Air plasma as an effective and promising method of treatment of the third degree burning wounds

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Introduction. A special importance in the treatment of burns is also given to the prevention of purulent complications of such a wound. One of the possible pathophysiological methods to improve the results of therapy of patients with extensive deep burns is the use of physical influence on the wound surface, in particular, the use of cold atmospheric plasma for this purpose.

The biological effects of cold atmospheric plasma with low-pressure include: antimicrobial and hemostatic, stimulation of tissue regeneration. Its antibacterial effect is caused by damaging the cell wall and membrane of bacteria by ultraviolet radiation and active radicals. In contrast to the existing physical methods to stop bleeding (electrocoagulation, argon-plasma coagulation), cold atmospheric plasma does not damage tissue, but provides hemostasis by accelerating the activation and aggregation of platelets, the formation of a fibrin clot. The issue of the direct effect of cold atmospheric plasma with low-pressure on tissue regeneration in case of damage remains debatable. Some researchers note the acceleration of the proliferation of fibroblasts in vitro when exposed to this type of plasma.

Materials and methods. Experimental research was performed on 40 male outbred rats weighing 230–250 g.

For the generation of cold atmospheric plasma with low-pressure. The device can be held in the hands, and touching the plasma beam to a biological object does not lead to electric shock.

When the generator starts, a plasma beam is generated between the tip of the electrode and the biological object, which in its physical essence is similar to a positive corona discharge.

Animals were divided into 3 groups (8 animals in each group) according to the method of treatment.

In the first group of animals, necrotomy till own fascia was performed 60 minutes after the third degree burn.

Immediately after necroectomy, the wound edges were fixed to the underlying tissues with interrupted sutures, then the entire wound surface was treated with cold atmospheric plasma for 10 minutes. The distance between the beam source and the wound surface was 0.5–1 cm. The device was grounded for the manipulation.

In the second group, early necrotomy and treatment of wounds of animals was not carried out (control group).

In the third group, without wounds treatment early necrectomy was performed (second control group).

Evaluation of the effectiveness of selected methods of treatment and wounds' photographing was performed every three days. The wounds were examined as well as the character of the discharge, the presence and type of granulations were noted, and the terms of the scab rejection and wound healing were recorded.

The selection of biopsy specimens for histological examination was carried out on 3rd, 7th, 12th, 15th, 21th, 28th days of the treatment. Biopsy specimens were fixed in a 10% solution of neutral formalin, followed by posting through alcohols of upward concentration (30% –100%) and pouring into paraffin. Paraffin sections were stained with hematoxylin and eosin with their further study by methods of light microscopy.

Processing of the results was carried out in accordance with generally accepted methods of variation statistics. As the criterion of validity was considered value $p<0,05$.

Results and discussion. The regeneration process in the zone of a deep burn of the third degree with the use of cold atmospheric plasma with low-pressure had distinguishing features. On 21st day of the research, this group of animals showed a reduction in the area of the wound to 6 cm2 ($p <0.05$). Treatment of a burn wound after early necroectomy makes it possible to accelerate regeneration processes in the early postoperative period by 20% ($p <0.05$), as well as to reduce the area of the scar tissue on the 28th day of observation by 52.5% ($p <0.05$) in comparison to the control group.

Performing a radical surgical necrotomy in the zone of deep burn of skin, without further treatment, reduces the wound area by the 21st day to 8 cm2 ($p <0.05$), the regeneration process is accelerated by 8.6%, after 28 days there is a decrease in the scar tissue area by 10% ($p <0.05$) compared with the control group.

The results of planimetric studies were confirmed by a morphometric estimate of the number of microvasculature vessels in wound biopsy specimens by 35th days of observation. The average number of microvessels in growing granulations against the background of wound treatment with cold atmospheric plasma was 5. Early necrotomy without subsequent treatment allows to increase the number of vessels by 13.4% in comparison to the control group ($p <0.05$).

Conclusions and discussion. The study results indicate that the use of cold atmospheric plasma without further application of wound dressings enables to achieve wound healing by 28 days, i.e. to accelerate the regeneration processes to 20% ($p <0.05$), and also to reduce the area of the scar tissue to 52.5% ($p <0.05$) in comparison to the results of control group animals. Against the background of the implementation of cold atmospheric plasma, an earlier development of mature connective tissue in biopsy specimens is noted, further the thickness of newly formed granulations exceeds the control to 4.8% ($p <0.01$). Early necrectomy without further treatment reduces the wound area by 21 days to 8 cm2, the regeneration process is accelerated to 8.6% ($p <0.05$), by 28 days there is a decrease in the scar tissue area to 10% ($p <0.05$) compared with the control group.

The use of cold atmospheric plasma in the treatment of deep thermal burns of the skin of the third degree (ICD-10) is a promising method. The literature data show that the local application of cold atmospheric low-pressure plasma in the area of the skin defect leads to antimicrobial effect, hemostatic action, and the stimulation of tissue regeneration. These phenomena are due to the generation of free radicals, UV radiation as well as charged particles. The results of our research indicate that the use of plasma in the zone of a deep burn of the third degree enable to reduce the area of the scar tissue to 52.5% ($p <0.05$).