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The first clinical experience with plasma flows during the treatment of pressure ulcers of critical patients.
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In the present paper, the authors, based on the experience of the treatment of 103 patients with pressure ulcers in critically ill patients, offer a new treatment technique based on the use of plasma radiation. Method of treatment of pressure ulcers using plasma flows enables high-quality Decubital prevention of complications as well as to provide treatment which developed bedsores. Comprehensive treatment of these patients, including the processing and exposure of the wound cavity with a plasma flows, significantly improves outcomes, reduces the number of complications, reduces the average time of treatment. The obtained results allow us to recommend to the widely this technique in the treatment of Decubital complications.

Keywords: bedsore, critical conditions, plasma.

Intraduction: Bedsore – a dystrophic necrotic process also known as pressure ulcer, which occurs in weakened patients, who are confined to bed for a long time and are not able to move, is one of the most spread problems at treating the critically ill patients, especially often occurring in patients will illness of neurological profile. In order to develop bedsores, it is not enough to be confined to bed for a long period of time. It requires the presence of additional factors, which help in developing the bedsores. These factor may be the presence of severe illness, accompanied by lowered protective strength of the body and skin regeneration. Bedsore often develops in patients with strokes, paralysis, vertebral-cerebrospinal injuries and is caused by mechanical factors (e.g. exogenic), which causes the skin to die, and by endogenic factors, the development of which is determined by impaired vitality of the organism (neurotrophic changes of the skin) [6; 7; 11; 14].

The rate of developing bedsore still remains to be high, despite the correct course of treatment. The frequency of bedsores is 40 cases per 100 000 population. This disease develops in 65% of elderly patients with the breaks of thigh, in 30% of the patients at the Intensive Care Unit (ICU), 60% of the patients with tetraplegia. The rate of developing bedsores in patients who have had vertebral-cerebrospinal injury is generally around 40-60%, and according to number of authors the rate might be as high as 80%. Along with this, the probability of developing the complications of bedsores, like pain, depression, infection (abscess, septic arthritis, bacteremia, sepsis) is 20-30%. In patients where bedsores are not healed for a long period of time, osteomyelitis might develop, which increases the possibility of lethal outcome by 4-5 times. This problem has even greater importance in our country. Because of the fact that most of critically ill patients are in lying condition, around 50-60% of these patients have bedsores of III-IV degree [3; 8; 13].

The process of treating bedsores is long and expensive. According to number of authors, the cost of treating patients with bedsores in the countries of Europe and Asia varies between 10 000 and 40 000 US dollars. In cases of surgical treatment, this number is increased and at the same time it is important to note that the percentage of post-surgical complications and lethal outcomes is high. On average, after surgery only 50-75% of bedsores are initially healed, in other cases additional,

prolonged, conservative therapy or another surgical intervention is needed. Because of this, in leading hospitals around the world, where this problem is being faced, surgery is performed only in 20-30% of the patients. Most of these patients have bedsores of IV degree. Operations are preceded by long preparation period, which takes from 2-3 months to 1 year. The II and III degree bedsores are treated conservatively. In Georgia, surgical treatment is rarely used – in only 10% of the patients. The rest of the patients are treated conservatively [1; 2; 5; 12; 15].

The use of components of plasma ray (especially plasma rays, ozone, ultraviolet radiation and nitrogen oxide) opens up new perspectives in treating bedsores. Number of experimental and clinical researches have shown that the use of plasma rays gives the possibility to achieve hemostasis quickly, effectively and with high quality by hermetically sealing the wounds, remove necrotic skin, sterilize the wound. Also the bactericidal effect of ozone and ultraviolet rays, and biostimulating effect of nitrogen oxide was revealed [4; 9; 10].

All of these data indicated the importance of conducted our research on using plasma rays in treating bedsores.

Materials and Methods:In the last decade our clinics started to use new method of plasma radiation in the patients with decubital wounds. They were undergoing different complex treatments of bedsores together with plasma beams (If hyperemia was detected, the skin was radiated by unfocused plasma rays). In case of signs for necrectomy, the method of plasma necrectomy was used.

Besides all above said, the patients were given medical standard examinations and treatments, which are normal in our clinics. To prevent further complications and keep skin healthy all patients were given appropriate nutrition (no less fat than 20%), including vitamin C preparations (500mg 2 times a day) and liquid (if there no indications of opposite, patients should have taken 1,5L+ liquid in 24 hours). Wet skin was dried, patients were given air bathes if possible. Several times a day patients were turned on a side, if their status allowed it. If patient could not move, his position was changed every 2 hours. Soft mattress, which was filled with air or made of foam, was used (thickness no more than 15 cm). Under sacrum a rubber circle was put with pillowcase in it; Under the motionless limbs special sacks were placed. Every day skin was processed with alcohol, warm water, disinfecting fluid and dried with blanket. After drying problematic regions were powdered by talc.

In the main group № 1 (53 patients) together with other treatments plasma beam radiation therapy mode was used. The radiation mode therapy was used either 5 times/day (33 patients) or 10 times/day (20 patients) on the regions with bedsores complications. The duration of each session was 5-7 minutes, the distance 10-15 cm from skin. Angle towards the skin was 30-45 degrees. Distance from the nozzle to the tissues were from 40-60 mm. Temperature of the plasma beam which reached the skin was safe and reached only 40-42 degrees C. The methodology itself did not need extra training or seriousness of the patient's status. The plasma evaporation therapy mode methodology was following: on the border of the skin damage a wet pattern was put for caution to prevent high temperature damage by high temperature recurrent turbulent streams reflected from the damaged skin. Angle was 30-45 degrees, the hand motion was translational and circular on the edge of the skin lesion, from distance of 10-15 cm. After removing necrotic tissues, the wound was processed plasma scalpel, which in a second evaporated necrotic tissues and exudate; It also caused haemostasis and instant coagulation. After the procedure wound surface was practically sterile. The manipulation lasted from 5-8 minutes.

The schemes, which included all the parts of pathogenesis, of decubital treatment were used. Those schemes included treatment in the obligatory order: Local treatment of the bedsores damage,

including surgical treatment of the wound together with plasma beam therapy; Changing bandages ; other manipulations, during which some of the patients were given local plasma beam radiation; General treatment by known methods was done, including infusive-detoxication, antibacterial, immune, physical therapies, exercises, general stimulating effects and biologically active regions and etc.

In control group № 2 (50 patients) in order to clean the wounds, dead cells were taken out and wounds were covered with sterile wipes with 1% of potassium permanganate. The bandage was being changed 2 times a day. Then Gauze wipes were used, which were put on wounds followed by Vishnevsky cream or other medicines, which fastens reparative processes on sluggishly granulating and slow epithelizing wounds. (“Levomicol” , “Levosin”, sea buckthorn oils and others). Upon joining a secondary infection of pressure sores used antiseptic and antibacterial agents: boric acid, hydrogen peroxide solution, Creams “Levomicol” and “Levosin”. If it was need to create content for the wound moist conditions, alginates were used in the form of wipes and powder for filling the wounds and hydrocolloid bandages, for wound clearance and closing. In order to establish the dynamics of healing bedsores, planimetric study and photometry were performed.

Results of the study:In the group number 1 immediately after plasma treatment, the wound surface became much cleaner, Microbial contamination was reduced by several orders of magnitude. In the first days after plasma treatment to 80% of patients had a subjective decrease in the intensity of pain in the wound, due to anesthetic effect of plasma flows. In the group number two less pain in the wound area was noted only in 30-35% of cases, other pain persisted, and in some cases increased.

Within three - four days more than 80% of patients in group number 1 noted further improvement, the indicators of body temperature decreased by an average of $0,8 - 0,9^0 \pm 0,2^0\text{C}$. Significantly decreased the ratio of cells in the peripheral blood ($11,9 \pm 1,1 * 10^9/\text{L}$) and leukocyte index of intoxication (LII) ($3,0 \pm 0,3$). In the group number 2 in this period improvement was observed in 45% of patients, average body temperature decreased by an average of $0,4 - 0,5^0 \pm 0,2^0\text{C}$. Indicators of white blood cells decreased moderately ($13,1 \pm 0,6 * 10^9/\text{L}$) and LII ($3,5 \pm 0,3$).

On the fifth - seventh day state of more than 60% of patients in Group number 1 was assessed as relatively satisfactory, others - as moderate. Indicators of body temperature varied between $37,4^0 \pm 0,2^0\text{C}$, the index LII progressively decreased to $2,5 \pm 0,2$. Performance of white blood cells was improved (mean values: $8,2 \pm 1,1 * 10^9/\text{l}$). Thus 30% of cases of wound indicated no growth of microorganisms. In the group number 2 state 40% of patients assessed as relatively satisfactory, 50% - as moderate, and 10% - as a heavy. LII index compared with the group number 1 is decreased to a lesser extent (up to $2,8 \pm 0,3$), as well as Figures leukocytosis (average values: $9,8 \pm 0,8 * 10^9/\text{l}$), the body temperature was observed within $37,7^0 \pm 0,3^0\text{C}$. However, only 5% of cases there was a lack of growth of microorganisms. Between 7 - 10 days in the group number 1 state 75% of patients rated as relatively satisfactory. Indicators of body temperature decreased to $37,0^0 \pm 0,2^0\text{C}$. The numbers of indicators LII decreased to $2,0 \pm 0,2$. The level of peripheral blood leukocytes was reduced to $7,5 \pm 0,6 * 10^9/\text{l}$. Body temperature returned to normal in more than 70% of patients. Reduced infiltration, compacted edges of the wound, the wound is almost completely cleared. In the group number 2 state 55% of the victims were assessed as relatively satisfactory. Indicator LII and leukocytosis level in comparison with the group number 1, decreased more slowly, the body temperature normalized only 35% of those affected. Moderately decreased infiltration, compacted edges of the wound, the wound cleaned. Bacteriological examination is often determined by mixed microflora, with a predominance of *S. aureus*, *Pseudomonas* and fungal cultures.

Application Mode "plasma blowing" infected Decubital surface led to unexpected results. Initially, the plasma was used only for additional drying of the wound, but it was later observed that "plasma blowing" has not only dry effect, but also bio-stimulating effects. Indicators of wound healing process indicate that the dynamic plasma irradiation wound defect on the background of vascular disorders helped reduce the level of microbial contamination by 2 - 4 orders of magnitude, regardless of the species and strain supplies micro flora. Even after the first 2 - 3 irradiations intensity of pain in the wound was markedly decreased, and after 4 - 5 granulation foci appeared on the surface of individual which were blended in a few days in the islets. At the same time it appeared on the surface of granulation areas of epithelial tissue. Characteristically, in some cases, epithelialization of the wound was not often started from the edges but the center in the form of foci, bridges, or radial tracks. This process has provided for the healing of the ulcer faster than conventional methods of treatment. Conducted planimetric study and photometric observations have confirmed these facts. Thus, we have found that the use of plasma streams in the treatment of wounds limbs can clean the wound from pathogenic micro flora more quickly, due to its bactericidal action of high-temperature plasma flows, ultraviolet rays and ozone. The use of plasma in most cases, receive virtually sterile surface of the wound, in other cases the concentration of microbes is far below the "critical" level. The studies made it possible to obtain reliable results confirming the feasibility of the plasma in order to sterilize the wound and prevent the development of septic complications.

Conclusions: From all that has been said, a complex treatment of bedsores in critically ill patients, including processing and irradiation of the wound surface by plasma rays and its components (ozone, ultraviolet radiation and nitrogen oxide), allows us to achieve noticeable positive effect. Herewith, the average length of treatment is reduced by 20-30%, regeneration process is enhanced near the wound area, wounds are less frequently developing complications like sepsis, post-surgery period is reduced by lowering the level of post-surgery pains, the function is restored sooner. The new method of treating bedsores by using plasma rays allows us to conduct a high quality prophylaxis of bed sore complications, as well as treating developing bedsores. Wound surfaces are recommended to be processed in modes <<coagulation>> and <<plasma radiation>>.

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ცენტრი, თბილისი, საქართველო)

ნაჩვენებია კრიტიკულ მდგომარეობაში მყოფი ნაწოლებიანი ჭრილობების მქონე 103 პაციენტის მკურნალობა პლაზმურ სხივების გამოყენებით. აღნიშნული მეთოდი შესამჩნევად აუმჯობესებდა მკურნალობის შედეგებს, ამცირებდა გართულებების სიხშირეს და მკურნალობისათვის საჭირო დროს.