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# ULTRASOUND THERAPY OF DIABETES MELLITUS TYPE 2

## Terapia ultradźwiękowa cukrzycy typu 2

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**Key words: ultrasound therapy, diabetes mellitus type 2.**

***Summary***

*We studied the possibility of low-frequency UST in the correction of carbohydrate metabolism by assessing levels of fasting glucose and C-*
*peptide, as well as the content of the contrinsuline hormones (cortisol, samatotropin) in groups of diabetic patients.*

*Ultrasonic treatment was carried out at 44 kHz and amplitude of oscillations 2 microns using the therapeutic device MIT-11 on the projection area of the pancreas stable technique, 5 times per week, exposure to the session for 3 minutes. As the contact material used liquid paraffin. To enhance the effect further impacted on the segmental zone Th7-Th12 labile technique for 2 min. for each area to the left and right. The treatment course consisted of 8-10 sessions. Patients were followed for 12 months. Ultrasonic treatment was carried out against lowering drug therapy, 91 patients aged 18-78 years, including type 1 diabetes was observed in 23 individuals (control group), and type 2 - 68 people. First identified diabetes was diagnosed in 47 patients, the remaining 44 suffered from more than 5 years. Before and after treatment were studied basal levels of C-peptide, cortisol and growth hormone (GH) in serum of venous blood radio immunoassay, we determined the glycemic profile and blood sugar levels in daily urine.*

*Analysis of results showed that 82% surveyed, under the influence of treatment was recorded reduction of hyperglycemia with newly diagnosed diabetes type 1 diabetes and type 2, as well as a long ill patients. Blood glucose levels prior to treatment during the day ranged from 10-15 mmol / l after the treatment - 6.10 mg / dL.*

*The resulting dynamics parameters after UST during observation showed an improvement insulinoproductive function of the pancreas under the influence of ultrasound exposure, which contributed to a more rapid onset of diabetes compensation and reduce the dose glucose-lowering drugs.*

*UST is combined with many kinds of physiotherapy effects: electrotherapy, massage, balneotherapy, laser-and SWT-therapy and other options for therapy with electromagnetic waves, enhancing their effect. This kind of treatment so far has not found wide application in the treatment of diabetes and its complications, however, is a promising method of physiotherapy treatment, given its mechanism of action and different ways of application.*

***Słowa kluczowe: terapia ultradźwiękowa, cukrzyca typu 2 Streszczenie***

*Badaliśmy możliwość UST niskiej częstotliwości w korekcji metabolizmu węglowodanów poprzez ocenę stężenia glukozy na czczo i C-*
*peptydu, a także treści contrhormonów insuliny (kortyzol, samatotropin) w grupach chorych na cukrzycę.*

*Leczenie ultradźwiękiem zostało przeprowadzone na 44 kHz i amplitudzie drgań 2 mkm przy użyciu urządzenia terapeutycznego "MIT-11 na obszar projekcji trzustki techniką stabilną, 5 razy w tygodniu, sesji po 3 minuty. Jako materiału do kontaktu używana parafina ciekła. Leczenie 8- 10 sesji. Pacjenci byli obserwowani przez 12 miesięcy. Leczenie ultradźwiękiem zostało przeprowadzone razem z farmakologicznym leczeniem, 91 pacjentów w wieku 18-78 lat, w tym cukrzycę typu 1 stwierdzono u 23 osób (grupa kontrolna), jak i typu 2 - 68 osób. Po raz pierwszy cukrzycę rozpoznano u 47 pacjentów, 44 pozostałych cierpi na nią więcej niż 5 lat. Przed i po zakończeniu leczenia podstawowego badano poziom peptydu C, kortyzolu i hormonu wzrostu (STG) w surowicy krwi żylnej radioimmunologiczną metodą, oznaczenie profilu glikemii i stężenia cukru we krwi w moczu na dobę.*

*Analiza wyników wykazała, że 82% badanych, pod wpływem leczenia odnotowano zmniejszenie hiperglikemii ze świeżo rozpoznaną cukrzycą typu 1 i cukrzycy typu 2, jak długo chorzy pacjenci. Poziom glukozy we krwi przed rozpoczęciem leczenia w ciągu dnia wahała się od 15/10 mmol / l po zabiegu - 6,10 mg / dL.*

*Uzyskane parametry dynamiki w okresie obserwacji po UST pokazali poprawę funkcji insulinoprodukującej trzustki pod wpływem ekspozycji USG, które przyczyniły się do szybszego zmniejszenia dawki leków hipoglikemizujących.*

Currently in therapy diabetes type-2 applies a broad arsenal of antihyperglycemic drugs with different pharmacokinetic and pharmacodynamic effects, aimed at addressing the underlying metabolic abnormalities that lead to hyperglycemia (disturbance of insulin secretion, insulin resistance, excessive production of glucose by the liver, slowing glucose absorption in the intestine, stimulation of insulin secretion and a simultaneous suppression of glucose release). In 2006, the American Diabetes Association (ADA) in conjunction with the European Association for the Study of Diabetes (EASD) adopted a consensus on the treatment of patients with diabetes mellitus type 2.

Basic principles of this approach to the treatment of diabetes include the following provisions (8).

1. Aim for good glycemic control defined as HbA 1c <7%.
2. Monitoring the level of HbA 1c every 3 months along with regular self-monitoring blood glucose.
3. Intensive correction of hyperglycemia, dyslipidemia and hypertension.
4. When newly diagnosed cases of diabetes patients should contact a specialized agency.
5. Selection of therapy should be pathogenetically substantiated, including but not limited correction of insulin

resistance.

6. From the moment of diagnosis diabetes type 2 for 6 months for patients to carry out intensive therapy to achieve HbA 1c levels below 7%.
7. If within 3 months not achieved target levels of glycemia, shows the use of combination hypoglycemic therapy.
8. If during the diagnosis level of HbA1c> 9%, immediately applied a combined hypoglycemic therapy or insulin therapy.
9. With a combination of glucose-lowering drugs are preferred drugs with different mechanisms of action.
10. In the complex of measures to achieve target levels glakemii have great value patient education and self-control patients.

However, despite the variety of anti-diabetic drugs and the possibility of their combined use, to achieve compensation for metabolic disorders in a sufficiently large part of patients with diabetes mellitus type-2 remains elusive. Numerous studies confirm that more than 60% of patients have an unsatisfactory compensation diabetes (11, 13). According to a study UKPDS efficacy of therapy with increasing duration of diabetes type-2 reduced: target HbA 1c <7% reaching about 50% of patients within 3 years and only 25% of patients - for the duration of diabetes 9 years (14). Requires new approaches in the treatment of diabetes type 2, including methods of physical therapy (PT).

The objectives of the FT in DM type-2 are: to increase insulin secretion, if it is not enough, increase the sensitivity of receptors to insulin; weaken contrinsular mechanisms (10); increase glikogenmaking liver function, increase oxygenation and hydration of tissues and their permeability to glucose, increase alkaline body reserves, and improve overall circulation and microcirculation; struggle with macro-and microangiopathy, and improve carbohydrate, lipid, protein, mineral metabolism, obesity, prevent the progression of diabetes and its complications. To solve these problems, various methods of physiotherapy: electrophoresis of zinc, copper, magnesium, niacin, calcium, sodium thiosulfate, heparin and other drugs, low-frequency pulsed currents, especially for the treatment of diabetic angio-and polyneuropathies.

In the FT DM also apply electrosleep, SMV, DMW-THERAPY, FL inductothermy UHF, UHF inductothermy and others (3-5). However, the most significant results in the treatment of diabetes were obtained with the use of low-frequency UST, in combination with other methods of CFT (1, 2, 6).

**Therapeutic and physiological effects of ultrasound therapy.**

Ultrasound therapy (UST) provides for the prophylactic or therapeutic purpose energy inaudible to the human ear mechanical vibrations of an elastic medium with a frequency above 20 kHz. In physical therapy practice used vehicles, which use ultrasonic vibrations of high chastoty1000-3000 kHz, 800-880 kHz medium, and low frequency 22-100 kHz (7). Ultrasound (US) - is the only physical factor (FF), able to carry out micro-massage is not only tissue but also in individual cells. US is also implementing energy impact with the formation of heat is a kind of catalyst for the physical, biochemical, biophysical and physical-chemical reactions and processes in the body. Under the influence of power ultrasonic waves occur microalterative changes in cellular structures, in particular the lipoprotein membranes of lysosomes, which leads to changes in cell homeostasis and activation sanogenetic mechanisms of protective reactions of intracellular regeneration (9).

In the mechanism of ultrasonic emit heat (nonspecific), mechanical and physico-chemical (specific) influences.

**Thermal effect is** associated with the processes of heat generation in the absorption of ultrasound by tissues. Heat buildup occurs selectively on the inner membranes of cells, depends on the sound and is more pronounced when using the continuous operation and stable method of exposure. Consequence of the thermal effect of ultrasound can be regarded as increasing the speed of the metabolic processes, the occurrence of temperature gradients, which improves blood circulation and limphocirculation, raising the elasticity of the vascular wall.

**Mechanical action** is due to the alternating acoustic pressure (in the center of the compression pressure = 2.6 atm, in the heart of dilution =- 2.6 atm) and manifests itself in a sort of "micro-massage" at the cellular level. As a result, increases the permeability of cell membranes and facilitates the process of transport of substances through the membrane and thus increasing their penetration into the cell. US carries out depolimerization effect on hyaluronic acid, activating the electrokinetic phenomena, which plays an important role in phonophoresis. This is especially true for low-frequency ultrasound, because the amplitude of oscillation is approximately 10 times higher than that of high-frequency ultrasound.

**Physico-chemical effect** is often secondary. Alternating elastic vibrations in the body tissues causing mechanical resonance, which resulted in accelerated motion and vibration of molecules, intermolecular bonds are weakened, there is their decomposition into ions. The formation of new electric field is disturbed isoelectric state, there are electronically excited states and the changes in cells and tissues, activation of physical and biochemical processes in tissues. US-listed effects improve local blood circulation, help to increase the permeability of the capillaries, strengthening the processes of diffusion and osmosis, and improved metabolism. The activity of hormones, ions and other biologically active substances as a result of their transition to a free state, increasing enzyme activity and metabolic processes. (4, 7).

Mechanisms of action of UST under the influence of different tissues are presented in Table. 1

**Table 1. Therapeutic and physiological effects of UST, occurring in various tissues of the body.**

| Tissue | Therapeutic and physiological effects |
|---|---|

| 1 | 2 |
|---|---|
| Scin | Changing skin resistance constant electric current, the redox potential and pH, activates excretory function of the skin (increased number of functioning of the sebaceous and sweat glands), increased excretion of lipids and chloride, increased the bactericidal properties and protective barrier function of the skin. These changes enhance the reparative processes in the skin that contributes to its regeneration. |
| Connective tissue | There is a rejuvenation of the cellular composition and fibrous structures, the activation of diamine, the binding and neutralization of excess histamine, blood proteins, free heparin and normalize blood coagulation. |
| Osteo-articular tissue | Slow development of degenerative process, stimulation of bone consolidation, increased recovery of the structure of fibrous ring and the nucleus pulposus to the accumulation of glycogen in the latter and acid mucopolysaccharides. |
| Nervous tissue | Changes energy metabolism in cells. The reaction of neurons is phase nature - from the primary stimulus for the restoration of damaged structures. Improves the speed of conduction along peripheral nerves. |
| Blood | US increases the activity of mast cells and phagocytic function of leukocytes, increases the tolerance of the plasma to heparin affects plasmocitive reaction of lymphoid tissue, normalize coagulation parameters. |
| Vessels | Normalizes vascular tone, increases lymphatic and blood flow, reveals reserve capillaries, reducing their spasm and venous congestion. Increased enzymatic activity of lysosomal enzymes alveocites; improve tissue oxygen uptake, US purifies the inflammatory lesion in the lungs of cellular detritus, clots of fibrin degradation products, stimulates the regeneration of alveolar tissue, eliminates spasm of the bronchi and pulmonary vessels. |
| Immune system | Active mechanisms of nonspecific immunological reactivity of organism due to histamine binding blood proteins and its cleavage histaminaze. |
| Endocrine secretion | Activation and normalization of pituitary-adrenal function, sympathoadrenal system, thyroid and sex glands, normal exchange catecholamines, activates the pituitary neuroendocrine regulation. Stimulates the formation of insulin, increases the sensitivity of tissues to its action. |

The principle of the biological action of ultrasound on the body is to increase the activity of adaptive and protective mechanisms. Despite the local impact of US in the formation reactions of the organism as a result of adaptive reflex action taking part the higher autonomic centers of the hypothalamic-pituitary region, the reticular formation and limbic system. Under its influence is activated and normal function of pituitary-adrenal axis and sympathoadrenal system, thyroid and sex glands.

**The main indications for UST (4).**

In Polish literature the use of UST is recommended primarily for diseases of the musculoskeletal system with the possible intensity of up to 2 W / cm 2 (12).

Therapeutic effect of ultrasound exposure is expressed in the anti-inflammatory, analgesic, antispasmodic, regenerating, and antipruritic hyposensitizing actions. Established improvement of local blood flow, acceleration of reparative processes in the nerves, bones, muscles, the normalization of the cardiovascular system, respiratory function, increase tissue oxygen uptake. US has a bactericidal effect, damaging the cell membranes of microorganisms. Most sensitive to low-frequency ultrasound exposure streptococci.

On nosological principles UST shown in diseases of the musculoskeletal system, chronic inflammatory processes, such as adnexitises, prostatitis, and others practiced methods UST with diabetes and other diseases, which is partially indicated in the table. 1 (medical and physiological effects UST).

**The main contraindications to the use UST:**

− Acute fever state unspecified nature;
− Pronounced mental disorders;
− Coronary artery disease with angina pectoris (III FC), rhythm disturbances or cardiac aneurysm;
− Circulatory failure in stage III;
− Thrombophlebitis (the impact on the affected area);
− Diseases of blood and bleeding tendency;
− Pregnancy.

**Relative contraindications:**

**-** Neoplasm (tumor);
- Syringomyelia.

**In physical therapy practice with 4 main methodological approach of US-exposure:**

− Directly to the pathological focus;
− On acupuncture points instead of traditional needles, ie, holding utraphonopunctura;

− On the segmental (reflex) zone;
− On the pathological focus in conjunction with the acupuncture points or reflex zones.

**It is not recommended** to work directly on the U.S. region of the heart, brain, bone protruding surfaces (patella, spinous processes of vertebrae), as well as the epiphyses of growing bones.

The use of ultrasound therapy in the treatment of diabetes is caused by its hypoglycemic action. Recommended that the impact on the projection of the pancreas by the following procedure: position of the patient sitting, scoring is done after receiving a large number (400-500 ml) of water, used machine UST-1.01, a technique labile, a radiator with an area of head 4 cm2, continuous mode, the intensity of 0.4 W / cm2, exposure 5 minutes on a course of treatment of 10 daily procedures (5). Impact in this way the projection of the liver blood circulation in the liver, most indicators of carbohydrate metabolism. Recently, low-frequency ultrasound is used. Thus, patients with diabetes mellitus-2 under the influence of complex treatment: Diet № 9, hypoglycemic agents, massage, and low-frequency ultrasound (device "Barvinok" affect every day or on a projection of the pancreas for 5 minutes, the frequency of 44 kHz, the course of 10 - 12 procedures), normalized blood sugar (3). Application in the treatment of patients with moderate to severe form of diabetes ultrasound on the area of the pancreas and liver (in the presence of hepatopathy) and interstitial zinc-phoresis hasten the onset of compensation (6).

Ultraphonotherapy applied under such severe manifestations of diabetes as diabetic retinopathy by the following method: the frequency of 880 kHz, the contact medium - sterile saline, continuous mode, the intensity of 0,2-0,3 W / cm 2, the exposure is 3-7 min, per treatment 10.12 daily procedures. And if turbidity or bleeding in the vitreous body can use ultrasound (by the method described) or phonophoresis papaine, litsinone or fibrinolizine (5).

We studied the possibility of low-frequency UST in the correction of carbohydrate metabolism by assessing levels of fasting glucose and C-peptide, as well as content contrinsuline hormones (cortisol, samatotropin) in groups of diabetic patients. Ultrasonic treatment was carried out at 44 kHz and amplitude of oscillations 2 microns using the therapeutic device MIT-11 on the projection area of the pancreas stable technique, 5 times per week, exposure to the session for 3 minutes. As the contact material used liquid paraffin. To enhance the effect further impacted on the segmental zone Th7-Th12 labile technique for 2 min. for each area to the left and right. The treatment course consisted of 8-10 sessions. Patients were followed for 12 months. Ultrasonic treatment was carried out against lowering drug therapy, 91 patients aged 18-78 years, including type 1 diabetes was observed in 23 individuals (control group), and type 2 - 68 people. First identified diabetes was diagnosed in 47 patients, the remaining 44 suffered from more than 5 years. Before and after treatment were studied basal levels of C-peptide, cortisol and growth hormone (GH) in serum of venous blood by radioimmune, we determined the glycemic profile and blood sugar levels in daily urine.

Analysis of results showed that 82% surveyed, under the influence of treatment was recorded reduction of hyperglycemia with newly diagnosed diabetes type 1 diabetes and type 2, as well as a long ill patients. Blood glucose levels prior to treatment during the day ranged from 10-15 mmol / l after the treatment – 6 -10 mg / dL.

The resulting dynamics of blood glucose (Table 2) was accompanied by increased basal level of C-peptide and lower content contrinsuline hormone - cortisol, regardless of the type of diabetes and duration of the disease. The level of growth hormone did not change (Table 3).

**Table 2. Effect of ultrasonic therapy on fasting glucose levels in diabetic patients, depending on the type of diabetes and duration of disease.** *

| Group patients | Glycemia before UST, mmol / l | Glycemia after UST ** mmol / l | P |
|---|---|---|---|
| Type 1 diabetes Group 1 | 11,2±1,0 | 7,3±0,8 | <0,01 |
| Type 1 diabetes Group 2 | 11,9±1,2 | 7,1±1,0 | <0,05 |
| Type 2 diabetes Group 1 | 11,6±1,1 | 9,1±0,7 | 0,05<P<0,1 |
| Type 2 diabetes, Group 2 | 12,9±1,3 | 9,40±0,7 | <0,05 |

*
Group 1, first identified DM
Group 2-long ill DM
P-reliability performance differences glucose before and after treatment
** UST was conducted against the backdrop of hypoglycemic drug therapy

**Table 3. The dynamics of hormonal parameters in patients with diabetes mellitus under the influence of ultrasound treatment, depending on the type of diabetes and duration of illness**

| Group patients | | C-peptide, ng / ml | Cortisol, nmol / ml | STH, ng / ml |
|---|---|---|---|---|
| Type 1 diabetes<br>Group 1 | *1/2 | 0,60±0,11 | 888±11 | 8,86±0,32 |
| | | 1,51±0,39 | 665±20 | 8,39±0,20 |
| | P | <0,05 | <0,05 | >0,5 |
| Type 1 diabetes<br>Group 2 | *<br>1/2 | 0,90±0,1 | 592±18 | 7,15±0,40 |
| | | 2,22±0,19 | 499±30 | 6,30±0,50 |
| | P | <0,001 | 0,05 | >0,5 |
| Type 2 diabetes<br>Group 1 | *<br>1/2 | 0,80±0,11 | 789±54 | 4,40±0,35 |
| | | 1,29±0,23 | 520±84 | 4,00±0,23 |
| | P | <0,05 | <0,05 | >0,5 |
| Type 2 diabetes<br>Group 2 | * | 1,01±0,27 | 804±80 | 7,0±1,80 |
| | | 2,05±0,23 | 480±30 | 1,50±0,90 |
| | P | <0,05 | <0,01 | >0,5 |

** 1/2- indicators: 1 - before treatment;
2 – 2 - after treatment.

Beginning of treatment effect was detected after 3-5 sessions, the maximum effect developed after 8-10 sessions UST. The positive dynamics of the studied parameters was also accompanied by a decrease in symptoms of cardiovascular manifestations, the disappearance of asthenia. is important that the disturbed carbohydrate metabolism in patients with diabetes type-2 compensated for without increasing the dose of antidiabetic drugs. At the end of treatment 60% of patients diabetes type-1 was necessary to reduce the insulin dose by 20-30% compared to its initial value. Patients with hypoglycemic agents were eliminated and only the recommended diet. UST was ineffective. Assessing the long-term outcomes at 3, 6, 12 months, 40% of patients after 3-6 months. After the first course of therapy found the signs of decompensation of carbohydrate metabolism in the remaining 60% of the surveyed state compensation was maintained during the year. Repeated courses of UST also hasten the onset of compensation of carbohydrate metabolism without increasing doses of basic treatment. Hormone levels were slightly lower compared with source. For example, levels of cortisol in the blood serum was in the range 363-1117 nmol / ml (before treatment 670-1160 nmol / ml), somatotropin - 1,1-30 ng / ml (before treatment 0,5-30 ng / ml). Levels of C-peptide was unstable and reached initial values, but after repeated courses of treatment again increased.

The resulting dynamics parameters after UST during observation showed an improvement insulinomaking function of the pancreas under the influence of ultrasound exposure, which contributed to a more rapid onset of diabetes compensation and reduce the dose glucose-lowering drugs.

US - perfect for FF combined use of drug therapy, since "loosens" the histological barriers, increasing the penetration of drugs that are in the blood. Ultrasound increases penetration of drugs by phonophoresis, amplifies their

effect at low dosages, changing their pharmacological activity.
US is the vibrational wave process is characterized by the wavelength, period, frequency, vibration amplitude and velocity of propagation in this environment. The main dosimetric parameters when the procedure is the power and intensity of ultrasonic vibrations, mode and duration of exposure.

Intensity is expressed in watts per square centimeter (W/cm2) and reflects the amount of ultrasonic energy passing through the area of 1 cm2 per second. Выделяют интенсивности: малую (0,05–0,4 Вт/см2), среднюю (0,4–0,8 Вт/см2) и большую (0,8–1,0 Вт/см2). Allocate intensity: low (0,05-0,4 W/cm2) average (0,4-0,8 W / cm 2) and large (0,8-1,0 W / cm 2).

In accordance with the requirements of gost low-frequency ultrasound is dosed in the amplitude of oscillations. 1 Вт/см2 = 5 мкм. Equating the intensity of ultrasonic vibrations on the therapeutic effect to the amplitude can be conditionally accept the following correspondence: 1-5 m W / cm 2.

The amount of absorbed ultrasonic energy depends on the type voiced tissue. Most absorbs ultrasonic bone tissue, then the nervous, muscular and less - fat. The depth of penetration of ultrasound in bone is minimal and is about 0.3 cm absorption coefficient of ultrasonic vibrations is reduced in the presence of tissue edema and an increase in the infiltration of tissue cellular elements.

With increasing frequency ultrasonic vibrations increases their absorption of the medium and decreases the depth of penetration into the tissues of the body. Ultrasonic frequency 2640 kHz is the penetration depth of 1-2 cm, frequency 880 kHz - 5-6cm, 22-100 kHz frequency - up to 10-12 cm.

UST is combined with many kinds of physiotherapy effects: electrotherapy, massage, balneotherapy, laser-and SWF-therapy and other options for therapy with electromagnetic waves, enhancing their effect. This kind of treatment so far has not found wide application in the treatment of diabetes and its complications, but is a promising method of physiotherapy treatment, given its mechanism of action and different ways application.

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