Cumhuriyet Tıp Derg 2010; 32: 308-314
Cumhuriyet Med J 2010; 32: 308-314

Original research - Orijinal araştırma

Management of popliteal artery injuries

Popliteal arter yaralanmalarının tedavisi

Halil Başel, Hasan Ekim, Dolunay Odabaşı, Cemalettin Aydın, Ayşenur Dostbil, Ünal Aydın

Department of Cardiovascular Surgery (Assist Prof. H. Başel MD., Assoc. Prof. H. Ekim MD., Assist Prof. D. Odabaşı MD.) Yüzüncü Yil University School of Medicine, TR-65200 Van, Cardiovascular Surgery Clinic **(**C. Aydın MD., Ü. Aydın MD.) Van Yuksek Ihtisas Hospital TR-65170 Van. Department of Anesthesiology and Animation (Assist Prof. A. Dostbil) Atatürk University School of Medicine TR-25240 Erzurum.

Abstract

Aim. Peripheral vascular injuries constitute a major problem in cardiovascular surgery. Popliteal artery injuries account for between 5 and 19% of extremity arterial injuries. Despite improvements in surgical techniques of peripheral vascular injuries, a high amputation risk is still seen. The aim of this study was to review our experience in the management of popliteal artery injuries. **Method.** We studied retrospectively a number of 41 patients with popliteal artery injuries in our department between May 1999 and March 2009. Injuries were related to stab wound in 11 patients, gunshots in 23, and blunt trauma in 7. Primary vascular repair was preferred where possible; if not possible the interposition graft was used. **Result.** The study group consisted of 33 males and 8 females, ranging in age from 18 years to 56 years with a mean age of 28.1±6.4 years. Penetrating trauma was the cause of a high proportion of cases. Arterial repair techniques performed were end-to-end anastomosis in 21 popliteal arterial injuries, saphenous vein graft interposition in 13, lateral arteriorrhaphy in 4, ringed PTFE graft interposition in 2, and patch plasty in 1. There were 19 patients with associated popliteal vein injury, of which 5 cases had end-to-end anastomosis, 7 had lateral venorrhaphy, 6 had vein graft interposition, and 1 had PTFE graft interposition. **Conclusion.** Although prompt arterial repair appears to be a critical factor that improves the extremity salvage rate, even in popliteal arterial injury with complete motor deficit without mottling, vascular repair should be considered regardless of ischemic time.

Key words: Popliteal Artery; injuries

Özet

Amaç. Kardiyovasküler cerrahide periferik vasküler yaralanmalar büyük bir sorun oluşturur. Popliteal arter yaralanmaları ise tüm ekstremite arter yaralanmalarının %5-19'unu oluşturur. Cerrahi tekniklerdeki ilerlemelere rağmen ampütasyon oranı halen yüksektir. Çalışmamızın amacı popliteal arter yaralanmalarıyla ilgili deneyimlerimizi gözden geçirmektir. **Yöntem.** Ana Bilim Dalımızda Mayıs 1999 ile Mart 2009 tarihleri arasında popliteal arter yaralanması nedeniyle opere edilen 41 olgu retrospektif olarak incelenmiştir. Yaralanma nedeni 11 olguda kesici delici alet, 23 olguda ateşli silah ve 7 olguda künt travma idi. Mümkünse primer vasküler onarım tercih edildi. Aksi halde greft interpozisyonu uygulandı. **Bulgular.** Çalışma grubumuzun 33'ü erkek ve 8'i kadın olup, yaşları 18 ile 56 arasında değişmekte ve ortalama yaşta 28,1±6,4 idi. Olguların büyük çoğunluğu penetre travmaya maruz kalmıştı. Arteriyal yaralanması olan 21 olguda uç uca anastomoz, 13 olguda safen ven greftiyle interpozisyon, 4 olguda lateral arteriorafi, 2 olguda ringli PTFE greft ile interpozisyon ve 1 olguda yama plasti uygulandı. Aynı zamanda popliteal ven yaralanması da olan 19 olgunun, 5'inde uç uca anastomoz, 7'sinde lateral venorafi, 6'sında safen ven greft interpozisyonu ve 1'inde PTFE greft interpozisyonu uygulanarak venöz onarım da yapıldı. **Sonuç.** Ektremitenin kurtarılmasında arteriyal onarımın zaman geçirilmeden yapılması önemli bir faktör olmakla birlikte, popliteal arter yaralanmalarında tam motor kayıp olan olgularda bile sabit benekli cilt görünümü yoksa iskemi süresine bakılmaksızın vasküler onarım düşünülmelidir.

Anahtar sözcükler: popliteal arter; yaralanmaları

Geliş tarihi/Received: November 18 2009; **Kabul tarihi/Accepted:** March 26 2010

İletişim adresi:
Dr. Halil Başel Yüzüncü Yıl Üniversitesi Tıp Fakültesi Hastanesi TR-65200 Van E-mail : hbasel@mynet.com

Introduction

Popliteal artery injuries constitute 5-19% of all extremity artery injuries in civilian life. However popliteal artery injuries have the highest rates of amputations amongst all lower extremity vascular injuries. Despite technical advancements, rate of amputation still remains at higher levels [1]. During World War 2 amputations were required for 73% of the cases in whom the popliteal artery was ligated. Rate of amputation decreased to 32.4% during Korean War with the application of vascular repair. This rate was in the range of 32-45% during Vietnam War. The rate was reduced to lower than 5% today thanks to the positive improvements such as experience gained from wars, earlier surgical interventions, usage of wide spectrum antibiotics and vascular grafts [2].

Material and Method

Forty-one patients operated at our Department between May 1999 and March 2009 due to popliteal artery injury were evaluated retrospectively.
All except 6 cases had been operated in the first 6 hours. Five later presented cases were operated after 10-12 hours and 1 case was operated 3 days later. Injuries were due to blunt traumas (traffic accident) in 7 cases and were due to penetrating traumas in 34 cases. Penetrating traumas were by gun-fire in 23 cases and by stab wound in 11 cases. Lower extremities were examined in detail in addition to the systemic physical examination and pulse examinations were done by palpation. Capillary filling, temperature, motor and sensory functions were evaluated.
Physical findings were classified as mild or severe. Findings such as cold and ischemic extremity, absence or mildness of pulses, murmur or thrill, widening pulsatile hematoma or pulsatile bleeding were evaluated as severe arterial injury findings (Table 1). Findings such as non-widening hematoma, paresthesis or paresis and injuries close to neurovascular structures were evaluated as mild findings.

Table 1. Severe physical findings in favor of arterial injury.

Physical findings	Number of cases
Significant pallor of extremity	32
Absence or mildness of peripheral pulses	34
Murmur or thrill	1
Gradually widening pulsatile hematoma	13
Pulsatile bleeding	12

Cases with severe findings suggesting arterial injury and whose hemodynamical balances were deteriorating rapidly underwent surgery immediately after physical examination without performing advanced assessments. Doppler ultrasonography was performed besides physical examination for other cases. Angiography was performed later if necessary.
Faciotomy was performed for cases with prolonged ischemic duration and has the potential of compartment syndrome. Decompression of four compartments was obtained by lateral and medial incisions. One case was operated by posterior approach (Figure 1) and others by medial approach. Bleeding was controlled by clamping proximal and distal ends of injured vessels. Thrombectomy was performed by sending Fogarty catheter to the distal segment and washed with diluted heparin. Primary repair was preferred whenever possible. Otherwise, repair was done by saphenic vein graft from other extremity. Accompanying venous injuries were also repaired. Cases with severe abdomen, thorax or

head trauma and cases in whom primary amputation was required had not been included into the study. Nerve injuries were determined during physical examination or operation. Vascular repair was performed after bone fixation for 3 cases without severe acute ischemia and who were initially operated by orthopedic surgeons and vascular injury was detected during orthopedic surgery. For other cases vascular repairs were performed initially.

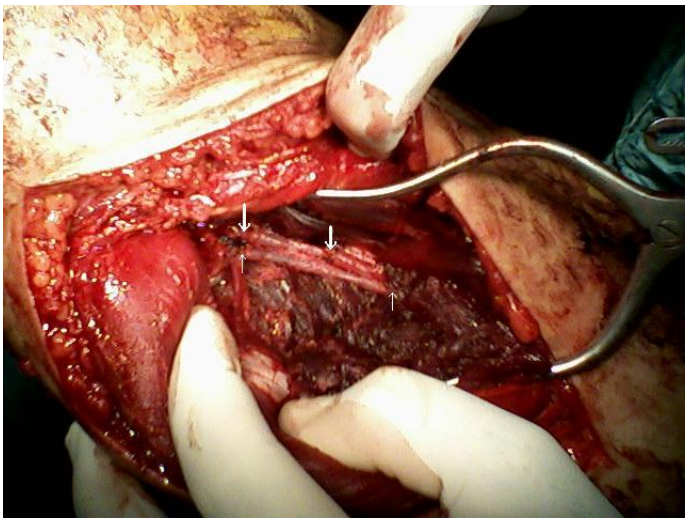

Figure 1. Repair of arterial and venous injury at popliteal region due to gun-fire wound by saphenic vein interposition graft. Between thick arrows arterial and between thin arrows venous interposition grafts were shown.

Results

Males were 33 of the cases and females were 8; age range was between 18 and 56 and mean age was 28.1 ± 6.4. Thirty four cases underwent surgery immediately, in 5 cases duplex sonography and in 2 cases both duplex sonography and angiographic evaluation were performed. There was accompanying popliteal vein injury in 19 of the cases. Bone fractures observed in 8 cases (6 cases distal femur fracture, 2 cases tibia fracture), nerve injury in 2 cases and diffuse soft tissue damage in 4 cases.

Popliteal arteries were repaired by end-to-end anastomosis in 21 cases, by interposition with saphenic vein in 13 cases, by lateral arterioraphy in 4 cases, by ring PTFE graft in 2 cases and by patch plasty technique in 1 case. In 2 cases in whom saphenic vein interposition was done, injury was at the branching site where the popliteal artery ends. For these cases saphenic vein graft was interposed between popliteal artery and posterior tibial artery and anterior tibial artery was ligatured.

In cases with accompanying popliteal vein injury, end-to-end anastomose, lateral venoraphy, saphenic vein graft interposition and PTFE graft interposition were applied respectively in 5, 7, 6, and 1 cases. External fixation was done for 8 cases with accompanying bone fractures. Primary nerve repair was not done for any cases. Faciotomy was performed in 8 cases.

Postoperative thrombectomy was performed in 3 cases because the grafts were thrombosed. Two of these cases were presented at late stage (after 10-12 hours) and there also were diffuse soft tissue damage, bone fracture and neurological impairment. These two cases did not recover and above knee amputation was done. Pulses were palpable after thrombectomy in other case; although temporary renal impairment developed due to reperfusion syndrome, he recovered without systemic sequel.

Discussion

Bleeding may stop at complete arterial cuts due to narrowing of upper end by arterial smooth muscle contraction and thrombosis. In contrast, because there is not a circular contraction for lateral cuts, bleeding continues and these cause more bleeding [3].

Amputation incidence is at highest levels for knee fractures or fractures close to the knee. Causes for this issue are: a) Popliteal artery is at close approximate to the bone and muscular protection is weak; b) End arterial state; c) Lack of adequate collateral web at knee region; d) Presence of rigid muscle compartments below the knee [4]. Following bone and soft tissue trauma limited collateral circulation at knee region spoils and if early revascularization cannot be provided aliveness of distal becomes imperiled [3].

Although repair of accompanying venous injuries are controversial, repair of popliteal venous injury is reported as essential if present in order to avoid loss of extremity due to massive venous occlusion [5]. If the popliteal vein is not suitable for primary repair, it should be repaired by venous graft [6]. Venous graft should be maintained as patent in particularly for the first 72 hours. Venous circulation may be provided by collaterals even if it is occluded after this period. Venous repair is required especially for diffuse soft tissue defects that may prevent the development of venous collateral circulation [7]. Restoration of venous circulation in order to enhance the patency of arterial anastomoses and to reduce the risk of late venous stasis may be more important at popliteal region than any other site [6]. In contrast, there are also reports indicating that venous ligation does not have an important sequel and venous ligation is tolerated well even at the popliteal region and does not have a negative impact on arterial circulation [2, 8].

It is a controversial issue that which one should be repaired first for cases that have both popliteal artery and popliteal vein injuries. Some indicated that first venous and then arterial repair should be done and thus venous circulation should be improved after arterial revascularization [9]. However some authors reported that arterial repair should be done first in order to reduce the duration of ischemia [10]. If this is the case prolongation of ischemia may be avoided by using intraluminal shunt both for artery and vein [11]. For our series, first arterial repair was done and thus ischemia duration was kept as short as possible. Shunt was not used because we thought venous circulation was provided partly by collaterals until venous repair was done. Additionally, usage of shunts was reported to lead vascular complications such as dissection or thrombosis [12].

Now it is accepted to do vascular repair first for cases with accompanying bone fractures. However in rare cases it is reported that bone fixation may be done first if necessary by using shunt [1]. Stabilization of the bone may be done beforehand when mobility of bone is excessive, duration of ischemia is short and hemodynamic balance is preserved [13].

Systemic anticoagulation with heparin may prevent development of thrombosis at small distal vessels and provides significant benefit for saving the extremity [14]. Thus, the success likelihood of the revascularization increases. However use of heparin may be contraindicated because of head injury, pelvic or intra-abdominal bleeding [1]. We apply diluted heparin in isotonic serum physiologic by punctured Fogarty catheter to the distal for these cases. Application of diluted heparin to the vascular bed instead of systemic heparin was shown to be also effective [15]. Fogarty catheter is effective for removing thrombus from large vessels. However this is not the case at microvascular level. Systemic heparinization should be initiated as early as possible in order to prevent the spread of thrombosis through microvascular level [16]. Also heparin has beneficial effect against reperfusion injury [3].

Theoretically thrombolytic agents resolve thrombus formed in small vessels and probably improves the microcirculation [17]. While thrombolytic treatment is of benefit for acute ischemia, its use for vascular trauma is controversial. Thrombolytic treatment was not applied to any case at our series.

Post-traumatic edema and ischemia accompanying to the trauma also decrease the oxygen delivery to the tissues. When tissue oxygen tension is below 30 mmHg, response to the

infection and ischemia deteriorates. Hyperbaric oxygen treatment may have a role for functional recovery by increasing tissue oxygen tension but this is controversial [1].

Occasionally for some popliteal artery injuries it is reported that operation was not necessary. In presence of minimal arterial wall disruption (intimal defect smaller than 5 mm), if distal circulation is intact and if there is no active bleeding; recovery rate without operation was reported to be 87% [18]. However this condition necessitates frequent angiographic control.

Angiography is controversial for trauma cases. Because angiography leads 1-2 hours delay, it should only be performed when distal perfusion is adequate [14]. Because a delay may threaten the extremity and even life, operation must be performed without angiography as is the case in our series. Duplex scanning may be an alternative of angiography and may provide information as close as the angiography. Doppler angiography is considered as an alternative for angiography in particularly for penetrated vascular injuries. Although it has some advantages such as being less invasive and giving same adequate information as angiography, it has suspicious accuracy because of skeleton changes, swellings and hematomas accompanying trauma. However, even distal pulses are palpable and tissue perfusion is adequate, Doppler ultrasonography which has 98% reliability may be performed [13]. If ultrasonography does not give any results, angiography may be necessary. Additionally, angiography is essential if endovascular intervention is being considered.

Recently stent grafts are used for vascular injuries. Integrity of injured artery is obtained by coated or un-coated stent-grafts. Shortest stent graft should be preferred in order to avoid the risk of bending and blockage of auxiliary branches in lower extremities [18]. We think stent grafts are not so much suitable for popliteal region.

Primary repairs such as end-to-end repair or lateral arterioraphy should be preferred if it is possible to perform them without causing tension at anastomose line. However, defects larger than 2 cm are not suitable for primary repair as they do not allow a relaxed anastomose without doing a diffuse mobilization and without cutting genicular collaterals [19]. In contrast to venous repairs, for arterial repairs anastomose should be avoided if it causes tension; else it may cause endothelial damage and stress at the anastomose line due to higher blood pressure in arteries than veins [13]. However we prefer end-to-end anastomose if a relaxed anastomose is possible because they are the primary repair cases that have the lowest amputation rates. If a complex repair is needed saphenic vein should be preferred instead of synthetic grafts. Thrombosis and graft insufficiency are seen more frequently when synthetic grafts were used due to the slower flow rate [14]. Prosthetic grafts should be avoided in popliteal artery injuries if possible [20]

Because flow rate of a 4 mm PTFE graft would be insufficient at popliteal level it causes thrombosis [16]. So 6 and 8 mm grafts were used in our series. If utility of synthetic grafts are essential for regions with low pressure and low capacity flow form and at the mobile regions of extremity such as femoropopliteal regions it is reported that PTFE grafts should be preferred. Late stage stenosis rates of the PTFE grafts are significantly lower [21]. Expanded PTFE grafts are shown to be more resistant against infections than other prosthetic grafts [3]. If we do not have any alternative than using synthetic graft we think that ring PTFE grafts should be used.

Critical factor for saving the extremity is duration of ischemia. Major principal for the acute traumatic lower extremity arterial injuries is doing what is required without losing time. By this way, it is possible to avoid both irreversible ischemia and morbidity related to ischemia reperfusion damage [12]. Ischemia duration longer than 8 hours is associated with an amputation rate as high as 89% [19]. After reperfusion of an ischemic extremity, cellular swelling at relatively rigid anatomic compartments of lower extremity may cause progressive microvascular thrombosis and muscular necrosis. In this case a faciotomy to relax each of the four compartments should be done [16].

Amputation rate is 8 times higher for popliteal artery injuries than any other vascular injuries despite the application of all modern vascular techniques [22]. Rate of amputation is inevitably high for popliteal artery injuries with abundant soft tissue and nerve damage

and stayed ischemic for a prolonged time. However, although ischemia duration more than 6 hours is a well-known cause of cell death, because tolerance duration to ischemia depends on the personal factors and degree of collateral flow [12] revascularization should be done for popliteal artery injuries in absence of fixed spotting even when complete paralysis is present. The most important is the liveliness of gastrocnemius muscle not sensorial functions [23].

Anticoagulation should be initiated immediately because anticoagulation is of benefit before development of thrombosis at distal arterial bed where Fogarty catheter cannot reach and because heparin has the potential of positive impact on reperfusion damage. Additionally, vascular repair should be considered whatever the duration of ischemia is for popliteal artery injuries even in cases with total motor loss providing that there is not spotty skin appearance which points out irreversible ischemia. Primary repair should be preferred if possible. Saphenic vein should be preferred if graft is required. However, if appropriate autogenous venous graft is not available, ring ePTFE graft should be used. Because popliteal vein ligation increases amputation rate, accompanying popliteal vein injuries should be repaired as it is the case at our series. Faciotomy should be done if there is suspicion of compartment syndrome.

Referances

1. Yahya MM, mwipatayi BP, Abbas M, Rao S, Sieunarine K. Popliteal artery injury: Royal perth experince and literature review. ANZ J Surg 2005; 75: 882-6.
2. Sucu N, Aytaçoğlu BN, Mavioğlu İ, Gül A, Karaca K, Dikmengil M. Peripheral arterial injuries. T Klin J Cardiovascular Surgery 2003; 4: 68-72.
3. Ünlü Y, Ceviz M. (Treatment of the peripheral vascular injuries). Türkiye Klinkleri J Surg Med Sci 2007; 3: 22-36.
4. Andrikopoulos V, Antoniou I, Panoussis P. Arterial injuries associated with lower extremity fractures. Cardiovasc Surg 1995; 3: 15-8.
5. Reyes DC. Popliteal artery injuries. Vascular and Endovascular Surgery 1983;17: 189-94.
6. Rich NM, Hobson RW II, Collins GJ, Andersen CA. The effect of acute popliteal venous interruption. Ann Surg 1976; 183: 365-8.
7. Çakır Ö, Eren N, Eren Ş, Balcı AE. (Popliteal arterial injuries). T Klin J Cardiovascular Surgery. 2002; 3: 155-61.
8. Yelon JA, Scalea TM. Venous injuries of the lower extremities and pelvis: repair versus ligation. J Trauma. 1992; 33: 532-6; discussion 536-8.
9. Lim LT, Michuda MS, Flanigan DP, Pankovich A. Popliteal artery trauma: 31 consecutive cases without amputation. Arch Surg 1980; 115: 1307-13.
10. Khalil IM, Livingston DH. Intravascular shunts in complex lower limb trauma. J Vasc Surg. 1986 ;4: 582-7.
11. Barros D'Sa AA, Moorehead RJ. Combined arterial and venous intraluminal shunting in major trauma of the lower limb. Eur J Vasc Surg. 1989; 3: 577-81.
12. Huynh TT, Pham M, Griffin LW, Villa MA, Przybyla JA, Torres RH, Keyhani K, Safi HJ, Moore FA. Management of distal femoral and popliteal arterial injuries: an update. Am J Surg 2006; 192: 773-8.
13. Andaç H. (Vascular injuries). T Klin J Surg Med Sci 2006; 2: 27-31.
14. Gupta R, Quinn P, Rao S, Sleunarine K. Popliteal artery trauma: a critical appraisal of an uncommon injury. Injury 2001; 32: 357-61.
15. Hafez HM, Woolgar J, Robbs JV. Lower extremity arterial injury: results of 550 cases and review of risk factors associated with limb loss. J Vasc Surg 2001; 33: 1212-9.
16. Melton SM, Croce MA, Patton JH Jr, Pritchard FE, Minard G, Kudsk KA, Fabian TC. Popliteal artery trauma. Systemic anticoagulation and intraoperative thrombolysis improves limb salvage. Ann Surg. 1997;225:518-27; discussion 527-9.
17. Wagner WH, Calkins ER, Weaver FA, Goodwin JA, Myles RA, Yellin AE. Blunt popliteal artery trauma: one hundred consecutive injuries. J Vasc Surg 1988; 7: 736-43.
18. Bechara C, Huynh TT, Lin PH. Management of lower extremity arterial injuries. J Cardiovasc Surg (Torino). 2007; 48: 567-79.
19. Özçelik C, İnci İ, Kir A, Toprak M,Kandemir N,Eren N,G. Özgen. Traumatic popliteal and trifurcation arterial injuries: how can we predict the ultimate outcome. Vasc Surg 1994; 28: 401-6.

20. Nair R, Abdool-Carrim AT, Robbs JV. Gunshot injuries of the popliteal artery. Br J Surg 2000; 87: 602-7.
21. Erdoğan A, Eser İ, Türk T, Gürses U, Demircan A. The types of prosthetic vascular grafts and their long-term outcome. Turkish J Thorac Cardiovasc Surg 2003; 11: 37-41.
22. Guerrero A, Gibson K, Kralovich KA, Pipinos I, Agnostopolous P, Carter Y, Bulger E, Meissner M, Karmy-Jones R. Limb loss following lower extremity arterial trauma: what can be done proactively. Injury 2002; 33: 765-9.
23. Moini M, Takyar MA, Rasouli MR. Revascularisation later than 24h after popliteal artery trauma: is it worthwhile? Injury 2007; 38: 1098-101.