Comparison of military and civilian popliteal artery trauma outcomes

Anahita Dua, MD,[a] Bhavin Patel, BS,[b] Sapan S. Desai, MD, PhD, MBA,[c,d] John B. Holcomb, MD,[a] Charles E. Wade, PhD,[a] Sheila Coogan, MD,[b] and **Charles J. Fox, MD,[e]** *Houston, Tex; Milwaukee, Wisc; Durham, NC; and Bethesda, Md*

Objective: **Popliteal artery injury has historically led to high amputation rates in both the military and civilian setting. Military and civilian popliteal injury patterns differ in mechanism and severity of injury, prompting us to compare modern management and report differences in outcomes between these two patient groups. We hypothesized that whereas amputation rates may be higher in the military, this would correlate with worse overall injury severity.**

Methods: **Military casualties from 2003-2007 with a popliteal artery injury identified from the Joint Theater Trauma Registry were compared retrospectively with civilian patients presenting to a single level I institution from 2002-2009 with popliteal arterial injury. Demographics, mechanism of injury, coinjuries, Injury Severity Score (ISS), Mangled Extremity Severity Scores (MESS), interventions, and secondary amputation rates were reviewed. Descriptive statistics and unpaired *t*-tests were used to compare data. Statistical significance was $P < .05$.**

Results: **The study group of 110 patients consisted of 46 (41.8%) military and 64 (58.2%) civilians with 48 and 64 popliteal artery injuries, respectively. The military population was younger (28 vs 35 years; $P < .004$), entirely male (46 [100%] vs 51 [80%]; $P < .0001$), and had more penetrating injuries (44 [96%] vs 19 [30%]; $P < .0001$). ISS (18.7 vs 13.9; $P < .005$) and MESS (7.3 vs 5.1; $P < .0001$) were higher in the military group. Limb revascularizations in both military and civilian populations were mostly by autogenous bypass (65% vs 77%) followed by primary repair (26% vs 16%), covered stent (0% vs 6%), or other procedure (ligation and/or thrombectomy) (9% vs 1%). Fasciotomy (20 [42%] vs 37 [58%]; $P = .14$), compartment syndrome (10 [21%] vs 15 [23%]; $P = .84$), and concomitant venous repair rates (14 [29%] vs 15 [23%]; $P = .42$) were not different between cohorts. There was no difference in the fracture rate (26 [54%] vs 41 [64%]; $P = .43$), but the civilian group had a higher rate of dislocation (1 [2%] vs 19 [30%]; $P < .0001$). Secondary amputation rates were significantly higher in the military (14 [29%] vs 8 [13%]; $P < .03$).**

Conclusions: **Although both civilian and military cohorts have high amputation rates for popliteal arterial injury, the rate of amputation appears to be higher in the military and is associated with a penetrating mechanism of injury primarily from improvised explosive devices resulting in a higher MESS and ISS. (J Vasc Surg 2014;59:1628-32.)**

Traumatic disruption of the popliteal artery is a challenging injury that leads to high rates of amputation in both the military and civilian populations. Civilian amputation rates due to popliteal injury are reported as consistently lower in the literature as compared with military rates. Amputation rates in the military remain at approximately 30% for popliteal artery injury, whereas civilian amputation rates range between 14.5% to 25%.[1-5] Possible explanations for this difference include variations in factors that influence amputation outcomes including patient age, associated injuries, ischemia time, and severity of injury.[6] Civilians are typically older, sustain blunt trauma, and have varying times of ischemia before definitive repair, whereas military patients are almost exclusively young males with penetrating mechanisms of injury and relatively short transport times (<30 min).[1,2,4]

These differences, along with the limb salvage outcome discrepancy after popliteal artery injury, have prompted a comparison in contemporary management between a military and civilian cohort with the aim of understanding what factors influence differences in limb salvage rates. We aim to compare characteristics, injury patterns, and limb salvage outcomes in military and civilian patients who sustained popliteal artery trauma. We hypothesized that whereas amputation rates are higher in the military, these correlate with an increased injury severity.

METHODS

Study design and data sources. Military and civilian popliteal artery injury patients were evaluated through a retrospective study design to determine management and subsequent outcome variance. Detainees and all patients with primary amputations were excluded. Data for all

From the Center for Translational Injury Research (CeTIR), Department of Surgery, UT Health, Houston[a]; the Department of Surgery, Medical College of Wisconsin, Milwaukee[b]; the Department of Cardiothoracic and Vascular Surgery, University of Texas Houston Medical School, Houston[c]; the Department of Surgery, Duke University, Durham[d]; and the Department of Surgery, Division of Vascular Surgery Walter Reed National Military Medical Center, Bethesda.[e]

Author conflict of interest: none.

This research was presented as a poster of distinction and won best poster at the 2013 International Surgical Congress of the Association of Surgeons of Great Britain and Ireland (ASGBI), Glasgow, United Kingdom, May 1-3, 2013.

Reprint requests: Anahita Dua, MD, University of Houston, 6431 Fannin St, Houston, TX 77030 (e-mail: anahita.dua@uth.tmc.edu).

The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214/$36.00

http://dx.doi.org/10.1016/j.jvs.2013.12.037

military casualties were identified from the Joint Theater Trauma Registry. Included were military patients who sustained blunt or penetrating popliteal artery injury and presented to a level III combat support hospital located in Iraq (Baghdad or Balad) or Afghanistan (Bagram Air Field) from 2003-2007. This military group was compared with civilian patients identified from the hospital electronic medical record that presented to a single urban, level I trauma center from 2002-2009 with blunt or penetrating popliteal arterial injury.

Data collection and statistical evaluation. Arterial injury was defined as cessation of flow requiring removal of thrombus, primary repair, or revascularization with interposition grafting to restore flow to the extremity. Major amputation was limb loss at or proximal to the ankle. Any lower extremity vascular injury repaired with an expectation of permanent viability was defined as vascular limb salvage. Limb salvage failed if the limb required a major amputation as a result of vascular compromise (secondary amputation). A complication was reported if the graft failed (infection, rupture, thrombosis, stenosis, or re-intervention by thrombectomy, revision, or replacement) but the limb remained viable. Primary outcomes were graft patency (palpable pulse and normal ankle-brachial index >0.9 for military patients and normal completion angiogram for civilian patients). All procedures were performed by vascular surgeons. All military patients had definitive management of their popliteal artery injuries before or within level III centers.

Demographics, including age and sex, mechanism of injury, orthopedic coinjury, Injury Severity Score (ISS), Mangled Extremity Severity Scores (MESS), popliteal vascular reconstruction, and secondary amputation (defined as an amputation after attempted revascularization) were documented. Injury data collected regarding the injury and subsequent management included associated venous trauma, revascularization technique, conduit type, graft configuration, temporary shunting, and fasciotomy utilization. Follow-up was for up to 30 days; civilian patients has short-term follow-up until hospital discharge, whereas military patients were followed up until transfer out of the level III healthcare facility.

Descriptive statistics and unpaired *t*-tests were used to compare the data. Statistical significance was $P < .05$. This study was approved by both the military and civilian institutional review boards at The Brooke Army Medical Center, San Antonio, Texas, and the University of Texas–Houston.

RESULTS

The study group of 110 patients consisted of 46 (41.8%) military and 64 (58.2%) civilians with 48 and 64 popliteal artery injuries, respectively. The military population was younger (28 vs 35 years; $P < .004$), entirely male (46 [100%] vs 51 [80%]; $P < .0001$), and had more penetrating injuries (44 [96%] vs 19 [30%]; $P < .0001$). ISS (18.7 vs 13.9; $P < .005$) and MESS (7.3 vs 5.1; $P < .0001$) were higher in the military group. In the penetrating military subgroup, 60% were direct blast injuries and 40% were gunshot wounds with the blast wounds portending a poorer outcome within the penetrating group.

Table. Comparison of demographics, associated injuries, and outcomes between military and civilian popliteal artery injury patients

	Military, No. (%)	*Civilian, No. (%)*	P *value*
Average age	28	35	<.004
Male	46 (100)	51 (80)	<.0001
Penetrating trauma	44 (96)	19 (30)	<.0001
ISS	18.7	13.9	<.005
MESS	7.3	5.1	<.0001
Fasciotomy	20 (42)	37 (58)	.14
Compartment syndrome	10 (21)	15 (23)	.84
Concomitant venous repair	14 (29)	15 (23)	.42
Fracture	26 (54)	41 (64)	.43
Dislocation	1 (2)	19 (30)	<.0001
Secondary amputation	14 (29)	8 (13)	<.03

ISS, Injury Severity Score; *MSS,* Mangled Extremity Severity Scores.

Limb revascularizations in both military and civilian populations were mainly by autogenous bypass (ipsilateral or contralateral) (31 [65%] vs 49 [77%]) followed by primary repair (12 [26%] vs 10 [16%]), endovascular stent placement (0 [0%] vs 4 [6%]), and other (ligations and/or thrombectomy) (4 [9%] vs 1 [1%]). There was no difference in success of revascularization, based on type of repair.

Compartment syndrome (10 [21%] vs 15 [23%]; $P = .84$), concomitant venous repair rates (14 [29%] vs 15 [23%]; $P = .42$), and fasciotomy rates (20 [42%] vs 37 [58%]; $P = .14$), were not different. There was no difference in the fracture rate (26 [54%] vs 41 [64%]; $P = .43$), but the civilian group had a higher rate of posterior knee dislocation (1 [2%] vs 19 [30%]; $P < .0001$). Secondary amputation rates were significantly higher in the military (14 [29%] vs 8 [13%]; $P < .03$). All amputations were either above the knee or below the knee. The Table provides a summary of our findings.

DISCUSSION

Lower extremity arterial injury occurs in 0.39% of civilian trauma admissions, of which 22% are popliteal artery injuries.[3,4,7] The incidence of lower extremity arterial injuries is 0.28% in the military, of which 20% are popliteal.[8-11] This study was performed to compare the modern differences in popliteal artery trauma outcomes between the military and civilian patients. It is important that military data be shared in the civilian literature to help shape appropriate civilian management practices. Our data found that military patients had an increased rate of secondary amputation with injury to the popliteal artery, probably as the result of the associated soft-tissue injuries that accompany improvised explosive device (IED) injury patterns.

In the military, penetrating explosive mechanisms constitute 78% of all vascular injuries from the Iraq and