MANAGEMENT OF POPLITEAL ARTERY INJURY: A PROSPECTIVE ANALYSIS OF POSTOPERATIVE OUTCOME AND PREDICTORS OF SUCCESS

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ABSTRACT:

Objective: To evaluate the outcome after management of popliteal artery injury and to identify the predictors of its success.

Patients and Methods: A prospective analysis of cases of popliteal artery injury that were admitted to Minia University Hospital from January 2009 to December 2011 was done. The collected data were about vital status, demographic data, clinical presentation, type of injury, type of surgery, time of operation, operative techniques, their outcome, immediate or late and complication. Arterial repair was performed according to the type of arterial injury either by end to end anastmosis, venous patch graft or saphenous vein graft.

Results: In a prospective study, the outcome of 24 cases with popliteal artery injury was analyzed. The most common mechanism of trauma was motor car accident (54.2%) and the most common hard sign of vascular injury was distal ischemia manifested by coldness, loss of motor power and absent pedal pulses in (50%) of cases. The artery showed complete cut in (62.5%) of cases. Fasciotomy was done intraoperatively in (62.5%) of cases. End to end anastmosis performed in (25%) of cases, reversed saphenous vein graft in (62.5%) and vein patch was performed in 12.5%. Death was reported in 2 patients (8.3%), amputation was done in 5 patients (20.8%), wound infection occurred in 9 patients (37.5%), and re-explortation was indicated in 3 patients (12.5%).

Conclusion: Delayed diagnosis and blunt or penetrating trauma associated with severe soft tissue injury is the cause of high rate of amputation in popliteal artery trauma. Multi-disciplinary team work, intra-luminal shunting, debridement and re-debridement, use of prophylactic heparin whenever possible and urgent attitude of management are the mainstay of acceptable limb salvage.

KEYWORDS:

Popliteal artery Injury Trauma
Ischemia Limb salvage.

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INTRODUCTION:

Vascular injuries of the extremities remain a major cause of limb loss if not treated early and competently[1]. Although popliteal artery constitutes 5-19% of all extremity arterial injuries in civilian life; it has the highest rates of amputations amongst all lower extremity vascular injuries. The

reduction in amputation rate reported by many authors is mainly related to penetrating trauma,[3] and most civilian series of blunt injuries still report a substantial amputation rate[4].

In blunt trauma, the high amount of energy that is typically absorbed causes severe damage to skeletal structures and soft tissues,[5] and frequently produces almost complete distal ischemia, because the crushing injury and soft tissue swelling obliterate the frail arterial collateral network around the knee[6]. In addition, the traction injury that causes the popliteal lesion usually results in severe spasm of the collateral circulation and distal arteries[7]. This clinical subgroup is associated with the highest morbidity among all blunt popliteal artery injuries, with an amputation rate as high as 60%[8]. Often the effect of ischemia produced by the initial trauma is further worsened by delayed revascularization, which results in exceeding the allowable warm ischemic time for skeletal muscles. Reasons for this delay include transference of patients from one hospital to another, and delay in diagnosis, preoperative resuscitation and evaluation, stabilization of extremely unstable associated fracture, repair of associated venous injury, and debridement of damaged soft tissue[9]. Although a substantial portion of this delay is beyond our control, rapid revascularization should remain the main goal in treating blunt trauma, to prevent irreversible ischemic damage to soft tissues.

In literature, several factors are important for determining the rate of limb salvage in popliteal vascular injuries: (1) early diagnosis and prompt treatment, (2) penetrating sharp injuries with minor soft tissue damage; (3) resection of damaged arterial tissue with end-to-end anastomosis or saphenous vein grafting in conjunction with the liberal employment of local heparin and a Fogarty catheter thrombectomy, (4) repair of concomitant popliteal venous injuries; (5) use of completion arteriography to reveal technical errors amenable to correction at time of operation; and (6) fasciotomy[10-13].

The aim of this study was to evaluate the outcome after management of popliteal artery injury and to identify the predictors of its success.

PATIENTS AND METHODS:

Patient Selection and Study Design:

This study was a prospective analysis of cases of popliteal artery injury that were admitted to Minia University Hospital (MUH) from January 2009 to December 2011. The patients were included in this study if they had history of penetrating or blunt trauma to knee joint; patients with hard or soft signs of vascular injury and patients with iatrogenic injury to popliteal artery.

The exclusion criteria were: electric injury or extensive burn; patients presented with time interval more than 24 hour and patients in need of primary amputation (the decisions were taken by the comity of vascular plastic and orthopedic surgeons).

History taking regarding age, sex, comorbidities, medications, time and mechanism of trauma, amount of bleeding and first aids. Clinical examination of the injured patient including pulse, BP, RR, systematic examination (head and neck, chest, abdomen, back, upper and lower limbs) was done. Special emphasis for evaluation of the injured lower limb

regarding its temperature, motor and sensory affection, pedal pulses, color changes, hematomas, fractured bones, bleeding and auscultation for bruit. Patients were resuscitated according ABCD system before transfer to either operating room or radiology unit.
Patients presented with hard signs of popliteal artery injury were transferred to OR directly after orthopedic evaluation and X rays, while others who showed soft signs were evaluated using Doppler US and in special cases angiography was done.

Surgical Technique:

The medial approach to the popliteal artery was performed preferably. Rapid control and wide exposure was performed by division of S.G.S muscles which were reconst-ructed at the end of procedure. The injured popliteal artery was identified, and severed ends were located, freed of surrounding tissue for 2-3 cm, geniculate collaterals were not being divided to achieve mobility because of the detrimental effect this may have on limb perfusion and ends were controlled with vascular clamps.

This was followed by debridement of the damaged vessel ends, application of vessel loops around the proximal and distal arterial segments, balloon catheter thromb-ectomy, and infusion of heparinized saline solution (5000U/L) in both the proximal and distal ends. Patients who had partial injury of popliteal artery, adequate debridement of the diseased segment, balloon catheter thromb-ectomy and infusion of heparinized saline solution (5000U/L).Cases with delayed presentation and need bony fixation a polyvinylchloride endotra-cheal suction catheter of suitable size was used as a temporary shunt. The shunt was inserted proximally, and the vessel loop was drawn tight around the catheter to prevent leakage. Then the catheter was flushed to remove air and intra-luminal debris by removal of the proximal vascular clamp. The distal end was then inserted and controlled in the same way. The vein was also shunted, if injured, in a similar manner, but starting with distal end first. Pulsation in the arterial segment distal to the shunt ensured adequate functioning of the shunt. Monitoring of the shunt during the remainder of the procedure was achieved by observing the distal pulses or by Doppler examination of the foot, and, if necessary, through direct examination of the shunt. Fasciotomy, debridement of devitalized tissues, fixation of fractures, harvesting of contra-lateral saphenous vein graft, and repair of venous injury were performed while the shunt was in place. The shunt was then removed from the distal arterial end, to allow plication of the venous graft over it before reinsertion to perform the proximal anastomosis while the shunt was still in place. A two-incision, four-compartment fascio-tomy was performed in patients with clinical evidence of increased compart-mental pressure, in patients with combined arterial and venous injury and in those with severe sensory and motor deficit or severe soft tissue injury in the leg in the absence of increased compartment tenseness. Hypertonic mannitol solution was infused peri-operatively in all patients, starting with a bolus of 25 g before revascularization, usually with induction of anesthesia, followed by continuous infusion of 5 to 10 g/hr during the remainder of the surgical procedure. Arterial repair was performed according to the type of arterial injury either by end to end anastmosis, venous patch graft or saphenous vein graft. End-to-end

anastomosis was preferred if it could be done without undue tension but it was generally not possible if more than 2 cm of artery was lost. Surgical repair was not considered complete until distal perfusion is clearly documented with palpable pulses in the feet or using hand held Doppler.

Follow up regarding general condition (Pulse, BP, Temp., RR, pallor) and vital state of the repaired limb (warmth, color changes, motor power, pedal pulses and muscle turgor).

Hand held Doppler was used in all patients; however duplex examination was used in some patients. The data were recorded about vital status, demographic data, clinical presentation and type of injury, type of surgery, time of operation, operative techniques, blood loss, patient outcome, immediate or late and complication.

RESULTS:

The prospective analysis of 24 cases with popliteal artery injury treated over a period of 3 years showed that most of cases were males (75%), of age between 20-40 years and the most common mechanism of trauma were road traffic accident (54.1%) (Table1).

The clinical presentation and methods of diagnosis of the studied patients are shown in (Table 2). The presenting hard signs of vascular injury were active bleeding in (50%) of cases, absent distal pulse and expanding haematoma in (25%) each, while the presenting soft signs of vascular injury were fracture dislocatin of nearby joint and history of bleeding in (25%) each. Patients were directly transferred to OR in (50%) of cases while duplex scan was performed preoperatively in (50%) of cases and it was conclusive in (37.5%), and pre-operative angiography was performed in 3 cases (12.5%), (Figure 1). The upper popliteal segment was injured in (75%) of cases while lower segment and trifurcation were injuried in (12.5%) each. Most of cases (75%) had associated musculoskeletal injury. Combined arterial and venous injuries were found in 9 cases (37.5%).

Operative data of the studied patients are shown in (Table 3). The artery showed complete cut in (62.5%) of cases, partial cut in (25%) of cases while it was contused in (12.5%) of the patients. Fasciotomy was done intraoperatively in (62.5%) of cases and post operatively in (12.5%) of cases. End to end anastmosis performed in (25%) of cases, reversed saphenous vein graft in (62.5%) and vein patch was performed in 12.5%.

Postoperative outcome of the studied patients is shown in (Table 4). Amputation was done in 5 patients (20.8%), wound infection occurred in 9 patients (37.5%), and re-explortation was indicated in 3 patients (12.5%). Patients who had amputation, showed profound ischemia at presentation (4 patients), combined arterial and venous injuries (2 patients), musculo-skeletal injuries (3 patients) and 4 patients had fasciotomy.

Table 1: Demographic data and mechanism of trauma in the studied patients.

Variable	No. of cases (Total = 24)	Percent (%)
Age groups:		
- <20 years	6	25%
- 20-40 years	12	50%
- 40-60 years	3	12.5%
- >60 years	3	12.5%
Sex:		
-Male	18	75%
-Female	6	25%
Mechanism of trauma:		
-Motor car accident	13	54.1%
-Firearm injury	6	25%
-Penetrating sharp object	5	20.8%

Table 2: Presentation and methods of diagnosis of the studied patients.

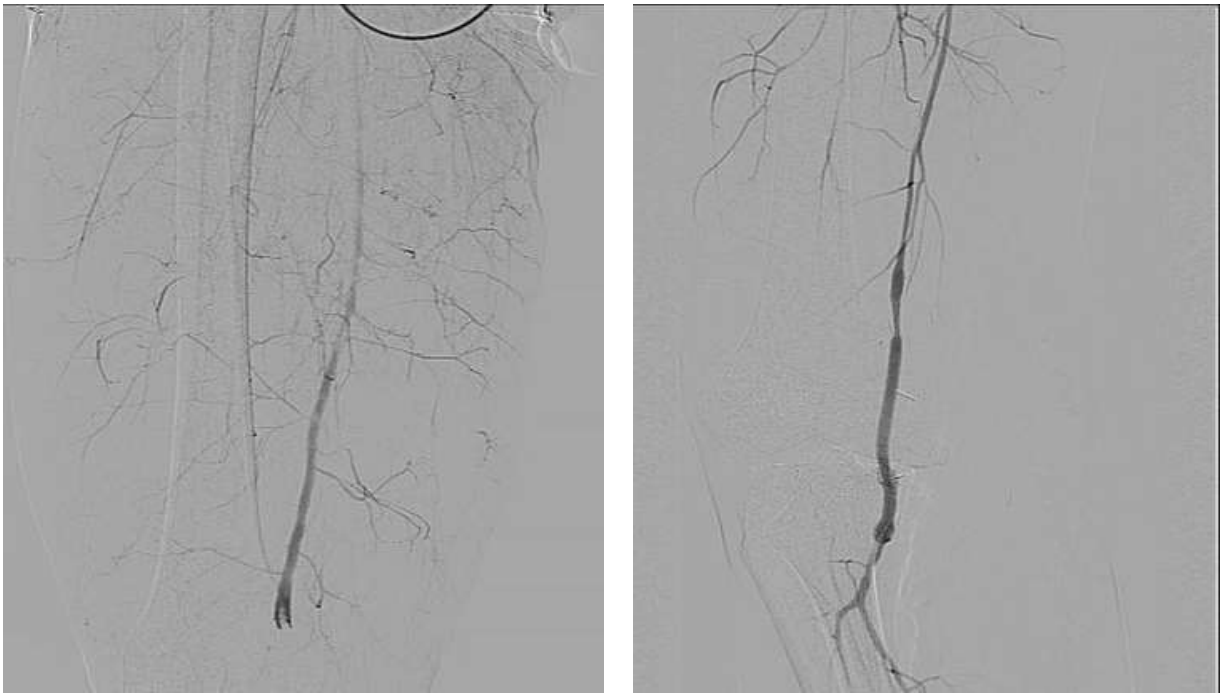
Variable	No. of cases (Total = 24)	Percent (%)
Clinical presentation:		
I-Hard signs:		
- Distal ischemia, absent pedal pulses	7/12	58%
- active bleeding	2/12	17%
- Thrill or bruit	1/12	8%
Expanding hematoma	2/12	17%
II-Soft signs		
-Diminished distal pulse	6/12	50%
-Fractured knee joint	2/12	17%
-History of bleeding	3/12	25%
Non expanding hematoma	1/12	8%
Methods of diagnosis:		
-Clinical	12/24	50%
-Doppler US	9/24	37.5%
-Angiography	3/24	12.5%
Ischemic time:		
- Less than 6 hour	16/24	66%
- 6-24 hours	8/24	33%

Table 3: Pathology of arterial injury.

Variable	No. of cases (Total = 24)	Percent (%)
- Complete cut.	15	62.5%
- Partial cut	6	25%
- Contusion	3	12.5%
Type of arterial repair:		
-Reversed saphenous graft	15	62.5%
- End to end anastmosis	6	25%
-Vein patch	3	12.5%
Fasciotomy:		
-Intra opertative fasciotomy	15	62.5%
-Post operative fasciotomy	3	12.5%
-No fasciotomy	6	25%

Table 4: Postoperative outcome and its predictors in the studied patients.

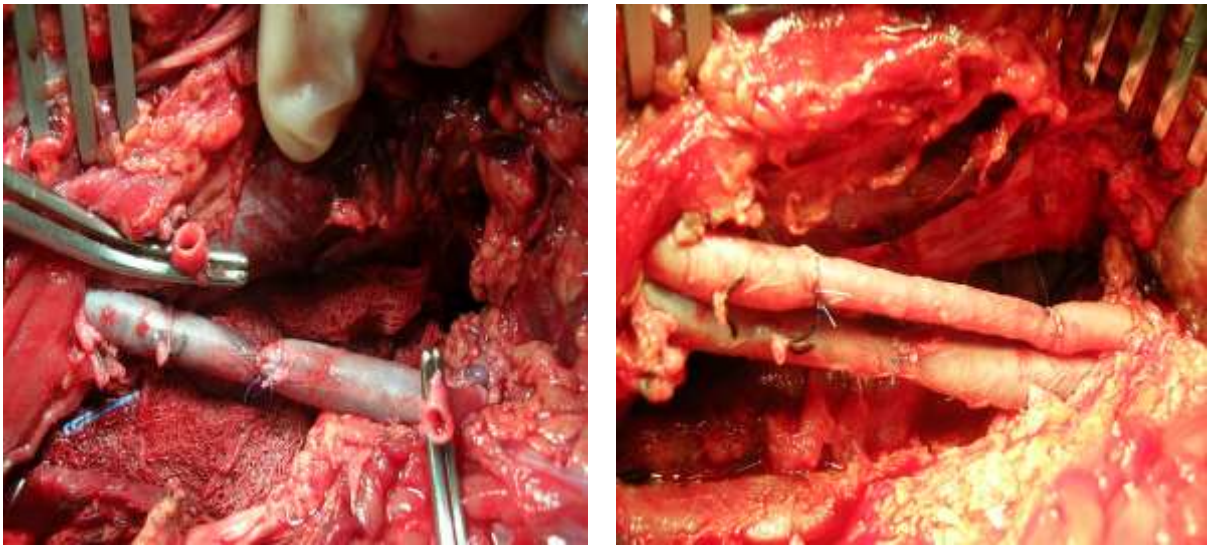
Variable	No. (%) Total= 24	Profound ischemia	Venous injury	Musclo-skeletal injury	Fasciotomy	Blunt trauma
Amputation	5 (20.8%)	4	2	3	4	5
Wound infection	9 (37.5%)	5	4	6	3	5
Re-exploration	3 (12.5%)	2	2	1	2	2



(A) (B)

Figure 1: (A): Preoperative right lower extremity arteriogram demonstrating popliteal artery injury. **(B):** Postoperative right lower extremity arteriogram demonstrating patent size-matched bypass graft.

Figure 2: Preoperative photography of a case with popliteal artery injury associated with musculoskeletal injury.



(A) (B)

Figure 3: (A): photography of a case with popliteal artery injury. (B): The same case after repair of popliteal artey and vein.

DISCUSSION:

Injury to the popliteal vessels has been recognized as one of the most limb-threatening peripheral vascular injuries as long as vascular trauma has been studied[7]. The current study represents a prospective analysis of patient characteristics, mechanisms of injury, methods of diagnosis, methods of treatment and predictors of postoperative outcome after management of acute traumatic popliteal artery injuries. Regarding age and sex of the patients, our results were similar to other reports showing that young males are affected more than other groups[8,9]. In this study, 75% of the patients were male, and 50% had age between 20-40 years.

Most of the vascular injuries in this study (54.1%) had resulted from blunt trauma. The mechanism of trauma in these injuries varies in different parts of the world[10-12]. In USA penetrating trauma accounts for >80% of vascular injuries, and the majority were due to gunshot wounds[13].

In this study 50% of cases were transferred directly to operative room as they had signs of arterial injury while angiography was used for diagnosis in 12.5% of cases. The role of angiography in trauma is controversial. Formal angiography usually results in a delay of 1−2 h and should be reserved only for patients with reasonable distal perfusion[13]. Abou-Sayed and Berger[14] concluded in their review that patients with hard signs of arterial insufficiency should either undergo emergency intervention or preoperative angiography, depending on the severity of ischaemia.

In the present study, duplex or Doppler was used in 50% of cases and it was conclusive in (37.5%). The use of Doppler ultrasound in vascular trauma had been studied by several authors as an alternative to angiography, especially in penetrating injury[15]. Although duplex has many obstacles in the injured limbs with

skeletal deformity, swellings, hematomas, bulky splints and dressings, and the lack of availability of the necessary skill and expertise, it still has a major role in vascular trauma[16]. Systemic anticoagulation with heparin may prevent development of thrombosis at small distal vessels and provides significant benefit for saving the extremity[17]. Thus, the success likelihood of the revascularization increases. However use of heparin may be contraindicated because of head injury, pelvic or intra-abdominal bleeding[5]. We applied diluted heparin to the vascular bed instead of systemic heparin which was shown to be also effective[11]. Fogarty catheter is effective for removing thrombus from large vessels. However this is not the case at microvascular level. Systemic heparinization should be initiated as early as possible in order to prevent the spread of thrombosis through microvascular level[10]. Also heparin has beneficial effect against reperfusion injury[18].

In cases with combined arterial and skeletal injury, the current consensus is that vascular repair should take precedence over skeletal reconstruction[19,20]. However, in rare instances when very unstable skeletal injuries exist and the subsequent orthopaedic manoeuvre may affect the vascular reconstruction, orthopaedic stabilization should be performed first. In this setting, temporary intraluminal shunts should be inserted to restore blood perfusion before definitive vascular reconstruction is performed[16,21].

In this study, fasciotomy was done intraoperatively in (62.5%) of cases and post operatively in (12.5%) of cases. Other investigators reported that fasciotomy has been performed as an adjunctive procedure in up to 80% of patients undergoing vascular repair[22]. It is often undertaken empirically or prophylactically, based on clinical assessment in patients at risk of compartment syndrome. However, controversy about the timing of the fasciotomy and the role of intracompartmental pressures remain[23]. Field et al. advocated prophylactic fasciotomy, even in the absence of signs of compartment syndrome, in patients with massive venous stasis, popliteal artery and vein injury, arterial or major vein ligation, failed arterial reconstruction, prolonged shock, massive tissue swelling and ischaemia time >6 h[24]. This study showed that delayed presentation of popliteal artery injury (greater than 6 hours), associated musculoskeletal and venous injury were associated with high amputation and worse outcome after management. Limb loss following lower extremity arterial injury has been variously ascribed to extent of tissue damage, duration of ischaemia before revascularisation, associated venous injuries and development of compare-tment syndrome[25-27]. Several studies have determined factors affecting amputation rates after popliteal artery trauma; time to revascularisation is one of these factors[8,27-30]. Dar et al.,[27] showed that revascularisation later than 12 h after injury is associated with a higher amputation rate. However, a recent study by Simmons et al.,[31] revealed that time from injury to repair of greater than 6 hours was not predictive of amputation. The study by Moini et al.,[8] concluded that revascularisation can be successful for patients who retain only one foot movement, and those authors recommend revascularisation also for cases presenting late and with complete motor deficit below the knee, but without mottling.In the present study, higher amputation rates were observed in

blunt trauma, as compared to penetrating injury. Frykberg in his review of 24 published civilian popliteal artery injuries from 1975 to 1998 noted that penetrating trauma resulted in only a 10.5% overall amputation rate, whereas blunt trauma resulted in amputation in 27.5% of all cases,[16]. It is well-known that beside blunt injury; high-velocity injuries also are associated with higher amputation rates because of the greater soft-tissue and bony damage[32]. In conclusion, popliteal artery injury is a very critical limb threatening condition specially when associated with severe musculoskeletal injury and when presented late with profound ischemia. Proper management, which includes attention to minimising delay, repair of venous injury, careful technique and appropriate fasciotomy, can result in substantial improvement in the rate of limb salvage. The co-ordinated multidisciplinary team work and urgent attitude of management can achieve very acceptable limb salvage.

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علاج إصابات الشريان المأبضي:
تحليل نتائج ما بعد الجراحة ومؤشرات نجاحها

الهدف من الدراسة: تقييم نتائج ما بعد الجراحة التي تجرى لعلاج إصابات الشريان المأبضي و تحديد مؤشرات نجاح تلك العمليات الجراحية.

المرضى وطرق البحث: الدراسة عبارة عن تحليل لحالات إصابة الشريان المأبضي في الفترة من يناير 2009 وحتى ديسمبر 2011 بمستشفى جامعة المنيا. تم تسجيل بيانات المرضى محل الدراسة بما فيها العلامات الحيوية، البيانات الديموجرافية، الأعراض الإكلينيكية، نوع الإصابة، نوع العملية الجراحية، مدة إجراء العملية الجراحية، التقنية الجراحية المتبعة، معدل فقدان الدم، والمضاعفات الفورية أو المتأخرة إذا ما وجدت. تم إصلاح إصابات الشرايين طبقا لنوع الإصابة سواء بوصل نهايتي الشريان أو بإضافة رقعة وريدية من الوريد الصافنى إلى الشريان المأبضي.

النتائج: شملت الدراسة 24 حالة بإصابات الشريان المأبضي، وكانت حوادث الطرق أكثر الأسباب المؤدية إلى تلك الإصابات (54,1٪). ظهرت علامات الإصابة الحرجة في صورة قصور شديد فى الدورة الدموية للساق. (50٪) من الحالات. وتم إجراء التدخل الجراحي في أغلبهم بعد مرورأقل من 6 ساعات على الإصابة (66٪)، وقد عانى أكثر المرضى (62,5٪) من قطع تام بالشريان المأبضي. أجري وصل طرفي الشريان بإضافة رقعة وريدية من الوريد الصافنى (62,5٪) من الحالات. كان معدل الوفاة المتأخرة بعد إجراء العمليات الجراحية (8,3٪)، وتم إجراء بتر الأطراف في (20,8٪). كان معدل الإصابة بالتهاب الجروح (37,5٪)، وتم إعادة استكشاف الجرح في (12,5٪). و قد لوحظ أن معظم المرضى الذين استدعت إصاباتهم إجراء بتر للأطراف (5 مرضى) أنهم كانوا يعانون من نقص مفرط للتروية الدموية (4 مرضى)، لديهم إصابات مزدوجة بالشرايين و الأوردة (مريضان) ولديهم إصابات بالعظام و العضلات (3 مرضى)، كما صاحب الإصابات الناتجة عن صدمات رضية كلية نتائج جراحية سيئة.

الاستنتاج: تأخر التشخيص و الصدمات الشديدة وإصابة الانسجة الرخوة والتلوث هي الأسباب الرئيسية المحتملة لارتفاع معدلات بتر الأطراف بعد إصابة الشريان المأبضي، ويمثل وجود فريق طبي متعدد التخصصات والتدخل الجراحي العاجل الدعامة الأساسية لإنقاذ أطراف هؤلاء المرضى من البتر.