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Clinical Patterns and Outcomes in Patients After Penetrating Lower Limb Vascular Injury in Taiz, Yemen

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ABSTRACT

Background: Popliteal arterial injury is associated with a high risk of limb loss of any peripheral vascular injury. The purpose of this study was to review our experience with complex penetrating popliteal arterial injuries, thereby focusing on initial presentation and early outcomes.

Methods: We conducted a retrospective study of 85 patients with popliteal arterial injuries who underwent surgical treatment from 2015 to 2019 at Authority of Althawra hospital in Taiz, Yemen. Variables were retrospectively collected included patient demographics, mechanism and type of injury, limb ischemia time, clinical status at presentation, type of vascular reconstruction, associated complications, limb salvage, and mortality.

Results: Reconstructions were performed for 85 patients with penetrating popliteal arterial injuries, consisting of 78 (92%) males and 7 (8%) females with an age range 3–75 years with a mean of 27.7 ± 12 years. There were 71 (83.5%) penetrating gunshot high-velocity injuries, and 14 (16.5%) blast injuries. Nearly more than half 54 (63.5%) of the patients sustained complex popliteal vascular injuries (arterial and venous injuries) and 31 (36.5%) isolated arterial injuries. Management of popliteal arterial injury was repaired by saphenous venous interposition graft in 68 (80%), end-to-end anastomosis in 16 (18.8%), and venous patch in 1(1.2%). Venous injury was repaired in 40 (74%) and ligated in 14 (30%). Less than 6 hours' time from injury to completed revascularization was achieved in 46 (54.1%) patients. The overall fasciotomy was 28 (33%) which significantly increased the length of hospital stays (17 days vs 6 days, P= 0.0003). The overall limb-salvage rate in our study was 93%. During study period, the most common complication was 14 (16.5%) graft thrombosis, 12 (14.1%) wound infection, 12 (14.1%) compartment syndrome, 7 (8.2%) lower limb edema. Early limb loss occurred in 6 (5.8%). In our study, amputation rate was 6 (7%) and mortality rate was 1 (1.2%).

Conclusions: Wartime penetrating PAI is complex dilemma and associated with a high rate of amputation. However, team approach and promptly vascular repair found to associate with remarkable limb salvage rate 93%. This study represents the clinical pattern and early outcomes of popliteal arterial injuries during the contemporary war in Taiz, Yemen. We found that wound and graft infection, graft thrombosis, and the need for embolectomy are significantly had high risk for amputation.

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Introduction

The popliteal artery injury (PAI) is the second most commonly injured vessel in the lower extremity in which its injury remains a challenging entity and is frequently associated with high levels of morbidity and poor rates of limb salvage compared with other vascular injuries [1,2]. There is a wide variation in the incidence, cause, and mechanism of vascular trauma depending on the local conditions.

In the current warfare conditions, vascular trauma represents 7-10% of total battle injuries [3-5]. PAI account for about 5-19% of extremity arterial injuries in civilians while in the military setting, the reported incidence of vascular injuries has changed significantly since World War I (WWI) [6,7].However, the rate increased to 12% during the recent tours in Afghanistan and Iraq. Of these injuries, 66% occurring in the lower extremities of which PAI constitute 50% to 60% of all extremity arterial injuries and had an increased rate of secondary amputation, probably as a result of the associated soft-tissue injuries that accompany improvised explosive

device (IED) injury patterns [8-12]. However, PAI has the highest rates of amputations among all lower extremity vascular injuries. Despite technical advancements and the lessons learned during the war era the associated amputation rates are high (10-16%) although in the military population remain at approximately 30%, whereas range between 14.5-25% in the literature for civilians [13,14,15,16-18,19].

The purpose of this study was to review our experience with penetrating PAI in Taiz, Yemen, thereby focusing on initial presentation, surgical management, and early outcomes and to highlight lessons learned from that period.

Materials & Methods

Data Collection

The study was approved by the local ethics committee. We conducted a retrospective study of 85 patients with PAI who underwent surgical treatment from 2015 to 2019 at Authority of Althawra hospital in Taiz, Yemen. Variables were retrospectively collected included patient demographics, mechanism and type of injury, limb ischemia time, clinical status, type of vascular reconstruction, associated complications, limb salvage, and mortality.

Exclusion Criteria

Any of the following was considered criteria for exclusion: isolated popliteal venous injury (PVI), presented with late complications of PAI (pseudoaneurysms and arteriovenous fistulas), primary traumatic amputation associated with PAI, blunt PAI, iatrogenic PAI, and incomplete or missed file data during the study period.

Diagnosis and Surgical Management

The diagnosis of PAI was based on clinical and radiologic examination (presence of peripheral pulses, time of revascularization, color, and temperature) combined with preoperative imaging, including standard radiographs of the knee in two planes, the use of a handheld duplex scanner, we were unable to send patients for computed tomography angiography because of limited sources in the city related to war. Time of limb ischemia was defined as time from injury to revascularization. Limb salvage was defined as the presence of a viable limb at 1 month after injury, regardless of functional outcome. Operative exploration of injured vessels was performed via standard incisions, distal and proximal control, and unfractionated heparin was applied for anticoagulation at the beginning of the vascular repair. Fogarty catheter embolectomy was performed if necessary to ensure physiologic inflow and unobstructed distal flow. Arterial repair methods included end-to-end anastomosis, interposition vein grafting, or patch. Prosthetic graft was not used in our study. Deep venous injuries were repaired rather than ligated if patients were hemodynamically stable and when judged necessary. Venous return was restored after arterial repair. Vascular reconstruction was performed before orthopedic stabilization whenever possible. We did not use temporary intravascular shunting (TIVS). We routinely performed calf fasciotomy (4 compartments via 2 incisions), when compartment syndrome was anticipated. Compartment syndrome was based primarily on the clinical finding of tense calf swelling. Compartment syndrome was based primarily on the clinical finding of tense calf swelling.

Post-Operative Follow Up

Postoperatively, the injured lower limb was kept elevated and wrapped with a compression bandage. Early ambulation was encouraged. All patients received antibiotics, which were continued postoperatively for 3–5 days unless prolonged use was dictated by the presence of obvious contamination or infection. Low molecular weight heparin was administered throughout hospital confinement. Antiplatelet therapy with 100-mg acetylsalicylic acid was given routinely for 90 days postoperatively. Complications and outcomes were reviewed through OPD appointment and telephone survey.

Statistical Analysis

Numerical values were expressed as mean ± standard deviation. Continuous data were compared with unpaired Student's t-tests. All statistical analyzes were performed using SPSS Statistics 24.0. Variables were compared by using analysis of Chi-square analysis or Fisher exact test. P- values ≤ 0.05 were considered statistically significant.

Results

During the period 1015–2019, 125 patients were surgically treated for injuries of the popliteal vessels. Forty patients were excluded from the study, as they were not candidates for the inclusion criteria. Among them: isolated venous injury (18 patients), blunt injury (one patient), iatrogenic injury (one patient), late presentations; including the delayed aneurysms (3 patients), and arteriovenous fistulas (one patient), branches injury (5 patients), and incomplete file data (11 patients). We analyzed 85 patients with PAI.

Demographics

Mean age was 27.7± 12 years and the majority of patients were males 78 (92%). There were 71 (83.5%) patients who sustained penetrating injury due to high-velocity gunshot and 14 (16.5%) were blast injuries (Table 1).

Table 1: Characteristics of the Patients with Surgically Treated Popliteal Arterial Injuries

Total of patients (n = 85)		
Demographics		
Mean (SD)	27.7 (12)	
Median [IQR]	26 [72–75]	
< 30 years	60	70.6
> 30 years	25	29.4
Gender (n, %)		
Male	78	91.8
Female	7	8.2
Mechanism of injury (n, %)		
Gunshot	71	83.5
Blast	14	16.5
Clinical presentation		
Active bleeding (n, %)		
Present	50	58.8
Absent	35	41.2
Distal pulse (n, %)		
Present	6	7.1
Absent		
Shock		
Yes	40	47.1
No	45	52.9
Ischemia > 6 h (n, %)		
Yes	39	45.9
No	46	54.1
Fracture (n, %)		
Yes	50	58.8
No	35	41.2
Fasciotomy (n, %)		
Yes	28	32.9

No	57	67.1
Popliteal arterial injury (n, %)		
Partial transection	26	30.6
Complete transection	57	67.1
Intimal injury	2	2.4
Arterial procedure (n, %)		
End- to- end anastomosis	16	18.8
Interposition grafting	68	80
Vein patch	1	1.2
Thrombectomy	12	14.1
Popliteal venous injury (n, %)		
Yes	54	63.5
No	31	36.5
Venous procedure (n, %)		
End- to- end anastomosis	24	44.4
Interposition grafting	14	25.9
Ligation	14	25.9
Venoraphy	2	3.7
30 days Outcome		
Amputation	6	7.1
Mortality	1	1.2
Limb salvage	79	92.9
Hospital stay mean (SD)	9.8 (9.5)	

Clinical Data

The distribution of soft and hard signs of PAI is 81 (95.3%) patients had both hard and soft signs and 4 (4.7%) patients had only soft signs. Upon ED arrival, 79 (93%) patients were presented with absent peripheral pulse, 50 (58.8%) patients were presented with active bleeding, 40 (47%) patients had shock with the mean systolic blood pressure (SBP) was 96± 18 mmHg, mean blood hemoglobin (Hb) was 10± 2 gm\dl, and 85 (100%) patients had injury in proximity of a major vessels. Regarding hard and soft signs, absent of distal pulses and injury in proximity of a major vessels were the most common. All patients presenting with hard signs on arrival were immediately transported to the operating room for vascular repair. In 38 (44.8%) patients, the signs or symptoms of ischemia lasted > 6 h prior to surgical treatment.

Adjacent concomitant injuries present in 67 (78.8%) patients included bony fractures 50 (58.8%), nerve injury 34 (40%), soft tissue defects requiring reconstruction 23 (27.1%), and 10 (11.8%) associated major body injuries. In orthopedic injuries; 39 (78%) patients required external stabilization, 3 (6%) patients were fixed with open reduction and internal fixation (ORIF), and 8 (16%) patients by back slap.

Surgical Management

Fifty-four (63.5%) patients had combined ipsilateral popliteal arterial and venous injuries and 31(36.5%) patients had isolated PAI. Regarding intra-operative findings, type of PAI were classified into 57 (67.1%) completely transected, 26 (30.6%) partially transected, and 2 (2.4%) contused with thrombosis and/or intimal injury. PVI findings were; 36 (66.7%) completely transected and 21 (33.3%) partially transected.

All PAI were managed with debridement and definitive repair. Optimal technical repair was used for each injury: 68 (80%) reverse saphenous interposition grafting, 16 (18.8%) end-to-end anastomosis, and 1 (1.2%) venous patch. PVI were repaired in 14 (25.9%) saphenous interposition grafting, 24 (44.4%) end-to-end anastomosis, 14 (25.9%) ligation, and 2 (3.7%) venorraphy. Less than 6 hours' time from injury to completed revascularization was achieved in 47 (55.3%) patients this short time of evacuation because the site of fighting is near our hospital.

The median time between injury and revascularization was 5 hours' (IQR, 2–14). The time to revascularization was not statically different among the categories age (p = 0.393), sex (p = 0.413), mechanisms of injury (p = 0.256), and fractures (p = 0.393). The mean time to revascularization was 5.5 h [IQR, 2.5–7] when active bleeding was present and 6 h otherwise (p=0.299), and 5.7 h when distal pulse was absent and 5.67 h otherwise (p = 0.905).

The overall fasciotomy was 28 (33%) of which 16 (57%) were prophylactically done immediately post vascular reperfusion and 12 (43%) were therapeutic done after clinical diagnosis of compartment syndrome. Patients with a fasciotomy had an amputation rate of 4.7% (4 patients) while the patients without fasciotomy had 2.4% (2 patients) amputation rare so the probability of amputation was nonsignificant when a fasciotomy is required (P = 0.088).

Outcome Assessment

The overall limb-salvage rate in this study was 93%. Complications in the survival group were 14 (16.5%) graft thrombosis, 12 (14%) wound infection, 12 (14%) compartment syndrome, 7 (8.2%) lower limb edema, 6 (7%) above-knee amputations (AKA), 5 (5.9%) bleeding and\or hematoma collections, 4 (4.7%) graft infection, 2 (2.4%) anastomotic aneurysm, and pulmonary embolism and acute kidney injury developed in one case for each (Table 2).

Table 2: 30-Days postoperative Complications, patients, n = 85

Postoperative complications	n	%
Graft thrombosis	14	16.5
Wound infection	12	14
Compartment syndrome	12	14
Significant Lower limb edema	7	8.2
Secondary amputations(AKA)	6	7
Bleeding and\or hematoma	5	5.9
Graft infection	4	4.7
Limb gangrene	4	3.9
Ligation of graft	3	2.9
Anastomotic Aneurysm	2	2.4
Pneumonia	2	2.4
Myocardial infarction	1	1.2
Acute kidney injury	1	1.2
pulmonary embolism	1	1.2

The overall amputation rate of the affected limb was 7% (6 patients) after revascularization. Among them 2 patients were associated with massive soft-tissue injuries and preoperative neurologic impairment in the injured limb. In-spite of good vascular repair, patients had recurrent infection and sensory and motor loss; they later developed wounds infection and did not regain motor or sensory function in the reconstructed limb. Two patients had failed revascularization and the last 2 patients had severe infection and graft thrombosis. Details about patients undergoing amputations are summarized in Table 3.

Table 3: Popliteal Arterial Injuries Requiring Amputation

Patient	No 1	No 2	No 3	No 4	No 5	No 6
Age (years)	20	25	33	3	60	18
MOI	Gunshot	Gunshot	Gunshot	Blast injury	Gunshot	Blast injury
Fracture location	Proximal tibia & fibula	Distal femur	Proximal tibia	Proximal tibia	Distal femur	-
Popliteal vessels injury	Artery/vein	Artery/vein	Artery/vein	Artery	Artery/vein	Artery/vein
Ischemic time (hours)	8	6	14	5	12	7
Method of repair popliteal artery\ vein	RSVG\ Ligation	RSVG\ Ligation	RSVG\ Ligation	RSVG	RSVG\ SVG	RSVG\ SVG
Nerve injury	Tibial nerve	Tibial nerve	Tibial nerve	-	Sciatic nerve	Sciatic nerve
Complication	Graft thrombosis	Wound & Graft infection, Graft thrombosis	Compartment Syndrome	Bleeding, Graft infection, Graft thrombosis	Wound infection, Graft thrombosis, limb edema	Bleeding, Wound & Graft infection, Graft thrombosis, Compartment syndrome, pseudoaneurysm
Re-operation	Embolectomy	Embolectomy 3 times	Fasciotomy	Embolectomy	Embolectomy, Regraft after 36 days, of Graft ligation after 40 days	Embolectomy, Regraft twice after 20 days, Graft ligation after 26days
Reason for AKA	Failed revascularization	Infection	Failed revascularization	Large tissue defect	Large tissue defect & Infection	Infection and sepsis
Time of amputation (days)	2	37	2	5	40	35
Hospital LOS (days)	20	9	7	10	45	40

Patients undergoing amputation were similar in age to patients not undergoing amputation (mean 26.5 and 27.8 years, respectively). The amputation rate was 5.9% in males (5 patients) and only 1 out of the 7 females in our study underwent amputation (5.9%). However, this difference did not reach statistical significance ($p = 0.413$).

The amputation rate was not statistically significantly in patients with active bleeding, absent pulse, or time of ischemia > 6 h and associated fracture ($p = 0.481$, $p = 1$, $p = 0.43$, $p = 0.393$, respectively). The six patients with amputation had arterial repair with interposition grafting. The amputation rates among the types of arterial procedures did not reach statistical significance ($p = 0.395$). Differences in the amputation rate between patients with and without associated PVI did not reach statistical significance ($p = 0.409$). Three patients with PVI and ligation of the ipsilateral popliteal vein underwent amputation, although venous ligation did not reach statistical significance ($p = 0.054$).

We found that wound infection, graft infection, graft thrombosis, graft ligation, and the need for embolectomy were statistically significantly associated with the risk of limb amputation ($p= 0.034$, $p = 0.001$, $p = 0.006$, $p = 0.012$, $p =0.0001$ respectively). However, development of compartment syndrome, fasciotomy, and lower limb edema were not statically significantly associated with limb amputation ($p= 0.199$, $p = 0.088$, $p = 0.001$, respectively).
All vascular repairs were patent upon hospital discharge. Seventy-five patients (81%) required ICU admission, with a mean length of stay of 1.3± 1.5 days and only 2 (2.4) patients need mechanical ventilation. The overall mean length of hospitalization was 9.8 ± 9.5 days. The hospital stay was significantly longer in patients who had fasciotomy and wound infection compared to patients without fasciotomy or infection (17 days vs 6 days, 23 days vs 8 days, $P= 0.0003$, $P= 0.0003$ respectively).

The overall mortality rate for patients who sustained penetrating PAI was 1.2 % (one patient), developed pulmonary embolism and died 3rd post-operative day.

Discussion

In this study, we analyzed 85 patients with penetrating PAI who underwent surgical management in a single trauma center in Taiz, Yemen, during the period 2015–2019. Now, as we approach this fifth year of the war in Yemen, we continue to evaluate and report the management of wartime PAI in an effort to enhance the care of such injuries for both military and civilian settings. This report comments on initial presentation and early outcomes of penetrating PAI during Taiz war.

In this study, the mean age of our patients was 27.7 ± 12 years (range 3 – 75, SD 12) with 94% being active young patients less than 50 years, and the majority of our patients were males 78 (92%). This is closed to the mean age, that reported in previous war and local studies; Jawas [4]. 29.8 years with 89% males during the Second Gulf War and Fox et al.20 24 years in Baghdad. Thus, optimal management to control bleeding and reestablish circulation is crucial. The management of complex injuries involving vascular and skeletal elements of the lower extremity remains challenging and still incurs a high incidence of limb loss and morbidity [21-25]. The management of military vascular trauma has changed

considerably as a result of the wars of the 20th century and the significant contributions of Debakey, Hughes, Rich, and others [13, 14,26].

Gunshot and blast injuries caused the penetrating PAI in our study. In which gunshot wounds from high-velocity weapons accounted for the majority (83.5%) of PAI, producing deep cavity wounds frequently associated with fracture and neurovascular injury. The majority of penetrating PAI can be detected by initial examination, Wagner [27]. found 55% of limbs preoperatively had clinical ischemia, and capillary refill was considered an unreliable measurement of distal perfusion. Some signs including motor and sensory dysfunction, pain, and pallor are signs of late distal ischemia and may delay appropriate management. Unmistakable frank hemorrhage and "hard" signs of vascular injury, including a pulsatile expanding hematoma, pulselessness, presence of bruit or thrill, and signs of distal ischemia require immediate surgical intervention.

Patients with soft signs of extremity vascular injury could benefit from radiographic studies. Some of the methods for vascular imaging are limited by the need for highly specialized training teams and sophisticated support requirements. In war settings, these are not often available at the time of the ED admission. However, in patients suspected to have peripheral vascular injuries, CTA can be used to diagnose arterial injuries rapidly and reliably in the setting of trauma, expediting treatment and decreasing the potentially devastating consequences of a delay in diagnosis [28].

Regarding hard and soft signs, absence of distal pulses and injury in proximity of a major vessels were the most common in our study. This is similar to the studies reported by Salimi [29]. in Tehran and Hussain in Pakistan but differ to a prospective study by Weaver [30,31]. found that proximity alone was a poor predictor of significant arterial injury in patients with soft signs.

PAI accounts for about 5-19% of extremity arterial injuries in civilians while in the military setting, the reported incidence of vascular injuries has changed significantly since WWI till now [6,7,21,32,33]. During WWI, Makins reported the British experience consisting of 144 PAI in 1,202 patients, for an incidence of 12% with an amputation rate of 43% [34]. During WWII, DeBakey and Simeone reported 502 PAI, an incidence of 20.3%. Of those patients, 499 were managed with ligation resulting in an amputation rate of 72.5% [13]. In one of the initial reports from the Korean conflict, Jahnke and Seeley reported 7 PAI, for an incidence of 9%, and Hughes, in a later series of 304 patients, reported 79 PAI, for a 26% incidence of which 32.4 % required amputations [16,35]. Rich in their hallmark report of 1,000 patients during the Vietnam war, reported 217 PAI, for an incidence of 21.7% [36]. The overall amputation rate was similar to the Korean War at 13.5 % (128 amputations) [36,37]. Another key accomplishment was the increased emphasis on routine repair of venous injuries as a vital component of limb salvage strategies [38,39]. PAI remain the most serious problem with a 29.5% amputation rate involving 64 amputations (one-half of the totals) in 217 patients. Elimination of PAI from the series would reduce the amputation rate for the remainder of arteries repaired to 6.7%. Joseph [36,40]. published 1570 patients injured in Iraq and Afghanistan with 143 (9.1%) popliteal vessels injury. Although the overall amputation rate was 14% (16 patients), it was noticeably higher among those with PAI (7 patients, 30.4%) [5,40-43]. Our overall amputation rate (7%) results are consistent with previous literature.

Our practice with concurrent venous injuries is to repair rather than ligated whenever possible. Although repair of accompanying venous injury is controversial, venous repair may enhance venous drainage and, therefore decreased compartment pressure and eventual limb loss [23,27,44]. However, others have found no vascular-related complications from venous ligation [25,45]. In an ideal setting, venous injuries should be repaired when possible and tolerated by the patient especially in a watershed area, as in PAI. Repair is especially encouraged to ameliorate the high risk of leg phlegmasia or fascial edema. In our study, there were no significantly different amputation rates for venous injuries patients who were treated by ligation of venous repair ($p = 0.409$).

A major concern is that repair of venous injuries will result in vein thrombosis and subsequent pulmonary emboli, although support for this scenario is somewhat anecdotal [46]. In the largest recent study, they have found this to be the contrary; in fact, the risk of pulmonary emboli is low in venous repair compare to venous ligation or equivalent [47]. In our study result, pulmonary embolism was recorded in one (1%) patient, in which venous injury was repaired by venous interposition graft.

More than half of the vascular injuries 50 (58.8%), were associated with long-bone fractures in our report. The timing of orthopedic fixation in concomitant bone injury is a source of debate. Prior skeletal fixation is strongly advocated in some series,48,49 while more recent reports have highlighted the importance of reducing ischemia time by proceeding with vascular reconstruction first [48,49,25,50]. Wolf [51]. reduced ischemia time by using TIVS and then performing orthopedic fixation before vascular reconstruction. In our practice, we use vascular repairs firstly in all cases followed by orthopedic fixations on a stable base. Based on this experience and that of others, we advocate that definitive arterial reconstruction should precede orthopedic intervention for combined complex lower-extremity injuries [20,50,52].

Fact, mortality in this series from penetrating PVI was 1.2% which is similar to previous studies ranging from 1 to 9% [20,53,54]. PAI are associated with higher rates of compartment syndrome. Predominant risk factors included prolonged ischemia (>6 h), combined vascular and skeletal injuries, or venous ligation [21]. In our experience, 2-incision fasciotomies were usually performed at the initial operation immediately after restoration of blood perfusion. The technique for a single-incision fasciotomy is a well-described alternative for adequate decompression of the lower extremity however, a more involved surgical dissection is required [55]. Also, the decision to perform fasciotomies was clinical one and its liberal use has been recommended by some groups [19,21,56,57].

The overall fasciotomy rate in this study (33%) is superior to previously reported series, and National Trauma Data Bank (50%) [25,27,57,58]. The liberal use of fasciotomies appears to be associated with lower rates of amputation but the fasciotomy wounds themselves are a source of morbidity. In fact, the length of stay was significantly longer in patients who had fasciotomy compared with no fasciotomy (17 versus 6 days, $P= 0.0003$). We acknowledge in this series, the fasciotomy wounds were associated with increased morbidity and longer length of hospital stay.

In our study, we found low amputation rates of only 7%, superior to previous studies (11% for penetrating injuries) and other series ranging as high as 71%.19,56 In a series of 550 patients with lower extremity arterial injury, of which 31% corresponded to PAI,

Hafez [25]. showed amputation rates of 16%. Nair [23]. reported a series of 117 popliteal artery gunshot wounds with 27% and 50% amputation rates for low and high-velocity injuries, respectively.

Although it is generally accepted that skeletal muscles can tolerate ischemia for up to 6 hours, we found that the ischemic time alone could not be used to predict limb viability. Prolonged ischemia is a well-recognized predictor of cell death, but the tolerance period varies between persons, depending on the severity of the ischemia and the presence of collateral flow.

Conclusions

Wartime penetrating PAI is complex dilemma and associated with a high rate of amputation. However, team approach and promptly vascular repair found to associate with remarkable limb salvage rate 93%. This study represents the clinical pattern and early outcomes of popliteal arterial injuries during the contemporary war in Taiz, Yemen. We advocate repair of arterial injury with vein graft as treatment of choice whenever possible. We found that wound and graft infection, graft thrombosis, and the need for embolectomy are significantly associated with amputation.

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