



# Ultrasound in Emergency Medicine

## POINT-OF-CARE ULTRASOUND DIAGNOSIS OF MEDIAL PLANTAR ARTERY PSEUDOANEURYSM SECONDARY TO PENETRATING INJURY

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**Abstract—Background:** Pseudoaneurysms of the foot are rare and can occur from a range of etiologies, including laceration from a foreign body. The majority of reported cases have been diagnosed by computed tomography, magnetic resonance imaging, or angiography. These tests require intravenous access and contrast, confer radiation, take time to perform and interpret, are expensive, and are not always readily available in the acute setting. No prior reported pseudoaneurysms of the foot have been diagnosed by point-of-care ultrasound (POCUS). **Case Report:** An 8-year-old boy presented to the emergency department for evaluation of left foot pain and swelling 2 weeks after stepping on small pieces of broken glass. He had a 3 × 3 cm area of painful swelling and erythema at the medial plantar aspect of his foot. A cutaneous abscess was the working diagnosis and preparations were made for an incision and drainage procedure. However, POCUS revealed a medial plantar artery pseudoaneurysm. Incision and drainage would have led to unexpected arterial bleeding. Instead, the pediatric surgery service was consulted for pseudoaneurysm excision and arterial ligation. **Why Should an Emergency Physician Be Aware of This?:** Incision of a pseudoaneurysm in the sole of the foot—thought to be an abscess based on clinical examination—would lead to unforeseen arterial bleeding. POCUS at the bedside can differentiate between simple abscess and pseudoaneurysm in order to guide appropriate and time-

sensitive management. Historical and clinical clues to the diagnosis may include heavier-than-expected bleeding at the time of laceration and a pulsatile quality to the painful erythema and swelling. © 2020 Elsevier Inc. All rights reserved.

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### INTRODUCTION

An aneurysm is a pathologic dilatation of an artery that contains all three layers of the arterial wall (i.e., tunica intima, tunica media, and tunica adventitia). In contrast, a pseudoaneurysm does not contain all three arterial layers. It usually occurs as a result of injury to an artery. As blood leaks out from the arterial wall defect, a new lumen is formed. Its contents are contained by a thin fibrous capsule and the soft tissues surrounding the vessel rather than by all three layers of the arterial wall. The fibrous scar tissue lining the arterial wall lacks the tensile strength of the native artery, and the pseudoaneurysm continues to expand. If untreated, growth of the pseudoaneurysm can lead to compression of the artery and accompanying nerve from mass effect, infection, ischemic complications, and possible eventual rupture (1).

Arterial pseudoaneurysms of the sole of the foot most frequently arise from either the lateral plantar artery

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(LPA) or medial plantar artery (MPA). Existing case reports of pseudoaneurysms of these vessels describe a variety of etiologies, including lacerations from stepping on foreign bodies such as glass or other sharp objects; remote calcaneal fracture; or as a sequelae of fasciotomy, calcaneal osteotomy, or other surgery to the foot (2–11). The arteries in the foot are smaller in children and more likely to be transected than simply punctured. Moreover, there is less soft tissue at the sole through which a foreign body can penetrate. As a result, children may be more susceptible to pseudoaneurysm formation in the foot than adults (2,3,5,10). Additionally, repeated trauma due to ambulation may prevent the lacerated skin from healing and achieving full tensile strength, making pedal pseudoaneurysms especially prone to enlargement.

The majority of plantar artery pseudoaneurysms have been diagnosed by advanced radiographic imaging modalities, such as computed tomography (CT), magnetic resonance imaging (MRI), or angiography (3,4,12–14). These tests require intravenous access for administration of contrast, which may be difficult to achieve in children and cause distress to both patient and parent. Contrast administration itself carries the inherent risk of allergic reaction. CT studies also subject patients to a considerable amount of ionizing radiation. In addition, these imaging studies are time-consuming to perform and interpret, expensive, and not always readily available in the acute setting. In the few case reports of pedal pseudoaneurysms diagnosed with ultrasound, the ultrasounds were performed by radiologists or ultrasound technicians (2,3,6,10). These types of ultrasounds take time to perform, are often performed outside of the emergency department (ED), and require radiologist interpretation.

Here we present the first known case of an MPA pseudoaneurysm diagnosed by point-of-care ultrasound (POCUS) at the bedside. The initial provisional diagnosis in this case was cutaneous abscess. Without the use of POCUS, the planned bedside incision and drainage procedure would have led to unforeseen and potentially heavy arterial bleeding. Instead, due to a rapid bedside diagnosis using POCUS, the pediatric surgery service was consulted for time-sensitive operative repair.

### CASE REPORT

An 8-year-old boy was sent to the pediatric ED by his pediatrician due to a presumed abscess at the medial plantar aspect of his left foot, causing persistent pain and swelling. Two weeks earlier, the patient had stepped on small pieces of broken glass and presented to an outside hospital, where x-ray study did not reveal any retained foreign body. Upon follow-up with his pediatrician, the patient was prescribed a course of oral antibiotics (amoxicillin) to treat presumed cellulitis. Over the following week, the patient developed

slowly progressive swelling and redness at the site of injury (Figure 1). He reported pain at the injured site that was worsened by ambulation. He denied fever, chills, or other systemic symptoms.

On examination, there was a 3 × 3 cm erythematous swelling at the medial mid-plantar aspect of the left foot. The swelling was nonfluctuant, nonpulsatile, warm, and tender to touch. Sensation and motor function were intact throughout the entire extremity.

The provisional diagnosis was abscess, and preparations were made for incision and drainage. However, a POCUS scan, performed to define the extent of the expected abscess, visualized hyperechoic debris adjacent to a subtly pulsatile anechoic pocket (Video 1), with color Doppler showing turbulent pulsatile flow arising from and returning toward the arterial wall defect (“ying-yang sign”) (Video 2). In addition, pulsed wave Doppler showed pulsatile flow away from the arterial wall defect with amplitude decreasing distally (Figure 2). Taken together, these findings were highly suggestive of an arterial pseudoaneurysm. When the posterior tibial artery (PTA) was compressed posterior to the medial malleolus, the pulsatile flow ceased almost immediately in both B-mode (Video 3) and using color Doppler (Video 4). Upon release of PTA compression, the pulsatile flow returned almost immediately (Videos 5 and 6).

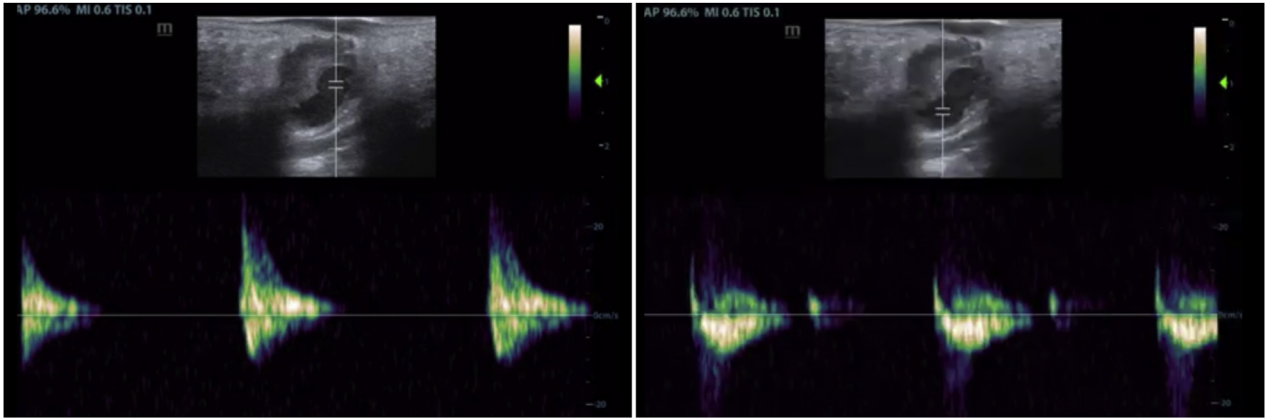
Based on the anatomic location of the swelling, the pseudoaneurysm was presumed to be from the MPA. The pediatric surgery service was consulted, and the patient was soon thereafter taken to the operating room for excision of the pseudoaneurysm and MPA ligation.

### DISCUSSION

The great majority of pseudoaneurysms in the sole of the foot occur in the LPA, whereas few have been reported



**Figure 1. Clinical appearance of the painful erythematous swelling that was presumed to be an abscess.**



**Figure 2.** Pulsed wave Doppler visualization of pulsatile flow away from (higher velocity) and back toward (slightly lower velocity) the arterial wall defect.

as arising from the MPA (2–10,12–15). This discrepancy is due to the differing anatomy of these arteries (3). At the medial plantar aspect of the calcaneus at the flexor retinaculum, the PTA bifurcates into the LPA and MPA. The LPA is larger than the MPA and is considered to be an extension of the PTA itself. The LPA passes to the lateral aspect of the foot under the proximal abductor hallucis and flexor digitorum brevis muscles. It runs superficially beneath the plantar fascia at the weight-bearing region of the foot (i.e., the instep). In contrast, the MPA runs more deeply along the medial aspect of the foot. It is more protected from traumatic injury by the thicker abductor hallucis, flexor hallucis longus, and quadrator plantae muscles. Of the few prior MPA pseudoaneurysms reported, only two were the result of nonsurgical trauma (12,14).

Pseudoaneurysm of the foot is a challenging diagnosis to make. The time course from the index injury ranges from 3 days to 5 years (16). In prior reports of MPA pseudoaneurysms, patients presented 2 weeks, 1 month, 45 days, and 56 days after injury. Moreover, arterial injury of the foot has not typically caused noticeable active bleeding and rarely has resulted in significant initial hemorrhage (3,17). Similar to the presentation of cutaneous abscesses, symptoms of pseudoaneurysms will generally consist of painful swelling and erythema. A pseudoaneurysm may be suggested by a pulsatile quality to the swelling, as well as heavier than expected bleeding at the time of injury. Four of the five previously reported MPA pseudoaneurysms were described as being pulsatile (11,12,14). No pulsation was palpated in the case we present. In two of the previous reported cases of MPA pseudoaneurysm, patients reported severe tingling of the sole reflective of tarsal tunnel syndrome from compression of the medial plantar nerve (12). However, our patient did not report a paresthesia. Furthermore, due to collateral perfusion from other vessels, an arterial injury may remain unrecognized if spon-

taneous thrombosis of the vessel occurs. In one prior report, an MPA pseudoaneurysm was diagnosed incidentally during preoperative testing using angiography (15).

Despite presenting a diagnostic challenge, the diagnosis of an arterial pseudoaneurysm of the foot can meaningfully change clinical management. Pain, swelling, and erythema to the sole of the foot may otherwise be misdiagnosed as a simple abscess. In our case, a pulsatile quality was not palpated on examination. An otherwise routine incision and drainage procedure could have led to unexpected and avoidable arterial bleeding.

Using POCUS, a pseudoaneurysm can be evaluated using B-mode, color Doppler, and pulsed wave Doppler. Firstly, B-mode can visualize an anechoic pocket and clotted blood, which appears as heterogeneous debris similar to an abscess. It is the pulsatility of the anechoic pocket, however, that indicates pseudoaneurysm as the diagnosis. Secondly, color Doppler will show turbulent flow arising from a narrow arterial flow region. The flow away from the arterial wall defect toward the transducer will appear red, whereas the reverse-direction flow of blood will appear blue. This appearance forms what has been called the “ying-yang sign.” Thirdly, pulsed wave Doppler will show pulsatile flow as the blood enters the pseudoaneurysm from the arterial defect, whereas the reverse-direction flow will have a slightly lower amplitude, reflecting decreased velocity of flow. In both Doppler views, compression and release of the PTA will elicit cessation and then return of the higher velocity flow signals. In contrast, an abscess will often have more irregular borders, internal echoes, posterior acoustic enhancement, a positive “squish sign” upon transducer compression, and no pulsatile motion (18).

None of the prior MPA pseudoaneurysm cases were diagnosed using ultrasound (11,12,14,15). This case is the first reported to have been diagnosed by POCUS. In contrast to the disadvantages of CT, MRI, and

angiography, POCUS requires no intravenous access, obviates the need for contrast administration and ionizing radiation, is performed at the bedside, is immediately available for use by the diagnosing physician, and comes at decreased cost.

The patient's MPA pseudoaneurysm was repaired by excising the pseudoaneurysm and ligating the arterial defect, as was one of the prior MPA pseudoaneurysm case reports (11). Two of the prior MPA pseudoaneurysm cases were treated with intra-arterial thrombin injection (14,15). Coil embolization was used in two prior cases as well (12). In our patient, the MPA had been wholly transected rather than partially injured, creating a defect too large to be successfully repaired using thrombin or coiling. In other pseudoaneurysms, pressure can also be used to cause spontaneous thrombosis. However, this method is unlikely to successfully treat pseudoaneurysm secondary to arterial transection.

### WHY SHOULD AN EMERGENCY PHYSICIAN BE AWARE OF THIS?

Pseudoaneurysm of the foot can be mistaken for the much more common cutaneous abscess, based on clinical examination alone. A simple bedside incision and drainage procedure would lead to the unforeseen consequence of arterial bleeding. Instead, POCUS can be used to make this critical differentiation and thus guide appropriate and time-sensitive management. Historical and clinical clues that should raise alarm for this diagnosis include heavier-than-expected bleeding at the time of injury and a pulsatile quality to the painful erythema and swelling.

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### SUPPLEMENTARY DATA

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.jemermed.2020.02.008>.

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