

### Combined Orthopaedic and Vascular Injuries: A Multicenter Analysis

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**Purpose:** Combined orthopaedic and vascular injuries are limb-threatening. Salvage requires revascularization and bony reconstruction with the goal of a solid union with good distal flow. The local anatomy often dictates the success of such salvage attempts, with more central injuries easier to manage than more distal injuries due to vessel size and soft-tissue coverage. The purpose of this study is to review a large multicenter experience with combined orthopaedic and vascular injuries to identify the current salvage and amputation rates and, where possible, the variables that predict amputation. Specifically, we hypothesized that the order of vascular and osseous reconstruction and the ischemia time may play a role.

**Methods:** We reviewed 199 patients presenting to 9 trauma centers with combined orthopaedic and vascular injuries. All patients for whom the orthopaedic service was involved with the decision for salvage versus amputation were included. Demographic data on patients, level of vascular injury, bony injury, ischemia time, order of repair, and complications including infection, vascular failure, nonunion, compartment syndrome, amputation were documented.

**Results:** We reviewed 199 patients (M: 150, F: 49), aged 17-85 years (average, 39.5) with 116 left and 83 right combined orthopaedic and vascular injuries. The most common fractures were: tibia (71), femur (52), and humerus (29). 27 of the injuries were closed and the rest were open. 38 (19%) were treated with amputation upon admission as they were deemed to be unsalvageable. Of the remaining 161 who had attempted salvage, 36 (22%) required late amputation. The most common reasons for failure of attempted salvage were: infection/wound failure (14), failed vascular repair (9), and compartment syndrome/myonecrosis (4). Closed injuries were successfully salvaged in 25/27 cases (93%). The highest rate of amputation was in tibia fractures with a combined amputation rate of 62%. In those attempted to

be salvaged, 21/48 (44%) required amputation. The rates of salvage and acute and delayed amputation are seen in the attached table. The ischemia time for successful salvage was less than those who went on to late amputation ( $5.3 \pm 3.8$  hours vs  $7.5 \pm 9.2$  hours;  $P = 0.03$ ). 124 patients had their definitive vascular repair prior to the boney reconstruction and 37 had it after. In the attempted salvage group there were a total of 74 complications, including 19 deep infections, 10 wound complications, 15 vascular complications, and 7 nonunions. Of the 15 vascular complications, 13 (87%) had the definitive vascular repair performed prior to the definitive osseous repair, although this was not statistically significant.

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### Bony Injury Location and Outcome

	Successful Salvage	Immediate Amputation	Delayed Amputation	Total Amputation	Percent Amputation
<b>Humerus</b> n = 29	23	3	3	6	20.7%
<b>Elbow Dislocation</b> n = 4	4			0	0
<b>Radius/ Ulna</b> n = 14	10	4		4	28.6%
<b>Hand</b> n = 1		1		1	100%
<b>Pelvis</b> n=1	1			0	0
<b>Femur</b> n = 52	37	6	9	15	28.8%
<b>Knee Dislocation</b> n = 24	21		3	3	12.5%
<b>Tibia/ Fibula</b> n = 71	27	23	21	44	61.9%
<b>Ankle Dislocation</b> n = 2	1	1		1	50%
<b>Foot</b> n = 1	1				0
<b>Total</b> n = 199	125	38	36	74	37.2%

**Conclusion:** In this series of combined orthopaedic and vascular injuries, we found a high rate of acute and late amputations. The complication rate for salvage attempts was 74%, which included a 22% rate of amputation after attempted salvage, primarily in open fractures. Vascular repair failure occurred in 15 (12%), the majority of which resulted in amputation (9 cases). Ischemia time had a marked influence on the ability to salvage the extremity with successful salvage averaging 5.3 hours compared to 7.5 for failed salvage attempts. Finally, 13 of the 15 vascular repairs that failed were performed prior to definitive boney stabilization. It is possible that other protocols, such as shunting and stabilizing the osseous injury prior to vascular repair may protect the repair, although this needs more study.

The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.