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Tactics of local and surgical treatment of local marginal and deep circular burns of the extremities due to blast trauma

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Abstract

Objective. To improve the effectiveness of treatment of patients with marginal and deep circular burns of the extremities due to combat trauma by improving methods of diagnosis, local and early surgical treatment, and prevention of deepening burn damage.

Materials and methods. The study used the results of treatment of 40 patients with marginal and deep circular burns of the extremities at the Kharkiv Burn Center between 2022 and 2025. All patients were divided into two groups depending on the depth of the injury: the first group consisted of 28 patients with marginal burns of the hands, and the second group consisted of 12 patients with deep circular burns, who in turn were divided into two subgroups–control and main–depending on the timing and extent of surgical intervention. Patients in group 2 had their interstitial pressure measured dynamically using the Kompartmentdruck Monitor System from MIPM (Mammendorfer Institut für Physik und Medizin) GmbH (Germany).

Results. Under the influence of local atraumatic treatment, patients in group 1 with marginal burns of the hands showed a decrease in the depth of thermal damage and an improvement in the subsequent course of the wound healing process with spontaneous epithelialization within an optimal time frame. Thanks to timely surgical intervention in patients in group 2 with deep burns, aimed at decompression of thermally damaged tissues, with dynamic measurement of intra–tissue pressure, the time required for free autodermoplasty with mesh grafts was reduced from (11.6 ± 0.6) days (control subgroup) to (7.3 ± 0.5) days (main group). The skin cover in patients of the control subgroup recovered within (28.6 ± 0.8) days, and in patients in the main subgroup – within (22.8 ± 1.2) days, which made it possible to reduce the duration of inpatient treatment from (34.5 ± 0.9) days (control subgroup) to (27.5 ± 0.7) days (main subgroup).

Conclusions. Effective, accessible, and atraumatic local treatment of patients with marginal burns of the extremities in functional areas in a moist environment and preventive infusion drug therapy reduces the destruction of thermally damaged tissues, prevents deepening of the burn surface, leading to spontaneous epithelialization within an optimal time frame. Thanks to active surgical tactics with objectification of intra–tissue pressure indicators in patients with deep circular burns of the extremities, compartment syndrome disappears, against which a secondary deepening of the burn wound forms. Non–deepening of burns is an optimal condition for the formation of granulation tissue and the performance of autodermoplasty with satisfactory results.

Keywords: burns; local treatment; compartment syndrome; intra–tissue pressure; surgical treatment.

Over the past three years, as Ukraine has been defending itself against unprovoked Russian aggression, the use of drones and unmanned aerial vehicles (UAVs) has increased significantly. They are constantly being modernized, which, unfortunately, makes it quite difficult to counter them with electronic warfare methods. All this leads to an increase in the number of wounded with explosive injuries and burns among both military personnel and civilians. Very often, in explosive injuries, marginal and deep burns are localized in the functionally active areas of the limbs.

Superficial burns against the background of local treatment epithelialize spontaneously due to skin appendages that remain in the viable dermis. In marginal burns, conversion of thermally damaged tissues very often occurs dynamically. Unfortunately, no modern treatment method can completely stop the conversion of a burn wound, attempts to slow down tissue damage remain unsuccessful, and therefore new conservative treatment methods are needed [1]. The deepening of burn damage is facilitated by ischemia due to thrombosis, vasoconstriction, and edema [2].

Numerous studies have shown that inadequate infusion and local therapy, as well as delayed surgical intervention, increase the tendency for burn wounds to deepen [3].

A moist environment has a significant effect on the healing of marginal burns, promoting cell division, autolysis of thermally damaged tissues, and reducing pain. With local treatment of marginal burns in a moist environment, growth factors are preserved in the wound, the necessary temperature is maintained, and the likelihood of reinfection of the burn surface is reduced [4]; epithelial cells can migrate and re–epithelialize the wound more effectively than in a dry environment [5].

In cases of deep circular burns of the extremities, intrafascial pressure increases with local tissue ischemia and the development of intercellular interstitial edema, which exacerbates tissue blood supply disorders, which in turn exacerbates tissue hypoxia and deepens the burn wound. After timely surgical intervention aimed at decompressing damaged tissues, intra–tissue pressure decreases and the scale of necrobiotic processes in these tissues decreases [6, 7].

Therefore, attention to local treatment of marginal burns and objectification of intra–tissue pressure indicators in deep circular burns can prevent the deepening of burn damage and shorten the recovery time of the skin.

The aim of the study: to improve the effectiveness of treatment of patients with marginal and deep circular burns of the extremities due to combat trauma by improving methods of diagnosis, local and early surgical treatment, and prevention of deepening of burn damage.

Materials and methods

The study involved 40 victims with combined injuries caused by drone strikes and impact UAVs who were undergoing inpatient treatment in the burn unit. They were divided into two groups depending on the depth of the burn injury. Group 1 included 28 patients with marginal burns of the hands, and group 2 included 12 patients with deep circular burns of the limbs, who were in turn divided into two subgroups depending on the timing of surgical treatment aimed at excising non–viable tissue and the number of intra–tissue pressure measurements using the Kompartmentdruck Monitor System from MIPM Mammendorfer Institut für Physik und Medizin Gmbn (Germany). The main subgroup consisted of 5 patients with deep circular burns, whose interstitial pressure was measured three times during surgical treatment (before necrophasciectomy, after necrophasciectomy, and after primary necrectomy). The control subgroup consisted of seven patients who underwent two measurements of intra–tissue pressure with standard necrofasciotomy.

The burn area in patients in group 1 ranged from 2 to 15% of the body surface area, with an average of 6% of the body surface area. Three victims were hospitalized in a state of burn shock. Four victims were diagnosed with respiratory tract damage, 15 with barotrauma and damage to the conjunctiva and cornea of the eye. Firearm shrapnel wounds to soft tissues were diagnosed in eight victims. Burns were usually localized on the face, trunk, and both upper limbs with damage to the hands.

Patients in group 1 underwent atraumatic treatment of burn wounds in a moist environment.

The age of patients in the main subgroup (n = 5) of group 2 ranged from 32 to 56 years. There were 4 men (80.0%) and 1 woman (20.0%). In patients of the main subgroup, the area of deep thermal damage ranged from 7 to 12% of the body surface, with an average of (8.6 ± 1.4)% of the body surface, and the total burn area ranged from 7 to 20% of the body surface, with an average of (16.5 ± 2.7)% of the body surface.

The age of the victims in the control subgroup (n = 7) ranged from 34 to 53 years. There were 5 men (71.4%) and 2 women (28.6%). In patients in the control subgroup, the area of deep burns ranged from 6 to 10% of the body surface, with an average of (8.3 ± 1.2)% of the body surface, and the total burn area ranged from 6 to 18% of the body surface, with an average of (15.4 ± 2.4)% of the body surface. In 6 patients, burns were accompanied by acoustic trauma without rupture of the tympanic membrane and damage to the conjunctiva and cornea of the eye.

All hospitalized patients received preventive infusion drug therapy, the volume of which depended on the severity of the thermal injury. Patients were consulted by related specialists (otorhinolaryngologist, ophthalmologist, and therapist in the presence of concomitant pathology). Therapy included saline solutions, anticoagulants, hormones, mucolytics, proton pump inhibitors, vascular antibacterial drugs, analgesics, Ringer's lactate solution, 5% glucose solution, rheosorbilact, heparin, dexamethasone, pentoxifylline and nicotinic acid, omeprazole, and ingamist. Clinical evaluation of the treatment outcomes included visual monitoring of the wound healing process, intra–tissue pressure indicators against the background of early surgical intervention, the timing of epithelialization of marginal burns, and skin restoration in cases of deep burns.

The duration of hospitalization in the burn unit ranged from 1 to 24 hours from the time of injury.

Results

In the treatment of patients in group 1 with marginal burns of the hands, a technique was used for managing burn injuries in a moist environment using hydrophilic oflocaine ointment or a solution of dioxizol–Darnitsa at the beginning of treatment, as well as silver sulfadiazine (argedin, dermazin, and sulfargin) and atraumatic wound dressings UrgoTul during the stages of active spontaneous epithelialization of burn surfaces that did not adhere to them. The use of a hydrolipid dressing during the epithelialization stages provided an optimal environment for the wound, did not traumatize the burn surface, and thus reduced the number of dressings. The technique is accessible, minimally traumatic, and painless, and does not restrict the victim's self–care.

In the dressing room, burn wounds were treated with antiseptic solutions (Decasan or chlorhexidine). A quarter of a tube of ofloquin ointment or 10 ml of dioxizol–Darnitsa solution was applied to sterile rubber latex gloves size 9, which were then placed on the injured hand and secured proximally with a bandage. It is advisable to use large gloves, as swelling increases on the first day. The choice of hydrophilic ofloin ointment or dioxizol solution was additionally justified by their anesthetic content, which reduced pain during dressing changes.

Fig. 1.
A method of local treatment of boundary burns of the hand in a humid environment.

Fig. 3.
The stage of local treatment of a boundary burn of the hand with the use of atraumatic wound covering.

Fig. 2.
Burned surface of the hand on the 6th day after receiving with a thick layer of fibrin formed.

Fig. 4.
Epithelialization of the boundary burn of the hand on day 14.

After dressing, approximately 2–5 hours after immersing the hand in a sterile latex surgical glove, clear moisture began to condense on its inner surface, the amount of which gradually increased over 3–4 days. The amount of fluid in the glove during the first 24 hours after dressing was approximately 300–400 ml, and exudation gradually decreased over the course of a week. Hand swelling, which increased during the first 2 days, usually decreased on the 4th–5th day (*Fig. 1)*.

The dressing was changed every day for a week. When replacing the glove, the burn surface was not thoroughly cleaned in order to reduce trauma to the dermis and the formation of a fibrin layer, a thick layer of which in a moist environment prevented the burn wound from deepening (*Fig. 2*).

On the 7th–9th day from the start of treatment, the burn wounds were cleaned with removal of the fibrin layer, which was easily and painlessly separated from the dermis for the patient . Over a larger area, the burn surface actively epithelialized without the formation of secondary necrosis. Subsequently, local treatment of marginal burns was continued with the use of silver sulfadiazine and atraumatic wound dressings, such as UrgoTul. Dressings with atraumatic wound dressings were performed after 1 day for 7–10 days, followed by epithelialization on the 14th–16th day from the moment of injury (*Figs. 3, 4)*.

Patients in group 2 with deep circular burns had their intra–tissue pressure measured after cleaning the burn surface with betadine solution (10% povidone–iodine solution), with normal values in intact tissues ranging from (8 ± 2) mmHg. Intratissue pressure values in the area of deep circular burns in both subgroups studied were (36 ± 2) mmHg (*Fig. 5)*.

After performing necrophasciectomy, including skin–fat tissue to fascial–aponeurotic formations, the pressure level in both subgroups decreased to (13 ± 3) mmHg.

In patients in the control subgroup, primary necrosectomy after necrophasciectomy was performed after (47.4 ± 1.5) hours; before necrosectomy, the intra–tissue pressure was (15 ± 3) mmHg.

In 5 patients of the main subgroup, against the background of complex anti–shock therapy for (18.6 ± 1.4) hours from

Fig. 5.
Measurement of intratissue pressure (47 mm Hg) in a deep circular burn of the lower extremity.

Fig. 6.
Reduction of intrathecal pressure (5 mm Hg) after primary necrectomy.

the moment of their hospitalization to the hospital after decompression necrophasciectomy, primary necrotomy was performed on the entire area of deep burns with a Hambi knife to viable tissues under a tourniquet to reduce blood loss during necrosis excision. The volume of blood loss during primary necrosectomy was also reduced by infusion and transfusion therapy.

After primary necrosectomy, the intra–tissue pressure was measured in patients of the main subgroup (*Fig. 6*), with an average value of (6 ± 2) mmHg. The difference between the intra–tissue pressure values after necrosectomy and primary necrosectomy was (8 ± 1) mmHg due to more radical decompression of the damaged tissues.

Fig. 7.
Autodermoplasty with perforated skin flaps (day 5 after primary necrectomy).

After primary necrectomy, patients in both groups underwent a complex of therapeutic measures aimed at stimulating the processes of demarcation, proliferation, and granulation of the wound bed according to the methodology developed by us [8]. Wound defects after primary necrosectomy were covered with a neutral mesh covering "Grassolind neutral." After that, using a spatula, a second layer (5 ± 1) mm thick (this layer retains maximum activity and is absorbed in about one day) of ointments containing silver (dermazin, argedin, etc.) was applied to the wound with fixation using multilayer gauze bandages of the "Cocoon" type and elastic bandages for hemostasis.

Dressings were changed daily until fine–grained pink granulations appeared. The day before autodermoplasty, the wounds were covered with aseptic gauze bandages and constantly moistened with a complex solution developed by us with a base of 400 ml of 0.9% sodium chloride solution, in which 12 g of boric acid, 0.1 g of rifampicin (benemicin), 30 ml of metronidazole with a concentration of 5 mg/ml, and 4 ml of 2.5% hydrocortisone solution were sequentially dissolved. 0.1 g of rifampicin (benemicin), 30 ml of metronidazole with a concentration of 5 mg/ml, and 4 ml of a 2.5% solution of hydrocortisone acetate. Irrigation was performed every 3–4 hours. This volume of solution was calculated for 4–5% of the affected area per day. This made it possible to reduce wound exudate, bacterial colonization of the recipient area, and ultimately improve the results of autodermoplasty (*Fig. 7*).

The time required for granulation formation in patients of the main subgroup after primary necrectomy was (5.8 ± 1.2) days, and in patients of the control subgroup – (9.7 ± 1.5) days. The advantage of the proposed method of early surgical treatment of patients with deep burns against the background of intra–tissue pressure measurement was the possibility of performing autodermoplasty with mesh grafts

sooner: in patients of the main subgroup, it was performed already on (7.3 ± 0.5) days, while in patients of the control group – on (11.6 ± 0.6) days.

The skin recovery time in patients of the main subgroup was (22.8 ± 1.2) days, and in patients in the control subgroup – (28.6 ± 0.8) days, which led to a reduction in the duration of inpatient treatment from (34.5 ± 0.9) days in the control subgroup to (27.5 ± 0.7) days in the main subgroup.

An important indicator for assessing the effectiveness of treatment of deep burns at the stage of reconstructive surgery is the survival rate of free skin grafts as a result of autodermoplasty. In the main subgroup, it was (94.3 ± 2.8)% of the body surface area, and in the control subgroup, it was (78.6 ± 3.4)% of the body surface area, which indicates an improvement in this indicator of clinical treatment of patients.

Conclusions

1. Effective, affordable, and atraumatic local treatment of marginal burns of the extremities in functional areas in a humid environment and preventive infusion and drug therapy reduces the destruction of thermally damaged tissues, prevents deepening of the burn surface, leading to spontaneous epithelialization within an optimal time frame.

2. Active surgical tactics with objectification of intra–tissue pressure indicators in patients with deep circular burns made it possible to eliminate compartment syndrome, in the presence of which secondary deepening of the burn wound occurs. Preventing the deepening of burns creates optimal conditions for the formation of granulation tissue and the performance of autodermoplasty with satisfactory results.

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Ethical considerations. All procedures performed in the study involving patients complied with ethical standards for clinical practice and the 1964 Declaration of Helsinki, as amended.

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