

Patency of Temporary Arterial Shunt in Penetrating Arterial Extremities Injuries, Shabwa Governorate, Yemen

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Abstract

Introduction: Combat-related vascular injuries represent as major challenge in war zones, with significant risks of limb loss and mortality. Temporary arterial shunts (TAS) are frequently used as damage control strategy to restore perfusion until definitive repair can be performed. However, their outcomes may differ according to the site of injury. This study aimed to compare the outcome of using TAS for limb salvage in upper and lower extremity vascular injuries.

Methods: This is a retrospective comparative study included 65 patients with penetrating vascular injury (gunshot, pump explosion and blast injuries) between January 2023 and January 2025. Injuries were divided into upper extremity (UE) and lower extremity (LE) vascular injuries according to anatomical site of penetration. All patients were managed in Osylan Hospital in Shabwa Governorate with TAS and damage control surgery within 20 hours until patients were stabilized and transferred to the referral hospitals for definitive treatment in Ataq City.

Results: Vascular injuries of LE were higher than UE (69.2% vs. 30.8%), where brachial artery was the common affected artery in the UE (35.0%), and popliteal artery was the common affected artery in the LE (37.8%). Significant mean age difference was found between LE and UE affected patients, but no significant difference found between the mean units of blood transfusion, percentage of hematocrit, SBP at presentation, and the revascularization time. No significant association found between the type of the associated penetrating injuries and the affected extremities. The outcome of TAS showed that significant higher percentage of patency in UE than with LE (90.0% vs. 64.4%), while limb amputation was higher in LE than with UE (24.5% vs. 5.0%), and death was reported higher in patients with LE than with UE (11.1% vs. 5.0%), without significant statistical association.

Conclusion: This study concluded that TAS demonstrated higher patency in the salvage of UE than in the LE vascular injuries, which might be attributed to the differences in anatomical, physiological, surgical factors, and the associated organ injuries.

Keywords: Temporary Arterial Shunt, Vascular injuries, Extremity, Damage control surgery, Yemeni War.

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نجاح سالكية التحويلة الشريانية المؤقتة في إصابات الشرايين الطرفية النافذة، محافظة شبوة، اليمن

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ملخص الدراسة

المقدمة: تُمثل الإصابات الوعائية المرتبطة بالقتال تحديًا كبيرًا في مناطق الحرب، لما تنطوي عليه من مخاطر جسيمة لفقدان الأطراف والوفاة. تُستخدم التحويلات الشريانية المؤقتة بشكل متكرر كاستراتيجية للسيطرة على الأضرار واستعادة التروية الدموية إلى حين إجراء الإصلاح النهائي. ومع ذلك، قد تختلف نتائجها باختلاف موضع الإصابة. هدفت هذه الدراسة إلى مقارنة نتائج استخدام التحويلات الشريانية المؤقتة لإنقاذ الأطراف في إصابات الأوعية الدموية في الأطراف العلوية والسفلية.

المنهجية: هذه دراسة مقارنة استرجاعية شملت 65 مريضًا يعانون من إصابات وعائية نافذة (إصابات ناجمة عن طلقات نارية، وقنابل، وانفجارات) خلال الفترة من يناير 2023 إلى يناير 2025. تم تقسيم الإصابات إلى إصابات وعائية في الأطراف العلوية وإصابات وعائية في الأطراف السفلية وفقًا للموقع التشريحي للاختراق. خضع جميع المرضى للعلاج في مستشفى عُسيلان بمحافظة شبوة، حيث تم إجراء جراحة التحويلة الشريانية المؤقتة وجراحة للسيطرة على الأضرار خلال 20 ساعة حتى استقرت حالتهم، ثم نُقلوا إلى مستشفيات الإحالة لتلقي العلاج النهائي في مدينة عتق.

النتائج: كانت إصابات الأوعية الدموية في الأطراف السفلية أعلى منها في الأطراف العلوية (69.2% مقابل 30.8%)، حيث كان الشريان العضدي هو الشريان الأكثر إصابة في الأطراف السفلية (37.8%). لوحظ وجود فرق إحصائي هام في متوسط العمر بين المرضى المصابين في الأطراف السفلية والعلوية، ولكن لم يُلاحظ أي فرق إحصائي هام بين متوسط وحدات نقل الدم، ونسبة كثافة الدم، وضغط الدم الانقباضي عند القدوم، ووقت إعادة التروية. لم يُلاحظ أي ارتباط إحصائي هام بين نوع الإصابات النافذة المصابة والأطراف المصابة. أظهرت نتائج التحويلة الشريانية المؤقتة للأطراف أن نسبة سالكية الأوعية الدموية كانت أعلى بشكل ملحوظ في الأطراف العلوية مقارنةً بالأطراف السفلية (90.0% مقابل 64.4%)، بينما كانت نسبة بتر الأطراف أعلى في الأطراف السفلية مقارنةً بالأطراف العلوية (24.5% مقابل 5.0%)، وسُجلت نسبة وفيات أعلى في المرضى المصابين في الأطراف السفلية مقارنةً بالأطراف العلوية (11.1% مقابل 5.0%)، دون وجود ارتباط إحصائي هام.

الخلاصة: خلصت هذه الدراسة إلى أن تقنية التحويلة الشريانية المؤقتة أظهرت معدل بقاء أعلى في إنقاذ إصابات الأوعية الدموية في الطرف العلوي مقارنةً بإصابات الأوعية الدموية في الطرف السفلي، وهو ما قد يُعزى إلى الاختلافات في العوامل التشريحية والفسيولوجية والجراحية، بالإضافة إلى إصابات الأعضاء المصابة.

كلمات مفتاحية: التحويلة الشريانية المؤقتة، إصابات الأوعية الدموية، الأطراف، جراحة السيطرة على الأضرار، الحرب اليمنية.

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Introduction

Penetrating vascular injuries are the most challenging conditions faced during armed conflicts, particularly in resource-limited and high-casualty settings such as the Yemeni war. The rapid and effective restoration of blood flow to injured limbs is crucial to prevent irreversible ischemia and limb loss. Temporary arterial shunting (TAS) has emerged as a valuable technique in damage control vascular surgery, allowing for prompt revascularization in critically injured patients until definitive repair can be performed [1]. In war-related trauma, the pattern and outcome of vascular injuries vary significantly depending on the anatomical site. Injuries involving the upper extremities (UE) often present different clinical challenges and outcomes compared to those affecting the lower extremities (LE). Due to the differences in vascular anatomy, collateral circulation, and functional demand, the success of TAS may differ between the surgeons [2].

Vascular injuries are common with LE than UE (66% vs. 34%) with penetrating traumas as the most common globally (60-80%). Due to the high risk of limb-threatening ischemia and the need for rapid hemorrhage control, the use of TAS is increasing, especially as a damage control technique in poly trauma patients [3]. Despite varied patency, early limb salvage had a success rate of (95%) for proximal shunt placement and (88%) for distal shunt. Shunt in wartime is more employed in the lower extremities than in the upper extremities. LE injuries, which

often require more frequent shunting, carry a 4.3 times higher risk of amputation and a 2.2 times higher risk of combined amputation and mortality compared to upper extremity injuries, after adjustment for confounding factors [3].

TAS is plastic cylinder tubes that connect between two vessels, and the followings are the procedure of TAS under general anesthesia [4]:

- Proximal and distal control of vessel injuries must be obtained.
- Proximal and distal Fogarty Catheter thrombectomy.
- Lavage with heparin saline.
- Diameters closely approximated to artery size because over size may lead to intimal tear.
- Two centimeters from proximal and two centimeters from distal with fixation of the shunt using silk suture.

The first TAS was described in 1919 after the end of the First World War, became more prominent during the conflict of Northern Ireland for fractures associated with vascular injuries and the first Gulf war since 1991[5]. TAS are used in cases of severe vascular injuries among trauma patients when immediate definitive repair is not possible due to hemodynamic instability or in the presence of associated life-threatening injuries such as abdominal or thoracic trauma. In mass casualty settings such as war zones, staged procedure is required and the time is critical. Temporary shunt can be placed to save limb or save life. Additionally, they are utilized during prolonged transfers to higher trauma centers where definitive repair can be performed [1].

This study aimed to compare the outcome of TAS used in salvage of UE versus LE vascular injuries.

Methods

Study design and setting

This is a retrospective comparative study conducted at Oyslan Hospital in Shabwah Governorate, Yemen, from January 1st, 2023, to January 1st, 2025 targeting patients with vascular injuries managed with TAS and followed for 20 hours for stabilization, and thereafter transferred to the main referral hospitals in the capital of the governorate (Ataq city). These hospitals are Mohammed bin Zayed hospital and Al-Afiyah Hospital, for completed definitive surgery within 24 to 72 hours of trauma.

Inclusion criterion

Male patients with penetrating vascular injuries of the extremities affected by gunshot, pump expulsion, or blast injuries in the combat zone in the context of Yemen war.

Exclusion criteria

1. Patients with associated head injuries in the combat zone.
2. Blunt vascular injuries of extremities in the military zone.
3. Penetrating vascular injuries of extremities in civilian patients.
4. Patients with nerve injuries.
5. Female patients.

The study included 65 patients (20 with UE and 45 with LE vascular injuries) fulfilling the study criteria.

Data Collection

All patients underwent a thorough clinical history and physical examination, data collected from the

emergency department notes and the operative notes recorded in patients' files, as well as the performed laboratory investigations. The data included patients' age, systolic blood pressure (SBP) at presentation, percentage of hematocrit, units of blood transfusion, the arrival time, the revascularization time (RT) which was < 6 hours, and the associated injuries that combined vascular injuries (penetrating venous injuries, penetrating abdominal injuries, penetrating thoracic injuries, open fractures, and contaminated wounds). All patients in this study underwent distal and proximal control of bleeding, thrombectomy of both ends of vessel with Fogarty Catheter, washing with intra-arterial heparin saline then the TAS performed within less than 6 hours of injury.

Statistical analysis

Data collected were analyzed by the Statistical Package for Social Sciences (SPSS) program version 20. Qualitative data were presented as frequency distribution and percentages, tested by the Fisher exact which is appropriate for small sample sizes. Quantitative data were first tested for normality distribution by the Kolmogorov-Smirnov test, which revealed parametric distribution, and accordingly presented as mean values with standard deviations (SD), and tested by parametric tests (independent t-test for 2 means). All tests were applied at the 95% confidence limits and a level of significance of $p \leq 0.05$ was considered statistically significant.

Results

The studied patients had LE more than UE vascular injuries (69.2% vs.

30.8%). The UE injuries included brachial artery (35.0%), axillary and ulnar artery (20.0% for each), radial artery (15.0%), and combined radial and ulnar arteries in (10.0%). The LE injuries included popliteal artery (37.8%), superficial femoral artery

(35.6%), common femoral artery (11.1%), posterior tibial artery (8.9%), anterior tibial artery (4.4%), and combined anterior and posterior tibial arteries (2.2%) as shown in Table 1.

Table 1: Studied Patients by the Site of Vascular Injuries (n=65)

Vascular injuries	No.	%
UE	20	30.8
LE	45	69.2
In the UE (n=20)*		
Brachial artery	7	35.0
Axillary artery	4	20.0
Ulnar artery	4	20.0
Radial artery	3	15.0
Combined radial and ulnar artery	2	10.0
In the LE (n=45)*		
Popliteal artery	17	37.8
Superficial femoral artery	16	35.6
Common femoral artery	5	11.1
Posterior tibial artery	4	8.9
Anterior tibial artery	2	4.4
Combined anterior and posterior tibial arteries	1	2.2

Percentages were calculated from the total injuries of the affected limb.

The baseline findings depicted that significant higher mean age found in patients with LE vascular injuries (28.1 years) than with UE vascular injuries (23.9 years). However, there is no significant difference between

the mean units of blood transfusion, percentage of hematocrit, SBP at presentation, and the revascularization time between both groups (Table 2).

Table 2: The Baseline Findings in Relation to the Site of Vascular Injury

Item	UE (n=20) Mean ± SD	LE (n=45) Mean ± SD	p
Age (years)	23.9 ± 4.8	28.1 ± 6.1	0.008*
Arrival time (hours)	3.8 ± 1.0	4.1 ± 1.2	0.333
Blood transfusion (units)	5.7 ± 1.2	6.2 ± 1.6	0.217
Hematocrit (%)	30.8 ± 2.7	29.6 ± 5.4	0.351
Systolic BP (mmHg)	61.6 ± 1.4	62.0 ± 1.3	0.268
Revascularization time (hours)	5.2 ± 1.2	5.5 ± 1.5	0.434

* $p \leq 0.05$ is statistically significant. BP: blood pressure

There is no significant association between the type of the associated

penetrating injuries and the affected extremities as illustrated in Table 3.

Table 3: Associated Injuries in Relation to the Site of Vascular Injury

Associated Injuries	UE (n=20)		LE (n=45)		p
	Nº	%	Nº	%	
Penetrating venous injury	4	20.0	10	22.2	0.840
Open fractures	5	25.0	12	26.7	0.887
Penetrating abdominal injuries	3	15.0	12	26.7	0.302
Penetrating thoracic injuries	4	20.0	5	11.1	0.338
Contaminated wound	4	20.0	6	13.3	0.491

The outcome of TAS in Table 4 showed significant higher percentage of patency associated with UE than with LE (90.0% vs. 64.4%). On the other hand, limb amputation was

higher in LE than with UE (24.5% vs. 5.0%), and death was reported more in patients with LE than with UE (11.1% vs. 5.0%), without significant statistical association.

Table 4: Outcome of the Studied Patients in Relation to the Site of Vascular Injury

Outcome	UE (n=20)		LE (n=45)		p
	Nº	%	Nº	%	
Patency of TAS	18	90.0	29	64.4	0.033*
Amputation	1	5.0	11	24.5	0.062
Death	1	5.0	5	11.1	0.432

* $p \leq 0.05$ is statistically significant. TAS: Temporary arterial shunting

Discussion

The management of war-related arterial injuries is complex and challenging due to high energy trauma, limited resource and life-threatening injuries that delay definitive vascular surgery in military zone. In such conditions, TAS has emerged as an important approach to improve extremity salvage and life-saving in poly traumatic patients by reduced time of operation and anesthesia during wartime as indicated in studies in Iraq [6],

Afghanistan [7], and Yemen [8]. The current study analyzes the patency of TAS in penetrating vascular injuries in 65 patients sustained weapon-related injuries (gunshot, pump expulsion, and blast injuries), these mechanisms contributed to the complexity of vascular trauma because of their high potential energy and associated tissue damage. The studied patients had LE more than UE vascular injuries (69.2% vs. 30.8%), this is similar to that reported by the

study of Peck *et al.*[9], in Iraq, where vascular injuries affected LE more than UE (70.1% vs. 29.9%). The commonly affected vessels in this study were brachial artery in the UE (35.0%), and popliteal artery in LE (37.8%). This is consistent to that reported by the study of Sridhar *et al.*[10], in India, where the most commonly involved artery in UE was brachial artery (93.0%), and in LE was popliteal artery (36.0%).

All of the studied patients were young in their third decade, with significant higher mean age found in patients with LE vascular injuries than those with UE vascular injuries. Meanwhile, previous studies found higher mean age for patients with UE than those with LE vascular injuries [10,11]. However, no significant difference found regarding the mean units of blood transfusion, percentage of hematocrit, SBP at presentation, and the revascularization time which was < 6 hours, between both groups. This is in agreement with that reported by Kim *et al.* [12] in Spain, and Guven and Kafadar [13], in Nigeria.

The associated penetrating injuries in this study didn't show any significant difference between patients with UE and LE. This finding was reported previously by the study of Guven and Kafadar [13], in Nigeria, and the study of Gallo *et al.*[2], in Georgia. The associated venous injuries were identified in 14 patients with UE and LE vascular injuries, they were similarly managed with venous ligation and extended fasciotomy to prevent venous hypertension within a time of less than 6 hours [8]. Choe *et al.* [14], in their study reported no significant clinical outcome

difference between shunted and non-shunted venous injuries.

The outcome of TAS in this study showed that significant higher percentage of patency was associated with UE than with LE (90.0% vs. 64.4%). This finding was found in various studies, which reported that TAS improved the patency in UE more than in LE [7,15-17].

Assessment of patency and complications of TAS was done within 20 hours after the time of revascularization in Osylan hospital. During this period no patient developed thrombosis of TAS. Serum potassium was not available in the hospital, but the ECG didn't showed signs of hyperkalemia, with absent reperfusion syndrome during monitoring in the intensive care unit (ICU), then patients were transfers to the referral hospitals by ambulance which was prepared with oxygen and intravenous heparin during transportation time of 3 hours. The assessment of TAS patency and complications within the referral hospitals was done within 24 to 72 hours.

The study of Oliver *et al.*[17], reported that the most common complication of TAS was thrombosis that led to TAS dysfunction. In the current study, in spite of the continuous intravenous heparin, after revascularization, 3 patients with UE and 15 patients with LE vascular injuries complicated by thrombosis. The three patients with UE thrombosis underwent surgical intervention, in two of them viable muscles contractility with successful capacity to bleed were found, the third one had non-viable muscles contractility with non-successful capacity to bleed, and secondary amputation done due to irreversible

ischemia. The rate of amputation in UE patients was (5%), which was lower than that in LE (24.5%).

Among the 15 patients with LE vascular injuries, who were complicated by thrombosis, all of them underwent surgical exploration, in 4 patients the muscles found viable and contractable, with successful capacity to bleed, they underwent successful revascularization with saphenous graft. In the other 11 patients, the muscles found non-viable, non-contractile, with non-successful capacity to bleed, they underwent secondary amputation due to irreversible ischemia, to prevent reperfusion syndrome if revascularized. Surgical intraoperative assessment of viability, capacity to bleed, and contractility is a good predictor for the decision of revascularization or amputation, it helps to reduced reperfusion syndrome that assesses healthy tissue macroscopic under vision [18].

Death in the current study was reported more in patients with LE than with UE (11.1% vs. 5.0%), without significant statistical difference. The first patient died after 32 hours of RT, he was admitted to ICU due to sudden collapse with massive pulmonary embolism, the second patient died after 36 hours of RT, he underwent open thoracotomy with peripheral arterial shunt, he developed secondary hemorrhage due to post lobectomy blow out ligation of inferior pulmonary artery. The third patient died due to septic shock after 42 hours of RT, due to post laparotomy spillage of small bowel content with increasing renal function tests, liver function tests, and hyperkalemia. The fourth and fifth patients died after 62 hours of RT, due

to soft tissue infectious necrotizing fasciitis, where the missile injury was contaminated with soil material that led to sepsis and septic shock. In spite of TAS revascularization, aggressive debridement, and antibiotics, investigation in these two patients before death showed leucocytosis up to $33.0 \times 10^9/L$, hepatorenal failure, hyperkalemia, and hyperglycemia.

Conclusion

This study concluded that TAS demonstrated higher patency in the salvage of UE than in the LE vascular injuries, which might be attributed to the differences in anatomical, physiological, surgical factors, and the associated organ injuries. It is recommended that TAS should be tried in any vascular injury of the limb as soon as possible upon arrival of patient to the emergency department of the hospital.

References

1. Rasmussen TE, Clouse WD, Jenkins DH, Peck MA, Eliason JL, Smith DL. The use of temporary vascular shunts as a damage control adjunct in the management of wartime vascular injury. *J Trauma*. 2006; 61(1): 8-12.
2. Gallo LK, Ramos CR, Rajani RR, Benarroch - Gampel J. Management and Outcomes after Upper versus lower extremity vascular trauma. *Ann Vasc Surg*. 2021; 76: 152 - 8.
3. Abou Ali AN, Salem KM, Alarcon LH, Bauza G, Pikoulis E, Chaer RA, *et al*. Vascular shunts in civilian trauma. *Front Surg*. 2017; 4: 39.

4. Hancock H, Rasmussen TE, Walker AJ, Rich NM. History of temporary intravascular shunts in the management of vascular injury. *J Vasc Surg.* 2010; 52(5): 1405-9.
5. Dunn JC, Kusnezov N, Schoenfeld AJ, Orr JD, Cook PJ, Belmont PJ Jr. Vascular injuries in combat-specific soldiers during operation Iraqi Freedom and Operation Enduring Freedom. *Ann Vasc Surg.* 2016; 35: 30-7.
6. Chambers LW, Green DJ, Sample K, Gillingham BL, Rhee P, Brown C, *et al.* Tactical surgical intervention with temporary shunting of peripheral vascular trauma sustained during operation Iraqi Freedom: one unit's experience. *J Trauma Acute Care Surg.* 2006; 61(4): 824-30.
7. Clouse WD, Rasmussen TE, Peck MA, Eliason JL, Cox MW, Bowser AN, *et al.* In-theater management of vascular injury: 2 years of the Balad Vascular Registry. *J Am College Surg.* 2007; 204(4): 625-32.
8. Almadwahi N, Barat AA, Al-Habeet A. Effect of combination of temporary vascular shunt and prophylactic fasciotomy on limb salvage after lower extremity arterial injuries among Yemeni patients with war-related polytrauma. *Surg Res.* 2023; 5(4): 1-7.
9. Peck MA, Clouse WD, Cox MW, Bowser AN, Eliason JL, Jenkins DH, *et al.* The complete management of extremity vascular injury in a local population: a wartime report from the 332nd Expeditionary Medical Group/Air Force Theater Hospital, Balad Air Base, Iraq. *J Vascular Surg.* 2007; 45(6): 1197-205.
10. Sridhar DR, Pramanik S, Dhar DR, Agarwal TM, Gupta A. Comparison & evaluation of outcomes of upper & lower limb vascular trauma: single centre retrospective observational study. *Eur J Cardio Med.* 2025; 15: 224-30.
11. Topal AE, Eren MN, Celik Y. Lower extremity arterial injuries over a six-year period: outcomes, risk factors, and management. *Vasc Health Risk Manag.* 2010; 6: 1103-10.
12. Kim S, Schneider A, Raulli S, Ruiz C, Marston W, McGinagle KL, *et al.* Current outcomes following upper and lower extremity arterial trauma from the National Trauma Data Bank. *J Vascular Surg.* 2024; 80(2): 365-72.
13. Guven C, Kafadar H. Evaluation of extremity vascular injuries and treatment approaches. *Nigerian J Clin Practice.* 2020; 23(9): 1221-8.
14. Choe LJ, Yelon JA, Kauvar DS. Venous shunting and limb outcomes in military lower extremity combined arterial and venous injuries. *Surg Pract Sci.* 2022; 11: 100145.
15. Kauvar DS, Sarfati MR, Kraiss LW. National trauma databank analysis of mortality and limb loss in isolated lower extremity vascular trauma. *J Vascular Surg.* 2011; 53(6): 1598-603.
16. Taller J, Kamdar JP, Greene JA, Morgan RA, Blankenship CL, Dabrowski P, *et al.* Temporary vascular shunts as initial treatment of proximal extremity vascular injuries during combat operations: the new standard of care at Echelon II facilities?. *J Trauma Acute Care Surg.* 2008; 65(3): 595-603.
17. Oliver JC, Gill H, Nicol AJ, Edu S, Navsaria PH. Temporary vascular shunting in vascular trauma: a 10-year review from a civilian trauma

- centre: general surgery. South Afri
J Surg. 2013; 51(1): 6-10.
18. Comprehensive risk and
prognostic analysis of
femoropopliteal vascular damage
in Yemen conflict: limb salvage
and mortality rates. Inter J Med
Res Surg. 2024; 1(5): 28-38.