

# ULTRASOUND THERAPY IN MEDICAL REHABILITATION POST-STROKE PATIENTS

## Terapia ultradźwiękowa w rehabilitacji medycznej pacjentów po udarze

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**Key words:** ultrasound therapy, medical rehabilitation, post-stroke patient.

### Summary

*The paper presents recommendations for the use of physical exercises and massage in the treatment and rehabilitation of patients with muscular torticollis. Recommendations are intended for surgeons, doctors and exercise instructors with higher and secondary education, massage therapists and paediatricians hospitals and clinics.*

**Słowa kluczowe:** terapia ultradźwiękowa, rehabilitacja medyczna, pacjent po udarze mózgu.

### Streszczenie

*W artykule przedstawione zalecenia dotyczące zastosowania ćwiczeń fizycznych i masażu w leczeniu i rehabilitacji chorych z mięśniowym kręcem szyi. Rekomendacje są przeznaczone do ortopedów, lekarzy i instruktorów ćwiczeń fizycznych z wykształceniem wyższym i średnim, masażyistów i lekarzy pediatrów szpitali i przychodni.*

### Ultrasound therapy in medical rehabilitation post-stroke patients

Ultrasound therapy (UST) is based on the use of therapeutic and prophylactic mechanical vibrations of high frequency - 20 to 3000 kHz. For medical practice in Ukraine, allowed the frequency of 22, 44, 880 and 2640 kHz.

Physical and biophysical mechanisms of action. Physical factors of the mechanical nature of the cause in the tissues of the body mechanical vibrations that propagate in the form of longitudinal and transverse waves.

Elastic vibrations of ultrasonic range creates a high sound pressure gradient -  $(10-150) \cdot 10^5 \text{ Pa} \cdot \text{cm}^{-1}$  and can cause high shear stresses in different biological tissues. Amplitude of vibrational displacement of tissue particles ( $\approx 1,0 \cdot 10^{-6} \text{ m}$ ) is not sufficient to excite the mechanoreceptors of the skin. However, such bias can change the conductivity of the stretch-channels of membranes of various cells and cause microflows metabolites in the cytosol and organelles (micro-massage of tissue). The resultant deformation of the tissue leads to increased permeability plasmolemma individual cells and various histogematic barriers.

Because biological tissue is a medium which offers resistance to the spread of mechanical vibrations in it, these oscillations become damped, and the energy loss of mechanical vibrations of the physical basis of converting mechanical energy into heat.

If the frequency of excited oscillations in the system coincides with the natural frequency of the system, there is a resonance (B. Beyer, 1962).

Mechanical vibrations are reflected from the interfaces due to the layered distribution of tissues in the body, with the incident and reflected waves can interfere to form standing waves. The greatest value of this process takes at high frequency ultrasound, when the wavelength of the mechanical oscillation becomes commensurate with the thickness of the layers of tissue. The absorption coefficient of ultrasonic some fabrics are: nerve - 0,2, heart muscle - 0,35, the tongue muscles (perpendicular to the fiber axis) - 0,57, and along the axis of the fiber - 0,25 (AP Speransky, 1976). The absorbed acoustic energy ultimately converted into heat, raising the temperature of the absorbing medium. Acoustic effects in liquid media having cavities (vesicles) filled with gas during the half-dilution. This phenomenon is called cavitation.

Biophysical studies have established that ultrasonic cavitation in water and liquid media (blood, urine) is accompanied by chemiluminescence due to the emergence of electronic excited states. It is established that a small movement of fluid around the cells, called microflows play an important role in the therapeutic effect of ultrasound. Change in permeability of cell membranes and the rate of diffusion of ions across the membrane causes the stimulating effect of ultrasound on the reparative processes through calcium ions as second conductor of biosynthetic activity of cells. Analgesic effect of ultrasonic connected with an increase in the rate of transport of sodium ions across the membrane, since this ion affects the electrical activity of neurons. Caused by ultrasonic complex physical and chemical changes, ranging from electronic excited states up to the formation of peroxide compounds, can activate the free radical oxidation. In addition, as a rule, increases free oxidation in the mitochondrial respiratory chain at the expense of phosphorylation associated with the formation of ATP in the cells "sounded tissues, and increases oxygenation of cells and tissues. At the same time strengthening the LPO in cell membranes against the backdrop of increased oxygenation promotes compensatory activation of antioxidant systems.

There is evidence of change in frequency of DNA molecules with a wide range (from several to hundreds of hertz)

to a single frequency - 10 Hz after treatment with solutions with ultrasonic intensity used for ultrasonic diagnosis.

Nitric oxide formation during ultrasound exposures, one of them - nitric oxide (NO) "relaxation of vascular endothelial factor" - a key mediator immunotropic. As a regulator of immune response and cytoprotective NO performs a function - nitrification of DNA and RNA, lengthening the life of nucleic acids and as a consequence of increased cytokine expression and synthesis of HSP-protein (heat shock proteins), as well as cytopathogenic function - the destruction of anti-oxidant (iron-, cobalt, manganese and zinc-containing) enzymes. (A. Kurin et al., 2000).

Antioxidant micronutrients (like selenium, zinc and copper in the metalloproteins) are the synergistic cytoprotective function of NO in the immune response. If this "many faces» NO add the ability to reduce the tone of vascular smooth muscle, reducing the systemic blood pressure and maintain systemic and local hemodynamics, it becomes clear that the U.S. is a very active physical factors.

If UST is a kind of "tissue and cellular massage" which promotes a small increase in tissue temperature. This massage provides the same anti-edema effect of ultrasound.

The use of pulsed ultrasound makes it possible to reduce the average intensity of exposure, since during the interval between pulses is heat dissipation due to heat conduction, "voiced by" activating blood circulation and tissues. Therefore, the higher the intensity of the appropriate and safe to use in the form of pulses of ultrasound. Intense, but short pulses can increase the rate of diffusion of ions across the cell membrane and increased the vibrations of phospholipids and proteins that form this membrane (M. Dyson, 1987). Frequency of 16 and 37.5 Hz is regarded as the characteristic frequency for the intracellular calcium system, and therefore is preferred for its regulation (the ability of ultrasonic frequency modulation in such cases).

#### **Mechanisms of action of ultrasound and its therapeutic effect**

UST commonly used intensity does not cause instability of cavitation, ie power flux density (MRP) is not higher than  $1.0 \text{ W / cm}^2$  (AP Speransky, 1976; VS Ulashchik, 2000). Sufficiently active intervention in the U.S. textile processes inevitably leads to increased blood flow and expand blood vessels and capillaries. With these effects due to increased metabolism of tissues under the action of ultrasound. Activation of membrane enzymes and depolymerization of hyaluronic acid may reduce the edema and resorption, lower compression nociceptive nerve conductors in the impact zone. Along with the deformation of biological tissues, ultrasonic vibrations cause the complex physical and chemical reactions in them. They accelerate the movement of biological molecules in cells, which increases the likelihood of their participation in metabolic processes. This also contributes to the rupture of weak intermolecular bonds, reducing the viscosity of the cytosol (thixotropy), transfer of ions and biologically active compounds in the free state. In the following mechanisms are activated nonspecific immunological resistance of the body by increasing the binding of biologically active substances (kinins, histamine), blood proteins and their cleavage enzymes.

Activation of ultrasound lysosomal enzymes of macrophages leads to the purification of inflammatory focus of cellular detritus and pathogenic organisms.

In summary, the mechanism of action of ultrasound on the body the main importance: thermal (nonspecific), mechanical and physico-chemical (specific) factors. The advantage of ultrasound compared to many physical factors is that he has a deep penetrating heat. Consequence of thermal effects of ultrasound is to increase the speed of the metabolic processes, the occurrence of temperature gradients, which improves blood circulation and limfocyrculation etc. Mechanical factor by alternating acoustic pressure and a kind of micro-massage at the cellular and subcellular level, activation of electrokinetic phenomena, leads to increased permeability of cell membranes that causes stimulation of the function of cellular elements and cells in general.

The specific physical and chemical effects of KM is to enhance the biochemical and physico-chemical processes in the tissues. The impact of all three factors (thermal, mechanical and physical-chemical) is closely related to each other and provides the body a combined multi-dimensional effect. Ultrasound - a kind of physical catalyst physical and chemical processes in the body.

The therapeutic effect of ultrasound depends on the frequency of ultrasonic vibrations, the intensity, exposure time and condition of the body.

Ultrasound has a pronounced anti-inflammatory, analgesic, antispasmodic, absorbing, trophic, hyposensitizing and antiallergic activity. In some cases, low-frequency ultrasound may be more effective form of thermotherapy than microwave radiation, paraffin baths, or infrared radiation.

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### **The main indications and contraindications to the use of ultrasound therapy in poststroke patients**

#### **Indications:**

UST in poststroke patients is used as a treatment for clinical manifestations of the underlying disease (stroke), and associated diseases. In the acute phase of ischemic stroke UST may be appointed from the early days, its safety is confirmed by clinical observations of the influence of the Doppler ultrasonic apparatus for transcranial projection of a thrombosed vessel.

In daily practice, the impact of ultrasound on the projection of the brain is not carried out due to lack of necessary clinical and experimental studies. We have no doubt that in the near future, clinical and experimental research

on the application of UST to the impact on the brain will be conducted and, accordingly, worked out methods of ultrasonic therapy of stroke in different periods. Those still scarce, foreign study using Doppler devices megahertz range with ischemic stroke (IS) in combination with thrombolysis indicate the prospects of UST for IS, especially the low frequency range.

In poststroke patients UST done to: prevention and treatment of arthropathy and contractures, reduce spasticity of muscles, if any, or toning during hypotension, the treatment of painful manifestations of different localization, particularly musculo-tonic and muscular-dystrophy, treatment of opportunistic diseases (myalgias, neuropathies, degenerative diseases of the joints and spine, diabetes, side etc.). effects: common for physical therapy (acute infectious diseases, severe somatic state with the need to intensive care or resuscitation, etc.), diseases of blood and bleeding tendency, thrombophlebitis (zone lesion), in patients with hemorrhagic stroke UST may be held not earlier than 2 months after the vascular accident.

#### **Contraindications:**

common to physical therapy (acute infectious diseases, severe somatic state with the need for intensive care or resuscitation, etc.); diseases of blood and bleeding tendency; thrombophlebitis (zone lesion): in patients with hemorrhagic stroke UST may be held not earlier than 2 months after the vascular accident.

Parameters of ultrasonic radiation in ultrasound therapy

At UST you must first navigate to the capabilities of the equipment used, as it allows us to estimate the depth penetration ultrasound (penetration depth - a depth that penetrates tissue to not less than 5,0% of ultrasonic energy supplied to the cutaneous projection voiced structures . Theoretically, the penetration depth of ultrasound - a distance at which the intensity of the wave decreases in  $E_2 \approx 7.3$  at times) (GN Ponomarenko, II Turovsky, 2003) and, consequently, on what structures and tissues that we act. To date, the medical practice used ultrasound machines class 3: Low-frequency (LF UST) generating ultrasonic waves 22 and 44 kHz, their power depends on the size fluctuations of ultrasonic waves. 2 mkm  $\approx 0,2$  W / cm<sup>2</sup>; 3 mkm  $\approx 0,4$  W / cm<sup>2</sup>; 4 mkm  $\approx 0,8$  W / cm<sup>2</sup>, 5 mkm  $\approx 1,0$  W / cm<sup>2</sup>.

The penetration depth LF UST ranges from 14-15 cm to 5 – 7 cm (then lower frequency, then deeper it penetrates into biological tissue); middle frequency - 880 kHz, the penetration depth of up to 5 cm; high frequency - 2640 kHz, the penetration depth of 2-3 cm.

#### **Energy dose UST**

Currently accepted point at UST power flux density (PFD) in W/cm<sup>2</sup>, which is dosed from 0,1 to 1,0 W / cm<sup>2</sup> and should not exceed 1.0 W/cm<sup>2</sup>. Hardware manufacturers typically indicate how these parameters are governed. This is easily achieved, because known area of the ultrasonic transmitter and ultrasonic power. Energy capacity of irradiated tissue is regulated by the time the procedure and area of impact. However, a more precise dosage of energy impact of ultrasound on a specific area is an indication of its options in J/cm<sup>2</sup>.

If UST sounded a certain part of the body (in a single session of up to 250 cm<sup>2</sup>). For the parameters UST from 0,1 to 1,0 W / cm<sup>2</sup> energy impact will depend on the time of exposure. The maximum recommended exposure time to 15 minutes (900 sec). When power 1 W/cm<sup>2</sup> time scoring 900 and an area of 250 cm<sup>2</sup> - results:  $1 \cdot 900:250 = 3,6$  J/cm<sup>2</sup>. If PFD 0.1 W/cm<sup>2</sup>, whereas  $0,1 \cdot 900:250 = 0,36$  J/cm<sup>2</sup>. Energy output impact on the fabric shall be not more than 15 J/cm<sup>2</sup> at an area of up to 50 cm<sup>2</sup> on the area 50-100 cm<sup>2</sup> to 10 J / cm<sup>2</sup> and 100-250 cm<sup>2</sup> - 3-7 J/cm<sup>2</sup>. These doses are therapeutic and comparable thermal effect with similar doses of IR exposure. Note therapeutic doses of ultrasound energy (J/cm<sup>2</sup>) is somewhat larger than for laser therapy because absorption of ultrasonic waves is much smaller than the laser radiation. Limiting boundary therapeutic dose of ultrasound believe the appearance of heat. Strong feelings of burning or pain even when the fixed effects technique should not be!

Duration of exposure to one field of up to 50 cm<sup>2</sup> is usually 2-5 minutes (from 2 to 15 J/cm<sup>2</sup>), and the region of large joints - sometimes up to 6-10 minutes. Area about 100 cm<sup>2</sup> - 10 J/cm<sup>2</sup>. Depending on the number of fields throughout the duration of the procedure when the procedure is stable up to 2 minutes on the field at the labile - up to 15 minutes. Procedure is usually carried out in a day, less frequently (1-2 times per week) - with the chronic course of the process. The average course of treatment consists of 7-14 treatments. Due to the prolonged and pronounced after-effect of treatment repeat it is recommended not earlier than after 3-5 months. After the X-ray radium therapy should refrain from 3-4 months of treatment with ultrasound. Ultrasound can be given to children at preschool age. Persons under 20 years and over 60 years the intensity and the procedure is reduced by 30%.

#### **Technique of ultrasound therapy**

Applied two basic methods of ultrasound treatment: a stable (fixed) and labile. When the fixed technique emitter set immovably at all during the procedure. When the labile technique emitter throughout the procedure moves slowly on the impacts of a rate of 1-2 cm / s, making a stroking motion, first line, and then circular. When this technique is sometimes useful to slightly delayed (up to 20-30 s) in the most marked pain areas. In all cases, contact the vibrator (transducer) with the skin should be a maximum (at a right angle, perpendicular to the skin) to eliminate the air gap between the transducer and skin. For this impact area is exposed, and rubbed into the skin contact agent (liquid paraffin, glycerol, gels and scoring is done through a tissue soaked in water, drug solution, etc.). Then, the skin tight impose radiator. Especially close contact must be achieved near the bones, joints and uneven surfaces of the body.

Ultrasound effects on the body parts of complex configuration (joints of the foot or hand) irradiation is carried out through the rubber bag (glove) with water. One takes the form of its surface area exposure, and the other in contact with the radiator. When the underwater radiation emitter keep at a distance of 1-2 cm from the area of impact.

#### **Ultrasound puncture**

Impact on biologically active points (TA) and of A-shih (pain points) with the help of ultrasonic vibrations was called ultrasonic puncture. The basis of this method is based on the same principles as in the general ultrasound therapy, the only difference is that the realization of the therapeutic effect is not only due to local effects, but also due to the effect of acupuncture - the acupuncture points → channel (meridian) → body. In connection with this expanded range of indications for ultrasonic therapy. Energy parameters of ultrasound treatment on biologically active points:

- a low degree of stimulation (stimulation, toning) with ultrasound exposure corresponds to the intensity of 0,05-0,2 W / cm<sup>2</sup>, with exposure times of 5-20 with one point (from 0,25 to 5 J / cm<sup>2</sup>),
- moderate stimulation (harmonization) corresponds to the intensity of the ultrasound 0,2-0,5 W / cm<sup>2</sup>, with exposure to 20-30 s with one point (from 0,5 to 10,0 J / cm<sup>2</sup>),
- a strong degree of stimulation stimulation (brake, sedation method) - respectively 0,5-1,0 W / cm<sup>2</sup> and 30-50 s with one point (from 10,0 to 15,0 J / cm<sup>2</sup>).

Frequency modulation of the ultrasonic radiation need to be recalculated from the known formulas. For example, if the frequency modulation of the ultrasonic radiation is 10 Hz, the duration of exposure to the TA is doubled. Sensations of the patient with probes - a deep, penetrating heat, but without the burning sensations (allowed distension):

- number of classical points on one procedure - up to 6,
- number of points of A-shih (pain) in one procedure - up to 10,
- the frequency of procedures - 1 - 3 of the procedure is carried out every day, the next - through the day
- on a course of treatment - up to 14-15 treatments.

### **Ultraphonophoresis (Uff)**

Drug ultraphonophoresis, or phonophoresis (last name obsolete not exact, because the act does not sound, but ultrasound) - combines physical and pharmacological treatment method in which the body affected by ultrasound and inputs with the help of drugs (VV Orzheshkovsky, VasV Orzheshkovsky, 1998).

In medical practice, this method has a significant place. It provides simultaneous complex effects on the body of ultrasonic vibrations and drugs. To this end, scoring is done through contact environment in which drugs are introduced. In this case, the drug must maintain its structure and biological activity, and the action it has to be unidirectional with the action of ultrasound, which provides a synergy of their effect on the body. The ability of ultrasound to increase blood circulation, increase blood flow and increase the permeability of cell membrane creates conditions for phonophoresis. According to most researchers, Uff through excretory ducts of sweat and sebaceous glands. Some role in the penetration of drugs with Uff are ion channels of the cell membrane and intracellular target, as one of the most important properties of ultrasound is its depolymerized and "disintegrating" effect.

Uff advantage compared with electrophoresis - to use for the introduction of uncharged substances and not only water-soluble ( hydrophilic) and fat-soluble (lipophilic) drugs.

Caused by ultrasound increased permeability of skin and other histogematic barriers create favorable conditions for the penetration of molecules through these drugs. When using this method for the therapeutic action of ultrasonic waves are added therapeutic effects of a particular drug. Due to the alternating pressure of ultrasonic waves molecule drugs become more agile and responsive capacity. This greatly increases the amount of drug that enters the body and the effectiveness of its therapeutic action.

Low-frequency ultrasound, due to the peculiarities of its absorption of biological tissues, strongly modifies the vascular and epithelial permeability, has a stronger effect on the disintegrating fabric that provides the possibility of introducing a greater number of drugs and to a greater depth at the low frequency phonophoresis compared with higher frequency ultrasonic effects (VS Ulashchik, 2000).

Foretic highest activity is shown when using 5-10% solutions, and only 1-5% deposited on the surface of the drug enters the body . For substances, poorly soluble in water, as well as to enhance the absorption of drugs across the epidermal barrier, and in the Uff is used as solvent dimethyl sulfoxide - DMSO (25% solution).

When phonophoresis potentiated the effects of many drugs and reduces their side effects. At the same time after ultrasound exposure inactivated by atropine, barbiturates, vitamins, codeine, caffeine, morphine, procaine, platifillin, quinine, ephedrine. A number of medicines for phonophoresis can be used in mixtures with the corresponding gels or creams, and gels for this purpose have been more appropriate.

To Uff used: hydrocortisone (hydrocortisone suspension of 5 g blended with lanolin and petroleum jelly, each of 25 g), lidazy ( 64 units. dissolved in 0.8 ml of distilled water and add 0.8 ml of vaseline oil), aloe (aloe extract liquid 1:3 to put on the skin and covered with a layer of vaseline oil), euffilin (a mixture of 1,5 g lanolin), prednisolone (0,5% ointment), baralgin (2-2,5 ml ampoule solution baralgine rubbed into the skin and covered with glycerol), benzocaine (5-10% anesthetic ointment), gangleron (a mixture of 0.25% solution ganglerona with petroleum jelly and lanolin), gels, nonsteroidal anti-inflammatory drugs (Fastum gel, etc.).

Number of injected substance is proportional to the time and intensity of ultrasound exposure. Established that one minute exposure is sufficient for the introduction of the drug on an area of 10 cm<sup>2</sup>, and according to some - even at 30 cm<sup>2</sup>. Usually used for this purpose a continuous US. Whew effectiveness also depends on the scope of its holding.

Sometimes ultrasound is used in combination with one type of nerve and muscle stimulation by electric current, such as ultrasound and interferential currents. This combination is based on the ability of ultrasound to reduce the electrical resistance of the tissues. (G Low, A Reed, 2004). Phonophoresis is essentially a form of combination therapy, since it calls for the simultaneous application of ultrasound and the drug. With proper selection of physical and chemical

(drug) factor, suitable for combination therapy, and their therapeutic efficacy significantly increased. Herbal Uff combined with electrophoresis (ultrafonoelektrophoresis) diadinamotherapy (ultrafonodiadinamophoresis) amplipulse (ultraphonoamplipulsphoresis), magnetotherapy, (magnetoultraphorophoresis), vacuum therapy (vakuumultraphonophoresis) conducted on acupuncture points in the form microultraphonophoresis.

### **Features of ultrasonic therapy in poststroke patients**

Ultrasound therapy in ischemic stroke can be applied 12-14 days after its occurrence, unless it is combined with thrombolysis during the therapeutic window for a special procedure. When hemorrhagic stroke UST designate, approximately 2-3 months after the vascular accident.

At the hospital stage of early recovery period UST assigned mainly to the prevention of possible complications (pneumonia, deep vein thrombophlebitis of the lower limb, urological disorders, arthropathy, spasticity etc.) and treatment of concomitant diseases (diabetes mellitus, neuropathy, arthritis, degenerative changes in the spine with pain syndromes, etc.). At all subsequent stages of medical rehabilitation of poststroke patients, UST becomes more popular, although it is recognized that many doctors, including neurologists, not fully aware of therapeutic options UST.

Experience with ultrasonic therapy talks about the next versions of its principles and applications. Impact of ultrasonic waves can be performed directly on the area of pathological changes. For example, the scoring of spastic muscles, keloids or contact scoring one or more affected joints with arthrosis. It is also possible to influence of ultrasound on the internal organs, placing the radiator on the liver, lung, stomach, spleen, etc. This principle is widely used in the UST, it is easily implemented and effective enough. In addition, as a rule, do not need long training for the use of this option UST.

However, a similar principle of ultrasound therapy is not always possible to use. For example, how to influence the pathological focus in hypertension, neurosis, etc.? In such cases, preference is given to the impact of ultrasound treatment on the reflex zones or acupuncture points (AP), ie ultrasonic puncture - ultrafonopuncture (USP).

It should be noted that the most effective for ultrasound therapy combination of multi-level principle, ie impact on the area of the pathological focus should unite with USP at the distal point and the segmental zones. Thus, professionals involved in the practical application of UST, there is a choice of methodological approaches:

- a direct effect on the pathological focus,
- the impact of the pathologic lesion in conjunction with reflexogenic (segmental) zones or acupuncture points.

Naturally, in each case, the doctor chooses the most appropriate methodical approach. However, if the impact on the pathological focus in the UST requires more purely technical training, then during the PCF requires basic knowledge of acupuncture.

The doctor who uses ultrasound therapy, is obliged to draw attention to the following:

1. During a healing session the patient, if possible, should be based on that reduces the likelihood of adverse reactions. Unacceptable conduct of the procedure by the patient.
2. At the first session, the doctor must determine individual therapeutic sensitivity of the patient to the ultrasound exposure, ie establish the necessary dosage to assess the effect on the condition of patients, changes in blood pressure, pulse and other objective measures. On the first runs (1-3) for successful adaptation to the UST time of exposure is desirable to reduce by 20-30% of the total exposure time. Throughout the course of treatment is carried out monitoring of the patient, and in case of adverse reactions to treatment is necessary to make adjustments, until the end of ultrasound therapy.
3. In the selection of dosage is necessary to consider the impact of the degree of weakening of the organism, the type of nervous system, the patient's age, the period of the rehabilitation process, etc.
4. It is not recommended to work with ultrasound in spots, nevi, angiomas due to its biostimulating effect.
5. In articulating the swollen tissue should be used subthermal doses of US (up to 0.4 W / cm<sup>2</sup>, 2 min, area of 50 cm<sup>2</sup>, about 2-3 J / cm<sup>2</sup> with a larger area, respectively, increases the time UST). If UST in arthrosis with the presence of synovitis, ultrasound making on the joint is not conducted, stimulated segmental area, and the joint – magnetolaserotherapy.

Furthermore, in his work the doctor relies on recommendations for the use of different modes of instrumentation: accounting capacity, frequency ultrasound, frequency modulation and other parameters.

As already stated, ultrasonic treatment is carried out, affecting the lesion, reflex zones or acupuncture points. For one procedure sounded a certain part of the body size of up to 250 cm<sup>2</sup>. If you need to work on a large surface it is divided into several regions. On the first day voicing 1 – 2 fields, and then - up to 3-4 fields. Scoring is carried out in a continuous or pulsed modes. Last milder, it is usually used for more severe stages of disease, not to overdose treatment dose as possible aggravation of the process.

UST done daily or every other day on the course - 6-14 procedures. Repeated treatment may be given within two months or more. Below we present some of the techniques of ultrasound therapy in the most common pathology in stroke patients.

### **Methods of UST in poststroke patients**

When conducting UST in poststroke patients should clear idea that this method is one of the components in medical rehabilitation, along with other methods of physical therapy, kinesis - or mechanotherapy, etc. In addition, UST can be used in its three standards

- versions: UST with an impact on the required area;
- ultraphonophoresis with a choice of procedures necessary for the drug;
- ultrasound puncture or ultraphonophoresis with the choice of the necessary points.

Optimally combine all of these options. Figures 1 and 2 show the point of tonic and immunomodulatory actions, 3-5 of which it is desirable to include in each session UST with an energy dose of exposure to 5 J / cm<sup>2</sup> (0.5 W / cm<sup>2</sup>, 10 s) on each point.

The remaining area UST determined to existing pathology.

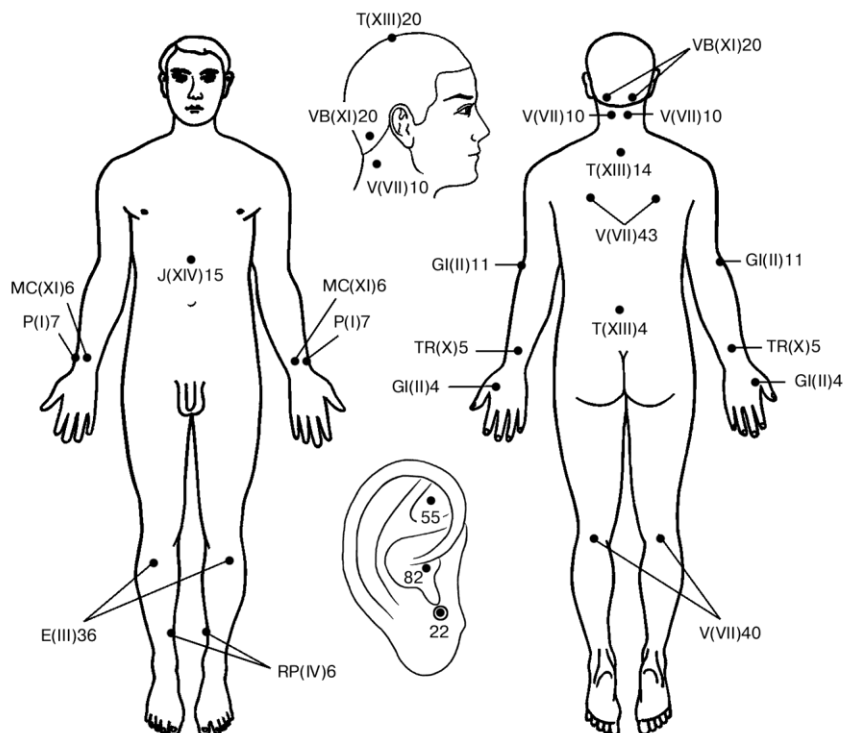


Figure 1. Acupuncture points of broad-spectrum (bracing), recommended for the stimulation methods puncture physiotherapy (ultrasound, laser, UST-lasero-electro-SWT- or classical acupuncture) in post-stroke patients in order to improve the psychosomatic condition of the patient (anti-depressant, analgesic and other actions).

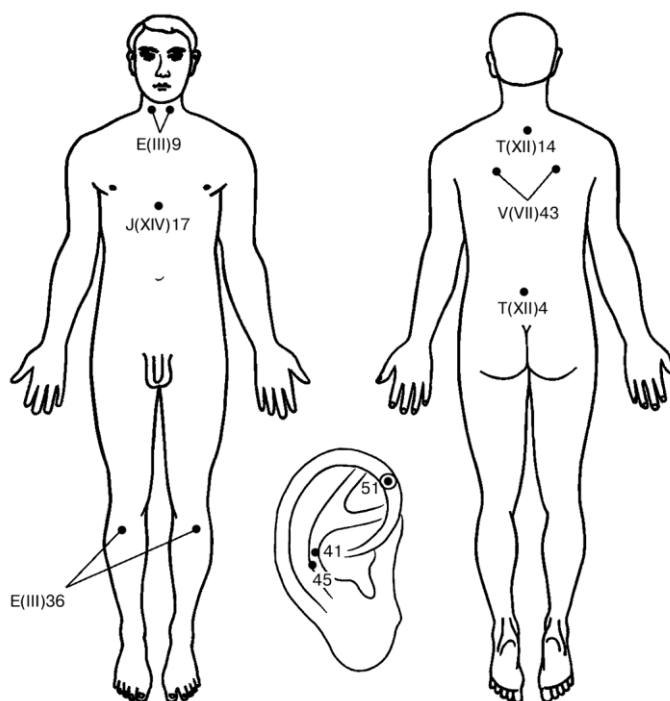


Figure 2. Area for puncture physiotherapy and possesses a strong immunomodulatory effect, stimulation of which helps to increase "resilience" of the body and improve the immune resistance.

### Respiratory Diseases

In Figure 3 shows the main impact area for UST to prevent or respiratory diseases. UST is effective with symptoms of bronchospasmus, chronic obstructive pulmonary disease (I-II cent.), Recurrent bronchitis, pneumonia prevention, and others recommend the use of low-frequency ultrasound (44 kHz, the device MIT-11) on the labile technique.

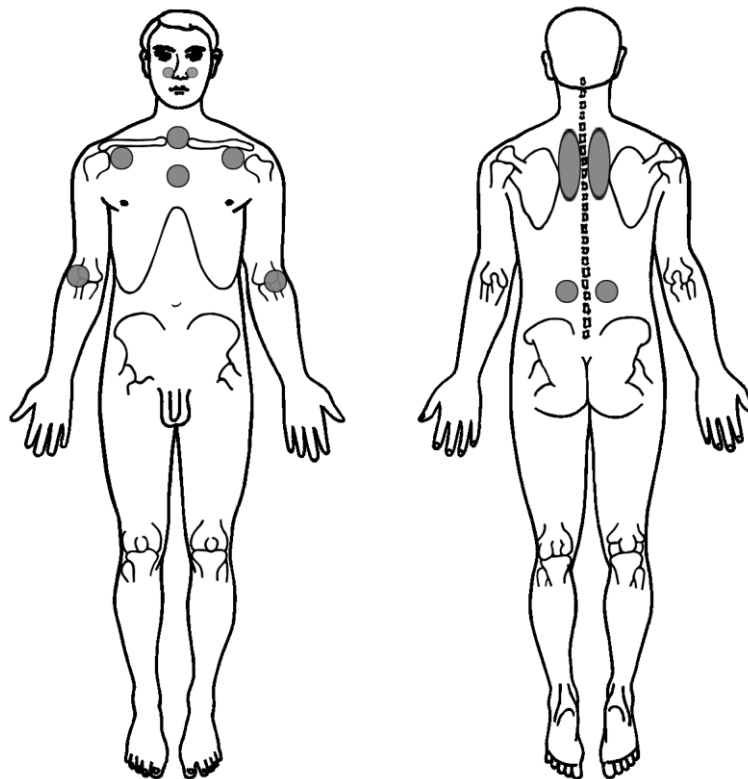


Figure .3 The main zones of influence for the UST to prevent or respiratory diseases.

On the first day of paravertebral affect two of the field (on the left and right) from Th1 to Th7 for 3 min, with the amplitude of oscillation - 2 mkm. On the second day of the attached impact on VII and VIII intercostal space on the paravertebral line to until mid axillary line and the projection of the thymus (through the breastbone) with the same amplitude. On the third day of the ultrasonic impact treatment is performed on all the previous field and add the right and left subclavian area, 1 min each, the amplitude - 3 mkm. Follow-up procedures performed on these areas with possible changes in the intensity of ultrasound exposure and procedure.

Additionally, as noted, is carried out low-frequency ultrasound probes on the acupuncture points: P1, P5, P7, V13, GI11, VG4, VG14, RP6, F2, F3, 10 with each. Use from 2 to 6 points for the procedure.

It is also appropriate an Uff with hydrocortisone in these areas instead of a UST. The overall rate of UST is 12-15 procedures.

Application of ultrasound reduces or eliminates bronchospasm, reduces hypertension in the vessels of pulmonary circulation does not cause negative reactions on the part of the cardiovascular system, has a powerful effect on sanogenetic mechanisms that helps to eliminate stagnation in the lungs and other .

### Diabetes mellitus (DM)

Diabetes mellitus - a frequent concomitant diseases in cerebrovascular diseases, which, together with hypertension and atherosclerosis is often the root cause of stroke. Naturally, post-stroke patients, in such cases requires a correction of carbohydrate metabolism. Most of the time poststroke patients registered with type 2 diabetes.

Penetration of ultrasonic waves of low frequency to a considerable depth of the human body can directly affect the pancreas with a view to its stimulation. To enhance the therapeutic effect of additional impact on the projection of the liver, segmental zones Th7-Th12 and acupuncture "points-herald" and "sympathetic" meridian spleen-pancreas. Sound projection of the pancreas and liver mushroom-shaped transducer is held for 5 minutes at a frequency of 44 kHz and an amplitude of 5 mkm in pulsed mode. Procedure is carried out every day or on a course of treatment - 10-12 procedures. Impact on the paravertebral region is held by a labile technique for 3 minutes on each area, with an amplitude of 3-4 m and the modulation frequency - 10.0 Hz. Stimulation of acupuncture points RP6, V20, GI11, E36, VC24, VG12, F13 is over 10 (cumulative up to 2 min.). The main zones of influence in diabetes mellitus are shown in Figure 4.

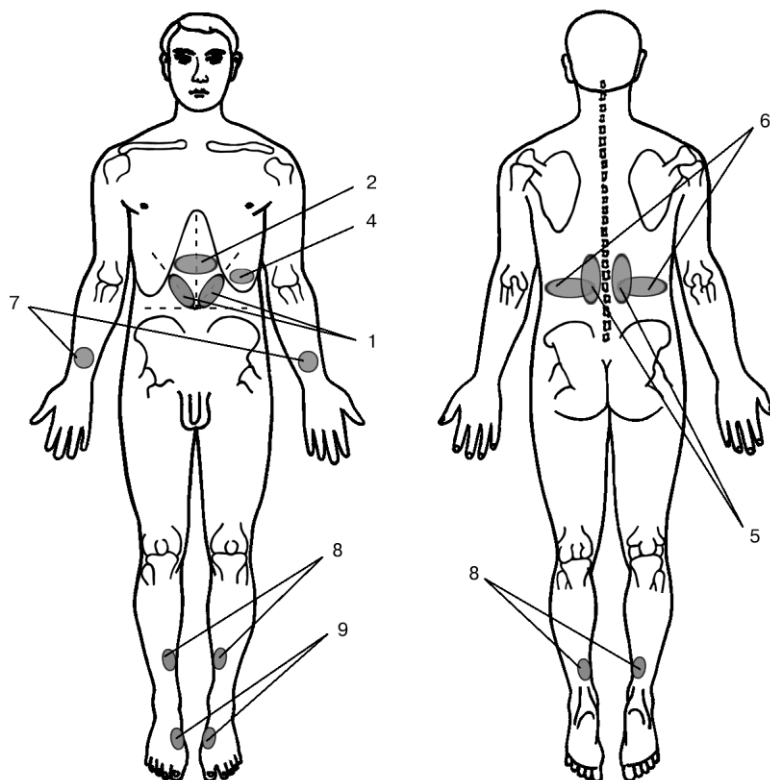


Figure 4. The main impact zones in diseases of the pancreas and diabetes mellitus: 1 - a projection of the pancreatic head, 2 - the projection of the pancreas, 3 - the projection of the tail of the pancreas, 4, 5 - segmental zones - 6 - the projection of the rear surface of the gland, 7, 8, 9 - distal areas for action, 10 - zone of liver.



## Diseases of urinary organs

Ultrasound therapy may have significant therapeutic and preventive effect for urolithiasis diathesis, chronic pyelonephritis, etc. You should not use UST in the presence of stones in the pelvis, the size of which preclude their passage through the ureter.

Fig. 5 provides a projection of the urinary organs for UST. The use of low-frequency ultrasound (44 kHz) allows a direct impact on the desired department urinary organs. Used a contact-scanning technique: the

- original sounded a projection of kidneys with the magnitude of the ultrasonic vibrations of 3-5 mm for 3-5 minutes on each kidney,
- then the projection of the ureter with the same parameters for 2-3 minutes on each,
- then the bladder, segmental zones and points acupuncture. The total procedure time of 15 min, 7-15 treatment sessions.

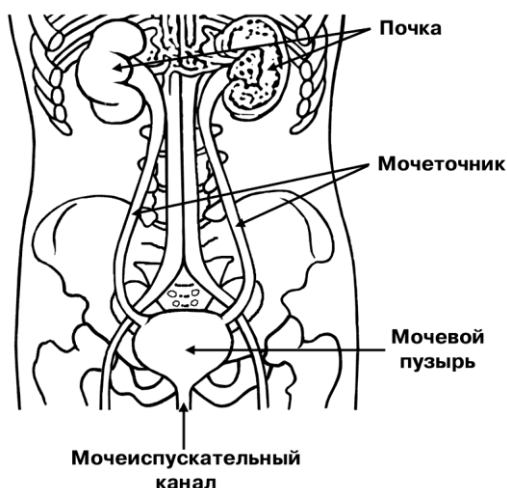


Figure 5. The projection of urinary organs for UST. Uses low-frequency ultrasound, contact-scanning technique. The remaining notes in the text.

### UZT in diseases of the locomotor apparatus

In poststroke patients is often associated pathology in the form of various joint arthrosis, degenerative changes in the spine with pain and autonomic-trophic disorders. In such cases, the use of UST in combination with electric and magnetic therapy, exercise therapy, massage provides a significant therapeutic effect.

Exemplary parameters UST with arthritis are:

Osteoarthritis deformans

UST appointed without concomitant synovitis. The frequency of 44 kHz ultrasonic vibration amplitude of ultrasonic vibrations  $2 \div 5$  mm ( 0,2-1,0 W / cm<sup>2</sup>) mode switching position of the emitter contact exposure method labile

drug is scoring was carried out using as a media contact, medical solutions, suspensions, emulsions and gels, the scope of the affected joint. Treatment time 07.10 minutes, more areas - segmental 3-5 minutes, interval between procedures every day or two quality procedures for the treatment 7-10 minutes.

Along with exposure to segmental zones and joints can use the following acupuncture points for scoring them low-frequency ultrasound: VG14, VG11, V11, RP15, R3, VB41, TR5. Duration of exposure - up to 30 seconds per point.

Possible combination with other physical factors and their sequence (for example coxarthrosis):

- massage UST → electromyostimulation gluteus magnitolaserotherapy (all in one session);
- 2-3 hours kinesitherapy;
- next day kinesiotherapy and spa procedures;
- subsequent alternation of these procedures.

### Calcaneal spur (phonophoresis)

frequency of ultrasonic vibrations at 44 kHz, ultrasonic vibration amplitude 5 mkm mode switching (modulation frequency 10 Hz) Regulations emitter contact area is the projection of the impact of heel spurs from the foot contact medium (drug substance) with a suspension of hydrocortisone analgin alternated with Fastum gel (a procedure) method is the impact of labile or stable Procedure time 3-10 min interval between procedures every day or number of treatments per treatment 15-20.

Additional treatment zones: the lumbosacral segments calf and Achilles tendon (Fig. 6).



Figure 6. Additional site of action for UST for calcaneal spur

Below are diagrams showing areas for UST with arthropathies and arthrosis of the joints of the upper (Fig. 7, 8), bottom (Figure 9-11) limbs and major acupuncture points (Fig. 12) used for diseases of the joints.

When UST arthrosis or arthropathy, note the following:

- scoring the most technically involves joint impact on the periarticular tissue, musculo-ligamentous apparatus and the projection of the joint space. Sounding a little bone efficiently. In the presence of synovitis ultrasonic effect on the joints is not recommended. Where indicated on the affected joint can be carried out Uff;
- addition to the session UST included segmental zones - Hand - cervical-upperthoracic segments cervical segments, legs - lumbar;
- inclusion of probes enhances the therapeutic effect, a
- combination of UST with other physical factors, and physical therapy is an important component of the rehabilitation process .

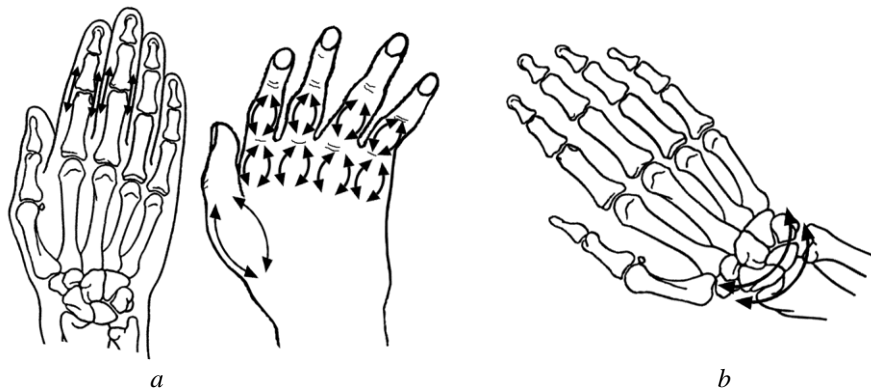


Figure 7. Impact area by ultrasound: a) in diseases of hand joints (preferably underwater method), b) wrist



Figure 8. Zone for the UST at the shoulder joint arthropathy

Sound shoulder joint is held around its perimeter with the direction of ultrasonic waves on interarticular gap periarticular tissue and place emphasis on the occurrence of tendon of long head biceps (1), subscapular bags (rear side) (2), Akromio -clavicular ligament (3).

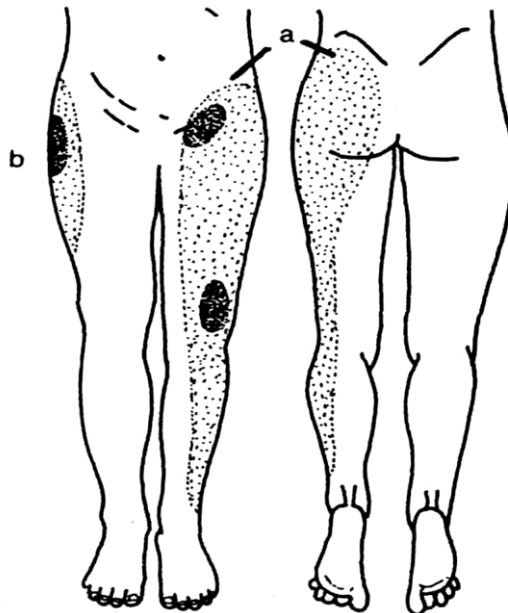


Figure 9. Zone of distribution of pain in (a) defeat of the hip joint and (b), trochanteric bursitis, which should be voiced in sessions UST.

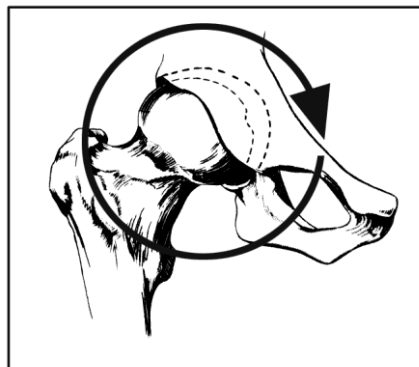


Figure 10. Zone of influence of ultrasound in diseases of the hip joint.

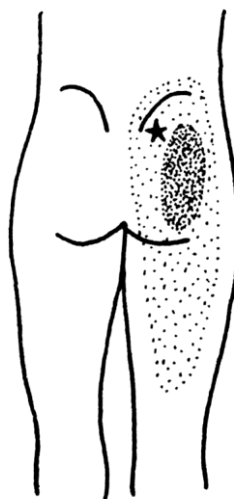


Figure 11. Zone of localization of pain in the pathology of the sacroiliac joint, the impact of which is shown in UST.

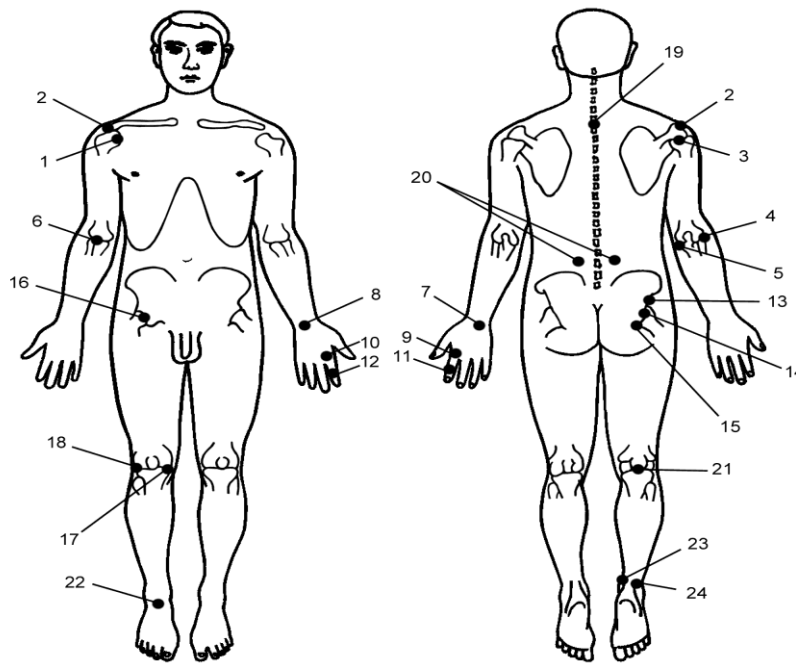


Figure 12 Site of action for UST in diseases of the joints: 1-3 - shoulder joint; 4-6 - elbow; 7-8 - radiocarpal joint; 9-12 - wrist; 13-16 - hip, 17, 18, 21 - knee joint; 22-24 - ankle joints of the foot (one field from the back and the plantar surface of the projection of the joint space), 19-20 - additional field effect regardless of the localization.

The process. area of bony protrusions and the small joints of the impact carried out underwater technique or through a rubber glove filled with water.

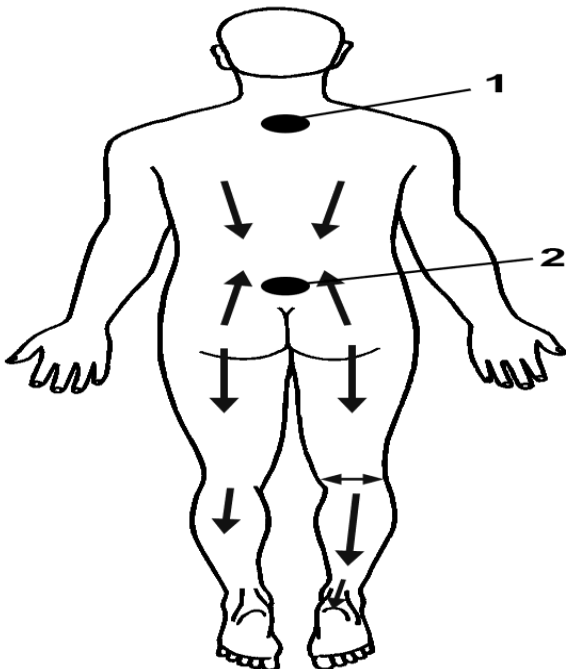


Figure 13. Projection zone for the UST or Uff in diseases of the lumbar-sacral of the peripheral nervous system. Sounded low-frequency ultrasound paravertebral area, rear surface of the thighs, legs or other areas of the irradiation of the pain. As the contact medium can be used by medicinal ointments, emulsions or gels, for example, Fastum gel. The remaining notes in the text. Numbers 1 and 2 indicated significant reflex zones (acupuncture points T14 and T4), located respectively at the spinous processes of C7 and L2 vertebrae. Impact on these areas contributes to intersegmental correction and stimulation of the diffuse nociceptive inhibitory control.

Figure 13 shows the areas for UST or Uff with nonsteroidal anti-inflammatory drugs for degenerative changes of the spine with muscular- tonic pain syndrome type sciatica. Impact by low-frequency ultrasound (44 kHz) Pain frequency modulation (77 Hz), amplitude from 2 to 5 microns (an increase of 1 mm in each subsequent session). Exposure time from 5 to 15 minutes, the treatment of up to 15 procedures. Combination: a massage, electrical and

magnitolazeroterapiey etc.

Effective use of UST with myofascial pain syndromes (MFBS), the presence of trigger points, miagelozov, etc. In such cases, the optimal combination farmacopunctura, UST and magnitolaserotherapy.

Initially, the pain zone is introduced 0.5 % novocaine solution - 0.5 ml or 2% lidocaine sol. - 0,5#ml, more UST in this area (up to 10 J / cm<sup>2</sup> - 0,5 W / cm<sup>2</sup> - 20) and after MLT (3 J / cm<sup>2</sup>).

Preferably, use of lidocaine. as procaine partially inactivated by ultrasound

Fig. 14 shows the impact zone for the UST at MFBS infraspinatus muscles.

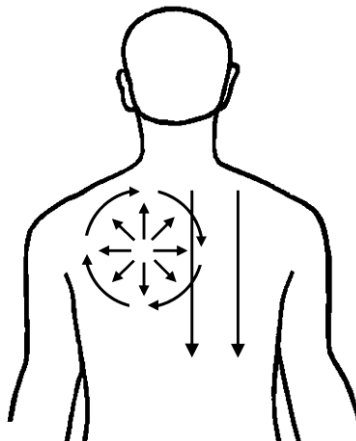


Figure 14. Site of action for UST at miofastsealnom pain syndrome localized in the infraspinatus muscle.

Is of practical interest to use UST in spastic paresis. Feature of the method for correcting influence on the muscular tone of ultrasonic impact is its different energy dosage to the spastic muscles and antagonists. Thus, at the spastic muscles affect low-frequency ultrasound (44 kHz) contact-scanning technique, the amplitude of the ultrasonic wave 5 microns (1 W / cm<sup>2</sup>) with frequency modulation of 10-15 Hz (the frequency of adequate red, tonic, muscle fibers for relaxation) . Duration of treatment for spastic muscles - to the feeling of pleasant warmth and relaxation of muscles, which can range from 10 to 20 minutes. Antagonists on muscle ultrasound exposure of 3-5 min, the amplitude of ultrasonic waves 2-3 microns (0,2-0,4 W / cm<sup>2</sup>), frequency modulation of 20-25 Hz. Such a modulation frequency ultrasound is optimal for effects on white muscle fibers. This technique corresponds sedation on spastic muscle and toning up - on the antagonists. Its advantage - a low-frequency ultrasound deep permeates all muscle groups and to individual fibers, US easily dosed and well tolerated by patients.

In addition to the direct articulation of muscles includes corresponding segmental areas for hands and feet, the exposure time which is 5-7 min, range ultrasonic waves 4 microns, frequency modulation - 10 Hz.

Fig. 15 are treated area in the spastic paralysis of lower extremities.

This technique works well in conjunction with electromyostimulation muscles (antagonists), which is given after the UST.

Regulatory UST may alternate with heat therapy and balneotherapy.

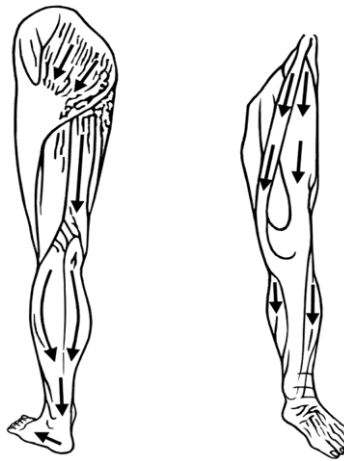


Figure 15. Site of action for UST in the spastic paralysis of lower limbs in spastic muscles of the front panel has a sedative (relaxing), ultrasound exposure, at the back of the group - a tonic. Others explained in the text.

Fig. 16 shows the acupuncture points that are used for probes or other variants of puncture physiotherapy for reduced muscle tone in post-stroke patients.

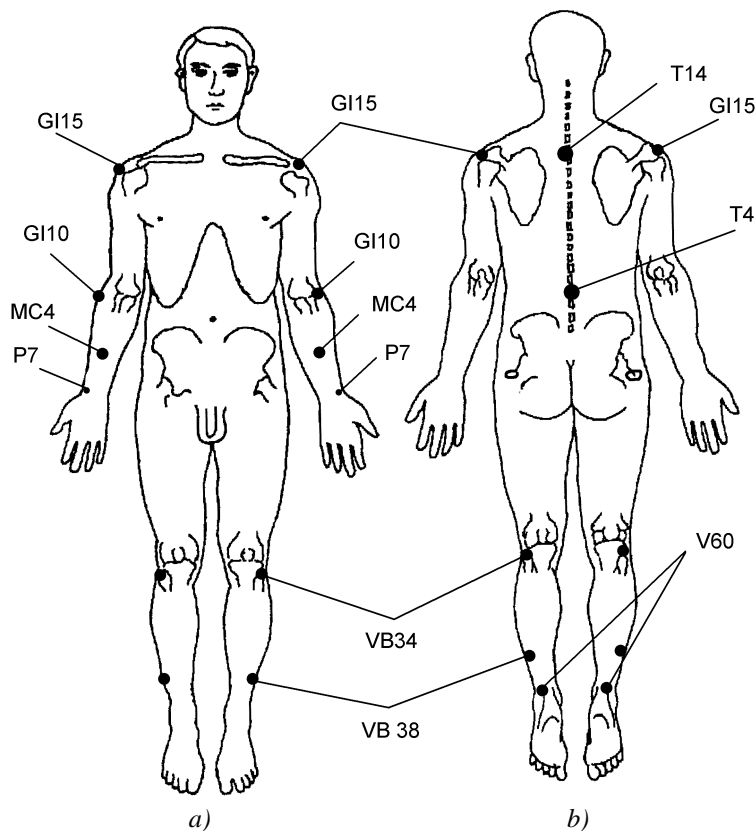


Figure 16. The acupuncture points are recommended for UST with hypotonia of muscles: a) front, b) on the back of the body surface

In Fig. 17 are areas for UST and magnetic therapy for prevention thromboembolic disease. UST held daily until the patient is in supine position, a day later, on a course of treatment - 7-10 procedures.

Parameters of exposure:

US - 44 kHz low-frequency ultrasonic vibrations intensity 0.4 W / cm<sup>2</sup> (3 min) continuous mode position of the emitter contact exposure method labile Procedure time 10-15 min.

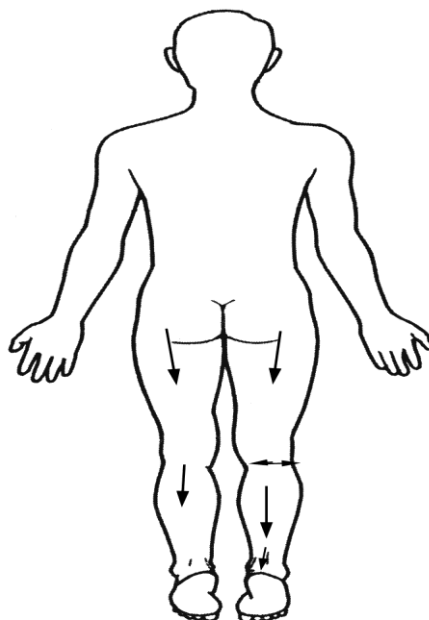


Figure 17. Projection zone for the UST and magnetic therapy for prevention of thromboembolic disease.

#### **Apparatus for ultrasonic therapy**

Is currently the domestic industry produces therapeutic ultrasonic equipment operating in the tri-band ultrasonic frequencies: low frequency - 22, 44 kHz, midranges - 880 kHz, high frequency - 2640 kHz.

In the majority of physiotherapy ultrasound machines forming an ultrasonic wave based on the principle of the piezoelectric effect, the essence of which lies in the fact that some crystals (quartz, lithium sulfate, tourmaline, barium titanate, etc., called piezoelectric crystals), change their shape under the influence AC sinusoidal electric current - is compressed in a single half-cycle and recover its shape within the next one. The main constituent elements of the ultrasonic devices are:

- the generator of sinusoidal electrical signals at a frequency of vibrations of ultrasonic waves,
- low-frequency master oscillator,
- a set of ultrasonic vibrators,
- a set of interchangeable nozzles,
- the control unit,
- power supply,
- timer.

Generator sinusoidal electrical signals designed to generate an electrical signal at a frequency of resonant oscillations piezoceramics and provides the required frequency of ultrasonic waves.

Woofer master oscillator is designed to generate a pulsed or modulated signal controls the formation of an ultrasonic wave.

Set the ultrasonic vibrator is designed to generate ultrasonic waves in a given range of wavelengths. The various devices they may be from one to ten pieces.

Set interchangeable attachments designed to supply ultrasonic vibrations to the area of impact. The number and configuration of nozzles is determined by the destination device.

The control unit is designed to enable and disable the device, a set of time-consuming procedure, the mode of the apparatus, such as a vibrator, the amplitude or power output.

The power supply is designed to generate supply voltages for all electric circuits.

Timer is designed to display and time management procedures.

#### **MIT-11**

For the low-frequency ultrasound therapy device manufactured by domestic industry "MIT-11 (Fig. 18). The main modifications to this unit are MIT-11 F (physiotherapy), MIT-11 K (cosmetology). Modification of different versions of attachments.

The device is intended for use in clinical practice and health resort for the effects on the organs, reflex zones and acupuncture points.

The device can be used by doctors or nurses to medical prescription.



Figure 18. Apparatus for low-frequency ultrasound therapy, MIT-11

Technical characteristics of MIT-11

The frequency of ultrasonic vibrations 44 (22 or 880) kHz amplitude ultrasonic waves 2, 3, 4, 5 microns Magnetic induction; 2, 8, 12, 15 mT modulation frequency ultrasound and magnetic signals of 0-99 Hz mode "swing" of the frequency of 1-10 Hz for 10 s, 10-100 Hz for 10 s settling time of procedure 1 to 99 minutes.

**MIT-11 MLT + ultrasound (880 kHz)**



Figure 19 .- The device MIT-11 MLT + ultrasound (880 kHz)

Apparatus for magnetic laser therapy of MIT-11 IMLT + ultrasound (880 kHz) (Fig. 19) is used to perform zonal physiotherapy using a magnetic field and optical flow of red and infrared ( or blue) ranges of the spectrum at the resonant frequencies of organs or systems, and also allows for mid-range ultrasound therapy.

Technical characteristics of TIM-11 MLT + ultrasound (880 kHz) power of optical flow: red,  $50 \pm 10$  mW infrared,  $50 \pm 10$  mW of blue ,  $20 \pm 10$  mW maximum value of magnetic induction at the surface of the applicator, 25-30 mT range set by the resonant frequency modulation of light and magnetic fields of 0-10 Hz with a step 0,1 Hz frequency ultrasonic vibrations 880 kHz power ultrasonic vibrations, less than  $1 \text{ W} / \text{cm}^2$ .

### **The combination of ultrasound and other physical factors**

Treatment with ultrasonic waves combined with virtually all types of electrotherapy, vacuum massage, balneotherapy, magnet. In this case, an ultrasound appropriate to apply first. It should be remembered that in physiotherapy conventionally distinguish two methods of exposure - combined and blended. Combined physical therapy is considered to be consistent (different times) the application of physical methods of treatment. At the same time be combined physical methods can be applied in one day, on different days (according to the method of alternation) or course of treatment, when some methods are replaced by others. The combined effect is a combination of two or more treatments simultaneously or sequentially (one after the other) on the same area. Enhancing effect of two or more treatment methods may be the result of the addition of operating in one direction (on the same physiological system), methods, or method of potentiating the actions of one another.

The effect of combined and physiotherapy is based on strengthening the local reaction, on the principle of contrast therapy and mechanism sensitization. Properly elected physiotherapy complex significantly increases the effectiveness of treatment has an impact on the ground and associated disease, the various physiological systems of the body and disease process, summarizes the positive effects of synergistic factors or weakens their negative impact, as well as extends the period of the aftereffect of the course of physiotherapy.

In one day compatible Procedure:

- general and local action on the underlying disease (eg, ultrasound, and then shared bath or general electrophoresis)
- of general application regarding the underlying disease and local action - for the treatment of concomitant diseases (eg, ultrasound on the area of tonsils and gas bath),
- two procedures for local action on the one disease (such as ultrasound and SWT-therapy),
- two procedures of local action, from which subsequent increases the effect of another (eg, phonophoresis and ampulse)
- acceptable use in one day three local procedures that do not cause a big burden and fatigue patients (eg, microwave therapy, then an ultrasound and electrophoresis).

In medical rehabilitation post-stroke patients with a combination of UST is especially shown with the electrical and magnet, massage and kinesitherapy.



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