CLINICAL MANAGEMENT extra

Learning from Clinical Experience with Necrotizing Fasciitis: Treatment and Management

CME
1 AMA PRA
Category 1 Credit™

CE
ANCC
1.5 Contact Hours

Yukun Liu, PhD • Research Fellow • Tissue Engineering and Wound Healing Lab • Division of Plastic Surgery, Department of Surgery • Brigham and Women's Hospital • Harvard Medical School • Boston, Massachusetts • Resident Doctor of Plastic Surgery • Department of Plastic Surgery • Wuhan Union Hospital • Tongji Medical College • Huazhong University of Science and Technology • Wuhan, China

Ke Guo, MD, PhD • Attending Surgeon • Department of Plastic Surgery • Wuhan Union Hospital • Tongji Medical College • Huazhong University of Science and Technology • Wuhan, China

Jiaming Sun, MD, PhD • Professor of Plastic Surgery • Department of Plastic Surgery • Wuhan Union Hospital • Tongji Medical College • Huazhong University of Science and Technology • Wuhan, China

The authors, faculty, staff, and planners, including spouses/partners (if any), in any position to control the content of this CME activity have disclosed that they have no financial relationships with, or financial interests in, any commercial companies pertaining to this educational activity.

To earn CME credit, you must read the CME article and complete the quiz online, answering at least 13 of the 18 questions correctly.

This continuing educational activity will expire for physicians on November 30, 2018, and for nurses on November 30, 2019.

All tests are now online only; take the test at http://cme.lww.com for physicians and www.nursingcenter.com for nurses. Complete CE/CME information is on the last page of this article.

GENERAL PURPOSE:

To provide information about necrotizing fasciitis (NF), how to recognize it, and evidence-based treatment.

TARGET AUDIENCE:

This continuing education activity is intended for physicians, physician assistants, nurse practitioners, and nurses with an interest in skin and wound care.

LEARNING OBJECTIVES/OUTCOMES:

After completing this continuing education activity, you should be able to:

1. Define NF and identify its signs and symptoms.
2. Outline the non-surgical and surgical treatments for NF.

ABSTRACT

Necrotizing fasciitis is a threatening, rapidly progressive, infectious disease of the soft tissue. In this article, based on 3 cases, the authors aim to summarize the clinical experience of patients with necrotizing fasciitis and the current concepts of the treatment and management of this disease.

KEYWORDS: necrotizing fasciitis, sepsis, soft tissue infection, surgical debridement, supportive therapy

ADV SKIN WOUND CARE 2017;30:486–493.

INTRODUCTION

Necrotizing fasciitis (NF) is a life-threatening, rapidly progressive, soft tissue infection. Because of its low incidence and high morbidity and mortality, it has drawn more attention from surgeons in recent years. Between October 2015 and July 2016, 3 patients with NF were admitted to the emergency department (ED) at the authors' hospital and were transferred to the plastic and reconstructive surgery department for treatment. Surgical debridement was performed, and supportive care was provided. Two of the patients were treated successfully; the third patient died because of severe infection, multiple organ failure, and disseminated intravascular coagulation.

The objective of this article is to summarize the authors' clinical experience with patients with NF, and the current treatment methods and management of this disease. The timing of surgery is extremely important and is predicated on prompt diagnosis, timely incision of the swollen area, and a simple incision for unstable patients. Appropriate surgical debridement, follow-up care in the intensive care unit (ICU), and postoperative wound repair are also important to effective treatment and a successful hospital stay.

BACKGROUND

Necrotizing fasciitis, characterized by widespread necrosis of the subcutaneous adipose tissue, fascia, or muscle, was first described by Hippocrates (500 BCE); however, the term itself was coined by Wilson in 1952.[1,2] The disease is difficult to diagnose in its early stages and progresses quickly with high mortality and morbidity. It can be caused by polymicroorganisms or monomicroorganisms. Sepsis and septic shock are usually observed in the late stages of the disease as a result of severe infection. As previous studies have noted, prompt diagnosis, broad-spectrum antibiotic coverage, surgical intervention, and supportive therapy have the potential to ensure a good prognosis and outcome for this disease.[3]

Based on 3 NF cases treated at the authors' facility between 2015 and 2016, this article compares the therapeutic method used in previous studies to recommend a systematic treatment and present a novel approach. The authors especially emphasize the importance of performing an immediate, temporary, and simple incision for unstable patients. Supportive treatments, including those frequently used in the ICU, will also be discussed in this article.

CLINICAL DATA

Case 1

A 36-year-old man presented to his local ED with swelling and intractable pain in his left knee compartment. He stated that he had sustained a small injury to his left knee a few weeks ago. His computed tomography scan was unremarkable. The patient underwent intravenous antibiotic treatment for 7 days. Subsequently, his pain escalated, and associated swelling and redness spread throughout his knee compartment. Because of his deteriorating condition, he was transferred to the hospital's plastic surgery service and subsequently admitted to the ICU.

The patient's laboratory results showed a white blood cell count (WCC) of 19×10^9/L (reference range, 4–10 $\times 10^9$/L); platelet count, 20×10^9/L (reference range, 100–300 $\times 10^9$/L); creatinine level (Cr), 203 μmol/L (reference range, 44-106 μmol/L); and albumin level, 14 g/L (reference range, 33–55 g/L). The patient's procalcitonin (PCT) exceeded 100 ng/mL (reference range, 0–0.5 ng/mL), and brain natriuretic peptide was 1640 pg/mL (reference range, 0–300 pg/mL).

The inflammation spread superiorly to the patient's left groin, inferiorly to the anterior part of the left thigh, and down to the inferior part of the knee joint (ie, the tibial plateau in the tibial tuberosity). Several blisters with purple and black discharge were observed. Considering these clinical observations and laboratory indicators, his providers suspected NF with sepsis and multiple organ failure, and he was taken to the operating room (OR) immediately for emergency surgery.

Several incisions were made over the most swollen area on the patient's left leg. Both the subcutaneous adipose and fascia tissue were gray and devitalized. The wound discharged significant amounts of yellowish fluid while the incisions were created. Negative-pressure wound therapy (NPWT) was used to cover the skin tissue defect temporarily and to help drain the pus after the wound was washed with iodine and hydrogen peroxide. After surgery, the patient was admitted to the ICU for treatment against infection, shock, multiple organ failure, hypoproteinemia, anemia, metabolic acidosis, and electrolyte imbalance.

After a week in the ICU, and when his hemodynamic parameters were stable, he was transferred to the hospital's plastic surgery service. Further surgical debridement was performed twice to remove additional necrotic tissue. Once granulation tissue on the wound was observed, providers applied a skin graft to reconstruct

the wound. The patient was discharged home following successful treatment during his 120-day hospital stay (Figure 1).

Case 2

A 68-year-old man was sent to a local hospital after he complained of pain on his right hip where a mass had formed. The patient was admitted, and on the fifth day of his hospital stay, the mass erupted spontaneously and discharged pungent pus and fluid. Simple debridement was performed in the OR but failed to control the patient's deterioration. Gray, necrotic tissue was found deep into the fascia and muscle layer of the patient's hip; subcutaneous fistulas were interconnected, indicating a high potential for spread of infection. Laboratory testing revealed the following values: WCC, 35×10^9/L (reference range, 4–10×10^9/L); Cr, 216 μmol/L (reference range, 44–106 μmol/L); albumin level, 19.4 g/L (reference range, 33–55 g/L); PCT, 24.36 ng/mL (reference range, 0–0.5 ng/mL). Based on these results, the patient was diagnosed with NF.

Surgical debridement was performed followed by NPWT. Widespread fascial necrosis without a visible border was found, and some of the necrotic tissue was easily removed with the surgeon's hand alone. Surgical debridement was utilized to remove these nonadherent tissues and release the dishwater-like fluid at the same time.

The patient was sent to the ICU, and antibiotic therapy, hypoalbuminemia treatment, and blood supplements were prescribed to correct the patient's hemodynamic instability. The pathology results for microorganisms in the substance secreted by the wound were negative, as well as a blood culture.

After the patient was transferred to the plastic surgery ward, blue-green exudate beneath the NPWT led providers to suspect the wound was infected by *Pseudomonas aeruginosa*, and bacterial cultures and antibiotic sensitivities suggested the patient might be sensitive to levofloxacin. Wet-to-dry dressing changes were applied 3 times per day along with specific antibiotic coverage to help control the infection. After a week of standard measures, autologous mesh skin grafting was performed to close the wound. The patient was successfully treated after wound repair (Figure 2). The patient stayed in the hospital for 30 days' treatment before he was discharged home.

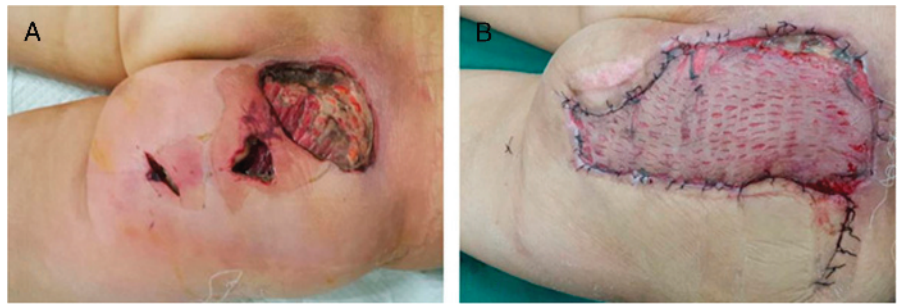
Case 3

A 37-year-old man with a minor injury on his lower right limb manifested an increase in swelling and pain over 3 days out of proportion to the injury. At a local community hospital, antibiotic coverage and supportive therapy were used to treat inflammation on his leg but failed to elicit signs of improvement, at which point he was transferred to the authors' facility. Early in his

Figure 1.
INITIAL CONDITION UPON PRESENTATION TO THE EMERGENCY DEPARTMENT

A, Widespread violet skin was observed on the patient's left leg with groin involvement, indicating potential deep tissue damage. B, Incision on the most obvious swollen area was performed to release the fluid. C, Stamp skin grafting was performed on the granulation tissue wound area during surgery. D, 4 months after the procedure.

Figure 2.
OLDER ADULT PATIENT WITH NECROTIZING FASCIITIS ON HIS RIGHT SUPERIOR, POSTERIOR, AND MEDIAL GLUTEAL AREA



A, Older adult patient with necrotizing fasciitis on his right hip. B, 2 weeks after mesh skin grafting was performed to cover the wound.

admission, the patient was diagnosed with acute respiratory dysfunction syndrome (ARDS), most likely caused by an overwhelming inflammatory response to his right lower leg infection as a result of advancing NF. The patient was placed on mechanical ventilation. In light of the patient's altered mental status, increased respiratory rate of 35 breaths/min, and systolic blood pressure of less than 100 mm Hg, he was diagnosed with acute sepsis and shock.[4]

The patient's right lower extremity presented with inflammation involving the right thigh, knee joint, leg, ankle, and foot. The skin on the posterior and lateral aspect of his leg was dark brown. Some of the area showed redness with skin exposure and tension blisters. In the central part of the affected area, black and firm eschar was found.

Laboratory tests showed WCC, 2.23×10^9/L (reference range, 4–10 $\times$ 10^9/L); platelet count, 35 $\times$ 10^9/L (reference range, 100–300 $\times$ 10^9/L); Cr, 635 μmol/L (reference range, 44–106 μmol/L); aspartate transaminase, 1505 U/L (reference range, 8–40 U/L); alanine aminotransferase, 113 U/L (reference range, 5–40 U/L); brain natriuretic peptide, 1725.2 pg/mL (reference range, 0–300 pg/mL); PCT, in excess of 100 ng/mL (reference range, 0–0.5 ng/mL). The patient's myocardial enzyme was extremely high. The clinical manifestation of infection and laboratory values revealed a poor prognosis consistent with advancing NF.

An adjunctive debridement with NPWT was performed immediately in the OR. Despite this, the infection rapidly progressed with subsequent hypotension, disseminated intravascular coagulation, and multiple organ failure. Death was inevitable despite best efforts (Figure 3).

RESULTS

In this study, 2 patients (cases 1 and 3) had a history of a minor injury before developing NF, which is part of the natural history of this devastating disease. The patient of advanced age in case 2 experienced an overwhelming infection, which was responsible for his NF diagnosis. The patients from cases 1 and 3 were seriously ill when they were transferred to the authors' facility, and both of them were treated in the ICU postoperatively because of their unstable vital signs. The difference in treatment between case 1 and case 3 was the operation method. The patient in case 1 primarily underwent incision and drainage with NPWT and a second operation for debridement followed by subsequent operations. The patient in case 3 underwent surgical debridement of all necrotic tissue and discharge of pus and fluid immediately, because he was in a more precarious situation. Compared with cases 1 and 3, the patient in case 2 was a moderate patient who did not need treatment in the ICU. Antibiotic coverage and supportive treatment were given in all 3 cases, and standard wound care was conducted for the patients in cases 1 and 2. Unfortunately, the medical condition of the patient in case 3 deteriorated after his first debridement, and he died of NF with sepsis and septic shock, which led to ARDS and multiorgan failure despite urgent surgical intervention.

DISCUSSION

Necrotizing fasciitis is a rare, life-threatening, and rapidly progressive disease. Its early diagnosis and treatment are challenging to both surgeons and nonsurgical wound care specialists. If the following signs and symptoms are present, providers should consider an NF diagnosis:

- extreme inflammation,
- ecchymosis,
- hemorrhagic bullae on the area involved, and
- pain out of proportion to the precipitating wound.

Previous studies have concluded that, to a large extent, effective and prompt surgical debridement as well as antibiotic therapy

Figure 3.
THE PATIENT'S RIGHT GASTROC SOLEUS AREA WAS VIOLET AND BLACK WITH BLISTERS

A, Subcutaneous necrotic tissue. B, Subcutaneous necrotic tissue was debrided down to the muscle.

and supportive treatment can reduce mortality and disability.[5] Considering the recent literature regarding treatment and management of NF, the study authors decided to include some key points drawn from their experience in treating NF. The healing potential of nonsurgical treatment options should not be underestimated, even when radical surgical intervention has been performed. Therefore, the following sections discuss not only the recommended timing between diagnosis and surgical treatment, but also related concerns about shock, antibiotic therapy, supportive treatment, and postoperative patient management.

Nonsurgical treatment

Treatment for shock. Shock results from severe infection and sepsis, which is common in NF patients. Antibiotic therapy needs to be initiated early for these patients; in order to control the infection effectively, providers should not wait until the results for bacterial culture and antibiotic sensitivity are received. Empirically, in these cases, providers can use broad-spectrum antibiotics such as imipenem and meropenem as the first-line antibiotics of choice. Teicoplanin is especially effective for gram-positive bacterial infection. The literature recommends a combination of 3 antibiotics that are effective against gram-positive, gram-negative, and anaerobic bacteria, respectively, in the early stages.[6,7] However, based on the authors' previous experience, 2 types of antibiotic are enough to cover most pathogenic bacteria. Bacterial cultures and antibiotic sensitivity can help guide adjustments in antibiotic coverage later in the treatment process. For example, in case 2, levofloxacin was used as a directed choice to control *P aeruginosa* infection.

Septic shock is a frequent complication of NF. Aggressive fluid resuscitation plays an important role in the treatment of these patients. Monitor these patients by taking their arterial blood pressure and central venous pressure and recording daily urine output to evaluate the blood volume supply. Correcting metabolic acidosis and electrolyte imbalance is the most essential intervention. Hypocalcemia caused by tissue necrosis and hyperkalemia

caused by metabolic acidosis are common in NF cases, and hypocalcemia can indicate a poor prognosis.[8,9] In late-stage shock, coagulation disorders (especially disseminated intravascular coagulation) should be suspected.

Shock and severe infection caused by NF may lead to multiple organ dysfunction syndrome. Cardiac dysfunction and acute renal failure should be considered if laboratory indicators are abnormal. A retrospective study suggested that renal dysfunction means a poor prognosis, although the relationship between them was not obvious.[10] Metabolic acidosis is always followed by hyperkalemia; these are usually treated through plasma exchange, or hemofiltration in severe cases. Antibiotic drugs excreted through the kidneys should be used with great caution. Vasopressors and diuretics are used for correction of cardiac dysfunction. Norepinephrine and dobutamine should be given in combination with antishock therapy. If the patient manifests acute respiratory distress postoperatively, he/she should be placed on mechanical ventilation. Finally, consider prophylaxis for stress ulcers.

Nutritional and supportive therapy. According to the Harris-Benedict equation, the daily caloric intake for patients with NF should be double their normal nutritional intake.[11] Comprehensive nutritional support for patients with elevated catabolism is necessary because of the large tissue defect caused by NF. To reduce protein catabolism and avoid perturbations on renal function, patients should consume the right amount of carbohydrates and protein via the gastrointestinal (GI) tract.

Enteral nutrition is the authors' first recommendation if the patient's GI function is normal. Parenteral nutrition is an option for patients who have difficulties with oral intake, but should be changed to enteral nutrition once the patient's GI function has recovered. Hypoalbuminemia is common in cases of NF and patients with large wounds. The amount of fluid protein and electrolyte loss may be similar to that of severe burn patients.[12] Older adults with or without high blood pressure, diabetes, and cardiac disease should be carefully evaluated to prevent serious complications.

Surgical Treatment

Necrotic tissue debridement. Radical debridement of the tissue involved should be performed as soon as NF is diagnosed in hemodynamic stable patients; the purpose of surgical debridement is to remove all infected tissue. Delayed surgical debridement will definitely increase patient mortality.[13] Previous studies have demonstrated that wide and aggressive debridement of all necrotic tissues as early as possible may decrease the mortality of NF patients.[14]

Patients with sepsis and shock may deteriorate if aggressive debridement is utilized in the first operation.[15] For example, the extensive debridement of necrotic tissue for the patient in case 3, who was already in serious condition, led to rapid and pronounced sepsis and shock, resulting in ARDS and multiorgan failure. In addition, wide debridement of all necrotic and low-perfusion tissues caused the loss of significant amounts of fluid and blood volume. However, the decision to treat with 1-time debridement versus multiple debridements is controversial. Legbo and Shehu[16] found that multiple debridements, which depend on the demand for additional operations, decrease ongoing tissue destruction. However, the possibility of toxin absorption in the late stages of NF should never be ignored. Multiple debridements reduce fluid loss, decreasing the possibility of death from shock. A retrospective study showed that a *Vibrio*-infected NF patient had a better outcome when a simple incision with drainage was performed on the areas involved, with a complete debridement after 24 hours, compared with patients who underwent debridement immediately during their first operation.[17] Empirically, the authors recommend that a second debridement be performed only once the patient's condition is stable enough for another operation, instead of repeating debridement after 24 hours.

Although prompt aggressive surgical debridement is recommended in the literature,[5] the patient's condition should dictate the type of procedure selected, whether simple or a more complete debridement. For relatively stable patients, wide debridement of necrotic tissue at the onset of the disease may be considered. For patients with sepsis shock and multiple organ dysfunction, a prompt incision on the site where inflammation is present, even in the ED under local anesthesia, could help release fluid and toxins and alleviate the high tension in the swollen area. Aggressive debridement may be delayed until the patient is stable, because the release of large amounts of pus and fluid could further exacerbate the patient's insufficient blood volume postoperatively.

In case 1, the course of treatment was appropriate to ensure the patient's hemodynamic stability. Providers created an incision for initial debridement, removed the nonadherent subcutaneous necrotic tissues with their fingers, and transferred him to the ICU. After 1 week in the ICU, the patient was treated for shock, and once he was hemodynamically stable, he was transferred back to the plastic surgery service for further treatment.

While early extensive debridement is indicated, the authors' experience demonstrates that early extensive debridement could decrease the absorption of toxic chemicals in the late stages of NF and reduce the incidence of sepsis in the long term.[18] However, the patient's clinical condition is the priority. An incision is performed to save the patient's life and to provide hemodynamic stability. To prevent the possible toxic absorption in the long run, timely repeated debridement with effective antibiotic use can be helpful.

During subsequent surgical debridement, all the suspected necrotic and nonviable tissue should be removed to prevent

extensive future necrosis. The literature recommends that all nonadherent tissue that can be easily detached from the fascia should be excised during the operation.[19] Based on these cases, an at least 1-cm border from the necrotic tissue should be excised, or until healthy tissue is found, because the necrotic area is usually larger than what can be observed. However, excessive debridement may lead to a patient's rapid clinical deterioration.[20] Thus, deciding between aggressive and conservative debridement is extremely important before embarking on a treatment course. Andreasen et al[21] found that vascular microthromboses and vasculitis occurred even when NF patients had a normal external skin appearance.[22] This is consistent with the authors' observation that extended debridement may help protect healthy tissue from necrosis.

No matter the course of treatment, it is imperative to inform patients that repeated operations may be needed in the course of a long hospital stay. In addition, the authors strongly recommend the use of NPWT to cover subsequent wounds, which can stimulate granulation tissue formation, promote angiogenesis, and prepare the wound bed for future repair.[23]

Reconstructive surgery. When the infection is under control, more debridement operations may be required depending on the condition of the wound.[24] Negative-pressure wound therapy should be in place until new granulation tissue appears on the wound area. Reconstructive procedures such as skin grafts and flap transfers may be considered later. Local flap transfers are typically used for relatively small wounds. Sequential stamp grafting is more suitable for larger wound areas. Stamp grafting is not only a solution for shortage of skin, but it also prevents local infection from spreading to the whole skin graft. Likewise, mesh skin grafting is another option when there is a shortage of skin; this can also decrease the rate of graft skin necrosis. Free rotating flaps are used to cover wounds with exposed bone after muscle necrosis in patients with NF.[22]

Functional Training

The typical hospital length of stay for NF patients ranges from a few weeks to several months. Providers must reduce or avoid the complications of long-term bed rest such as hypostatic pneumonia, bedsores, thrombosis, and sarcopenia. To avoid disuse atrophy and joint stiffness, functional training of joint and limbs should begin as soon as reconstructive operations are complete.[25]

CONCLUSIONS

Necrotizing fasciitis is difficult to diagnose early; it is a rapidly progressive infection with a high mortality and disability rate, and successful treatment requires prompt recognition and surgical intervention. Surgical debridement, antibiotic coverage, and supportive care, as well as comprehensive nutritional support, are vital to quality care. More extensive and radical incisions should be reserved for patients who are stable and able to withstand the surgery, because these extensive procedures essentially release more toxins from infected tissues. However, in patients who are unstable and at risk of shock, a simpler, less radical surgery is indicated to stabilize the patient.

The provider's first priority should be saving lives; appropriate debridement should be secondary and considered in accordance with the patient's clinical condition. Further, the importance of wound management during surgery and wound repair after debridement cannot be overstated. Functional training and recovery treatment should be used concomitantly during the recovery period. In conclusion, multidisciplinary care is essential to ensure a good prognosis for patients with NF.

PRACTICE PEARLS

- Rapidly diagnose NF based on the following signs and symptoms: extreme inflammation, ecchymosis, hemorrhagic bullae on the area involved, and pain out of proportion to the precipitating wound.
- Consider a prompt incision for hemodynamically unstable patients and wide debridement for stable patients.
- Use antibiotics empirically, and adjust the regimen later according to drug-sensitive testing.
- Monitor NF patients closely for vital sign changes and send them to ICU if necessary.
- Reconstructive surgery and nutritional and supportive therapy are important during the late period of NF treatment.

REFERENCES

1. Descamps V, Aitken J, Lee MG. Hippocrates on necrotising fasciitis. Lancet 1994;20;344(8921):556.
2. Wilson B. Necrotizing fasciitis. Am Surg 1952;18(4):416-31.
3. Majeski JA, Alexander JW. Early diagnosis, nutritional support, and immediate extensive debridement improve survival in necrotizing fasciitis. Am J Surg 1983;145:784-7.
4. Singer M, Deutschman CS, Seymour CW, et al. The third international consensus definitions for sepsis and septic shock (Sepsis-3). JAMA 2016;315(8):801-10.
5. Bilton BD, Zibari GB, McMillan RW, Aultman DF, Dunn G, McDonald JC. Aggressive surgical management of necrotizing fasciitis serves to decrease mortality: a retrospective study. Am Surg 1998;64(5):397-400.
6. Naqvi GA, Malik SA, Jan W. Necrotizing fasciitis of the lower extremity: a case report and current concept of diagnoses and management. Scand J Trauma Resusc Emerg Med 2009;17:28.
7. Salcido RS. Necrotizing fasciitis: reviewing the causes and treatment strategies. Adv Skin Wound Care 2007;20(5):288-93.
8. Bellapianta JM, Ljungquist K, Tobin E, Uhl R. Necrotizing fasciitis. J Am Acad Orthop Surg 2009;17(3):174-82.
9. Nakamura S, Hashimoto Y, Ishida-Yamamoto A, et al. Hypocalcaemia: a sign of severity of necrotizing fasciitis. Dermatology 2004;209(1):64-5.
10. Norton KS, Johnson LW, Perry T, Perry KH, Sehon JK, Zibari GB. Management of Fournier's gangrene: an eleven year retrospective analysis of early recognition, diagnosis, and treatment. Am Surg 2002;68(8):709-13.

11. Majeski J, Majeski E. Necrotizing fasciitis: improved survival with early recognition by tissue biopsy and aggressive surgical treatment. South Med J 1997;90(11):1065-8.
12. Morgan MS. Diagnosis and management of necrotizing fasciitis: a multiparametric approach. J Hosp Infect 2010;75(4):249-57.
13. Misiakos EP, Bagias G, Patapis P, Sotiropoulos D, Kanavidis P, Machairas A. Current concepts in the management of necrotizing fasciitis. Front Surg 2014;29;1:36.
14. Sudarsky LA, Laschinger JC, Coppa GF, Spencer FC. Improved results from a standardized approach in treating patients with necrotizing fasciitis. Ann Surg 1987;206(5):661-5.
15. Voros D, Pissiotis C, Georgantas D, Katsaragakis S, Antoniou S, Papadimitriou J. Role of early and extensive surgery in the treatment of severe necrotizing soft tissue infection. Br J Surg 1993;80(9):1190-1.
16. Legbo JN, Shehu BB. Necrotizing fasciitis: a comparative analysis of 56 cases. J Natl Med Assoc 2005;97(12):1692-7.
17. Hong GL, Dai XQ, Lu CJ, et al. Temporizing surgical management improves outcome in patients with Vibrio necrotizing fasciitis complicated with septic shock on admission. Burns 2014;40(3):446-54.
18. McHenry CR, Piotrowski JJ, Peterinic D, Malangoni MA. Determinants of mortality for necrotizing soft tissue infections. Ann Surg 1995;221:558-63.
19. Edlich RF, Cross CL, Dahlstrom JJ, Long WB 3rd. Modern concepts of the diagnosis and treatment of necrotizing fasciitis. J Emerg Med 2010;39(2):261-5.
20. Sun X, Xie T. Management of necrotizing fasciitis and its surgical aspects. Int J Low Extrem Wounds 2015;14(4):328-34.
21. Andreasen TJ, Green SD, Childers BJ. Massive infectious soft-tissue injury: diagnosis and management of necrotizing fasciitis and purpura fulminans. Plast Reconstr Surg 2001;107(4):1025-34.
22. Sarani B, Strong M, Pascual J, Schwab CW. Necrotizing fasciitis: current concepts and review of the literature. J Am Coll Surg 2009;208(2):279-88.
23. Roje Z, Roje Z, Matić D, Librenjak D, Dokuzović S, Varvodić J. Necrotizing fasciitis: literature review of contemporary strategies for diagnosing and management with three case reports: torso, abdominal wall, upper and lower limbs. World J Emerg Surg 2011; 23;6(1):46.
24. Singh G, Bharpoda P, Reddy R. Necrotizing fasciitis: a study of 48 cases. Indian J Surg 2015;77(S2):345-50.
25. Hakkarainen TW, Kopari NM, Pham TN, Evans HL. Necrotizing soft tissue infections: review and current concepts in treatment, systems of care, and outcomes. Curr Prob Surg 2014;51(8):344-62.

CE CONNECTION

CONTINUING MEDICAL EDUCATION INFORMATION FOR PHYSICIANS

Lippincott Continuing Medical Education Institute, Inc. is accredited by the Accreditation Council for Continuing Medical Education to provide continuing medical education for physicians.

Lippincott Continuing Medical Education Institute, Inc. designates this journal-based CME activity for a maximum of 1 *AMA PRA Category 1 Credit™*. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

PROVIDER ACCREDITATION INFORMATION FOR NURSES

Lippincott Professional Development will award 1.5 contact hours for this continuing nursing education activity.

LPD is accredited as a provider of continuing nursing education by the American Nurses Credentialing Center's Commission on Accreditation.

This activity is also provider approved by the California Board of Registered Nursing, Provider Number CEP 11749 for 1.5 contact hours. LWW is also an approved provider by the District of Columbia, Georgia, and Florida CE Broker #50-1223.

OTHER HEALTH PROFESSIONALS

This activity provides ANCC credit for nurses and *AMA PRA Category 1 Credit™* for MDs and DOs only. All other healthcare professionals participating in this activity will receive a certificate of participation that may be useful to your individual profession's CE requirements.

CONTINUING EDUCATION INSTRUCTIONS

- Read the article beginning on page 486. For nurses who wish to take the test for CE contact hours, visit www.nursingcenter.com. For physicians who wish to take the test for CME credit, visit http://cme.lww.com.
- You will need to register your personal CE Planner account before taking online tests. Your planner will keep track of all your Professional Development online CE activities for you.
- There is only one correct answer for each question. A passing score for this test is 13 correct answers. If you pass, you can print your certificate of earned contact hours or credit and access the answer key. Nurses who fail have the option of taking the test again at no additional cost. Only the first entry sent by physicians will be accepted for credit.

Registration Deadline: November 30, 2018 (nurses); November 30, 2018 (physicians).

PAYMENT AND DISCOUNTS

- The registration fee for this test is $17.95 for nurses; $17.95 for physicians.