INTRODUCTION
Trauma is the leading cause of death and disability in young adult males. The incidence of vascular trauma varies from 2 to 5% of all trauma cases.\(^1\) Mortality and the utilization of medical resources are higher in patients with vascular injury than the trauma patients without vascular injuries.\(^2\) Vascular injuries which were missed at the time of initial presentation and assessment will be reported later on with pseudoaneurysm (PA), arteriovenous fistula (AVF) or arterial thrombosis/occlusion.\(^3,4\) Complications of missed vascular injuries can result in serious lifelong functional disability or even loss of limb.\(^3,4\) A low velocity penetrating and blunt injury in close proximity to main vessels usually causes partial injuries to the vessels wall. These injuries are missed due to the absence of hard signs of vascular injuries and presence of distal pulses at the time of initial presentation. High index of suspicion, detail history including mechanism of injury and meticulous clinical assessment can prevent this unfortunate outcome. When in doubt, conventional angiography or CT angiography should be performed in order to exclude the vascular injury.\(^5\)

When low velocity penetrating trauma causes partial injury of an artery, blood passes out through the arterial rent and surrounding muscles and fascia prevent its escape externally due to small external wound. A hematoma formed which is communicating with an arterial defect, when it organized, it becomes a pseudoaneurysm. When both the adjacent artery and vein are partially injured an AVF is formed. The presentations of pseudoaneurysm and traumatic AVF depend upon their site and size. PA usually presents with swelling, pain due to pressure on the surrounding structures, distal ischemia and external bleeding. Post-traumatic AVF usually present late with local and systemic effects like swelling, secondary varicosities, venous ulcers and heart failure.\(^7,8\)

The objective of this study was to describe the etiology, presentation, management and outcome of missed vascular injuries presenting in a military hospital vascular unit.

METHODOLOGY
This study was carried out at Combined Military Hospital, Rawalpindi and Combined Military Hospital, Kharian.
Missed vascular injuries

Kharian, from June 2009 to June 2012. Permission from the Hospitals’ Ethical Committees was obtained prior to the study. Informed written consent was obtained from the patients before their enrollment in the study. All the cases of missed vascular injury presented with post-traumatic pseudoaneurysm, arteriovenous fistula and post-traumatic arterial occlusion reporting in these hospitals during study period, were included. Patients presenting with acute vascular injuries and those who presented with iatrogenic and pseudoaneurysm at the vascular anastomosis site were excluded. Vascular injury which was not diagnosed at initial evaluation and operative intervention but reported later on with complications after variable time interval was considered a missed vascular injury. Patient’s particulars, age, gender, time between the onset of injury and presentation, trauma mode (penetrating, blunt or iatrogenic) and site of injuries were recorded. Diagnosis was made on the basis of history and clinical examination and with Doppler study of the affected part. All the patients were evaluated with conventional arteriography or CT angiography before surgical intervention. Blood complete picture, blood grouping and cross-match, blood sugar, renal function tests, coagulation profile and screening for hepatitis B and C were advised before surgery. Broad spectrum antibiotics (Cefuroxime 1.5 g) was started intravenously before surgery and continued for 4 - 5 days after surgery.

All cases of pseudoaneurysm and traumatic AVF were explored through longitudinal incision extending proximal and distal to the injury site. Proximal and distal control of the affected vessels was achieved before exploring the pseudoaneurysm and traumatic AVF. In all patients, 5000 units unfractionated heparin was administered 3 minutes before applying the vascular clamps. After exploration and opening of the communication between artery and vein in case of traumatic AVF, the extent of vessel injuries was assessed. Type of repair depended upon the extent and type of injury. Postoperatively, the patency of repair was assessed by palpation of distal pulses, capillary refill and with intraoperative probe of hand held Doppler. In all patients repaired vessels were covered with muscles/ soft tissue and wounds were washed with normal saline. Suction drain was placed in all cases for 24 - 48 hours. Postoperatively, all the patients were closely monitored regarding the state of circulation (presence of distal pulses, capillary refill and the temperature), signs of secondary hemorrhage and wound infection.

At the time of discharge, they were advised to follow-up in vascular outpatient department after 2 weeks. On follow-up, the vascularity of the limb was assessed both clinically and by Doppler examination. Any neurological deficits and other wound related complications were recorded and patients advised to continue follow-up, initially after one month and then after every 3 months.

Data was analyzed by using Statistical Package for Social Sciences (SPSS) version 10. Frequency and percentages were used to describe the data.

RESULTS

Twenty eight patients reported with complications of missed vascular injuries and underwent various vascular repair procedures. Age of the patients ranged from 16 to 78 years (mean age 33.7 ± 15.4 years). Male to female ratio was 6:1. Twelve (42.8%) patients presented with pseudoaneurysm, 10 (35.7%) with traumatic arteriovenous fistulae, 4 (14.3%) post-traumatic thrombosis and occlusion and 2 (7.1%) with false aneurysm and recurrent bleeding. Penetrating trauma (gunshot or splinter injuries) was the most common cause of injury present in 18 (64.2%) patients, blunt trauma occurred in 6 (21.4%) and 4 (14.2%) patients had iatrogenic injury. Time interval between injury and presentation in the hospital ranged from 2 to 1300 weeks (mean 228 weeks). One case of traumatic AV fistula reported at 25 years after initial injury with secondary varicose veins and venous ulcers. Lower limb vessels were affected in 20 (71.4%), the upper limb in 5 (17.8%) and neck vessels in 3 (10.7%). Superficial femoral artery was the most frequently involved in 9 (32.1%) cases (Table I).

Interposition reverse autogenous saphenous vein graft was the most common type of repair in all types of missed injuries (Table II). Hospital stay ranged from 4 to 6 (50%) days.

Table I: Site of vascular injury (n=28).

<table>
<thead>
<tr>
<th>Anatomical site of injured vessel</th>
<th>Number of cases (n)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial femoral artery</td>
<td>9</td>
<td>32.1%</td>
</tr>
<tr>
<td>Popliteal artery</td>
<td>6</td>
<td>21.4%</td>
</tr>
<tr>
<td>Common carotid artery</td>
<td>3</td>
<td>10.7%</td>
</tr>
<tr>
<td>Common femoral artery</td>
<td>2</td>
<td>7.1%</td>
</tr>
<tr>
<td>Axillary artery</td>
<td>2</td>
<td>7.1%</td>
</tr>
<tr>
<td>Brachial artery</td>
<td>2</td>
<td>7.1%</td>
</tr>
<tr>
<td>External iliac artery</td>
<td>1</td>
<td>3.5%</td>
</tr>
<tr>
<td>Subclavian artery</td>
<td>1</td>
<td>3.5%</td>
</tr>
<tr>
<td>Radial artery</td>
<td>1</td>
<td>3.5%</td>
</tr>
<tr>
<td>Peroneal artery</td>
<td>1</td>
<td>3.5%</td>
</tr>
</tbody>
</table>

Table II: Causes, presentations and management of missed vascular injuries (n=28).

<table>
<thead>
<tr>
<th>Cause of injury</th>
<th>Presentation</th>
<th>Operative management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetrating n=18 (64.2%)</td>
<td>Pseudoaneurysm n= 12 (42.8%)</td>
<td>Excision and interposition vein graft 6 (50%)</td>
</tr>
<tr>
<td></td>
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<td></td>
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<tr>
<td>Blunt n = 6 (21.4%)</td>
<td>AV fistulae n= 10 (35.7%)</td>
<td>Excision and repair with reverse vein graft 7(70%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iatrogenic n = 4 (14.2)</td>
<td>Thrombosis n = 4 (14.2%)</td>
<td>All with bypass reverse vein graft</td>
</tr>
</tbody>
</table>

All with bypass reverse vein graft |

Excision and repair with inter-position vein graft |
16 days (mean 5.8 days). One (3.5%) patient had secondary hemorrhage due to infection and anastomosis blowout which was managed by ligation of vessel as a life saving measure. Later on, he had above knee amputation. Superficial wound infection occurred in 4 cases (14.2%) which were managed with wound debridement, dressing and secondary suturing. Five patients (17.8%) had persistent swelling of distal limb managed by elevation, compression stocking and anticoagulant therapy.

**DISCUSSION**

Vascular injuries are usually missed in mass casualty scenario, polytrauma with altered level of consciousness and absence of hard signs of vascular trauma. It can be missed during physical examination and by other various diagnostic modalities. The natural history of missed vascular injuries varies with the extent and type of injury. Most of the occult arterial injuries healed spontaneously or stabilized without compromising the distal circulation and perfusion.9,10 These vascular injuries present at variable time interval after initial trauma. Early cases of missed vascular injuries present with recurrent hemorrhage from the wound or excessive blood in drain and late presentations are pseudoaneurysm, traumatic AVF, thromboembolism, arterial occlusion, congestive heart failure and chronic venous insufficiency. Majority of our cases presented late with their secondary effects.

Detailed history which includes mechanism and site of injury, amount and character of hemorrhage and careful physical examination with high index of suspicion of vascular injury is important to diagnose the arterial injuries. Tertiary trauma survey and strictly following the diagnostic algorithm for vascular injuries, have been suggested to avoid missing arterial injury in mass casualty scenario.11,12 In tertiary trauma survey, patients should be re-examined before shifting for definitive management, or in case of head injury patient, after regaining consciousness. In the absence of hard signs of vascular injury, physical examination alone can be deceptive, at times distal pulses were palpable even in the presence of arterial injury.13 These patients should further be evaluated by Doppler Pressure Index (DPI) measurement, Duplex scan or angiography. Ankle Brachial Pressure Index (ABPI) less than 1.0 indicate significant vascular injury.14 All the cases with low DPI in the affected limb should be subjected to Computerized Tomographic (CT) angiography or conventional catheter angiography.15,16 In this study, angiography was done in all the cases in order to confirm the diagnosis and planning the management. CT angiography has proved to be an effective alternative to conventional angiography in assessing vascular injuries. It is less invasive and easily available.17 Arteriogram is mandatory for penetrating wounds proximal to major arteries of the extremities because of the 5 - 15% incidence of occult injuries.

Traumatic vascular injuries that were caused by low-velocity small fragment wounds can result in serious delayed complications months or even years after the injury.18 Patients with penetrating injuries must be closely monitored, and arteriogram is recommended to evaluate the conditions of patients with potential vascular injury even when overt clinical signs or symptoms of vascular injury are absent. In this study, low velocity penetrating injuries were the commonest cause and pseudoaneurysm was the most frequent presentation of the missed vascular injuries as in most of the published series.19,20 In this study, all the cases of missed arterial injuries were treated by various open surgical techniques. Catheter-based endovascular techniques have been used with increasing frequency for the management of post-traumatic AVF and pseudoaneurysm. Endovascular coil embolization has been used for ligation of arteriovenous fistulas in smaller vessels and can help temporize bleeding if open repair is necessary. Covered stent grafts have been reported to be used in the exclusion of both pseudoaneurysms and arteriovenous fistulas.21,22

**CONCLUSION**

Vascular injuries caused by low-velocity small fragment wounds can result in serious delayed complications months or even years after the initial injury. In order to avoid missing the vascular injuries, clinicians should have high index of suspicion and strictly follow the diagnostic algorithm of vascular trauma.

**REFERENCES**


