Amputation-free treatment of vascular trauma patients

Ampütasyon yapılmadan tedavi edilen vasküler yaralanmalı hastalar

İlker Mataracı,[1] Adil Polat,[2] Murat Songur,[1] Burak Kıran,[1] Deniz Çevirme,[1] Hasan Sunar,[1] Kaan Kırali,[1] Cevat Yakut[1]

[1]Department of Cardiovascular Surgery, Kartal Koşuyolu Heart and Research Hospital, İstanbul
[2]Department of Cardiovascular Surgery, Elazığ Military Hospital, Elazığ

Background: In this study we have retrospectively evaluated the patients who were surgically treated due to vascular trauma, and the results of the operations.

Methods: One hundred and sixty-five patients (140 males 25 females; mean age 30.1±11.5 years; range 12 to 73 years) who were operated on in our clinic due to vascular injuries between June 2005 and September 2008 were included in the study. Of the injuries causing vascular traumas, 96 were in the lower extremity, 61 in the upper extremity and eight in the abdomen.

Results: The most frequent cause of injury was penetrating injury (n=110) and 55 patients had gunshot wounds. One hundred and forty-five patients had arterial injury. One hundred and eight patients had isolated arterial injury and 20 had isolated venous injury. The most frequently injured arteries were femoral (n=47) and popliteal arteries (n=35). The most frequently injured vein was femoral vein (n=26). The most frequently used repair was primary repair (n=105). Two patients died in the postoperative period, giving a mortality rate of 1.2%. Fasciotomies were necessary postoperatively in seven patients (4.2%). The mean duration of hospitalization was 5.2±5.0 (range 0-30) days.

Conclusion: Early surgical approach, extent and site of the damage and presence of concomitant injuries are the most important factors affecting the morbidity and the mortality in vascular injuries.

Key words: Emergency; surgery; vascular trauma.

Amaç: Bu çalışmada vasküler yaralanma nedeniyle cerrahi onarım işlemi uygulanan olgular ve tedavi sonuçları geriye dönük olarak değerlendirildi.

Çalışma planı: Haziran 2005 - Eylül 2008 tarihleri arasında vasküler yaralanma nedeniyle kliniğimizde cerrahi onarım işlemi uygulanan 165 hasta (140 erkek 25 kadın; ort. yaş 30.1±11.5 yıl; dağılım 12-73 yıl) çalışmaya dahil edildi. Vasküler travmaya yol açan yaralanmaların 96'sı alt ekstremitede, 61'i üst ekstremite ve sekizi ise batında idi.

Bulgular: Yaralanmaların en sık nedeni penetran yaralanmalardı (n=110) ve hastaların 55'i ateşli silahla yaralanmıştı. Hastaların 145'inde arteriyel hasar saptandı. Yüz sekizinde izole arter ve 20'sinde izole ven hasarı tespit edildi. En sık yaralanan arterler femoral (n=47) ve popliteal (n=35) arterler idi. En sık hasar gören ven femoral ven (n=26) idi. En sık tercih edilen cerrahi tedavi primer onarım (n=105) idi. Ameliyat sonrası mortalite oranı iki hastanın kaybıyla %1.2 oldu. Ameliyat sonrası dönemde yedi hastaya (%4.2) fasyotomi açılması gerekti. Ortalama hastane kalış süresi 5.2±5.0 (dağılım 0-30) gün oldu.

Sonuç: Erken cerrahi girişim, yaralanma şekli, yara yeri ve ek lezyon varlığı vasküler yaralanmalarda morbidite ve mortaliteyi etkileyen en önemli parametrelerdir.

Anahtar sözcükler: Acil; cerrahi; vasküler travma.

A trauma patient often necessitates a crucial approach. According to many guidelines, there should be a general surgeon in the emergency team.[1] In those patients who are seriously injured, the diagnosis of vascular trauma may often be overlooked or delayed.[2] Vascular injury must be routinely controlled in the ABC of a trauma approach. Due to the small percentage of the vascular trauma cases among all the trauma admissions,[3] the diagnosis may often be missed by the emergency team.

In this study, we have retrospectively analyzed the vascular trauma patients operated in our clinic between June 2005 and September 2008.

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Correspondence: İlker Mataracı, M.D. Kartal Koşuyolu Yüksek İhtisas Eğitim ve Araştırma Hastanesi Kalp ve Damar Cerrahisi Kliniği, 34846 Cevizli, İstanbul, Turkey. Tel: +90 216 - 459 40 41 e-mail: fafataris@hotmail.com

PATIENTS AND METHODS

Patient data were gathered from our hospital files. All of the continuous data were expressed as mean ± standard deviation.

The patients were either admitted to our hospital with the diagnosis of a vascular trauma or our emergency team was consulted for a trauma case. Systemic approach is the rule and we try not to make a misdiagnosis. During the diagnostic studies, we try to figure out the etiology of the trauma. The penetrating and gunshot wounds may differ in the nature of the damage they cause. Especially in the gunshot wounds, we show extra care to observe any collateral damage near the trauma site.

Our approach to a trauma patient always starts with the ABC (airway, breathing and circulation) as the standard. The vital signs and the consciousness are evaluated in order to detect any probable hypovolemia and shock. All patients are monitorized for continuous electrocardiogram (ECG) and non-invasive blood pressure measurement (unless they are unstable). As the diagnostic work-up continues, the peripheral intravascular lines are placed so that blood sampling is proceeded with for the routine blood tests along with fluid replacement. If there is excessive blood loss or the suspicion of a blood loss, the necessary precautions for blood transfusion are taken. The site of the trauma is important as it dictates the approach and the priorities. An extremity trauma is expected to cause hypovolemia and shock whereas abdominal and thoracic traumas are important for the organ damage they may cause. We avoid tourniquet application in extremity traumas. In the abdominal traumas, if the cause is a gunshot wound, an emergency laparotomy is performed. If the cause of an abdominal trauma is a penetrating injury, we evaluate the patient in order to see if there is any transperitoneal injury. In cases with a high index of suspicion or when the patient cannot be stabilized, then these patients may be taken to the operation theatre immediately. In extremity traumas, if there is an actively bleeding damage, an emergency operation is undertaken. Patients are evaluated for a probable vascular injury by the physical examination. We perform an angiography when the signs and symptoms point to a vascular injury diagnosis or if the patient is admitted to our hospital delayed or with complications after the trauma. If there is no active bleeding, but the trauma is in the vicinity of a major artery, an emergency arteriography is performed to rule out any vascular injury. We do not routinely perform arteriographies especially in traumas distant to the arterial locations.

Two hundred and twelve patients were admitted to our hospital with vascular trauma suspicion and 165 of them (140 males 25 females; mean age 30.1±11.5 years; range 12 to 73 years) were operated after vascular injuries were diagnosed. Forty-seven patients were not operated. Of these 47 patients, 25 had an arteriography and any vascular trauma suspicion was ruled out. The patients who were discharged had no vascular trauma signs whereas 25 of them were discharged after they had an angiographic examination. In eight patients, the vascular traumas were in the abdomen; in 61, in the upper extremities and in 96 patients, these traumas were in the lower extremities. Three patients who were operated for pseudoaneurysms were referred to our clinic with a delay after the diagnosis.

During the operations, all patients were heparinized with unfractioned heparin at a dose of 50-100 IU/kg. Heparinization was continued postoperatively with unfractioned heparin until the patients reached full ambulation. After the vessel exposure, a thrombectomy was done if the vessel was transected. In vascular repairs, we preferred a primary repair with prolene sutures. In case a graft was necessary, we preferred autogenous grafts from the contralateral extremity. Synthetic grafts were preferred in case a diameter incompatibility was present. In order to use an autogenous graft in a patient needing a femoral arterial repair, we divided the saphenous vein, wrapped it around a bougie and reconstructed a compatible sized graft with the native femoral artery.

RESULTS

The most frequent causes of vascular injuries were penetrating trauma in 110 patients and gunshot wounds in 55 (Table 1). Among these 165 patients, 145 had arterial injuries (Table 2). One hundred and eight patients had isolated arterial injuries and 20 had isolated venous ones (Table 3). The most frequently injured arteries were the femoral artery (n=47) and the popliteal artery (n=35). Among the venous injuries, the femoral vein was the most frequently injured vein (n=26). Along with the arterial damage, some of the patients also had concomitant vein, tendon, nerve and bone injuries, with the veins being the most frequently concomitantly injured structures (Table 4). Tendon injuries were only seen in the upper extremity arterial injuries and these were the least frequently injured structures along with the arteries (n=4).

In all the arterial and venous repairs, the primary repair was the one we used most frequently (n=105). In Table 5, we present a summary of the arterial repair operations. The most frequently performed repair was the primary repair (n=86). Synthetic grafts were most frequently used in iliac artery repairs (40%), whereas saphenous vein grafts (SVG) were most commonly used in popliteal artery repairs (51.4%). Patchplasty with an

Table 1. Etiology of injury

Trauma	n	%
Stabbing wound	110	66.7
Gunshot injury	55	33.3

autogenous graft was used in a single patient with femoral arterial injury.

In venous injury repairs, primary repairs were the most commonly used technique except for the popliteal, iliac, radial and ulnar veins. In isolated venous injuries, all vessels were primarily repaired. In popliteal vein repairs, SVG interposition was the leading method (61.5%). Ligation has been used only in radial and ulnar venous repairs and synthetic graft interposition in a single patient with an iliac vein injury (Table 6).

In the postoperative course, two patients died due to their severe injuries, resulting in a mortality rate of 1.2%. One of these patients was referred to our clinic with a considerable delay and with complications. He had a gunshot wound and his iliac artery was injured. In another clinic, endovascular repair with stenting had been performed before he was referred to our clinic with bleeding. We performed a synthetic graft interposition. Postoperatively, he developed sepsis and died due to multiorgan failure. The other mortal case was also referred to us with a considerable delay and cardiopulmonary resuscitation had to be performed prior to the surgery to repair his femoral artery. Postoperatively, he did not wake up from anesthesia and died due to ischemic encephalopathy. The postoperative mortality and morbidity has been outlined in Table 7.

Apart from the cases outlined above, among the 47 patients who were discharged, three returned with pseudoaneurysms at their lesion sites. One had a penetrating trauma on his forearm and was readmitted to our hospital with an ulnar artery pseudoaneurysm. Another one with a penetrating trauma below his knee was also readmitted with a popliteal artery aneurysm. The third patient had an abdominal injury and was evaluated in another clinic and had a consultation after a Doppler study that showed no sign of vascular trauma at that time. This patient also presented with abdominal pain and was seen to have an iliac pseudoaneurysm. All three were operated and primary repairs of the damaged arteries were accomplished. No arteriovenous fistula in any of the cases was detected.

Table 3. Isolated venous injuries

Injured vein	n	%
Femoral	10	50
Brachial	3	15
Popliteal	2	10
Jugular	2	10
Inferior vena cava	1	5
Axillary	1	5
Iliac	1	5
Total	20	100

Table 2. Injured arteries

Injured artery	n	Isolated	Total (%)	Isolated (%)
Femoral	47	30	32.4	63.8
Popliteal	35	22	24.1	62.9
Radial	17	17	11.7	100
Brachial	16	13	11.0	81.3
Ulnar	12	12	8.3	100
Axillary	6	6	4.1	100
Iliac	5	3	3.4	60
Carotid	4	2	2.8	50
Anterior tibialis	1	1	0.7	100
Dorsalis pedis	1	1	0.7	100
Abdominal aorta	1	1	0.7	100
Total	145	108	100	–

Total %: Percent of that artery's injuries to total number of injured arteries; Isolated %: Percent of isolated injury of that vessel to the total number of those vessel injuries.

No amputations were needed and no patient had a limb loss postoperatively. Fasciotomies have been necessary postoperatively in seven patients (4.2%) with lower extremity injuries. One patient with a femoral artery injury had a severe scrotal damage and was referred to the urology department for repair. Of the nine patients with concomitant neural injuries, three had severe sequela and had to be transferred to the concerning departments. One of them had a carotid artery injury. After the operation, he was tetraplegic and was referred to a neurosurgery clinic for his cervical injury. One had an axillary gunshot injury and he presented with a motor loss of the arm due to the brachial plexus injury. The other patient had a popliteal gunshot injury and after the operation he was referred to an orthopedic surgery department for his dropped foot. Wound infections were seen in 11 patients (6.7%). The mean duration of hospitalization was 5.2±5.0 (0-30) days.

Table 4. Concomitantly injured structures

Injured artery	Vein	Tendon	Bone	Nerve
Femoral	16	–	2	1
Popliteal	13	–	3	1
Iliac	2	–	–	–
Abdominal aorta	–	–	–	–
Axillary	1	–	–	3
Carotid	2	–	–	1
Brachial	3	2	2	3
Radial	6	2	3	–
Ulnar	2	–	–	–
Total	45	4	10	9

Table 5. Arterial repairs

Artery	Primary repair		Synthetic graft interposition		SVG patch		SVG interposition	
	n	%	n	%	n	%	n	%
Femoral	23	48.9	10	21.3	1	2.1	13	27.7
Popliteal	9	25.7	8	22.9	–	–	18	51.4
Radial	17	100	–	–	–	–	–	–
Brachial	10	62.5	–	–	6	37.5	–	–
Ulnar	12	100	–	–	–	–	–	–
Axillary	5	83.3	1	16.7	–	–	–	–
Iliac	3	60	2	40	–	–	–	–
Carotid	4	100	–	–	–	–	–	–
Abdominal aorta	1	100	–	–	–	–	–	–
Dorsalis pedis	1	100	–	–	–	–	–	–
Tibialis anterior	1	100	–	–	–	–	–	–
Total	86	21	1	37	–	–	–	–

SVG: Saphenous vein graft.

DISCUSSION

In a trauma patient, evaluating vascular trauma is easy if a complete transection has occurred. Bleeding, an enlarging hematoma or the ischemia of the limb may all guide the physician to an appropriate diagnosis. Problematic cases are the patients with a laceration, dissection or contusion, which are not only potentially hazardous but may also result in serious complications.[2] Penetrating and shotgun wounds have different mechanisms of injury along with their direct effects on the vessels. High velocity injuries with firearms lead to concomitant injuries on the neighboring structures both with their high energy traumatic and concussive effects.[2]

In a vascular trauma patient, the initial approach should include fundamentals like the stabilization of the airway, reconstitution of breathing and the support of circulation. After the initial evaluation results, vascular trauma can be evaluated more accurately, considering a patient with shock, absence of distal pulses and circulatory abnormalities cannot be addressed properly. While some authors advocate that the presence of some physical findings are enough for the diagnosis,[4] Küçükarslan et al.[5] warn us about the misdiagnosis of arterial injuries in their large series: they have examined 275 shotgun injuries they operated on and report that 27% of all arterial injuries were missed and 33% of all venous injuries they repaired were disregarded until the time they performed the operations. Johnson et al.[6] found 38% sensitivity and 90% specificity with the physical examination and the positive and negative predictive values were 85% and 51%, respectively. Even an aortic transection has been reported to be missed after a blunt trauma and has been presented three years after the accident.[7] Therefore, angiography remains the gold standard of diagnosis, but the accuracy obtained with multislice computed tomography may lead to its more common use in the near future.[8,9] The delay in diagnosis leads to an increased incidence of neurologic and infectious complications and reoperations.[5] Quick assessment and accurate imaging modalities help physicians in diagnosing these patients. Aduful and Hodasi[10] report a 7.7% amputation rate from Ghana, which they think is due to inabilities in imaging modalities. Although the use of Doppler examination with its noninvasive nature seems to be useful, misleading arterial signals have been reported in the literature.[2] Still, with its noninvasive, rapid and

Table 6. Repair of the concomitantly injured veins

Injured vein	Primary repair		Saphenous vein graft interposition		End to end anastomosis		Synthetic graft interposition		Ligation	
	n	%	n	%	n	%	n	%	n	%
Femoral	10	62.5	2	12.5	4	25	–	–	–	–
Popliteal	2	15.4	8	61.5	3	23.1	–	–	–	–
Radial/ulnar	–	–	–	–	–	–	–	–	9	100
Brachial	3	100	–	–	–	–	–	–	–	–
Iliac	1	50	–	–	–	–	1	50	–	–
Jugular	2	100	–	–	–	–	–	–	–	–
Axillary	1	100	–	–	–	–	–	–	–	–
Total	19		10		7		1		9	

Table 7. Morbidity

Morbidity	No	%
Infection	11	6,7
Fasciotomy	7	4,2
Pseudoaneurysm*	3	1,4
Neurologic sequela	3	1,8
Urologic complication	1	0,6
Death	2	1,2

*: Percent of pseudoaneurysm has been calculated over the total number (212) of patients admitted.

accurate nature in diagnosis; Doppler ultrasonography is widely used by clinicians.[11] In our trauma patients, we used angiography in all the stable patients when in doubt. The clinical picture sometimes mandates the surgeon to hurry, especially when the patient's hemodynamic status is compromised. Some have argued the use of angiography in a trauma setting.[12] The false positive results and the option to follow-up and see the patient's status may make angiography unnecessary, which is an expensive and unavailable test for many centers anyway. However, although these objections may be of interest, angiography is still the gold standard of the diagnosis.[13]

The most frequently injured vessel was the femoral artery in our patients, which is the case reported by some others as well. Özkökeli et al.[4] from İstanbul also gave similar results with some minor changes in the order. Contrary to our report, they most frequently used SVG interposition for the repairs. In the repair of the damaged vessels, the control of bleeding, a good access to the traumatized site, diagnosis and debridement of the contused tissue are important. Primary repair, patchplasty and graft interposition are the options for vascular repair. Synthetic grafts should rather be avoided as much as possible in order to decrease the incidence of postoperative infections. We have tried to avoid synthetic graft use, but in patients with large vessel injuries, the surgeon may be obligated to use these grafts in order not to avoid an iatrogenic stenosis.

Venous repair may cause debate among surgeons. Venous injuries have been disregarded mostly and they are still not much of a concern.[5] After the Vietnam War, the importance of venous repair in limb salvage has been emphasized.[14] Venous repairs increase the success of arterial repairs and reduce the need for a fasciotomy. An important factor in missing these venous injuries is the masking of the venous trauma by the arterial injury. Swelling in the injured limb may also be seen after the reconstruction procedure, but seems to vanish in time. Nitecki et al.[14] report that the peak systolic velocity in the repaired vein should be less than 120 cm/sec and the ratio of the velocity proximal to the distal to the repaired venous site should be less than 1.5 for a favorable postoperative course. Some others may argue that limb edema develops postoperatively no matter what technique of repair is chosen.[15] Graft interposition has shown postoperative thrombosis in 30-70% of the patients in different series.[14] We used graft repair in 11 vein damage repairs and encountered no thrombosis postoperatively.

Mortality is rarely encountered in extremity traumas. As you see in our report, the two mortal cases have occurred due to the delay in the referral to the appropriate management. The main problem has been the amputation rate until after the Korean and Vietnam Wars. Amputation rates up to 80% have been reported in the First World War; this decreased to 36% after the Second World War and to 13% after the Korean War.[16] Nowadays, we accept an amputation rate up to 1.5% within the normal ranges. Considering this result, the mainstays of the approach to a trauma patient are important. Fasciotomy should be considered in patients with more than two hours of ischemia, who had venous repairs or patients with extensive soft tissue damage.[12] Since the duration from trauma to the intervention may be important, temporary intraluminal shunts have been recommended in order to decrease the ischemic time,[13] but in fact the decision for amputation also depends on the extent of damage and the final decision must be made intraoperatively. In the perioperative follow-up of these patients, a fasciotomy may be required in case a compartment syndrome is encountered. Some authors recommend fasciotomy in every popliteal artery injury and in patients with delay in diagnosis and operation.[2] In the postoperative course, continuous re-evaluation may force the physician to apply the fasciotomy, which formerly seemed to be unnecessary. Classically, an increase in the tissue pressure above 30 mmHg is an indication for fasciotomy.[16] Fasciotomies have been reported to be more often necessary in patients who have concomitant fractures.[17] The amputation risk increases in blunt trauma, high velocity and close range shotgun traumas due to the extent of the damage.[2] Özkökeli et al.,[4] report neither amputations nor mortality, which is in conformity with our results. Disregarding the delayed transfer of the patients who demised, we did not have any fatal results either.

Surgeons face dreadful conditions with the increased use of endovascular therapies. The fatal course of the patient with iliac artery trauma who has had an endovascular stent is an example. Çınar et al.,[18] report another failure of endovascular therapy and its correction with surgery. Endovascular embolization is not recommended in traumatic arteriovenous fistula contrary to the treatment of its congenital variant.[19] Despite these contrary cases, successful treatment with endovascular techniques is also reported[20] and some authors even advocate the use of these techniques in military settings.[6]

The lack of patients injured in traffic accidents may be an important criticism to our report. The reason for this is that our center is a tertiary health center and a busy hospital with adequate equipment and staff is in the close neighborhood of our hospital. Patients are initially referred to that center and transferred to our hospital only if necessary. The multitrauma victim of a traffic accident is best evaluated and treated in a center where all the necessary staff is present. Our emergency team joins the other surgeons for these traffic accident victims when we are invited. That is why we did not include these patients operated outside of our clinic to our analysis.

One of the important limitations of this study is the lack of post-discharge follow-up results of our patients. We believe, the nature of these traumas, which are mostly criminal events, and the socioeconomic status of these victims are the most important reasons why these patients are lost to follow-up. In fact, post-discharge evaluation is mandatory to evaluate the long term results of the surgery. Our results may seem to be ordinary trauma series, but the increasing incidence of our vascular trauma patients is an issue. Before our hospital moved to Kartal, this kind of cases were rarely admitted to our clinic. Previously, we had only reported some cases occurring after the cardiac catheterization procedures.[21] This increase seems to be of importance to us, and considering some other series that report almost half the number of cases in more than the double time period,[4] this report becomes even more valuable. This great number of the cases not only shows our increasing experience, but it also sheds light to the increasing violence within the society.

In conclusion, vascular traumas may cause extremity dysfunction, limb loss and death. Early surgical approach, the extent and site of the damage and the presence of concomitant injuries determine the morbidity and mortality of the condition.

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