Combined Orthopedic and Vascular Lower Extremity Injuries: Sequence of Care and Outcomes

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Abstract

Combined vascular and orthopedic injuries requiring repair are rare. However, these injuries have a high amputation rate and significant morbidity.

In a retrospective review of lower extremity injuries managed at a level I trauma center over 9 years, we identified 26 patients with combined vascular and orthopedic injuries. We evaluated their rates of amputation and revascularization procedures based on sequence of care and initial intervention. Patients were stratified into 3 groups based on the initial intervention given: definitive vascular repair (n = 17), orthopedic stabilization (n = 4), and temporary shunt (n = 5).

Amputation rates were 29% (5/17) in the vascular group and 20% (1/5) in the shunt group; there were no amputations in the orthopedic group (0/4). Revascularization rates were 41% (7/17), 25% (1/4), and 20% (1/5) in the vascular, orthopedic, and shunt group, respectively. Mangled Extremity Severity Scores higher than 6 had an overall relative risk of 5.5 for amputation ($P<.05$).

We conclude that temporary vascular shunting followed by orthopedic stabilization and then definitive vascular repair is the most reasonable sequence of care for minimizing rates of amputation and revascularization procedures in this cohort of patients.

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High-energy lower extremity injuries have a significant adverse impact on society. Authors have repeatedly documented the significant morbidity and disability associated with such injuries.[1] The combination of vascular and orthopedic injuries requiring repair is rare, with a reported incidence as low as 1.5%.[2] The issue of managing concomitant vascular and orthopedic extremity injuries has been debated within the surgical trauma community for a number of years.[3] Ischemia time, which has been found to be linked to limb viability and outcome,[4] has been at the crux of the debate. With emphasis being placed on minimizing warm ischemia, there is no question that priority should be given to restoring blood supply to the extremity, but whether vascular repair should be definitive or temporized by way of intraluminal shunts is still debated at many centers. In the 1980s, reports on the value of temporary intraluminal shunts as a resolution to a management dilemma surfaced.[5,6] Despite these encouraging results, the practice of routine vessel instrumentation was questioned out of fear of iatrogenic intimal injury and, in the mid-1980s and 1990s, authors continued to perform definitive vascular repair first and reported no anastomotic disruptions.[7,8] Meanwhile, the orthopedic community claimed skeletal stabilization can safely be performed before vascular repair.[9] The pendulum swung back toward temporary shunting in 1999, when Reber and colleagues[4] again advocated use of temporizing shunts, particularly in cases of prolonged ischemia time. Among the 7 patients in their study, there were no cases of limb loss. McHenry and colleagues,[10] citing longer hospital stays and increased fasciotomy rates in patients treated with skeletal stabilization first, concluded that revascularization should be given priority over orthopedic fixation. However, they did not report Glasgow Coma Scale (GCS) or Injury Severity Scale (ISS) scores for their study groups, potentially confounding the finding of longer hospital stays. Clearly, clinicians are still debating the sequence of surgical intervention as it relates to temporizing vascular shunt, definitive vascular repair, and orthopedic fixation.

We conducted a retrospective review to evaluate the rates of amputation and revascularization procedures in these treatment groups.

Materials and Methods

More than 36,000 patients were treated at a level I trauma center between 1996 and 2005. Inclusion criteria were patients with com-

Table I. Baseline Demographics and Injury Characteristics by Treatment Group

	Treatment Group											
	Vascular				Orthopedic				Shunt			
Demographics	n	Mean or %	p50	SD	n	Mean or %	p50	SD	n	Mean or %	p50	SD
Age, y	17	36.2	31.1	8.9	4	23.8	25.5	16.5	5	30.9	30.2	9.1
Injury Severity Score	—	15.2	16	6.7	—	14.8	11.5	8.5	—	16.2	16	7.3
Glasgow Coma Score	—	14	15	1.9	—	15	15	0	—	12.4	15	5.3
Ischemia time, min	—	194.9	176	63	—	102	62.5	122	—	180.2	207	89.1
Length of stay, d	—	15.2	12	14	—	21	19	11.3	—	27	12	25.2
Mangled Extremity Severity Score	16	5.4	5	2.4	4	3.5	3	1	5	5.8	6	0.8
MESS>6	3	18%	—	—	0	0%	—	—	1	20%	—	—
No. of open fractures	8	47%	—	—	3	75%	—	—	2	40%	—	—
Angiogram performed	14	82%	—	—	3	75%	—	—	4	80%	—	—
Vascular Injury												
Superficial femoral artery	10	59%		—	1	25%		—	2	40%		—
Superficial femoral vein	5	29%		—	0	0%		—	0	0%		—
Popliteal artery	8	47%		—	2	50%		—	3	60%		—
Posterior tibial artery	1	6%		—	2	50%		—	1	20%		—
Anterior tibial artery	0	0%		—	1	25%		—	1	20%		—
Dorsalis pedis artery	0	0%		—	1	25%	—		0	0%		—
Deep femoral artery	0	0%		—	0	0%	—	—	0	—		

bined lower extremity traumatic injuries requiring both orthopedic and vascular surgical repair. Patients with traumatic amputations, who died within 24 hours of arrival, who did not undergo a revascularization procedure, and with insufficient medical records were excluded. A retrospective chart review was conducted based on a patient list generated from the trauma registry at our institution. The data of included patients were compiled in a database of the variables of age, mechanism of injury, GCS and ISS scores, length of stay (LOS), ischemia time, angiograms performed, open fractures, amputations, vascular reoperations, vessels injured, incidence of compartment syndrome, deaths, and management sequence. Patients were stratified into 3 groups based on the initial intervention given: vascular, orthopedic, and shunt.

Details of the patient demographics are listed in Table I. Data analysis of the 3 study groups was performed with Stata version 11 (StataCorp, College Station, Texas). Statistical tests included, where applicable, the 2-tailed Fischer exact text, the χ^2 test, and the Kruskal-Wallis test.

Table II. Mechanism of Injury by Treatment Group

	No. of Patients		
Mechanism of Injury	Vascular	Orthopedic	Shunt
Motor vehicle collision	1	1	1
Motorcycle collision	5	0	2
Pedestrian vs automobile	3	2	0
Gunshot wound	5	0	2
Crush	2	1	0
Bicycle vs automobile	1	0	0
Total	**17**	**4**	**5**

Results

Of 3059 patients with lower extremity fractures generated from the trauma registry, 159 had vascular injuries requiring repair, and 54 underwent traumatic amputations. Twenty-six (0.07%) of the 36,000 patients met criteria for inclusion.

Seventeen patients were classified in the vascular group and underwent a definitive vascular procedure as the initial surgical intervention, followed by orthopedic intervention. No shunts were used. Four patients were categorized in the orthopedic group and underwent either definitive or temporary (ie, external fixation) orthopedic surgery as the initial intervention, followed by vascular repair. Five patients were categorized in the shunt group and received a temporizing shunt to address the vascular injury before definitive vascular repair or orthopedic stabilization.

There was no statistical difference among the 3 groups with respect to patient demographics (Table I), injury characteristics, or mechanisms of injury. Mean age of the study cohort was 33 years (range, 6-80 years). Mechanisms of injury were motor vehicle collision (n = 3), motorcycle collision (7), crush (3), pedestrian struck by automobile (5), gunshot wound (7), and bicycle struck by automobile (1). The most common mechanisms of injury, accounting for more than half the patients, were motorcycle collision and gunshot wound (Table II). Mean GCS score was 13.8 (range, 3-15), mean ISS score was 15.4 (range, 9-30), median LOS was 12 days (range, 1-63 days), and mean ischemia time before any vas-

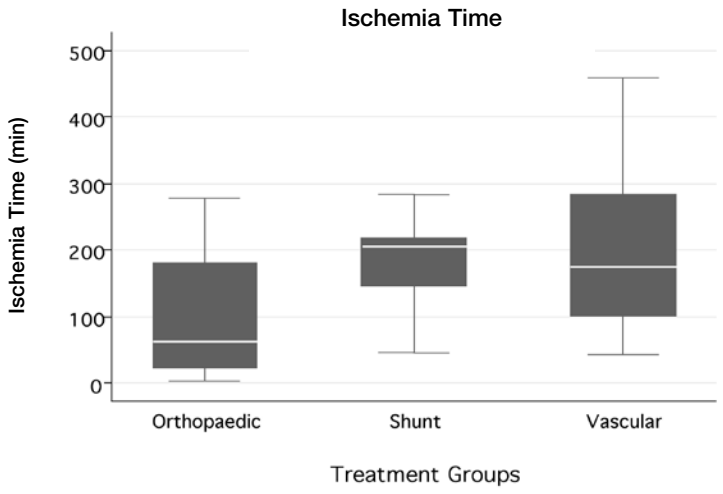

Figure 1. Ischemia time by treatment group.

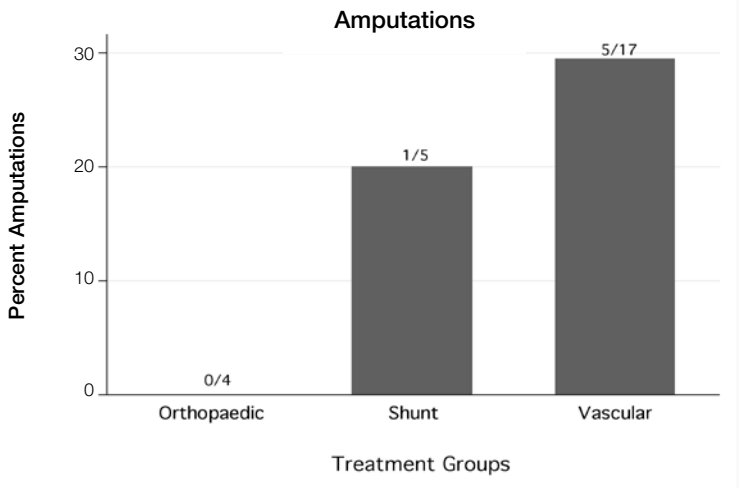

Figure 2. Amputation rate by treatment group.

cular procedure was 177 minutes (range, 4-458 minutes).

The orthopedic group had the shortest mean ischemia time. The mean ischemia times of the vascular and shunt groups were similar to each other (Figure 1). Twenty-one of the 26 patients underwent angiograms in the trauma center, in the angioembolization suite, or on the operating room table, and 20 of the 21 results were positive. There were 13 open fractures: 8 in the vascular group, 3 in the orthopedic group, and 2 in the shunt group. Six patients required amputations: 1 below-knee, 2 through-knee, and 3 above-knee (Figure 2). There were 9 vascular reoperations: 7 in the vascular group, 1 in the orthopedic group, and 1 in the shunt group (Figure 3). The vascular reoperation performed in the shunt group was not for anastomotic disruption, but for graft infection. Three cases of compartment syndrome were documented: 1 in the orthopedic group and 2 in the vascular group. The vessels most commonly injured were the popliteal artery (n = 13) and the superficial femoral artery (n = 13), followed by the superficial femoral vein (n = 5), the posterior tibial artery (n = 4), the deep femoral artery (n = 1), and the dorsalis pedis artery (n = 1). Seven patients sustained injuries to more than 1 vessel. Mean Mangled Extremity Severity Score (MESS), as defined by Johansen and colleagues,[11] was 5.2 (range, 3-13). There was a significant difference among those with higher MESS and associated amputations (Table III). Moreover, MESS higher than 6 was associated with a relative risk of 5.5 for amputation (P = .028; 95% confidence interval, 1.7-18.1). The primary outcome measures were the numbers of revascularization procedures and amputations in the groups (Table IV). Of the 26 patients in the study, only 1 (vascular group) died.

Discussion

This retrospective study was conducted to evaluate the rates of amputation and revascularization procedures in patients with combined vascular and orthopedic injuries. Other investigators have

Table III. Predictive Value of MESS Higher Than 6 for Amputation by Treatment Group

	No. of Patients							
	Vascular		Orthopedic		Shunt		Total	
Amputation Group	MESS >6	MESS ≤6	MESS >6	MESS ≤6	MESS >6	MESS ≤6	MESS >6	MESS ≤6
Amputation	2	3	0	0	1	0	3	3
No amputation	1	11	0	4	0	4	1	19
Total	3	14	0	4	1	4	4	22
Total risk	0.67	0.21	0	0	1	0	0.75	0.14
Risk ratio (95% CI)	3.1 (0.9-11.1)		CBD		CBD		5.5 (1.7-18.2)	

Abbreviation: CBD, cannot be determined (because of small sample size and too few or no events); MESS, Mangled Extremity Severity Score.

Table IV. Outcome by Treatment Group

Outcome	No. (%) of Patients			
	Vascular	Orthopedic	Shunt	Total
Vascular reoperation	7 (41%)	1 (25%)	1 (20%)	9
Compartment syndrome	2 (12%)	1 (25%)	0 (0%)	3
Amputation Incidence	5 (29%)	0 (0%)	1 (20%)	6
AKA	2 (12%)	0 (0%)	1 (20%)	3
TKA	2 (12%)	0 (0%)	0 (0%)	3
BKA	1 (6%)	0 (0%)	0 (0%)	1
Death	1 (6%)	0 (0%)	0 (0%)	1
Total	**20**	**2**	**3**	**26**

Abbreviation: AKA, above-knee amputation; BKA, below-knee amputation; TKA, through-knee amputation.

reported amputation rates as high as 78% for this unique injury[12,13]; the rate in our study was 23%. It has been unclear whether the high rate of limb loss is the result of anastomotic disruptions and subsequent repeat revascularization procedures. What has been borne out is that infection[14] and longer warm ischemia time[4,15] are associated with amputation. In a LEAP (Lower Extremity Assessment Project) study, Patterson and colleagues[16] prospectively evaluated 18 knee dislocations necessitating vascular repair and concluded that prolonged warm ischemia time was associated with a high rate of amputation. In addition, much work has been done with regard to popliteal vascular trauma. Blunt versus penetrating trauma has been associated with longer hospital stays, worse functional outcomes, and higher amputation rates. Despite early reports of no effect on limb salvage or outcome,[17] the currently recognized independent predictors of amputation are fractures, complex soft-tissue injuries, and delays in surgery.[18-21]

Our findings suggest that for each group, there is a trend toward longer LOS for patients with polytrauma. This trend is supported by lower GCS and higher ISS scores. In addition, we found a trend toward higher rates of amputation and revascularization procedures in patients who had definitive vascular repair as their index procedure. This finding is intuitive, as patients who undergo vascular surgery first are more at risk for subsequent anastomotic disruption. Such a complication would further compromise an already threatened extremity, and it follows that the amputation rate would thereby increase. Although patients in the vascular group had a higher mean MESS, the value was not statistically significant, likely because of the small sample size and the rare nature of this combined injury.

The decision tree for amputation of a mangled extremity has been a subject of considerable debate and of a multitude of contributions to the medical literature, but there is no clear management algorithm.[22-27] Many predictive scoring systems are described in the literature on mangled and severely injured extremities. Of these systems, the MESS is arguably the most widely used and studied. Despite the encouraging results with use of this system, clinicians hesitate to rely solely on any single scoring system when deciding whether to amputate an extremity. Moreover, further study has suggested that predictive scoring systems are highly specific, but lack sensitivity.[28] In our study, MESS higher than 6 was statistically significant for amputation ($P = .028$). Of the 4 patients with MESS values meeting this criterion, 3 were in the vascular group, likely accounting for its higher amputation rate. However, we agree with cautious interpretation of scoring systems that guide decisions about extremity amputation, and we advocate combining clinical judgment with objective scoring systems. Although some cases of successful orthopedic stabilization before vascular repair have been reported without adverse outcomes,[29] we recommend the

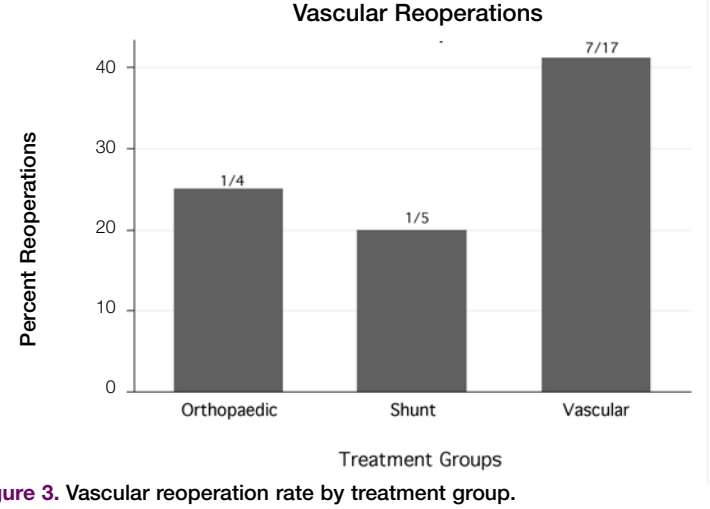

Figure 3. Vascular reoperation rate by treatment group.

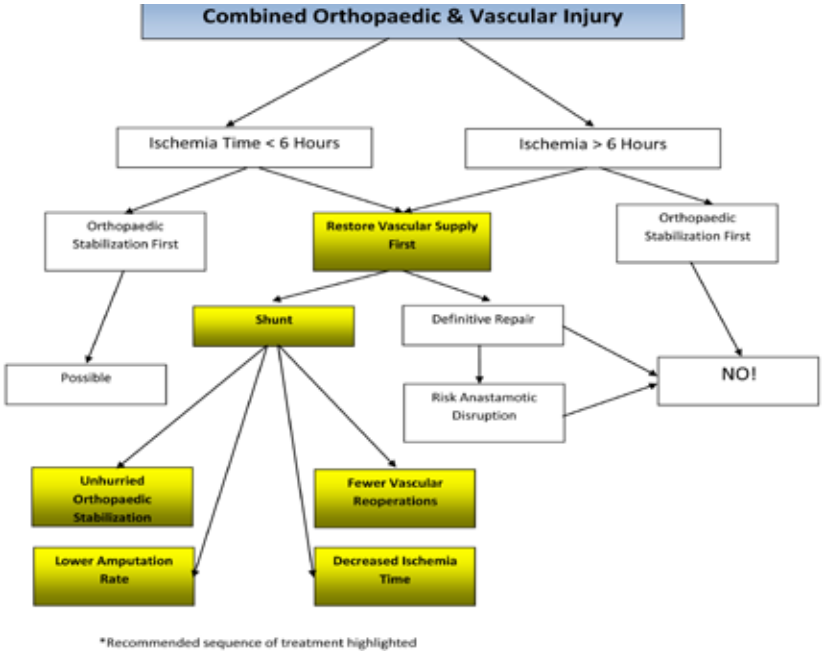

Figure 4. Proposed sequence of care

management algorithm outlined in Figure 4 when this unique injury is encountered.

The extremity with concomitant vascular and orthopedic injuries is a very rare but challenging problem. Our study results show trends toward higher rates of amputation and revascularization procedures when the index procedure is definitive vascular repair. In addition, MESS higher than 6 was predictive of amputation. We feel that this cohort of patients requires a standardized management algorithm.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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