TRATTAMENTI FISIOTERAPICI E STRUMENTALI (ULTRASUONI, RADIOFREQUENZA, MICROONDE)

LA TERAPIA STRUMENTALE

PRINCIPALI METODICHE PER LA TERAPIA FISICA

- Therapy by mechanical treatment
- Non-electric thermotherapy – (heating and cooling, hydrotherapy)
- Electrotherapy
- Ultrasound therapy
- Magnetotherapy
- Phototherapy

Appendix: safety aspects of use of electric currents

THERAPY BY MECHANICAL TREATMENT

Massages – manual or instrumental

Changes in blood circulation, muscular relaxation

Rehabilitative exercises

increase of body strength and mobility, psychical effects, improvement of body posture

TERMOTERAPIA

THERMOTHERAPY

The application of heat is (from biophysical point of view) an intervention in the body thermoregulation. Heat can be delivered to the organism (**positive thermotherapy)**, or taken away from the organism **(negative thermotherapy)**. The body response depends on:

- **the way of application -** heat conduction, convection or radiation (see electrotherapy and phototherapy)
- **the intensity, penetration ability and duration of the heat stimulus**. Non electric thermotherapy causes mainly changes of body surface temperature (to depths of 2 - 3 cm), with electrotherapy we can heat deeper tissues.
- **the size and geometry of the application area** in the case of **local application**: The tissue temperature increases when the heat input from outside exceeds the heat output. Cylindrical body parts are heated faster when the radius is small. Considering only conduction, the **resistance to heat flow** increases linearly with the thickness of tissue layers. In cylindrically shaped tissues it increases non-linearly.
- **the patient's health (ability of thermoregulation)**.

THERMOTHERAPY

The following **sources** of heat are used in thermotherapy:

a) **Internal** (heat produced by the organism itself).

b) **External.** Considering the origin and transfer of heat, the thermotherapeutic methods can be divided into five main groups based on:

- heat conduction
- heat convection
- radiation
- high-frequency electric currents
- thermal action of ultrasound

HEAT CONDUCTION

- Mainly **packs and compresses.** According to the extent of the covered body part, they can be total or partial, according to the temperature **hot, indifferent** or **cold**, and also wet or dry.
- The compresses can be dry (blankets, bottles), peloids (mud) and paraffin. Their temperature ranges from 45 to 55 ºC in dry compresses up to 60 - 77 ºC in paraffin compresses.

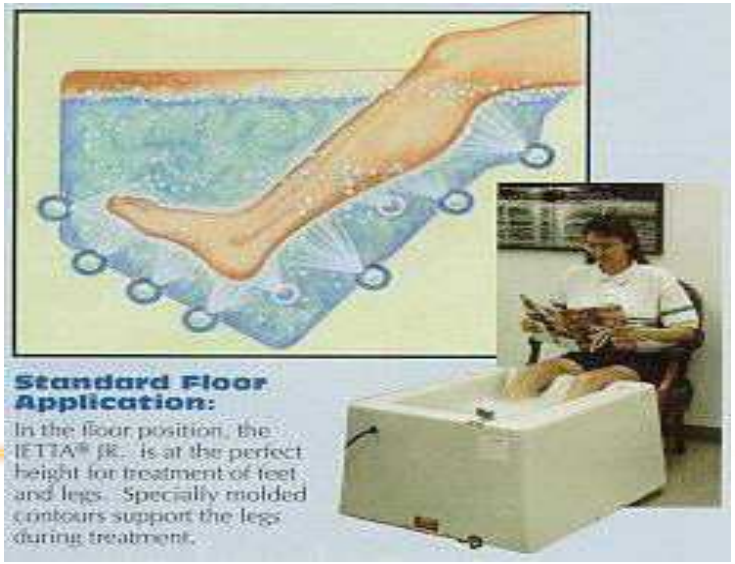
HEAT CONVECTION – HYDROTHERAPY

- **hydrotherapy** encompasses, besides heat effects, also mechanical action (buoyancy, hydrostatic pressure, impacts of water streams, water movement). It acts mainly on the cardiovascular system, vegetative nerves and psychology. Heat helps muscles to relax, reduces pain, accelerates resorption of oedemas. The procedures differ from each other in the **way of heat transfer**, in the **ratio of conduction and convection**, and in the degree of **homogeneity** of heat flux:
- **cold** (less than 18 °C), **cool** (18 – 24 °C), **tepid** (24 – 33 °C), **warm** (33 – 36 °C) or **hot** (37 – 42 °C).
- **Or: hypothermic** (10 - 34 °C, 5 min.), **isothermal** (34 - 36°C, 20 - 30 min), **hyperthermic** (37 - 42°C, short duration).
- The effect of the whole-body bath is given mainly by the surface body temperature. After immersion, the body surface is exposed to the actual medium temperature until thermal equilibrium is formed in several millimetres thick water layer, and the **effective bath temperature** starts to act**.** Disturbing the layer prevents stabilisation of the effective temperature, that is why the patient should not move during the bath.

WHIRLING BATHS, UNDERWATER MASSAGES, HOT AND COLD WATER JETS

Alternative application of sharp hot and cold water jets – a method with outstanding activation effect.

For upper and lower limbs moderately hyperthermic – increasing blood supply and metabolism, skin receptors activated



SAUNA

Effects of hot (80 - 100°C) air of low relative humidity (10-30%) are utilised, followed by cooling in cold water. Outstanding tonic action.

ELETTROTERAPIA

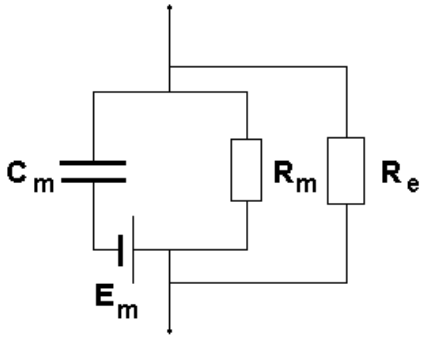
ELECTROTHERAPY

Electrotherapeutic methods utilise

- Direct electric current (galvanotherapy, iontophoresis)
- Low-frequency alternating current or short impulses of direct current (stimulation)
- High-frequency alternating current (diathermy)
- High frequency electromagnetic radiation

In this section we will deal also with the safety aspects of electric current.

CONDUCTION OF ELECTRIC CURRENTS IN TISSUES



- Passage of electric current through human body obeys the Kirchhoff's laws. Tissue resistance varies. The **ions** are current carriers.
- We can distinguish two types of tissue electric conductivity. Cytoplasm and intercellular medium behaves like conductors whose resistance does not depend on frequency. Membrane structures have properties of capacitors, i.e. their **impedance** *Z* depends on frequency:

$$Z = \sqrt{R^2 + X_C^2}$$

RESISTIVITY (P) OF TISSUES

Tissue	resistivity $[\Omega m]$
cytoplasm	1
body fluids	0,8 - 1,3
muscle tissue	3
parenchymatous organs	4 - 6
fat tissue	10 - 15
bone tissue	30

$$R = \rho \cdot \frac{l}{S} \Rightarrow \rho = \frac{R \cdot S}{l} [\Omega \cdot m]$$

TISSUE POLARISATION

- The electric charges present in tissues are not always free, they are often bound to macromolecules which are an integral part of cellular structures and their mobility is limited. The macromolecules behave like **electric dipoles –** variously oriented – their dipole moments are mutually compensated.
- The electric dipoles are **oriented** according to the direction of the outer electric field when it is present – their **polarisation** occurs. So an inner electric field of opposite polarity arises, and the intensity of the outer electric field is **lowered**. This turning of polar molecules gives rise to the so-called **displacement current**. **Permittivity** ε is a measure of this ability.

EFFECTS OF DIRECT ELECTRIC CURRENT (GALVANOTHERAPY, IONTOPHORESIS)

- Continuous direct current (DC) does not stimulate, but can change conditions for that. This effect of DC is called **electrotonus** and is used in galvanotherapy.

  - Around cathode (-) an increase of stimulation of motor nerves occurs = **catelektrotonus**.
  - Around anode (+) a decrease of stimulation of sensitive nerves occurs = **anelectrotonus**.
  - Application in electrotherapy.

- Electrokinetic phenomena **–** movement of ions or solvent in electric field – iontophoresis – ions are transported inside the body.

LA RADIOFREQUENZA

LA RADIOFREQUENZA

La metodica

- non invasiva
- non dolorosa
- contrasta efficacemente i segni dell'invecchiamento cutaneo
- consente di ottenere un duraturo miglioramento della qualità della pelle del corpo e del viso
- attenua con una certa stabilità i principali inestetismi come le rughe o le lassità.

Viene applicata anche per trattare in maniera efficace gli inestetismi della pelle causati dalla cellulite

EFFETTI TERMICI

- Si basa sul concetto di far scorrere correnti a RF attraverso il corpo o una parte di esso concentrandole in corrispondenza di un elettrodo "caldo" di piccole dimensioni (funzionamento monopolare)

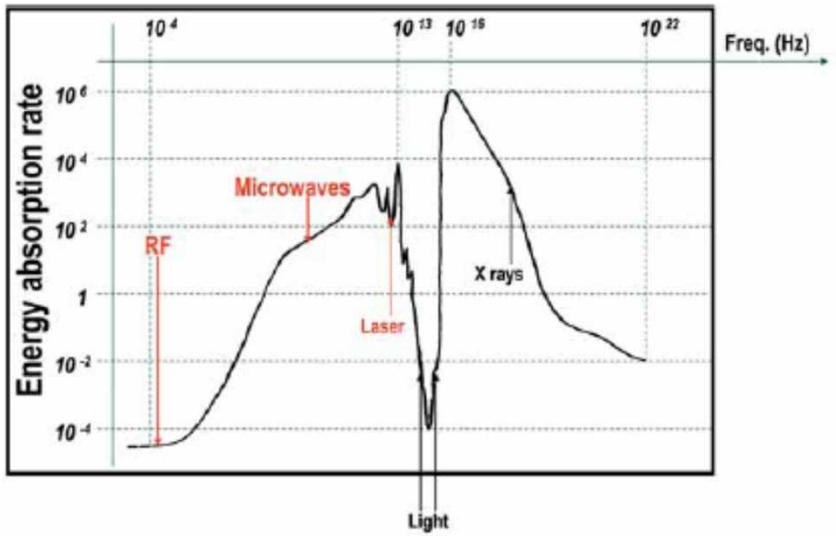
- Il calore, e quindi l'innalzamento di temperatura si produce per effetto Joule laddove la densità di corrente RF è più forte (spigoli, discontinuità)

- Per il monopolare è necessario un secondo elettrodo di drenaggio "freddo" di grandi dimensioni per la richiusura delle correnti a RF

- Deve essere assicurato un buon contatto ohmico o capacitivo degli elettrodi con l'epidermide

IPERTERMIA A RF

- Si basa sul concetto di far scorrere correnti a RadioFrequenza attraverso il corpo o una parte di esso (corrente elettrica alternata ad alta frequenza/fra 1 e 6 MHz)
  - Il calore, e quindi l'innalzamento di temperatura si produce per effetto Joule laddove la densità di corrente RF è più forte (spigoli, discontinuità)
    - Il calore è legato alla resistenza che viene opposta dai tessuti attraversati dalla corrente
  - Deve essere assicurato un buon contatto ohmico o capacitivo degli elettrodi con l'epidermide



MONOPOLARE (TECAR) O BIPOLARE

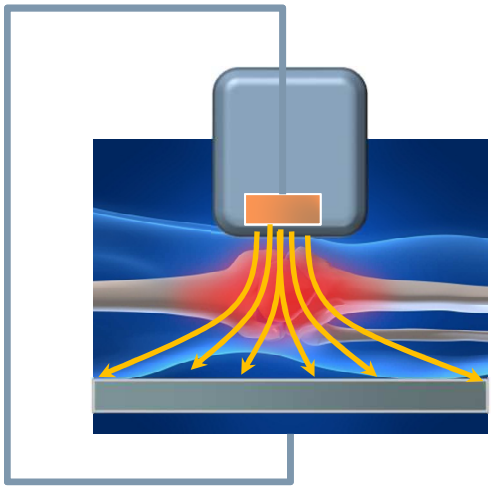
Penetra nel derma a tutto spessore e, percorrendo i setti fibrosi dell'ipoderma, giunge fino alla fascia muscolare superficiale,

- **MONOPOLARE:**
  concentrandole in corrispondenza di un elettrodo "caldo" di piccole dimensioni (funzionamento monopolare)
  - Per il monopolare è necessario un secondo elettrodo di drenaggio "freddo" di grandi dimensioni per la richiusura delle correnti a RF
- **BIPOLARE**
  - Nel caso bipolare i due elettrodi sono incorporati all'interno del manipolo

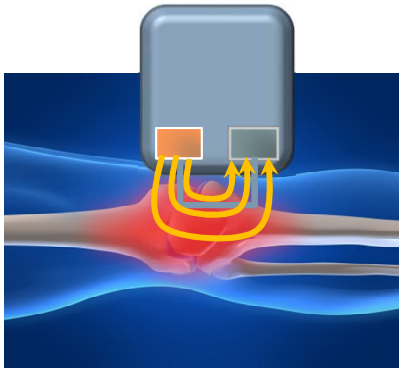
Rimanendo più in superficie non raggiunge, con una temperatura clinicamente efficace, gli strati profondi del derma e i setti fibrosi.

La profondità di penetrazione della RF viene considerata come circa la metà della distanza tra I due elettrodi
Es. elettrodi a distanza di 4 cm, target distance di 20 mm a bassa frequenza

Monopolare



Bipolare



IPERTERMIA A RF MONOPOLARE (TECAR)

- Si basa sul concetto di far scorrere correnti a RF attraverso il corpo o una parte di esso concentrandole in corrispondenza di un elettrodo "caldo" di piccole dimensioni (funzionamento monopolare)

- Il calore, e quindi l'innalzamento di temperatura si produce per effetto Joule laddove la densità di corrente RF è più forte (spigoli, discontinuità)

- Per il monopolare è necessario un secondo elettrodo di drenaggio "freddo" di grandi dimensioni per la richiusura delle correnti a RF

- Deve essere assicurato un buon contatto ohmico o capacitivo degli elettrodi con l'epidermide

THERMAL EFFECTS OF HIGH FREQUENCY (HF) CURRENTS

- Mechanism of the HF currents action is based on transformation of the absorbed electric energy into heat *Q* according to Joule's law:

$$Q = U.I.t$$

where *U* is voltage, *t* is the time of current *I* passage. This mechanism of heat production depends on the way of HF currents application.

  - **Dielectric heating** (due to dielectric losses) takes place when applying currents by means of a capacitor field.
  - When using induction fields, heat is produced by the so called **eddy currents**.

UTILISATION OF HIGH-FREQUENCY (HF) ELECTRIC CURRENTS

- In the case of alternating electric HF currents (>100kHz), the heat effects dominate totally. The heat originates directly in tissues due to dielectric heating, eddy currents or absorption of electromagnetic energy.

- For HF therapy, international agreements specified the following frequencies:

  - **Short-wave diathermy** (27.12 MHz, i.e. wavelength of 11.06 m),
  - **Ultra-short-wave diathermy** 433.92 MHz (69 cm),
  - **Microwave therapy** 2 400 or 2 450 MHz (12.4 or 12,25 cm) .
  - HF therapy makes possible deep heating.

THREE WAYS OF APPLICATION OF HF CURRENTS:

- 1. The tissue is connected in the electric circuit as a **resistor** by means of contact electrodes – classical diathermy. It is not used in practice today.

- 2. Tissue is connected as **dielectric** placed between insulated electrodes – **heating in the capacitor field**. The heat produced is proportional to the dielectric loss. Amount of heat arising in subcutaneous fat tissue is lower than in the muscles.

- 3. Use of **eddy currents** in magnetic field of a coil – **inductive heating**. An insulated cable is wound round a limb or a coil is laid to the body. The skin is less heated, 2 cm thick muscle layer lowers the heating to one half.

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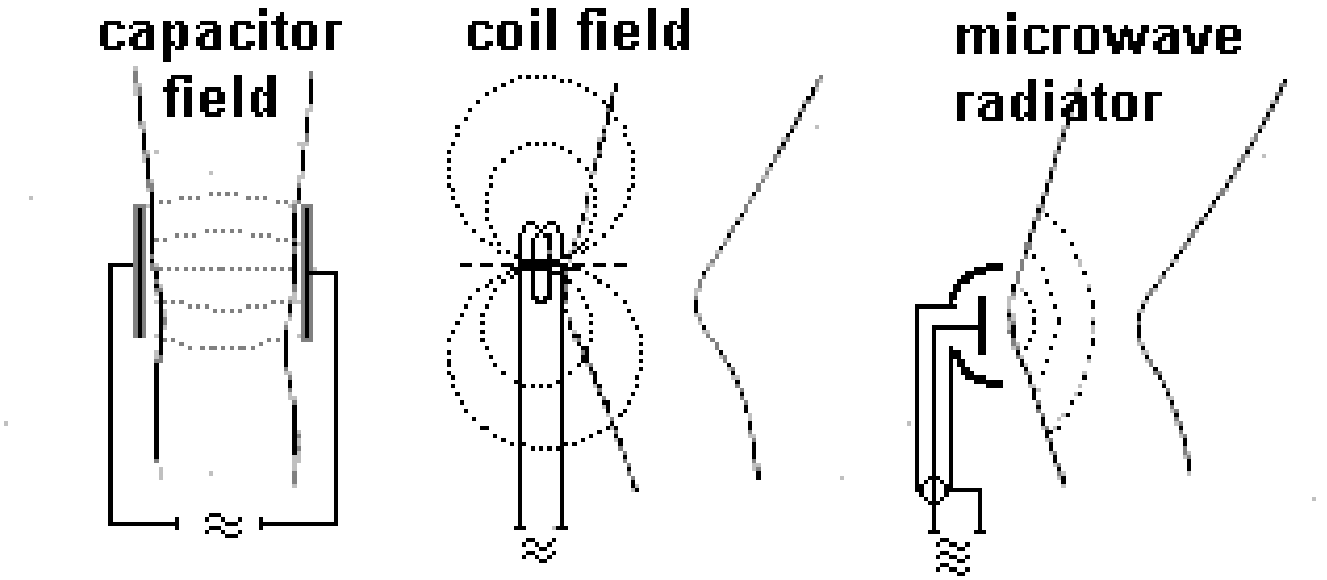
DIFFERENT WAYS OF HF DIATHERMY



Application of HF currents

(a- condenser field, b- inductive, c- microwaves)

Diapositiva 27

IH1 obrázek vyměněn - anglický popis

Ivo Hrazdira; 11/10/2008

IPERTERMIA CAPACITIVA A 27 MHz

SHORT-WAVE DIATHERMY – HEATING IN CAPACITOR FIELD

MICROVAWE NON ABLATIVE (MWNA)

- Si basa sul concetto di instaurare un intenso campo elettrico nei tessuti concentrandolo al disotto di una apertura radiante (antenna)
- Utilizza energia radiante come il Laser, ma penetra più in profondità
- Il calore, e quindi l'innalzamento di temperatura, si produce per isteresi dielettrica a livello tissutale, laddove la densità di flusso del campo è più forte
- Non è necessario alcun elettrodo di drenaggio perché non scorrono correnti a RF nei tessuti
- Non è necessario che l'apertura radiante sia a perfetto contatto con l'epidermide

IPERTERMIA LOCALIZZATA A MICROONDE

- Si basa sul concetto di instaurare un campo elettrico localizzato nei tessuti concentrandolo al disotto di una apertura radiante (antenna)
- Il calore, e quindi l'innalzamento di temperatura, si produce per isteresi dielettrica a livello tissutale, laddove la densità di flusso del campo è più forte
- Il processo di riscaldamento tende a privilegiare il tessuto muscolare
- Non occorre alcun elettrodo di drenaggio della corrente perché non scorrono correnti a RF nei tessuti
- Non è necessario che l'apertura radiante sia a perfetto contatto con l'epidermide

MICROWAVE THERAPY

Source: magnetron. The oscillations of electromagnetic field are led to an emitter - a dipole with a reflector. 1 cm of muscle is enough to lower the intensity to one half, the relation between heat production in the skin and the muscles is almost equalised. Microwaves put electrically charged particles (ions, dipoles) into oscillatory motion which is transformed into heat by friction.

MICROWAVE DIATHERMY

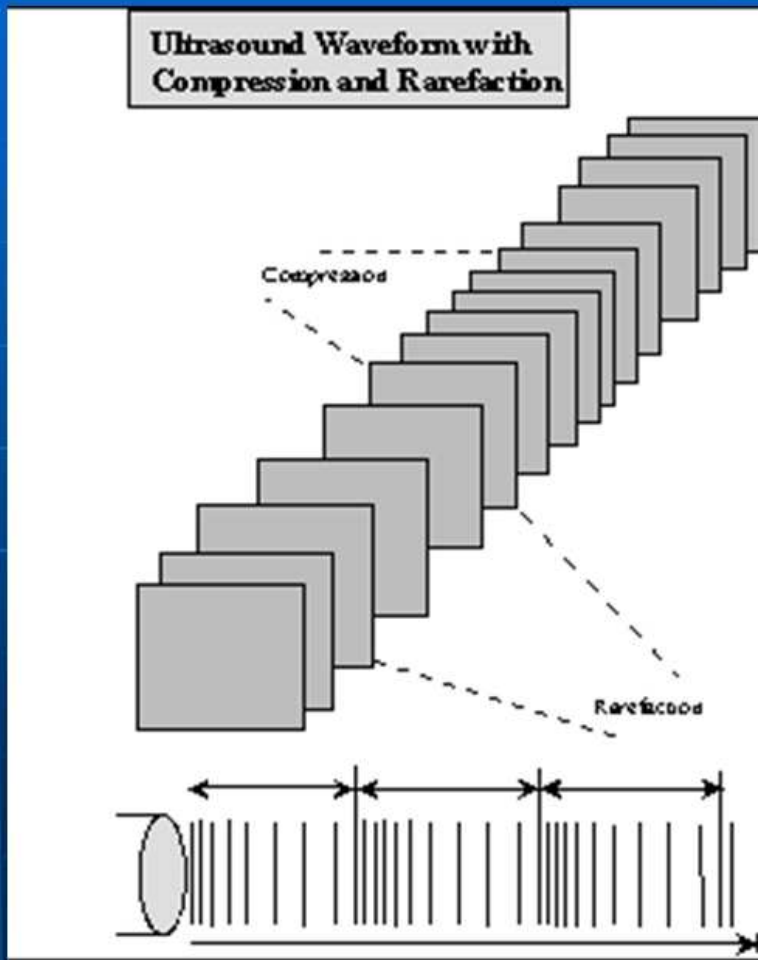
(older type)

GLI ULTRASUONI

THERAPEUTIC ULTRASOUND

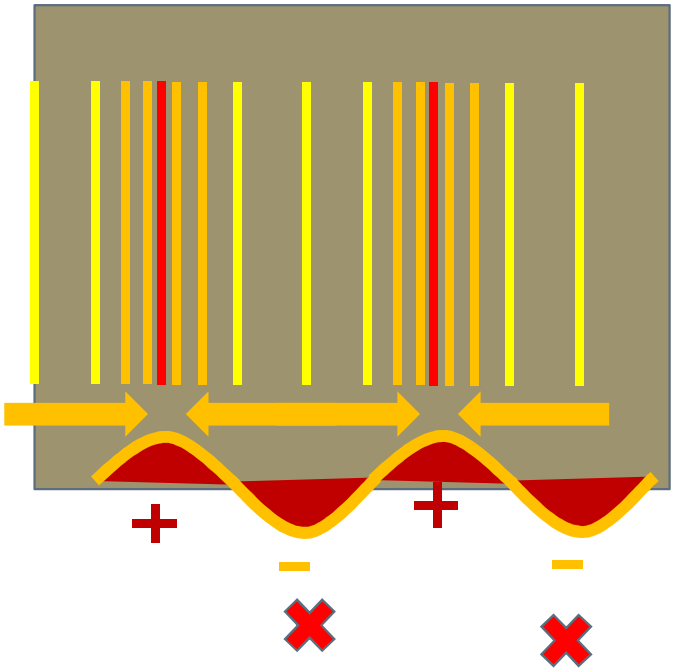
Ultrasound is mechanical energy. Made up of longitudinal waves consisting of areas of compression and rarefaction.

Sound waves from 20 Hz to 20,000 Hz are within the audible range. Beyond this upper limit, mechanical vibration is known as ULTRASOUND. The frequencies used in therapy are typically between 0.75 and 3 MHz.



APPLICAZIONI

- L’applicazione di onde ultrasoniche con una frequenza compresa trai 25 e 50 Khz riEsce a generare fenomeni di cavitazione nelle parti corporee



ULTRASOUND THERAPY

- Ultrasound therapy is based on biological effects of ultrasonic oscillations which are not electric. Despite of that, this therapy is sometimes included in the list of electrotherapeutic methods.

- An ultrasound (US) therapeutic system consists of two main parts: generator of HF electric current and the application probe, the US source itself, which consists of a piezoelectric transducer.

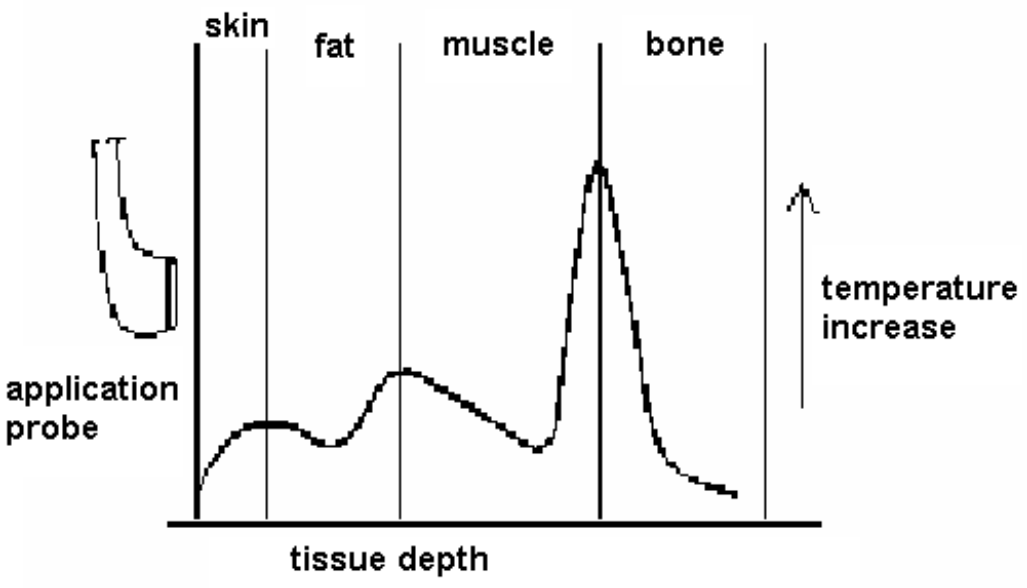
- In therapy, f = 0,8 - 1 MHz is used, sometimes up to 3 MHz, with intensity of US - typically 0.5 - 1 $W.cm^{-2}$. Exposure time is 5 - 15 min., in 5 - 10 repetitions. US can be applied continuously or pulsed.

- The main therapeutic mechanism is **high-frequency massage** of tissue. Additional effects are caused by tissue **heating** (causing hyperaemia) and some **physico-chemical effects**.

- Acoustic coupling between the probe and the skin is secured by an oil or gel (local application) as well as water (underwater application).

- Main indications of US therapy: chronic joint, muscle and neural diseases. Limited success is reported in healing wounds after surgery, healing injuries and varicose ulcers.

THERMAL ACTION OF ULTRASOUND



- In US therapy, thermal dissipation of acoustic energy takes place. Tissue heating depends on physical properties of tissue and its blood supply. The highest heating appears at the interfaces between tissues of very different acoustic impedances.
- The thermal action of US cannot be considered without respect to other healing mechanisms (micromassage etc.)

US - THERAPY

GRAZIE PER L’ATTENZIONE