Case Report
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# Successful Prosthetics for Traumatic Femoral Vascular Injury: A Case Report

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***Background.*** Injury to the main vessels is often accompanied by life-threatening bleeding, permanent disability or death. In the modern literature, only isolated cases of reconstructive surgery for major vein injury are described, their long-term results are insufficiently studied, there is little information about the introduction of telemedicine technologies into the practice of emergency angiosurgical care.
***The aim of the study*** is to demonstrate the immediate and long-term results of the joint work of trauma surgeons and angiosurgeons in helping a patient with injury to the main femoral vessels.
***Case presentation.*** The results of treatment of the patient with the diagnosis: laceration of the upper third of the right thigh with rupture of the common femoral vein and superficial femoral artery and the development of threatening ischemia of the right lower limb; severe blood loss; hemorrhagic shock IV; severity of injury: VPH SP 33; MESS 7. Treatment of the patient took place in several stages. At the first of them, hemostasis was performed, the hemorrhagic shock was resolved. Further, the patient was consulted by an angiosurgeon through telecommunication technologies, after which it was decided to include an angiosurgeon in the surgical team. The prosthetics of femoral vessels was performed: the main venous and arterial blood flow was restored in the affected limb. The patient was discharged in a satisfactory condition with no signs of thrombosis.
***Conclusions.*** Compliance with consistent actions in helping a patient with a vascular injury prevents the development of a «deadly triad» and a fatal outcome. The use of telemedicine consultations provides the angiosurgeon with the opportunity to remotely assess the clinical picture, the severity of the injury, discuss the sequence and volume of necessary medical care at the place of primary hospitalization. Performing reconstructive surgeries using various types of grafts allows you to restore the main blood flow through damaged vessels with good immediate and long-term results.

**Keywords:** vascular injury, artery and vein trauma, thigh laceration, specialized care, telemedicine consultation.

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# Успешное протезирование при травматическом повреждении бедренных сосудов: клинический случай

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***Актуальность.*** Повреждение магистральных сосудов нередко сопровождается жизнеугрожающим кровотечением, стойкой утратой трудоспособности или летальным исходом. В современной литературе описаны лишь единичные случаи реконструктивных вмешательств при травме магистральных вен, недостаточно изучены их отдаленные результаты, мало информации о внедрении телемедицинских технологий в практику неотложной ангиохирургической помощи.

***Описание случая.*** Представлены результаты оказания ангиохирургической помощи пострадавшему с диагнозом: рваная рана верхней трети правого бедра с разрывом общей бедренной вены и поверхностной бедренной артерии, развитие угрожающей ишемии правой нижней конечности; кровопотеря тяжелой степени; геморрагический шок IV степени. Тяжесть травмы: ВПХ СП 33; MESS 7. Оказание помощи пострадавшему проходило в несколько этапов. На первом этапе была выполнена остановка кровотечения, пациент выведен из геморрагического шока. Затем была проведена телемедицинская консультация, после чего было принято решение о включении в бригаду ангиохирурга. Была выполнена реконструктивная операция – протезирование бедренных сосудов. В пострадавшей конечности восстановлен магистральный венозный и артериальный кровоток. Пациент в удовлетворительном состоянии был выписан без признаков тромбоза.

***Заключение.*** Соблюдение последовательных действий при оказании помощи пациенту с травмой сосудов позволяет не допустить развитие «смертельной триады» и фатального исхода. Применение телемедицинских консультаций предоставляет ангиохирургу возможность дистанционно оценить клиническую картину, тяжесть повреждения, обсудить последовательность и объем необходимой медицинской помощи по месту первичной госпитализации. Выполнение реконструктивных операций с использованием различных видов трансплантатов позволяет восстановить магистральный кровоток по поврежденным сосудам с хорошими ближайшим и отдаленным результатами.

**Ключевые слова:** повреждение сосудов, травма магистральных сосудов, рваная рана бедра, специализированная помощь, телемедицинские консультации.

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## BACKGROUND

According to the literature, the incidence of open traumatic vascular injuries ranges from 2.0% to 25.5% [1, 2, 3, 4]. According to Quan et al., they are caused by injuries in 95% of cases [5]. Szaniewski et al. noted an increase in the incidence of damage to the main vessels due to the impact of firearms, sharp and piercing objects, and traffic accidents [4]. Injuries resulting from occupational accidents are considered important among the causes of injury. Annually, 340 million such accidents of varying severity are recorded worldwide, and the mortality rate is 2.3 million people per year [6].

Damage to two or more great vessels is accompanied by massive bleeding, often leading to the development of refractory hemorrhagic shock, lethal outcomes, and amputation due to the development of irreversible limb ischemia [5, 7, 8].

Until now, the question of the expediency of restoring the main venous blood flow, especially with massive severe injuries, remains unresolved. The lateral suture of the vessel is the main type of surgery for vein injuries in 90% of cases [8, 9]. Total damage to a vein requires a reconstructive intervention, and the absence of the necessary graft sometimes ends with ligation.

The modern literature describes isolated cases of reconstructive interventions for injuries of the major veins, their long-term results are insufficiently studied, and there is little information on the introduction of telemedicine technologies into the practice of emergency angiosurgical care.

Herein, we present a rare clinical case of the formation of an autovenous conduit for prosthetics of a damaged vein.

## CLINICAL CASE

A 56-year-old patient was transferred to the trauma department of the Central City Clinical Hospital No. 24 in Yekaterinburg by an ambulance team on 04/09/2020 in a terminal condition due to stage IV hemorrhagic shock according to the Advanced Trauma Life Support classification. Forty minutes before admission, during the installation of a metal constructional timber, the patient received a blow with the end of an iron beam (weighing 30 kg) on the upper third of the right thigh, followed by loss of consciousness. At the pre-hospital stage, a tight pressure aseptic bandage was applied to the patient in the wound area, anesthesia was performed with narcotic analgesics, and an infusion of crystalloids and colloids was started with the administration of direct-acting adrenomimetics (norepinephrine) at a rate of 1 μg/kg/min. The total volume of infusion therapy by the ambulance team was 1000 mL.

During the physical examination in the admission department of a trauma hospital, the level of consciousness on the Glasgow scale was estimated at 10 points (sopor). The skin was pale, breathing was spontaneous, and the respiratory rate was 28 per minute. Hemodynamic parameters were unstable, with a pulse of 90–120 beats/min and blood pressure of 40/0 mm Hg. In the upper third of the right thigh, in the projection of the neurovascular bundle, there was a lacerated wound sized 30×20 mm with signs of continuing bleeding, and the blood loss volume was 2500 mL (Fig. 1). The right lower limb was cyanotic and cooler than the left one. Pulsation was not detected distal to the wound, and there was no contracture in the ankle joint.

**Fig. 1.** Wound with ongoing venous bleeding

Indicators of the general blood test showed hemoglobin of 78 g/L, erythrocytes of 2.6×1012/L, and hematocrit of 19%. Given the severity of the condition due to continuing bleeding, the patient was transported immediately to the operating room. The trauma team performed a revision of the femoral vessels under endotracheal anesthesia and revealed a rupture of the vascular bundle of the right inguinal region. Bleeding was stopped by applying hemostatic clamps to the proximal and distal ends of the vessels (Fig. 2).

Intensive therapy was continued with 1500 mL of crystalloids, 705 mL of erythrocyte suspension, and 400 mL of fresh frozen plasma. The vascu-

lar surgeon on duty at the Territorial Center for Disaster Medicine consulted the patient via a secure videoconferencing channel with a further decision on the urgent inclusion of a vascular surgeon in the operating team. At the time of the arrival of the vascular surgeon (1.5 h from the moment of injury), the patient's condition was stabilized, blood pressure was 110–130/90 mm Hg with minimal doses of vasopressor support, the HR was 80–90 bpm, and anuria resolved. Ischemia of the right lower limb was assessed as threatening, the skin of the right lower limb remained pale, the foot and lower leg were hypothermic, and the saphenous veins were empty, but there was no contracture. Specialized care was started for the patient. After the excision and mobilization of the ends of the damaged vessels, diastasis was determined for 5 cm between the arterial ends and 4 cm between the venous ends.

To restore the main arterial blood flow and to arrest acute ischemia of the injured limb, replacement of the superficial femoral artery was performed first, followed by the replacement of the common femoral vein. During the revision of the great saphenous vein on the left thigh, its small diameter was revealed; therefore, a blood vessel prosthesis was used. The defect of the superficial femoral artery was replaced with a polytetrafluoroethylene explant with end-to-end anastomoses. The main pulsatile blood flow was restored at all levels of the injured limb. To form an autovenous conduit of the common femoral vein of a suitable diameter, two parts of the great saphenous vein of the contralateral limb were used, which were collected over a distance of 12 cm. Subsequently, both sections of the great saphenous vein were dissected longitudinally and then, without reversion, sutured together on a 5-mL syringe barrel (Fig. 3).

Then, the graft was hydraulically dilated, and end-to-end anastomoses were formed with the common femoral vein (Fig. 4).

By the end of the surgical treatment, the ischemia of the right lower limb regressed, without impairments in arterial and venous hemodynamics. The time of ischemia of the injured limb from the moment of injury to the complete restoration of blood flow was 3.5 h. During the surgery, the total volumes of transfusion of erythrocyte suspension, fresh frozen plasma, and crystalloids were 2081 mL, 1010 mL, and 1750 mL, respectively.

In the postoperative period, in addition to infusion therapy, compression therapy was performed, therapeutic doses of anticoagulants were used, and antibacterial prophylaxis was also conducted.

On postoperative day 10, against the symptoms of infection of the postoperative wound of the left thigh, a phlegmon occurred accompanied by febrile hyperthermia, bright hyperemia of the wound edges of the left inguinal region with propagation to the womb area, and serous purulent discharge. In the general blood test, leukocytes reached the level of 15.0×109/L. The wound on the right thigh remained without signs of inflammation. The patient was transferred from the traumatological hospital to the department

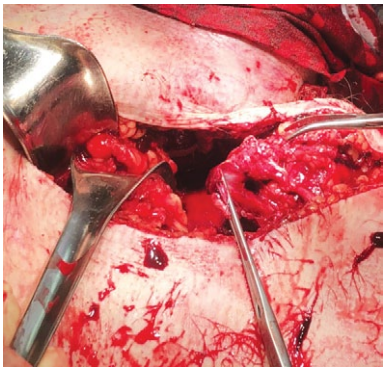

**Fig. 2.** Revision of the wound and stopping the bleeding

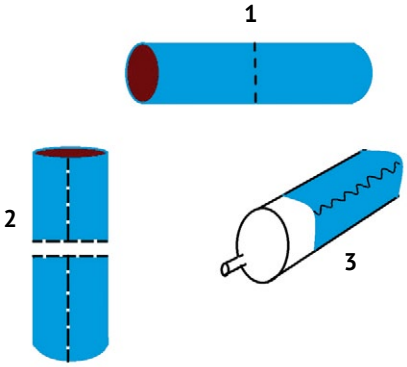


**Fig. 3.** Stages of an autovenous graft formation from a great saphenous vein:
1 — division of great saphenous vein into two fragments;
2 — dissection of two fragments of great saphenous vein along;
3 — formation of a venous conduit on a syringe cylinder

of purulent surgery. The left thigh wound was successfully drained, and a pus leak was opened in the womb region.

Bacteriological studies of the wound discharge revealed the growth of gram-negative flora with Klebsiella pneumoniae and Proteus mirabilis. Taking into account the sensitivity of microorganisms, antibiotic therapy with a broad-spectrum drug Amoxiclav 1200 mg given three times a day intravenously was continued.

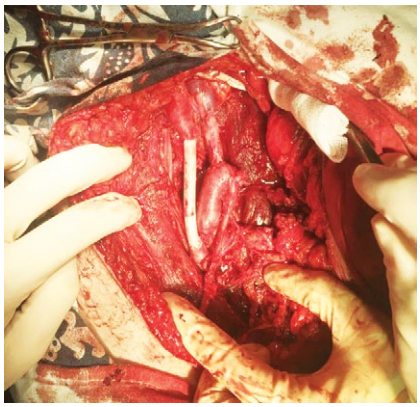

**Fig. 4.** Prosthetics of the common femoral vein with the formed autovenous conduit and the superficial femoral artery with an explant

After another 10 days, the patient was discharged in a satisfactory condition; the left thigh wound healed with secondary intention, without suturing. The right thigh wound remained without signs of infection; according to clinical and ultrasound data, the main arterial and venous blood flow was preserved. At the outpatient stage, a regimen of elastic limb compression and intake of therapeutic doses of direct anticoagulant rivaroxaban 20 mg once a day was recommended. The patient was examined by a vascular surgeon after 3, 6, and 12 months.

Three months after the discharge, the rivaroxaban dose was reduced to 10 mg/day, and after 6 months, the drug was discontinued; low doses of acetylsalicylic acid (50 mg/day) were prescribed. Data from repeated clinical examinations and control ultrasound studies demonstrated the preservation of the main blood flow through the damaged vessels (Fig. 5).

No recurrences of the infectious process were registered. The patient gained full recovery of the ability to work.

## DISCUSSION

The results of treatment of combined injuries of arteries and veins are not often discussed in modern literature. Thus, in PubMed, from 2016 to 2022, we found only eight publications on this subject. The keywords used for the search were *combined injury veins, arteries; injury veins and arteries extremities; autovenous graft, telemedicine* [8, 9, 10, 11, 12, 13, 14, 15].

The principles of care for patients with vein and artery injuries have been developed and improved over the centuries. Until the 1960s and 1970s, the main type of surgical intervention was ligation of the vessel, especially in the case of damage to the venous vessel. On this occasion,

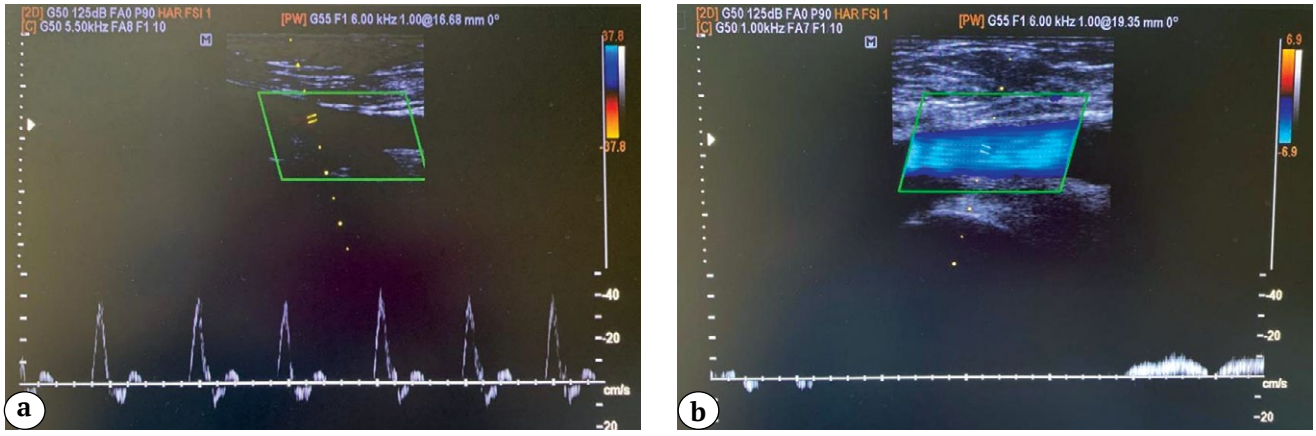


**Fig. 5.** Ultrasound duplex scanning (control study after 12 months):
a — superficial femoral artery; b — common femoral vein

N.I. Pirogov wrote during the Crimean War: "The wounded after ligation of major vessels mostly die." The famous surgeon himself had the greatest experience in such surgeries, performing more than 80 of them, while 46% of patients recovered [16].

For a long time, such an approach was considered appropriate in military field surgery. Thus, the frequency of ligature surgeries during World War II reached 97.5% of cases, and the proportion of amputations exceeded 40% [17, 18, 19]. Evidence also presents that not only ligation of arteries can lead to impaired limb viability, but also ligation of large main veins can cause the development of ischemic venous thrombosis [1]. Vein ligation still accounts for a high proportion of cases and reaches 57%, and the lateral suture prevails in the range of restorative surgeries [8].

To date, arterial prosthesis techniques have been developed and are widely used in practice. An autovein is the optimal plastic material for restoring the integrity of the main vessels, especially in the initial microbial contamination of the wound at a young age. The use of the great and small saphenous veins of the lower extremities, as well as the cephalic and main veins of the upper extremities as an autograft, has been described [1, 4, 7]. Vascular prostheses can be used in the case of damage to the aorta or the absence of an autovein of the required diameter in cases of injury to other vessels.

Severe trauma is not a simple clinical situation, and standard solutions are often not suitable for it. Many factors depend on the surgeon's experience. The variant of the main vein replacement with an autograft we presented was first described in 1952 by Hurwitt and Kantarowitz [20]. In 1979, Vedensky studied in detail the technical aspects of this and other techniques of reconstructive vein surgery. The author also noted several disadvantages, namely, the surgery duration and the need for the application a longitudinal suture, explaining the rare practical use of the described technique in injury [21].

Unfortunately, the desire to restore only the main arterial blood flow, without taking into account the role of the venous system in limb hemodynamics, does not always lead to the desired result. Thus, cases of the development of phlegmasia cerulea during ligation of the main veins were described. Al-Ganadi pointed out the important role of the restoration of major damaged venous trunks of the extremities in trauma. The author performed such interventions in 77% of cases with combined damage to veins and arteries, reaching a frequency of limb amputations of no more than 5% [1]. The time of limb ischemia is also significant in the restoration of the main arterial blood flow; a period of 6-8 h from the moment of injury is considered critical, while no data in the literature provide the acceptable period for the restoration of venous vessels [7, 8, 22, 23]. In our patient, the time from the moment of injury to the restoration of arterial and venous blood flow was 3.5 h. The absence of venous thromboembolic complications during the intake of therapeutic doses of anticoagulants helped avoid post-thrombotic disease in the future.

Continuing bleeding and unstable hemodynamics are indicative of damage to the main vessel and significant blood loss, which can lead to the deadly triad [7].

The current principles of injury surgery are formulated in the concept of "damage control," which is the control of bleeding, intensive therapy of life-threatening conditions, normalization and stabilization of the physiological parameters of the patient, and provision of specialized surgical intervention. In the case of vessel injury, this concept can be implemented, including using temporary prosthetics for the main vessels [7, 24, 25].

In the clinical case presented, a set of measures aimed at arresting the hemorrhage and quick resolving of hemorrhagic shock enabled the prevention of a lethal outcome. Soft vascular clamps were used during the surgical treatment of the wound. Temporary shunts were not used in this case because of the possibility of performing reconstructive surgery in a trauma hospital. Feliciano noted that with the correct provision of primary care, timely hospitalization of the patient in a specialized trauma hospital, and performing all the possibilities of contemporary surgery, anesthesiology, and intensive care, the number of amputations for vascular injury in peacetime does not exceed 7.8% [19].

Diagnostics of vascular injury is based on the patient's complaints, anamnesis data, physical examination, and various instrumental research methods. Computed angiography is recognized as the gold standard for examining an individual with wounds [7, 22, 23]. In the terminal state of the patient, every second counts, the level, lo-

cation, and nature of the damage should be assessed intraoperatively.

In the Sverdlovsk Region, vascular surgeons from the Territorial Center for Disaster Medicine are involved in assisting patients in trauma hospitals in the case of damage to the main vessels. In the period from 2015 to 2020, in cooperation with traumatologists, 240 surgical interventions were performed in patients with main vessel injuries. Since 2020, remote consultations using telemedicine technologies have been introduced into the practical activities of the angiosurgical service. The use of imaging techniques in emergencies enables the collection of the most complete amount of information, assessment of the real condition of the patient, discussion of the technical capabilities of the medical institution, and decision on the need and timing of high-tech intervention. The evolvement of videoconferencing allows for initial consultations, postoperative examinations, case follow-up, and advising of the operating team by highly specialized doctors. Telemedicine consultations are widely used in abdominal and endocrine surgery, traumatology, and urological practice [26]. However, the available literature provides no information on the use of telemedicine consultations in the treatment of patients with great vessel injuries.

Any purulent complication is naturally a cause for concern for doctors due to the risk of thrombosis, arrosive bleeding, and generalization of the infectious process. Mortality in the event of the development of such complications can reach 60% [25]. The developed suppuration of the postoperative wound of the left thigh after the autovenous graft sampling was diagnosed on day 10. The focus was drained, and the patient was treated with a broad-spectrum antibacterial drug, taking into account the microflora sensitivity.

The clinical case presented once again demonstrates that quality medical care for a patient with main vessel injury is important at every stage of treatment, namely, at the injury site, stage of transportation, and hospital stage. Adequate primary surgical treatment of the wound; activities of the competent anesthetic team; use of standard and nonstandard methods of prosthetics of the main vessels; prevention, timely diagnostics, and treatment of complications; and the patient's adherence to the treatment prescribed enable not only to save lives but also achieve good long-term results and restore working capacity after severe damage to the main vessels.

## CONCLUSIONS

Awareness of the clinical presentation in the case of damage to the main vessels and adequate assessment of the severity of the patient's condition allow for the selection of the most appropriate surgical approach within the contemporary scientific ideas about vascular injuries. Thanks to real-time telemedicine consultations, it is possible to obtain the most complete information about the patient, coordinate the management of the patient before the arrival of the vascular surgeon, and make a consensus decision on the required amount of surgical treatment at this stage. A multidisciplinary approach to providing care to patients with injuries of the great vessels contributes to the use of a wider range of reconstructive interventions. When the general condition of the patient is stabilized, the use of nonstandard methods for the formation of an autovenous conduit can be considered an alternative to ligature interventions.

## DISCLAIMERS

### *Author contribution*

*Chernyadyev S.A.* — research concept, interpretation of data, editing of the text.
*Leshchinskaya A.Yu.* — research concept, interpretation of data, editing of the text.
Bochegov V.S. — collecting, analyzing data, writing the text of the article.

All authors have read and approved the final version of the manuscript of the article. All authors agree to bear responsibility for all aspects of the study to ensure proper consideration and resolution of all possible issues related to the correctness and reliability of any part of the work.

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***Competing interests.*** The authors declare that they have no competing interests.

***Ethics approval.*** Not applicable.

***Consent for publication.*** Written consent was obtained from the patient for publication of relevant medical information and all of accompanying images within the manuscript.

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