ORIGINAL ARTICLE

Vascular Trauma in Penang and Kuala Lumpur Hospitals

M N Lakhwani*, B H Gooi, C D J Barras*****

*Penang Adventist Hospital, Penang, **Department of Surgery, Penang Hospital, 10990 Penang, ***St.Vincent's Hospital, Melbourne, Australia

Summary

Objectives: The nature of vascular trauma varies greatly between continents and across time. The aim of this study was to prospectively analyse the demographics, pathology, management and clinical outcomes of vascular injuries in two urban Malaysian hospitals and review of international literature on vascular trauma. From this information, preliminary management and preventive implications will be described.

Methods: Eighty-four consecutive cases of trauma requiring vascular surgery were prospectively analysed over three years at Hospital Kuala Lumpur and Hospital Pulau Pinang, Malaysia. Extensive patient demographic and injury data, including the mechanism of injury, associated injuries, angiographic findings, operative details and post-operative complications, were systematically gathered.

Results: Most vascular injuries were incurred by males (76/84), with 37% (28/76) of them aged between 21 and 30 years. Malays were most frequently injured (n=36) followed by Chinese and Indians. Road traffic accidents (n=49) substantially outnumbered all other causes of injury. Lower limb injuries (n=57) occurred more than twice as often as upper limb injuries (n=27). Complete arterial transections (n=43) and intimal injuries (n=27) were more common than arterial lacerations (n=10) and pseudoaneurysms (n=4). The most frequently damaged vessels were the popliteal/tibioperoneal trunk (n=33). All patients received urgent Doppler ultrasound assessment and, where possible, ankle-brachial systolic index measurement. Of all patients, 40 received an angiogram, haemodynamic instability making this investigation impractical in others. Primary arterial repair was the most frequently employed surgical procedure (n=54) followed by autogenous reverse long saphenous vein (LSV) interposition graft (n=14), embolectomy (n=5) and PTFE interposition graft (n=3). The most common post-operative complication was wound infection (n=11). Amputation, as a last resort, was required in 13 cases following either primary or autogenous reverse LSV repair complicated by sepsis or critical ischaemia.

Conclusions: Vascular trauma, especially in conjunction with severe soft tissue, nerve or orthopaedic injury carries colossal physical, psychological, financial and social costs. Associated nerve and venous injury portended poor outcome in this study. Whilst orthopaedic trauma was a common association, the concurrence of occult vascular trauma and soft tissue injury without fracture emphasises the crucial importance of thorough and rapid clinical vascular assessment, investigation, and surgical intervention. Fasciotomy, especially for the lower limb, is important for the prevention of compartment syndrome

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Corresponding Author: Gooi BH, Department of Surgery, Penang Hospital, 10990 Penang

and its limb-threatening sequelae. Primary preventive road safety promotion and interventions, with attention to high-risk groups (young males and motorcyclists), is urgently required.

Key Words: Vascular, Vessels, Trauma, Injury

Introduction

Severe vascular injuries make up 4-6% of major trauma[1]. Escalating violence in major cities has prompted an increased awareness of vascular injuries and modified methods for the assessment and management of the injured. Much information has resulted from the application of the principles of management of multiple traumas and especially vascular trauma learned from the experience of military surgeons during the World Wars and the Korean War. During the latter conflict, emphasis was placed on the vascular reconstruction using vein grafts with a consequent reduction in amputation rate from 50%, which had been experienced during World War 2 to 13%[2]. Civilian vascular injury in the USA is associated with a high incidence of penetration trauma from gunshot and stab wounds, of the order of 90%[3], but in Australia blunt trauma from road traffic accidents is more common[4,5].

This paper reviews the demographic aspects, pathology and current approach to management of vascular injuries in two urban hospitals in Malaysia where the first author had worked.

Materials and Methods

The personal vascular trauma experiences of the first author accumulated over a period of 8 years (1993-2000) were recorded prospectively in Hospital Kuala Lumpur and Hospital Pulau Pinang, Malaysia. Eighty four cases were collected. Demographic data, occupation, mechanisms of injury, associated injuries, angiographic findings and operative details including types of operation and postoperative complications were recorded. Time between injury and operation was also noted. Combined management with the orthopaedic units was performed where fractures were present and bone fixation always preceded vascular repair. Only patients requiring vascular repair were considered in the study. When there was severe instability of the limbs, an external fixator was placed to provide stabilization. Gustilo classification[6] for compound fractures was utilized to categorize the different open bony injuries. Gangrenous or non-viable limbs with injuries below the popliteal trifurcation were excluded from the study.

Results

The demographic data are shown in Table I and Table II.

Male patients in the age group of 21-30 significantly outnumbered the others. The majority were Malays (n=36) followed by Chinese (n=25), Indians(n=15) and other ethnic groups (n=8). In terms of socio-economic status, those involved were mainly from the lower socio-economic groups. They were mainly factory workers, laborers, construction workers, drivers and carpenters. The injuries sustained were not necessarily at place of work. There were more road traffic accidents than occupation-related injuries.

There were a total of 56 cases of penetrating trauma (road traffic accidents, stab wounds,

assaults) in contrast to 28 cases of blunt injuries. Road traffic accidents constituted 49 cases (37 lower limbs, 12 upper limbs) while industrial accidents in 12 cases, falls from height in 5 cases, iatrogenic injuries (arterial catheterization) in 14 cases and assaults in 3 cases. Iatrogenic injuries were mainly due to percutaneous femoral catheterization (n=7), pelvic vein laceration (Wertheim operation) (n=1), intra-arterial cannulation (n=4), and orthopaedic procedure related (n=2).

The commonest modes of presentation to the casualty officer were the 5 Ps of vascular occlusion (pain, pallor, pulselessness, paraesthesia and paralysis) including frank bleeding, swelling (haematoma), cooling and mottling of affected part. Open fractures constituted the highest number (n=23) of associated injuries followed by closed fractures (n=14) (Table III). Ten cases had closed joint dislocations (elbow and knee). Twenty two cases had associated compartment syndromes (open and close fractures). The most common cause of compartment syndromes in our study was blunt trauma with resulting soft tissue injuries, oedema and haemorrhage into the compartment from associated fractures. Reperfusion injuries with production of oxygen derived free radicals also caused compartment injuries but less commonly. Other causes included venous thrombosis with venous hypertension. Decompression fasciotomy was the mode of treatment in these injuries. Thirty seven cases had soft tissue injuries with no fractures.

The most important investigations done were the Doppler ultrasound and angiography. All patients had assessment with Doppler ultrasound and ankle-brachial systolic index (ABSI) obtained, if possible, in lower limb injuries. Only 40 cases had the benefit of angiogram while 44 cases did not. The indications for surgery were arterial bleeding (n=25), arterial insufficiency (n=56) and expanding haematoma (n=3).

The types of vascular injury for different arteries are shown in Table IV. The most common types of injuries were complete arterial transections (n=43) and intimal injuries (n=27). Arterial lacerations (n=10) and pseudoaneurysms (n=4) were less common.

The most common arteries injured in the lower limbs were the popliteal and tibioperoneal trunk (n=33) and the femoral arteries (n=23). In the upper limbs, the brachial artery was most commonly involved (n=17). In both situations there were associated compound injuries involving nerves, muscles and bones.

Open fractures associated with external injury requiring vascular repair were all under Gustilo classification 3c clinically. Fracture management consisted of careful debridement, removal of foreign bodies, wound irrigation, fasciotomy and fracture stabilization.

The type of vascular repair most frequently performed was primary repair of the injured artery (n=54). This type of repair was performed in the popliteal (15/54), brachial (13/54), femoral (12/54), axillary (3/54) and others (11/54). Long saphenous vein interposition graft (n=14) was less commonly performed and was performed in the femoral (6/14), popliteal (5/14) and brachial (2/14) arteries. The saphenous vein in this study was harvested from the thigh of the contra lateral uninjured extremity so as to preserve the superficial venous system of the injured extremity in case a concomitant ipsi-lateral deep venous injury was present. PTFE interposition graft was utilized in only 3 cases, these were in axillary(1/3) and popliteal arteries (2/3). Embolectomy was performed in 5 cases, these were brachial (2/5) and femoral arteries (3/5) where soft tissue injury only was involved. Eight cases had amputation when extensive soft tissue and bony injuries were discovered on exploration.

The postoperative complication most frequently encountered was wound infection (n=11). Other complications of significance included thrombosis (n=1) and haemorrhage (n=2). Amputation as a last resort for life saving was performed in 13 cases, most of whom, developed complications (sepsis, bleeding or gangrene limbs) following a primary or autogenous reverse LSV repair.

Good upper limb function was obtained in 100% (7/7) of isolated subclavian and axillary artery injuries, 88% (15/17) of brachial artery injuries and all radial and ulnar artery injuries. In the lower limbs, good function was restored in 74% (17/23) of femoral artery injuries and 73% (24/33) of popliteal/tibioperoneal artery injuries. In both the upper and lower limbs injuries, function was worsened with associated venous injuries.

Table I: Vascular Injuries by Age Groups and Sex

Age Groups	Male(*UL/LL)	Female(*UL/LL)
11-20	15 (4/11)	2 (0/2)
21-30	28 (11/17)	2 (0/2)
31-40	12 (4/8)	0 (0/0)
41-50	8 (4/4)	3 (0/3)
51-60	6 (1/5)	0 (0/0
61-70	5 (1/4)	1 (0/1)
71-80	2 (2/0)	0 (0/0)
Total	76 (27/49)	8 (0/8)

* UL - Upper Limb LL - Lower Limb

Table II: Occupations and Vascular Injuries

Occupational groups	Numbers
Professional and Administrative	1
Managerial and Executive	1
Intermediate non-manual	2
Skilled Manual	5
Semi-skilled manual	6
Unskilled	26
Unemployed	14
Unknown	29
Total	84

Table III: Types of Associated Trauma in Limbs

Associated limb injuries	Upper Limb	Lower Limb
Closed Fractures	2	12
Open Fractures	4	19
Dislocation	2	8
Soft Tissue Injuries	19	18
Total	27	57

Table IV: Types of Vascular Injuries

Arterial Injuries	Intimal tear	Laceration	Transection	Pseudoaneurysm	Total
Subclavian	0	0	3	0	3
Axillary	2	0	2	0	4
Brachial	5	0	11	1	17
Radial	0	0	3	0	3
Iliac	0	1	0	0	1
Femoral	9	7	6	1	23
Popliteal/Tibioperoneal Trunk	11	2	18	2	33

Table V: Types of Operation Performed

Types of Surgery	Number
Primary Arterial Repair	54
Autogenous Reverse LSV Graft	14
PTFE Interposition Graft	3
Embolectomy	5
Amputation	8
Total	84

Discussion

ascular injuries are a major cause of morbidity and mortality in trauma patients. In our series most vascular injuries occurred in the younger age group (<40 years old), mainly among patients who are factory workers (Table II) and in those who are highly mobile. Lower limb injuries were most common in view of the majority of victims being motorcyclists (>90%) who were involved in road traffic accidents. The lack of leg-protection compared to other vehicles probably resulted in the severe lower limb injuries.

Occupation related vascular accidents were less common. In this group, the upper limb (n=7) was relatively more common to involve compared to lower limbs (n=4). Penetrating injuries constituted of those with more severe vascular injuries. This was consistent with most other findings[7,8]. Douglous et al reported that 90% of arterial injuries were due to penetrating trauma[9]. In a significant percentage (33%) of our cases, the injuries were due to blunt trauma sustained during RTA and fall from a height. Blunt vascular injuries tend to occur in areas where there are strong attachment of vessels to adjacent bone, tendon and soft tissues. An injury such as a bony fracture or joint dislocation produces traction on nearby vessels with subsequent intimal stretch and disruption, which lead to dissection of vessels wall, thrombosis or both. In addition fractures may directly lacerate or transect adjacent vessels; a direct blow may lead to intimal injury or thrombosis[9].

Iatrogenic injury usually follows percutaneous arterial puncture for diagnosis or therapy and these vascular injuries accounted for 17% (n=14) at one medical centre as compared to 30% at another medical center[10].

A significantly higher number of cases had vascular injuries from open fractures (n=23), in comparison to close fractures (n=14) and closed dislocations (n=10). Also a significant number of soft tissue injuries were associated with vascular injuries (n=37). This implies a significant force at impact. Among those without fractures, intimal injuries occurred in 14 patients, lacerations in 4 patients, transections in 16 patients, and pseudoaneurysms in 3 patients. The types of vascular injuries associated with fractures or dislocations (n=47) were intimal injuries in 13 patients, lacerations in 5 patients, transections in 25 patients, and pseudoaneurysm in 1 patient. Thus, in our study, the types of vascular injury has no relationship with the severity of trauma, i.e. bony, muscle, nerve and other soft tissue injuries. Nevertheless when the vascular injury has been identified, assessment should also be made of any associated bony, muscular, neural and other soft tissue damage. Whereas treatment of the vascular injury in a timely manner may be life saving and limb saving, care of the associated soft tissue injuries is of utmost important in preserving a functional extremity.

While partial tearing or disruption of the arterial wall was the most common type of injury encountered by Austin et al[11] in their vascular trauma review, this was not the case in our study where total transection of the vessels was more common. This may be due to higher forces of impact during the road traffic accident.

In the lower limbs, knee dislocation is associated with vascular trauma in over 50% of cases and arteriography should be performed liberally to exclude popliteal artery injury which carries a significant amputation rate[12,13]. However it has

been demonstrated that a careful pulse examination by a physician and the use of ABSI can detect all significant injuries that required operative repair[7]. Seven of our cases had dislocations with popliteal artery injury, 3 of whom had intimal injuries with successful primary repair. The remaining 4 cases were found to have complete transection at exploration, necessitating interposition grafting (n=2), primary repair in one case and below knee amputation in another case. Popliteal vein injury commonly occurs together with the arterial injury and if possible should be repaired to improve the immediate chances of limb salvage and to avoid later post phlebitic venous insufficiency. However those who are less enthusiastic about venous repair referred to the high incidence of thrombosis of these repairs and the risk of pulmonary embolism[9]. Meyer and colleagues also showed that a substantial percentage of venous repairs thrombosed in the postoperative period, especially if interpositon grafting is used[14]. Eight of our patients with popliteal/tibioperoneal vessels injury (n=33) required amputation. All these patients had Gustilo type 3c fractures.

Concurrent use of mannitol as oxygen free radical scavenger has been reported to markedly decrease the incidence of compartment syndrome and its sequelae[9].

Posterior humeral dislocation in the elbow (n=2) was less common and ischaemic complication was rare because of good collateral circulation. Nevertheless arterial repair is important to prevent later claudication, cold intolerance and Volkmann's ischaemic contracture[15].

In the lower limb injuries Doppler ultrasound with ABSI is an important and useful investigation tool in the casualty room, thus not all cases required angiogram as in this study. Arteriography is useful in stable patients with suspected arterial trauma. It allows assessment of the extent of injury and of distal vessels and may prevent unnecessary exploration. It is useful if the site of injury is unclear, the trajectory of a missile is unknown or there are multiple pellet injuries. However, it is unnecessary if there is an obvious vascular injury and it should not be performed if the patient is haemodynamically unstable[15]. Colour duplex scanning in the assessment of peripheral vascular trauma avoids the complication of angiography and is less expensive to perform. In addition to assessing the presence of flowing blood, it gives an accurate measurement of the velocity of flow, and the presence of reverse flow. Early reports showed a 95% or greater sensitivity in predicting major arterial injury. However these studies are technically demanding and are heavily reliant on the skill of the technologist and the ability of the surgeon to interpret the findings[9].

Fasciotomy for compartment syndrome is often recommended in all cases of ischaemia beyond four hours or in cases where compartment interstitial fluid pressure can be measured and is greater than 30 to 40 mmHg (normal range 0-8 mmHg)[6]. In this study 21 patients had compartment syndrome that needed fasciotomy either preoperatively or postoperatively. The procedure should be considered useful procedure in attempting to salvage an injured ischemic limb.

Most repairs were performed primarily by opposing the 2 ends after excising the necrotic ends (n=53). This is useful up to 1-2cm of artery loss as mobilizing the artery proximally or distally is usually sufficient to bring the ends together. Tension was avoided in all these cases to ensure success. In most extensive arterial injuries with arterial loss, autogenous reverse LSV was utilized as interposition grafts effectively. There was good patency in all the 3 PTFE grafts. Martin et al reported patency of PTFE was significantly worse in the popliteal laceration[16].

It has been reported that neurologic injury occurs in about 50% of upper extremity vascular injuries,

and 25% of trauma of the lower extremities. Invariably the nerve injury and not the vascular injury determine the long term functional status of the traumatised extremities[9].

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