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BLIND FRAGMENT INJURY OF A BRANCH OF THE DEEP FEMORAL ARTERY WITH DELAYED HEMORRHAGE: A CLINICAL CASE

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Introduction. In some cases, fragment wounds are accompanied by damage to major arteries. The choice of a treatment strategy at the stage of military-field hospital care determines the life prognosis of the serviceman.
Case description. A case of successful surgical treatment of a serviceman in a military field hospital is presented. The case involved a blind fragment wound to the thigh with avulsion of a branch of the deep femoral artery, which manifested 24 h after the initial surgical debridement of the wound and removal of a metallic shell fragment. An open surgery with ligation of the branch of the deep femoral artery with removal of the pulsatile hematoma was performed. The postoperative period proceeded without complications.
Conclusions. Convincing data on the necessity of conducting ultrasound examination of blood vessels in cases of fragment wounds in all instances, even in the absence of signs of hemorrhage, were obtained. In the case of a ruptured branch of the deep femoral artery, its ligation under the conditions of a military field hospital is an effective and safe method of surgical correction.

Keywords: pulsatile hematoma of the thigh; rupture of a branch of the deep femoral artery; first perforating artery; fragment wound; hemorrhage; military field hospital

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СЛЕПОЕ ОСКОЛОЧНОЕ РАНЕНИЕ ВЕТВИ ГЛУБОКОЙ БЕДРЕННОЙ АРТЕРИИ С ОТСРОЧЕННЫМ КРОВОТЕЧЕНИЕМ: КЛИНИЧЕСКИЙ СЛУЧАЙ

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Введение. Осколочные ранения в ряде случаев сопровождаются повреждением магистральных артерий. От выбранной стратегии лечения на этапе военно-полевого госпиталя зависит дальнейший прогноз жизни военнослужащего.
Описание клинического случая. Представлено успешное хирургическое лечение военнослужащего в военно-полевом госпитале с осколочным слепым ранением бедра и отрывом ветви глубокой бедренной артерии, проявившимся через сутки после первичной хирургической обработки раны и удаления металлического осколка снаряда. Выполнена открытая операция — лигирование ветви глубокой бедренной артерии с удалением пульсирующей гематомы. Послеоперационный период протекал без особенностей.
Выводы. Получены убедительные данные о необходимости проведения ультразвукового исследования сосудов при осколочном ранении во всех случаях, даже при отсутствии признаков кровотечения. При разрыве ветви глубокой артерии бедра ее лигирование в условиях военно-полевого госпиталя является эффективным и безопасным методом хирургической коррекции.

Ключевые слова: пульсирующая гематома бедра; разрыв ветви глубокой бедренной артерии; первая прободающая артерия; осколочное ранение; кровотечение; военно-полевой госпиталь

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INTRODUCTION

According to the analysis of modern combat injuries, the proportion of fragment wounds significantly exceeds that of gunshot bullet wounds. Thus, injuries caused by elements of explosive devices account for up to 75–80% of all wounds, which determines the polymorphic nature of the trauma with the predominance of multiple injuries to soft tissues, bones, major blood vessels, and peripheral nerves [1–3]. This circumstance influences the tactics of diagnosis and treatment, increasing the importance of imaging methods, such as ultrasonography, for accurate intraoperative assessment of neurovascular structures [1].

In modern military conflicts, fragment wounds to the extremities constitute the overwhelming majority of combat injuries [1–3]. In a number of cases, the penetrating elements lead to rupture of major arteries [4, 5]. When wounded on the battlefield, the serviceman, either independently or with the assistance of comrades, applies a tourniquet and is subsequently evacuated to the battalion medical post (Level 1) for first-aid measures (dressing, infusion of medications, etc.) [6]. Transportation to a military field hospital (Level 2) is then carried out. At this stage, operations aimed at stabilizing the condition and preserving the life of the wounded are performed [6]. In cases involving arterial damage, either a temporary shunt is installed or, given sufficient technical capability, a reconstructive intervention is performed [6–8].

This article describes a case of surgical treatment of a patient with a blind fragment wound to the thigh, involving avulsion of a branch of the deep femoral artery and the formation of a pulsatile hematoma 24 h after the injury.

CLINICAL CASE DESCRIPTION

A serviceman, a 30-year-old male, was admitted to a military medical hospital (Level 2). While performing a combat mission in an active combat zone, he sustained a blind fragment wound to the left thigh. No hemorrhage was noted at the time of injury, and there was no need to apply a tourniquet. Subsequently, within an hour, he was evacuated to the nearest military field hospital. Upon admission, the casualty complained of pain in the wound area.

Objective status: consciousness clear (15 points on the Glasgow Coma Scale). Hemodynamics stable: blood pressure 125/70 mmHg, heart rate 78 bpm, SpO_2 99%.

General Condition: according to the “Military Field Surgery, Admission Status” scale — satisfactory (12 points); “Military Field Surgery — Injury” — mild injury (0.05 points) [6, 9, 10].

Local Status: a wound 1 cm in diameter was identified on the lateral surface of the upper third of the left thigh, without discharge; the wound base was muscle tissue. No signs of hematoma/hemorrhage were present.

Complete Blood Count: within reference values.

A radiograph of the left thigh visualized a metallic density foreign body in the soft tissues of the medial surface of the upper third of the left thigh (Fig. 1).

Primary Diagnosis: blind fragment wound to the soft tissues of the left thigh with injury to the deep femoral artery, resulting in the formation of a pulsatile hematoma.

Medical interventions

An emergency surgical intervention was performed (within 10 min of admission): the fragment was removed via a separate incision on the medial surface of the thigh (Fig. 2). The time from injury to initial surgical debridement was 1 h and 30 min.

Following approximately 24 h, while walking, arterial hemorrhage developed from the surgical wound on the thigh through which the foreign body had been removed. Hemodynamics remained stable:

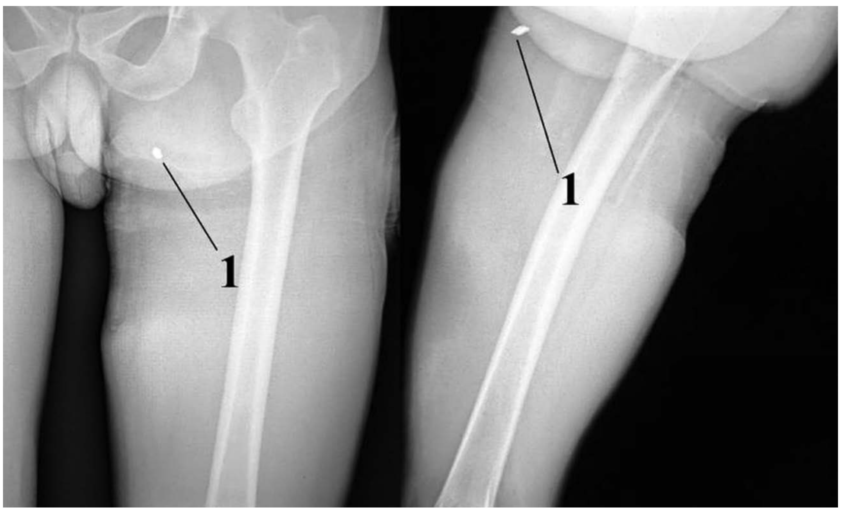


Photo taken by the authors

Fig. 1. Radiography of the left thigh: 1 — metallic density foreign body in the soft tissues of the medial surface of the left thigh

blood pressure 114/75 mmHg, heart rate 85 bpm, SpO_2 99%. Examination revealed a pulsatile, elastic formation approximately 5 cm in diameter in the area of the surgical wound, non-tender to palpation. Wound tamponade followed by digital pressure was performed (Fig. 3).

To clarify the cause of the hemorrhage, an ultrasound examination with color duplex scanning was performed. A pulsatile hematoma of the left thigh with a volume of approximately 30 mL and paravasal blood flow in the area of the deep femoral artery were identified (Fig. 4).

Due to the presence of ongoing hemorrhage, a consultation consisting of a vascular surgeon, a traumatologist, a surgeon, and an anesthesiologist made the decision to proceed with surgical treatment. Under intravenous anesthesia, an incision was made along the medial surface of the thigh, proximal to the wound site. The common femoral artery, superficial femoral artery, and deep femoral artery were isolated. 5000 IU of unfractionated heparin was administered intravenously as a bolus. The arteries were clamped. The tissue incision was extended along the course of the deep femoral artery, the hematoma was opened, and thrombotic masses of up to 30 mL were evacuated (Fig. 5).

Subsequently, the source of bleeding was visualized. This was a rupture of a branch of the deep femoral artery, specifically the first perforating artery (Fig. 6A). Given its small size (2 mm) and the presence of functioning second and third perforating arteries, it was ligated (Fig. 6B). The wound was sutured with a drain placed. The duration of the operation was 45 min, with a blood loss of 10 mL.

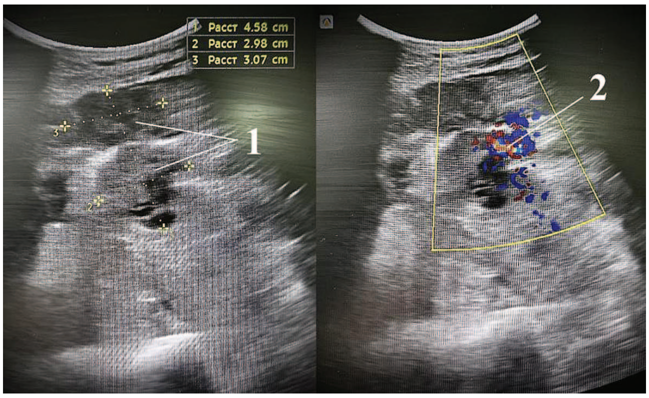
The postoperative course was uneventful. The following therapy was administered: ceftriaxone 1.0 g twice daily intramuscularly for 7 days; ketorolac 1.0 mL twice daily intramuscularly for 3 days. The drain was removed 2 days postoperatively, and the sutures were removed 14 days postoperatively. The serviceman was

Photo taken by the authors

Fig. 2. Metallic fragment removed from the soft tissues of the left thigh

Photos taken by the authors

Fig. 3. Local status 24 h post-injury: 1 — wound on the medial surface of the thigh through which the metallic fragment was removed.; 2 — wound on the lateral surface of the thigh — the site of injury

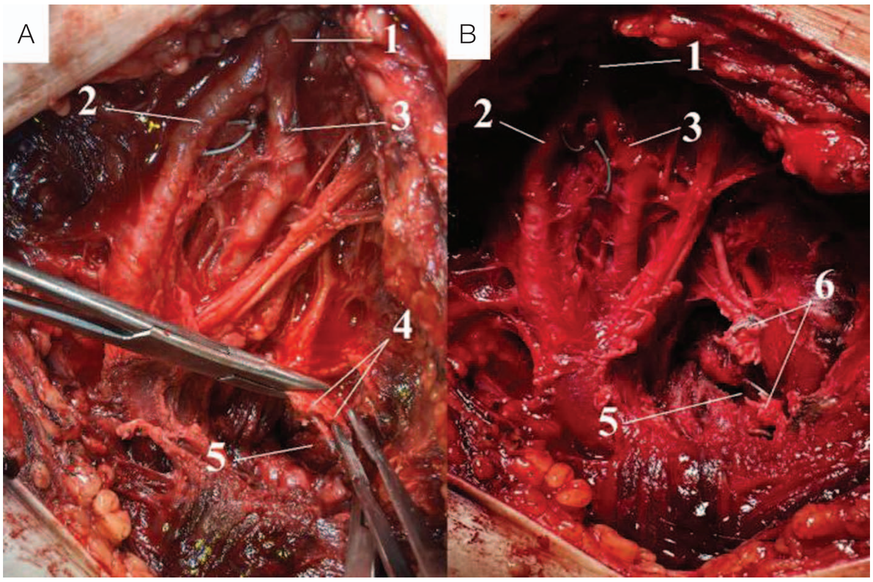


Photos taken by the authors

Fig. 4. Ultrasound examination with color duplex scanning of the vessels of the left thigh: 1 — pulsatile hematoma of the left thigh; 2 — paravasal blood flow in the area of the deep femoral artery

Photo taken by the authors

Fig. 5. Thrombotic masses from the cavity of the pulsatile hematoma of the left thigh



Photos taken by the authors

Fig. 6. Intraoperative photographs: A — isolation of the rupture site of a branch of the deep femoral artery (first perforating artery); B — ligation of the branch of the deep femoral artery (first perforating artery); 1 — common femoral artery; 2 — superficial femoral artery; 3 — deep femoral artery; 4 — rupture site of the first perforating artery; 5 — cavity of the thigh hematoma; 6 — site of ligation of the stumps of the first perforating artery

discharged and returned to duty 30 days after the operation.

CLINICAL CASE DISCUSSION

Battlefield injuries to major arteries represent one of the most complicated and life-threatening categories of combat surgical trauma. Their characteristic features include high pre-hospital mortality and a significant risk of limb loss even provided timely and qualified medical assistance. Modern armed conflicts, characterized by the use of high-velocity firearms and explosive devices with mass fragment injuries, create new, more severe types of damage where arterial injury is rarely isolated [11, 12]. The evolution of treatment approaches, including the adoption of tactical combat casualty care, the concept of damage control surgery, and the development of staged medical evacuation systems, has fundamentally changed outcomes for the wounded. However, the problem continues to remain extremely relevant, as evidenced by the emergence of new research addressing both organizational and purely clinical aspects of this pathology.

Epidemiology and mechanisms of injuries

The analysis of large-scale studies forms the basis for understanding the structure and scale of the problem. Sharrock et al. [13] carried out an analysis of 597 penetrating injuries to arteries of the lower extremities among international coalition service members and confirmed this location to be predominant in combat settings, constituting the main share of all vascular injuries. The superficial femoral and popliteal arteries are affected most frequently, which is critically important for the prognosis of limb viability [13, 14].

The mechanism of injury is a key factor determining the severity of damage and the outcome. A clear distinction should be drawn between gunshot (bullet) and explosive (fragment) wounds. The study by Siracuse et al. [15], involving a civilian population but focusing on gunshot etiology, demonstrated that gunshot wounds to the vessels of the lower extremities are associated with a statistically significantly higher risk of amputation (2.5 times) and mortality (3.4 times) compared to other types of penetrating trauma. The authors attributed this observation to the high kinetic energy that results in an extensive zone of primary and secondary necrosis.

A more detailed differentiation was provided by the work of Prat et al., dedicated to upper extremity injuries in modern conflict settings [16]. Their comparative analysis showed that explosive injuries statistically significantly more often result in multiple and bilateral injuries, more extensive soft tissue defects, thus requiring a greater number of surgical stages compared to gunshot wounds. This distinction directly influences surgical tactics and the planning of reconstructive measures [16].

A separate — highly vulnerable and diagnostically and therapeutically challenging — category comprises children in conflict zones. A review conducted by Ali et al. in Somalia revealed specific patterns of pediatric vascular trauma: a higher frequency of iatrogenic injuries, delayed presentation (over 6 h), and anatomical features (small vessel diameter) that complicate the performance of reconstructive operations [17].

Diagnosis and care organization

The diagnostic algorithm begins on the battlefield within the framework of Tactical Combat Casualty Care (TCCC), the key element of which consists in the rapid identification of life-threatening hemorrhage and the application of tourniquets. TCCC is a tactical combat casualty care protocol that prescribes the order of actions taken by a service member when providing aid to a comrade on the battlefield (literally, "tactical combat casualty care") [18]. Within a medical facility, diagnosis is based on the clinical picture (signs of acute ischemia) and instrumental methods. Angiography remains the gold standard; however, its implementation is not always possible in the acute phase (within an hour). Ultrasonography is a rapid and effective screening method [19]. The clinical case described by Yatsun et al., where an injury to the femoral vessels was diagnosed and operated on day 4, underscores the importance of sustained vigilance even with delayed presentation [19].

The organization of care is a critical factor in its successful outcome. The study by Priyadarshini et al. [18] convincingly demonstrated that the implementation of a protocolized approach at all stages, from pre-hospital tourniquet application to standardized surgical algorithms, statistically significantly increases survival and reduces the amputation rate. The modern system is built on the principles of echeloned care with evacuation by purpose, where forward surgical teams (Role 2) perform life-saving interventions according to the principles of Damage Control Surgery (DCS), while definitive reconstruction is carried out in rear specialized centers (Role 4/5) [1, 20].

Surgical treatment methods and their evolution

The primary objective in vascular trauma is the rapid and reliable restoration of major blood flow. A key milestone in military field vascular surgery was the widespread adoption of temporary vascular shunting. The study by Gifford et al. [21], which remains the methodological foundation for the modern surgical approach, demonstrated that the use of temporary shunts for extremity vascular injuries during the "Global War on Terrorism" led to a significant reduction in the rate of primary amputations. Shunting enables the immediate restoration of perfusion, arrests the progression of ischemia, and provides a critical temporal window for patient stabilization, completion of the required orthopedic stage (external fixation), and subsequent evacuation for definitive reconstruction under optimal conditions [20, 21].

Definitive arterial reconstruction is typically performed using an autogenous vein graft (most commonly the great saphenous vein), which is considered the gold standard of surgical treatment due to its superior resistance to infection compared to synthetic materials [14, 20]. Ligation of major arteries is used in modern practice on a limited basis, primarily for injuries to vessels with a well-developed collateral network or as a desperate life-saving measure when implementing the DCS principle.

The experience of a single center, presented in the work of Katelenets et al. [20], summarizes the modern technical aspects and organizational principles for the successful treatment of combat-related extremity vascular injuries, emphasizing the importance of a multidisciplinary approach involving vascular, orthopedic, and plastic surgeons.

Features of injuries in different vascular areas

- Injuries to lower extremity vessels are among the most frequent and prognostically unfavorable cases in terms of condition and subsequent disease progression. Wounds to the popliteal artery, due to anatomical features, carry the worst prognosis. Damage combined with venous injury and complex fracture is conventionally associated with a high risk of amputation [13, 15]. The management strategy includes urgent shunting, mandatory fasciotomy, and delayed definitive reconstruction [13, 15, 20].
- Injuries to neck vessels fall into the category of the most dangerous cases. The study by Katsura et al. on the surgical treatment of penetrating carotid artery injuries introduced an important prognostic criterion: the outcome directly correlates with the patient's preoperative neurological status [22]. In patients in a coma or with severe neurological deficit (≤ 8 on the Glasgow Coma Scale), revascularization was associated with high mortality, while in conscious patients it yielded good results. This necessitates an individualized approach that considers not only the anatomy of the injury but also the state of cerebral perfusion [22].
- Rare locations. Cases of injury even to small arteries, such as the lingual artery, were described to lead to life-threatening pseudoaneurysm formation presenting with recurrent oral hemorrhages [23].

Long-term and rare complications

Of particular concern are delayed complications, which can manifest many years or even decades after the injury. This necessitates lifelong follow-up monitoring for this category of patients.

- False aneurysms (pseudoaneurysms) form due to an incomplete rupture of the arterial wall. The literature describes cases of giant pseudoaneurysms that developed 24 years after a gunshot wound to the popliteal artery and several months after an injury to the superficial femoral artery [17, 24]. These cases demonstrate that an unrecognized or inadequately treated vascular injury represents a "ticking time bomb."

- Traumatic arteriovenous fistulas (AVF) form due to a combined injury to an artery and an adjacent vein. A unique clinical example described by Nagra et al. illustrates the diagnosis and successful treatment of an AVF 58 years after a combat explosion [24]. The prolonged existence of the fistula led to the development of heart failure, necessitating surgical correction in adulthood.

Functional outcomes and quality of life

The question of the optimal choice between limb salvage and primary amputation remains debatable. A secondary analysis of data from the METALS study (Levack et al.), indicated that the level of injury is significant for long-term functional outcomes [25]. Patients with complex injuries at the tibial level who underwent limb salvage after multi-stage reconstructions might have worse functional scores and quality of life in the long term compared to those who underwent primary below-knee amputation followed by high-quality prosthetic fitting [25]. This is not a call for a more radical approach, but rather an argument in favor of a strictly individualized, multidisciplinary assessment that considers not only the technical feasibility of revascularization but also the predicted functional outcome, rehabilitation prospects, and psychosocial aspects.

In this article, we conducted a comparative analysis of the presented clinical case with literature data on delayed presentations of arterial injuries, paying particular attention to diagnostic and tactical features determined by the level of medical care provided. The interest of this case lies in its atypical, delayed presentation. In the classic scenario of combat vascular trauma, a rupture of a major artery leads to profuse, life-threatening hemorrhage directly on the battlefield, necessitating the immediate application of hemostatic tourniquets and urgent surgical hemostasis within the framework of DCS (Damage Control Surgery) tactics. For comparison, in the presented case, the clinical picture developed only 48 h after the injury.

This pattern aligns our case with rare, literature-described examples of delayed complications. In particular, Martirosyan et al. described a rupture of a branch of the deep femoral artery, which manifested as a massive hematoma only 26 days after the injury and evacuation to a rear specialized center [7]. However, there exists a fundamental and indicative difference in the choice of diagnostic and therapeutic tactics between these two clinical situations, a difference that stems directly from the level of medical care provided and the equipment available.

In the conditions of a multidisciplinary specialized hospital (Level 4/5), as described in the literature, angiography was performed, followed by a high-tech endovascular intervention (stent implantation with embolization). In our case, however, the patient was in a forward surgical unit (Level 2), located close to the line of contact, where the range of diagnostic methods, as noted earlier in the discussion, was limited to radiography and ultrasound examination. It was this limitation that dictated the choice of tactics: the diagnosis was based on ultrasound data, which revealed significant mural thrombus formation at the injury site (Fig. 4), and the treatment consisted of open surgical exploration and vessel ligation under intraoperative ultrasound guidance.

The diagnostic complexity in such cases of delayed hemorrhage from small arterial branches, similar to ours, is exacerbated by their pathophysiology. The gradual accumulation of blood in the extensive intermuscular spaces of the thigh leads to tamponade and the formation of an organized hematoma with thrombosis, which can temporarily stabilize the condition. Hemorrhage may resume and become externally apparent, as in our case, only with a change in pressure, e.g., when the patient attempted to stand and walk two days later. An important anatomical nuance was that the wound channel was initially covered from the inside by the dense fascia lata of the thigh, which also contributed to the delay in clinical manifestation.

Thus, the presented clinical case serves as a clear illustration of the practical application of the general principles of staged management of combat trauma (DCS, initial surgical debridement at the forward stage) and the adaptation of the diagnostic algorithm (priority of ultrasound) in a specific, complex situation involving delayed presentation of a peripheral arterial injury. It emphasizes that a successful outcome depends not only on surgical technique but also on a clear understanding of the capabilities and limitations of a specific stage of the medical evacuation chain.

CONCLUSION

Ultrasound examination of blood vessels is necessary in all cases of fragment wounds, even in the absence of signs of hemorrhage. In cases of a ruptured branch of the deep femoral artery, its ligation under the conditions of a military field hospital is an effective and safe method of surgical correction.

Modern literature reflects significant progress in the understanding and treatment of combat arterial trauma. A clear paradigm has been established, based on a protocolized prehospital phase, a DCS strategy with active use of temporary shunting, staged evacuation, and definitive multidisciplinary reconstruction in specialized centers. The focus has shifted not only toward saving lives but also toward optimizing long-term functional outcomes. At the same time, the problem of late vascular complications, such as pseudoaneurysms and arteriovenous fistulas, which can develop decades later, has gained particular importance. This necessitates the organization of lifelong monitoring systems for veterans. Further research should be aimed at improving endovascular methods in field conditions, developing bioartificial conduits, and conducting in-depth analysis of long-term psychosocial and functional outcomes.

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