Acute Compartment Syndrome in Patients With Tibia Fractures Transferred for Definitive Fracture Care

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Abstract

We sought to determine if patients evaluated at an outside institution for a tibia fracture and transferred to a referral hospital for fracture management were at risk for having acute compartment syndrome (ACS) on arrival.

We conducted a database search for cases in which patients were referred for definitive fixation of tibia fractures, and on initial evaluation at our institution were diagnosed with ACS that necessitated fasciotomy. Incidence, demographics, fracture type, early complications, and factors that predict ACS were evaluated.

Between 1996 and 2008, 9 patients (6 men, 3 women; mean age, 44.4 years) were transferred for definitive fixation of a tibia fracture and on presentation had ACS of the involved extremity (1.0% of all tibia fractures treated during this period). Two of the 9 patients developed contractures. Seven of the 9 patients had a good clinical result, and there were no amputations.

There is increased risk for ACS in all patients with musculoskeletal trauma, irrespective of age, sex, fracture type, or injury mechanism. Given this risk, physicians must closely monitor patients. A patient should not be transferred until a fasciotomy is performed, if there is a significant risk of developing compartment syndrome prior to or during transport.

One of the few orthopedic surgery diagnoses still considered an absolute surgical emergency is acute compartment syndrome (ACS). It has been shown repeatedly that the most important predictor of outcome of ACS is time from injury to diagnosis.[1-16] The diagnosis must be made promptly so that decompression can be performed early and the sequelae of ischemia to the affected limb prevented. These complications include contractures, irreversible muscle damage, neurologic injury, infection, amputation, renal failure, and even death.[2-4,6,8-10,13,15,16] Heightened awareness of the possibility of ACS clearly can lead to shorter delays in diagnosis and lower incidence of such disastrous complications. Orthopedic surgeons and emergency medicine staff alike should remain aware of the possibility of ACS when treating patients with trauma. In particular, patients with lower extremity musculoskeletal trauma must be closely monitored.[1,3,6,7,12] To make the diagnosis, clinicians must maintain a high index of suspicion, perform meticulous serial examinations, and, if uncertain, measure compartment pressures.

Despite precautions, ACS continues to be one of the most common causes of morbidity and reasons for malpractice claims,[1,17] and the diagnosis is often missed when a patient is evaluated at an institution and then transferred to another for definitive care.

In the study reported here, we sought to determine the number of cases in which ACS was diagnosed immediately on arrival at a university hospital setting (level I) after being evaluated and cleared for transfer by an outside orthopedic surgeon and by emergency medicine personnel. We also examined the incidence, demographics, fracture type, early complications, and factors that predict ACS in patients with tibia fractures who were referred to our institution.

Materials and Methods

After institutional review board approval was obtained, we conducted a retrospective chart review on patients transferred to a single academic trauma referral center (level I) who presented with ACS in association with a tibia fracture. Patients were identified by querying the operative medical record database using the *ICD–9* (*International Classification of Diseases, Ninth Revision*) codes for Volkmann contracture (958.6) and fasciotomy (83.14). All other data were obtained from a detailed database. Study inclusion criteria were initial evaluation by an orthopedic surgeon at an outside facility and ACS diagnosed at the academic trauma referral center immediately on arrival.

Between January 1996 and August 2008, Dr. David Helfet treated 889 patients with tibia fractures who were transferred to a level I academic regional trauma referral center after being

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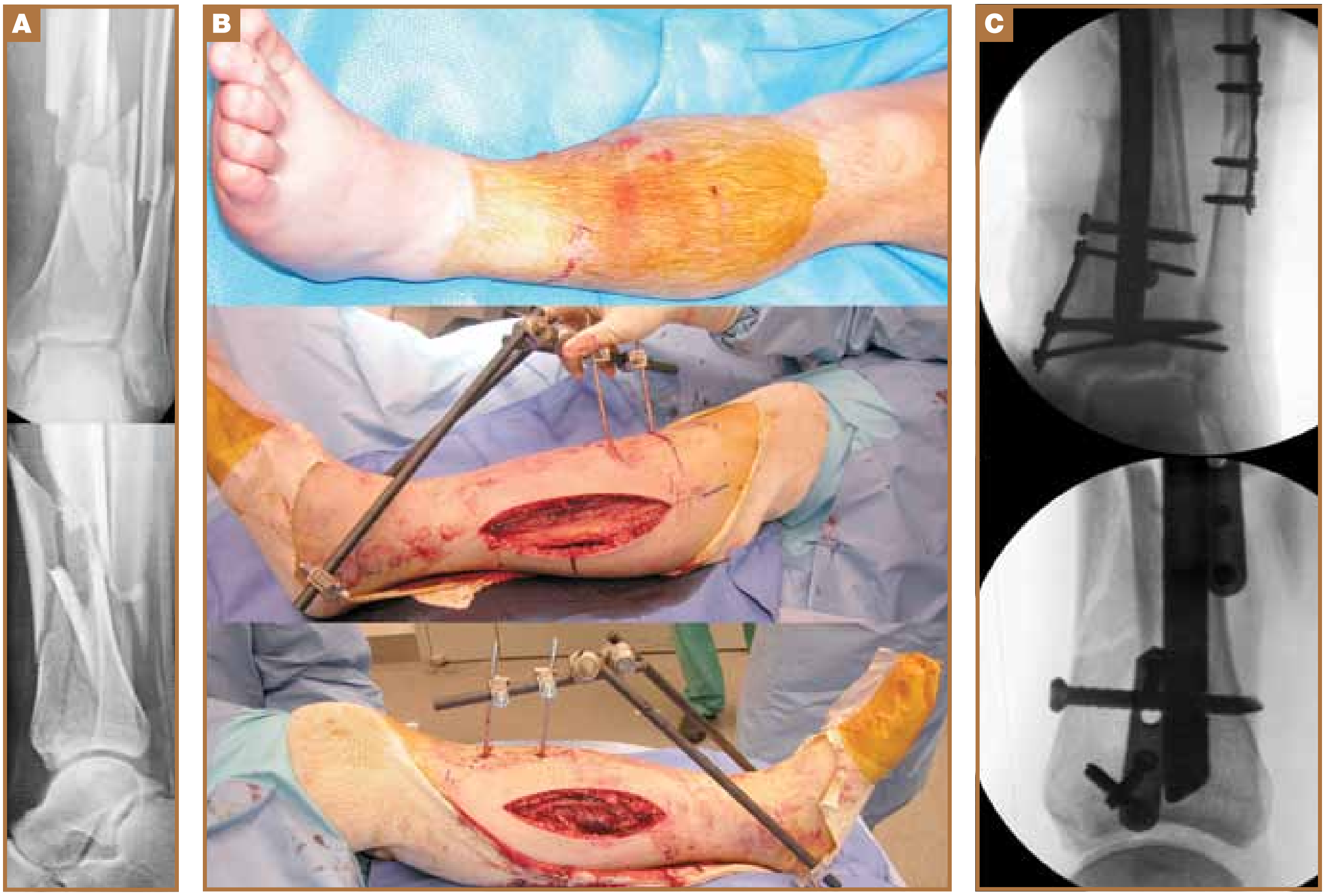

Figure. The patient in case 9 was a 35-year-old man whose leg had been crushed between his motorcycle and a car. He was seen at an outside hospital and splinted. (A) Anteroposterior and lateral radiographs show an AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association) type 42-C3 with associated OTA type 44-A2 fractures. (B) Clinical photographs before and after 4-compartment fasciotomies. (C) Anteroposterior and lateral fluoroscopic images immediately after open reduction and internal fixation.

evaluated at an outside institution. Of these patients, 704 (79%) had periarticular fractures. For a referral to be accepted, the patient had to be seen by an orthopedic surgeon at the outside institution, and that surgeon had to speak with a member of the referral center's medical staff, which included nurse practitioners and orthopedic trauma fellows. The referring orthopedist was thoroughly questioned about the patient before acceptance. We identified 9 patients (1.0%) who, on arrival for treatment at the referral center, were diagnosed with ACS of the involved extremity. Each patient was emergently taken to the operating suite for decompressive fasciotomy and adjunctive external fixation (**Figure**).

Mean follow-up for the 9 patients (6 men, 3 women) was 16.4 months (range, 6 to 38 months). Mean age was 44.4 years (range, 27 to 63 years). Four patients had comorbidities, and 3 were active smokers. No patient had diabetes or any form of neuropathy. Of the 9 patients, 2 were injured in high-speed motor vehicle collisions (1 was riding a motorcycle), 1 while riding a moped, 1 while jet-skiing, 3 in falls from a height of less than 12 feet, 1 while skiing, and 1 from a horse kick. Three of the 9 patients had associated injuries, including 2 distal radius fractures and 1 mandible fracture (**Table**).

Results

Each patient was evaluated and stabilized at an outside hospital. Then, because the patient requested it or the facility was not capable of treating the fracture, each patient was transferred to our institution. Four of these outside institutions were located in the same state as our facility, 3 were in other states, 1 was in Canada, and 1 was in the Bahamas.

On arrival at our institution, 3 patients were in knee immobilizers (for plateau fractures), 3 in splints (2 pilon fractures and 1 tibia fracture with associated medial malleolar fracture), 1 in a long-leg U-splint (plateau fracture), and 2 in circumferential casts (1 plateau fracture, 1 pilon fracture; the short-leg cast for the pilon fracture was bivalved).

All fractures were closed injuries. Neither surgical intervention nor compartment pressure measurement was performed on any patient before transfer to our institution. All patients were awake and alert on arrival.

There were 4 tibial plateau fractures, 3 pilon fractures, 1 distal tibial shaft fracture with associated medial malleolus fracture, and 1 plateau fracture with associated shaft fracture. All fractures were comminuted. The AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Associa-

Table. **Patient Data**

Case	1	2	3	4	5	6	7	8	9	Mean
Age/sex	32M	49F	63M	49F	42M	42M	27F	61M	35M	**44.4**
Comorbidities	None	Anxiety, depression	CAD, HTN, lipidemia	None	None	Cardio-myopathy	Depression	None	None	
OTA type	43-C3	41-C3	41-C3	41-B3, 42-B3	41-C3	43-C3	43-C1	41-B3	42-C3, 44-A2	
Side	R	R	L	R	L	R	L	L	L	
Mechanism of Injury	Jet ski	Horse kick	Moped	Skiing	Fall, ladder	Fall (10 ft), ladder	MVC	Fall, ladder	MCC - crush	
Smoker	No	Yes	Yes	No	No	Yes	No	No	No	
Initial Immobilization	Splint	Knee immobilizer	Splint	Cast	Knee immobilizer	Splint	Bivalved cast	Knee immobilizer	Splint	
Concomitant Injury	None	None	None	None	None	Distal radius	Distal radius	None	Mandible fracture	
Transfer Time, h	> 24	> 24	> 48	> 24	28	48	> 24	> 48	> 24	
Finding	Viable muscle	Viable muscle	Viable muscle	Viable muscle	Dusky, slow contractions	Viable muscle	Viable muscle	Viable muscle	Viable muscle	
Complications	None	Equinous contracture, neuropathy	Varus collapse	None	DVT, arthrofibrosis	Painful hardware	Painful hardware, contracture, shoe lift	None	Nonunion	
Secondary Surgeries	Split-thickness skin graft	Split-thickness skin graft	None	None	Split-thickness skin graft, MUA	Split-thickness skin graft, HWR	HWR	None	Iliac crest bone graft	
Follow-up (months)	6	6	6	14	12	10	38	26	30	**16.4**

Abbreviations: CAD, coronary artery disease; DVT, deep venous thrombosis; HTN, hypertension; HWR, hardware removal; MCC, motorcycle collision; MVC, motor vehicle collision; MUA, manipulation under anesthesia; OTA, Orthopaedic Trauma Association.
[a]In this series, all 9 tibia fractures were closed, comminuted fractures, and each patient underwent decompressive fasciotomy of all 4 leg compartments.

tion) system was used to classify the fractures: 41-C3 (3 cases), 41-B3 (1 case), 43-C3 (2 cases), 43-C1 (1 case), 41-B3 with associated 42-B3 (1 case), and 42-C3 with associated 44-A2 (1 case).

Of the 9 patients, 6 were taken to the operating room more than 24 hours after injury; the other 3 were taken more than 48 hours after injury. Only 2 patients had exact transfer times documented in their charts (one underwent fasciotomy 28 hours after the outside hospital contacted us, and the other waited 48 hours).

All patients had tense, full compartments on examination, but all compartments were neurovascularly intact. All compartment pressure measurements were taken with a Stryker Intra-Compartment Pressure Monitor (Kalamazoo, Michigan), either in the office or in the operating suite before fasciotomy. Mean compartment pressures were anterior 60 mm Hg (range, 40 to 73 mm Hg), lateral 54 mm Hg (range, 25 to 87 mm Hg), deep posterior 56 mm Hg (range, 35 to 83 mm Hg), and superficial posterior 50 mm Hg (range, 35 to 65 mm Hg). Decompressed compartments had measurements within 30 mm Hg of diastolic blood pressure. Each patient underwent decompressive fasciotomy of all 4 leg compartments. Of the 9 patients, 8 were noted to have viable muscle on release of the involved compartments, and 1 had dusky, slowly contracting muscle fibers. In all cases, muscle was bulging and edematous.

Five patients had complications. There were 3 contractures (1 knee, 2 equinus). The knee regained full motion after manipulation under anesthesia. One of the patients with equinus contracture required a percutaneous Achilles tenotomy; the other had to wear a shoe lift for persistent leg-length discrepancy. There was 1 varus malunion after open reduction and internal fixation of a bicondylar plateau fracture, and 1 nonunion of a distal tibia fracture (this healed after iliac crest bone grafting performed 5 months later). One patient developed a deep venous thrombosis without sequelae. Two patients underwent hardware removal for symptomatic hardware. Another patient, after the fracture was healed (and 6 months after fasciotomy), experienced neuropathic pain, which resolved after treatment with medication. Four patients required split-thickness skin grafts for coverage of lateral fasciotomy wounds. There were no infections and no amputations.

Discussion

In a series of 164 patients, McQueen and colleagues[18] found that the most common cause of ACS was fracture (69%) and that the tibial diaphysis was the most common fracture location (36%). They identified injury patterns and patient groups at highest risk for the condition and recommended pressure monitoring for young men (age, < 35 years) with fractures of the shaft of the tibia. Our patient group was more diverse with respect to age and fracture location. Only 1 of our 6 male patients was younger than 35, and there were only 2 diaphyseal fractures of the tibia with associated periarticular fractures. Therefore, all tibia fractures in this series had a periarticular component. There are several explanations for this difference. It is likely that most simple diaphyseal fractures are comfortably treated by community orthopedic surgeons and are not referred to orthopedic trauma specialists (79% of tibia fractures referred for treatment in our series were periarticular injuries). In addition, it is possible that young male patients with diaphyseal tibia fractures who develop ACS are diagnosed and appropriately treated. It is the outliers who are not young men and who have complex periarticular fractures who might be getting missed.

We propose that, when evaluating the amount of energy absorbed by the extremity after a fracture, the treating physician should look closely for fracture comminution and for fractures of increased AO/OTA classification severity.

Only 2 of our 9 patients were in high-speed motor vehicle collisions. The other 7 had much lower energy mechanisms of injury. In addition, only 3 patients had associated injuries. We suspect that, because of the nature of the presenting injuries, the evaluating orthopedic surgeons overlooked the possibility that ACS would develop. We propose that, when evaluating the amount of energy absorbed by the extremity after a fracture, the treating physician should look closely for fracture comminution and for fractures of increased AO/OTA classification severity. All 9 tibia fractures in this series were comminuted, and 6 of these were type C3 fractures. In addition, 1 of the 2 type 41-B3 fractures had an associated comminuted shaft fracture, indicating a high-energy mechanism of injury. It should also be noted that our patients did not have significant confounding medical conditions that would have made the diagnosis more difficult to make. No patient was obtunded, and no patient had neurologic comorbidities that might have masked ACS.[19]

The consequences of missing an ACS diagnosis, or of there being a delay in diagnosis, are grave. Heckman and colleagues[20] found that, in cases in which intracompartmental pressure is within 30 mm Hg of mean arterial pressure, muscle ischemia begins in approximately 8 hours. Possible outcomes are muscle and nerve cell death, contracture, infection, amputation, rhabdomyolysis, and even death.[2-4,6,8-10,13,15,16] It is likely that the patients in our series did not have intracompartmental pressures high enough to cause ischemia up until the time they were released for transfer (no patient required amputation or developed rhabdomyolysis). It is also possible that several patients developed compartment syndrome during transfer, as ACS takes time to develop. Even so, these patients clearly were at risk and should not have been released given the possibility of long transfer time or lack of adherence to emergent transfer procedures. Another possibility is that, absent bed rest with ice and elevation, mobilization during transfer may add to the injury insult and factor into development of ACS.

We have found that, even when patients arrive with ACS of unclear time of onset, emergent fasciotomy can lead to good clinical results. Only 2 patients developed contractures, all other patients had good clinical results, and none developed infections. Therefore, we contend that an orthopedic traumatologist should perform emergent fasciotomy for a transfer patient who has ACS and remains neurologically intact. In doing so, the orthopedic traumatologist can save the patient from the grave consequences of compartment syndrome and prevent potential litigation.[1,17] A recent report, focused on the medicolegal aspects of ACS, found that only 7 (44%) of 16 cases of ACS were closed in favor of the treating surgeon.[17] This is in contrast to what the Committee on Professional Liability reported at the 2000 meeting of the American Academy of Orthopaedic Surgeons: 75% of all orthopedic surgery malpractice claims are won by the surgeon.[21] So, although most malpractice claims against orthopedic surgeons end in favor of the physician, almost half of ACS cases are lost by the surgeon. Bhattacharyya and Vrahas[17] found that the mean indemnity payment for ACS cases was $426,000, versus $136,000 for orthopedic cases. Not only are ACS cases often lost by the physician, the payment to the patient is more than 3 times as much as for other lawsuits.

Prompt diagnosis of this clinical syndrome and early, aggressive fasciotomy are key in lowering patient morbidity and preventing litigation. Insufficient awareness and lack of extreme vigilance are likely the underlying causes for missed diagnoses.

Between 1996 and 2008, 9 patients with periarticular tibia fractures were transferred to our institution and on arrival had ACS. These cases represented 1.0% of all tibia fractures transferred to our care—which agrees with the finding, reported by Delee and Stiehl,[22] that 1.2% of closed tibia fractures developed ACS. We thus have highlighted a significant subset of patients who had not been previously described. Underlying problems likely are the lack of awareness of development of ACS in periarticular fractures and the process of interfacility transfer. We believe that an orthopedic surgeon should not allow an emergency department patient to be released from care if there is even the slightest suspicion of ACS, and that each patient with a tibia fracture should be carefully evaluated, regardless of fracture location, age, or mechanism of injury.

The major shortcomings of this study are its small size, retrospective design, and lack of functional outcome scores. In addition, from patient records alone, we could not determine how long ACS was present before fasciotomy or when ACS began.

This study brings to light a rare but clinically significant problem, in a subset of patients not previously identified, that could be easily resolved with an increased level of vigilance.

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