Non iatrogenic paediatric vascular trauma of the extremities and neck

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ABSTRACT

Aim: Vascular trauma in children is uncommon. Considering the complexity of these injuries, we have tried to determine their demographic data, the different factors changing their outcome, the different modalities of management, and their outcomes. **Patients and Methods:** We reviewed the medical records of 52 pediatric patients of less than 15 years f age for about ten years (1996 to 2006) .The review was followed by physical examination done by two surgeons. Vascular injuries included blunt and penetrating injuries to the neck and extremities. Their management included conservative management, primary closure, end-to-end anastomosis, graft interpositioning, and fasciotomy. **Results:** The patients included 41 males and 11 females and their mean age was 9.7 years (ranging from 3 to 14 years). Males were significantly more (78%) involved. Penetrating upper extremity injuries were the most common cause of vascular injury in the paediatric population (65% on the right side). The most common mechanism was cutting the hand by glass (most of them on the ulnar side). These vascular injuries per se did not cause any disability in the upper extremities. The outcome of these injuries depended more on simultaneous nervous injury and to a lesser extent, on tendon injury. There was no significant long-term difference between ligation and anastomosis of the radial and ulnar arteries. Lower extremity vascular injuries had significantly higher mortality and morbidity. **Conclusion:** As the reconstructive procedures to manage vascular injuries are technically difficult, we suggest conservative managements to be applied first. Prompt surgical intervention is necessary if there are any critical signs of ischaemia or unsuccessful conservative management,

Key words: Anastomosis, graft interposition, noniatrogenic, pediatrics, vascular trauma

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INTRODUCTION

In spite of the fact that vascular injury is reasonably uncommon in children, it leads to significant morbidity and mortality in this population.[1-3] Surgical management has conventionally been based on adult vascular trauma due to the low number of vascular injuries in childhood. Considering the complexity of these injuries, it is worthwhile to determine their demographic data. Unfortunately, the outcomes of traumatic, paediatric vascular injuries have not been well documented in comparison to adult traumatic, peripheral vascular injuries. Indubitably, the negative outcomes associated with vascular trauma could be decreased following improvements in diagnostic and therapeutic possibilities. The aim of this study was to consider the causes and types of vascular injury in children, management, and the associated morbidity and mortality.

PATIENTS AND METHODS

We reviewed the medical records of 52 children with vascular injuries caused by either a blunt or a penetrating mechanism between 1996 and 2006 in the two major referral trauma centres of Isfahan province, namely, Alzahra and Kashani hospitals. Patient charts were reviewed and those with isolated digital vascular injuries, digital amputations, and forefoot amputations were excluded from the study. Patients older than 15 years were also excluded. The management included conservative management, primary closure, end-to-end vascular anastomosis, graft interpositioning, and fasciotomy. Data collected and analysed included age, sex, clinical status in the emergency department, type of injury, concomitant injuries, mechanism, diagnostic imaging (doppler ultrasonography, bedside angiography, standard angiography), operative management, primary surgical service, anticoagulation requirement, length of stay, and clinical outcome. Finally, the long-term outcomes of our vascular trauma patients were determined.

RESULTS

Injuries were more common in male patients (n = 41, 78.8 %). Patients' ages ranged from three to 14 years (mean age of 9.7 ± 3.7 years) with a slightly older mean age in male patients (mean age of 11.2 ± 3.7 years). The mean time elapsed before arriving at the hospital was about 3 h and 13 minutes (range: 17 min to 25 h and 47 min). Six of the patients arrived at the hospital after 24 h. Thirty-five (67.3%) patients had upper extremity injuries (23 on the right and 12 on the left side). Four of them were as a result of blunt trauma and 31 were caused by penetrating trauma (glass: 17, gunshot: two, others: 12). Twelve (23.1%) patients had lower extremity injuries (four on the right and eight on the left side), of which seven of them were as a result of blunt trauma and the rest of them due to penetrating trauma (glass: four, gunshot: one). Vascular trauma to the neck included five (9.6%) penetrating injuries (gunshot: one, others: 4) [Table 1]. Most penetrating injuries resulted from glass (n = 21, 51.2%), whereas blunt vascular injuries were most commonly a result of traffic accidents, with patients being either a passenger or a pedestrian. Associated nonvascular injuries included 16 tendon injuries, 22 nerve injuries, and one fracture-dislocation in the 31 penetrating upper extremity trauma patients and four fracture-dislocations and one associated nerve injury in the four blunt upper extremity trauma patients. The corresponding data for the lower extremities was one nerve injury in the penetrating group (five patients) and seven fracture-dislocations, two nerve injuries in the blunt trauma group (seven patients). Management of injuries used a multidisciplinary approach, including the paediatric, orthopedic, plastic, vascular, neurologic, cardiothoracic, and hand surgeons with active involvement of interventional radiologists. Approaches to nonoperative and operative treatment are summarized in Table 2.

Doppler ultrasonography based on the presence of soft signs (proximity, minor haemorrhage, small haematoma, associated nerve injury) was done in six (11.5%) patients (three in upper and three in lower extremities); bedside angiography in six (11.5%) patients (one upper extremity, five lower extremity (three of them followed blunt trauma). Standard angiography (based on presence of hard signs) was done in two cases (3.9%) with lower extremity trauma who were referred after 24 h of trauma. Bedside angiography was done to localise the injury in patients with penetrating injuries and hard signs (pulsatile haemorrhage, significant haemorrhage, thrill or bruit, acute ischaemia). Soft signs are indications for observation or further testing with Doppler ultrasonography, Ankle Branchial Index (ABI) and standard angiography [Figure 1].[4] ABI was evaluated in 11 patients with lower extremity trauma and soft signs, angiography being performed in one patient due to an ABI < 0.9.

The management of these cases included: 1. Conservative management of two of upper extremity and none of lower extremity injuries, 2. Primary ligation of the vessel—all of them were penetrating upper extremity vascular injuries (ten ulnar, two radial arteries), 3. End-to-end anastomosis: (penetrating upper extremity trauma: eight brachial, three radial, and seven ulnar arteries; four penetrating lower extremity trauma; two blunt lower extremity trauma), 4. Graft interpositioning (three in upper and seven in lower extremities), 5. concurrent fasciotomy (one blunt upper extremity trauma, one lower extremity penetrating trauma, and three blunt lower extremity trauma) and late fasciotomy in one blunt lower extremity trauma. The indications of graft interpositioning placement in the presence of acute limb ischaemia were a large arterial defect in the main artery of the limb along with inability to perform end-to-end anastomosis. Neck injuries were managed by ligation of the bleeding vessel (three patients) and by primary repair (two patients) [Table 2]. Operative management generally favoured the use of autologous tissue (vein patches) rather than synthetic materials, primary repair, or ligation. The average length of stay of the patients was 9.55 ± 7.1 days (range, 1–67 days), with 7.1 ± 4.8 days (range, 1–36 days) for female patients and 13 ± 10.3 days (range, 1–67 days) for male patients. Two surgeons examined 45 patients physically in their offices. None of upper extremity repairs, including ligation, and anastomosis, had a disabling vascular complication or required a reoperation. One blunt lower extremity trauma needed re-operation and fasciotomy which led to salvaging of the limb and some remaining defects. Two deaths have occurred after lower extremity revascularisations due to blunt trauma. One patient with aneurismal change of the ulnar artery following

Table 1: Distribution of penetrating and blunt vascular trauma

	Upper extremity	Lower extremity	Neck	Number of patients
Penetrating	31 (75.6)	5 (12.2)	5 (12.2)	41 (78.8)
Blunt	4 (36.4)	7 (63.6)	0	11 (19.2)
Total	35 (67.3)	12 (23.1)	5 (9.6)	52

Figures in parentheses are in percentage

Table 2: Management of the injuries

	Upper extremity	Lower extremity
Doppler ultrasonograghy	3	3
Bedside angiography	1	5
Standard angiography	0	2
Nonoperative management	2	0
Primary ligation	12	0
End-to-end anastomosis	18	6
Graft interposition	3	7
Concurrent fasciotomy	1	4
Late fasciotomy	0	1
expired	0	2

penetrating injury was operated on successfully. About 73% of patients with nervous injury repairs still had sensory and motor neurological deficit (diagnosed by NCV). .After a three months' follow-up, about 86% of patients with neurological deficit had sensory deficit and the remained had motor disturbance. About 26.6% of patients who had concomitant tendon repair had some remaining disability. All fracture dislocations were treated successfully. Neck injuries were managed by ligation of the bleeding vessel (3) and by primary repair (2). One of the patients with concomitant carotid, jugular, and vagus nerve injuries due to a car accident, who was referred to this centre after ligation of the bleeding vessels, succumbed to the injuries after several hours.

DISCUSSION

Trauma of major vascular structures often causes death or significant disability leading to amputation or long-term functional impairment in adults. The triad for successful management of vascular trauma in paediatric patients is: 1) a high index of suspicion, 2) performance of aggressive diagnostic studies when indicated, and 3) prompt surgical intervention.[4] Open tibial fractures associated with vascular injuries have

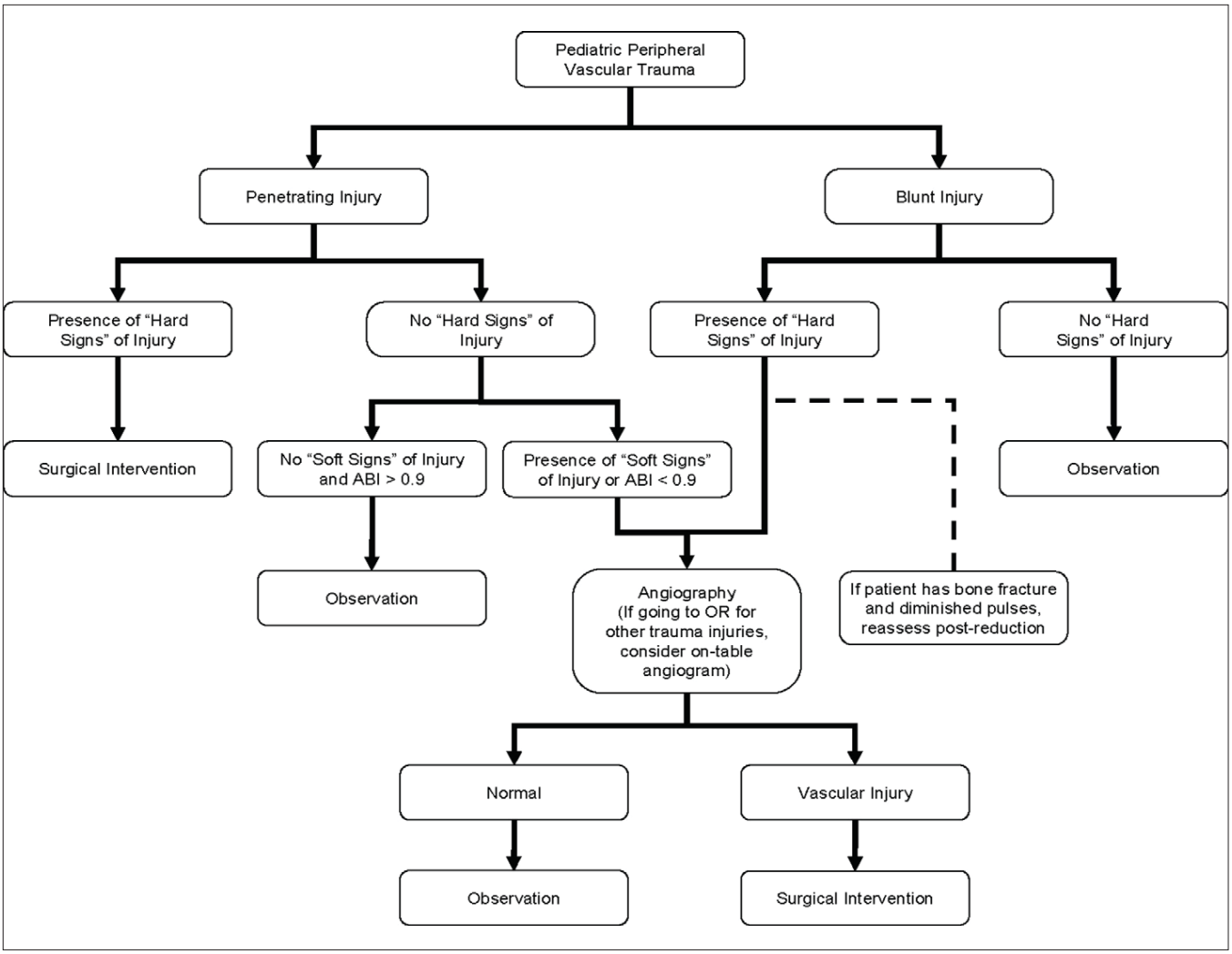


Figure 1: A proposed diagnostic algorithm for the management of paediatric peripheral vascular injuries.. "Hard Signs" of injury include distal ischaemia or absent pulses, active haemorrhage, expanding or pulsatile haematoma, and a bruit or thrill. "Soft Signs" of injury include a history of pulsatile bleeding, a stable haematoma, or proximity to a known vessel

been reported to have amputation rates as high as 78%.[5,6] Even single tibial vessel injury is associated with up to a 15% amputation rate due to the increased incidence of infection, myonecrosis, and delayed fracture healing.[7] Functional recovery after upper extremity injuries, however, depends mainly on the presence and severity of concomitant neurological injury in adults. Only 8% of patients with neurological injuries fully recuperate, as compared to 65% with isolated vascular injuries.[8] However, children recover more completely and faster from peripheral neurological injuries than adults.[9]

Some researchers have shown good recovery of limb use even with neurological injury in two-thirds of the patients sustaining combined injuries.[10] Approximately 2% of limb fractures in children may be associated with vascular injuries.[11] Noniatrogenic paediatric vascular injuries, while infrequent, differ in several ways from adult vascular trauma. Similar to adults, angiography is infrequently indicated in paediatric trauma patients. Angiography should be utilised only when the injury is questionable or when it is necessary for planning appropriate surgical revascularisation. In children, angiography itself may pose a risk of vascular injury. Mills and Robbs recommend exploration rather than angiography in patients without distal pulses but with a viable limb after blunt injury to the extremity, even though spasm was found to be the aetiology of temporary ischaemia in 41% of their patients.[11] Delay in recognition of the associated vascular injury or delay in appropriate repair has been associated with poor outcomes after extremity fracture.[12-14]

In our study, fasciotomy was performed in six patients (early in five and late in one patient). Fasciotomy is indicated in the primary operation in most cases to prevent the development of compartment syndrome.[15]

The average age of the male patients was 11.3 years and that of the female patients was 9.1 years (range, 1–18 years; overall, 10.7 years) in a study by Denise *et al*. Penetrating wounds caused 68% of the injuries, followed by blunt trauma (31%) and burns (0.97%). Anatomical locations of injury included the head/neck (19.4%), torso (13.5%), and extremities (67%); amputation was required in 11 (10.7%) patients.[5] The average length of hospital stay of the patients was 12.1 days (range, 1–155 days). The overall mortality was 9.7%.[16] Despite the available multidisciplinary diagnostic and treatment modalities in tertiary care paediatric trauma centres, traumatic vascular injuries in children and adolescents are associated with significant morbidity and mortality in contemporary surgical practice.[17] Patients with significant orthopaedic and vascular injury appear to be at the highest risk for suboptimal long-term outcomes. Prolonged follow-up of these injured children helps to determine whether they are at any increased risk of vascular compromise, late graft failure, and limb loss. We found that males are significantly more (78%) involved. Penetrating upper extremity injuries were the most common cause of vascular injury in the paediatric population (65% on the right side). The most common mechanism was cutting the hand by glass (most of them on the ulnar side). These vascular injuries *per se* did not cause any disability, probably due to rich collaterals. The outcome of these injuries depends mostly on simultaneous nervous injury and to a lesser extent, on tendon injury. There was no significant long-term difference between ligation and anastomosis of the radial and ulnar arteries. Lower extremity vascular injuries are associated with significantly higher mortality and morbidity. The successful early revascularisation of the injured limb leads to good short-term results in most of the injured children, although a redo vascular repair of one lower extremity led to some disability. Data showed two deaths after revascularisation, both in the lower extremities. Multispeciality team approaches are warranted in treating injured children, particularly in cases where amputation may have been considered in an adult with similar injuries, because of the improved neurological and functional recovery even when significant nerve injury is present. Therefore, we suggest: 1. To educate families and to execute safety measures in buildings to reduce the most prevalent cause of paediatric vascular trauma—laceration by glass; 2. Special attention to lower extremity blunt trauma (because of high mortality); 3. Due to the greater difficulty of performing technical procedures in children due to their smaller size and because of better outcomes, we suggest conservative managements (in the absence of critical limb ischaemia) to be implemented first. Prompt surgical intervention is recommended in the presence of critical signs of ischaemia (pulsatile haemorrhage, significant haemorrhage, thrill or bruit, acute ischaemia) or unsuccessful conservative management (following 24–48 h).

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