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A 56-Year-Old Man With Necrotizing Fasciitis

The patient is a 56-year-old man who presented to the hospital for a swollen left lower extremity and generalized weakness. A few days before his presentation he had injured his foot when he bumped it on the side of the bed. The patient described the wound as "a small bruise with minimal pain." The patient is blind so he was unable to describe the initial wound in detail. During his presentation to the emergency department (ED), he was found to be in diabetic ketoacidosis (DKA). He was admitted and treated for his DKA with insulin and fluids. The initial wounds on his left foot were small. The first wound was 2 × 2 cm and was located on the dorsal surface of the foot over the metatarsals. The second wound was 1 × 1 cm and was located over the tarsal bones. The third wound was on the plantar surface of the foot and was 1 × 1 cm. Significant bruising and swelling were noted. During this admission, a podiatrist was consulted. The patient was found to have 3 small abscesses. These were drained by the podiatrist and packed with sterile gauze. His DKA was effectively treated. Twenty-four hours after admission, increased swelling and drainage were noted in his leg. The wounds significantly increased in size. Plain films of the left foot and lower leg were ordered, which revealed air within the soft tissues. The decision was made to transport the patient to a surgical center. A local flight team was contacted to provide air medical transport.

The initial hospital started the patient on vancomycin and piperacillin/tazobactam antibiotic therapy. The patient was awake and alert. His vital signs were pulse of 85 beats/min, blood pressure of 134/70 mm Hg, respirations of 18 breaths/min, SaO_2 of 99% on room air, and temperature of 99.8°F. While in flight, the patient became tachycardic with a heart rate of 118 beats/min. His blood pressure dropped to 80 systolic. The flight crew provided a 20 mL/kg normal saline bolus and a drip of 150 mL/h. The patient was found to have a temperature of 102.3°F. He remained hypotensive and subsequently was initiated on norepinephrine at 5 μg/kg/min for blood pressure support. His vital signs were continually monitored.

Upon arrival to the receiving hospital, the patient was brought into the resuscitation room. The patient received an additional 2 L normal saline. Norepinephrine was continued at 5 μg/kg/min. He was given 1 g acetaminophen orally for the fever. His initial vital signs in the emergency department revealed a rectal temperature of 103.5°F, blood pressure of 94/54 mm Hg, heart rate of 115 beats/min, respirations of 18 breaths/min, and SaO_2 of 99%. He reported pain of 1 out of 10 on the pain scale. His physical examination was benign other than his left lower extremity. The left foot had a previous surgical scar secondary to the removal of his great toe. His left foot had 3 large wounds. These wounds had increased in size over the past 24 hours. He had 2 large wounds on the dorsal surface of his foot. The first wound was approximately 8 × 7 cm. The second wound was 5 × 3 cm (Fig. 1).

There was a third wound on the plantar surface of the foot that was approximately 3 × 2 cm (Fig. 2). All 3 wounds still had packing material in place from the incision and drainage that was completed at the outside hospital.

There was considerable swelling, ecchymosis, and foul-smelling drainage. There was crepitance on palpation of the foot. The surgical team presented immediately to the ED and evaluated the patient. After reviewing the films from the outlying facility, they requested radiographs of the knee and femur to determine the extent of the free air. The knee radiograph indicated free air in the soft tissues along the posterior lateral aspect of the upper popliteal fossa (Fig. 3).

The radiograph of the femur showed no definite evidence of free air in the thigh, but there was a, small loose, irregular-shaped lucency in the popliteal fossa that was suggestive of free air. Because the air was located in the popliteal fossa, a computed tomographic scan was ordered to determine the extent of the infection and gas in the soft tissues. This revealed free air in the soft tissue of the foot ascending superiorly into the leg (Fig. 4).

Free air was present in the anterior compartment muscles, and these muscles showed enhancement, which is concerning for compartment syndrome. The decision was made to take the patient for emergent exploratory surgery by the surgical team. The patient consented to the procedure. He was prepared and taken directly to the operating room. The surgeons evaluated the compartments and found significant edema of the muscle. A supramalleolar guillotine amputation of the left lower extremity was completed. His official diagnosis was necrotizing fasciitis. The patient was kept on broad-spectrum antibiotics, and he made an excellent recovery. Six weeks after this surgery, he was fitted for a prosthetic.

Discussion

Necrotizing soft tissue infections (NSTIs) are a very rare but severe form of microbial infection. Although estimates vary, recent studies place the incidence at 500-1,500 new cases per year in the United States or 0.4 cases per 1,000 person years.[1,2] Multiple subtypes have been identified, with the 2 most lethal being gas gangrene and necrotizing fasciitis.[3,4] The majority of these infections are associated with trauma in a patient who is immunosuppressed, obese, diabetic, or malnourished.[5,6] Other causes are chronic skin ulcers, surgical incisions, or idiopathic infections in a patient with intact skin.[5] The diagnosis of any necrotizing soft tissue disease can be challenging so misdiagnosis is common.[1-11] Furthermore,

Figure 1. Dorsal Left Foot Wounds

Figure 2. Plantar Foot Wound

these diseases are rapidly progressive, and complications appear early in the course with high mortality.[1-6]

Classically, the primary culprit in gas gangrene is identified as the bacteria *Clostridia perfringens*; however, recent studies show that a polymicrobial mixture is more common.[7] This mixture of bacteria tends to span the spectrum from aerobic to anaerobic, gram positive to negative, and spore forming to non–spore forming.

Aerobic bacteria require oxygen to survive, and they predominate in wound cultures, with gram-negative bacilli making up the largest component of this subgroup. *Escherichia coli* and *Proteus species* are the most commonly identified isolates.[7] Gram-positive cocci are the next most common isolates, which include *Staphylococcus aureus* and *Streptococcus species*. These bacteria are suspected to be autoinoculated from the patient.[7,8] Anaerobic bacteria do not require oxygen to grow. These bacteria are found in gas gangrene cultures and include, in equal likelihood, *Clostridia* and *Bacteroides* species.[7,9] Among the spore-forming *Clostridia* genus, *C perfringens* is the most commonly identified isolate with smaller contributions from *Clostridia bifermentans*, *Clostridia sporogenes*, and *Clostridia septicum*.[7-11] Within the non–spore-forming *Bacteroides* genus, *B fragilis* is the most commonly identified isolate. Both *C perfringens* and *B fragilis* are normal flora of the gastrointestinal tract. Additionally, the bacteria, *C perfringens* can also be found commonly in the outside environment.[7,8]

Clostridial species produce exotoxins as the chemical mediators that lead to gas gangrene. Over 20 specific types have been identified, with 9 directly implicated in the local and systemic changes of the disease.[10] Two of the most commonly identified toxins are alpha and theta toxin, with the remainder varying between species. The other clostridial toxins enhance the spread of infection by liquefying and dissecting healthy tissue.[10] Alpha toxin is the most destructive because it lyses the cell membranes of red blood cells, platelets, and endothelial cells. This lysis leads to anemia, thrombocytopenia, jaundice, hemoglobinuria causing renal failure, tissue necrosis, and when the toxin spreads systemically, cardiotoxicity and cerebral dysfunction.[9-11] Theta toxin promotes direct vascular injury in low concentrations by activating inflammatory cells. This leads to distal tissue injury as well because of vascular obstruction.

The pathogenesis of gas gangrene is not a direct result of *Clostridia* in wounds but rather a complex systemic interaction at the cellular level. There are 4 stages to the development of the disease.[3]

- Stage 1 is contamination and proliferation. Blood supply interruption results in a drop in tissue oxygenation with resulting acidosis. Anaerobic bacilli inoculate and thrive in these conditions. Moreover, the immune response is attenuated because of ischemia and hypoxic conditions, which impair the destruction of the bacteria.
- Stage 2 is toxin production. With organism proliferation, the pH and oxygen content are reduced, further providing ideal conditions for growth. Toxins are elaborated in the presence of low pH.
- Stage 3 is local tissue destruction. Toxins produced during stage 2 start to take effect; neutrophils invade the tissue but are lysed, immediately causing an absolute neutropenia in the wound tissue. Tissue perfusion is further impaired by toxin-mediated platelet and neutrophil clumping that cause vascular occlusion, further expanding the zone of devitalized tissue.
- Stage 4 is systemic toxicity, including shock and organ failure. Alpha and theta toxins spread systemically and cause brisk intravascular hemolysis. This leads to high-output heart failure because of decreased systemic vascular resistance, causing increased heart rate and cardiac output.

The most commonly identified inciting event leading to gas gangrene is severe penetrating trauma with crush injury and interruption of the blood supply.[10] Atraumatic precipitants include intravenous drug use, neutropenia (low white blood cell count), and colonic lesions. For colonic lesions, those