Delayed Complete Limb Ischemia Following a Closed Tibial Shaft Fracture

Perry J. Evangelista, MD, Lauren M. Evangelista, BA, Gregory T. Evangelista, MD, John T. Ruth, MD, and Joseph L. Mills Sr, MD

Abstract

We present a 19-year-old collegiate athlete who sustained a low-energy closed tibial shaft fracture. Following closed reduction, the dorsalis pedis and posterior tibial pulses were symmetric to the contralateral limb on physical examination. Angiography later confirmed triple vessel arterial disruption complicated by delayed ischemia requiring limb revascularization. Lower extremity triple vessel occlusion from a low-energy injury is rare, and delayed presentation requiring limb salvage is even more unusual. We review the literature, describe the diagnosis and treatment, and propose a strategy for post-fracture reduction management of vascular status.

Physical examination of distal pulses is necessary after extremity trauma. Despite limited data, palpable and symmetric distal pulses, with or without Doppler-derived limb blood pressures, have been used in orthopedics to exclude significant vascular injury in the presence of a tibial shaft fracture.[1] Although several studies show that physical examination reliably excludes significant vascular injury in patients who sustain knee dislocations, the vascular literature would suggest that ankle brachial index (ABI) measurements and some form of popliteal artery imaging be performed in patients with posterior knee dislocations.[2-5] Orthopedic traumatologists have extrapolated and interpreted these data and generally believe that normally palpable distal pulses exclude major vascular injury in patients with tibial shaft fractures.

Multiple studies indicate that when pedal pulses are symmetric to the uninjured extremity, significant vascular injury is unlikely. This case calls into question the adequacy of physical examination alone to accurately exclude significant vascular injury in patients with tibial shaft fractures. We also review the literature and propose appropriate diagnostics and treatment.

The patient provided written informed consent for print and electronic publication of this case report.

Case Report

During low-speed, noncontact drills, a 19-year-old collegiate football player collided with another player. An obvious deformity, diminished dorsalis pedis and posterior tibial pulses were noted at the scene when examined by emergency medical technicians. The patient was splinted as he lay and arrived in the emergency room 2 hours later. He did not report any history of previous injury, neurologic, or vascular symptoms in the affected leg. His medical history was unremarkable. He also did not report using any medications or drugs. His family history was significant for cardiovascular disease but negative for coagulation disorders.

On physical examination at arrival to the emergency department, his foot was externally rotated and there was an obvious deformity at the midportion of the affected leg. His

Figure 1. Anteroposterior radiograph of isolated tibia and fibula midshaft fractures (A). Radiograph demonstrating reduction with external fixation (B).

Authors' Disclosure Statement: The authors report no actual or potential conflict of interest in relation to this article.

skin was intact and his compartments were compressible and non-tender. His motor and sensory examinations were normal, with palpable, but diminished dorsalis pedis and posterior tibial pulses. His foot was warm and well perfused. Left lower extremity radiographs confirmed isolated midshaft fractures of the tibia and fibula (**Figure 1A**).

Closed reduction was performed and a long leg splint was applied. Following the reduction, his dorsalis pedis and posterior tibial pulses were now equal to the contralateral leg with a present Doppler signal. He had no findings of compartment syndrome. His motor and sensory examinations remained intact and he received 30 mg of enoxaparin subcutaneously for deep venous thrombosis prophylaxis. Hourly postoperative nursing notes documented palpable left lower extremity pulses. Approximately 12 hours after the closed reduction, the patient reported paresthesias in the first web space. Upon examination, the foot was cool, pedal pulses were no longer palpable, and ankle Doppler signals were not detectable.

The on-call orthopedic surgeon was present and able to repeat the examination after less than 15 minutes from the onset of symptoms. At this time, the foot was slightly cooler than the contralateral extremity. His sensation was decreased to light touch in the deep peroneal distribution. The remainder of the motor and sensory examination was normal. He exhibited no other signs of compartment syndrome, but the dorsalis pedis and posterior tibial pulses were not palpable nor was flow detectable by continuous wave, hand held Doppler.

The patient was emergently taken to the operating room with suspected vasospasm. The splint was removed and traction applied. No improvement in the pulse examination was noted and Doppler signals remained absent. The patient was urgently transferred to the care of a University vascular surgeon. The leg was rapidly prepared and an external fixator was applied, but the pulses did not return (**Figure 1B**).

A weak, monophasic Doppler signal was present in the posterior tibial artery distal to the medial malleolus. An intraoperative angiogram was then rapidly performed of the thigh (**Figure 2A**) and lower extremity (**Figures 2B, 2C**); this study demonstrated complete occlusion of the anterior tibial and peroneal arteries at the level of the fracture. The posterior tibial artery was occluded just distal to the level of the fracture but subsequently reconstituted just proximal to the ankle joint, with minimal collateral flow to the foot. Surgical exploration demonstrated that the posterior tibial artery was in continuity. Attempts to pass a 2 mm Fogarty catheter distally via the proximal posterior tibial artery were not successful. Therefore, a segment of great saphenous vein was harvested from the contralateral, uninjured extremity for bypass grafting of the injured extremity. A reversed saphenous vein popliteal to paramalleolar posterior tibial artery bypass graft was performed. The total ischemia time to the extremity was less than 4 hours, and after revascularization, there were no signs of ischemia. The joint decision by orthopedics and vascular surgery was made to forego formal 4-compartment fasciotomy since the posterior compartments were opened during bypass grafting and circulation was maintained proximally in the lower extremity.

The following morning, the patient reported leg tightness and pain. His anterior and lateral compartments were now tense and tender to palpation. Passive stretch of his ankle and toes exacerbated his leg pain. His motor and sensory examinations remained unchanged compared to his preoperative examinations and the posterior tibial pulse was palpable. He was emergently taken to the operating room for anterior and lateral compartment fasciotomies. The patient was subsequently discharged from the hospital without any further complications. At the time of the patient's final evaluation 18 months after repair, there were no signs of infection, no claudication or recurrent limb ischemia, the popliteal to posterior tibial artery bypass was patent, and radiographs demonstrated union and callus formation at the fracture sites (**Figures 3A, 3B**).

Discussion

The presented case questions the common practice of using physical examination findings of symmetric distal pulses to

Figure 2. Angiography of femoral to popliteal artery of the distal femur and knee demonstrating bifurcation into anterior tibial artery and posterior tibial artery (A). Angiogram demonstrating occlusion with collaterals of the anterior and posterior tibial and peroneal arteries at the level of the fracture (B). Angiogram demonstrating triple-vessel complete occlusion distal to the fracture site (C).

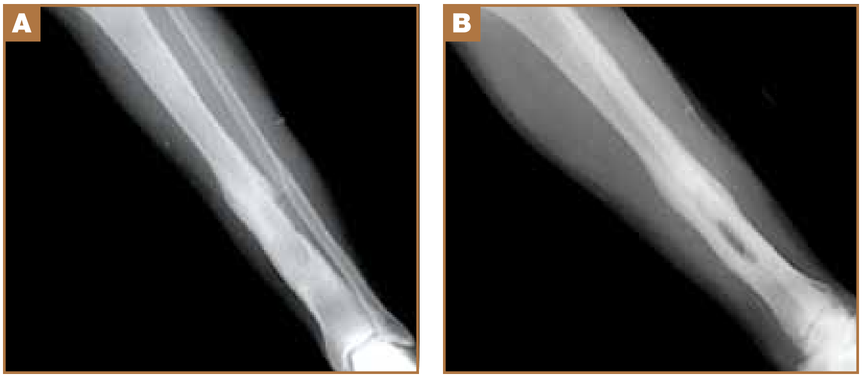

Figure 3. Anterior/posterior radiograph demonstrating fracture callus and union at 18-month follow-up (A). Lateral radiograph demonstrating fracture callus and union at 18-month follow-up (B).

exclude the presence of significant vascular injury in patients with tibial shaft fractures caused by low-energy mechanisms. This practice has been extrapolated from studies performed on patients who sustained knee dislocations.[2-4] It could be speculated that the multiple anastomoses and collaterals between the 3 major vessels of the lower extremity, particularly around the foot and ankle, may have provided palpable pulses.[6] Normal anatomic variants may also have been present, such as primary contribution to the dorsalis pedis from the peroneal artery.[7] An alternative explanation would be that pulse examination alone is subjective and may be less accurate and reliable than objective tests such as Doppler-derived ankle pressures or ABI measurements.

Despite anatomic variants, in our experience, diminished pulses are relatively common following tibial shaft fractures with obvious deformity. The most common suggested etiology involves arterial spasm, kinking of vessels, or direct compression from bone, which has been demonstrated to occur in other regions of the body.[8] Our experience has shown that pulses typically return following closed reduction, as was demonstrated in this case. However, delayed arterial occlusion is not common and likely occurred due to initial acute intimal fracture or partial disruption, and subsequent arterial occlusion, from delayed thrombosis at the sites of intimal injury. If delayed thrombosis at the site of subclinically detectable intimal injury is the cause, then physicians must be aware of this and have their team perform physical examinations hourly in order to quickly detect changes in vascular status and palpable pulses.

There is no accepted universal algorithm for subsequent evaluation of vascular status in such cases of tibial shaft fractures. There are several tests to evaluate vascular status: ABI, duplex ultrasonography, conventional angiography, and multiple-slice helical computed tomography or computed tomography angiography. Of these, ABI is a quick, useful, inexpensive, cost-effective, and extensively studied noninvasive test for assessing the vascular status of a traumatically injured extremity.[9-13] Multiple-slice helical computed tomography angiography (MCTA) and computed tomography angiography (CTA) have a more limited role in the routine evaluation of patients with tibial shaft fractures, as their role has not been well defined and they are more expensive and invasive.[12,13] Nassoura and colleagues[14] compared ABI to angiography after suspected vascular occlusive injury secondary to trauma and found ABI to be a useful tool for assessing significant vascular injury with a reported sensitivity and specificity of 72% and 100%, respectively. Furthermore, they found a positive predictive value of 100% and negative predictive value of 96%. However, Causey and colleagues[15] described a patient with a tibial fracture secondary to blunt trauma who initially had normal pulses on physical examination and an ABI of 1.0, but who subsequently developed limb ischemia and was found to have triple-vessel occlusion. In the latter case, angiography demonstrated vessel injury and assisted in making the decision for revascularization and limb salvage. Screening methods using audible characteristics of the Doppler signals such as pulsatility and phasicity also need to be considered by physicians as tools for assessing patients with tibial shaft fractures, but these studies are subjective, and unless the examiner is extremely experienced, likely are less reproducible and accurate than ABI determination. With the assistance of our vascular surgery colleagues, we used physical examination, hand-held Doppler interrogation, and conventional angiography to detect and define the delayed presentation of triple-vessel injury, establish a timely diagnosis and prompt revascularization for limb salvage. Limb salvage following blunt orthopedic trauma with triple vessel injury is challenging; amputation rates of 60%-90% have been reported in such scenarios.[15,16]

To our knowledge, this is the second case of blunt tibial trauma resulting in triple-vessel arterial disruption despite initially normal pedal pulses. Currently there is limited published literature to guide vascular status evaluations of the lower extremity following a tibial shaft fracture. Further research is needed in this area.

Conclusion

The literature related to low impact, blunt shaft tibial fractures suggests that when a patient has pulses in the injured extremity that are symmetric in comparison to the contralateral extremity, a significant vascular injury is highly unlikely. This case, in addition to the one reported by Causey and colleagues,[15] indicates that a normal physical examination does not exclude limb threatening arterial injury. Physicians who treat these types of injuries must be aware of this fact and implement close observation. In addition, more objective serial evaluations such as hand held Doppler interrogation or ABI determination might be prudent.

With the lack of adequate literature available regarding assessment of vascular injury in patients with tibial shaft fractures, further research should aim at defining the best method to assess these patients in an effective, timely, and cost-effective manner. It is our recommendation that physical examination consisting of pulse checks prior to and after fracture reduction, along with 1-hour pulse checks for a minimum of 24 hours will adequately detect significant vascular injury in a manner that is timely and cost-effective. Any subsequent and concerning change in physical examination should then be further assessed with ABI or duplex ultrasound. Prompt vascular surgical consultation in cases of possible or suspected vascular injury is essential, as signs and symptoms may be subtle.

Dr. Evangelista (PJE) is Orthopaedic Surgeon, New York University Hospital for Joint Diseases. Mrs. Evangelista (LME) is Medical Student, Temple University School of Medicine, Philadelphia, Pennsylvania. Dr. Evangelista (GTE) is Orthopaedic Surgeon and Chief of Orthopaedic Surgery, Scottsdale Healthcare-Osborn, Scottsdale, Arizona. Dr. Ruth is Orthopaedic Surgeon and Department Head, Department of Orthopaedic Surgery, University of Arizona Medical Center-Alvernon Clinic, Tucson, Arizona. Dr. Mills is Vascular Surgeon; Professor of Surgery; Chief, Vascular and Endovascular Surgery; and Co-Director Southern Arizona Limb Salvage Alliance, University of Arizona, Tucson, Arizona.

Address correspondence to: Perry J. Evangelista, MD, 301 E 17th St #1402, New York, NY 10003 (tel, 212-598-6205; fax, 623-249-5740; e-mail, perry.evangelista@nyumc.org).

Am J Orthop. 2013;43(12):569-572.

References

1. Norman J, Gahtan V, Franz M, Bramson R. Occult vascular injuries following gunshot wounds resulting in long bone fractures of the extremities. *Am Surg.* 1995;61(2):146-150.
2. Treiman GS, Yellin AE, Weaver FA, et al. Examination of the patient with a knee dislocation. The case for selective arteriography. *Arch Surg.* 1992;127(9):1056-1062.
3. Martinez D, Sweatman K, Thompson EC. Popliteal artery injury associated with knee dislocations. *Am Surg.* 2001;67(2):165-167.
4. Kendall RW, Taylor DC, Salvian AJ, O'Brien PJ. The role of arteriography in assessing vascular injuries associated with dislocations of the knee. *J Trauma.* 1993;35(6):875-878.
5. Halvorson JJ, Anz A, Langfitt M, et al. Vascular injury associated with extremity trauma: initial diagnosis and management. *J Am Acad Ortho Surg.* 2011;19(8):495-504.
6. Cone JB. Vascular injury associated with fracture-dislocations of the lower extremity. *Clin Orthop Relat Res*. 1989;(243):30-35.
7. Ali MW, Mohajir AM. Dorsalis pedis artery: variations and clinical significance. *J Indian Med Assoc.* 1996;94(11):417-418.
8. Sharrock NE, Go G, Mayman D, Sculco TP. Decreases in pulmonary artery oxygen saturation during total hip arthroplasty variations using 2 leg positioning techniques. *J Arthroplasty.* 2005;20(4):499-502.
9. Hirsch AT, Haskal ZJ, Hertzer NR, et al. ACC/AHA 2005 guidelines for the management of patients with peripheral arterial disease (lower extremity, renal, mesenteric, and abdominal aortic): executive summary a collaborative report from the American Association for Vascular Surgery/ Society for Vascular Surgery, Society for Cardiovascular Angiography and Interventions, Society for Vascular Medicine and Biology, Society of Interventional Radiology, and the ACC/AHA Task Force on Practice Guidelines (Writing Committee to Develop Guidelines for the Management of Patients With Peripheral Arterial Disease) endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation; National Heart, Lung, and Blood Institute; Society for Vascular Nursing; TransAtlantic Inter-Society Consensus; and Vascular Disease Foundation. *J Am Coll Cardiol*. 2006;21;47(6):1239-1312.
10. McDermott MM, Criqui MH, Liu K, et al. Lower ankle/brachial index, as calculated by averaging the dorsalis pedis and posterior tibial arterial pressures, and association with leg functioning in peripheral arterial disease. *J Vasc Surg.* 2000;32(6):1164–1171.
11. Mills WJ, Barie DP, McNair P. The value of the ankle-brachial index for diagnosing arterial injury after knee dislocation: a prospective study. *J Trauma.* 2004;56(6):1261-1265.
12. Inaba K, Potzman J, Munera F, et al. Multi-slice CT angiography for arterial evaluation in the injured lower extremity. *J Trauma.* 2006;60(3):502–506.
13. LeBus GF, Collinge C. Vascular abnormalities as assessed with CT angiography in high-energy tibial plafond fractures. *J Orthop Trauma*. 2008;22(1):16-22.
14. Nassoura ZE, Ivatury RR, Simon RJ, Jabbour N, Vinzons A, Stahl W. A reassessment of Doppler pressure indices in the detection of arterial lesions in proximity penetrating injuries of extremities: a prospective study. *Am J Emerg Med*. 1996;14(2):151-156.
15. Causey MW, Oguntoye MO, Miller S, Anderson C, Singh N. Limb salvage after delayed diagnosis for blunt traumatic infrapopliteal occlusion. *J Vasc Surg*. 2010;52(3):734-737.
16. Padberg FT Jr, Rubelowsky JJ, Hernandez-Maldonado JJ, et al. Infrapopliteal arterial injury: prompt revascularization affords optimal limb salvage. *J Vasc Surg*. 1992;16(6):877-885; discussion 885-886.