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Aplastic Posterior Tibial Artery in the Presence of Trimalleolar Ankle Fracture Dislocation Resulting in Below-the-Knee Amputation

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A B S T R A C T

We present an interesting, but unfortunate, case of an 86-year-old female who sustained a trimalleolar ankle fracture dislocation that resulted in below-the-knee amputation after open reduction and internal fixation of the fracture. To the best of our knowledge, this is the first case report describing popliteal variants that ultimately resulted in critical limb ischemia and below-the-knee amputation after foot and ankle trauma. The anatomic variation altered the expected outcome from a relatively straightforward surgical case. We introduce the previously described lower extremity Allen test and describe how it can be a useful adjunct in the initial physical examination of lower extremity trauma. The ability to identify abnormal distal perfusion to the foot could provide enough insight to warrant evaluating the patient with angiography or computed tomography angiography.

Knowledge of anatomic variations in the branching pattern of the popliteal artery is important because damage to its branches can be limb threatening. Kim et al (1) proposed a new classification of the branching pattern of the popliteal artery by modifying the original classification system by Lippert and Pabst (2). They classified the branching patterns into 3 categories and 3 subtypes (Table). The main distinction of the new classification system is their third category. This describes a normal branching pattern and sequence; however, the proximal segments of the anterior tibial (AT) and/or posterior tibial (PT) branches are congenitally absent or hypoplastic. Category III anatomic variants have the most clinical significance to vascular, orthopedic, and podiatric foot and ankle surgeons. The 3 major variants in the popliteal branching pattern reported by Kim et al (1) are its trifurcation (IB), high division with a normal branching sequence (IIA), and the hypoplastic-aplastic PT with the distal PT replaced by the peroneal (PR) artery (IIIA). These major variants were also predominantly seen in a review by Kropman et al (3).

Normally, the popliteal artery divides into the AT and PT arteries. In some cases, it can bifurcate into the AT and PR arteries, with the PT artery absent or rudimentary (4–6). Angiographic studies have shown the incidence of a hypoplastic-aplastic PT artery ranges from 0.8% to 3.8%. In anatomic studies, the incidence has ranged from 1.5% to 11% (1,2,5,7–11). Compensatory hypertrophy of the PR artery with a hypoplastic or aplastic PT or AT artery might indicate a variant arterial supply to the foot (1). This enlarged PR artery, the “peronea magna” or “great” peroneal artery as described by Senior (6,12) either joins and reinforces the PT artery or replaces it in the distal leg and foot (4,6,12,13). When the PR artery has replaced the PT artery at the ankle, the distal aspect typically continues into the sole as the lateral plantar artery. The medial plantar artery is then usually absent (6,12,13). Cases have been reported in published studies that have documented the PR artery replacing the PT artery but with the distal segment in the same anatomic location as the expected, but absent, PT artery (1,14). Cases of a hypoplastic-aplastic PT artery have also been documented in individuals with inborn foot deformations (15–17). In other cases, the arterial defect might not be diagnosed for years and might only be recognized incidentally (11,18).

Detection of this anatomic variant on physical examination can be deceiving and not easily determined. Chow et al (19) retrospectively evaluated multidetector computed tomographic angiography (CTA) to determine donor and recipient site arterial suitability for vascularized free flap transplantation. They found 4 of 32 lower extremities (12.5%) had anatomic variants. These variants involved the popliteal, AT, PT,

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Table
Classification of branching pattern of popliteal artery

Class	Description
I	Normal level of popliteal arterial branching
A	Usual pattern: AT is first arterial branch; tibioperoneal artery follows and bifurcates into PR and PT arteries (92%)
B	Trifurcation: AT, PR, and PT arise within 0.5 cm; no true tibioperoneal trunk is present (2%)
C	Anterior tibioperoneal trunk: PT is the first branch, the tibioperoneal trunk follows and bifurcates into the PR and AT arteries (1.2%)
II	High division of popliteal artery
A	AT arises at or above the knee joint (3.7%)
B	PT arises at or above the knee joint and is the common trunk for the PR and AT arteries (0.8%)
C	PR arises at or above the knee joint and is the common trunk for the AT and PT arteries (0.16%)
III	Hypoplastic or aplastic branching with altered distal supply
A	Hypoplastic-aplastic PT; distal PT replaced by PR artery (3.8%)
B	Hypoplastic-aplastic PT and AT arteries; dorsalis pedis replaced by PR artery (1.6%)
C	Hypoplastic-aplastic PT and AT arteries; PT and dorsalis pedis arteries replaced by PR artery (0.2%)

Abbreviations: AT, anterior tibial; PR, peroneal; PT, posterior tibial.

and pedal arteries. All results were compared with their original physical examination findings. Their physical examinations findings, in all cases, were not predictive of the presence of any arterial anomaly.

Significant negative outcomes can occur when anatomic variations of the popliteal artery have not been appreciated. Orthopedic, vascular, and podiatric foot and ankle surgeons should be aware that anatomic variants exist. However, the question remains whether we necessarily need to perform preoperative vascular screening with angiography and/or CTA. No guidelines have been set for its use in foot and ankle surgery and trauma. According to the published data, the routine use of angiography and/or CTA is controversial, even for cases in which such imaging modalities are most commonly used, such as free flap reconstructive surgery (19).

We present an interesting, but unfortunate, case of an 86-year-old female who sustained a trimalleolar ankle fracture dislocation that resulted in below-the-knee amputation after open reduction and internal fixation of the fracture. This patient ultimately had a type IIIA popliteal variant (Table) that was not appreciated on physical examination. The incidence of this variant is approximately 3.8% according to the published data. To the best of our knowledge, this is the first documented case report discussing type III popliteal variants in foot and ankle surgery.

Case Report

The patient was an 86-year-old female who presented to the emergency department with a right ankle fracture dislocation. She had no secondary injuries. The right ankle was globally tender. The patient had full, painless range of motion at the right hip and knee. The compartments were soft. Her skin was intact, with diffuse ecchymosis and edema localized to the ankle. Sensation was intact to all lower extremity nerve distributions. The PT and dorsalis pedis (DP) pulses distally were 2+ and palpable. Radiographs revealed a displaced trimalleolar fracture with the talus posteriorly dislocated. The fibula was comminuted and displaced. Fractures were present in the medial and posterior malleolus (Fig. 1). The right ankle fracture was reduced and splinted without complications. Postreduction plain radiographs confirmed the reduction. A noncontrast-enhanced computed tomography scan of the right lower extremity was obtained for preoperative planning. The patient was admitted for pain control and social placement.

The patient returned 8 days later for definitive fixation. On admission, the examination findings were unchanged. The vascular examination revealed palpable PT and DP pulses with a brisk capillary fill time (CFT). The next day, she underwent open reduction and internal fixation of the right trimalleolar ankle fracture with posterior lip fixation. The patient was positioned prone. The posterior malleolus was stabilized with a posterior malleoli plate and 3.5-mm locking and nonlocking screws. The fibula was stabilized with an anatomic fibular plate, and the medial malleolus was fixated with 2 partially threaded cannulated screws (Fig. 2). No intraoperative complications were noted. Shortly after the procedure, the nursing staff noted delayed CFT to the digits; however, the CFT returned when the foot was placed in a dependent position. The next day the patient was evaluated and found to have palpable PT and DP pulses and a brisk CFT. The patient's pain was well controlled, and she was discharged to a local skilled nursing facility.

The patient returned for a follow-up examination 1 week after being discharged from the hospital. The physical examination revealed nonpalpable pedal pulses, but the PT and DP pulses were identifiable on ultrasound examination with a handheld Doppler probe. Ischemic changes were noted along the dorsal and lateral aspects of the foot. The hallux and third toe remained viable but demonstrated prolonged CFTs. The incision was well approximated. No erythema, discharge, drainage, or dehiscence was present; however, full-thickness tissue necrosis had developed, consistent with dry gangrene, along the lateral aspect of the right heel and measuring 5×5 cm. The patient was readmitted to the hospital, and vascular surgery was consulted. A lower extremity arterial duplex Doppler examination was ordered by the vascular surgery team, with the official impression of the study noting no hemodynamically significant arterial disease at the right lower extremity. Because of the degree of necrosis, the vascular surgery team consulted with the interventional radiology staff to evaluate the limb with angiography with right lower extremity runoff. The official interventional radiology report (Fig. 3*A*,*B*) concluded:

- Traumatic occlusion of the distal aspect of the right AT artery at the level of the superior aspect of the talus with no reconstitution of the DP artery
- Likely congenital absence of the PT artery
- Traumatic segmental occlusion of the PR artery approximately 10 cm above the ankle that was reconstituted approximately 5 cm distally into the normal expected course of the PT artery and was the only significant arterial supply to the foot

The angiogram revealed no trifurcation of the popliteal artery. The branch of the PT artery was congenitally absent. The branches of the AT and PR arteries were present (Fig. 3*C*). When reviewing Fig. 3*A*,*B*, the interventional radiology report noted traumatic occlusion of the AT artery. The prevailing explanation was that the AT artery had been traumatically occluded. This could have resulted from either an iatrogenic cause or intimal injury (20) not detected during the index examination. It is also plausible that the AT artery was congenitally hypoplastic; however, this would be difficult to prove definitively without a previous arteriogram or CTA. The finding of a congenitally aplastic PT artery is consistent with the IIIA popliteal variant using the Kim classification (1). This has an occurrence rate of 3.8%. This, combined with the traumatically occluded AT and PR artery, singlehandedly eliminated all the blood supply to the foot, causing critical pedal ischemia. Peculiarly, the patient still exhibited pedal pulses identifiable on ultrasound examination with a handheld Doppler probe, although obvious clinical and angiographic signs of pedal ischemia were present. The results of the angiogram demonstrated a result consistent with that described by Chow et al (19). The physical