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Necrotizing Fasciitis
Early Detection May Save Your Patient's Limb

Tina Astorino ▼ Ilean Genrich ▼ Laura MacGregor ▼ Carol S. Victor ▼ Diane R. Eckhouse ▼ Laurel Barbour

Necrotizing fasciitis (NF) is a rapidly spreading infection affecting the subcutaneous soft tissue. Because of its rapid progression and high mortality, it is essential that the patient is diagnosed and treated early. Over the past century and a half, little has changed in the mortality of this disease. The orthopaedic nurse is in a key position to assist with the early detection and treatment of NF. In the following article, the pathophysiology, early disease detection, diagnostic and treatment challenges, and appropriate nursing interventions will be discussed as it relates to improving the care of the patient with NF.

Description of Disease

Necrotizing fasciitis (NF) is a progressive, rapidly spreading inflammatory infection resulting in extensive destruction of fat and fascia. This infection is located in the deep fascia, but in the early stages of the disease, the skin and the muscle are spared (Ruth-Sahd & Gonzales, 2006). The bacteria can enter the body through an opening in the skin, many times because of a minor trauma such as a paper cut or insect bite. Bacteria can also enter through weakened skin, such as bruised, blistered, or abraded tissue. Access can also follow a major traumatic injury to the skin or a surgical incision. The most troubling cases are those in which no portal of entry is identified (Batdorff & Roemmele, 2005). If allowed to progress, NF will expand along the fascial plane in direct proportion to the subcutaneous layer. Untreated, the skin, fat, muscle sheath, and eventually the muscle will become involved. Necrotizing fasciitis is a potentially life-threatening infection in which bacteria can destroy up to 1 in. of tissue per hour (Ruth-Sahd & Gonzales, 2006).

Pathophysiology

Once bacteria penetrate the protective barrier of the skin, tissue destruction is possible. These pathogens multiply rapidly, spreading from the subcutaneous tissue along the fascial planes, invading the lymphatic system and blood vessels. The bacteria release chemicals that impede the immune system's ability to fight infection by decreasing the normal protective tissue factors. As the chemicals are released, the immune system has an exaggerated response. The blood vessels in the area, which have dilated to facilitate distribution of immune components and removal of toxins, begin to leak. This increased permeability reduces the actual flow of blood and oxygen, resulting in cell death. As the ischemia progresses, the vessels develop a thrombosis, leading to greater damage (McGee, 2005). The resulting deep infection causes vascular occlusion, ischemia, and tissue necrosis. As further necrosis occurs, superficial nerves are damaged, resulting in localized anesthesia instead of pain. Septicemia will develop as infection progresses systemically (Maynor, 2006).

Causative Factors

Necrotizing fasciitis is classified into two types based on the organisms present on culture (see Table 1). Type 1 is characterized as a polymicrobial infection, which includes bacteria with both gram-positive and gram-negative organisms, along with anaerobic and aerobic varieties. In more than 70% of these patients, more than two organisms are present on culture, with maximum of 6–10 identified (see Table 2). Type 1 is the more common variety, making up approximately 90% of all cases. It usually strikes abdominal or peritoneal tissue, with underlying risk factors such as postoperative, diabetes, or advanced age (McGee, 2005). Type 2 is more rare, making up only 10% of NF patients. The media has nicknamed Type 2 NF as the "flesh-eating bacterial

Tina Astorino, BSN, RN, Registered Nurse, Clinician III, Advocate Lutheran General Hospital, Park Ridge, IL.

Ilean Genrich, BS, RN-BC, Registered Nurse, Clinician III, Advocate Lutheran General Hospital, Park Ridge, IL.

Laura MacGregor, BSN, RN, Registered Nurse, Clinician III, Advocate Lutheran General Hospital, Park Ridge, IL.

Carol S. Victor, BSN, RN-BC, CDE, Registered Nurse, Clinician III, Advocate Lutheran General Hospital, Park Ridge, IL.

Diane R. Eckhouse, MS, APN/CNS, OCNS-C, Advance Practice Nurse, Advocate Lutheran General Hospital, Park Ridge, IL.

Laurel Barbour, MSN, AOCN/CNS, Advance Practice Nurse, Advocate Lutheran General Hospital, Park Ridge, IL.

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TABLE 1. TEN COMMONLY CULTURED ORGANISMS

Type 1, gram (+) and gram (−)		Type 2
Aerobic (oxygen-using bacteria)		Aerobic (oxygen-using bacteria)
Escherichia	working alone or in conjunction with	Group A β-hemolytic streptococci
Klebsiella		*Staphylococcus aureus*
Pseudomonas		
Staphylococcus		
Streptococcus (none Group A)		
Anaerobic (oxygen-avoiding)		
Bacteroides		
Clostridium		
Enterobacter		
Peptococcus		

infection." It is a more dangerous infection, usually affecting the upper or lower extremities. It involves Group A β-hemolytic streptococcus, with or without *Staphylococcus aureus*. This is the same streptococcus that is responsible for streptococcal pharyngitis, impetigo, cellulitis, and toxic shock syndrome. Type 2 NF may affect healthy individuals at any age (McGee, 2005).

Patients at Risk/Occurrence Rates

Occurrence of NF affects healthy as well as immunocompromised individuals. The disease has become increasingly more common in the United States since the late 1980s and has a history that dates back to the civil war (Bashford, Yin, & Pack, 2002). In 2001, the Centers of Disease Control and Prevention released national projection numbers stating that invasive Group A streptococcal disease was responsible for 10,650 cases, of which 7% were NF (Centers for Disease Control and Prevention, 2003). Although NF amounted to 700 cases in 2001, the disease has gained attention because of an overall morbidity and mortality of 70%–80%, aggressive progression, and a high rate of systemic toxicity (Ruth-Sahd & Gonzales, 2006). According to the National Necrotizing Fasciitis Foundation, "two words can decrease the risk of death and disfigurement from NF: *prompt diagnosis*!"

TABLE 2. BACTERIAL TYPES CAUSING NECROTIZING FASCIITIS

Type 1	Type 2
90% cases	10% cases
Common	Dangerous
Abdominal/peritoneal tissue	Arms/legs
Underlying conditions	Previously healthy, may or may not have major illness
Postoperative	
Diabetes	
Elderly	Occurs in any age group
Polymicrobial infection	1/2 occurs in the young
70% patients have two or more organisms cultured (maximum 6–10)	1–2 microbial infection

Predisposing factors in the development of NF include surgical or traumatic wounds, burns, frostbite, insect bites, and skin lesions such as open sores or varicella. There are occasions when the infection is idiopathic (Walker, 2005). Frequently, a comorbid medical condition (see Table 3) may create an environment that can potentiate the development of the infection. Conditions the orthopaedic nurse may see include diabetes mellitus, obesity, renal failure, vascular insufficiency, and the immunocompromised (Fink & DeLuca, 2002).

Signs and Symptoms of NF

Nurses are in a key position to assess and monitor the progression of skin changes for any patient who presents with the rapid onset of a sudden illness and pain disproportionate to the injury. Because early detection is crucial, healthcare professionals need to be knowledgeable about early signs and symptoms of NF. The initial signs including pain, erythema, edema, and fever may be vague and often confused with cellulitis. A definitive diagnosis can be made by visualization and dissection of the necrotic fascia, usually in the operating room. The key factor is pain disproportionate to the amount of "redness." If a "cellulitis" fails to respond to antibiotics within 24–48 hr, NF must be considered (Varma & Stashower, 2006).

Recognition of the signs and symptoms of NF can assist the orthopaedic nurse in taking action when changes are noted. These symptoms can be divided into *early, advanced*, and *critical* symptoms. Each phase is characterized by unique physical signs.

EARLY SYMPTOMS

The earliest symptoms occur in the first 24 hr of a bacterial invasion. These include fever, pain, malaise, and thirst. Initially, the appearance of these symptoms can mimic a myriad of other conditions and may be missed or misdiagnosed. Incorrect diagnosis is common in NF as the progression of the disease is not visible until the tissue destruction is already under way (McGee, 2005).

Nurses need to be prepared to recognize the hallmark of NF as erythema that quickly spreads with a margin of redness that extends to normal skin without being raised or sharply demarcated (Walker, 2004).

TABLE 3. PATIENT RISK FACTORS

Diabetes mellitus
Obesity
Immunosuppression
Renal failure
Vascular insufficiencies
Neutropenia
Undergoing chemotherapy and radiation therapy
Alcohol abusers
Malnourished
Intravenous drug use
Organ transplant
HIV

Advanced Symptoms

During the next 48–72 hr, as the NF progresses, the patient experiences advancing symptoms. There is significant pain at the wound site, accompanied by increasing erythema, edema, and warmth. The surrounding skin tissue may further deteriorate and become discolored. The redness changes to dusky or blue and bullae (vesicles) appear. These bullae enlarge and rupture and then leak out a foul-smelling, thin, dirty-gray fluid called "dishwater pus" (Kessenich, 2004; Ruth-Sahd & Gonzales, 2006).

Critical Symptoms

Within 4–5 days of the appearance of the first symptoms, patients may demonstrate critical symptoms, including numbness, hypotension, toxic shock, and unconsciousness. The disease may progress to gangrene, sepsis, and potential death (McGee, 2005).

Diagnosis of NF

Differentiating NF and Cellulitis

Proper diagnosis of NF presents challenges for a myriad of reasons. It is imperative for orthopaedic nurses to recognize that symptoms such as edema, erythema, and fever can initially appear to be a simple cellulitis; however, severe pain disproportionate to the underlying cause and the presence of nonpitting edema beyond the area of erythema are classic signs of NF, differentiating it from cellulitis (Bashford et al., 2002). As NF progresses, skin color can change from red–purple to patches of blue–grey. Within 3–5 days of onset, skin breakdown with bullae and frank cutaneous gangrene can be seen. By this time, the involved area is no longer painful but has become anesthetic secondary to thrombosis of small blood vessels and destruction of superficial nerves located in the necrotic, undermined subcutaneous tissue (Mandell, Bennett, & Dolin, 2005). These late signs are definitive for NF and not simple cellulitis.

Laboratory Studies

Laboratory studies used to help diagnose NF include complete blood cell count with differential, which may show an increase in white blood cell count greater than 14,000/uL and electrolytes, which may show a reduced sodium level of less than 135 mmol/L. The blood urea nitrogen (BUN) level may also be elevated to greater than 15 mg/ml (Schwartz, 2006). Other laboratory tests include creatinine phosphokinase, which, when elevated, (normal level for males range from 38 to 174 units/L and for females range from 96 to 140 units/L) (Daniels, 2003), indicates the presence of tissue breakdown. Abnormal C-reactive protein results when levels greater than 10 mg/L may indicate a clinically active inflammation. Abnormal urinalysis results may indicate the presence of white blood cells, and arterial blood gases that, when abnormal, can signal a severe infection (Maynor, 2006). Microscopic blood and tissue tests may include a rapid streptococcus test, which can show the presence of Group A β-hemolytic streptococcus. A culture and sensitivity with a Gram stain can not only determine whether the infection is Type 1 or Type 2 NF but also help determine the antibiotic course. Histologically, a fine needle aspiration, fascial biopsy, or incisional biopsy can be done. The microscopic section obtained may indicate superficial fascial necrosis with the blood vessels occluded by thrombi. A dense infiltration of neutrophils may be observed in deeper parts of the subcutaneous tissue and fascia.

Imaging Studies

Radiographs, computed tomography (CT) scan, or magnetic resonance imaging (MRI) can be used to aid in the diagnosis of NF. The majority of necrotizing soft tissue infections have anaerobic bacteria present, usually in combination with aerobic gram-negative organisms. These organisms multiply rapidly in an environment of local tissue hypoxia (Ruth-Sahd & Gonzales, 2006). If the infection involves gas-forming organisms, such as clostridial or mixed aerobic/anaerobic infections, the infection site may contain subcutaneous gas (Walker, 2004). Although local radiographs can detect the presence of soft tissue gas, CT scans may be more sensitive than plain radiography in visualizing subcutaneous air (Schwartz, 2006). Computed tomography scanning can also pinpoint the anatomic site of involvement by detecting necrosis with asymmetric fascial thickening (Maynor, 2006). Magnetic resonance imaging may show well-defined areas of deep tissue involvement; however, when the area of abnormality on MRI is compared with the extent of infection revealed at the time of surgery, the sensitivity of the MRI generally overestimates the extent of disease (Habif, 2004) by detecting adjacent noninfectious edema. Magnetic resonance imaging or CT delineation of the extent of NF may be useful in directing rapid surgical debridement (Schwartz, 2006). Therefore, it is preferred that a composite diagnosis is made from a collection of laboratory data, clinical presentation, surgical findings, and studies such as CT scan and MRI (Childs, 1999).

Treatment

Rapid, aggressive treatment is required to decrease the risk of disfigurement and death in patients with NF. Initially, broad-spectrum antibiotics are administered to cover gram-negative and gram-positive aerobes as well as anaerobes. After the organisms have been identified, the antibiotic choice often includes a combination of penicillins, aminoglycosides, and clindamycin administered around the clock. Because of the potential for toxicity, kidney and liver function need to be monitored.

Aggressive surgical debridement of all necrotic tissue is necessary. This is best accomplished by early and extensive excision of all necrotic fascia and nonviable skin and subcutaneous tissue. This process may need to be repeated multiple times (Maynor, 2006).

Hyperbaric therapy may be used as an adjunctive therapy along with antibiotics and surgical debridement. Hyperbaric oxygen therapy elevates the normal oxygen saturation in the infected wounds by a thousand-fold, leading to a bacteriocidal effect (Maynor, 2006). In addition, the use of hyperbaric therapy can enhance wound healing by reduction of tissue swelling, enhancing the body's ability to fight infection and stimulating the

growth of new capillaries into the injured area (Walker, 2004).

Limb Preservation

Necrotizing fasciitis wounds are extensive and often involve tissues with a higher content of potentially pathogenic organisms. These wounds may be seen in body parts, such as the digits of the hands and feet, the legs and abdomen, and the perineum (Childs, 1999). Extensive surgical debridement of necrotic tissue is often needed to prevent the spread of infection and to salvage the limb. Fasciotomies (division of the fascia surrounding a muscle compartment to relieve pressure) are performed in extremities with compromised viability (Maynor, 2006). These incisions are then left open to heal by secondary intention rather than primary closure. As disfiguring and emotionally distressing as it is, a fasciotomy may be a limb-saving procedure.

NF Nursing Interventions

It is critical to administer meticulous nursing care to ensure the best possible patient outcome. Because of the aggressive nature of the infection, care should be delivered in a setting that provides close patient monitoring. A collaborative multidisciplinary care approach should include acute monitoring, administration of antibiotics and intravenous fluids, wound management, pain management, nutritional support, physical therapy, psychosocial support, and patient and family education.

Acute Monitoring

A thorough baseline assessment will assist the bedside orthopaedic nurse in detecting condition changes that necessitate prompt interventions. Vital signs, intake and output, and laboratory data should be monitored for impending signs of infection or sepsis. Febrile, tachycardic patients with laboratory values consistent with dehydration, such as increased BUN and hematocrit, may be observed. Patients should be weighed daily. "Suspicions raised by the nurse may be the initial factor in proper diagnosis of a disease where a missed diagnosis or even a delayed diagnosis, could be the difference between life and death" (McGee, 2005, p. 83).

Wound Management

The wound assessment should include observation for expansion of erythema or an increase in edema, pain, color, or drainage. Wound care for the patient with NF is challenging because it often involves extensive wound management. Patients are often placed in isolation and require multiple time-consuming dressing changes. Typically, this needs to be done one to two times a shift, usually with at least one additional staff member. It is important to remember to follow universal precautions and to wash hands before and immediately after the dressing change to reduce the transmission of bacteria to others (Bashford et al., 2002).

Advances in wound management have led to negative pressure wound therapy as a treatment for managing the closure of wounds resulting from NF. Negative pressure wound therapy promotes wound healing by enhancing blood flow to and from the wound bed, increasing the proliferation of granulation tissue, and decreasing the tissue bacterial counts (Phelps, Fagan, & Pirela-Cruz, 2006). A healthy wound bed increases the likelihood for a split-thickness skin graft to be successful for these patients who are candidates for a graft (Trent & Kirsner, 2002). Wound vacuum-assisted devices help close the wound and keep the blood vessels open, supply blood flow to the wound, and promote healing (Ruth-Sahd & Gonzales, 2006). V. A. C. devices also help relieve pain at the site by removing irritating exudates that cause pressure on the wound. This advanced form of wound care is superior to wet-to-dry dressing changes because negative pressure wound therapy increases the rate of tissue granulation and decreases microorganism and bacterial counts, thus speeding up the healing process (Krasner, 2002; Phelps et al., 2006).

Pain Management

To best manage the patient's pain, a thorough pain assessment should be performed by the orthopaedic nurse and reassessed every 2 hr until the patient's pain goal is met. The assessment should include the location, intensity, type, and quality of pain. The visual analog 0–10 scale and the Face, Leg, Activity, Cry, Consolability (FLACC) scale are two reliable ways for the nurse to measure pain intensity. The FLACC score is a behavioral pain management tool that is an interval scale. Five categories of behavior are quantified with scores ranging from 0–10 (Jacobs, 2007). A multimodal pain regimen including opioids, muscle relaxants, neuropathic agents, antianxiety medications, and local anesthetic should be utilized in the pain plan. Typically, opioids administered by patient-controlled analgesia are used (Bashford et al., 2002). It is crucial for the patient to be premedicated prior to painful dressing changes. Additional opioids given intravenous push combined with an antispasmodic like diazepam have proved effective in reducing pain and suffering during dressing changes (Walker, 2004). If the patient has increased anxiety, it can potentiate the sensation of pain, prolonging the experience (Childs, 1999). Administering antianxiety agents may also alleviate some of the pain and anxiety NF patients have during their daily care. Some nonpharmacological interventions that may help relieve pain are imagery, music therapy, distraction, and cold therapies (Bashford et al., 2002). Massage and frequent reposition changes also promote comfort. The orthopaedic nurse should determine each individual's acceptable level of pain and develop an individualized pain management plan that achieves those specific goals.

Nutritional Support

Nutritional support for the patient with NF helps heal these extensive wounds. Together, the orthopaedic

nurse and registered dietician calculate the amount of calories required per day based on laboratory values and daily weights. The amount of calories and proteins should be double that of the normal basal requirement (Ruth-Sahd & Gonzales, 2006). Prompt and aggressive nutritional support has been shown to lower complication rates; thus, nutritional support should begin within the first 24 hr of hospitalization (Trent & Kirsner, 2002). Parenteral or enteral nutrition is required for these patients. Feeding the patient via enteral nutrition is the preferred method because the use of the gastrointestinal tract will inhibit bacteria from moving through the bowel, which now has become highly permeable as a result of the sepsis (Fink & DeLuca, 2002). To ensure that the patient is receiving adequate nutrition, baseline and repeated monitoring of albumin, prealbumin, transferrin, BUN, and triglycerides should be performed. These patients may also require supplements including iron, vitamin C, and vitamin E to promote wound healing (Fink & DeLuca, 2002).

Physical Therapy

Physical therapy is an important part of the plan of care for the patient with NF. Encouraging mobility, increasing range of motion of extremities, and participating in activities of daily living (ADLs) will promote circulation and tissue perfusion. These activities can prevent complications associated with immobility such as deep vein thrombosis and pneumonia (Ruth-Sahd & Gonzales, 2006). To help ensure that the patient has enough energy, strength, and mobility to perform various ADLs and their therapies, the bedside nurse needs to assess the oxygen saturation every 4 hr (Bashford et al., 2002). Posting a daily written plan of care will help keep the patient and family better informed of the daily routine.

Psychological Support

There can be psychological consequences of NF resulting from intense discomfort, serial surgical debridements, painful dressing changes, physical disfigurement, and a myriad of emotions such as anxiety, worry, guilt, anger, and hopelessness. The orthopaedic nurse needs to provide ongoing support for the NF patient because conditions, such as depression and anxiety, can slow the healing process and lead to poor pain management (Fink & DeLuca, 2002). Antidepressant medications may reduce feelings of depression and hopelessness (Ruth-Sahd & Gonzales, 2006). Supportive counselors can help patients cope with pain, anxiety, and body image disturbances caused by the appearance of extensive reconstructive surgery and interventions.

Education

It is important to reinforce in patients with NF and their significant others vigilant hand-washing and strict adherence to isolation precautions (McGee, 2005). The orthopedic nurse should also educate the patient and his or her family regarding hospitalization that includes the need for medical and nursing expertise and frequent dressing changes. Throughout the hospitalization, continue to teach and evaluate the patient's understanding of wound care and other specialty needs. To meet criteria to go home with home health services, patients must be able to care for their wound(s), administer intravenous antibiotics, prepare nutritious meals, maintain a clean environment, perform ADLs, obtain medications and supplies, and ambulate safely (Bashford et al., 2002). It is important to determine the patient's and family's abilities to meet these needs and involve the discharge planner to set up services needed for a safe discharge. Some patients are initially discharged to an extended care facility to meet their extensive care needs before going home with home health services. Together with the patient and family, the interdisciplinary team including physicians, nursing, the pain management team, physical and occupational therapy, wound care, dieticians, care coordinators, and discharge planners will collaborate on an individualized discharge plan.

NF Prevention

Currently, 15%–20% of the population is asymptomatic carriers of Group A streptococcus. The bacterium is harbored in the mouth and the throat and can be transferred to other persons by respiratory droplets or direct contact with persons carrying Group A streptococcus (Batdorff & Roemmele, 2005; see Box 1).

Case Study Presentation

H. S. is a previously healthy 54-year-old woman who presented to a local hospital with bilateral lower extremity pain that worsened throughout the day of her admission. Her history was significant for obesity and Type 2 diabetes. Upon examination, she was found to have a deep gluteal abscess with no known portal of entry. The culture was positive for *Bacteroides fragilis* (anaerobic). Because of worsening symptoms, she underwent a fasciotomy and debridement from hip to ankle at the local hospital. Then she was transferred to a Level I trauma center for hyperbaric oxygen therapy and definitive management of a necrotizing soft tissue infection of the bilateral lower extremities. Additional wound cultures were consistent with a polymicrobial Type 1 NF made up of aerobic and anaerobic bacteria.

Box 1. The Following Practices Will Lessen Your Chances of Becoming Infected

- Washing hands or using antibacterial soap
- Disposing of used tissues
- Minimizing exposure to persons with sore throats
- Covering your mouth when coughing or sneezing
- Caring for the smallest wound with soap, water, antibacterial ointment, and covering it with a sterile dressing

Note. From "Necrotizing Fasciitis: Commonly Known as the 'Flesh-Eating' Bacteria," by D. Batdorff and J. Roemmele, 2005, Retrieved March 8, 2007, from National Necrotizing Fasciitis Foundation Web site: http://www.nnff.org/nnff_factsheet.htm

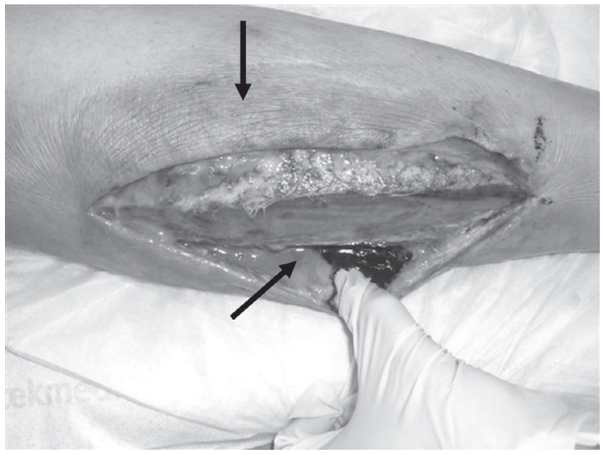

FIGURE 1. H. S.'s left medial calf prior to debridement in the operating room. Note the skin changes circumferentially around the wound and purulence along the facial plane. Photograph courtesy of Loren Schechter, MD, FACS, Division Director, Plastic Surgery, Advocate Lutheran General Hospital.

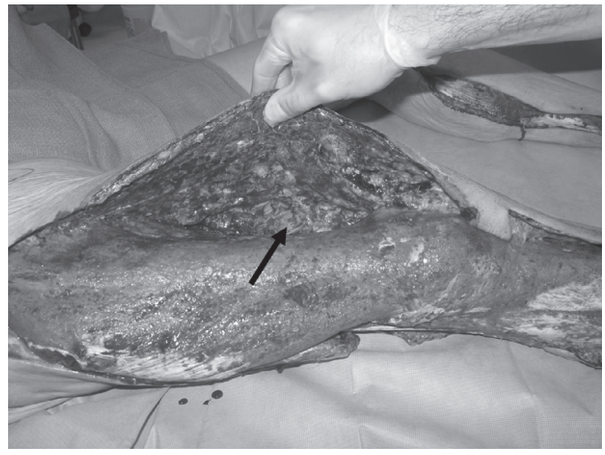

FIGURE 3. H. S.'s left leg postdebridement and prior to application of wound V. A. C. in the operating room. Note healthy muscle and loss of subcutaneous tissue and fascia. Photograph courtesy of Loren Schechter, MD, FACS, Division Director, Plastic Surgery, Advocate Lutheran General Hospital.

Over the course of the next 3 weeks of her hospitalization, H. S. underwent three serial surgeries, which involved extensive circumferential, bilateral lower extremity debridements, complex closures of the wounds, split-thickness skin grafting, and wound V. A. C. application. A peripherally inserted central catheter was placed to administer intravenous antibiotics (see Figures 1–3).

H. S.'s daily postoperative wound care was complex and required two staff members to change the extensive dressings. Pain was controlled with a patient-controlled analgesia and intravenous morphine prior to dressing changes. Emotional support was provided by daily visits from her spouse and son along with pastoral care and music therapy. After her hospitalization, H. S. was transferred to an extended care facility, where she spent the next several weeks for continued care of her extensive wounds. During her recuperation, because of her diminished appetite and increased calorie demands required to heal her large wounds, she had significant weight loss. Once H. S. returned to her home, her spouse and son learned how to manage her care with the support of home health services.

Nine months after diagnosis, H. S.'s wounds were fully healed, and she had full range of motion of both lower extremities, was able to ambulate, and had resumed her previous lifestyle.

FIGURE 2. H. S.'s bilateral lower extremities and wounds prior to further debridement in the operating room. This was subsequent to a previous debridement. Note the necrotic changes along the anterior aspect of the skin margins and the extensive amount of debridement. Photograph courtesy of Loren Schechter, MD, FACS, Division Director, Plastic Surgery, Advocate Lutheran General Hospital.

Conclusion

A diagnosis of NF poses a challenge to all healthcare professionals as they care for these patients. The key to overcoming the risk of this disease process is in rapid identification and prompt treatment. As a direct patient care provider, the orthopaedic nurse can be instrumental in identifying early signs and symptoms of NF and its dangerous progression. As part of the multidisciplinary team, the nurse forms an individualized treatment plan to meet the needs of this complex patient. Working with members of the team to focus on appropriate antibiotic therapy, early surgical intervention, daily wound care, and the meeting of comfort and psychosocial needs, the nurse can be an essential part of the patient's successful treatment. It is through prompt diagnosis and treatment that the healthcare professional can reduce the morbidity and mortality of this infection.

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