

Penetrating Injuries of Peripheral Vascular Structures: Short -Term Follow-up Study

Periferik Vasküler Yapıların Delici Kesici Alet Yaralanmalarının Kısa Dönem Takibi

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ABSTRACT

Objective: Penetrating vascular injuries are medical conditions that we often come across and require urgent treatment. Early diagnosis and treatment play a big role reducing the mortality and morbidity in patients suffering from penetrating vascular injuries.

Method: We retrospectively observed 168 patients who were operated by us between January 2016 and September 2019 because of peripheral vascular injuries. Demographic features, clinical findings at diagnosis and follow-up and 3rd month arterial duplex ultrasound (DUS) findings were evaluated.

Results: In our study, 244 vascular structures were repaired in 168 patients. The most commonly injured vascular structure was femoral artery in 54 (22%) cases. Other injured vascular structures were radial artery in 47 (19%), superficial femoral vein in 33 (14%), deep femoral vein in 28 (11%), ulnar artery in 23 (9%), brachial artery in 21 (9%), popliteal artery in 12 (5%), posterior tibial artery in 9 (4%) and the anterior tibial artery in 3 (1%) cases. When it comes to surgical techniques, while primary repair was performed in 57 (23%), and end-to-end anastomosis in 92 patients (38%). As a graft material saphenous vein was used in 60 (25%) and PTFE (polytetrafluorethylene) in 35 patients (14%). Two patients (1.19%) with femoral artery repair had suffered from compartment syndrome and fasciotomy had to be done. In a patient with bone fracture accompanied to vascular injury, amputation was performed by the orthopedic clinic due to severe osteomyelitis and necrosis after discharge. At follow-up control after 3 months, stenosis above 70% was not detected with arterial duplex ultrasound (DUS) in any patient and no intervention was required.

Conclusion: Immediate arrival of patients with penetrating injuries to the hospitals and approach to the patient in consideration of vascular injury in the emergency rooms are significantly important in reducing limb loss and mortality.

Keywords: peripheral vessel, vascular injury, penetrating injury

Öz

Amaç: Delici kesici alet yaralanmaları (DKAY) sık gördüğümüz ve acil tedavi gerektiren bir durumdur. Erken tanı ve tedavi bu hasta grubunda mortalite ve morbiditeyi azaltır.

Yöntem: Çalışmamızda 2016 Ocak ile 2019 Eylül arasında DKAY nedeniyle ameliyat ettiğimiz 168 hastayı retrospektif olarak inceledik. Hastaların demografik özellikleri, tanı ve izlem sırasındaki klinik bulguları ile 3. ay doppler ultrason bulguları değerlendirildi.

Bulgular: Çalışmamızda 168 hastada, 244 vasküler yapı onarımı yapıldı. Elli dört olgu (%22) ile en sık yaralanan vasküler yapı femoral arter olarak saptandı. Yaralanan diğer vasküler yapılar sırasıyla 47 olguda (%19) radial arter, 33 olguda (%14) yüzeysel femoral ven, 28 olguda (%11) derin femoral ven, 23 olguda (%9) ulnar arter, 21 olguda (%9) brakial arter, 12 olguda (%5) popliteal arter, 9 olguda (%4) posterior tibial arter ve 3 olguda (%1) anterior tibial arterdi. Cerrahi teknik olarak 57 hastada (%23) primer onarım, 92 hastada (%38) uç-uç anastomoz tercih edildi, 60 hastada (%25) safen ven greft ve 35 hastada (%14) PTFE (polytetrafluoretilen) greft interpozisyonu uygulandı. Femoral arter tamiri yapılan 2 hastada (%1.19) kompartman sendromu gelişti ve fasyotomi ihtiyacı oldu. Kemik fraktürü ve vasküler yaralanması olan bir hastaya ise taburculuk sonrası osteomyelit ve nekroz nedeniyle ortopedi kliniği tarafından amputasyon uygulandı. Üçüncü ay doppler kontrollerinde hiçbir hastada %70 üzeri darlık saptanmadı ve herhangi bir girişim gereksinimi olmadı.

Sonuç: Delici kesici alet yaralanması olan hastaların hastaneye vakit kaybetmeden ulaşması ve acil serviste vasküler yaralanma şüphesi ile yaklaşım, uzuv kaybını ve mortaliteyi azaltmak için önemlidir.

Anahtar kelimeler: periferik damar, damar yaralanması, kesici alet yaralanması

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INTRODUCTION

Penetrating injuries happen to be more common in patients with low socioeconomic status. Penetrating injuries are more common than firearm-related injuries. The features of the sharp objects (length, thickness, sharpness) play a key role in the degree of damage in the injuries. Course of treatment may vary depending on the body area damaged with the penetrating injury. When the penetrating injuries happen to be in thorax and abdomen, they are considered as multiple traumas and require a multidisciplinary approach as well. Penetrating injuries in isolated limbs are more common and nerve, muscle and bones might be damaged along with the vascular injuries. In such cases, since the operation and follow-up period can become more complex than usual, after evaluating the patient with the relevant clinics, multidisciplinary approach should be considered. Quickly determining whether or not there is a vascular pathology and consulting the patient to vascular surgery for its treatment is really important for decreasing the mortality and morbidity of the patient with penetrating injuries.

MATERIAL and METHOD

This study is a descriptive retrospective study in which we examined 250 patients who applied to the emergency service of Bakirkoy Dr. Sadi Konuk Research and Training Hospita Training and Research Hospital between January 2016 and September 2019 and operated due to peripheral vascular injuries. We only included patients with peripheral vascular injuries in this study. Patients with penetrating injuries to abdominal and thorax, patients with gunshot wounds and missing 3rd month follow-up results were excluded from the study. All these mentioned information of 168 patients were accessed and these patients were included in the study. Cases with multiple vessel injuries were also included in the study and counted as one patient, but when it comes to total number of vessels, we counted each vascular structure individually. A total of 168 patients and 244 vascular repair structures were included in the study.

All of the patients were operated in consideration of BT angiography findings. The repair methods were

chosen according to mechanism of vascular injures and severity of vascular damage. While the primary repair was the first choice in simple injuries where vascular integrity was not impaired, end-to-end anastomosis was preferred with the fragmented injuries. Also, if end-to-end anastomosis cannot be performed; saphenous vein or PTFE graft interposition methods became our first choice. When a graft was required for repair, the diameter of the native vessel has been the primary guide for our graft choices. Saphenous vein graft was preferred firstly and if the diameter of the saphenous vein graft was not suitable, then the PTFE graft which is suitable for the native vessel diameter was chosen for interposition, and 6/0 or 7/0 prolene sutures were used for the anastomosis and repair.

Patients who had venous intervention with saphenous vein or PTFE graft interposition, were treated both with warfarin and low- molecular weight heparin (LMWH). We aimed to keep the INR (international normalized ratio) around 2-2.5. When the INR value reached to the therapeutic dose, LMWH treatment was stopped. In patients who had arterial intervention, dual anti-platelet therapy (aspirin and clopidogrel) was prescribed.

In these patients, we had checked and observed the affected vascular structures and the procedures applied to these structures (repair methods), postoperative pulsations of the affected extremities, the amount of erythrocyte suspension used during all process, the follow-up during hospitalization time, whether there was a pathology in the vascular structures in imaging procedure performed after 3 months, whether there was a patient applied to the emergency service during these 3 months and whether there was any pathology during the 3 month follow-up period. During the follow-up, it was checked whether there were any emergency applications and whether any pathology developed during the follow-up period.

The study protocol was approved by the local ethics committee. The data were analyzed with SPSS v21. Descriptive statistical categorical variables were expressed in frequency (n) and percentage (%), while numerical variables were expressed in mean standard deviation.

RESULTS

A total of 168 patients and 244 vascular repair structures were included in the study. Most of (n=129 :77%) of the patients included in the study were male, and 39 (23%) of them were female. Mean age of the patients was 28.34±8.42 years. While 91 (37%) of the injured vascular structures were on the upper limbs and 153 (63%) on the lower limbs. The injured vascular structures in the upper limbs were radial artery in 47 (19%), ulnar artery in 23 (9%), and brachial artery in 21 (9%) patients. The injured vascular structures in the lower limbs were femoral artery in 54 (22%), superficial femoral vein in 33 (14%), deep femoral vein in 28 (11%), popliteal vein in 14 (6%), popliteal artery in 12 (5%), posterior tibial artery in 9 (4%) and anterior tibial artery in 3 patients (1%).

As a treatment, vascular structures were not sutured, however, the primary repair or end-to-end anastomosis were first choices. Primary repair was performed in 57 of the injured vascular structures , and end- to -end anastomosis was carried on in 92 vessels. Sixty cases were repaired with saphenous vein graft and 35 of them with PTFE graft interposition.

Graft thrombosis developed in the upper extremities

of 2 patients (3.33%) who had saphenous vein graft interposition procedure in the brachial artery. While embolectomy was performed in one of them and in the other patient revision of the surgery was made by removing the saphenous graft and re-interposing with saphenous vein graft.

PTFE graft thrombosis developed in 3 patients (8.57%). In one patient thrombosis developed in the popliteal vein, and in the other two patients in the femoral artery. Graft thrombosis in the popliteal vein was treated by interposing the saphenous vein graft instead of the prosthetic graft. One of the patients with graft thrombosis in the femoral artery was treated by embolectomy and the other by replacing PTFE graft. with saphenous graft. Complication of thrombosis occurred in all patients before discharge and no patient needed amputation.

Two cases with femoral artery injury who applied relatively late to our clinic had a fasciotomy because the patients suffered from compartment syndrome. These patients were transferred to the orthopedic clinic for follow-up and treatment. Bone fracture was accompanied by only one of the all cases, and this patient was amputated by the orthopaedic clinic due to osteomyelitis developed 2 months after discharge. The mean amount of erythrocyte suspension

Table 1. Demographic, operative and postoperative data.

Gender	Male Female	129 (77%) 39 (23%)
Age	28.34±8.42	
Injured vascular structure	Femoral artery Radial artery Superficial femoral vein Deep femoral vein Ulnar artery Brachial artery Popliteal vein Popliteal artery Posterior tibial artery Anterior tibial artery	54 (22%) 47 (19%) 33 (14%) 28 (11%) 23 (9%) 21 (9%) 14 (6%) 12 (5%) 9 (4%) 3 (1%)
Vascular repair technique	Primary repair End to end anastomosis Saphen vein interposition PTFE graft interposition	57 (23%) 92 (38%) 60 (25%) 35 (14%)
Erythrocytes suspension Transfusion (unit)	1.4±0.8	
Complication	PTFE graft thrombosis Saphen vein graft thrombosis Compartment syndrome Fasciotomy Amputation	3 (8.57%) 2 (3.33%) 2 (1.19%) 2 (1.19%) 1 (0.59%)
Hospital stay (day)	3.88±2.14	

Table 2. Third month duplex ultrasound (DUS) results.

Repaired Vascular Structure	No Stenosis	0-50% Stenosis	50-70% Stenosis	>70% Stenosis
Femoral artery	49 (91%)	4 (7%)	1 (2%)	-
Radial artery	45 (96%)	1 (2%)	1 (2%)	-
Ulnar artery	22 (96%)	1 (4%)	-	-
Brachial artery	17 (81%)	3 (14%)	1 (5%)	-
Popliteal artery	11 (92%)	1 (8%)	-	-
Posterior tibial artery	8 (89%)	1 (11%)	-	-
Anterior tibial artery	3 (100%)	-	-	-
Superficial femoral vein	27 (82%)	5 (15%)	1 (3%)	-
Deep femoral vein	21 (75%)	5 (18%)	2 (7%)	-
Popliteal vein	11 (79%)	2 (14%)	1 (7%)	-

used was 1.4±0.8 units (Table 1).

Patients with nerve injuries had sensory and/or motor defects. These patients were consulted to the neurosurgery and neurology clinics and treated in compliance with their recommendations.

Patients were checked up at postoperative 3rd month. A DUS was performed to detect restenosis. The postoperative 3rd month total patency rate was 87%. Postoperative 3rd month patency rates for repaired radial artery (n=45: 96%) ulnar artery (n=22:96%), brachial artery (n=17: 81%), femoral artery (n=49:91%) superficial femoral vein (n=27: 82%), deep femoral vein (n=21:75%), popliteal vein (n=11: 79%), popliteal artery (n=11: 92%), posterior tibial artery (n=8: 89%) and anterior tibial artery (n=3:100%) were as indicated. None of the patients had stenosis above 70% and no intervention was required (Table 2).

DISCUSSION

Vascular injuries are medical problems that require immediate treatment. When not treated early, they can be fatal secondary to bleeding. The damage in the vascular structure and the severity of the injury should be diagnosed and treated as quickly and appropriately as possible. Regardless of the course of treatment, the follow-up period of the patient is also essential. Vascular injuries can occur in five different patterns; intimal injuries (subintimal hematoma, flap), total wall defects (bleeding, hematoma, pseudoaneurysm), loss of vascular integrity (bleeding or total occlusion), arteriovenous fistula and spasm (1). In addition, arterial examination and imaging can be misleading due to hematoma. Firstly, we must determine the entry and exit areas of the injury. After

that, we must perform a physical examination in accordance with the anatomy of the injured area. In this physical examination, while we may find serious problems such as active bleeding, severe hematoma, thrill, loss of pulsation, paleness, coldness, paraesthesia and paralysis, it is also possible to encounter mild hematoma, unilateral loss of pulsation or no symptoms at all. The patients' condition will determine the process until the operation (2).

Contrast-enhanced computed tomography (CECT) is the imaging method when evaluating the patient with penetrating injuries. Arterial duplex ultrasound (DUS) does not play a role in the evaluation of patients suffering from such injuries (1,2). CECT is the gold standard (3). In CT (computed tomography), the presence of arterial extravasation of the contrast agent, narrowed image of arterial lumen or its complete disappearance, pseudoaneurysm and arteriovenous fistula should be carefully evaluated (4) (Figure 1). Venous and late phase images should also be taken after arterial imaging due to the possibility of the damage in the venous structures, in all patients

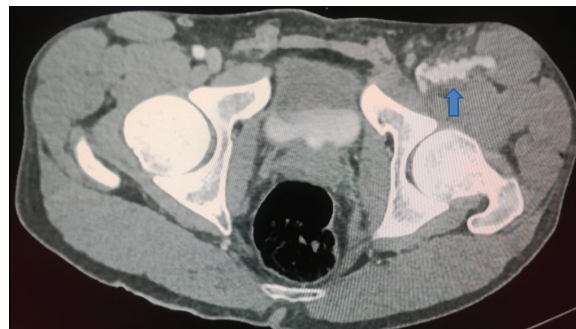


Figure 1(→). Arterial phase axial CT angiography image. Contrast extravasation (arrow) in the left common femoral artery due to penetrating injury.

if possible. After the clinical evaluation and CT imaging, we should decide whether the patient needs an intervention or not. If intervention is required, it is necessary to decide whether endovascular or surgical intervention will be performed. To prevent blood loss in patients with especially severe bleeding, tourniquet should be applied to the proximal part of the injury. On the other hand, tourniquet should be carefully loosened to allow the flow while the CT imaging was performed, otherwise the images may be misleading as there will be no contrast transition to the distal tourniquet. If the vascular structures are visible, applying direct pressure to these structures will reduce blood loss, mortality and morbidity. Penetrating injuries mostly happen to be in the upper extremities (73%) and usually together with tissue and nerve injuries (78%)⁽⁵⁾.

Leyland et al. reported that, in their study conducted between 1981 and 2003, 66.6% of patients with penetrating injuries were at the ages of 15-34 and 53.7% were male⁽⁶⁾. In the study of Karger et al., it is seen that male to female ratio was 3.64 and 48% of the patients were at 21-40 years old⁽⁷⁾. In the study of Köksal et al., 60.5% of the cases were under the age of 30 and 94.4% were male⁽⁸⁾. In our study, 77% of the cases were male, 23% female, and the average age was 28.34±8.42 years, similar to other studies.

In the study of Wong et al., the average time of hospitalization was 10.4 days, while it was 4.64 days in Köksal's study, and 3.88 days in our study^(8,9). Since Wong et al. included in their study not only patients with penetrating injuries but also patients with multiple traumas, the hospitalization time of their patients was longer.

In the studies of Boström et al. with more than 1000 patients, the mortality rate was 3.4%⁽¹⁰⁾. Jacob AO et al. found mortality rate as 2.26% in their study, which included 1500 penetrating injury cases⁽¹¹⁾. While the mortality rate was 5.6% in the study of Köksal et al., there was no mortality in our study. The most important reason for this is that, while only vascular injuries in the extremities were included in our study, the other studies had included cases with abdominal and/or thoracic penetrating injury. Patients deceased independent of penetrating injury were also included in Boström's study. Since our

study had a retrospective design, 250 patients were examined, but only 168 patients were included in the study because they attended follow up visits after discharge. The mortality rate of 82 uncooperative patients without follow-up data was therefore unknown.

Edema and compartment syndrome are the most common complications after delayed vascular repair, due to longer ischemic period of the tissue. Raised pressure within the compartments of an injured extremity following reperfusion can cause mechanical injury to muscle and nerve, exacerbating the initial ischemic insult. This can be avoided by prompt application of prophylactic fasciotomy in high-risk limbs⁽¹²⁾.

Flint et al. reported that 27.2% of patients undergoing vascular repair developed compartment syndrome and had fasciotomy⁽¹³⁾. In the study of Tunenir et al., 5.6% of the patients needed fasciotomy⁽¹⁴⁾. Perkins's meta-analysis with 971 patients presented that performing prophylactic fasciotomy did not make a significant difference compared to those who did not, in terms of complications⁽¹⁵⁾. In 2 patients (1.19%) in our study, compartment syndrome and the need for fasciotomy occurred. In the meta-analysis published by Perkins et al., 1384 of 2416 limbs affected were accompanied by nerve injury⁽¹⁵⁾. In our study, 41 of 168 patients had nerve injuries. Although fasciotomy does have risks, it is an important surgical adjunct to improve neuromuscular recovery following vascular injury and reperfusion, supported by research and clinical observation⁽¹⁶⁾. Ligation of the vessels in the treatment of venous injuries especially in the lower extremity increases the risk of secondary amputation 6 times⁽¹⁵⁾. Therefore, in our clinic, all venous injuries in deep venous system were approached and treated either by primary repair or interposition with saphenous vein or prosthetic grafts. To ensure the patency of these vascular structures, appropriate anticoagulant agents were prescribed for the patients, and therapeutic levels INR (2-2.5) were targeted.

Twenty-six studies and 1184 injuries were included in the meta-analysis of Perkins et al. and it was found that the risk of amputation was lower in patients with the saphenous vein grafts compared to the

prosthetic grafts⁽¹⁵⁾. In our study, PTFE grafts were used in 35 (14%) patients, other repairs were performed with primary repair or saphenous vein grafts. The most important reason for not using saphenous vein was that the diameter of the native vein to be repaired was clearly incompatible. The other factor we believe is that the preparing the saphenous vein graft prolongs the process even for a small period of time for the limb that needs urgent perfusion.

In the study of Shackford et al., it was observed that the amputation rate was high especially in the patients older than 55 years and the secondary amputation was needed mostly in women⁽¹⁷⁾. In our study, the male patients were more numerous and patients happened to be in a younger age. In our study, one patient who had a bone injury along with the vascular injury, suffered from soft tissue infection and osteomyelitis, which resulted in below-the-knee amputation. The risk of an amputation caused by secondary reasons may last years, therefore, the secondary amputation rates may seem relatively lower. However, patients were followed-up for only 3 months in our study.

Although, penetrating injuries mostly involved upper limbs in 73% of the cases⁽⁵⁾, in our study lower limb injuries 63% were more common.

Study limitations

The shortcomings of our study are its retrospective design, lack of comparison between vascular repair methods, and relatively shorter follow-up period of 3 months.

CONCLUSION

Immediate arrival of patients with penetrating injuries to the hospitals and consideration of vascular injury in the emergency rooms are significantly important in reducing limb loss and mortality rates. The multidisciplinary management of these patients is as important as the correct diagnosis.

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