



Comparison of Conventional Angiographic Findings between Trauma Patients with or without Runoff

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ABSTRACT

Objective: To compare the conventional angiographic findings in extremity trauma patients with or without runoff.

Methods: This was cross-sectional study including all the patients with extremity trauma who underwent conventional angiography during the 2 year period from 2011 to 2013 in Angiography departments of Mashhad University of Medical Sciences. Mechanism of trauma, type of injury and angiographic findings were recorded in a questionnaire for each patient. After completion of treatment and discharge, the treatment type was added. The characteristics as well as clinical findings were compared between those who were diagnosed to have arterial runoff and those who did not.

Results: One hundred and forty eight traumatic patients including 15 female with age range of 11-82 years and 133 men ranging from 25 to 40 years were enrolled. Abnormal angiographic findings were provided in 99 (66.9%) patients including cutoff with distal runoff (n=60, 60.6% of abnormalities), cut off without distal runoff (n=21, 21.2%) and spasm (n=14, 14.1%) and other findings (n=4, 4%). Fifty one cases were treated under open surgery and amputation of traumatic limb was done for 13 patients. Amputation rate was higher in patients with cutoff and without runoff than those with cutoff and runoff (33.3% vs. 6.78%; $p=0.002$).

Conclusion: Causes and types of traumatic arterial injury in our study were different with other reports. It was shown that angiographic findings were less important in prognosis and management of patients. Patients with spasm in angiographic findings had a better prognosis than other patients and mostly did not need any vascular surgery. The presence or absence of a distal runoff in primary angiographic findings can have a predictive value in the final amputation rate.

Keywords: Trauma; Vascular injury; Angiography.

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Introduction

Trauma is considered as a common healthcare issue and is also regarded as the third cause

of mortality in several societies. Most of injuries resulting from trauma is due to a vascular damage. Tissue ischemia is associated with vascular injuries and is regarded as a medical emergency which may

lead to irretrievable ischemia if it continues for 6 hours. So early diagnosis and quick treatment of vascular injuries are of great importance [1]. Arterial injury in an extremity trauma is uncommon [2]; but if untreated, would be associated with severe complications like severe ischemia and even limb loss. In recent decades, improvement in localization and characterization of vascular injuries and using new surgical methods and better cooperation between orthopedic and vascular surgeons lead to a decrease in arterial related limb loss [3,4].

Angiography is gold standard for diagnosis of vascular extremity trauma. Indications of angiography during blunt and penetrating extremity trauma remain a challenging problem [5-8]. Some authors believe that referring patients for angiography can be associated with a significant increase in ischemic time [8], while many others believe that angiography would be necessary for accurate localization and characterization of injuries and would be beneficial in patients' management and treatment planning [9,10]. Limb loss following an extremity arterial injury has been variously ascribed to some factors such as extent of tissue damage, duration of ischemia prior to revascularization, associated venous injuries, site of arterial involvement and/or development of compartment syndrome and etc. [11]. This study was performed to determine angiographic findings in trauma patients with or without runoff in conventional angiography in those who were admitted to our trauma center in north eastern Iran.

Materials and Methods

This was a cross-sectional study being performed from September 2011 to March 2013 in angiography departments of Mashhad University of Medical Sciences, Mashhad, Iran. We included all patients who referred for angiography due to extremities trauma and any suspected arterial injuries. Those with peripheral arterial disease, vasculitis, atherosclerosis, collagen-vascular diseases and inflammatory disorders were excluded from the study. The study protocol was approved by the institutional review board and ethics committee of Mashhad University of Medical Sciences. All the patients provided their informed written consents before inclusion in the study.

All the patients undergone complete history evaluation and physical exam on referral and all the positive points were recorded in a data gathering form. Data including patient demographic characteristics (age, gender), mechanism of injury, indication for angiography, associated possible fracture or dislocation, associated possible nerve injury, and angiography report were entered into a vascular trauma database. After completion of treatment and discharge, treatment type and any possible limb loss were added. Distal runoff was recorded in conventional angiography and all the patients were categorized based on the distal arterial runoff. All angiography examinations were performed with

Siemens device (Erlangen, Germany) according to the standard protocols. A Board certified radiologist or an expert resident of radiology performed all angiographic procedures.

Statistical analyses were performed by SPSS software (Version 16, Chicago, Ill, USA). Mean and standard deviation (SD) were determined for continuous variables. Fisher Exact and Pearson Chi-Square tests were used to analyze the categorical variables. A p -value <0.05 was considered statistically significant.

Results

During the study period, 148 patients underwent angiography for any possible arterial injury. Presenting characteristics and mechanism of injury were demonstrated in Table 1. The range of age was 25 to 40 years in the 133 enrolled men and 11-82 years in the remained 15 female patients. The most common mechanism of injury was motor vehicle accident and the majority of trauma types were blunt ones (76.4%).

Table 1. Baseline characteristics of 148 patients with extremity trauma undergoing angiography in our center during the study period.

Variable	Value (n=148)
Age (years)	31±14.9
Sex	
Male (%)	133 (89.9%)
Female (%)	15 (10.1%)
Mechanism of injury	
Motor vehicle accident (%)	127 (85.8%)
Stab wound (%)	11 (7.4%)
Gunshot (%)	5 (3.4%)
Fall (%)	3 (2%)
Other causes (%)	1 (1.4%)

Ninety one (66.9%) patients had obvious arterial injury of extremities in angiographic study. There was no evidence of arterial injury in 49 (33.1%) patients. Angiographic findings of patients were shown in Table 2. Among 73 patients with lower extremity arterial injury, the most common site of injury was main branches of calf (37 patients with one arterial injury, 13 patients with two arterial injury and 3 patients with three arterial injury) followed by popliteal arterial injury (11 patients) and superficial femoral arterial injury (9 patients).

Table 2. Angiographic findings of patients with abnormal angiography result.

Angiography findings	Frequency (n=148)
Cutoff with distal runoff	60 (60.6%)
Cutoff without runoff	21 (21.2%)
Arterial spasm	14 (14.1%)
Active bleeding	2 (2%)
Pseudoaneurysm	1 (1%)
Arteriovenous fistula	1 (1%)

The most frequently damaged vessels in upper

extremities were the brachial and axillary arteries [12], followed by the radial [4], ulnar [2] and thyrocervical branch of subclavian (2.1%) arteries.

Associated injuries to peripheral nerves (sensory or motor nerve damage in a similar limb) were present in 35 (23.6%) patients. Bone fractures and dislocations were seen in 126 (85.13%) cases.

Fifty-nine arterial injuries were treated surgically. Forty three patients were treated conservatively and received anticoagulative therapy without surgery or intravascular intervention.

The mechanism of definitive arterial repair was available for 31 patients. Of these patients, 23 underwent arterial repair using reversed saphenous vein graft. The remaining 8 patients underwent direct repair and/or thrombectomy. Ligation of artery was done in 7 patients. In 2 patients, an endovascular intervention was indicated. Overall mortality was 3 and limb loss was noticed in 13 cases (Table 3). Totally, 12.32% of lower extremity arterial injuries and 15.4% of upper extremity arterial injuries lead to an amputation intervention.

Table 3. Amputation rate in relation to anatomic site of arterial injury.

Arterial injury site	Amputation rate (%)
Superficial femoral (n=9)	3 (33.3%)
Popliteal (n=11)	2 (18.2%)
Crural (n=53)	4 (7.5%)
Brachial & Axillary (n=19)	3 (15.8%)
Radial (n=4)	0 (0%)
Ulnar (n=2)	1 (50%)

According to treatment and management type, patients were divided into 3 groups: Patients with normal angiography report without arterial related therapy (33.1%, 49 patients), patients with mild arterial injury that managed conservatively without surgical or radiological intervention (29.1%, 43 patients) and patients with severe arterial injury who required surgical arterial repair or radiological intervention (37.8%, 59 patients).

The most important factor in patients' treatment was anatomic site of arterial injury. In most cases, arterial injury in calf was treated conservatively (77.35% of calf arterial injury). Conversely, most patients with superficial femoral, popliteal, brachial, ulnar or radial injury were treated surgically. The most treatment option for brachial, popliteal and superficial femoral artery injuries was placement of saphenous vein graft. Elbow ulnar injuries were treated only with thrombectomy and primary repair and radial injuries with ligation. Endovascular intervention was done for treatment of pseudoaneurysm and arteriovenous fistula.

There was a relationship between angiography results and nerve injury ($p=0.001$) and treatment type. Of 43 patients who received conservative therapy, nerve injury was observed in only 4 patients. In contrast, in 59 patients who were treated surgically, 27 subjects had associated nerve injury. Also there was

a relationship between amputation and nerve injury. The presence of runoff in angiography decreased amputation rates and absence of runoff was closely correlated with amputation rate ($p=0.002$). Patients with spasm in angiography had good prognosis and they were almost treated conservatively.

Discussion

One of major causes of limb amputation is vascular injury of the extremities; especially if not treated early and competently. Despite remarkable improvements in diagnostic procedures and treatment planning, the rate of limb loss following vascular injuries is still high for civilian injuries [13,14].

There are multiple risk factors associated with limb loss following vascular injuries of the extremities including injury mechanism, extent of tissue damage, the sequence of the surgical approach, duration of ischemia before revascularization, combined above- and below-knee injuries, associated venous injuries, popliteal artery involvement and development of compartment syndrome, failed revascularization, and anticoagulation. However, there are some controversies about impact of some above risk factors in amputation rates following the extremity trauma [3,11,14-18].

Blunt trauma injuries can be associated with significant morbidity and mortality due to subtle or no clinical findings [8]. In addition, due to possible severe associated injuries, most frequently orthopedic and soft tissue blunt vascular traumas may go undetected. However, the risk of limb loss because of a blunt trauma has decreased because of early diagnosis and improved surgical techniques [10,11,13,14].

Compared with those of isolated arterial injuries, there are higher amputation rates in cases of combined arterial and skeletal trauma because of delayed diagnosis of vascular damage, more extensive soft-tissue destruction, higher incidence of graft failure due to the disruption of collaterals and possible delay in diagnosis and treatment of compartment syndrome. Fractures of the lower limb with vascular disruption are severe and complex injuries requiring prompt diagnosis and management to avoid irreversible soft-tissue ischemia with consequent reperfusion injury which may necessitate amputation. Compound fractures especially combined above- and below-knee injuries were significant independent factors for limb loss due to extensive soft tissue damage [2,19].

In our study, blunt vascular trauma is more common due to high rate of motor vehicle accident and a low rate of gunshot. All patients with limb loss in our study had motor vehicle accident related trauma and associated fractures. None of the patients with gunshot or stab wound injury finally required amputation surgery.

Nerve deficits and soft tissue injuries have been found to be highly correlated with disability and amputation. Some researchers believe that primary cause of long-term morbidity and functional disability

following extremity arterial trauma is associated nerve injuries. In our study, abnormal angiographic findings were more common in patients with associated nerve injuries in contrast to patients without nerve injuries. Also, the rate of surgical procedure was higher in patients with extremity nerve injuries. Seven out of 13 patients with amputation showed associated nerve injuries in same extremity [3,19].

Crucially, the sequence of the surgical approach to the skeletal, vascular and soft-tissue aspects of each injury remains unclear. The order in which these injuries are to be treated remains debatable. Some authors found re-vascularisation as the first step to minimize ischemic time. Others favor skeletal fixation first to protect the subsequent vascular repair from movement and shear [12,20-22].

Although some reports continue to demonstrate a correlation between combined arterial and venous injury and limb loss, others have found no correlation between combined arterial and venous injury and each mentioned the need for fasciotomy and limb loss [2].

Failed revascularization also carries a high risk of limb loss; some studies have shown that it is the most significant independent risk factor. With performing on-table angiography and close postoperative monitoring, the surgeons can easily manage this problem. Once graft occlusion has been detected, this should be re-explored whenever possible and the problem corrected. Also the presence of compartment syndrome on admission was associated with increased risk of limb loss. In contrast, early use of anticoagulation was associated with reduced limb loss [2,23].

Although angiography is the gold standard for diagnosing traumatic arterial injuries of extremities, there are some controversies about its indications. Some authors reported arteriography for localization and characterization of any associated vascular injury. Arteriography may demonstrate arterial lesions which can undergo sequential endovascular treatment such as active hemorrhage, occlusions, arteriovenous fistulae or pseudo-aneurysms. Alternatively accurate localization of these lesions greatly assists surgical planning. In addition, arteriography can distinguish between intimal disruption and spasm through the use of vasodilators. The diagnosis of vascular dissection may only be apparent with conventional angiography. However, investigating vascular integrity can be

time consuming and misleading. Well recognized complications include puncture site complications, contrast nephropathy, allergic reactions and local vessel injury. Exclusion angiography fell out of favor as it was noted that positive studies in the absence of hard signs of arterial injury were rare and injuries that were detected were minor. The published data suggest that preoperative angiography was associated with a significant increase in ischemic time. Angiography can cause delay without demonstrating an appreciable advantage in terms of limb salvage. However some authors did not find any correlation between ischemia time and outcome. The morbidity that accompanied the high false-negative rate of exclusion arteriography led authors to recommend selective angiography for patients with extremity injury but with no hard clinical signs [24-26].

Although the most important factor in treatment planning in our study was anatomic site of arterial injury, there was some diagnostic and predictive value for angiographic findings. The presence or absence of distal runoff in primary angiography has predictive value in final amputation rate. The presence of runoff in angiography decreased following amputation rates and absence of runoff was closely related to limb loss. In another study, arterial trans-section carried a high risk of limb loss due to propagating thrombosis [2]. We showed that patients with spasm in angiography had better prognosis than other abnormal angiographic findings and they mostly did not need any vascular surgery.

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