrombophlebitis is a contraindication of thermotherapy.
3. Hot packs provide deep heating to body tissues.
4. Moist heat is not included in thermotherapy.

FILL IN THE BLANKS

1. Kenny's packs are made from ____________.
2. The temperature of hydrocollator pack should be ______________.
3. Protein denaturation and cell death occurs due to ____________ heat.
4. Increased temperature ____________ nerve conduction velocity.

CHAPTER

12

Short Wave Diathermy

Learning Objectives: At the end of this chapter, students will be able to learn

1. Define diathermy and enumerate the types
2. Describe the production of SWD, MWD.
3. Enumerate the physiological effects and therapeutic effects of diathermy
4. List out the Indications and contraindications of diathermy
5. Demonstrate the skills on application of diathermy for various clinical conditions

INTRODUCTION

- **Diathermy** is from the Greek word meaning "through heating".
- It is the application of electromagnetic energy to produce heat and other physiological changes in tissues.
- The use of diathermy dates back to 1891 when d'Arsonval used radiofrequency electromagnetic fields with 10 kHz frequency to produce a sensation of warmth without the muscular contractions.
- The clinical use of short wave diathermy became popular in 20th century and was used to treat infections.

SHORT WAVE DIATHERMY

Diathermy gives a deeper heating than hot packs at larger areas.

- It is a high frequency deep tissue heating modality having a frequency of 27.12 MHz.
- It sets up radio waves with a wavelength of 11 m.

Diathermy gives a deeper heating than hot packs at larger areas.

Production

- The current is generated in a machine circuit, which is in turn coupled to a patient circuit which is to treat the patient
- The main principle beyond working of a SWD machine is capaciting and decapaciting a condenser to maintain machine circuit and patient circuit in resonance.
- The high frequency current is generated by an oscillator circuit consisting of a capacitance and inductance.
- The regular oscillations are maintained by feeding electric current into the circuit at right moment in the cycle by using a thermionic valve or a transistor.

Circuit

Machine circuit	Patient circuit
Mains power supply	Variable capacitor for tuning
High frequency generator	Electrodes
Amplifier	Spacing
Oscillator coil	Tissues
Resonator coil	

- The circuit consists of machine circuit and patient circuit.
- The part to be treated is included in the patient circuit.
- The patient circuit is coupled inductively to oscillator circuit.
- The capacity of the resonator circuit is adjusted by tuning to bring the circuits into resonance in accordance with the capacity of the tissue.
- Once tuned, the heating of the tissues is controlled by regulating the output of the machine.

The radiation used for diathermy falls with the radiofrequency and can interfere with communications. So it is advised that patients and therapist should switch off all electronic gadgets when using diathermy.

Methods of Application

> The radiation used for diathermy falls within the radiofrequency and can interfere with communications. So it is advised that patients and therapist should switch off all electronic gadgets when using diathermy.

There are two methods of applications
- Capacitor field method
- Cable method/inductive method

Capacitor field technique

- Capacitive plate diathermy applicators are made of metal encased in a plastic housing or transmissive carbon rubber electrodes that are placed between the pads.
- A high frequency alternating current flows from one plate to the other through the patient, producing an electric field and a flow of current in the body tissue that is between plates. Thus the patient becomes a part of the electrical circuit connecting the two plates.
- As current flows through the tissue, it causes oscillation of charged particles and thus an increase in the tissue temperature occurs.
- Heating with capacitive plate diathermy application is known as heating by the electric field method because electric current that generates the heat is produced directly by an electric field.
- The amount of heat generated depends on the strength and density of the current.

Principles of Application

The following factors influence the effects of diathermy and should be kept in mind and well maintained for effective heating effects.

Spacing of Electrodes

- Suitable spacing by means of towel is advised to ensure the safety of SWD.
- 2–4 cm skin–electrode distance is maintained.
- Wide spacing gives most uniform field in the tissues.
- Closer spacing of one electrode leads to concentration of field on that side.
- When the distance between skin and electrode is large the spreading out of the electric field is minimal, and there will be deep tissue heating.
- When the electrode–skin spacing is narrow, the superficial tissues will get more heated than the deep structures.
- Thus wide spacing helps to reduce the tendency for superficial tissue heating.
- The effects also depend on the dielectric constant of the spacing material and thus a material of low dielectric constant should be used, e.g. towel.

- When treating a structure which lies nearer to one surface of the body than to the other, e.g.: Hip joint, the directing electrode on the further surface is placed at a greater distance from the skin than the active one.

Size of the Electrodes

- A little larger electrode than the part to be treated is used to achieve an uniform electric field through the tissues.
- If uneven size electrodes are used, it results in the concentration of the heat under the smaller electrode.
- If the electrodes are too smaller than the area to be treated, then more superficial heating occurs than the deep.

Positioning of Electrodes

- The position of the electrodes is chosen with the aim of directing the electric field through the structure to be treated.
- Electrodes are placed parallel to the skin surface so that skin–electrode distance is as constant as possible.
- The distance between the electrodes must be greater than the combined skin–electrode distance of the two electrodes.
- If the structure is of high impedance the electrodes should be arranged, as far as possible, i.e. at right angles to the electric field.
- To heat a structure of low impedance, they are placed parallel to the electric field.

  Example: When treating ankle joint, the electrodes are placed medial and lateral so that the tissues lie in series with each other and some heating of the joint occurs.
- For treating soft structures, the electrodes are placed parallel to the tissue.
- The distance between the electrodes must be greater than the total spacing.
- There are three methods of placement of electrodes.
- Coplanar—for superficial.
- Contraplanar—for deep.
- Cross-fire—very deeply placed structures, cavity walls, extensive vascular areas, pelvic organs.
- Monoplanar: Active electrode over the tissue and indifferent at a far distance from the body usually used for superficial heating.
- Contraplanar: Electrodes are placed on opposite side of the part.
- Coplanar: Electrodes are placed on the same side of the part.
- Cross-fire: Initial half of the treatment is given in one direction, e.g. anterior-posterior and the later half in opposite direction, e.g. medial and lateral.
- This technique assures uniform heating of the tissues.

Inductothermy

In this technique the applicator is made up of a coil through which an alternating electrical current flows and this in turn produces a magnetic field perpendicular to the coil.

This effect causes production of eddy currents in the tissues which makes the tissue to oscillate.

Because of the oscillation, a friction is produced in the tissues leading to increase in the local temperature.

Inverse square law "The intensity of radiation from a point source is inversely proportional to the square of the distance from source".

Factors Affecting Inductive Diathermy

> Inverse square law "The intensity of radiation from a point source is inversely proportional to the square of the distance from source".

- The amount of heat generated in the tissues depends on the strength of the magnetic field.
- The strength of the magnetic field is determined by the distance between the applicator and tissue (based on the inverse square law).
- The strength of the magnetic field doesn't depend on the type of tissue.

- The strength of the induced eddy currents depends on the strength of magnetic field and electrical conductivity of the tissues.
- The electrical conductivity of tissue depends on type of tissue and frequency of the current applied.

Methods of application of Inductive diathermy

This technique can be applied in the following ways:

- A monode or drum electrode: In drum applicator, a flat spiral coil is enclosed in a plastic housing. It may have one or two drums or a single drum that can be bent to apply to various tissues.
- Coil or cable method: The cables are bundles of plastic-coated wires that are applied by wrapping round the patient's limb.
- A garment in the form of sleeves, have cables inside that are wrapped around the patient's limb when the garment is worn.

Therapeutic Effects

Effects on inflammation:

- On application of SWD, there will be vasodilatation of the blood vessels and results in increased supply of oxygen, nutritive materials, antibodies and WBC.
- These effects help to bring about the resolution of the inflammation.

Effects on Bacterial Infections

- With application of SWD, there will be vasodilatation of the blood vessels and results in increased supply of oxygen, nutritive materials, antibodies and WBC.

Note: In some cases SWD appears to aggravate the condition.

Traumatic conditions:

- It is proved that SWD can help in promoting the healing, by decreasing the time of healing.
- It also reduces pain.

Note: Caution with acute injuries.

Effects on muscular tissues

- The heating of tissues causes relaxation of muscles, thus SWD may be used to relieve spasms associated with injury and inflammation.
- Heat can also improve the efficiency of the muscle activity.

Fig. 12.1: SWD with disc electrodes

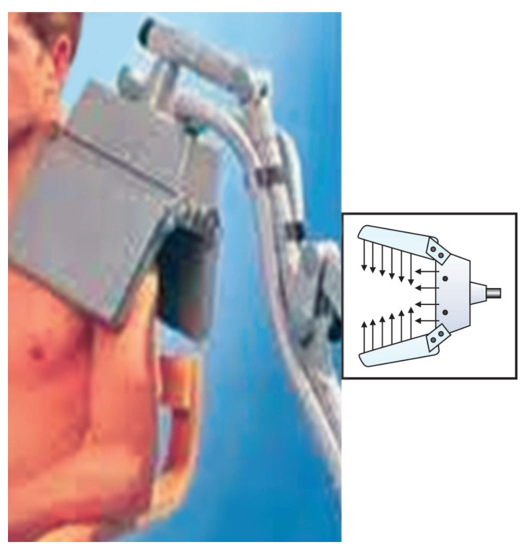


Fig. 12.2: Electrode for treating shoulder periarthritis condition

Indications:

- Disorders of musculoskeletal system
  - Degenerative joint diseases like rheumatoid arthritis and osteoarthritis
  - Sprains
  - Hematoma
  - Muscle and tendon tears
  - Capsule lesions
  - Lumbar and cervical spondylosis
  - Periarthritis of shoulder/frozen shoulder
  - Mechanical pains
- Inflammatory conditions
  - Boils
  - Carbuncles
  - Sinusitis
  - Pelvic conditions
  - Infected surgical incisions

Contraindications

- Cardiac pacemakers
- Metal implants in tissues
- Altered skin sensitivity
- Patients with epilepsy
- Pregnant uterus
- Unhealed scars and wounds
- Malignancy
- Active tuberculosis
- Venous thrombosis
- Acute sepsis

Dangers

- Burns
- Scald or moist heat burns
- Overdosage
- Electric shock
- Sparking
- Fainting
- Giddiness
- Damage to the equipment

Dosimetry

- The treatment is given about 15–20 min and intensity depends upon the area treated, condition and tolerability of the patient
- In cases where a vascular response is required, a longer duration of treatment may be necessary approximately 20–30 min.

Pulsed Short Wave Diathermy

Also known as PEME (pulsed electromagnetic energy), where the output of SWD machines can be pulsed.

Principles of production of PEME

1. The principle of production of oscillating high-frequency 27.12 MHz continuous output has been described in the earlier section.
2. The same principle is used for the production of PEME, by incorporating a timing circuit, the output is turned on and off, allowing pulses of oscillations to be emitted for a given period of time.
3. The output mainly depends on the following parameters
   - Peak power in watts
   - Pulse length in μs
   - Pulse frequency in Hz.

> Application of PSWD for 40–45 minutes with suitable parameters can improve microvascular perfusion without increase in tissue temperature and can be used safely in patients with diabetic ulcers for rapid healing effect.

Physiological effects of PEME

1. Acceleration of tissue healing
2. Enhanced nerve regeneration
3. Enhanced post operative healing
4. Reduced pain and swelling in acute injuries

Indications

1. Skin grafting donor sites
2. Dental surgeries
3. Acute ankle sprains
4. Sport injuries
5. Chronic back pain
6. Osteoarthritis

Contraindications

1. Cardiac pacemakers
2. Metal implants in tissues
3. Altered skin sensitivity
4. Patients with epilepsy
5. Pregnant uterus
6. Unhealed scars and wounds
7. Malignancy
8. Active tuberculosis
9. Venous thrombosis
10. Acute sepsis

On some animal studies, it is shown that there is accelerated regeneration in spinal cord and nerve regeneration in response to application of PSWD. It has also shown acceleration of bone healing in animal studies.

Dosimetry

Usually, the PEME application is done on the manufacturer's recommendations of the applicator. Most of the manufacturers recommend nonthermal PEME treatments are administered for 30–60 minutes once or twice a day, 5 to 7 times a week with 600 pulses/sec, 38 W mean power.

SHORT ESSAY QUESTIONS

1. **Define SWD and enumerate the principles of production of SWD.**
2. **List out indications and contraindications of SWD.**
3. **Write a short notes on dangers of SWD.**
4. **What is PEME? Explain briefly the production of PEME.**

LONG ESSAY QUESTIONS

1. **Describe the techniques of application of SWD by capacitor field technique.**
2. **Describe the physiological and therapeutic effects of SWD and PEME.**

MULTIPLE CHOICE QUESTIONS

1. **Diathermy means**
   A. Deep heating
   B. Through heating
   C. Heating of tissues
   D. All of the above
2. **In SWD, the regular oscillations are maintained by feeding electric current into the circuit by using**
   A. Radiator B. Transistor
   C. Amplifier D. Rectifier
3. **Which of the following condition is contraindicated for SWD?**
   A. Malignancy
   B. Osteoarthritis
   C. Sacroilitis
   D. Spondylosis

4. What is the ideal spacing required for application of SWD?
A. 2–4 cm
B. 20–30 cm
C. 2–4 metre
D. No spacing required

5. The principle of production of SWD is capaciting and decapaciting a
A. Condenser
B. Amplifier
C. Resistor
D. Rectifier

6. In which of the following cases, SWD should not be given
A. Metallic implants
B. Growing epiphysis
C. Eyes
D. All of the above

7. What is the ideal duration of treatment when using PEME?
A. 30–60 min
B. 10–15 min
C. 10–20 min
D. 15–20 min

STATE TRUE or FALSE

1. **Diathermy heats deeper than hot packs and a larger area than Ultrasonic therapy.**
2. **SWD cannot be pulsed for Therapeutic purposes.**
3. **Wider spacing will give more uniform heating in the tissues.**
4. **The amount of heat generated by the SWD depends on the strength and density of the current.**
5. **A little larger electrode than the part to be treated is used to achieve a uniform electric field through the tissues.**

MODEL OSPE QUESTIONS

1. **A male patient of age 60 nondiabetic, nonhypertensive came to physiotherapy with chronic pain in the right knee. On examination, there was crepitations and X-ray showed degenerated changes. Demonstrate the correct and suitable technique of the SWD for right knee.**

Answers MCQs	1. B	2. B	3. A	4. A	5. A	6. D	7. A

CHAPTER

13

Microwave Diathermy

Learning Objectives: At the end of this chapter, students will be able to learn

1. Definition of MWD and principles of production
2. Physiological effects of MWD
3. Indications and contraindications of MWD
4. Principles of application of MWD.

INTRODUCTION

The wavelength of MWD lies between infrared radiation and shortwave diathermy

- Microwave diathermy is irradiation of the tissues with radiation in the shorter wireless part of the electromagnetic spectrum.
- It has a wavelength between infrared and short wave.
- Radiation with a wavelength of 12.25 cm and frequency of 2450 MHz is frequently used.
- The basic principal function of the application of microwaves to the tissues is to produce a local rise in temperature at the point they are absorbed.

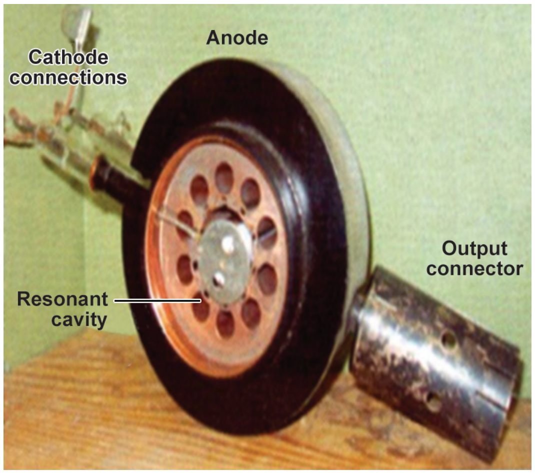
DEFINITION

Microwave diathermy is irradiation of tissues with radiation in the shorter wireless part of electromagnetic spectrum with frequency 2450 MHz and wavelength 12.25 cm.

The therapeutic effects of MWD are same as those of SWD.

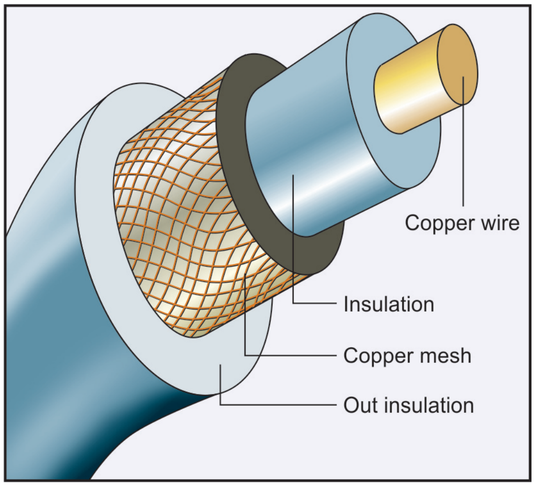
Principles of Production

- The apparatus used to produce microwaves has 3 components:
  i. A multicavity magnetron valve.
  ii. A coaxial cable.
  iii. A director for transmitting the energy to the patient.
- A direct current is shunted to the cathode to anode of magnetron.
- Electrons are released from cathode to anode of magnetron.
- These electrons oscillate within the cavity at a fixed frequency and generate high frequency current.
- The high frequency current is transmitted along a coaxial cable. (A copper core surrounded by copper shield.)
- The coaxial cable transmits the energy and is transmitted to an antenna present inside a reflector.
- The reflector transmits the microwave radiations to the patient.



Magnetron valve

MWD unit



Coaxial cable

MWD gives superficial heating where most energy is absorbed at the surface of the body.
It increases the extensibility of collagen fibres.

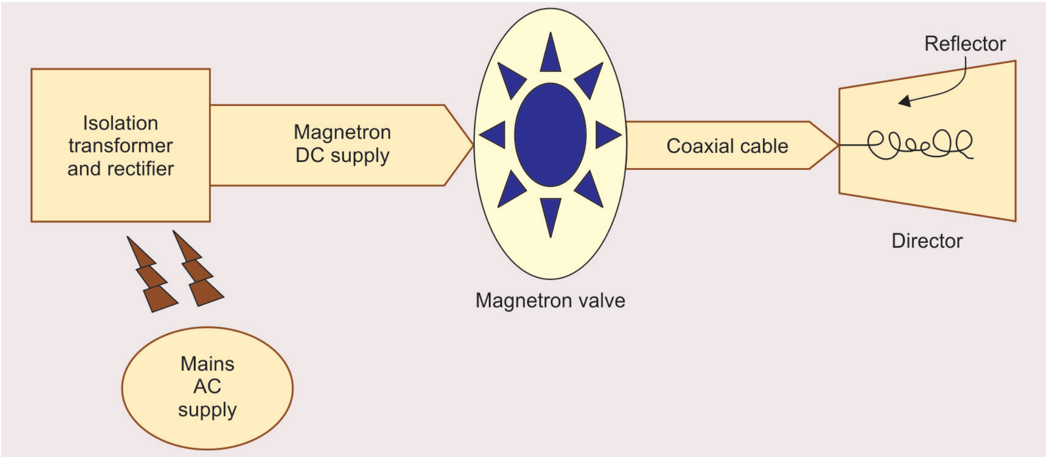


Fig. 13.1: Mechanism of MWD production

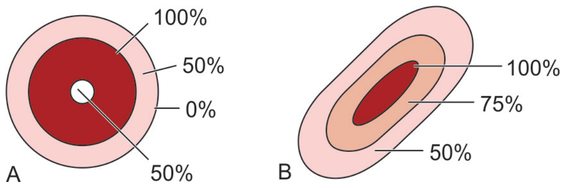


Fig. 13.2: Various reflectors and their energy transmission

Depth of Penetration

- Microwaves penetrate more deeper than infrared rays but less than shortwaves.
- These are less suitable for structures which are more than 3 cm deeper from the surface.
- Microwaves are best absorbed by water, so there is appreciable heating of tissues which have good blood supply, such as muscle and less absorbed in areas like fat.

Physiological Effects

- Thermal effects
  - If applied with sufficient intensity, a sensation of heat and increase in tissue temperature is attained.
  - Vasodilatation, increase in nerve conduction velocity, elevation of pain threshold occurs.
  - It increases enzymatic activity and increases soft tissue extensibility.
- Nonthermal effects
  - Increased microvascular perfusion
  - Altered cell membrane activity
  - Promotes phagocytosis
  - Local tissue oxygenation

Therapeutic Effects

Effects on inflammation

- On application of MWD, there will be vasodilatation of the blood vessels and results in increased supply of oxygen, nutritive materials, antibodies and WBC.
- These effects help to bring about the resolution of the inflammation.

Effects on bacterial infections

- With application of MWD, there will be vasodilatation of the blood vessels and results in increased supply of oxygen, nutritive materials, antibodies and WBC.

Note: In some cases MWD appears to aggravate the condition

Traumatic conditions

- It is proved that MWD can help in promoting the healing, by decreasing the time of healing
- It also reduces pain.

Note: Caution with acute injuries

Effects on Muscular Tissues

- The heating of tissues causes relaxation of muscles, thus MWD may be used to relieve spasms associated with injury and inflammation.
- Heat can also improve the efficiency of the muscle activity.

Indications

- Chronic osteoarthritis
- Mechanical local back pain
- Spondylosis
- Periarthritis
- Sinusitis
- Myofascial pain

Contraindications

- Cardiac pacemakers
- Metal implants
- Altered skin sensitivity
- Patients with epilepsy
- Pregnant uterus
- Unhealed scars and wounds
- Malignancy
- Active tuberculosis
- Venous thrombosis
- Acute sepsis

Dangers

- Burns
- Scalds
- Over dosage

- Damage to eyes
- Electric shock
- Spreading of existing infections
- Metastasis of malignancy

MULTIPLE CHOICE QUESTIONS

1. **What is common therapeutic frequency of MWD?**
   A. 1250 MHz
   B. 2450 MHz
   C. 3290 MHz
   D. 2250 MHz
2. **Which of the following is an indication of MWD?**
   A. Scalds
   B. Acute tuberculosis
   C. Cardiac pacemaker
   D. Periarthritis of shoulder
3. **Which of the following is a contraindication of MWD?**
   A. Metal implant **B.** Acute sepsis
   C. Pacemaker **D.** All of the above
4. **Which of the following is a possible danger of MWD?**
   A. Erythema **B.** Pain relief
   C. Muscle spasm **D.** Metastasis
5. **What is the wavelength of MWD waves?**
   A. 12.25 cm **B.** 22.5 cm
   C. 50 m **D.** 22.75 m

STATE TRUE or FALSE

1. Microwave diathermy has a wavelength between infrared and short wave.
2. Microwaves are not absorbed by water.
3. Microwaves are best absorbed in areas like fat.
4. Microwaves penetrate more deeper than infrared rays but less than shortwave.

FILL IN THE BLANKS

1. Heat can ________ the efficiency of the muscle activity.
2. Microwave diathermy is irradiation of tissues with radiation in the shorter wireless part of electromagnetic spectrum with frequency ________ and wavelength ________.
3. MWD is ________ over metal implants.
4. The basic principle function of the application of microwaves to the tissues is to produce a local ________ in temperature at the point they are absorbed.

Answers MCQs 1. B 2. D 3. D 4. D 5. A

CHAPTER

14

Therapeutic Ultrasound

Learning Objectives: At the end of this chapter, students will be able to learn

1. Definition of ultrasound and principles of production
2. Thermal and nonthermal effects of ultrasound
3. Physiological effects of ultrasound
4. Indications and contraindications of ultrasound
5. Principles of application of ultrasound

INTRODUCTION

- Ultrasound means sound having frequency more than 20,000 Hz
- Human ear can hear within a range of 20–20000 Hz

Fig. 14.1: Direct contact technique of ultrasound

- Methods to generate ultrasound first became available in USA in the 19th century.
- They were used for sound navigation and ranging (SONAR) during World War II to identify the obstacles to the submarines.
- Ultrasound is used in medical imaging technology like viewing the foetus or internal masses by using the pulse-echo technology.
- Therapeutically, ultrasound is found beneficial in heating tissues and are used widely by the physiotherapists.

DEFINITION

- These are mechanical vibrations of sound waves of frequency ranging from 0.7 to 3.3 MHz.
- They can be absorbed by the soft tissues at a depth of 2–5 cm.

Production

The therapeutic ultrasound is produced by ***"reversed Piezoelectric effect".***

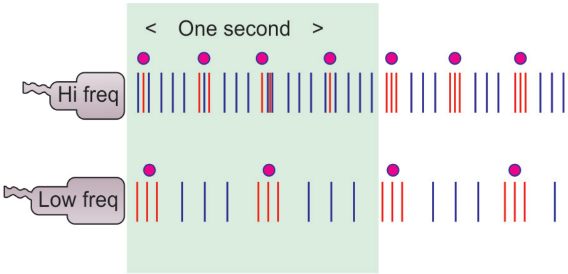


Fig. 14.2: Difference between high and low frequency currents

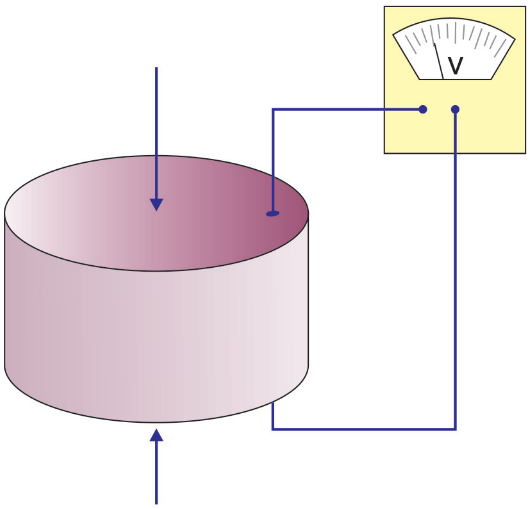


Fig. 14.3: Piezoelectric effect

What is piezoelectric effect?

It means when a piezoelectric crystal is compressed and rarefacted (press and release) causing a stress internally, it produces an electric field.

The therapeutic ultrasound uses a reverse principle, that is, when an alternating current is passed into a piezoelectric crystal, it causes compressions and rarefactions inside the crystal.

- Quartz is used to achieve a high frequency ultrasound energy (piezoelectric crystal).
- To achieve a single frequency of ultrasound, a single frequency of alternating current is passed into the crystal.
- **Pulsed ultrasound is produced when the current is passed in cycles.**

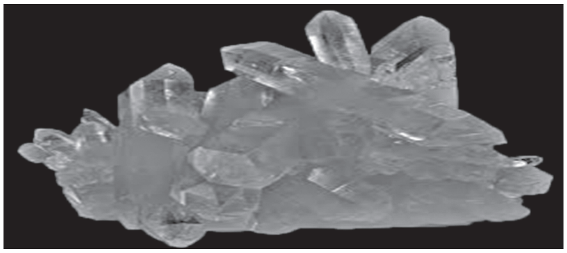


Fig. 14.4: Quartz piezoelectric crystal

- The other important parts of therapeutic ultrasound generator are
  a. Circuit to produce oscillating voltages
  b. Oscillator
  c. Coaxial cable
  d. Transducer

The best ultrasound absorbing tissues in terms of clinical practice are those with high collagen contents: Ligament, tendon, fascia, joint capsule, and scar tissue.

Physiological Effects

The therapeutic ultrasound produces thermal and nonthermal effects.

- Thermal effects
  - Deep tissue heating locally

The tissues with high protein content will absorb ultrasonic waves to a greater extent, thus the tissue with high water content and low protein content absorb a little of ultrasonic energy (e.g. blood and fat)

  - Increases extensibility of connective tissues
  - Decreases joint stiffness
  - Reduces muscle spasm
  - Relieves pain
  - Promotes healing of tissues
- Non-thermal effects
  - *Produces cavitations:* It is formation of tiny gas bubbles in the tissues as a result of ultrasound vibration.
  - These cavitations can be
    - *Stable cavitations:* These bubbles oscillate to and fro and does not collapse.

The tissue with low water content and high protein content will absorb ultrasound far more efficiently

– *Unstable cavitations:* Bubbles increase in volume and collapse rapidly. They can cause gross damage to the tissue.

Acoustic Streaming

- It is unidirectional movement of a fluid in an ultrasound field.
- It stimulates cell activity.
- It increases protein synthesis.
- Accelerates healing of tissues.

Standing Waves

- When an ultrasound wave hits the interface between two tissues of different acoustic impedances, e.g. bone and muscle, reflection of some waves occurs resulting in standing waves.
- These waves can damage the transducer head.
- Therefore, it is important that therapists move the transducer continuously and use lowest intensities to prevent standing waves.

Micro Streaming

- Due to acoustic streaming, an eddy current is formed in the tissues causing the release of free-floating ions and small molecules increasing the cell permeability across the cell membrane.
- Hence this effect enhances nutrient delivery.
- This effect is used for resolution of inflammation, angiogenesis, enhanced and speedy bone healing in fractures.

Micro Massage Effect

- The micro massage effect occurs at cellular level when the cells are alternatively compressed and then pulled further apart.

Fig. 14.5: Cavitations

- The waves of compression and rarefaction may produce a form of micro massage, which could reduce oedema.

Principles of Application

- A number of factors must be considered before using ultrasound.
- Choice of ultrasound machine.
- Coupling medium which is gel like, sterile, hypoallergenic, chemically inert. It is essential for effective transmission of ultrasound.

In transmission of ultrasonic waves through the tissues, it is noted that the greater the difference in impedance at the boundary, the greater the reflection that will occur, and therefore the smaller the amount of energy that will be transferred.

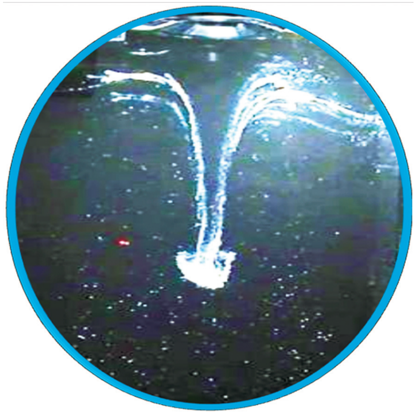


Fig. 14.6: Acoustic streaming

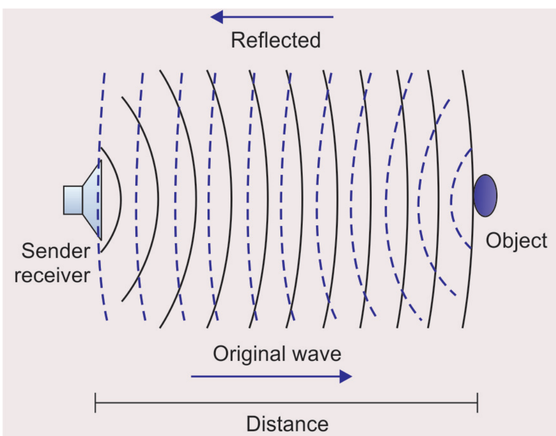


Fig. 14.7: Standing waves

Frequency used

- Intensity applied
- Mode of transmission whether continuous or pulsed.
- Treatment intervals
- Duration of treatment
- Potential hazards to both therapist and patient.

Attenuation of Ultrasound in the Tissues

The loss of energy from the ultrasound beam in the tissues is called *attenuation*.

The attenuation depends on absorption and scattering capabilities of tissue and nature of tissue. The absorption of ultrasound depends on

a. Nature of the tissue and its protein and water composition.
b. Frequency and wavelength of the ultrasound beam.

The scattering depends upon the

a. reflection at interfaces
b. refraction at interfaces.

Indications

- Varicose ulcers
- Dermal ulcers

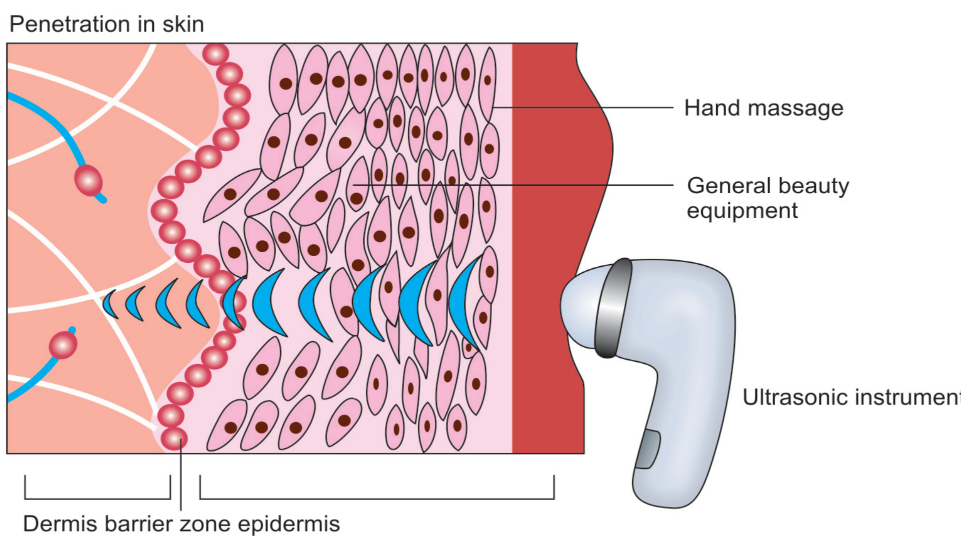


Fig. 14.8: Micro massage effect

- Pain relief
- Acute tissue injuries by pulsed mode
- Mobilization of scar tissue
- Healing of chronic ulcers and wounds
- Ligament injuries
- Neurogenic pains
- Athralgia

Contraindications

- Malignant tumours
- Pregnancy
- Central nervous system tissue
- Joint cement
- Plastic components
- Metal implants
- Pacemaker
- Thrombophlebitis
- Over the eyes
- Reproductive organs
- Acute sepsis

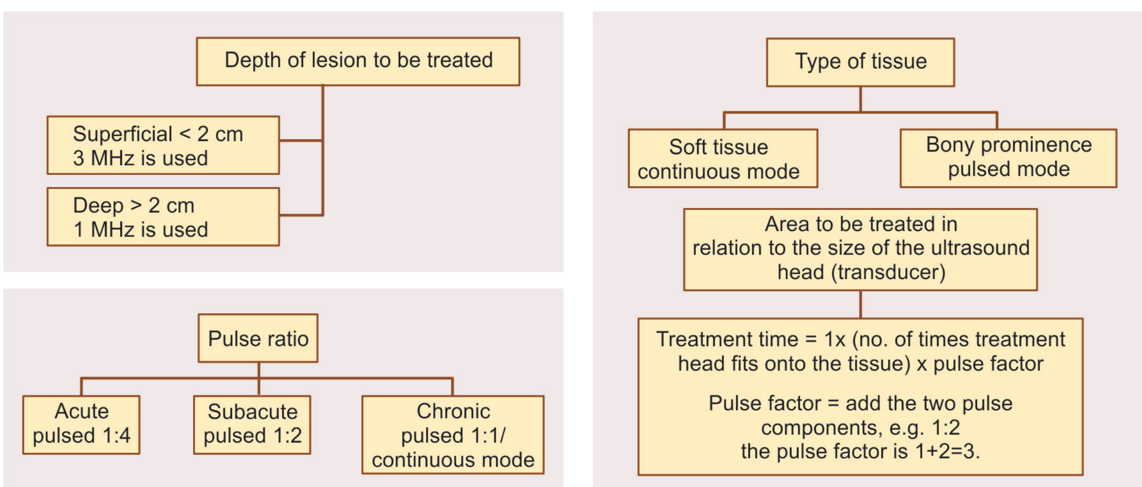
Dosimetry

- Always remember on the bony prominences, pulsed ultrasound is given.
- Always in acute conditions pulsed and in chronic conditions continuous ultrasound is given.
- If chronic and over bony prominence, then pulsed ultrasound mode is selected.

Adverse Effects

- Burn
- Standing waves
- Blood cell stasis
- Blood vessel endothelium damage
- Cross contamination and spread of infections

Condition/Goal	Frequency and intensity	Duration
To increase tissue temperature	1 MHz and 1.5–2.0 W/cm^2 3 MHz and 0.5 W/cm^2	For treatment area 20 cm^2, 5–10 min For 40 cm^2, 10 to 20 min
Nonthermal effects	0.5 MHz and 1.0 W/cm^2	
Acute conditions	0.1 MHz and 0.25 W/cm^2	
Chronic conditions	0.25 MHz and 1.0 W/cm^2	



Dosimetry

Phonophoresis

- It is the movement of medicated molecules through biological membranes by means of ultrasound.
- The effects are due to absorption of drug as well as ultrasound.
- Lower frequencies appear to lead to deeper drug penetration.
- The best results are obtained if the ultrasound is pulsed for the purpose of phonophoresis.

Combination Therapy

- The combination treatment of ultrasound and electrical stimulation has been used for treatment of trigger points and other superficial painful sites.
- In this technique, the ultrasound head acts as an electrode for an electrical stimulating current.

Long Wave Ultrasound

- Therapeutic traditional ultrasound has been used with an output frequency that ranges between 1.0 and 3.3 MHz.
- Long wave ultrasound employs a wavelength ranging 20 to 45 kHz and is used for both deep heating and for phonophoresis.
- The longer wavelength is capable of effective and deep penetration when compared to traditional ultrasound.

DANGERS

(A) Shear waves can be formed which transmit the energy along the periosteal surfaces at right angles when given on the bone surfaces resulting in marked heating at the bone surface. (B) Self-administered abuse. (C) Burns (D) Tissue destruction because of unstable cavitations. (E) Blood cell stasis and endothelial damage because of standing waves.

MULTIPLE CHOICE QUESTIONS

1. The frequency of therapeutic ultrasound is

A. 0.7 to 3.3 MHz **B.** 25–50 MHz
C. 40–50 MHz **D.** 25–50 Hz

2. Which of the following is a Piezoelectric crystal?

A. Quartz **B.** Celenium
C. Titanium **D.** Radium

3. What is the frequency of long wave ultrasound?

A. 0.7 to 3.3 MHz **B.** 20–45 kHz
C. 40–50 MHz **D.** 25–50 Hz

4. The pulse factor in the pulse ratio of 1 : 4 is

A. 4 **B.** 1
C. 5 **D.** 6

5. Which transducer is used for deeper penetrations?

A. 1 MHz **B.** 3 MHz
C. 1 Hz **D.** 1 kHz

Answers MCQs 1. A 2. A 3. B 4. C 5. A

STATE TRUE or FALSE

1. Low intensity pulsed ultrasound produces only thermal effects.
2. Humans can hear sounds with a frequency of above 20,000 Hz.
3. Drugs delivered by phonophoresis become systemic.
4. Attenuation means the decrease in ultrasound intensity as ultrasound travels through tissue.

FILL IN THE BLANKS

1. The process of formation, growth and pulsation of gas-filled bubbles caused by ultrasound is termed _______________.
2. The application of ultrasound with a topical drug to facilitate transdermal drug delivery is known as ____________.
3. The movement of the transducer head throughout the treatment is essential to avoid production of ___________ waves.
4. The cell membrane permeability can be altered by __________effects of ultrasound.

CHAPTER

15

Cold Therapy

Learning Objectives: At the end of this chapter, students will be able to learn

1. Definition of cryotherapy
2. Various physiological effects of cryotherapy
3. Indications and contraindications of cryotherapy
4. Methods of application of cryotherapy for various patients

INTRODUCTION

Application of cold to the tissues after injury is a practice as old as medicine itself. This is also called Cryotherapy. Nowadays local temperature of the tissues may be reduced by the application of various forms of ice or frozen jell packs. Often the skin temperature is reduced to 10°C.

How do you feel when cold is applied?

Here is the sequence of sensations

Intense cold → burning → aching → loss of pain → numbness.

Ice therapy may be used to:

- Reduce pain
- Reduce spasticity
- Reduce muscle spasm
- Reduce swelling
- Promote repair

Cryotherapy: The application of ice to cause local or general body cooling for therapeutic purposes is called cryotherapy.

Effects of Cold

Physiological effects: The physiological effects of cold therapy can be summarized or grouped into nine categories

1. Decreased temperature
2. Tissue destruction
3. Decreased inflammation

Cryokinetics is a technique of improving range of motion, reducing the pain and promoting healing by combining cold and exercise. In this the cold is applied for 20 min or until the client feels numbness followed by stretching or strengthening exercises

4. Decreased metabolism
5. Decreased pain
6. Decreased muscle spasm
7. Increased tissue stiffness

8. Decreased arthrogenic muscle inhibition
9. Circulatory effects.

Decreased temperature

Immediately upon the application of cold, heat begins to move from the tissue into the cold modality, resulting in the decreased body temperature. For treating orthopedic injuries, the tissue is usually cooled to a surface temperature of 1–10°C.

Tissue destruction

Tissue destruction occurs at extreme temperatures –20 to –70°C, such as liquid nitrogen. This cold application is used to remove unwanted tissue, such as warts.

Decreased inflammation

Cold reduces the inflammation in acute injuries due to vasoconstriction and reduced cellular activity.

Decreased metabolism

The decrease in temperature results in decreased tissue metabolism, the more the cooling, the greater decreased metabolism.

Decreased Pain

The pain is reduced by the decreased nerve conduction, and stimulation of cold receptors. Pain is also reduced by the block of inflammatory chemicals like bradykinins and prostaglandins.

Decreased muscle spasm

Muscle spasm is decreased by the cold application by the following mechanisms:

- Decreased nerve conduction
- Breaking the pain-spasm cycle
- Reflex mechanism by the stimulation of sympathetic nerves

Increased tissue stiffness

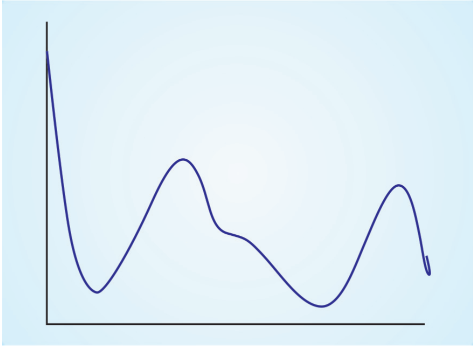
Cooling of tissues causes them to become more stiff and less elastic and more resistant

Decreased arthrogenic muscle inhibition

Arthrogenic muscle inhibition (AMI) is an ongoing reflex inhibition of muscle surrounding a joint, caused by the distension or damage to that joint. By application of cold, it causes reverse inhibition following injury and may facilitate muscular activity to normal levels.

Circulatory effects

- The initial response of the skin to cooling is an attempt to preserve heat, and this is accomplished by an initial local vasoconstriction.
- After a short period there follows a vasodilatation and then alternate periods of constriction and dilatation. This is called "Lewis Hunting reaction".
- The initial phase of vasoconstriction helps to reduce the flow of blood into the tissues following recent injury. This helps to limit swelling and extent of tissue damage.
- The alternate phases of vasoconstriction and vasodilatation help removing the waste products of metabolism like lactic acid and thus delays fatigue.



Lewis Hunting reaction

> When using cryotherapy in controlling inflammation, application of cold should not be longer than 20 minutes.

Therapeutic Effects

The therapeutic effects of cold therapy are:

1. Pain relief: Cold is one of the highly effective physiotherapeutic modalities in relieving pain.
2. Muscle spasm: Cold therapy is effective in relieving muscle spasm.

3. Inflammation: It brings about early resolution of inflammation by reducing vascular or cellular component of inflammation as a result of vasoconstriction.
4. Altering muscle tone: Prolonged ice towels can cause decrease in muscle tone and ice brisk stroking can increase the tone of the muscle.
5. Reduction of warts: Severe cooling of warts by using liquid nitrogen can cause destruction of warts.

Methods of Application

1. Immersion of part in cold water at a temperature of 4°C
2. Ice massage at temperatures of 2°C
3. Evaporation sprays
4. Ice towels
5. Ice packs at temperature of 0–3°C
6. Controlled cold compressions 10–15°C

Fig. 15.1: Techniques of application of cryotherapy

Indications

- Recent injuries (acute)
- Reduction of pain
- Spasticity
- Flaccidity
- Muscle spasm
- All inflammatory conditions
- Chronic oedema
- Chronic joint effusions

Contraindications

- Raynaud's disease
- Raynaud's phenomena
- Burger's disease
- Cryoglobulinaemia
- Regenerating peripheral nerves
- Impaired sensation
- Arteriosclerosis
- Cold utricaria
- Sensory defects

Precautions

Special care is taken in case of

1. Cardiac diseases
2. Hypertension
3. Thick subcutaneous fat
4. Close to superficial nerves
5. Psychologically unstable patients

Dangers

- Severe local cooling can result in hypothermia. It may be a life-threatening situation.
- The patient's having fear of the cold may react adversely. They start producing histamine-like substance causing urticaria with skin rash and itching.
- Cold burns

SHORT ESSAY QUESTIONS

1. **Define cryotherapy. Enumerate the physiological effects of cryotherapy.**
2. **Enumerate the indications and contraindications of cryotherapy.**
3. **List out the precautions and dangers of cryotherapy.**

LONG ESSAY QUESTIONS

1. **Describe the procedure of administration of ice brisk stroking technique for a flaccid muscle.**
2. **Describe the procedure of giving ice bath.**
3. **Describe the procedure of giving ice toweling.**

MULTIPLE CHOICE QUESTIONS

1. **What is the name of the treatment with ice?**

   A. Thermotherapy
   B. Chemotherapy
   C. Cryotherapy
   D. All of the above

2. When Ice is applied there will be alternative vasoconstriction and vasodilatation, this reaction is known as

A. Lewis Hunting reaction
B. Lewis triple response
C. Starling's law
D. Lenz law

3. What happens to body metabolism when there is application of cold?

A. Decreases
B. Increases
C. No change
D. None of the above

4. Which of the following is a contra-indication of cryotherapy?

A. Raynaud's disease
B. Burger's disease
C. Impaired sensation
D. All of the above

5. When a patient having fear of cold, have been applied cryotherapy, his body responds as

A. Utricaria
B. Itching
C. Rashes
D. All of the above

6. When you apply ice to the skin, the immediate effect on the blood vessels is

A. Vasodilatation
B. Vasoconstriction
C. Vasodilatations followed by constriction
D. None of the above

7. When cold is applied, what happens to the oxygen demand of the tissues?

A. Increase
B. Decrease
C. No effect
D. Hypoxia

8. What is the effect of cryotherapy on inflammation?

A. Early resolution
B. Changes acute to chronic
C. Intensive tissue damage
D. All of the above

9. Which of the following techniques is used in cryotherapy ?

A. Ice massage
B. Ice towels
C. Icepacks
D. All of the above

10. Which of the following is a therapeutic use of ICE?

A. Reduce pain
B. Reduce muscle spasm
C. Reduce swelling
D. All of the above

Answers MCQs	1. C	2. A	3. A	4. D	5. D	6. B	7. B	8. D	9. D	10. D

MODEL OSPE QUESTIONS

1. A female patient, who is a teacher, has acute sprain of her left ankle while climbing the stairs. Demonstrate the procedure of ice bath for her.
2. A 20-year-old male football player with injured right knee 2 days ago while playing a football was referred for physiotherapy. His chief complaint was pain around knee with on observation acute inflammation around knee is seen. Perform cryotherapy.
3. A 30-year-old female patient came with left wrist drop after an injection palsy. She is non-diabetic, but hypertensive. Perform the ice brisk stroking for wrist extensors.

STATE TRUE or FALSE

1. Cryotherapy can be used for controlling acute inflammation.
2. Cold increases nerve conduction velocity and thus reduces the pain.
3. Brief application of cryotherapy is thought to facilitate the motor neuron activity.
4. The prophylactic use of cryotherapy after exercise can increase the severity of delayed onset muscle soreness (DOMS).
5. To minimize the oedema formation, cryotherapy should be applied as soon as possible after an acute trauma.

FILL IN THE BLANKS

1. Rapid application of ice as a stimulus to elicit motor patterns (desired) is known as ____________.
2. The technique of use of cold and exercise in combination in management of a disease or pathology is called ___________.
3. The primary or idiopathic form of paroxysmal digital cyanosis is known as ________ disease.
4. ________ units alternatively pump cold water and air into a sleeve that is wrapped around a patient's limb.
5. When cold applied for longer periods until the tissue reaches a temperature of 10°C, then cold induced ________occur.

CHAPTER

16

Contrast Bath Therapy

Learning Objectives: At the end of this chapter, students will be able to learn

1. Definition and principles of contrast bath.
2. Indications and contraindications of contrast bath.
3. Physiological and therapeutic effects of contrast bath.
4. Technique of application of contrast bath.

INTRODUCTION

Contrast bath is a technique that applies alternative hot and cold to an area. A lot of researches have proved the efficiency of the contrast baths. A lot of evidences through research are available that contrast bath may increase superficial blood flow and skin temperature.

DEFINITION

Contrast bath therapy, also known as "hot/cold immersion therapy" is a form of treatment where a limb or the entire body is immersed in ice water followed by the immediate immersion of the limb or body in warm or hot water. This procedure is repeated several times, altering hot and cold.

This causes alternate contraction and dilation of blood vessels, which increase blood flow, white blood cell activity, and the oxidation process to speed up healing.

"This treatment is based on the principle that by alternate vasoconstriction and vasodilatation of the blood vessels, by the contrasting application of heat and cold, the circulation is improved and the removal of waste products is hastened."

INDICATIONS

1. Congestive headaches
2. Infections (a protocol of 2–6 times per day stimulate local defense mechanisms against infection)
3. Sprains, strains and other traumas
4. Poor circulation, congestions, ulcers
5. Osteoarthritis
6. They are also used in the psychiatric conditions like delirium, agitation, insomnia, gastrointestinal disturbances and pain syndromes.

Fig. 16.1: Contrast bath in clinical setup

Fig. 16.2: Contrast bath

CONTRAINDICATIONS

- *Ischaemia—e.g. arterial insufficiency*
- *Bleeding disorders (e.g. hemophilia),*
- *Haemorrhage—there is an increased arterial and capillary blood flow with heat*

Physiologic and therapeutic effects
- Decreased pain and oedema
- Decreased Inflammation
- Increased mobility and flexibility

- Impaired sensation
- *Uncooperative patients*
- *Malignancy—may increase tumour growth*
- *Acute trauma or inflammation.*
- *Scar tissue—elevation of temperature increases the metabolic demand of the tissue. Scar tissue has inadequate vascular supply, and is not able to provide an adequate vascular response when heated, which can lead to ischaemic necrosis.*
- *Atrophic skin*
- *Impaired thermal regulation.*

Physiology of Working

- The theory behind the use of contrast baths in physical therapy is that the rapid change from warm to cold helps to quickly open up and close the tiny capillaries in the body.
- Warmth causes these small arteries to open; cold causes them to close.
- The rapid opening and closing of the arteries near the site of the injury creates a pumping action.
- This pumping is thought to help decrease swelling and inflammation around the injured area.
- By decreasing the swelling and inflammation, pain can be reduced and improved mobility can be achieved.

Physiological and Therapeutic Effects

- Decrease pain: When alternating heat and cold is applied, this varying sensory stimulus promotes pain relief and desensitization.
- Decrease oedema: Alternating heat and cold causes alternating vasodilatation and vasoconstriction of the blood vessels which cause a pumping effect and relieves oedema.
- Control inflammation: Application of contrast bath relieves inflammation in conditions like sprains, strains or tendinitis by alternative vasoconstriction and vasodilatation.
- Improve mobility and flexibility: The application of hot and cold improves the flexibility of muscles by promoting relaxation and alternating the spasm cycle.

LONG ESSAY QUESTIONS

1. **Define contrast bath therapy. Describe the procedure of giving contrast bath.**
2. **Discuss briefly the physiology of working of contrast bath.**

SHORT ESSAY QUESTIONS

1. **Define contrast bath. List out the indications and contraindications of contrast bath.**

MULTIPLE CHOICE QUESTIONS

1. **What is the hot and cold immersion therapy also known as?**
   A. Wax bath **B.** Contrast bath
   C. Cryotherapy **D.** Thermotherapy
2. **What is the temperature used in hot tub for contrast bath?**
   A. 98–110°F **B.** 90–200°F
   C. 45–70°F **D.** 70–100°C
3. **What is the temperature used in cold tub for the contrast bath?**
   A. 50–60°F **B.** 90–200°F
   C. 45–70°F **D.** 70–100°C
4. **Which of the following is a contraindication for contrast bath?**
   A. Acute trauma
   B. Ischaemia
   C. Malignancy
   D. All of the above
5. **Which of the following is a therapeutic effects of the contrast bath?**
   A. Decrease pain
   B. Decrease swelling
   C. Decrease inflammation
   D. All of the above

MODEL OSPE QUESTION

1. **Demonstrate the technique of giving contrast bath for a patient with sprain of deltoid ligament of right foot.**

Answers MCQs 1. B 2. A 3. A 4. D 5. D

CHAPTER 17

LASERS

Learning Objectives: At the end of this chapter, students will be able to learn

1. Definition of laser and classification
2. Principles of production of laser
3. Physiological effects of lasers
4. Technique of application
5. Indications and contraindications of laser therapy

Low intensity laser therapy promotes the restoration of normal cellular function, regeneration of damaged cells and enhancement of the body healing processes.

INTRODUCTION AND HISTORY

- Albert Einstein—1st described this theory that was transformed into laser therapy
- By the end of the 1960s, Endre Mester (Hungary)—was reporting on wound healing through laser therapy.
- In early 1960s, the 1st low level laser was developed.
- In February 2002, the MicroLight 830 (ML830) received FDA approval for Carpal Tunnel Syndrome Treatment (research treatment).
- Laser therapy has been studied in Europe for past 25–30 years; US 15–20 years.

Definition

- LASER is an acronym for Light amplification by the stimulated emission of radiation.
- It refers to the production of a beam of radiation which differs from ordinary light in many ways.

Production

- Components of a generator:
  - Power supply–electrical power supply that can deliver up to 10,000 volts and 100 amps
  - Lasing medium—gas, solid, liquid
  - Pumping device–high voltage, photo-flash lamps, radio-frequency oscillators or other lasers (pumping is used to describe the process of elevating an orbiting electron to a higher, excited energy level)
  - Optical resonant cavity—contains lasing medium
- The original clinical lasers used vacuum tube technology, a gas filled in the glass tube with semi-mirror ends.

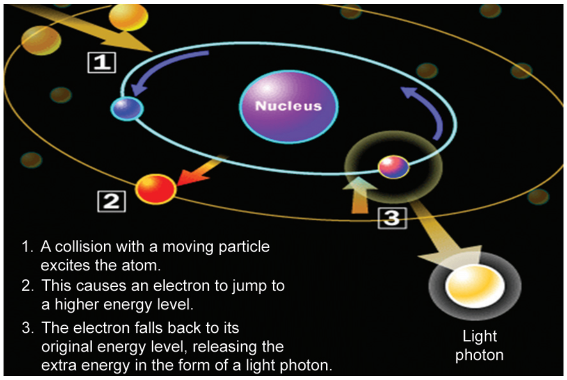


Fig. 17.1: LASER production

- When an electricity is passed into this tube, it causes the electrons of the gas to jump up to a higher energy level.
- Later they fall back to the normal levels
- When they fall back, the difference in the energy levels will be emitted in the form of photons
- As the photons move back and front in the glass mirror tube, from one end to the other, they excite another atom, and two more identical photons are released and the process continues, where many photons are released.
- When sufficient photons are released, this forms a strong light which is having single wavelength and colour and thus escapes from the semimirror end of the tube as LASER light.
- Today, therapeutic light sources use a photodiode, instead of gas tubes.
- Photodiodes use two layers of semiconductors, one layer with P-type material and one with N-type material.
- When electrons are released from P type to N type, photons are released with various frequencies, if the photodiode has mirror ends, then they can be engineered to produce monochromatic laser light.

Physical Properties of Lasers

- Monochromaticity: Lasers are of specific wavelength and hence of a definite frequency. In case of visible lasers, a single pure colour is produced, e.g. Ruby lasers give red light.
- Coherence: Laser radiation is not only of the same wavelength but also in the same phase.
- Collimation: As a consequence of spatial coherence, lasers remain in a parallel beam.
- Microdot focusing: The property of lasers to get focused at a single point.
- Pulsed: This property of laser to give discontinuous beams at regular intervals.

They also exhibit general properties of light like

- Refraction
- Reflection
- Absorption

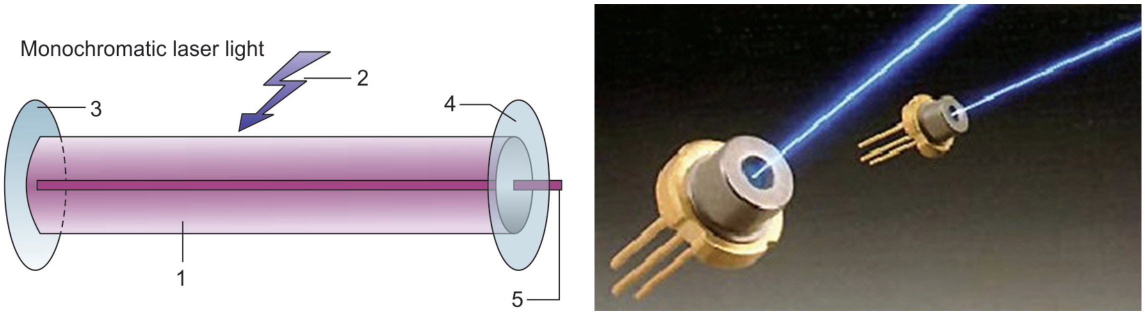


Fig. 17.2: Vacuum tube and LASER diode

Classification of Lasers

Classification	Type
According to emitting mode	• Continuous • Pulsed
According to power	• High power lasers • Medium power lasers • Soft lasers
According to wavelength	• Ruby: 694.3 nm • He-neon: 632.8 nm • Argon: 476.5 to 514.5 nm • Kryptonin: 476.1 to 647 nm

Classified by the FDA's Center for Devices and Radiological Health based on the Accessible Emission Limit.

Class levels 1–4

- 1 = incapable of producing damaging radiation levels (laser printers and CD players).
- 2 = low-power visible lasers (400–700 nm wavelength, 1 mW).
- 3 = medium-power lasers—needs eye protection
  - 3a–up to 5 mW
  - 3b–5 mW–500 mW
- 4 = high-power lasers—presents fire hazard (exceeds 500 mW).

Physiological Effects

- Laser light waves penetrate the skin with no heating effect, no damage to skin and no side effects.
- Laser light directs biostimulative light energy to the body's cells which convert into chemical energy to promote natural healing and pain relief.
- Optimizes the immune responses of blood and has anti-inflammatory and immuno-suppressive effects.
- Biostimulation—improved metabolism, increase of cell metabolism.
- Increases speed, quality and tensile strength of tissue repair.
- Improved blood circulation and vasodilation.
- Increases blood supply.
- Increases ATP production.
- Analgesic effect.
- Relieves acute/chronic pain.
- Anti-inflammatory and anti-oedematous effects.
- Reduces inflammation and relieves oedema.
- Stimulation of wound healing.
- Promotes faster wound healing/clot formation.
- Helps generate new and healthy cells and tissue.
- Increases collagen production
- Develops collagen and muscle tissue
- Increases macrophage activity
- Stimulates immune system
- Alters nerve conduction velocity
- Stimulates nerve function

Indications

- Soft tissue injuries
- Fractures
- Osteoarthritis, rheumatoid arthritis
- Pain
- Wounds and ulcers
- Acupuncture

Contraindications

- Application over eyes.
- Possibly can damage cellular structure or DNA.
- Cancerous growths.
- Pregnancy—over and around uterus.
- Over cardiac region and vagus nerve.
- Growth plates in children.

- Over and around thyroid gland and endocrine glands.
- Patients who have been pre-treated with one or more photosensitizers.

MULTIPLE CHOICE QUESTIONS

1. **Laser have the following effects**
   A. Analgesic
   B. Anti-inflammatory
   C. Anti-oedematous
   D. All of the above
2. **Laser light penetrates the skin with**
   A. Heating effect
   B. No heating effect
   C. Both
   D. None
3. **Laser is classified according to**
   A. Emitting mode
   B. Power
   C. Wavelength
   D. All of the above
4. **Physical properties of laser are**
   A. Monochromatocity
   B. Coherence
   C. Collimation
   D. All of the above

STATE TRUE or FALSE

1. **Light with the longer wavelength penetrates more deeply than light with shorter wavelength.**
2. **Laser can be used in case of malignancy.**
3. **Laser can be used immediately after radiotherapy.**
4. **Chromophores are light absorbing parts of a molecule that gives it colour.**

FILL IN THE BLANKS

1. **Electromagnetic radiation is composed of ______________ and ______________ fields.**
2. **Laser light has unique features of____________, ____________ and ____________.**
3. **LASER stands for ______________.**

Answers MCQs 1. D 2. B 3. D 4. D

CHAPTER

18

Ultraviolet Therapy

Learning Objectives: At the end of this chapter, students will be able to learn

1. Define UVR therapy and describe the production of UVR therapy
2. Discuss briefly about the physiological and therapeutic effects of UVR therapy
3. Enumerate the indications and contraindications of UVR therapy
4. Demonstrate the skills on application of UVR therapy for various clinical conditions

INTRODUCTION

UVR therapy was first started by the work of Danish physician Neils Finsen. Ultraviolet radiation is electromagnetic radiation with a frequency range of 7.5×10^{14} to 10^{15} Hz and wavelengths from 400 to below 290 nm. The frequency of UV radiations lies between that of X-rays and visible light.

WAVELENGTHS OF UVR

The ultraviolet radiation is divided into three bands: UVA, UVB and UVC. The wavelengths

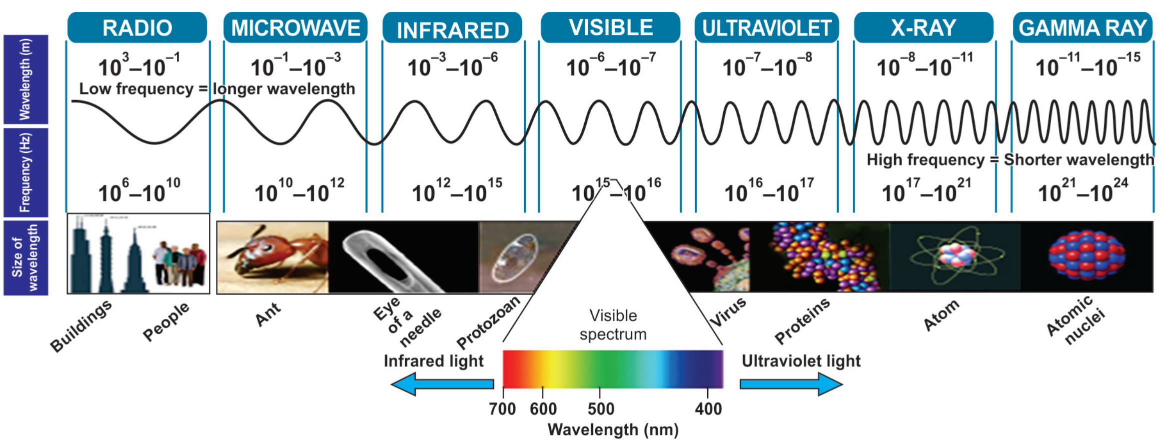


Fig. 18.1: Electromagnetic spectrum

of these radiations are described in the table below

Rays	Wavelength
UVA	315–400 nm
UVB	280–315 nm
UVC	Below 280 nm

UVA also known as long wave UV, produces fluorescence in many substances. UVB also known as middle wave UV, produces the most skin erythema. UVC or short wave UV is germicidal in effect.

> The most important source of ultraviolet radiation is sun, It emits broad spectrum UV rays which include UVA, UVB, UVC. UVA and UVB rays directly reach the earth while UVC is filtered by ozone.

PHYSICAL PROPERTIES OF UVR

UV rays are just beyond visible light at shorter wavelengths than the last visible ray which is violet. These rays are part of the electromagnetic spectrum.

UV rays do not produce heat, hence the physiological effects it produces is believed to be because of the non-thermal effects of the UV radiations.

The physiological effects of UV radiations depend upon wavelength of the radiation and intensity of radiation and depth of penetration.

The depth of penetration depends upon wavelength of UV rays, power of source of UV rays, size of the area treated and intensity of radiation.

The intensity of UV radiations is proportional to the power output of the lamp, the inverse square of the distance of lamp and penetration, and the cosine of the angle of incidence of the radiation beam with the tissue.

> Penetration of UVR is deepest with high intensity, longest wavelengths and lowest frequency. The penetration of UVR is less if the skin is thicker or darker.

PRODUCTION OF UVR

The UVR generators commonly used for therapeutic purposes are

- High pressure mercury vapour burner
- Kromayer lamp
- Theraktin tunnel
- PUVA apparatus

High Pressure Mercury Vapour Burner

1. It consists of a 'U'-shaped tube made up of quartz which can withstand high temperatures.
2. The tube is filled with Argon gas at lower temperatures with small quantity of mercury enclosed in the tube.
3. At both ends of the tube, elecrodes enclosed by metal caps are present across which a high potential difference is allowed in order to ionize the gas.
4. UVR radiation is produced by the recombination of electrons and positive mercury ions and the photons released when excited electrons return from higher energy level to normal level within the mercury atoms.

Kromayer Lamp

1. It is a medium pressure vapour ultraviolet lamp designed tube used in contact with the tissues.
2. The emitting tube is enclosed in a water jacket which cools it and filters infrared and allowing UVR and visible light.
3. The entire set up is enclosed in a jacket of circulating distilled water
4. A pump and cooling fan are incorporated into the body of Kromayer lamp.

Theraktin Tunnel

1. It is a semi-cylindrical frame in which four fluorescent tubes are present
2. Each tube is mounted in its own reflector

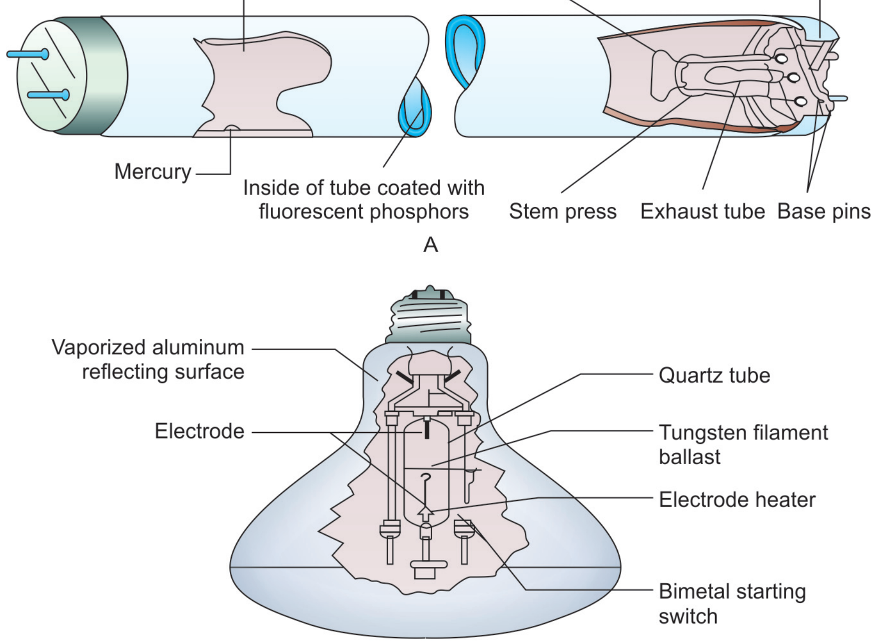


Fig. 18.2: UVR lamp

3. Fluorescent tubes here emit UV rays with a spectrum of 280–400 nm.

PUVA Apparatus

1. It is a special apparatus which emits UVA radiations.
2. Special fluorescent tubes, which may be mounted in a vertical battery on a wall, or on four sides of a box totally surrounding the patient, are present
3. The UVA radiations are given along with a photosensitizing agent called Psoralen.

PHYSIOLOGICAL EFFECTS

Erythema: UVR exposure results in erythema or redness of the skin due to vasodilatation of superficial dermal blood vessels.

Tanning: UVR exposure results in the delayed pigmentation of the skin known as tanning. It is due to melanin pigmentation. Depending upon the tanning nature, we classify the skin as

Group	Tanning
Group 1	Always burn, never tan
Group 2	Always burn, sometimes tan
Group 3	Sometimes burn, always tan
Group 4	Never burn, always tan

Hyperplasia: Prolonged exposure results in epidermal thickening called hyperplasia. Hyperopia occur around 72 hours of exposure.

Synthesis of Vitamin D: The skin absorbs UVB radiation in sunlight for production of vitamin D.

Ageing of skin: Prolonged, chronic exposure of skin to UV rays can result in premature ageing of skin. The skin becomes dry, coarse, leathery with wrinkling.

Carcinogenic effect: Exposure to UVR is considered to cause cancer of skin. The common skin cancers are:

- Basal cell carcinoma, squamous cell carcinoma, malignant melanoma
- *Effect on eyes:* The acute effects of exposure to UVC and UVB radiation are primarily conjunctivitis and photokeratitis. UVB radiations can predispose cataract resulting impartial or complete loss of transparency of lens.

THERAPEUTIC EFFECTS OF UVR

The principle therapeutic uses of UVR are of **skin diseases.**

1. Psoriasis

It is a skin condition which presents localized **thick pink/red** plaques, sharply demarcated and covered with **silvery scales**. In this state the aim of UVR irradiation is to decrease the DNA synthesis in the cells of the skin and to improve the skin condition.

2. Acne Vulgaris

Acne is also a skin condition which presents **pustules, papules** formed by blocking of sebaceous pores and hair follicles affecting mainly the face, chest and back. The more severe and long-lasting forms cause disfiguring and serious distress. Using UVR is aiming to produce desquamation to open the blocked pores and hair follicles. E2 dose is given to the face, chest and neck.

3. Eczema

It is an **inflammatory response** in the skin associated with **oedema**. The patient suffers marked **itching** with **redness, scaling, vesicles** and exudation of serum on the skin. A mild UVR treatment will help (subacute and chronic stage).

4. Chronic Infections and Infected Wounds

Infected wounds such as **ulcers, pressure sores, surgical incisions** are often treated with **high doses** of UVR. The aim of UVR irradiation is to destroy the surface bacteria, remove the (**slough**) infected material and promote repair. E3 dose is sufficient, the dose may be given daily and is not being applied to normal skin.

5. Vitiligo

It is a condition in which destruction of **melanocytes** in local areas causes **white patches** to appear on the skin. Both UVA and UVB stimulate melanocyte activity. UVA seems to provoke a **darker and longer lasting tanning**. UVB provokes more **thickenning**.

CONTRAINDICATIONS OF UVR

- Porphyrias
- Pellagra
- Sarcoidosis
- Xeroderma pigmentosum
- Acute psoriasis
- Renal and hepatic insufficiencies
- Hyperthyroidism
- Generalized dermatitis
- Advanced arteriosclerosis
- Acute eczema
- Herpes simplex
- Hypersensitivity to sunlight
- Known photosensitivity
- Photosensitizing medication
- Deep X-ray therapy
- Acute febrile illness
- Recent skin grafts

DANGERS OF UVR

1. Shock
2. Eyes: UVR may produce conjunctivitis, iritis or cataract.
3. Over dosage: UVR burn can occur. Mainly E4 reaction.
4. Ozone: Important to ensure adequate ventilation in the area.

MULTIPLE CHOICE QUESTIONS

1. UVR therapy was first started by

A. Neils Finsen
B. Madam Curie
C. Galvani
D. None

2. The wavelength of UVR is

A. 600–800 nm
B. 400–290 nm
C. 800–1000 nm
D. Below 200 nm

3. Which technique is used for treating psoriasis?

A. UVB **B.** UVC
C. PUVA **D.** All of the above

4. The physiological effects of UVR is based on

A. Thermal effects
B. Non-thermal effects
C. Both A and B
D. None

Answers MCQs	1. A	2. B	3. C	4. B