



Angiographic Findings of Patients with Blunt or Penetrating Extremity Injuries: Focus on Indications and Contraindications

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ABSTRACT

Objective: To determine the etiology, signs and symptoms, angiography indications and angiography findings in patients with limb penetrating injuries suspected to have arterial injury.

Methods: This was a cross-sectional study being performed in Imam Reza Hospital affiliated with Mashhad University of Medical Sciences, Iran between September 2011 and March 2013. We included those patients with extremity blunt and penetrating injuries who were referred for angiography according to standard indications including abnormal distal pulses, complex fracture or dislocation, vascular proximity, fixed hematoma, distal nerve deficit, arterial bruit, thrill and massive soft tissue injuries.

Results: During the study period, 148 patients (15 women and 133 men) with a mean age of 31±14.9 (11-82) years were evaluated. The most common cause of injury was motor vehicle accident (127 patients 85%). Angiography indications included abnormal distal pulse examination (124, 83.8%), complex fracture or dislocation (7, 4.7%), near arterial trauma (4, 2.7%), fixed hematoma (3, 2%), nerve damage (1, 0.7%). The angiography was found to be normal in 49 (33.1%) patients. In patients with abnormal angiography findings, 60 (60.6%) had cutoff with distal runoff, 21 (21.2%) had cutoff without runoff, 14 (14.1%) had arterial spasm. Other uncommon findings included active bleeding in 2 patients (2%), pseudoaneurysm in 1 (0.7%) and arteriovenous fistula in 1 (0.7%). Out of 4 patients (2.7%) with vascular proximity, only 1 (0.7%) had abnormal angiography.

Conclusion: The most important factor in prediction of result of angiography was distal arterial pulses examination. But these data confirm the low incidence of vascular injury in asymptomatic patients with proximity. So the use of angiography when proximity is the sole indication in an asymptomatic patient with a normal vascular examination should be questioned.

Keywords: Vascular proximity; Angiography; Vascular injury; Trauma.

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Introduction

Arterial injury is one of most devastating injuries of extremity trauma. Peripheral injuries account

for 80% of all cases of vascular trauma. Although most patients with vascular injuries have clear signs and symptoms, some others might be relatively

asymptomatic and accurate diagnosis of vascular injuries may be problematic. Prompt diagnosis and treatment of arterial injuries reduce morbidity and mortality especially amputation rates [1,2]. Unlike many countries, due to high rate of motor vehicle accidents, blunt vascular injuries of extremities are common in Iran and many patients are referred for angiography in order to diagnose suspected arterial trauma [3,4]. Despite advances in computed tomography angiography (CTA) and magnetic resonance angiography (MRA), conventional angiography is still considered the gold standard for diagnosis and management of suspected arterial injury [5].

Certain clinical findings in extremity trauma increase the suspicion to arterial injury. Some of them such as severe ischemia and active hemorrhage have very high diagnostic value and immediate surgical exploration and vascular repair are warranted [1,4]. Abnormal distal pulse examination is an absolute indication of angiography [6]. There are some controversies about angiography in some other conditions including proximity of trauma to vascular anatomy and complex fracture or dislocation without abnormal distal pulse examination [7,8]. Some surgeons suggest immediate operation and exploration of the penetrating and blunt extremity wounds with vascular proximity while others suggest angiographic evaluation [9]. Contrary to these two groups some others recommend conservative and watchful treatment without any diagnostic or surgical intervention [10,11]. We performed this prospective study in order to determine the etiology, signs and symptoms, angiography indications and angiography findings in patients with limb penetrating injuries suspected to have arterial injury.

Materials and Methods

Study population

This was a cross-sectional study being performed in Imam Reza Hospital affiliated with Mashhad University of Medical Sciences, Iran between September 2011 and March 2013. The study protocol was approved by the institutional review board and research ethics committee of Mashhad University of Medical Sciences. All the recruited patients provided their informed written consents before inclusion in the study. All patients with extremity blunt or penetrating trauma who were referred for conventional angiography were examined about possible associated vascular injury. We included those patients with extremity blunt and penetrating injuries who were referred for angiography according to standard indications including abnormal distal pulses, complex fracture or dislocation, vascular proximity, fixed hematoma, distal nerve deficit, arterial bruit, thrill and massive soft tissue injuries. Vascular proximity was defined as any wound, laceration or

missile tract within one centimeter of a major vessel being measured by a senior surgical resident or an attending physician.

Study protocol

All the eligible patients underwent a complete history taking and physical examination by a senior surgery resident or an attending physician on admission. All the signs and symptoms related to vascular diseases especially distal pulse examinations as well as all demographic information was recorded into a standard data gathering form. We also recorded etiology, angiography indications and angiography results in separate questionnaire. After completion of treatment and discharge, treatment type was added. All the patients underwent conventional angiography (Siemens, Erlangen, Germany) by a single attending interventional radiologist. The angiographic findings were further recorded and entered into a computer database.

Statistical analysis

Statistical analyses were performed by SPSS version 16 (SPSS Inc., Chicago, Illinois, USA). Descriptive data analysis was performed and the results were presented as mean \pm SD and proportion whereas appropriate.

Results

Overall we included 148 patients with extremity trauma and vascular proximity. The mean age of the patients was 31 ± 14.9 (ranging from 11 to 82) years. There were 133 (89.9%) men and 15 (10.1%) women among the patients. The angiography was performed in one lower limb in 105 patients (70.9%), for both lower limbs in 6 (4.1%), for one upper limb in 35 (23.6%), for both upper limb in 1 (0.7%) and for both upper and lower limbs in 1 (0.7%). The most common cause of extremity trauma was motor vehicle accident (127 patients 85.8%) following: 11 patients (7.4%) with stab wound, 5 patients (3.4%) with gunshot, 3 patients (2%) with falling down and 2 (1.4%) with other causes. Indications for angiography including: abnormal distal pulses examination in 124 patients (83.8%), complex fracture or dislocation with normal distal pulses examination in 7 patients (4.7%), near artery trauma in 4 patients (2.7%), fixed hematoma in 3 patients (2%) and distal nerve deficit in 1 patient (0.7%) (Table 1). Indications for angiography were undetermined in 9 patients (6.1%).

Regarding the angiographic results, 49 patients (33.1%) had normal angiography and arterial injury was found in 99 patients (66.9%): 73 patients with lower extremity arterial injury and 26 patients with upper extremity arterial injury (Table 2). All of the patients with arterial injury in angiography were followed and were further categorized into three

Table 1. Indications for angiography in 148 patients with blunt or penetrating injuries of extremities referred for angiography.

Variable	No. (%)
Abnormal distal pulse	124(83.8%)
Complex fracture or dislocation	7 (4.7%)
Near artery trauma	4 (2.7%)
Fixed hematoma	3 (2.0%)
Nerve damage	1 (0.7%)
Undetermined	9 (6.1%)

subgroups:

1. Patients with normal angiography report without arterial related therapy (49 patients, 33.1%)
2. Patients with mild arterial injury that managed conservatively without surgical or radiological intervention (43 patients, 29.1%).
3. Patients with severe arterial injury who required surgical arterial repair or radiological intervention (59 patients, 37.8%).

In patients with abnormal angiography results, 60 (60.6%) had cutoff with distal runoff, 21 (21.2%) had cutoff without runoff, 14 (14.1%) had arterial spasm. Other uncommon findings included active bleeding in 2 patients (2%), pseudoaneurysm in 1 (0.7%) and arteriovenous fistula in 1 (0.7%). In 124 patients who had abnormal pulses examination, 95 (76.6%) patients had abnormal angiography results and arterial injury. But in other conditions, rates of abnormal angiography were much lower. In those that angiography was performed because of arterial proximity, reports were normal except in 1 patient (0.7%) with pseudoaneurysm in thyrocervical branch of subclavian artery following stab wound injury. In 3 patients (2.1%) with fixed hematoma, angiography was abnormal only in 1 patient (0.7%). All of patients with complex fracture or dislocations and normal distal pulses examination had normal angiography results. In patients who referred for unknown cause, angiographies were normal except in 1 patient (0.7%)

Table 2. The location of injury in 99 patients with abnormal angiography findings following blunt or penetrating extremity injury.

Variable	No.
Superficial femoral artery	9 (9.1%)
Popliteal artery	11 (11.1%)
1 Lower limb artery ^a	37 (37.3%)
2 Lower limb arteries ^a	13 (13.1%)
3 Lower limb arteries ^a	3 (3.1%)
Subclavian artery branches	1 (1.0%)
Brachial & axillary	19 (19.1%)
Ulnar artery	2 (2.1%)
Radial artery	4 (4.1%)

^aLeg Arteries: Posterior Tibial Artery; Anterior Tibial Artery; Peroneal Artery

with blunt trauma and proximal tibial fracture. In this patient anterior tibial artery only had spasm and he was treated conservatively without any complication.

Discussion

This series was aimed to target indications for vascular imaging of patients with vascular injury of the extremities following trauma and validation of indications especially vascular proximity. Similar to previous studies [4,9-11], in our study the largest group of our patients was men ranging in age from 25 to 40 years. Vascular injury of the extremities was a complication following both penetrating and blunt trauma. The incidence of these mechanisms varies widely in different regions according to the rate of trauma [5,12]. In our study, the most common cause of injury was blunt trauma due to motor vehicle accident. In Turkey [13,14], Britain [4], Georgia [11] and United States [15] penetrating trauma due to gunshot and stab wound was reported to be the most common cause of peripheral vascular injury.

There are four hard signs for extremity vascular injury including a pulseless limb, an expanding hematoma, a palpable thrill or audible bruit, or pulsatile hemorrhage. Any of these signs often lead to surgical intervention without need to diagnostic procedure [16]. Soft signs of vascular injury include a non-pulsatile hematoma, history of hemorrhage at seen of accident hematoma, unexplained hypotension and peripheral nerve deficit. A more difficult diagnostic problem occurs in patients who present with these signs. In 3 patients with fixed hematoma in our study, angiography was abnormal only in one patient who had arteriovenous fistula due to stab wound injury in posterior tibialis artery. Indications of angiography in diminished pulse situation especially in the presence of penetrating trauma remain controversial [16]. That evaluation can occur using various diagnostic modalities. In our study, 76.6% of patients with abnormal pulse examination had abnormal angiography results. Although many of these patients (44.21%) were managed non-surgically. Angiography was not useful for this group. Palpation of a pulse is a subjective measure prone to wide interobserver variation.

In our study four patients referred for angiography due to vascular proximity and similar to other studies they had normal angiography except for one patient. There is no consensus about management of extremity trauma with proximity of the wound to vascular structures. The recommendations are not evidence based, and actual practice patterns at individual institutions vary [17]. Some studies believe that proximity related penetrating trauma does not require routine arteriography and can be detected with physical examination and Arterial Pressure index [18]. Some studies rely on physical examination and duplex

ultrasonography results, reserving angiograms only for patients with inconclusive results [19]. Some studies propose that physical examination and observation should be the modality of choice in most instances of penetrating extremity trauma without hard signs. The observation period for non-operative management of proximity wounds studied in the literature is routinely 24 hours [17,20].

Against theory for selective angiography are the occasional reports of missed injuries in patients who present with late squeal [21]. Pseudoaneurysms, arteriovenous fistulas and arterial occlusion are the described late complications of missed arterial injuries. Up to 23% of proximity wounds were found to have occult vascular injuries [22]. There is the potential for continued hemorrhage with limb and life threatening scenarios [18]. Surgical repair was required only in 2% of clinically occult vascular injuries found on arteriography [23]. In our study, one patient had pseudoaneurysm in thyrocervical branch of subclavian artery following stab wound injury. This patient had normal pulse examination and referred for angiography without any hard and soft signs of vascular injury. The physical examination and API are only useful for detecting vascular injury to the 'main' vascular system. Injury to the branches of subclavian artery will not alter distal pulses or cause distal ischemia, may not show active hemorrhage, and is difficult to assess for an expanding hematoma or thrill. Like this, a notable exception to the proximity to major vessels approach occurs in the thigh, specifically where the wound travels medial to the femur, thus traversing the anatomy of the deep femoral artery. Doppler ultrasound, arteriography, or non-operative observation is indicated for these injuries [17,18]. Some researchers recommend delayed vascular evaluation with Doppler ultrasound within 12 months in this situation [18].

For diagnosis of vascular injury in patients with penetrating proximity trauma to the extremities arteriography has been advocated in 80s researches [24]. With the widespread use of arteriography from the 1980s through the 1990s, however the rate of finding abnormal lesions was reportedly low and clinical significance uncertain [25]. Angiography itself has potential risks, morbidities and costs as well as any open surgical repair that might be required. Some surgeons questioned whether the benefits of an aggressive approach were entirely justified. Angiography particularly is useful in blunt trauma due to the high incidence of associated bone, nerve, and soft tissue injuries that could be responsible for clinical hard signs and obscure an accurate diagnosis [26]. Some researchers recommend computed tomographic or conventional angiography in penetrating injuries with soft clinical signs to assist in injury location and

extent and to aid in staged planning for reconstruction [27]. Also when the patient presents with multilevel trauma to an extremity (eg. a shotgun injury or an extremity with 2 fractures), the level of arterial injury may be in question and an arteriogram is indicated. We had 7 patients with complex fracture or dislocations without diminished distal pulses. All of them had normal angiography results. Some orthopedic injury patterns have been associated with a high incidence of arterial damage include knee dislocations, ipsilateral fractures on either side of the knee (floating knee), open or segmental distal femoral shaft fractures and certain displaced tibia plateau fractures [28,29]. The popliteal artery becomes vulnerable to stretch, tear, or intimal damage when the knee becomes displaced by dislocation or widely displaced fracture. Despite major advances in vascular trauma surgery, the evaluation and diagnosis of patients with popliteal artery injury associated with posterior knee dislocation continue to challenge the surgeon [30,31].

Five patients in our study had knee dislocation due to trauma. Among them 2 patients had diminished distal pulses and report of angiographies were abnormal. (Popliteal artery injury finally need to repair) 3 patients of them had normal distal pulses and in these patients the angiography reports were normal. Similar our findings, other studies confirmed the role of physical examination in determining the need for arteriography. Arteriography appears to be unnecessary in complex fracture or dislocations when physical examination is negative [32-35]. Indication for angiography was unknown in 9 patients in our research. Perhaps their pulse examinations were abnormal when they admit and recovered with or without conservative therapy before referred for angiography. Angiography in this group did not have any benefit.

In conclusion, the most important factor in prediction of result of angiography was distal arterial pulses examination. But these data confirm the low incidence of vascular injury in asymptomatic patients with proximity. So the use of angiography when proximity is the sole indication in an asymptomatic patient with a normal vascular examination should be questioned.

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