

You're the Flight Surgeon

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You are the flight surgeon in a Flight Medicine clinic at a nuclear missile base. After a 3-h flight in an H-1 Huey helicopter, you see the senior pilot, a 29-yr-old captain, rubbing his right calf. When you ask, he replies, "It's been bugging me a little for a few months." You reassure him that it is probably nothing serious, but since it has been going on for a while he should stop by the clinic the following day to be evaluated.

The pilot comes to the clinic the next morning. He has had cramping, sometimes sharp, pain in his right calf intermittently for 9 mo. He thinks it has gotten a little worse since it started. The pain may occur mildly during longer flights, but has never interfered with his ability to fly. He mainly notices it while running. He used to run marathons in his early 20s, but backed off in the past 6 yr. In the past few months, he can only make it 2 mi before the cramping starts. He has noticed distal tingling and numbness on the right periodically after he runs and thinks his right leg may have been swollen before. He denies erythema, weakness, paralysis, low back or joint pain, and bowel/bladder incontinence. The symptoms resolve at rest. He denies any history of injury, infection, or occurrences of the pain prior to 9 mo ago.

The patient has no relevant past medical or family history and takes no routine medications. He denies ever using tobacco and has one or two beers four times a month. He attended the Air Force Academy and has been flying helicopters on active duty for 7 yr. He was off flying duties once 3 yr ago for a sinus infection.

1. Which of the following is LEAST consistent with this patient's history thus far?

- A. Medial tibial stress syndrome (MTSS), or shin splints.
- B. Atherosclerosis (ASC).
- C. Common peroneal nerve entrapment.
- D. Popliteal artery entrapment syndrome (PAES).
- E. Chronic exertional compartment syndrome (CECS).

ANSWER/DISCUSSION

1. B. Although ASC is more common in the general population, this is a young, healthy, athletic patient with no risk factors such as personal/family history, signs, or symptoms suggestive of early onset ASC. You focus on a differential diagnosis of chronic leg pain with those

disorders affecting primarily young athletes. The structures of the lower extremity that can cause pain include the following: 1) bone, 2) myofascia, 3) nerve, and 4) vasculature.

Bone disorders that can cause chronic leg pain include MTSS, stress fractures, and infection. MTSS and stress fractures occur as a result of repetitive stress loading and overuse in athletes.^{2,3} MTSS can account for up to 16% of all running injuries and up to 50% of lower leg injuries in certain populations, e.g., military personnel. Stress fractures of the lower extremity account for 80–95% of all stress fractures, with the majority involving the tibia.²

Disorders/injuries of the muscle and fascia are common in athletes. Gastrocnemius muscle strain and Achilles tendinopathy may cause subacute or chronic pain and are extremely common, but the pain would not resolve completely with rest and would improve with augmented training. CECS is caused by increased pressure in the fascial compartments during exercise and leads to recurrent episodes of pain. It most often occurs in the anterior compartment and is usually bilateral, and pain typically occurs at the same intervals with consecutive workouts.^{2,3} Pain from CECS will become progressive with continued exercise or increased intensity and will decrease with rest.³

Nerve disorders that would localize to one specific location are lumbar radiculopathies and nerve entrapment syndromes. Your patient has no history of back pain, back injury, or numbness down his buttocks or thighs, which makes a lumbar radiculopathy unlikely. Nerve entrapment typically presents as pain, often described as a burning pain,² brought about by activity and worsened by continued exercise. The pain usually originates at the site of compression and is frequently referred to the region the nerve innervates. The common peroneal, superficial peroneal, and saphenous nerves are most at risk for entrapment in the lower extremity, with trauma being the primary cause.^{1,2}

Vascular disorders of the lower extremity may be arterial or venous. Venous disorders include deep vein thrombosis (DVT) and venous insufficiency. Arterial disorders include ASC, popliteal artery aneurysm, endofibrotic disease (primarily involves the external iliac artery), peripheral arterial dissection, cystic adventitial disease, and PAES.² Symptoms from each of these disorders would likely be worsened by exercise. PAES is a vascular disorder that is classically

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exercise-induced and occurs in the absence of ASC risk factors (e.g., hyperlipidemia, hypertension, smoking, insulin resistance, diabetes mellitus, obesity, age > 45 in men and > 55 in women, and a strong family history of cardiovascular disease¹). Any exercise-related vascular disorder is a possibility, but they are all rare. Of these rare disorders, PAES is the most common.²

You move on to the physical exam. Vital signs are normal. Pain level is currently 0/10, but can get as high as 5/10 when he runs. He is a well-developed man in no acute distress and appears healthy. His physical exam shows no abnormalities in his head, eyes, ears, nose, throat, neck, lungs, heart, abdomen, or flank.

2. As you prepare to perform the musculoskeletal portion of the physical exam, which exam finding in this patient would most likely warrant urgent lab tests?

- A. Tibial tenderness to palpation.
- B. Positive straight leg raise.
- C. Distal/toe paresthesias.
- D. Leg swelling.
- E. Diminished distal pulses.

ANSWER/DISCUSSION

2. D. Leg swelling would most likely warrant urgent labs in this patient. Because he just had a long flight the day before and did not report leg swelling prior to the flight, this finding could raise concern for DVT. Tibial tenderness would indicate MTSS and a positive straight leg raise would indicate a lumbar radiculopathy. Both of these disorders are routine and do not require specific lab tests. Distal/toe paresthesias and diminished distal pulses would require urgent/emergent studies if, for example, associated with a traumatic injury. Under the chronic conditions seen in this patient, lab tests would be routine and used to rule out diseases such as diabetes mellitus, ASC, and peripheral vascular disease.

Examination of the lower extremities reveals no atrophy, erythema, edema, warmth, palpable cords in the popliteal fossa, or tenderness to palpation of the knees, calves, tibias, or malleoli. His bilateral hips, knees, and ankles are stable with no pain. He has 5/5 strength bilaterally in all the muscle groups. Popliteal, dorsalis pedis, and posterior tibial pulses are equal and 2+ bilaterally. Patellar and Achilles reflexes are 2/4 bilaterally. Vibration, pinprick, temperature, fine touch, and proprioception are intact and symmetric.

3. What additional test(s) should be included in your physical exam?

- A. Tinel's sign.
- B. Positional stress test.
- C. Homan's sign.
- D. Straight leg raise.
- E. All of the above.

ANSWER/DISCUSSION

3. E. Consider your differential diagnosis. You have already palpated the patient's tibia to assess for MTSS and/or stress fractures. No pain

could be reproduced at the posteromedial distal third of the tibia, proximal to the distal third, or distal to it at the malleoli. Nerve function is grossly intact on exam. This is reassuring, but does not rule out nerve entrapment, so performing the Tinel's test helps determine which, if any, of the nerves may be entrapped or irritated. Tapping on an irritated nerve causes an electric/tingling sensation that radiates down the nerve if it is entrapped, i.e., Tinel's sign.

You should also perform the positional stress test by placing the knee in full extension followed by active plantar flexion and passive dorsiflexion. If you obtain diminished dorsalis pedis/posterior tibial pulses as a result of these provocative positions, the test is positive and pathognomonic for PAES. Although this test only has moderate sensitivity, a negative does not rule out PAES.^{3,5,8,11} Homan's sign can be done at the same time as the positional stress test because it also requires full extension of the knee followed by passive dorsiflexion of the foot. A positive Homan's sign would be indicated by calf pain. This is used to detect the presence of a DVT. Keep in mind this test is less commonly used in recent years due to its poor positive predictive and negative predictive values and risk of dislodging a DVT if one is present.¹² The straight leg raise is an easy test to perform as part of any physical exam for lower extremity pain below the knee. Although it is not specific, the straight leg raise is the most sensitive test for lumbar disk herniation and a negative result strongly indicates the absence of lumbar disk herniation.⁶

Tinel's sign is negative for all three nerves. Homan's sign and the straight leg raise are both negative as well. It is difficult to tell but you think the distal pulses may be slightly diminished when you perform the positional stress test. You think about the more significant diagnoses that you do not want to miss: MTSS, CECS, stress fracture, nerve entrapment, and PAES. The symptoms associated with these conditions often overlap, making chronic, exercise-induced leg pain a diagnostic dilemma. You recall an article you read a few months ago and excuse yourself to pull it up on your computer. Edwards et al.³ created an algorithmic approach using the history and physical exam to evaluate these patients and recommend diagnostic studies for the suspected conditions. The algorithm is separated into three categories: 1) pain at rest with palpable tenderness; 2) no pain at rest with palpable tenderness; and 3) no pain at rest with no palpable tenderness. Category 1 is suggestive of MTSS and stress fractures, category 2 is suggestive of nerve entrapment, and category 3 is suggestive of PAES and CECS.

4. Based on the algorithm proposed by Edwards et al., what disorders are consistent with your patient's signs/symptoms?

- A. MTSS, stress fracture.
- B. Nerve entrapment.
- C. CECS, PAES.
- D. None of the above.

ANSWER/DISCUSSION

4. C. Your patient has no pain at rest (in fact, rest resolves his pain) and you are unable to elicit pain with palpation. Based on the algorithm and what you know about each of the disorders, you determine that CECS and PAES are most consistent with his signs/symptoms. Because you had a questionable result with the positional stress test, this increases your level of concern for PAES as well.

You decide to order a few lab tests to rule out exacerbating illnesses that would contribute to poor circulation, such as anemia, and illnesses that may result from CECS and/or PAES, such as rhabdomyolysis, which could lead to renal injury. As noted previously, disorders that cause chronic, exercise-induced leg pain in athletes can have similar presentations and may even occur concurrently, so you order an X-ray of the leg to check for callous formation where there may have been a previous stress fracture. You also do not want to overlook the common causes of muscle cramps, such as dehydration and low calcium, magnesium, potassium, thiamine, pantothenic acid, and pyridoxine, so you order blood levels for these as well. A normal fasting lipid profile in his record from a year ago confirms he has no atherosclerotic risk factors. You place him on a 30-d profile prohibiting him from running farther than 100 yd. This will allow him to remain on flight status while limiting him from running recreationally. You instruct the patient to complete all the ordered tests and to return to the clinic the following week.

When the pilot returns to your clinic, he has not had the right calf pain in the past week since he stopped running and has only been on short sorties with no issues. You pull up his test results, which are normal. The X-ray shows no evidence of previous fracture. You again consider the algorithm recommended by Edwards et al.³ that suggested CECS and PAES as the disorders most consistent with your patient's signs/symptoms. Since you are uncertain whether you detected diminished distal pulses with the positional stress test, you move on to diagnostic studies. To differentiate between CECS and PAES with an ambiguous presentation based on history and physical exam, you order magnetic resonance imaging/angiography (MRI/MRA) with provocative foot positioning or with symptom generating activity. Edwards et al. suggests a bone scan after plain radiographs and before the MRI/MRA when using the diagnostic studies algorithm only. Since the history/physical exam narrowed the differential diagnosis beyond this test to CECS and PAES, the bone scan is bypassed in this case. However, it would still be considered standard of care to obtain a bone scan to rule out other causes of chronic lower leg pain. The results confirm arterial compression in the popliteal artery with provocative positioning of the foot.

5. Which of the following should be done at this point?

- A. Order arteriography as a confirmatory test.
- B. Develop a nonoperative plan to treat the patient.
- C. Order a referral to Vascular Surgery.
- D. Disqualify the pilot from flying duties.
- E. Diagnose the patient with PAES.

ANSWER/DISCUSSION

5. C. MRI/MRA is considered a screening test for PAES. If it is positive, arteriography with provocative positioning of the foot or symptom-generating activity should then be used to confirm the diagnosis of PAES. Most vascular surgeons perform their own angiography for both diagnostic and interventional purposes. In addition, the vascular surgery consultant will likely have a vascular lab where noninvasive diagnostic testing options can be performed

as needed. Ordering the arteriography prior to the patient seeing a vascular surgeon may result in unnecessary testing or repeat testing if the first arteriogram does not give the surgeon the information he/she needs to properly evaluate the patient. Be careful not to diagnose PAES until it is confirmed so the patient is not unnecessarily disqualified! Once the diagnosis is confirmed, it is then appropriate to disqualify the patient. You would not develop a non-operative plan to treat the patient. While conservative treatment is standard primary therapy for other causes of chronic leg pain, the preferred management of PAES is surgery.

Arteriography performed by the vascular surgeon confirms a diagnosis of unilateral PAES in your pilot. You unfortunately have to recommend disqualification from flying duties and update his profile to a 469 since he will obviously have to refrain from running for longer than 30 d.

Popliteal artery entrapment syndrome is a disorder of altered anatomy. It is caused by an anatomical variation most often from a congenital anomaly resulting in an abnormal course of the popliteal artery in the popliteal fossa.^{3,8,10} This abnormality causes a functional occlusion of the artery. The most common anomaly results from a developmental defect in which the popliteal artery passes medial to and beneath the medial head of the gastrocnemius muscle or a piece of that muscle, although other anomalies can be responsible as well.^{8,10} When the muscle contracts (i.e., active plantar flexion) or is put under strain (i.e., passive dorsiflexion), it causes compression of the popliteal artery. Over time, this altered anatomy can cause permanent arterial damage that requires reconstruction (i.e., a bypass graft, most often from the saphenous vein). However, if it is discovered early before significant arterial injury occurs, PAES is more of a musculoskeletal issue. It is much easier to surgically resolve with simple musculotendinous release and subsequent restoration of normal arterial flow. Early intervention in this case is crucial and often results in good functional outcome with likely preservation of flight status. Without surgical intervention, PAES will tend to recur with activity and can lead to long-term arterial damage as previously noted.^{3,5,8,10,11}

As noted above, surgical release of the popliteal artery with or without saphenous vein grafting is the primary and definitive method of treatment. Most patients are completely cured of their symptoms following surgery.^{5,10} Long-term prognosis is great for patients with early surgical intervention for PAES. Studies suggest high rates of patency (greater than 80% or 90% depending on the study) at 10 yr postoperatively.^{5,7,8,10} With early intervention, it is less likely that the arterial occlusion has extended beyond the popliteal artery. When the occlusion is confined to the popliteal artery, patency rates improve even if a graft is needed.⁷

AEROMEDICAL DISPOSITION

Popliteal artery entrapment syndrome is disqualifying for all aeromedical authorities, including the Air Force,^{*} Army,¹³ Navy,⁹ and Federal

^{*} U.S. Air Force. Section H: heart and vascular USAF medical standards, H42. In: Medical standards directory. 2013:27. [Accessed 4 Sept. 2014]. Available to those with access from [https://kx2.afms.mil/kj/kx4/FlightMedicine/Documents/Medical%20Standards%20Directory%20\(MSD\)/MSD%202013-Dec-2.pdf](https://kx2.afms.mil/kj/kx4/FlightMedicine/Documents/Medical%20Standards%20Directory%20(MSD)/MSD%202013-Dec-2.pdf).

Aviation Administration.⁴ None of these entities have specific standards for PAES; however, they have blanket categories for vascular disorders that are disqualifying. Because PAES is not specifically listed in any of the medical standards or waiver guides, the best practice would be to obtain recommendations from the granting medical waiver authority.

In this patient's case, he is a trained asset with mild symptoms and he received early intervention for his PAES. His symptoms were completely resolved 4 mo after surgery. He stands an 80–90% chance of his popliteal artery remaining patent 10 yr postoperatively and, if it does start to occlude again, it will be a slow process that will not be suddenly debilitating with symptoms he will recognize in the future. According to the Air Force Medical Standards Directory, PAES is disqualifying for all flying classes but not retention standards,^{*} so no Medical Evaluation Board was needed. The waiver authority required all clinical notes from the Primary Care Manager and the vascular surgeon as well as all studies that were done prior to surgery, the operative report, postoperative notes, and a follow-up lower extremity duplex 3 mo after surgery to demonstrate continued patency of the right popliteal artery. The case was referred to the Aeromedical Consult Service for review, ultimately recommending a 3-yr waiver for continued, unlimited service. For patients requiring a vein graft repair in addition to surgical release, the recommendation would be a 3-yr waiver with repeat arterial duplex and vascular surgery follow-up annually for the first 3 yr postoperatively. If the vessel maintains patency, the follow-ups and waiver may be extended in the future.

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You are the flight surgeon deployed to an expeditionary medical unit at a U.S. air base located in the Middle East. It is summer and the average temperature ranges from 115°F to 130°F. An Army aviator en route to the United States after a 6-mo deployment in Afghanistan was brought in by his battle buddy for elevated temperature and decreased level of consciousness, concerning for heat stroke. Further history reveals that the patient has been having intermittent fever, chills, headache, body aches, and fatigue for the last several days. His initial vitals include the following: blood pressure 100/60 mmHg, heart rate 140 bpm, respiration 20/min, and

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oral temperature 105°F. Physical exam reveals a drowsy, muscular white man who is oriented only to person and place when aroused. His skin is warm and flushed without rash, his mucous membranes are dry, and he is tachycardic. The patient has no cough or rhinorrhea, his throat is clear, and his lungs are clear. His neck is supple, and his abdomen is soft and nontender. A rapid diagnostic antigen test is positive for malaria.

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