Ultrasound/Terapeutic application

Therapeutic application of ultrasound

Principles of therapeutic use of ultrasound

The therapeutic effect of ultrasound is caused by different UV light absorption of material.

- **[coefficient|The coefficient of absorption (Https://en.wikipedia.org/wiki/Attenuation)]:** is directly proportional to the efficiency of the treatment. It increases with the increasing amount of proteins in a tissue, on the other hand with the increasing amount of water decreases. The absorption coefficient of frequency 1MHz is three times smaller than the absorption coefficient of 3MHz and penetrates three times deeper. Therefore, an ultrasound with a frequency of 3MHz is used for tissues closer to the surface, while ultrasound with a frequency of 1MHz is better to use for deeper structures and it has almost no effect on the surface.
- On the interface of materials is **ultrasound waves** repulsed differently — it is caused by different impedance of specific tissues. Air has the impedance really high, its 10 nm thick layer repulses up to 99% of ultrasound waves. [1]
- **effective radiating area (ERA)** is set by the size of **piezoelectric crystal** which generates ultrasound. It reaches a value of 1−10 cm2. Based on the *distance of the radiating area*, we distinguish the close field of ultrasound, which is characterized by a low **divergence** of ultrasound rays and by quite big variations of intensity caused by strong **interference effects** (decreasing or increasing the energy of ultrasound). On the other hand, the distant ultrasound field is characterized by a high divergence of rays and lower intensity.
  - **Semi-depth of penetration** is a distance, in which the intensity of ultrasound decreases to 50 % of its original size
  - **Depth of penetration** is maximal depth in which we can anticipate therapeutic effect (intensity of radiation in this place is ten times smaller than the intensity close to the radiation area)

Examples of use

Use in stomatology

Magnetostriiction sources are used as a **source of ultrasound waves**, which differentiates stomatology from another medical field, where is ultrasound used. Source of vibration is ferromagnetic stick, which changes its volume. Magnetostriction sources are used as a source of ultrasound waves, which distinguishes dentistry from other fields where ultrasound is used therapeutically. The source of oscillations is a ferromagnetic rod which changes its volume in rapid succession due to the magnetic field. The advantage of this method of generation is high power, however, only **frequencies up to 60 kHz** can be achieved [2]. Frequencies in the range of 24-42 kHz (*low-frequency ultrasound*) with an intensity of more than 10 W / cm2 [3] are usually used to remove tartar and tooth decay. This method is disproportionately faster, less demanding and saves enamel compared to manual removal. The main factor disrupting tartar is the creation of cavitation in water, which flows down the tool itself, which is made of titanium. [3]

Hyperthermia

Ultrasound, alongside microwave radiation, is one way to overheat the tumour and then damage it (see hyperthermia for more details). The tumour must be exposed to 41-43 °C for approximately 20 minutes [3]. The targeted effect is achieved by **focusing**, that is, concentrating ultrasonic waves coming from different directions to the tumour site; so there is minimal damage to healthy tissue. A frequency of 1 MHz is usually used, the temperature is still controlled by thermocells.

Harmonic scalpel

The harmonic scalpel works on the principle of longitudinal ultrasonic oscillation at a frequency of 55 MHz. This generates energy at low temperatures of 50 to 100 °C. It enables cutting and coagulation of soft tissues, blood vessels and sealing of lymphatic pathways at the same time. Bleeding with the use of harmonic scalpel is 4 to 6 times smaller than in other surgical methods. It is a very gentle surgical technique used especially in plastic and endoscopic surgery, close to nerves and blood vessels.

Physical therapy

One type of physical therapy that is widespread is ultrasonotherapy, which uses the acoustic energy of ultrasound. The ultrasound is applied by a special device, which is equipped with a radiation head with an effective area of different size from 1 to 10 cm2. It forms a mechanical wave with a treatment frequency of 0.7 to 3.3 MHz, which is absorbed maximally at a tissue depth of 2 to 5 cm. Therefore, it is used in the therapy of soft tissue damage. Ultrasound has analgesic, spasmolytic and vasodilating effects.

Applications

We divide warheads according to the **movement** of : - static (the warhead is placed on one affected place and does not move); - semi-static (circular motion around the affected area); - dynamic (movement of the head, for example, over the entire limb).

Further, we divide according to the **contact** of the head with the skin: - direct contact of the head with the skin (using gel or oil); - contact through the aquatic environment.

The application usually takes several minutes and is repeated several times during consecutive days.

Indications

- myalgia
- muscle pain after stretching and solidification (spinal muscles)
- lumbago
- arthrosis, arthritis, joint swelling, morbus Bechterew
- therapy post-traumatic pain (after the dislocation of the joint or distortion ligament) enthesopathy (tennis elbow)
- therapy post-herpetic neuralgia
- legulcers, scars

Contraindications

- fresh bleeding
- fracture
- hematoma, menstruation

Transdermal drug delivery

The principle of the ultrasonic wave is a liquid which is associated with the formation of **pseudocavitations** (tiny bubbles) which moves chaotically and after reaching a certain size is destabilized and falls apart. This creates a **jet micro-flow** in the surrounding liquid, which causes abrasion of the upper skin layer. In addition to this abrasion, there appears to be an **increase in the permeability** of the phospholipid bilayer of biological membranes, which together results in higher skin permeability even for high molecular weight substances that do not otherwise pass through it. Greater skin permeability is achieved by simultaneously **acting on two frequencies** ranging from 20 kHz to 3 MHz. **High-frequency ultrasound** generates additional bubbles that burst rapidly in the presence of low-frequency ultrasound waves. In addition, high-frequency ultrasound reduces the lateral movement of bubbles and keeps them in one place, resulting in more uniform **abrasion**.

Such a liquid may be a medicament liquid applied on the skin. This has been used (so far rather experimentally) for chronic application of drugs such as **insulin**, which previously had to be injected only. The therapeutic effect thus consists of minimal invasiveness of such application. **The abrasive effect** of ultrasound is temporary and painless, the upper layer of the skin (stratum corneum epidermis) quickly (within a few hours) regenerates from the basal layer of the epidermis.

Other uses

Further, is the ultrasound used for the **accelerated healing** of bone fractures, for joining bone fragments of the synthetic binder (application of ultrasound reduces the curing time from days to seconds due to local effect of high temperature), removal of **atherosclerotic plaques** in blood vessels in the treatment of **prostate cancer**, surgery on **ovaries**, also in **plastic surgery** (removal of adipose tissue by extrusion).

Odkazy

Související články

- Ultrasound
- Diagnostic application of ultrasound
- Ultrasound imagining
- ultrasound and its medical application

Externí odkazy

- WIKIPEDIA,. *Therapeutic ultrasound* [online]. [cit. 2013-10-31]. <https://en.wikipedia.org/wiki/Therapeutic_ultrasound>

References