Arterial Injuries of the Lower Extremity from Blunt Trauma

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Abstract

Thirty patients with 33 arterial injuries from blunt trauma of the lower extremity at Chulalongkorn Hospital, Bangkok, Thailand from January 1989 to December 1995 were reviewed. Eight patients (26.6%) were in shock on arrival. Twenty four (80%) presented with signs of ischemia. Twenty six (86.7%) had asociated fractures and/or dislocations, 14 of them were compound fractures. Nine (30%) had associated injuries at other parts of the body. Ten (33.3%) underwent preoperative angiography. The preoperative time ranged from 1 to 72 hours, median 4 hours. One patient who had intimal tear of the popliteal artery and was successfully treated conservatively. Popliteal artery was the most common injured artery; followed by common femoral, superficial femoral, and anterior tibial artery. Most arterial injuries were repaired by using reversed saphenous vein grafts. Associated venous injuries were repaired in 5 patients. Fracture fixation was performed in 18 patients; 8 of them were performed before arterial repair and 10 were performed after arterial repair. No intravascular shunt was inserted in this study. Fasciotomy was performed in 15 patients. Five patients had limb amputation (16.7%). Univariate analysis by Chi Square test revealed that associated venous injuries, severe soft tissue injuries, and fasciotomy were statistically significant factors associated with amputation. One patient who had external iliac artery injury died from severe head injury in spite of a successful arterial repair (mortality rate 3.3%).

Injury to arteries supplying the lower extremity may result in amputation or even fatality if improperly treated. Although vascular trauma management has been significantly improved during the past 20 years, the limb loss rate following vascular injuries of the lower extremity is still relatively high[1-3]. Prolonged ischemic time, severe soft tissue injuries, fractures and dislocations, and associated veins and/or nerve injuries are factors contributing to treatment failure[4-6]. Some areas of controversy exist concerning revascularization in patients with associated fractures. Stablization of fractures before revascularization makes it convenient for vascular repair but lengthens the warm ischemic time. On the other hand, revascularization before fracture stabilization is appropriate for pre-

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venting irreversible ischemic damage to muscle and nerve but the procedure is more tedious and subsequent orthopedic procedures may jeopardize previous vascular repair. Preoperative angiography is also another controversial issue regarding the appropriate indication to perform. Although preoperative angiography gives a precise diagnosis of arterial injury, its routine use may further lengthen the ischemic time of an obviously ischemic limb which may lead to amputation in spite of a successful arterial repair.

Generally, blunt trauma to the lower extremity causes a more severe injury than penetrating trauma. Consequently, management is more difficult and outcome is poorer[7,8]. The purpose of this study is to examine the results of management of arterial injuries of the lower extremity from blunt trauma and factors associated with amputation.

PATIENTS AND METHOD

The medical records of patients who sustained blunt trauma and had lower extremity arterial injuries from January 1989 to December 1995 at Chulalongkorn Hospital, Bangkok, Thailand were reviewed. Arterial injuries were suspected by the following findings: absent or decreased pedal pulses; coolness, numbness and decreased motor function or paralysis of the involved leg and foot; and an open wound at the site of named artery. Diagnosis of arterial injuries was made from angiography and/or at operation. Patients who had a severely injured limb or dead limb and underwent primary amputation were not included in this study.

During the study period, it was our policy to give 5,000 units of heparin intravenously when an arterial injury resulting in limb ischemia was diagnosed except those who had associated head or intraabdominal injuries. Patients who had obvious ischemic limb underwent immediate operation without preoperative angiography. Those who were suspected of having arterial injuries and had good limb viability underwent angiography followed by arterial repair if indicated. In patients who had associated fractures and/or dislocations the decision to perform arterial repair before or after orthopedic procedures depended on degree of ischemia, viability of limbs, and technical aspect of arterial and orthopedic procedures. The latter referred to situations in which limb ischemia was present but orthopedic procedure was performed first because the fractures and/or dislocations were so unstable that prior arterial repair was impossible. In most circumstances, arterial repair usually took priority in obvious ischemic limbs. No patient in this study had temporary intravascular shunt inserted. Fixation of fractures was performed before arterial repair only when good limb viability was obtained. Repairing of associated venous injuries was attempted whenever possible. Fasciotomy was performed if the ischemic time was long or the limbs were severely ischemic before revascularization. Double-incision fasciotomy as described by Mubarak was used in all patients[9].

In this study, preoperative time was defined as duration from injury to operation. Shock was defined as a systolic blood pressure of less than 90 mmHg when the patient was first seen in the emer-

Table 1. Patient characteristics

		%
Number of patients	30	
Male	27	90.0
Female	3	10.0
Age (year)	13-50 (mean 25.8±9.5)	
Direct admission	25	83.3
Transferred from another hospital	5	16.7
Shock on arrival	8	26.6
Presented with signs of ischemia	24	80.0
Associated fractures and/or dislocations	26	86.7
Open wound at sites of fractures or dislocations	14/26	53.8
Associated injuries at other parts of the body	9	30.0
Preoperative angiography	10	33.3
Number of patients operated	29	96.7
Preoperative time (hour)	1-72 (median 4)	

gency room. Severity of soft tissue injuries was classified into mild and severe according to degree of muscle, veins and nerve injuries found at operation. Badly injured muscle and/or accompanied veins or nerve was classified as severe soft tissue injuries. Minimal muscle damage without nerve or major venous injury was classified as mild soft tissue injuries. In order to examine the relation of the size of the injured arteries to the amputation rate, the injured arteries were grouped into large and small. Large arteries referred to external iliac, common femoral, and superficial femoral artery. Small arteries referred to popliteal, anterior tibial, posterior tibial, and peroneal artery.

Univariate analysis of factors that may associate with amputation was performed by using Chi Square test. A P-value of <0.05 was considered statistically significant.

Table 2. Associated injuries at other parts of the body

Injuries*	Number of patients (n=9)
Multiple fractures	6
Severe chest injury	1
Severe head injury	1
Ruptured liver	1
Ruptured urinary bladder	1
Bleeding from torn mesentery	1

* Some patients had more than one associated injury.

Table 3. Associated injuries at sites of arterial injuries found at operation

Associated injuries	Number of patients (n=29)
Venous injuries	11
Mild soft tissue injuries	19
Severe soft tissue injuries	10

RESULTS

Thirty patients with 33 arterial injuries were entered in this study. Twelve patients were classified as having large arterial injuries and 18 patients having small arterial injuries. The age ranged from 13 to 50 years, mean 25.8±9.5 years (Table 1). Twenty seven (90%) were males and 3 (10%) were females. Twenty five (83.3%) were admitted to Chulalongkorn Hospital directly while 5 (16.5%) were transferred from other hopitals. Eight patients (26.6%) were in shock on arrival. Twenty four patients (80%) presented with signs of limb ischemia. Twenty six patients (86.7%) had associated fractures and/or dislocations near the injured arteries; of these, 14 (53.8%) had open wound at sites of fractures or dislocations. Ten patients (33.3%) had preoperative angiography. Twenty nine patients (96.7%) were operated on for arterial repair or ligation. The only patient who was successfully treated conservatively had fractures of the tibial plateau and an intimal tear of the popliteal artery demonstrated by angiography. Associated injuries at other parts of the body were present in 9 patients (30%) as shown in Table 2.

Table 4. Treatments of arterial injuries

Arteries	Number of patients (N=30)	Treatments		Amputation (N=5)
Popliteal	14	reversed saphenous vein graft	12	3
		end-to-end anastomosis	1	-
		conservative	1	-
Common femoral	6	end-to-end anastomosis	3	-
		reversed saphenous vein graft	2	-
		Dacron graft	1	-
Superficial femoral	5	end-to-end anastomosis	3	-
		reversed saphenous vein graft	2	1
Anterior tibial	4	reversed saphenous vein graft	3	1
		ligation	1	-
Posterior tibial	1	reversed saphenous vein graft	1	1
Peroneal	1	ligation	1	1
External iliac	1	end-to-end anastomosis	1	-

Table 5. Adjunctive operative procedures

Procedures	Number of patients
Fracture fixation before arterial repair	8
Fracture fixation after arterial repair	10
Venous repair	5
Fasciotomy	15

For patients who were operated, the preoperative time ranged from 1 to 72 hours (median 4 hours). The preoperative time was less than 6 hours in 20 patients (69%). The remaining (31%) had a preoperative time of 6 hours or more. At operation, severe soft tissue injuries were found in10 patients, the remaining (19 patients) had mild soft tissue injuries. Eleven patients had associated venous injuries, 5 of them underwent venous repair (Table 3). Details of the injured arteries, treatments and results are shown in Table 4. Popliteal artery was the most common injured artery (14 patients), followed by common femoral artery (6 patients), superficial femoral artery (5 patients), anterior tibial artery (4 patients), posterior tibial artery (2 patients), external iliac artery (1 patient) and peroneal artery (1 patient). Two patients had more than 1 site of arterial injury. One of them had popliteal artery injury concomitant with posterior tibial and peroneal artery injuries. The other had anterior tibial and posterior tibial artery injuries. Twenty arteries were revascularized by using reversed saphenous vein grafts. End to end anastomosis was employed in 9 arteries. A 8 mm Dacron graft was used in 1 patient who had injury to the common femoral artery. Ligation was performed in 2 patients, 1 had anterior tibial artery injury and the other had peroneal artery injury.

Concomitant fracture fixation was performed in 18 patients. Eight of them had fracture fixation before arterial repair. The remaining (10 patients) had fracture fixation after arterial repair (Table 5). Fasciotomy was performed in 15 patients. Five patients in this study had amputation (4 above knee and 1 below knee amputation), the amputation rate was 16.7 per cent. Details of patients who underwent amputation are shown in Table 6. There was 1 death in this study (mortality rate 3.3%). This patient had injury to the external iliac artery which was successfully repaired. He died from severe head injury.

Univariate analysis by using Chi Square test revealed that associated soft tissue injuries, associated venous injuries, and fasciotomy are statistically significant factors in association with amputation (Table 7).

DISCUSSION

Arterial injuries are major risk factors of limb amputation following extremity trauma. With the exception of high velocity gun-shot injuries

Table 6. Details of patients who were amputated

Variable	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5
Age	30	34	13	19	32
Sex	male	female	male	male	male
Cause of injury	MCA	P	CA	MCA	MCA
Shock	yes	no	no	no	yes
Preoperative time (hour)	6	35	5	4	72
Signs of ischemia	yes	yes	yes	yes	yes
Associated injury at other parts of the body	yes	yes	no	no	no
Preoperative angiography	yes	yes	no	no	no
Associated fractures and/or dislocations	yes	yes	yes	yes	yes
Closed or open fractures	open	open	open	open	closed
Associated soft tissue injuries	severe	severe	severe	severe	severe
Associated venous injuries	yes	yes	yes	yes	yes
Repairing of venous injuries	no	no	no	yes	no
Large or small arteries	small	small	small	small	large
Fracture fixation before or after artery repair	after	before	before	before	after
Fasciotomy	yes	yes	yes	yes	yes

MCA = motor cycle accident; P = pedestrain; CA = car accident

Table 7. Univariate analysis of factors that may associate with amputation

Variables		No. of amputations/No. of patients	P-value
Cause of injury			
motor cycle accident		3/21	
pedestrian		1/6	N.S.
car accident		1/2	
train accident		0/1	
Preoperative angiography			
yes		1/10	N.S.
no		3/18	
Shock			
yes		2/8	N.S.
no		3/22	
Signs of ischemia			
yes		5/24	N.S.
no		0/6	
Injury to large or small artery			
large (EIA, CFA, and SFA)		1/12	N.S.
small (PA, ATA, PTA, and PNA)		4/18	
Associated fractures and/or dislocations			
yes		5/26	N.S.
no		0/4	
Closed or open associated fractures and/or dislocations			
closed		1/12	N.S.
open		4/14	
Associated venous injuries			
yes		5/11	0.003
no		0/19	
Repairing of associated venous injuries			
yes		1/5	N.S.
no		4/6	
Associated soft tissue injuries			
mild		0/19	0.002
severe		5/10	
Fracture fixation before or after arterial repair			
before		3/8	N.S.
after		2/10	
Associated injuries at other parts of the body			
yes		2/9	N.S.
no		3/21	
Fasciotomy			
yes		5/15	0.025
no		0/14	
Preoperative time			
amputation group	4-72 hours	median 6 hours	N.S.
limb salvage group	1-50 hours	median 4 hours	

which usually occur in the battle fields, blunt trauma generally produces more serous injuries and a higher rate of amputation than penetrating injuries[7,8]. Various degrees of soft tissue and/or veins and/or nerve injuries, fractures and/or dislocations, and associated injuries in other parts of the body are usually present in blunt trauma resulting in a more difficult management plan. Furthermore, delayed recognition of arterial injuries frequently occurs in blunt trauma because symptoms of associated fractures and soft tissue injuries may overshadow symptoms of ischemia.

Ischemia following arterial injuries may result from thrombosis or complete avulsion of the injured arteries. Viability of the distal limb depends on collateral circulation. When collaterals are inadequate, permanent damage to muscle and nerve will occur in 6 to 8 hours without revascularization [10,11]. Injury to more proximal arteries such as external iliac artery, common femoral artery, or superficial femoral artery tolerates ischemia better than distal arteries such as popliteal artery and the tibial arteries (anterior tibial, posterior tibial, and peroneal artery) owing to more collaterals of the proximal arteries. Surgical repair to restore perfusion of the distal limb should be performed whenever arterial injuries are diagnosed. When ischemia is obvious or ischemic time is prolonged, operation should be performed without preoperative angiography[12]. In such circumstances, if angiography is still needed for proper management plan, intraoperative angiography may be performed. When viability of the limb is good, preoperative angiography may be performed to obtain a precise location and pattern of arterial injuries and provide a more appropriate management plan[12-14]. Preoperative angiography is invaluable when there are more than one possible sites of arterial injuries such as in patients who had multiple fractures in the same limb. However, if the limb is severely ischemic, vascular exploration should be performed at the most probable site of arterial injury without wasting time for angiography.

Several factors have been claimed to be associated with treatment failure after arterial repair. Among these, distal thrombosis and propagation of thrombus in the distal arterial tree are well known risk factors. We routinely administered 5,000 units of heparin intravenously when arterial injuries were diagnosed, even before performing angiography. Exceptions are those who were contraindicated for heparinization such as those who had associated head or intraabdominal injuries. Preoperative and intraoperative intravenous heparinization in vascular injuries of the extremity has been recommended by several investigators[5,7,12,15].

In patients with associated long bone fractures, the decision to perform arterial repair before or after fracture fixation depends on status of limb viability. When good viability of the limb is present, fracture fixation may be performed first for more convenient subsequent arterial repair[16,17]. In a situation that threatens limb loss i.e. obvious ischemic limb and/or prolonged ischemic time, arterial repair should be performed first. Some vascular surgeons recommend routine initial vascular repair for fear of prolonged ischemic time to the muscle[2,18,19]. However, technical difficulty and thrombosis or disruption of the repaired arteries following subsequent fracture fixation are major disadvantages[7,17]. Temporary intravascular shunt is currently recommended in complex vascular injury of the lower extremity[12,20,21,22]. Perfusion of distal limb is maintained with temporary intravascular shunt while fracture fixation, debridement of badly damaged soft tissue and saphenous veins harvesting for further revascularization with vein graft are being performed. Formal arterial repair can be performed later in a stabilized extremity and unhurried manner.

Treatment of an injured artery depends on site, size, magnitude of injury, and condition of the patient. Generally, end to end anastomosis of the injured artery after resection of the damaged segment is a simple and less time consuming procedure. Unfortunately, most arterial injuries from blunt trauma often produce significant damage to the artery that after adequate debridement, end to end anastomosis without excessive tension is impossible. Revascularization with a reversed saphenous vein graft was the method of choice for superficial femoral artery, popliteal artery and the tibial arteries in this study. Results were satisfactory and previous reports also confirmed this observation [1,5,7,13,21-24]. When an autogenous vein is not suitable or available, a synthetic graft such as polytetrafluoroethylene (PTFE) may be used[22,25]. PTFE gave a satisfactory result in superficial femoral or larger artery injuries but in popliteal or smaller artery injuries, a higher failure rate was obtained[22]. When injuries involve common iliac, external iliac, or common femoral artery and end to

end anastomosis cannot be safely performed, synthetic graft has been used with an acceptable result [25-27]. However, some investigators advocated the use of autogenous veins with a satisfactory outcome[28].

When injuries to the tibial arteries are encountered, management is usually difficult owing to the smallness of the arteries and associated fractures and soft tissue injuries. When only one tibial artery is injured and the foot is viable, ligation can be safely performed[29,30]. Some investigators recommend that a single anterior or posterior tibial artery injury should be repaired but if only the peroneal artery is injured then it may be ligated. When 2 or more tibial arteries are injured, revascularization must be performed irrespective of how good the foot looks[24]. In this study, ligation of the tibial arteries injuries were performed in 2 patients. No ischemic symptom occurred in one patient who had anterior tibial artery ligation which was the only injury to the patient's leg. Amputation was required in another who had peroneal artery ligation, he had compound fractures of the tibia and fibula and also had injuries of the popliteal and posterior tibial artery which were repaired with reversed saphenous vein grafts.

Associated venous injuries are usually found in severely injured limbs[5,7,21,22]. This study has confirmed this observation and also showed that severe soft tissue injuries and associated venous injuries were statistically significant factors associated with amputation. High rate of amputation has been reported in patients who had concomitant arterial and venous injuries[31]. Generally, concomitant venous injuries should be repaired in order to improve venous drainage and prevent venous gangrene or subsequent thrombosis of the repaired arteries[7,21,31,32].

Increased intracompartmental pressure and compartment syndrome are expected complications following revascularization of the injured extremity. This condition occurs more frequently in a badly injured limb or when ischemic time is prolonged. Compartment syndrome may result in mal or non functioned limb or even amputation in spite of successful arterial repair. We routinely performed double-incision fasciotomy in severely injured limbs or when ischemic time was prolonged[9]. Some investigators recommended administration of intravenous mannitol to prevent compartment syndrome[33]. Although acceptable outcome has been reported with intravenous mannitol, we are satisfied with double-incision fasciotomy and do not use mannitol to prevent or treat compartment syndrome. While fasciotomy is a procedure performed to prevent compartment syndrome and decrease risk of amputation, in this study fasciotomy was a statistically significant factor associated with amputation. This can be simply explained: most patients who had fasciotomy in this study had severely injured limbs or prolonged ischemic time.

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การบาดเจ็บต่อหลอดเลือดแดงที่ไปเลี้ยงขาจากภยันตรายชนิดทู่

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ได้รายงานการศึกษาผู้ป่วยจำนวน 30 รายที่มีหลอดเลือดแดงที่ไปเลี้ยงขาได้รับบาดเจ็บจากภยันตรายชนิดทู่ที่เข้ารับการรักษาที่โรงพยาบาลจุฬาลงกรณ์ กรุงเทพมหานคร ตั้งแต่เดือนมกราคม 2532 ถึงเดือนธันวาคม 2538 รวมระยะเวลา 7 ปี มีหลอดเลือดแดงที่ได้รับบาดเจ็บทั้งหมด 33 เส้น ผู้ป่วย 8 ราย (ร้อยละ 26.6) อยู่ในภาวะช็อคเมื่อแรกรับ ผู้ป่วย 28 ราย (ร้อยละ 80) มีอาการของการขาดเลือดไปเลี้ยงขาเมื่อแรกรับ ผู้ป่วย 26 ราย (ร้อยละ 86.7) มีกระดูกหักหรือข้อเคลื่อนใกล้กับตำแหน่งหลอดเลือดที่ได้รับบาดเจ็บ ในจำนวนนี้ 14 ราย มีบาดแผลติดต่อกับบริเวณที่กระดูกหัก ผู้ป่วย 9 ราย (ร้อยละ 30) มีการบาดเจ็บร่วมที่ส่วนอื่นของร่างกาย ผู้ป่วย 10 รายได้รับการฉีดสารทึบรังสีเข้าหลอดเลือดแดงเพื่อวินิจฉัยการบาดเจ็บ ผู้ป่วย 1 ราย ที่มีการบาดเจ็บต่อชั้น intima ของ popliteal artery ได้รับการรักษาด้วยวิธีไม่ผ่าตัดได้ผลดี ผู้ป่วยที่เหลือได้รับการรักษาโดยการผ่าตัด ระยะเวลาตั้งแต่ได้รับภยันตรายถึงการผ่าตัดรักษาอยู่ระหว่าง 1-72 ชั่วโมง เฉลี่ย 4 ชั่วโมง หลอดเลือดแดงที่ได้รับบาดเจ็บที่พบบ่อยที่สุดคือ popliteal artery รองลงมาคือ common femoral, superficial femoral, และ anterior tibial artery ตามลำดับ หลอดเลือดแดงที่ได้รับบาดเจ็บส่วนใหญ่ได้รับการรักษาโดยใช้ reversed saphenous vein graft ผู้ป่วย 5 รายได้รับการซ่อมแซมหลอดเลือดดำที่ได้รับบาดเจ็บร่วมด้วย ผู้ป่วย 18 รายที่มีกระดูกหักร่วมด้วยได้รับการผ่าตัด open reduction และ internal fixation ในการผ่าตัดเดียวกับการผ่าตัดซ่อมแซมหลอดเลือดแดง โดยผู้ป่วย 8 รายได้รับการผ่าตัดซ่อมแซมหลอดเลือดแดงก่อน และผู้ป่วย 10 รายได้รับการทำ internal fixation ของกระดูกที่หักก่อน ไม่มีผู้ป่วยรายใดในรายงานนี้ได้รับการใส่ intravascular shunt ผู้ป่วย 15 รายได้รับการทำ fasciotomy ผู้ป่วย 5 ราย (ร้อยละ 16.7) ถูกตัดขา จากการหาความสัมพันธ์ของปัจจัยต่าง ๆ ที่เกี่ยวข้องกับการถูกตัดขาด้วยวิธี univariate analysis โดยใช้ Chi Square test พบว่า การมีการบาดเจ็บร่วมด้วยต่อหลอดเลือดดำ, การมีเนื้อเยื่อกล้ามเนื้อ เส้นประสาทและเส้นเอ็นบริเวณใกล้เคียงกับหลอดเลือดแดงที่ได้รับบาดเจ็บเสียหายมาก, และการทำ fasciotomy มีความเกี่ยวข้องกับการถูกตัดขาอย่างมีนัยสำคัญทางสถิติ ผู้ป่วย 1 รายซึ่งได้รับบาดเจ็บต่อ external iliac artery เสียชีวิตจากการบาดเจ็บร่วมอย่างรุนแรงที่ศีรษะ คิดเป็นอัตราตายของผู้ป่วยในรายงานนี้ร้อยละ 3.3

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