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Treatment of the Low Extremity Severe Mechanical Injury with Uncompensated Ischemia (Case Report)

V.V. Khominets, A.V. Shchukin, S.V. Mikhailov, D.A. Shakun, M.V. Endovitskaya, M.V. Zakharov

Kirov Military Medical Academy, St. Petersburg, Russian Federation

Abstract

Relevance. Discussion of the criteria for decision making "amputation vs. preservation", when viability of the extremity is uncertain, has been continuing. ***The case description.*** The lower extremity of a serviceman was injured by a caterpillar tractor. The severity of the damage was determined by the following conditions: open segmental fracture of the femoral diaphysis, 5 cm traction-compression damage of the popliteal artery, acute thrombosis of the popliteal and tibial arteries, sciatic nerve damage, circular detachment of the thigh skin, acute hemorrhage, II degree shock, and uncompensated lower extremity ischemia throughout 24 hours. The MESS score of the injured extremity was 8 indicating that an amputation would have been considered. Nevertheless, we choose the organ preservation solution with the revascularization of the injured limb segment. A multi-stage treatment was carried out including stabilization of bone fragments, primary reconstruction of the popliteal artery to restore the arterial blood flow in the injured extremity, reperfusion injury and myoglobinuria elimination, intensive kidney protection therapy, infection management, skin defects replacement, orthopedic surgery. As a result of the treatment, the injured limb was saved. The femur fracture healed allowing the patient to walk without assistance. ***Conclusion.*** The use of the programmed surgical treatment for severe mechanical injury of the lower extremity, an individual multi disciplinary approach, assessing the severity of systemic disorders, and timely use of extracorporeal detoxification made it possible to avoid amputation, perform organ preservation surgery, and create favorable conditions for restoring the supporting function of the lower extremity.

Keywords: amputation, ischemia, selective plasma exchange, severe limb trauma, surgical infection.

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Aleksei V. Shchukin; e-mail: ossa.76@mail.ru

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Introduction

The medical care of the severe limb trauma with great vessels damage is a serious problem due to complicated diagnostics and outcome prediction. All this eventually results in the difficulty of the optimal medical tactics determination [1, 2, 3]. The literature discusses the decisions making criteria in a dilemma whether the major arterial blood flow restoration in the patients with a dubious prognosis for limb viability or the limb amputation for vital indications [4, 5, 6].

It is particular difficult to make a decision for limb segment revascularization in the borderline conditions between uncompensated and irreversible ischemia. Common tactics in acute arterial ischemia involves the blood flow restoration in uncompensated ischemia and limb segment amputation in irreversible ischemia [7]. According to the clinical recommendations of the Association of Cardiovascular Surgeons of the Russian Federation (2016) [8], V.S. Savelyev's classification is used to determine the treatment tactics of acute arterial ischemia [9].

Another criterion that determines the treatment tactics is the severity of the limb damage. In order to objectify the severity of an extremity injury, the following scales are used: Mangled Extremity Severity Score (MESS); Predictive Salvage Index (PSI); Nerve injury, Ischemia, Soft-tissue injury, Skeletal injury, Shock, Age of the patient Score (NISSSA); Limb Salvage Index (LSI). However, a number of researchers showed a lack of effectiveness of the above scales in choosing treatment tactics of the injured [10, 11].

Solving the problem of limb preservation after a serious injury requires an individual approach for each patient. These scales help to assess the severity of the injury, but do not help in the comprehensive analysis of the injury. In addition, the experience of surgeons, as well as the diagnostic and therapeutic capabilities of a medical facility, are important when deciding whether to maintain or amputate the limb.

An important point in the decision to the preserve the limb in the prolonged uncompensated ischemia is the preparedness to maintain reperfusion and myonephropatic syndromes, acute renal damage, and the quick access to the emergency extracorporeal detoxification.

We would like to share our experience of successful treatment of a severe mechanical limb trauma, accompanied by uncompensated ischemia. In this clinical observation, the severity of the limb injury and the risk of life threatening complications, including infectious, in accordance with generally accepted scales and recommendations suggested the feasibility of amputation. Nevertheless, the availability of a vascular surgeons team and the necessary equipment made it possible to preserve the patient's limb. The patient gave an informed consent for the publication of this clinical case.

Case report

The left lower limb of a 23-years-old soldier was injured by a caterpillar tractor. At the local district hospital, the injured was undergone the following surgical treatments: primary wound debridement, primary wound closure, femoral fragments fixation with a single-plane nail apparatus. At that time, the major vessel damage was not diagnosed.

The next day, the patient was transferred to the department of military traumatology and orthopedics. There were the obvious signs of uncompensated lower limb ischemia. The skin of the foot and leg was pale, cold, venous circulation could not be determined, the foot in plantar flexion, active and passive movements in the left ankle were extremely limited, pulsation in the popliteal artery, posterior and anterior tibial arteries was not detected, tactile and proprioceptive sensitivity was absent, hypesthesia of the lower third of the leg and foot.

In this condition, the patient was taken for the emergency surgery. The injured limb appearance, as well as the X-rays of the thigh are presented in Figure 1.

The severity of the condition was determined by the following injuries and complications:

– open (Gustilo-Anderson IIIC) segmental femoral diaphyseal fracture (32C2),

– 5 cm traction-compression damage of the popliteal artery,

– acute thrombosis of the popliteal and tibial arteries,

– sciatic nerve damage at the middle third thigh level,

– circular skin detachment throughout the middle and lower third of the thigh,

– acute severe grade hemorrhage,

– II degree shock,

– uncompensated lower extremity ischemia throughout 24 hours.

The general condition of the injured by the Combat Surgery-Condition on Admission Scale was 22 points (severe), the severity of the damage by the Combat Surgery-Severity of the Damage (Mechanical Injury) was 7 points (also severe) [12]. On the AIS scale, the severity of damage was 5 points.

The limb condition according to the MESS scale* was 8 points. This indicated the need for amputation. According to the V.S. Saveliev' classification, the quality of the patient's limb circulation was regarded as borderline, namely 3A-3B, which, according to the clinical recommendations of the Russian Association of Cardiovascular Surgeons, could be considered as an indication either for emergency revascularization surgery or for emergency limb amputation for vital indications.

The presence of a vascular surgeons team and the necessary equipment allowed us to choose an organ-preserving treatment tactics, the main element of which was revascularization. The condition of the major limb circulation was borderline. Therefore, we assessed the risk of reperfusion syndrome developing as high. For timely prevention of possible complications, the selective plasma exchange was at hand.

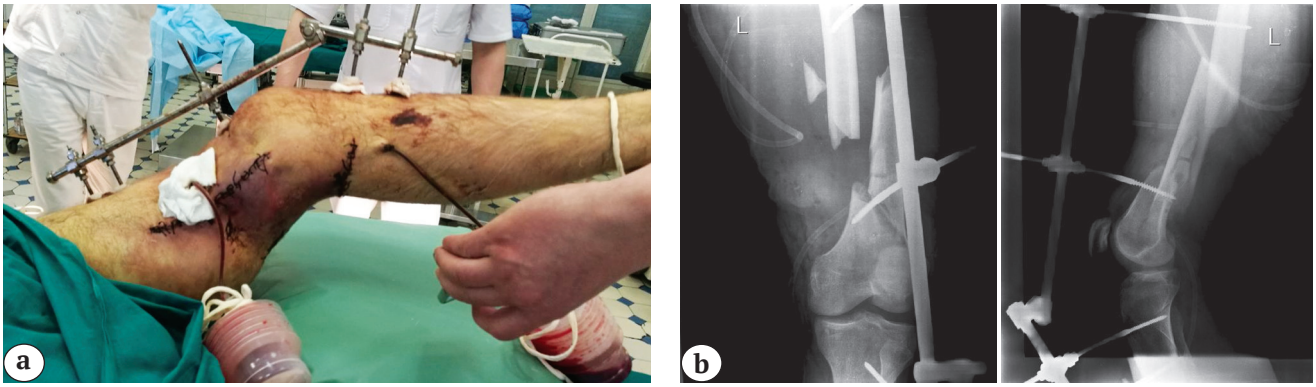

Fig. 1. View of the injured left lower extremity upon admission to the hospital on the first day after injury (a) and X-ray of the left femur in two projections (b)

* Johansen K, Daines M, Howey T, Helfet D, Hansen ST Jr. Objective criteria accurately predict amputation following lower extremity trauma. *J Trauma.* 1990, 30(5):568–572. doi: 10.1097/00005373-199005000-00007.

A multi-stage treatment was carried out. The main parts of which are presented below.

1. *The bone fragments stabilization*. All elements of the nail apparatus, which was placed at the previous treatment facility, were located on the front surface of the thigh and leg. This made it difficult to operate on the popliteal vessels in the prone position. We replaced the apparatus "Multple Trauma Kit" with the apparatus "Combat Nail Kit". The latter could be placed on the lateral surface and allowed the lower limb suspension to exclude the posterior tibia group muscles compression (Fig. 2).

2. *Primary reconstruction of the popliteal artery and restoration of limb arterial blood flow*. The femoral-popliteal arterial segment was examined. The complete 5 cm popliteal artery damage and the popliteal, posterior and anterior tibial arteries thrombosis were found. The left popliteal artery and leg arteries thrombectomy was carried out. The popliteal artery prosthesis with a reversed section of the great saphenous vein was placed. The open fasciotomy of all left leg compartments was performed (Fig. 3).

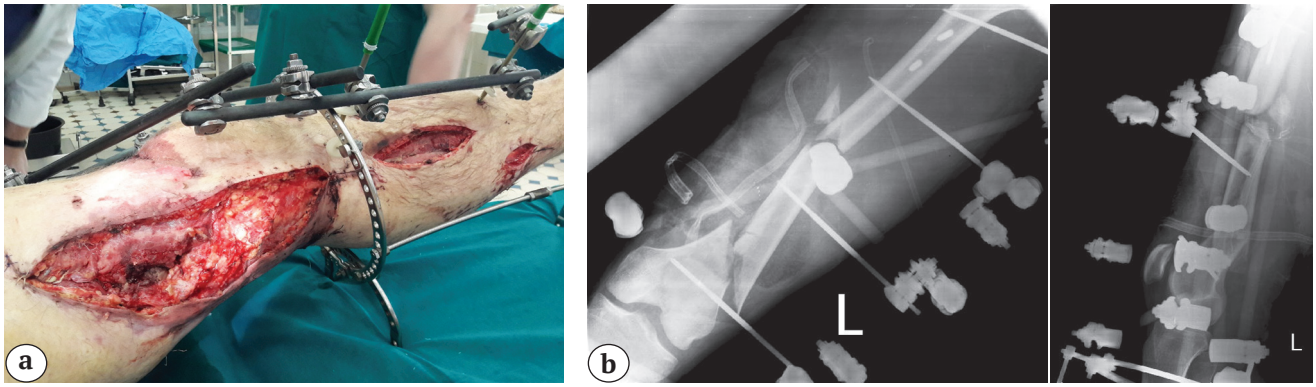

Fig. 2. View of the injured limb (a) and X-ray of the left femur in the direct and lateral projections after fixation by the combat rod kit (b)

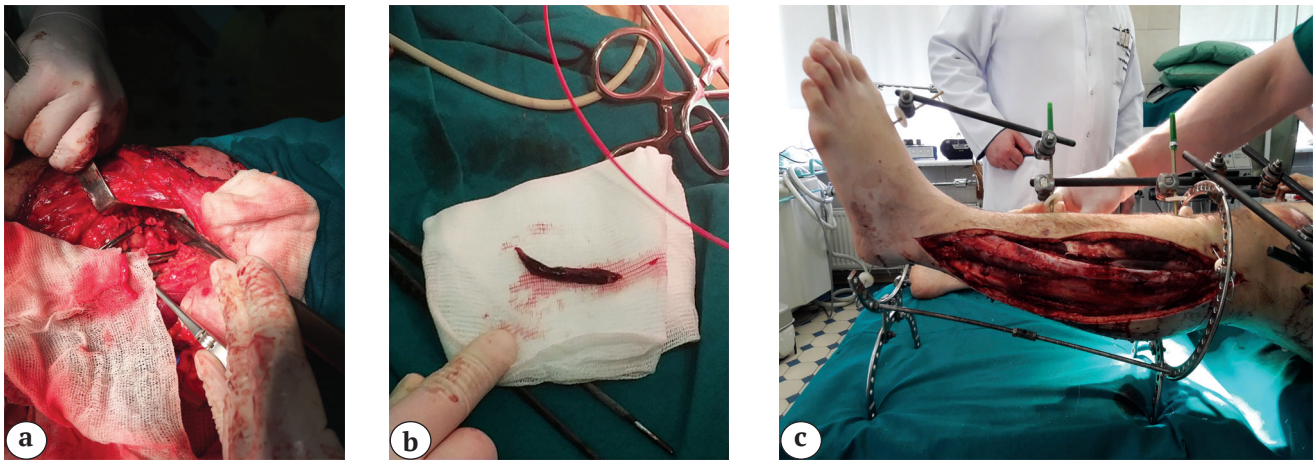

Fig. 3. Intraoperative photos:
a — popliteal artery defect;
b — thrombus removed from the popliteal artery;
c — wound of the lateral surface of the lower leg after open c, nonviable muscle areas are visible

Subsequent monitoring of the limb showed the appearance of a distinct collateral blood flow on the 1st day after surgery and restoration of the major blood flow on the 5th day.

3. *Relief of reperfusion and myonephropatic metabolic syndromes, intensive nephroprotective therapy*. The development of reperfusion syndrome with significant signs of endogenous intoxication, but with preserved kidney function, is an indication for the early use of extracorporeal detoxification methods, such as plasmapheresis (plasmofiltration) or selective plasmofiltration (plasma exchange). On the 1st day after lower limb revascularization, the laboratory signs of post-traumatic rhabdomyolysis and reperfusion syndrome were noted. The blood myoglobin concentration on the 2nd day reached 4,0105 ng/ml (normal range 17.4–105.7 ng/ml), the blood creatine kinase activity — 31323 IU/L (normal range 38–174 IU/L). To eliminate these adversed syndromes, we performed open fasciotomy of all left leg compartments, daily revisions of the tibial muscles through fasciotomic accesses and excision of their non-viable areas. A clearly non-viable skin was also excised at the zone of its extensive circular detachment with an area of 4%. In addition, five selective plasma exchange sessions were performed. The inclusion of these methods in intensive therapy made it possible to reduce the severity of endogenous intoxication due to the large-molecular-weight products of myolysis elimination, first of all myoglobin, from the systemic circulation, and to prevent the acute renal failure. The selective plasma filtration is more effective method of extracorporeal detoxification in case of prolonged compression syndrome compared to plasmapheresis. For selective plasma filtration carrying out, the necessary equipment was deployed in the intensive care unit next to the patient. The use of such complex of surgical and detoxification measures made it possible to stop the reperfusion and myonephropatic syndromes by the 7th day after revascularization. The dynamics of blood flow restoration is shown in Figure 4.

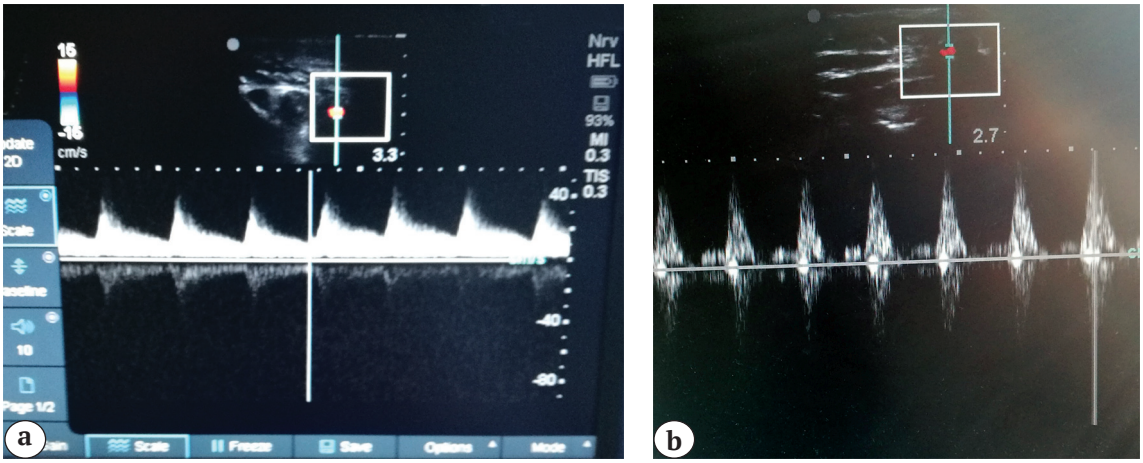

Fig. 4. Dynamics of blood flow restoration:
a — collateral blood flow on day 1–2; b — direct blood flow on the days 5–6

4. *Infectious complications management*. On the 12th day, despite the ongoing prevention of infectious complications in the form of daily necrectomies and antibiotic prophylaxis, multiple intermuscular and paraosseal abscesses were noted. Microbiological culture revealed *Klebsiella pneumoniae* as the causative agent. Figure 5 shows purulent leaks and mosaic muscle necrosis.

At this point of treatment, the question was raised about the possibility of amputation due to purulent complication development. Nevertheless, the limb remained viable, as evidenced by adequate blood flow in the popliteal artery and arteries of the leg. Signs of the inflammatory response generalization were also not determined (negative procalcitonin test and sterile blood culture). The intermediate fragment of the femur was deprived of the periosteum, however, when it was reared, the distinct bleeding was obtained. This testified to the preserved blood supply and the prospects of union. Thus, there were no absolute indications for left lower limb amputation. However, with the aggravation of the general condition of the victim due to generalization of the infection process, we were ready to perform the lower limb amputation according to vital indications.

Repeated debridement and antibiotic etiotropic therapy made it possible to eliminate the infection process on the 11th day. Despite the leg muscles repeated necrectomy, we were able to maintain a viable lateral head of the gastrocnemius and part of the soleus muscle, as well as a part of the flexor digitorum longus. Unfortunately, all muscles of the front and outer groups died and were excised. The obvious muscle imbalance led to the stable equinus position of the foot and claw-like toes deformation. By this stage of treatment, the patient was in the fourth period of the traumatic disease (recovery), which allowed us to begin the patient activation, skin defects replacement and orthopedic surgeries carrying out.

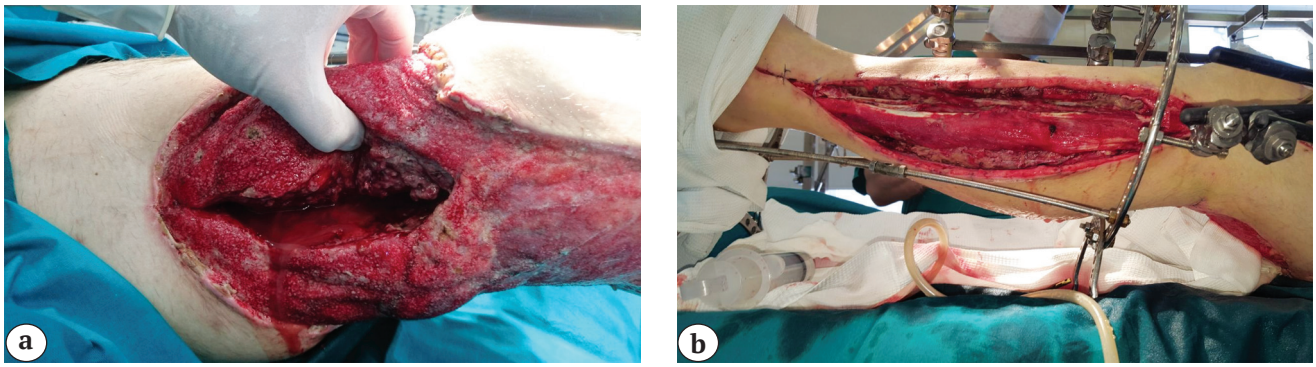

Fig. 5. Infectious complications:
a — purulent leak into the Hunter's canal of the left thigh;
b — mosaic necrosis of the lateral group muscles of the leg

5. *Skin defects replacement*. After the infectious complications elimination, the problem of replacing the circular defect of the femoral skin after necrectomy became the main topic. To prepare the recipient zone, the negative pressure therapy was applied for 10 days. Then, the defect was closed with a split skin autograft. The steps of the skin defect replacement are shown in Figure 6. Autograft engraftment passed uneventfully. The wounds after the leg open fasciotomy were sutured. Significant muscle deficiency after necrectomy allowed suturing wounds without skin tension (Fig. 7).

6. *Orthopedic correction of the foot position* was required due to the stable equinus foot and the claw-like toes deformation. Given the impossibility of the ankle movements restoration, we performed fixation of the ankle in the Ilizarov apparatus in the mid-physiological position. This position is convenient for support after tendoachille lengthening and intersection of the toes flexor tendons. The toes were intraossally fixed with pins in a straightened position. Fixation of the ankle in the apparatus for fibrous ankylosis required for 2.5 months (Fig. 8).

The external osteosynthesis for the femur fracture was selected as a decisive. The "Combat Nail Kit" was replaced by the Ilizarov's apparatus in 1.5 months after injury (Fig. 9).

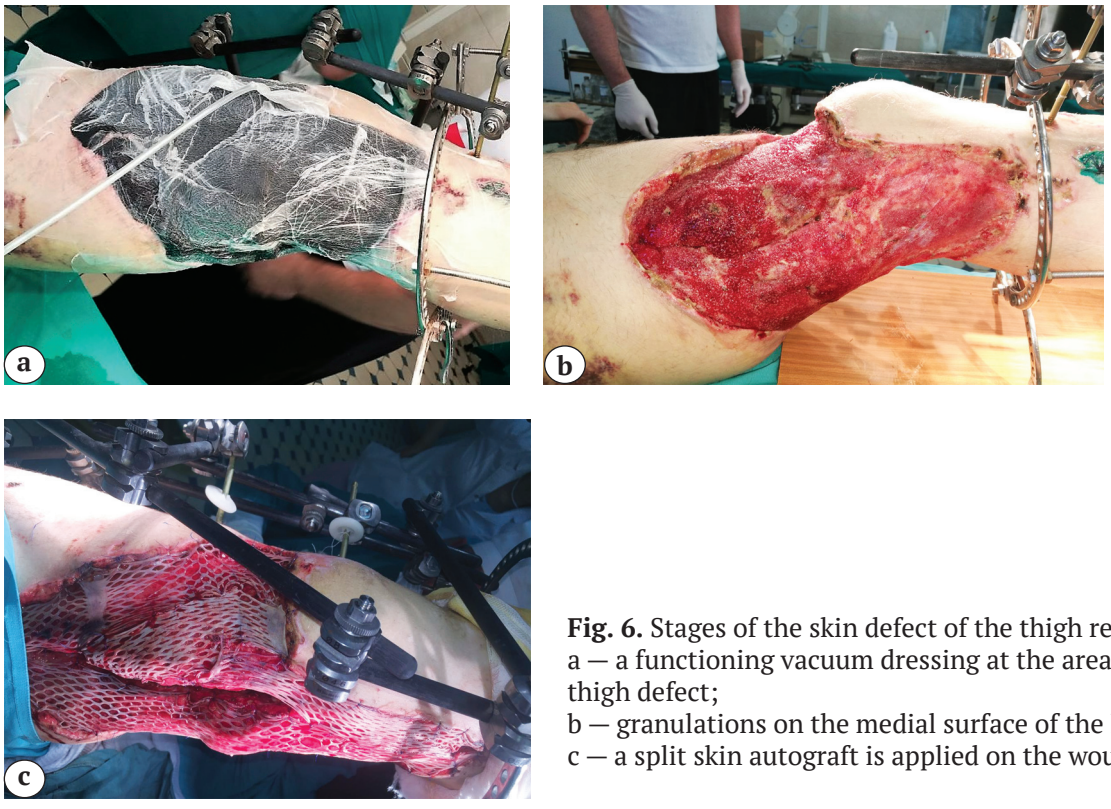

Fig. 6. Stages of the skin defect of the thigh replacement:
a — a functioning vacuum dressing at the area of a circular thigh defect;
b — granulations on the medial surface of the left thigh;
c — a split skin autograft is applied on the wound defect

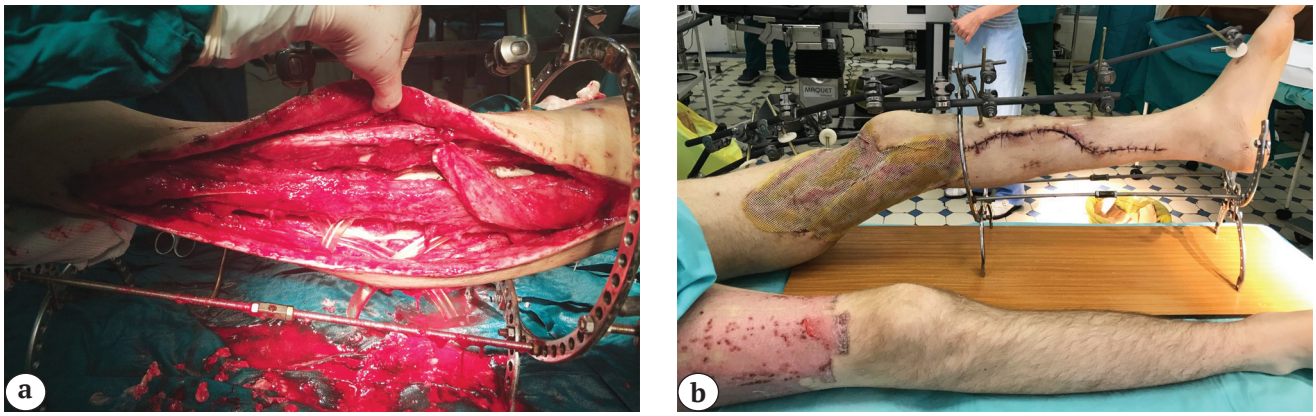

Fig. 7. Muscle deficiency after necrectomy of the left lower extremity (a); the wound after open fasciotomy on the lower extremity is sutured without tension (b)

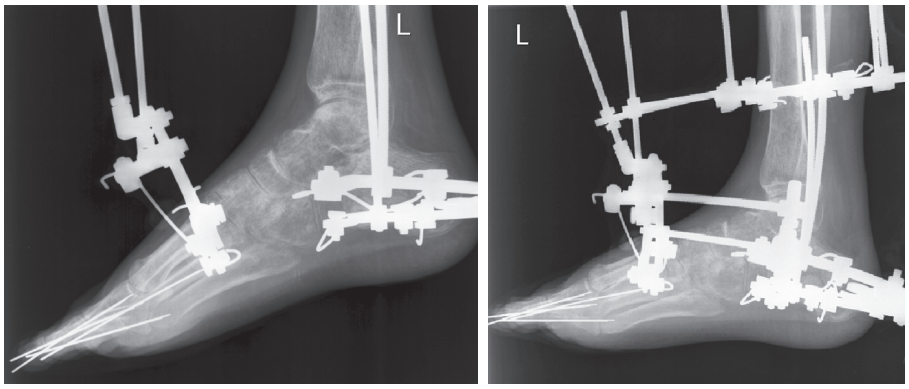

Fig. 8. Stages of eliminating the equinus position of the foot using the Ilizarov apparatus

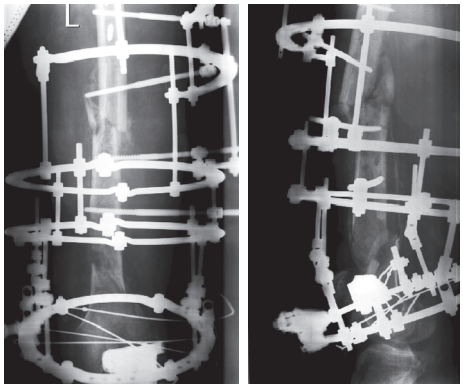

Fig. 9. X-ray of the left femur in the direct and lateral projections after osteosynthesis with Ilizarov apparatus

Throughout the treatment, the victim received rehabilitation treatment: hyperbaric oxygen therapy, exercise and nutritional therapy.

The inpatient treatment in the department lasted 3 months. Subsequently, the patient was followed-up by the department's specialists. The medical rehabilitation and sanatorium treatment were available. Fracture of the femur consolidated after 9 months. Ilizarov's apparatus was removed.

Currently, the patient's condition is characterized by the following:

– union of the femur fracture,

– normal blood circulation of the left lower limb,

– normal proprioceptive sensitivity of the left foot,

– permanent left knee extensor contracture,

– fibrous ankylosis of the left ankle (Fig. 10).

The patient walks without additional support.

Discussion

The treatment of severe skeletal trauma, accompanied by damage to major vessels, is a complex problem both for making tactical decisions and for the direct implementation of the surgical program.

Currently, the traditional tactics of treating such injuries is based on the V.A. Kornilov's classification (1978). It suggested performing amputation of a limb segment in the case of irreversible or prolonged uncompensated ischemia [13].

Also, as an algorithm, the clinical recommendations of the Association of Cardiovascular Surgeons of the Russian Federation (ASCH of the Russian Federation) can be considered. They recommend that both an emergency revascularization and amputation can be performed in case of ischemia 3A-3B [8].

For example, Novak et al. in an article on treatment tactics for victims with leg dislocation, complicated by popliteal artery damage, confirmed the need for amputation

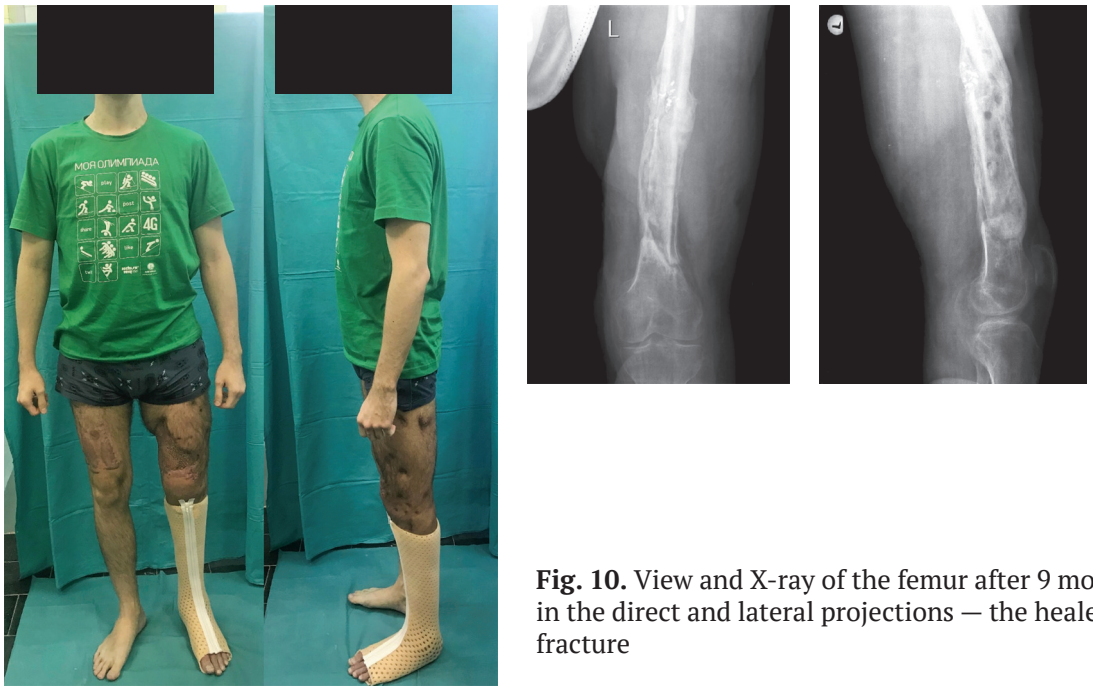

Fig. 10. View and X-ray of the femur after 9 months in the direct and lateral projections — the healed fragmental fracture

at the femur level if after revascularization the acute renal failure developed [14]. Also, according to Sultanov et al., surgical tactics in traumas with leg arteries injury depended on the severity of the general condition and the degree of limb ischemia. According to their data, the rate of amputations, carried out by primary and secondary indications, reached 26.6% [15].

In the literature devoted to the problem of making tactical decisions in case of reperfusion and myonephropatic syndromes development after revascularization, limb segment amputation was definitely recommended for vital indications [16, 17, 18].

In the presented clinical case of successful treatment of the injured with severe mechanical trauma of the lower extremity on the background of prolonged uncompensated ischemia due to the damage and thrombosis of the popliteal artery and leg arteries, the programmed use of selective plasma exchange and active surgical tactics made it possible to eliminate life-threatening complications, preserve limb viability and create the conditions for the restoration of the limb supporting function.

Despite the favorable outcome, such a tactics cannot be recommended for widespread use. The decision on revascularization and preservation of the limb should be made carefully and collectively, taking into account the condition, first of all, the patient's and the limb condition, as well as the capabilities of the medical facility.

Publication ethics

The patient had given the voluntary informed consents for this clinical case publication.

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Authors' contributions

V.V. Khominets — text preparation and editing.

A.V. Shchukin — text and figures preparation.

S.V. Mikhailov — text editing, literature review.

D.A. Shakun — text editing.

M.V. Endovitskaya — text editing, literature review.

M.V. Zakharov — text editing.

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AUTHORS' INFORMATION:

Vladimir V. Khominets — Dr. Sci. (Med.), Professor, Head of the Military Traumatology and Orthopedics Department, Kirov Military Medical Academy, St. Petersburg, Russian Federation

Aleksei V. Shchukin — Cand. Sci. (Med.), Head of the Traumatology and Orthopedics Clinic's Unit, Kirov Military Medical Academy, St. Petersburg, Russian Federation

Sergei V. Mikhailov — Cand. Sci. (Med.), Assistant Professor of the Military Traumatology and Orthopedics Department, Kirov Military Medical Academy, St. Petersburg, Russian Federation

Dmitrii A. Shakun — Cand. Sci. (Med.), Senior Professor of the Military Traumatology and Orthopedics Department, Kirov Military Medical Academy, St. Petersburg, Russian Federation

Maria V. Endovitskaya — Vascular Surgeon of the Military Traumatology and Orthopedics Department, Kirov Military Medical Academy, St. Petersburg, Russian Federation

Mikhail V. Zakharov — Cand. Sci. (Med.), Deputy Head of the Department of Nephrology and Efferent Therapy, Kirov Military Medical Academy, St. Petersburg, Russian Federation