

Case Report

Occult major venous injury in penetrating thigh trauma: An underdiagnosed cause of morbidity and mortality

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ABSTRACT

Background: There are no current consensus guidelines that address screening patients who may have occult major venous injury in the setting of penetrating thigh trauma. Yet, such injuries confer significant morbidity and mortality to trauma patients if left untreated.

Methods: This paper examines the cases of three patients who presented to our single level I trauma center after sustaining penetrating thigh trauma with negative CT arteriography, all of whom were eventually diagnosed with occult major venous injury.

Results: One patient developed massive pulmonary embolism with death and the other two patients required operative exploration due to a foreign body within a major vein and major venous hemorrhage.

Conclusion: These cases underscore the importance of having a high index of suspicion for occult major venous injury in select patients with penetrating thigh trauma and negative CT arteriography.

Level of evidence: V Study type: therapeutic/care management.

Background

Current guidelines thoroughly discuss the diagnosis and management of patients with penetrating extremity trauma. In evidence-based algorithms, patients with “hard signs” of vascular injury require emergent operation and patients with “soft signs” or proximity injury require further evaluation with ankle-pressure indices (APIs) and/or CT arteriography (CTA). However, we have recently encountered several occult venous injuries associated with need for intervention and in one case death.

We recently managed a young man who died of a massive pulmonary embolism following a gunshot wound to the thigh who had no “hard signs” of vascular injury and a negative CTA; autopsy confirmed femoral vein injury. This prompted an immediate modification of how we managed patients with penetrating trajectories in proximity to the neurovascular bundle. Specifically, even if the CTA is negative for arterial injury, venous duplex ultrasound is now used to screen for an ‘occult’ venous injury in select patients.

Methods

In this brief report, we present three cases of patients who sustained penetrating thigh trauma at our mature, level I trauma center who had a major venous injury despite a CTA which was negative for arterial injury. We conclude that CTA is insufficient to diagnose

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major venous injuries and recommend that further screening be obtained in select patients.

Cases

Cases are presented in chronological order of presentation. Admitting parameters are depicted in [Table 1](#).

Case 1

A 23-year-old man with no medical history was brought to the hospital by ambulance after sustaining gunshot wounds to the right lower extremity. On arrival, examination of the affected extremity revealed two wounds to the anteromedial and posterolateral thigh without bleeding or expanding hematoma after the prehospital tourniquet was removed. No sensorimotor deficits were noted and an ankle-brachial index was performed showing a diminished ratio of 0.85 on the right. Given the patient's hemodynamic stability and no hard signs of vascular injury, CTA was performed showing evidence of gas tracking near the right femoral vessels but no evidence of arterial or venous injury ([Fig. 1](#)). The patient was admitted to the hospital for observation to monitor for extremity compartment syndrome.

Hours later, serial examination showed significant improvement in the patient's pain with a neurovascularly intact right lower extremity and a soft thigh compartment. Twelve hours after arrival to the hospital the patient suddenly developed respiratory distress, became agitated and confused and rapidly lost pulses. Cardiopulmonary resuscitation was attempted but return of spontaneous circulation was not able to be achieved. A postmortem examination of the patient revealed right femoral vein perforation with surrounding clot and hemorrhage with bilateral massive pulmonary embolism as the cause of death.

Case 2

A 62-year-old man with no medical history was brought to the hospital by ambulance after sustaining gunshot wounds to the right lower extremity. Upon arrival, examination of the affected extremity revealed four puncture wounds to the anterior and posterior thigh. The patient had no sensorimotor deficits and exam showed 2+ palpable pedal pulses and an ankle-ankle index of 1.0. Given the estimated trajectory of the missiles, a CTA was performed showing stranding and metallic fragments near the proximal popliteal artery and vein but no contrast extravasation concerning for major vascular injury ([Fig. 2a](#)). The proximity of the metallic fragments to the vascular bundle subsequently led to a venous duplex ultrasound which showed concern for an echogenic foreign body within the popliteal vein ([Fig. 2b](#)).

The patient was taken to the operating room and exploration of the popliteal fossa was performed. The popliteal artery was found to be free of injury, but the popliteal vein had injuries to the anterior and posterior wall as well as a bullet lodged within the lumen of the vessel with associated intraluminal thrombus. The bullet was removed and the vein was primarily repaired. Postoperatively, the patient was placed on systemic anticoagulation for a planned duration of 3 months. He was well at the post-discharge clinic visit.

Case 3

A 40-year-old man with no medical history was brought to the hospital by ambulance after sustaining gunshot wounds to the left lower extremity. On arrival, examination of the affected extremity revealed two puncture wounds to the medial and lateral distal thigh without bleeding after the prehospital tourniquet was removed. His blood pressure and heart rate stabilized in the trauma bay after transfusion. No sensorimotor deficits were noted. He had a 2+ dorsalis pedis pulse, but the posterior tibial pulse was not palpable. CT arteriography was pursued which showed subcutaneous emphysema near the neurovascular bundle, but no evidence of arterial or venous injury ([Fig. 3](#)).

The patient was admitted to the hospital, and a duplex ultrasound was performed which found acute deep venous thrombosis in the distal superficial femoral vein with active bleeding from the vein at the level of the GSW. He was taken to the operating room for wound exploration where the superficial femoral artery was intact but a 2 cm injury to the femoral vein with high volume venous bleeding was encountered after surrounding clot was removed. The femoral vein was ligated and the patient was heparinized. Postoperatively, the patient was continued on systemic anticoagulation. At his post-discharge clinic visit, his surgical wounds were healing well and he was compliant with his anticoagulation.

Table 1
Presenting vital signs and lab values of penetrating thigh trauma patients.

	Case 1	Case 2	Case 3
Sex	Male	Male	Male
Age	23	62	40
Initial blood pressure	123/101	168/100	113/30
Initial heart rate	122	71	144
Initial respiratory rate	30	16	17
Hemoglobin	13.8	13.2	12.8
Lactate	10.1	1.4	5.4
Base excess	-11	5	-6
Outcome	Death, massive PE	Popliteal venorrhaphy	Femoral vein ligation

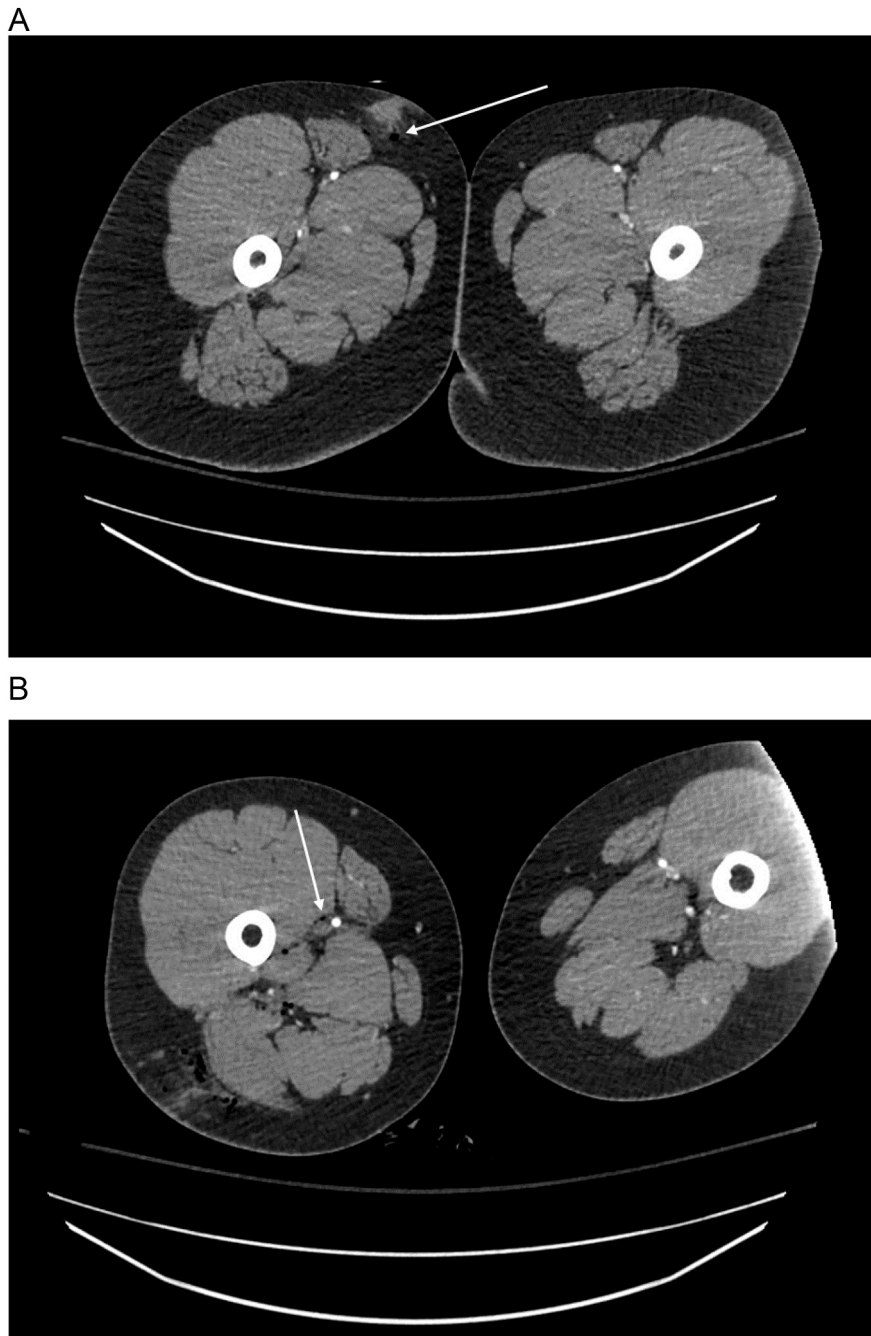


Fig. 1. Case 1 CTA showing no arterial injury but evidence of stranding and subcutaneous emphysema (arrow) tracking toward and around the neurovascular bundle (a) proximal medial thigh GSW entry site (b) distal lateral thigh GSW exit site.

Discussion

In this series we report three major occult venous injuries in patients with penetrating extremity trauma that initially screened negative for vascular injury using “hard signs,” API, and CTA. One of these patients died and two required surgical intervention.

In reviewing these patients, several trends warrant emphasis. Both the first and third patients arrived with tourniquets in place, but with signs of compensated shock. Neither patient had ‘hard signs’ once the tourniquet was removed. Given that these patients were diagnosed with *isolated* venous injury, we hypothesize that pre-hospital tourniquet use may curtail major venous bleeding which could have presented as a “hard sign” in the pre-tourniquet era. Patients with evidence of hemorrhagic shock without evidence of arterial injury should be closely evaluated for major venous injury even if the CTA is negative.

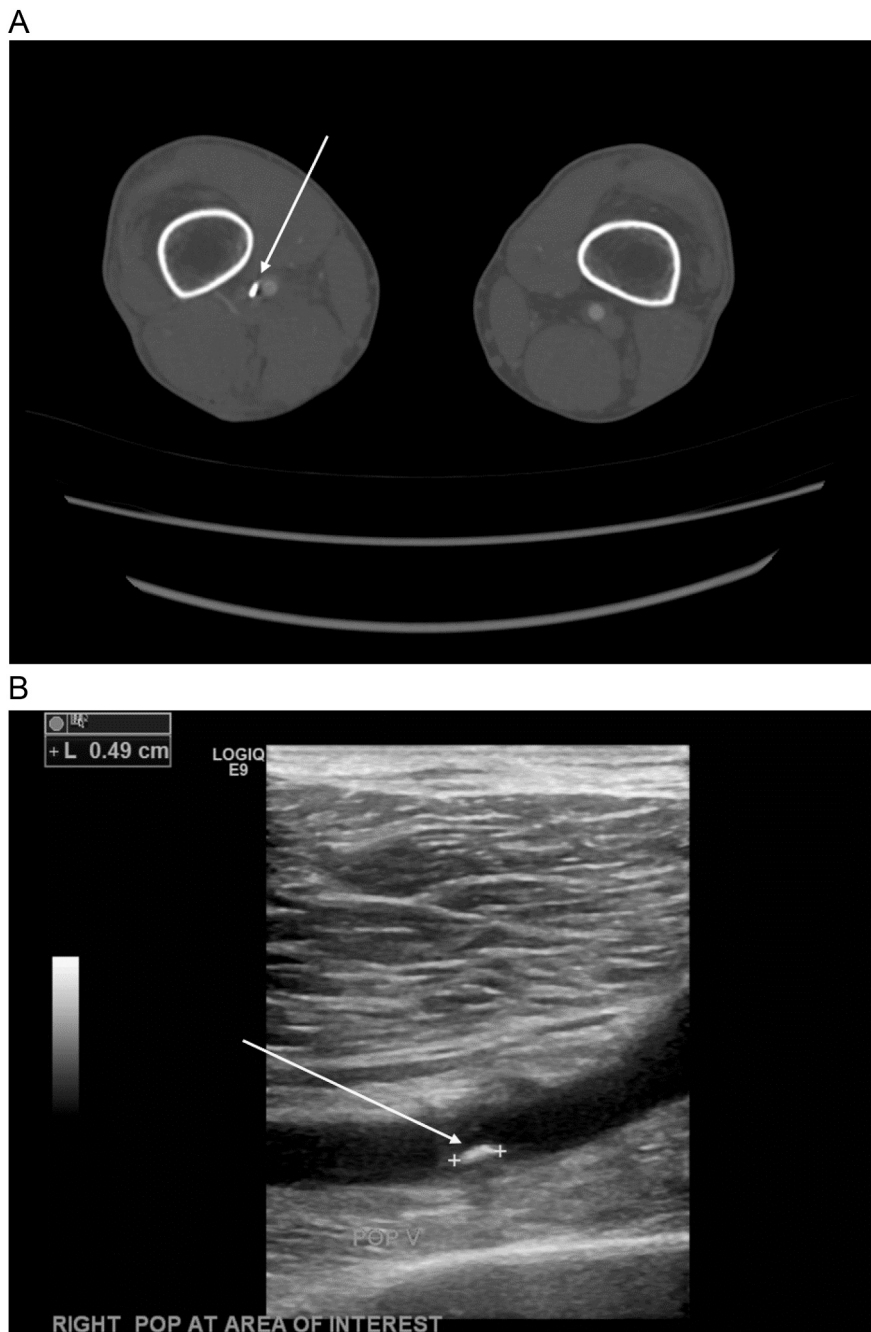


Fig. 2. Case 2 (a) CT arteriography showing no arterial injury but a hyperdense foreign body (arrow) adjacent to the neurovascular bundle (b) lower extremity US showing foreign body within the lumen of the popliteal vein.

Pre-CTA practice patterns identified major venous injury and its morbidity. In a prospective study from 1995, Gagne et al. screened 33 patients with what was coined as penetrating proximity extremity trauma (PPET) and found eight isolated venous injuries (22 % incidence) with 50 % of the femoropopliteal injuries resulting in a major thromboembolic event [1]. In this study, color-flow duplex ultrasonography was found to be 88 % sensitive in detecting major venous injury with the reference being venography. Ultrasound was still the major diagnostic modality for evaluating penetrating vascular (arterial or venous) injuries that didn't warrant emergent exploration.

CTA found its place in the 2000s with ongoing refinement of its indications for diagnosing penetrating arterial injury. In 2014, Mollberg used duplex ultrasound to screen for venous injuries in 167 patients with normal physical exams and API, but attending surgeon defined PPET. Of note, CTA was not used in any of these patients. Eight (4.6 %) of these patients had isolated acute venous

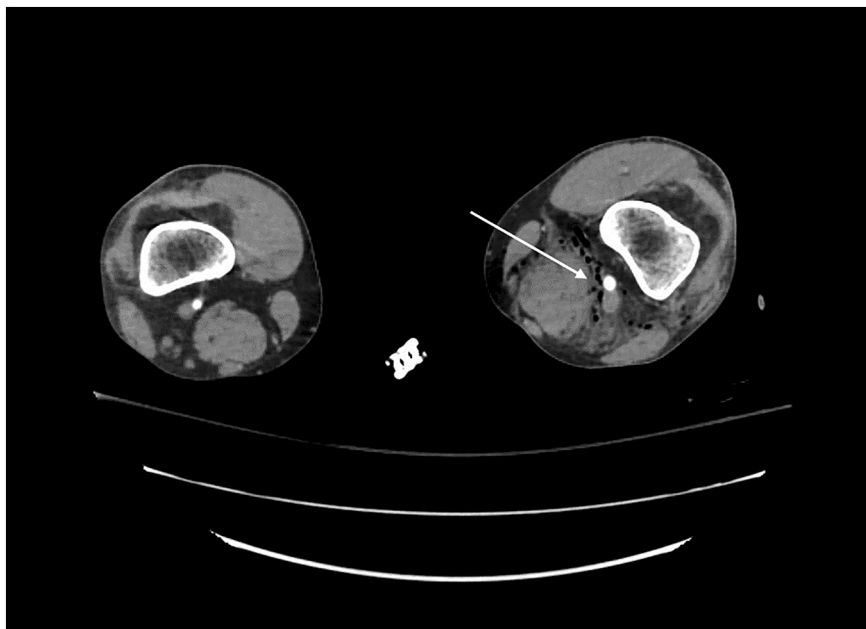


Fig. 3. Case 3 CT arteriography showing significant stranding, hematoma, and subcutaneous emphysema (arrow) surrounding the distal left femoral neurovascular bundle without arterial injury.

injury, 50 % of which resulted in significant morbidity (pulmonary embolism, post-thrombotic syndrome, and bleeding secondary to anticoagulation) [2]. This is the extent of existing literature evaluating specifically for venous injury in penetrating extremity trauma. While extraordinarily limited, both support our assertion that diagnosing venous injury on clinical exam and CTA is challenging and underscore the subsequent morbidity of major venous trauma.

Current American Association for the Surgery of Trauma-World Society of Emergency Surgery guidelines [3], Eastern Association for the Surgery of Trauma guidelines [4], and Western Trauma Association guidelines [5] do not include indications or guidance for screening patients for venous injury, mainly due to the lack of high-quality data. With the liberal use of CTA in the modern era, screening for vascular injury has improved dramatically. However, with one preventable death being too many, we propose there is more work to be done specifically in the identification of isolated major venous injury.

For as far as we have come in our understanding in the diagnosis and management of penetrating extremity trauma, clearly there is more to be done particularly with regard to venous injury. In our very small series, we demonstrate three cases where CTA failed to identify a major venous injury. In two of these patients though, when our index of suspicion was high based on CTA trajectory, ultrasound found an occult venous problem. This 100 % incidence varies dramatically from the 4.6 % demonstrated by Mollberg where CTA was not used pre-emptively to evaluate for trajectory. Questions emerge as to the cost feasibility of using CTA routinely to assess for proximity to the neurovascular bundle to help guide decision making. What specific CTA findings would prompt further imaging? Should duplex ultrasound be the next study of choice? Is there a role for CT venogram? Questions regarding the management of major venous injuries are even more vexing with treatment options including open surgical repair, ligation, anti-coagulation, or IVC filter? We propose it's time for a new prospective multi-institutional trial to determine the incidence of occult venous injury and to determine best management practices.

Conclusion

Trauma surgeons should be aware of the limitations of physical exam, API, and CTA to diagnose major venous injuries and have a high index of suspicion to pursue further imaging if trajectories are in proximity to extremity vasculature. Further research on optimal diagnostic and therapeutic modalities for venous injury is warranted.

CRedit authorship contribution statement

NB: study design, literature search, data collection and interpretation, writing.

DYK: study design, writing, critical revision.

JK: study design, writing, critical revision.

AN: study design, literature search, data interpretation, writing, critical revision.

Declaration of competing interest

The authors declare that there is no conflict of interest for this manuscript.

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