

Blunt Lower-Extremity Trauma and Popliteal Artery Injuries

Revisiting the Case for Selective Arteriography

Hatem Abou-Sayed, MD; David L. Berger, MD

Hypothesis: Abandoning mandatory angiography in patients with blunt lower-extremity trauma and normal neurovascular examination results does not affect limb salvage.

Design: Retrospective, nonrandomized cohort study. Mean follow-up (31 of 52 patients) of 9.5 months (range, 0-96 months).

Setting: Single-institution, academic level I trauma center.

Patients: Medical records of patients presenting emergently with knee dislocation, distal femoral fractures, or proximal tibial fractures during a 20-year period were reviewed. Fifty-three injuries occurred in 52 patients. Patients were predominantly male (81%) and young (mean age, 32.7 years). Mechanisms and side of extremity injury, coincident injuries, and neurovascular status on admission were recorded. Hard signs of arterial insufficiency or compartment syndrome were identified.

Interventions: Angiographic findings and operative and nonoperative interventions were recorded to identify whether angiographic data would alter therapy dictated by clinical findings alone.

Main Outcome Measures: Limb salvage rate and necessity for vascular surgical intervention based on an-

giographic data in patients with normal neurovascular examination results.

Results: Multiorgan trauma occurred in 11 patients. Pulses were normal in 35, absent in 16, and diminished or identified by Doppler signal in 2. Arterial insufficiency or compartment syndrome was present in 29%. Twenty-seven patients (28 limbs) underwent angiography at the discretion of the attending surgeon. Of 13 abnormal arteriograms, 2 occurred in patients with normal pulses and 11 in patients with abnormal examination results. Thirteen of 36 patients with normal pulses underwent angiography; none had clinically significant arterial injuries that necessitated intervention. No vascular interventions were necessary in 23 patients with normal pulses who did not undergo angiography ($P < .001$). Normal neurovascular status bore a 100% negative predictive value in determining the necessity of vascular intervention.

Conclusions: Angiography is unnecessary in the routine evaluation of the patient with blunt lower-extremity trauma who presents with a normal neurovascular examination result and can be used selectively for patients with diminished pulses who lack associated indications for mandatory operative exploration.

Arch Surg. 2002;137:585-589

From General Surgical Services, Massachusetts General Hospital, Boston. Dr Abou-Sayed is now affiliated with the Department of Plastic Surgery, University of California at San Francisco.

BLUNT TRAUMA to the lower extremity has been associated with a 28% to 46% rate of injury to the popliteal artery¹⁻³ in the form of transection, occlusion, or intimal injury. The popliteal artery, by virtue of its ligamentous fixation and anatomic relationships to the femur, tibial plateau, and knee joint apparatus, is uniquely susceptible to injury with blunt extremity trauma. Early literature⁴ documented the considerable risk of limb loss with these injuries, particularly when managed with ligation alone, with reported amputation rates of up to 49%. Delay in diagnosis of major arterial injuries

represents a significant contributor to high amputation rates, although increasingly sophisticated orthopedic and vascular surgical techniques have markedly improved overall outcomes in most modern series. Recent studies⁵⁻⁷ of both military populations and civilian data have demonstrated a marked improvement in limb salvage with early recognition of arterial injury and application of advanced techniques of vascular repair. Early literature^{8,9} demonstrated a high rate of association of vascular injuries with blunt lower-extremity trauma and emphasized the importance of rapid diagnosis and aggressive efforts at limb salvage, advocating mandatory arteriogra-

PATIENTS AND METHODS

A retrospective follow-up study of patients with blunt lower-extremity trauma was performed to evaluate the likelihood of missed, yet clinically significant, arterial injuries if mandatory arteriography were abandoned in favor of a selective algorithm in the evaluation of patients with normal pulses and neurologic findings.

Medical records of 53 emergency presentations for blunt lower-extremity trauma (among 52 patients) were reviewed. *International Classification of Diseases, Ninth Revision*, codes for anterior and posterior knee dislocations, tibial plateau fractures, distal femoral fractures, and knee injuries otherwise unspecified were included for review. Patients with knee injuries who presented more than 24 hours from the inciting event were specifically excluded, because most of these were ligamentous or meniscal tears that did not represent significant disruption of the knee apparatus. Demographic data were gathered using a Microsoft Excel (Microsoft Corp, Redmond, Wash) spreadsheet data instrument for collation. Demographic data included patient age and sex, side of injury, mechanism of trauma, and associated organ system injuries. The principal clinical data point was neurovascular examination result on admission, as documented, when available, by the fifth year general surgery resident who served in the capacity of chief resident in the trauma service or, when unavailable, by the most senior surgical evaluator in the emergency department. Pulses were documented as palpable, nonpalpable but with detectable Doppler signals, or absent. Duplex studies were not obtained. A Boolean value was assigned based on whether diagnostic preoperative arteriography was performed in the emergency department, the radiography suite, or the operating room before formal exploration of the extremity for vascular injury. Angiographic findings were logged, including the presence of vessel transection, occlusion, or intimal flap. Operative procedures were recorded, including details of vascular repairs (if performed) and adjunct procedures, including fasciotomies. Outcomes of interest included limb salvage and changes in management dictated by angiographic findings, particularly in patients with normal preoperative neurovascular examination results. Posthospitalization follow-up was poor and was obtained from patient records in the outpatient trauma clinic. Statistical significance was determined by χ^2 analysis and recorded as significant at $P \leq .05$.

phy in all patients irrespective of the results of neurovascular examination on admission. Considerable recent literature lends credence to a selective posture in patients with a normal admission neurovascular examination result in the injured extremity.¹⁰⁻¹²

RESULTS

Fifty-three injuries were identified in 52 patients. One patient (2%) had bilateral injuries, with normal palpable pulses in one extremity but clinical evidence of compartment syn-

Pulse Examination and Angiographic Findings

Examination and Findings	No. of Patients
Normal palpable pulses	
Peroneal palsy or parathesias	3
Compartment syndrome	1
No signs of arterial insufficiency or compartment syndrome	33
Angiogram performed	13
Normal angiograms	11
Fasciotomy for compartment syndrome	1
Abnormal angiograms	2
Intimal flap	1
Anterior tibial occlusion	1
No angiogram performed	23
Fasciotomies for compartment syndrome	2
Vascular interventions	0
Abnormal pulse examination result	
Distal ischemia	13
Traumatic near amputation	1
Hemorrhaging wound with ischemia	1
Pulse abnormality without ischemia	1
Angiogram performed	15
Normal angiograms	4
Fasciotomies	0
Vascular repairs	0
Abnormal angiograms	11
Dorsalis pedis occlusion—no intervention	1
Anterior tibial occlusion—no intervention	1
Intimal flap—no intervention	1
Popliteal artery occlusion	7
Popliteal artery transection	1

drome in the contralateral limb. Of the 52 patients, 42 (81%) were male and 10 (19%) were female; their mean age was 32.7 years (range, 15-76 years). The predominance of men was consistent with the demographics of most large series detailing blunt injuries to the lower extremity. Right extremities were injured more frequently than the left (29 [56%] and 22 [42%], respectively). Mechanisms of injury were as follows: fall, 12 (23%); sports, 10 (19%); pedestrian struck, 10 (19%); motor vehicle crash, 10 (19%); motorcycle crash, 6 (12%); industrial accident, 2 (4%); and crush, 2 (4%). Extremity injuries—in the form of ligamentous disruptions of the knee apparatus, distal femoral fractures, or tibiofibular fractures—were solitary and limited to one extremity in 22 (42%) patients. Additional extremity injuries, either ipsilateral or contralateral to the principal injury, were present in 19 patients (37%). Seven patients (13%) sustained trauma to 2 or more organ systems, and 4 (8%) sustained head trauma as their only additional injuries. Pulses in the injured extremity were palpable in 35 patients (67%), absent in 16 (31%), and nonpalpable but identifiable by Doppler signal in 2 (4%).

Of particular interest in the determination of the necessity of angiography is an accurate assessment of signs of arterial insufficiency or compartment syndrome in the injured limb. Thirty-seven (70%) injured extremities showed neither hard signs of arterial insufficiency nor evidence of compartment syndrome. Angiography was performed at the discretion of the attending trauma surgeon in the evaluation of 28 extremities (53%), whereas 25 were not studied. Angiographic findings are listed in the **Table**. Fifteen of 28 extremities had normal angio-

grams. In the group for which angiography was performed, no vascular intervention was necessary in 22 patients (79%), although this group included 2 patients operatively explored and found to have no popliteal or other vascular injuries that necessitated further intervention. In addition, 3 patients in the angiography group required fasciotomies, which were all performed for clinically apparent compartment syndrome.

Angiography was deferred in 26 extremities. Twenty-four of these extremities required no intervention. One patient experienced a near-complete traumatic amputation that required operative completion. The remaining patient required a saphenous vein bypass graft for a popliteal artery disruption, which was clinically evinced by frank arterial hemorrhage, absent distal pulses, and pallor and poikilothermia of the foot. Thus, both patients had preoperative evidence of arterial insufficiency or an obligate indication for amputation, which were apparent on clinical grounds alone and therefore did not require confirmatory angiography. The limb salvage rate in the remaining patients who did not undergo angiography was 100%.

Normal neurovascular status was present in 33 extremities. Three patients had peroneal palsies or distal paresthesias, and 1 of these also demonstrated evidence of compartment syndrome. Angiography was deferred for 23 limbs, none of which showed signs of arterial insufficiency or compartment syndrome. No vascular intervention was necessary in these 23 patients. Fasciotomies were performed on 2 limbs, both of which had significant tibial plateau fractures with massive soft tissue injury and edema, again clinically apparent even in the absence of angiography. There was no subsequent limb loss in these patients, with completely normal neurovascular examinations on admission, and no need for additional invasive procedures, despite deferral of arteriography.

Moreover, of the 13 limbs with normal palpable pulses for which angiography was performed, the only injury that required any nonorthopedic intervention showed obvious evidence of compartment syndrome, which was treated with fasciotomies. The angiogram in this patient was normal.

Two patients in this series with normal pulses and normal neurologic examination results had arteriographic abnormalities. The first was an intimal flap treated nonoperatively with aspirin and short-term heparin sodium, and the second was an anterior tibial artery occlusion that required no vascular intervention and was identified in the patient with bilateral injuries who was to undergo surgery for contralateral compartment syndrome. In short, no patient with normal pulses and no other obligate indication for prompt surgery (to remediate major unstable orthopedic injuries, to address clinically apparent compartment syndrome, or to deal with these features in a contralateral injured limb) required a vascular intervention. All patients with angiographically identified injuries that required surgical repair had abnormal neurovascular examination results ($P < .001$). Sensitivity of the abnormal pulse examination in identifying the need for vascular intervention in patients who would not otherwise require operative management of associated injuries was 100%, with a specificity of 80%; to wit, 9 (20%) of 45 patients who required no vascular procedures had

abnormal neurovascular examination results. Included among this last group were 4 patients who underwent either completion amputation for massive soft tissue injury or fasciotomy for clinically apparent compartment syndrome. Negative predictive value of the normal neurovascular status was 100%, whereas positive predictive value was 47%. Follow-up data were obtained in 31 (60%) of the 52 patients. Mean follow-up time was 9.5 months (range, 1-96 months), and the median follow-up time was 3 months. There were no cases of delayed amputation after the initial hospitalization nor were there any recorded sequelae of pseudoaneurysm or delayed vascular reconstruction of occult injuries undetected at the initial evaluation. The authors conclude, on the basis of 100% negative predictive value and the absence of initial delayed morbidity or limb loss in 60% of the population for whom data were available, that angiography is unnecessary in the short-term evaluation of the bluntly injured extremity with a normal admission neurovascular status.

COMMENT

The association of popliteal and other lower-extremity vascular injuries with blunt and penetrating trauma to the lower extremity is well described.¹³⁻¹⁸ Popliteal arterial injuries, particularly disruptions and occlusive insults, represent a significant threat to limb viability in the traumatized patient. DeBakey and Simeone,⁴ in their seminal article detailing wartime experience with major-extremity arterial injuries, cited a 49% amputation rate with simple arterial ligation and a disastrous 73% with ligation of the popliteal artery, in particular. Limb loss rates improved to 32% in the Korean conflict^{5,6} and the Vietnam War,⁷ owing largely to improvements in battlefield triage, transport mechanisms, and increasingly sophisticated options for vascular repair. Early civilian studies demonstrated similarly dismal outcomes for simple vascular ligation (an amputation rate as high as 70%), and more recent data mirror the improvement in limb salvage in the modern era (9% to 42% limb loss). A review of civilian population literature from the 1970s and 1980s demonstrated rates of popliteal arterial injury accompanying blunt knee trauma of up to 46%. A similar single-institution review¹⁷ spanning 3 decades noted an amputation rate of 74% in the first decade, when simple ligation was the standard of care. With increasing use of arterial repair, vein grafting, and fasciotomy, markedly decreased primary and secondary amputation rates, from 28% to 6% during the next 2 decades, were achieved. These historical data underscore the great potential for major limb-threatening vascular injuries from blunt trauma to the lower extremity and, in particular, from knee dislocations.

Analysis of literature from the 1980s and 1990s reveals increasing support for selective angiography. Treiman et al¹¹ published a review of 115 patients who underwent routine angiography for unilateral knee dislocations. Pulse examination was 100% sensitive in predicting the presence of arterial injury that required repair. More importantly, the negative predictive value of a normal pulse examination result was 100% and overall accuracy was 93.9%. Four nonoperative, nonocclusive injuries occurred in 86 patients with normal pulses. The authors concluded that

all patients with abnormal pulses should undergo angiography or prompt exploration, whereas those with normal pulses could be safely observed with serial examinations for 24 to 48 hours. This stance was similarly supported by data from Dennis et al.¹² In their series, 17 of 36 injured limbs without hard signs of arterial insufficiency were studied with angiograms, whereas the remainder were observed. In the angiography cohort, all patients had either normal studies or minimal, nonoperative injuries. All 36 limbs had either normal pulses or diminished but detectable ones. There were no complications in the "minimal injury" group. Again, physical examination alone predicted the need for surgical intervention with 100% accuracy based on the presence or absence of hard signs of arterial insufficiency, and information on angiography did not alter treatment plans made on the basis of clinical data alone. The data from Harrell et al.¹⁸ of the University of Louisville, Louisville, Ky, are similarly encouraging: no patients (N=38 injuries) with posterior knee dislocations and pulses or Doppler signals lost a limb, and 90% of patients with vascular injuries had abnormal examination results. One patient with palpable pulses had an intimal injury managed conservatively.

Against the current of support for selective angiography are the occasional reports of missed injuries in patients who present with late sequelae. Interestingly, in the same year as the University of Louisville published favorable outcomes with a selective approach, the same institution presented a case report¹⁹ of a 28-year-old patient for whom angiography was initially deferred on the basis of a normal pulse examination result and subsequently presented with a popliteal pseudoaneurysm 5 weeks after his initial injury. Despite their own quasi-meta-analysis of major series, which in aggregate strongly supported a selective approach, the authors cautioned against relying solely on normal physical examination findings. The patient presented, however, had an occult injury that only became manifest in delayed fashion and was reparable without limb loss.

The objective of this analysis was to determine the reliability of the normal extremity neurovascular examination result in predicting the absence of clinically significant vascular injuries that might require operative repair or additional invasive procedures. In this series, there were no instances of occult limb-threatening injury presenting with normal initial neurovascular examination results and delayed sequelae. Every patient who required operative management for a vascular injury presented with abnormal pulses or associated limb injuries that necessitated prompt surgery. Had the criterion of a normal neurovascular examination result been used to defer angiography in those patients, 13 unnecessary studies could have been avoided without incurring significant morbidity.

Moreover, there were no cases of delayed sequelae in those patients with normal neurovascular examination results in whom angiography was deferred, and limb loss in these patients was nil. In 36 patients with normal neurovascular status, 2 angiographic findings warrant specific discussion: the first, an anterior tibial occlusion, and the second, a nonocclusive intimal flap. In the former case, the patient was taken to the operating room for management of a contralateral injury with attendant compart-

ment syndrome, and no vascular repair or invasive intervention was necessary in the limb with the angiographic finding of anterior tibial artery occlusion. In the latter case, the patient was treated with aspirin and heparin. The lone patient with an intimal flap treated nonoperatively is therefore the only case of overall surgical management alteration as a consequence of radiographic abnormalities in a limb with normal neurovascular status. The necessity of formal systemic anticoagulation or subsequent platelet inhibition in patients with clinically inapparent nonocclusive injuries is poorly addressed in the surgical literature. The authors recommend that all patients with posterior knee dislocations take aspirin for 6 months after injury, unless contraindicated by comorbid conditions.

In the remainder of patients with normal neurovascular examination results, there was no alteration in treatment made on the basis of angiographic data. Two patients who underwent fasciotomies had tibial plateau fractures that required prompt operative repair, and, in both instances, fasciotomy was performed as a matter of routine by the orthopedic surgeons. Preoperative evidence of compartment syndrome was absent in both cases. One patient with normal pulses had other clinical signs of compartment syndrome and accordingly underwent fasciotomy, although the angiogram was normal. Again, in this case, an invasive therapeutic procedure was performed on clinical grounds alone, and the same intervention would have been performed even in the absence of adjunctive angiography.

The data presented herein support a posture of selective angiography and, in particular, suggest that patients with normal neurovascular examination results can be safely observed with serial examinations and, where indicated, with adjunctive noninvasive studies. In the short-term presentation, static and fluoroscopic angiography can generally be performed in the operating room for patients who require prompt surgical management of associated unstable orthopedic or other operative injuries. Patients with hard signs of arterial insufficiency who do not otherwise require rapid operative management of other injuries can be safely studied with expeditiously obtained formal arteriograms in the radiology suite or explored formally without preoperative angiography in the setting of immediate limb-threatening neurovascular findings. Follow-up data were obtained in only 60% of patients, and there is a risk of unrecognized injuries presenting in delayed fashion with limb-threatening complications. However, there were no presentations to the hospital during the study period of this type of occurrence. It is unknown if patients included in this series presented to other institutions with sequelae of their injuries.

CONCLUSIONS

Popliteal artery trauma is a major source of patient morbidity and is highly associated with blunt injuries to the lower extremity. Normal initial neurovascular examination results reliably predict the absence of arterial injury that requires surgery. Patients with normal neurovascular examination results can be observed with serial examinations without requiring formal angiography. Patients with

obligate indications for prompt surgical management of orthopedic or other injuries and abnormal neurovascular examination results can be evaluated with on-table angiography as necessary. Patients without obligate indications for immediate surgery that present with abnormal pulses or neurologic deficits should undergo formal angiography or duplex ultrasonography. Although a high index of suspicion for vascular injury should be maintained in all patients who present with blunt trauma to the lower extremity, limb loss rates do not appear to be affected by a selective approach to angiography.

This study was presented at the 82nd Annual Meeting of the New England Surgical Society, Providence, RI, September 21, 2001.

Corresponding author and reprints: David L. Berger, MD, Room ACC 465, General Surgical Services, Massachusetts General Hospital, 15 Parkman St, Boston, MA 02114.

REFERENCES

1. Welling RE, Kakkasseril J, Cranley JJ. Complete dislocations of the knee with popliteal vascular injury. *J Trauma*. 1981;21:450-453.
2. McCabe CJ, Ferguson CM, Ottinger LW. Improved limb salvage in popliteal artery injuries. *J Trauma*. 1983;23:982-985.
3. Alberty RE, Goodfried G, Boyden AM. Popliteal artery injury with fracture dislocation of the knee. *Am J Surg*. 1981;142:36-40.
4. DeBakey ME, Simeone FA. Battle injuries of the arteries in World War II. *Ann Surg*. 1946;123:534-571.
5. McNamara JJ, Brief DK, Stremple JF, Wright JK. Management of fractures with associated arterial injury in combat casualties. *J Trauma*. 1973;13:17-19.
6. Hughes CW. Arterial repair during the Korean War. *Ann Surg*. 1958;147:555-561.
7. Rich NM, Baugh JH, Hughes CW. Popliteal artery injuries in Vietnam. *Am J Surg*. 1969;118:531-534.
8. Shields L, Mital M, Cave EF. Complete dislocations of the knee: experience at the Massachusetts General Hospital. *J Trauma*. 1969;9:192-215.
9. O'Donnell TF, Brewster DC, Darling RC, Venn H, Waltmin AA. Arterial injuries associated with fractures and/or dislocations of the knee. *J Trauma*. 1977;17:775-784.
10. 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;35:875-878.
11. Treiman GS, Yellin AE, Weaver FA, et al. Examination of the patient with a knee dislocation: the case for selective arteriography. *Arch Surg*. 1992;127:1056-1063.
12. Dennis JW, Jaggar C, Butcher JL, Menawat SS, Neel M, Frykberg ER. Reassessing the role of arteriograms in the management of posterior knee dislocations. *J Trauma*. 1993;35:692-697.
13. Kennedy JC. Complete dislocation of the knee joint. *J Bone Joint Surg Am*. 1963;45:889-906.
14. Lefrak EA. Knee dislocation: an illustrative cause of critical arterial occlusion. *Arch Surg*. 1976;111:1021-1024.
15. Dart CH, Braitman HE. Popliteal artery injury following fracture or dislocation at the knee. *Arch Surg*. 1977;112:969-973.
16. Miller HH, Welch CS. Quantitative studies of the time factor in arterial injuries. *Surgery*. 1979;85:101-107.
17. Fabian TC, Turkelson ML, Connelly TL, Stone HH. Injury to the popliteal artery. *Am J Surg*. 1982;143:225-228.
18. Harrell DJ, Spain DA, Bergamini TM, Miller FB, Richardson JD. Blunt popliteal artery trauma: a challenging injury. *Am Surg*. 1997;63:228-232.
19. Gable DR, Allen JW, Richardson JD. Blunt popliteal artery injury: is physical examination alone enough for evaluation? *J Trauma*. 1997;43:541-544.

DISCUSSION

Brad Cushing, MD, Portland, Md: Popliteal artery injury is seen in about 25% to 46% of patients with blunt trauma with

knee dislocation. This association has led many to advocate mandatory arteriograms in this population. Several authors, and now Drs Abou-Sayed and Berger, have questioned this mandatory arteriography and have attempted to evaluate its selective use.

The authors succinctly state that the objective of their study is to identify the likelihood of missed, yet, clinically significant, arterial injuries in patients with knee dislocation or fracture around the knee who have a normal neurovascular examination. Given this objective, I counted 33 limbs, not 53, that met criteria for inclusion by virtue of having the marker injuries and a normal neurovascular examination. Of the 33, 12 underwent angiography and 2 had findings. One finding was an intimal flap treated nonoperatively, and the other was an anterior tibia artery occlusion. I agree you never needed to know about the anterior tibial artery occlusion, but you did elect to treat the intimal flap with heparin and aspirin, suggesting that it was clinically significant.

Nineteen patients who met inclusion criteria did not undergo angiography. The only way to discern missed injuries in this subset would be with solid follow-up. You gave us the mean follow-up time but did not tell us really how many in the population were actually followed up, and I am very concerned about your statement, "Follow-up was not found in the chart." The first question, therefore, is how many of the 19 patients not angiogrammed were followed up and are you confident that they did not manifest late sequela of missed arterial injury?

Before we can generalize your findings to the patients we see, we need to know a little bit more about your population. We know that the incidence of arterial injury with knee dislocation is high but the incidence in patients with proximal tibial and distal femoral fractures without dislocation, though poorly defined in the literature, is considerably less. You did not provide us with the distribution of specific injuries in your population. If you have a preponderance of patients without dislocation, then selective angiography would appear safe, but we would be a lot more reluctant to apply that approach to the patient on the stretcher before us with a posterior knee dislocation. My second question is then, what is the distribution of injuries in your population? How many patients had knee dislocations and how many had only fractures?

In summary, I agree that patients without neurovascular findings have a low incidence of arterial injury and that selective use of angiography is safe. I did not, however, base that agreement on the data that you provided. If you convince us that your follow-up is solid and you better describe your population, you may well support your conclusions but as yet you have not.

Dr Abou-Sayed: With respect to our patient population, the distribution of injuries was roughly about 50% of patients with knee dislocations and approximately 50% of patients who did not have a concomitant knee dislocation with fracture alone. I think it is difficult to perhaps generalize on the basis of the knee dislocation to all patients with bony and ligamentous injury to the knee apparatus or to the distal femur or proximal tibia, although that is supported in the surgical literature that we reviewed.

With respect to the follow-up, follow-up in those 19 patients was available for about 60%, and in some of those patients, again the records we reviewed during a 20-year period, we did not have access to clinic follow-up visits. Regarding their hospital courses, certainly there was no evidence of limb loss during their hospital course, and to the extent that follow-up was available, again there was no evidence of limb-threatening injuries in those patients. I cannot speak to whether those patients were seen at other institutions subsequently with delayed pseudoaneurysm formation and that is certainly a drawback of the study. Hopefully, with more work on this topic and maybe a more longitudinal study we could answer that a little bit better for you.