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Case report

Temporary arterial shunts in combat patient with vascular injuries to extremities wounded in Russian-Ukrainian war: A case report

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ABSTRACT

Introduction and importance: Vascular injuries to extremities are common in armed conflicts. Such kind of injury is associated with a high risk of critical ischemia, limb amputation, and high morbidity. There is a clinical challenge for the management of vascular injuries to extremities in ongoing warfare due to limited medical resources.
Presentation of case: A 34 years old male received a gunshot injury to both low extremities on March, 23rd 2022 in a battlefield area 30 km away from Kyiv city. CAT tourniquet was applied to stop the bleeding and the patient was transported to Level II by ambulance 40 min after the injury. The patient was diagnosed with a gunshot injury to the left superficial femoral artery (SFA) followed by primary surgical debridement and temporary arterial shunting at Level II hospital. Then the patient was evacuated to Level IV hospital, diagnosed with an injury to the right popliteal artery, and underwent vascular reconstruction.
Clinical discussion: Arterial shunting is a well-known approach to prevent critical ischemia and limb amputations of injured extremities in both combat and civilian patients. This case report provides evidence for the utility of temporary arterial shunting in combat conditions, which is supported by data from the larger cohorts. We consider temporary vascular shunting as a damage control measure to be associated with high chances of limb salvage in ongoing warfare.
Conclusion: Our study demonstrated the utility of temporary arterial shunting in combat patients with gunshot wounds in ongoing warfare, which could be performed even in case of limited medical resources.

1. Introduction

Vascular gunshot wounds are common in armed conflicts [1–3]. Such kind of injury is associated with a high risk of critical ischemia, limb amputation, and high morbidity [4]. Ongoing warfare is associated with frequent applications of multiple-launch rocket systems and other high-energy weapons causing massive soft tissue and internal organ damage, limb amputations, longer treatment and rehabilitation time, or lethal outcomes [1,5,6]. A frequent violation of the international law for humanitarian treatment during the war by the Russian army is associated with problems of the safe evacuation of injured people to appropriate Levels of medical care and interrupted supply of medical equipment, due to frequent artillery strikes on medical facilities. There is a clinical challenge for the management of gunshot wounds under the abovementioned conditions as well as application of damage control surgery in case of severe vascular injury.

The aim of this report is to demonstrate a case of successful limb salvage after the application of a temporary vascular shunt in a combat patient with gunshot wounds to the lower extremities with a damage of femoral artery and right popliteal artery in conditions of interrupted supply of medical equipment, due to frequent artillery strikes on medical facilities.

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2. Presentation of case

A 34 years old male received a gunshot injury to both low extremities on March 23rd, 2022 in a battlefield area 30 km away from Kyiv city. Management of the patient was performed according to medical military doctrine of Ukraine, which is included 5 Levels of medical care [5,7]. To stop the bleeding CAT tourniquet was applied and the patient was transported to Level II by ambulance 40 min after the injury, which is in line with the principle of "golden hour" [1,5]. Level II hospital was located within the area of high risk for artillery strikes from the aggressor site. At admission to Level II, the patient was diagnosed with a gunshot injury to the left superficial femoral artery (SFA) with complete rupture and underwent primary surgical debridement of the wounds as well as temporary arterial shunting (Fig. 1). Considering the severity of the trauma, the decision was made to transfer the patient to Level IV, which is the Department of Vascular Surgery National Military Medical Clinical Center of the Ministry of Defense of Ukraine in Kyiv.

The medical evacuation to Level IV was performed under lung ventilation 6 h after the injury on March 24th, 2022. It is worth to mention, that both transport immobilization and tourniquet were not applied to the patient's extremities, indicating a high risk for temporary arterial shunt failure and bleeding.

Upon arrival at Level IV, the left lower extremity was warm with preserved passive movements, with detectable pulsation in the tibial arteries. The right lower extremity was cold, and swollen with restricted passive movements, indicating critical ischemia. Further revision showed moderate venous bleeding from the inlet and outlet gunshot wounds in the area of the right knee (Fig. 2). There were also identified gunshot wounds to the right popliteal artery, moderate hemorrhagic shock as well as acute compartment syndrome of the right lower limb. Upon admission to Level IV, the patient underwent routine clinical and physical examinations. The presence of critical ischemia was taken into consideration; thus, we did not apply any additional diagnostic methods and immediately transport the patients to the operation room in order to limb salvage. The patient had no special features for drug history, family history including any relevant genetic information, and psychosocial history.

There were two surgical teams. To further evaluate gunshot wounds, we approached vessels through the right Hunter's canal to check the vessels' integrity. Then right Jobert's fossa was approached showing moderate hematoma and absence of arterial pulsation in that area, indicating injury to the right popliteal artery. Given such a finding, one surgical team extended approach from the 1/3 of the femoral to distal parts of the right extremity to perform revision and decompressive fasciotomy for the medial (superficial and deep compartments), lateral and anterior compartments, extensor digitorum longus muscle. Prior to shunting, a careful wound revision was made for the muscles of right extremity and fasciotomy. Fasciotomy was planned specifically before the shunting, because performance of such a procedure after the arterial reconstruction would have caused vein thrombosis, significant decreasing of blood supply, and increase the risk for muscles ischemia and necrosis. At revision, we found bleeding from both a partially damaged right popliteal artery and a branch of a right popliteal vein (Fig. 2). Meanwhile, the second surgical team harvested 18 cm of saphenous vein graft for further reconstruction of both damaged arteries. An end-to-end bypass of the right popliteal artery was performed with 7 cm saphenous vein graft using 5/0 prolene sutures. Vein injury was not repaired. The Mangled Extremity Severity Score (MESS) showed 7 points for this case, indicating borderline risk for limb amputation [8].

At further revision, the temporary arterial shunt of the left SFA was fully functioning (Fig. 3). We performed both proximal and distal control of the damaged arteries, followed by thrombectomy by Fogarty catheter as well as lavage using heparinized saline. End-to-end bypass of left SFA was performed with a 9 cm saphenous vein graft using 5/0 prolene sutures.

Postoperatively, Doppler ultrasonography showed regular blood flow. An X-ray showed the presence of a metal-density object (*i.e.* bullet) within the area of the right hip (Fig. 4). Three days after the injury, the patient underwent surgical revision of the wounds with subsequent removal of the bullet followed by the application of VAC-therapy to the wound. An angiography was not performed at any hospital at all Levels, although this method was available in the hospital at Level IV. The angiography was not performed at Level IV due to sufficient data obtained from Doppler ultrasonography. A 16 days after the surgical management at level IV, the wound of the right lower extremity was closed using a dermal flap. On the 29th day after the injury patient was

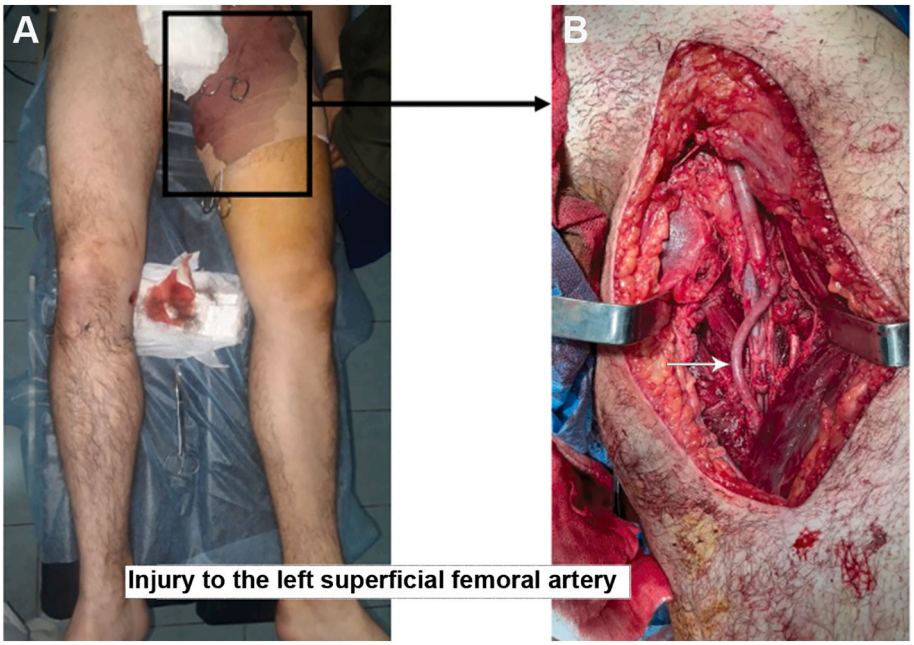

Fig. 1. Illustration of the intraoperative view of the left superficial femoral artery. A. The overall view of the patient at admission shows surgical clamps fixed within the gunshot wound in the upper 1/3 of the left femur (marked with a rectangle). B. Functioning temporary arterial shunt (marked with arrow) of the left superficial femoral artery.

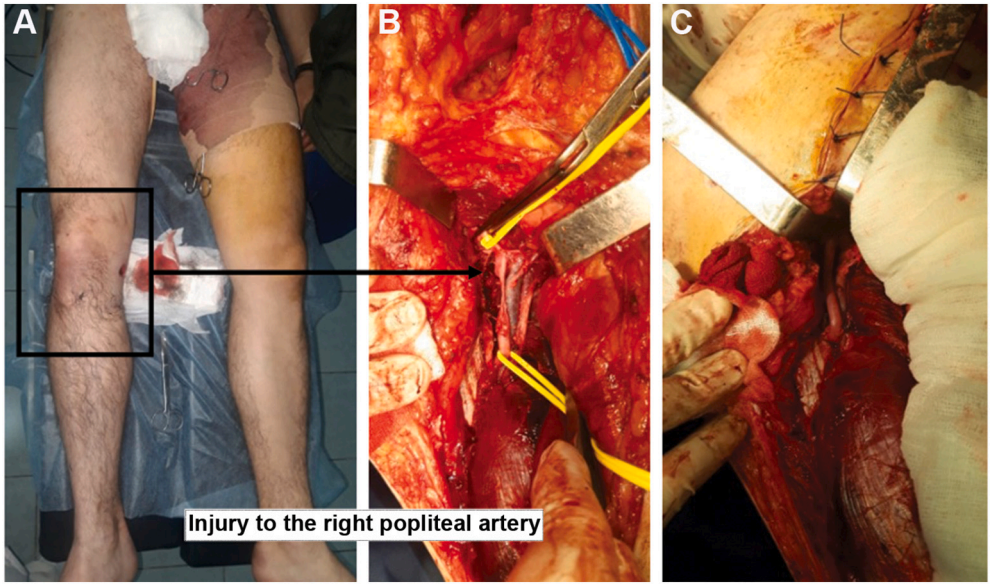

Fig. 2. Photo of the intraoperative view of the right popliteal artery injury. A. The overall view of the patient at admission shows an inlet hole within the area of the right knee (marked with a rectangle). B. The right popliteal artery edges were fixed with two elastic bands, and the injured part is marked with an arrow. C. Right popliteal artery after the reconstruction with a saphenous vein graft.

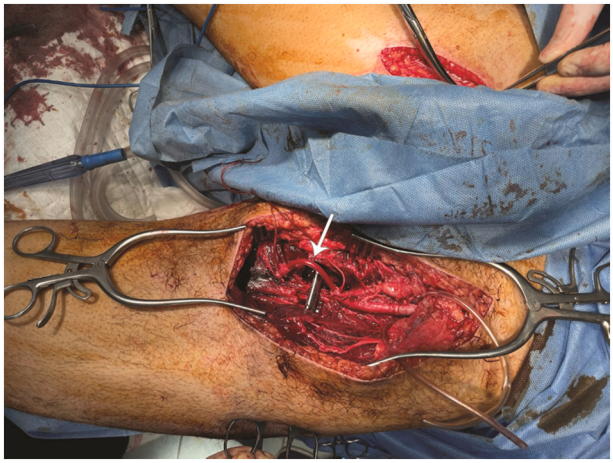

Fig. 3. Intraoperative view of the functioning temporary arterial shunt for left superficial femoral artery (marked with an arrow) as found at revision in the hospital of Level IV.

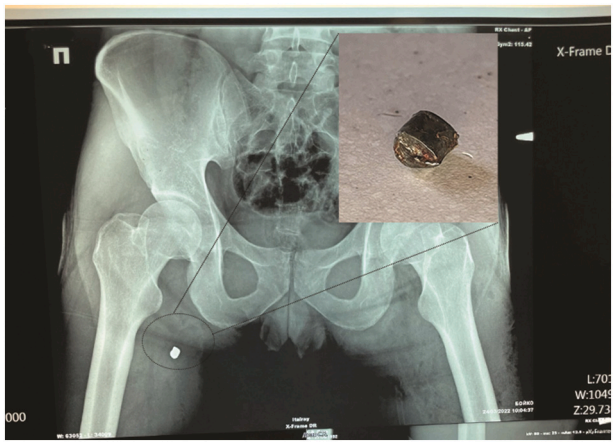

Fig. 4. Illustration of the bullet as a methal-density object on X-ray film (marked with a circle) in the area of the right hip and its presentation after removal.

discharged from the hospital to continue treatment at the rehabilitation center. This study was approved by the Ethical Committee at the Ukrainian Military Medical Academy (Kyiv, Ukraine). The manuscript was written according to SCARE Guideline [9].

3. Discussion

In this study, we reported an example of successful temporary arterial shunts in combat patient who was treated at Level II after receiving a gunshot injury to lower extremities with the damage to the major artery vessels. This case report is provided an example of possibility to perform vascular repair in conditions of limited medical recourses as well as under the continuing strikes by high-energy weapon and violation of international humanitarian rules by Russia, using as cruise missiles strikes on critical infrastructure such as civil power stations around Ukraine [10,11]. Limited medical recourses were and remained a common problem for the medical care in Ukraine due to various causes, including insufficient planning [12]. However, military and civil surgeons are able to diagnose and to consider management of such a severe vascular injury even in unstable combat conditions with a regard to available resources.

Arterial shunting is a well-known approach to prevent critical ischemia and limb amputations of injured extremities in both combat and civilian patients [4,13,14]. This case report provides evidence for the utility of temporary arterial shunting in war in Ukraine, which is supported by data from the larger cohorts, however demonstrating new insights on the example of ongoing warfare [4]. In line with Polcz et al. and Hornez et al., we consider temporary vascular shunting as a damage control measure to be associated with high chances of limb salvage in ongoing warfare [4].

Results from our study highlighted that temporary arterial shunting might help to prevent critical ischemia and limb amputation at Level 2, which is located 20–30 km from the battlefield line in case of described warfare. At the presented timeline, there was a high risk for the transportation of the patients at the higher level of medical care within 4–6 h due to an unstable combat situation. Similar to other studies reporting combat patients from wars in Iraq and Afghanistan, we showed that

restoring arterial blood supply within 6 h after the injury is associated with limb salvage [15]. Therefore, damage control surgery should include temporary arterial shunting in case of a major vessel gunshot injury [16]. It is worth also to mention, that data from systemic reviews also supported temporary arterial shunting for both civil and combat gunshot wounds within 6 h after the injury to prevent critical ischemia [17]. In this case we reported fasciotomy on the Level IV of medical care, but this procedure was not performed on Level II. The reason to postpone the fasciotomy at higher level was based on the clinical evaluation of the patients showing neither signs of major veins damage nor signs for compartments syndrome, and consideration of damage control surgery. Although we have diagnosed compartment syndrome later at Level IV and performed fasciotomy in our patient, such a complication was not associated with limb amputation or death. The possible reason for the limb salvage could be also associated with temporary arterial shunting. Such a hypothesis is supported by the results from studies by Inaba, et al., Wlodarczyk, et al., and Polcz et al. who demonstrated decreased rate of compartment syndrome onset and morbidity in patients with temporary arterial shunting [4,16].

A saphenous vein graft was used for further reconstruction of both damaged arteries, which was performed at a higher level of medical care as soon as the evacuation of the patients as possible. Similar to Polcz et al. [4], we also consider such a procedure to be performed by an experienced vascular surgeon, who is usually not in charge at Level II in Ukraine.

Although Level II military surgeons in Ukraine can perform temporary arterial shunting, it is not always possible due to previous poor medical equipping as a result of failures in the planning of the healthcare system as well as targeting of healthcare infrastructure by the Russian army [11,12].

4. Conclusion

Our study demonstrated the utility of temporary arterial shunting in combat patients with gunshot wounds in ongoing warfare, which could be performed even in case of limited medical resources, violation of international humanitarian law and under frequent strikes of high-energy weapons.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Ethical approval

This study was approved by the Ethical Committee at the National Military Medical Center of the Ministry of Defense of Ukraine (Kyiv, Ukraine).

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N/A.

Author contribution

Volodymyr M. Rogovskyi - Conceptualization; Data curation; Formal analysis; Writing - original draft; Writing - review & editing; **Boris Koval** - Formal analysis; Visualization; Writing original draft; Writing – review & editing; **Igor A. Lurin** - Formal analysis; Visualization; Writing original draft; Writing – review & editing, final approval; **Kostiantyn Gumeniuk** - Writing - review & editing; editing figures; **Maksym Gorobeiko** - Writing - review & editing; **Andrii Dinets** - Supervision; Writing - review & editing, critical revision of the manuscript, final approval.

Guarantor

Dr. Volodymyr M. Rogovskyi MD, PhD.

Research registration number

N/A.

Declaration of competing interest

N/A.

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