

You're the Flight Surgeon

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On a nation-building assignment in Liberia, Africa, you are helping build and train the medical corps of the newly vetted Armed Forces of Liberia. Following a brutal civil war lasting the better part of two decades, the Liberian people are eager to pick up the pieces of their lives and discover a renewed faith in their military force. As an advisor embedded into the local national military, the mentoring team is living on the Liberian military base in relatively meager conditions compared to Western standards.

As the sole medical provider and flight surgeon for the American mentoring team, your cell phone rings and a Second Lieutenant, a 22-yr-old female, is frantic on the other end. She reports that over the last 2 d, she began experiencing a gradual worsening in her ability to stand, independently bear weight, and walk. Initially in the last several days, she simply felt fatigued and thought that she needed more rest; however, over the last 36 h she developed a progressive weakening of her muscles and increasing ataxia throughout the day. She states that she is most capable at the beginning of the day; however, after a few hours of activity, she is no longer capable of ambulation without supportive assistance from others. This evening she is unable to control her lower extremities and stand.

1. Which of the following conditions are included in the differential for generalized weakness?

- A. Spinal cord disease.
- B. Autoimmune muscle disease.
- C. Neurological disorders.
- D. Systemic medical conditions.
- E. All of the above.

ANSWER/DISCUSSION

1. E. The initial differential diagnosis is vast. Spinal cord disease such as cord compression can result from inflammatory conditions such as autoimmune disorders (sarcoidosis, systemic lupus erythematosus) or neoplastic conditions. Neurological considerations include Guillain-Barré syndrome, myasthenia gravis, and multiple sclerosis. General medical causes for lower extremity weakness can range from routine conditions to life-threatening causes. Important conditions to consider include thyroid dysfunction, sepsis, adrenal insufficiency,

polypharmacy, post viral myelopathies, parasitic infections, or sexually transmitted infections such as human immunodeficiency virus and syphilis.

The patient is a flight nurse embedded with the Liberian field medics in a small satellite clinic approximately 1 h from the coast in the jungles. You grab your jump bag from the clinic and drive the ambulance to her location. When you arrive, she is tearful and frightened. Upon further questioning, you learn that she has spent the last 7 mo teaching the Liberian medics essential field triage and battlefield first aid techniques. During her training exercises she is consistently exposed to the harsh conditions in the jungle. Over the last several weeks, she has conducted training on basic patient movement from the point of injury, over various terrains, through both shallow lakes and streams to casualty collection points in more secured environments. She states that over the last few weeks, she began experiencing episodic bouts of fevers, chills, fatigue, malaise, pruritus, abdominal pain, diarrhea, urinary frequency, hematochezia, joint pain, and muscle aches. She has attempted to manage her symptoms conservatively with hydration, rest, and with both ibuprofen and loperamide from her personal supply with little benefit. Yesterday afternoon, she realized that her muscles were becoming increasingly more weak and required assistance walking to her hooch after dinner. This morning she was feeling a little better and was initially able to stand and walk, but as the day progressed, she completely lost motor control of her lower extremities and is unable to stand.

Her past medical history is unremarkable aside from routine childhood illnesses and the chicken pox when she was 5 yr old. She had her appendix removed when she was 11 yr old and required a dilation and curettage following a missed abortion 2 yr ago. Her family history is significant for diabetes mellitus and hypertension in her father and multiple sclerosis in her mother's family. She is married, has not been sexually active since before her deployment, and has had more than two sexual partners in her lifetime. She denies tobacco, alcohol, or illicit drug use. She does not normally take any medications aside from a daily multivitamin, but acknowledges that she is taking her atovaquone/proguanil (Malarone) daily as prescribed. She admits that she is not sleeping under a mosquito net at night and has not used one for over 5 mo. She denies experiencing regular headaches, visual changes,

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chest pain, palpitations, respiratory distress, heat intolerance, recent trauma, or significant sensory deficits in the lower extremities.

On physical exam, she is alert and oriented to person, place, and time. She is not in distress but is extremely anxious. Her head is normocephalic, atraumatic; her neck is supple with full range of motion and no lymphadenopathy or thyromegaly. She has normal S1/S2 heart sounds without murmur, gallop, or rubs. Her lungs are clear to auscultation bilaterally, without wheeze or rhonchi. Her respiratory effort is normal. Abdomen is soft, mildly tender to palpation, nondistended, with hyperactive bowel sounds, but no hepatosplenomegaly. Her extremities are without cyanosis, clubbing, or edema. Neurological exam demonstrates intact cranial nerves II–XII, 4+ strength bilaterally in the upper extremities, 2+ strength bilaterally in the lower extremities, with hyper-reflexive response at the patellae bilaterally. She does exhibit dorsiflexion of the big toe after stroking the sole of the foot (positive Babinski sign) bilaterally.

2. What is the next step in managing her condition?

- A. Further laboratory testing.
- B. Magnetic resonance imaging (MRI).
- C. Specialty consult.
- D. Medical evacuation.
- E. All of the above.

ANSWER/DISCUSSION

2. E. This patient requires further medical evaluation, specialty consultation, and advanced imaging to further determine the cause of her condition. MRI of the spine will help visualize multiple sclerotic lesions, neoplastic growths, or infarction. Given her lower motor weakness and abnormal neurological exam findings, specialty consult to neurology is appropriate. In Liberia, Africa, the medical capabilities are severely limited. The closest imaging machines are in Accra, Ghana, two countries to the east. Her best chance for appropriate diagnostic evaluation and management is to medically evacuate her to a higher echelon of care.

You transport the patient by ambulance back to the U.S. Embassy in Monrovia and call the Tricare Patient Movement Requirement Center-East at Ramstein Air Base, Germany. Despite the urgent nature of her condition, it will take approximately 72 h to divert a military aircraft to sub-Saharan Africa and the case is diverted to International SOS, which will have an aircraft in country within 36 h. While waiting for medical evacuation, you decide to use the limited medical capabilities at your disposal by collecting blood, urine, and stool samples to narrow the differential of potential medical conditions or infectious causes. Your initial evaluation includes a complete blood count, comprehensive metabolic panel, thyroid studies, sexually transmitted disease panel (human immunodeficiency virus; hepatitis A, B, C; syphilis; herpes simplex 1 and 2; gonorrhea; and *Chlamydia*), and parasitic infection (malaria, typhoid, schistosomiasis, leishmaniasis).

Laboratory evaluation demonstrates normal thyroid studies and chemistry panel. Her complete blood count shows a leukocytosis at 14.5 with manual differential revealing a left shift in addition to a mild to moderate eosinophilia. Her sexually transmitted disease screen is negative for any acute infections, but shows antibodies against herpes

simplex 2 and hepatitis B surface antigen. Her antigen test is positive for an active subclinical case of malaria. Microscopic examination of a stool smear reveals parasitic eggs.

3. Which pathogenic organism is most likely responsible for her symptoms?

- A. Malaria.
- B. Hookworm.
- C. Schistosomiasis.
- D. Leishmaniasis.
- E. *Giardia*.

ANSWER/DISCUSSION

3. C. Although the *Plasmodium falciparum* protozoan has the ability to infect the central nervous system and cause ataxia, patients with acute cerebral malarial infections commonly exhibit confusion with possible psychosis and tremor.⁵ The fact that she was not sleeping under a protective bed net exposed her to the *Anopheles* mosquito bites. Her daily Malarone kept her malarial infection subdued and she remained relatively asymptomatic clinically. Hookworm commonly sheds in the intestine and is diagnosed with visualization of eggs in the stool.³ However, hookworm life cycle does not enter the central nervous system. Human hosts become infected when hookworm larvae cross through the skin or mouth. The larvae enter the blood stream, deposit in the lungs, and through respiratory secretions are coughed into the mouth then swallowed into the stomach.⁸ Passing into the intestine, the larvae mature into worms and hook into the intestinal wall as they feed and lay eggs that are then passed into the stool. The eggs hatch in the soil and the cycle begins again. Neither leishmaniasis nor *Giardia* has the potential to affect the central nervous system. Schistosomiasis infection can cause this patient's symptoms. *Schistosoma mansoni* is a trematode platyhelminth found in fresh water snails. In response to sunlight, cercariae are released into the water, which then infect humans by penetrating the skin.⁹ The cercariae continue to mature in the human host, infiltrate the visceral tissue, and ultimately enter the vascular system. Ova deposited in the spinal cord can cause both cellular and inflammatory responses that lead to myelopathy and thrombosis formation, potentially infracting the spinal cord.¹

International SOS provides an aircraft for medical evacuation to Landstuhl Regional Medical Center in Germany. The presumptive diagnosis of schistosomiasis is confirmed through serological testing for the presence of antischistosomal antibodies.⁶ The spinal cord lesion is visualized on MRI (Fig. 1).

AEROMEDICAL DISPOSITION

Unfortunately, this patient experienced a thrombosis in the leptomeningeal artery⁴ and her neurological deficits are likely permanent. Without appropriate muscle strength or adequate motor control of her extremities, she is unable to bear weight, safely egress an aircraft, or acceptably perform her flying duties. According to the waiver guides from each of the military branches, she would be permanently disqualified from flying duty. Specifically, her peripheral neuropathy is



Fig. 1. Visualization of schistosomiasis spinal cord lesions on MRI. Courtesy of Dr. Elliott.

grounding pending full recovery per the U.S. Navy Aeromedical Reference and Waiver Guide⁷ and the U.S. Army Flight Surgeon's Aeromedical Checklists.¹⁰ The U.S. Air Force Waiver Guide requires that she receive a full neurological evaluation after a 3-yr asymptomatic period following her neurological event.* Additionally, if she wanted to become a civilian pilot, she would be declined a Federal Aviation Administration certificate in any class.²

* U.S. Air Force. Section K: spine and extremity USAF medical standards, K21. In: Medical standards directory; 2017:35. [Accessed 2 Jan. 2018]. Available from [https://kx2.afms.mil/kj/kx4/FlightMedicine/Documents/Medical%20Standards%20Directory%20\(MSD\)/MSD%2020170529.pdf](https://kx2.afms.mil/kj/kx4/FlightMedicine/Documents/Medical%20Standards%20Directory%20(MSD)/MSD%2020170529.pdf) to those with access.

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Erratum

DiZio P, Ekchian J, Kaplan J, Ventura J, Graves W, et al. *An active suspension system for mitigating motion sickness and enabling reading in a car.* *Aerosp Med Hum Perform.* 2018; 89(9):822–829; DOI: <https://doi.org/10.3357/AMHP.5012.2018>.

There was an error in the abstract as printed. In the first sentence of the Results paragraph, it states “Both ride conditions reduced the 0 to 8 Hz vibrations to below threshold for evoking motion sickness during passive exposure.” This sentence should read “Both ride conditions reduced the 0 to 0.8 Hz vibrations to below threshold for evoking motion sickness during passive exposure.”

We sincerely apologize for the error and any inconvenience this may cause.