Necrotizing fasciitis (NF) is a predominantly adult disorder with bacterial infection of the soft tissue. In children, it is relatively rare and has a fulminating course with a high mortality rate. In the neonate, most cases of NF are attributable to secondary infection of omphalitis, balanitis, mammitis, postoperative complications, and fetal monitoring. The objective of this communication is to report 3 cases of neonatal NF and provide a literature review of this disorder.

Results. This review yielded 66 cases of neonatal NF. Only 3 cases were premature. There was no sex predilection and the condition rarely recurred. Several underlying conditions were identified that might have contributed to the development of neonatal NF. These included omphalitis in 47, mammitis in 5, balanitis in 4, fetal scalp monitoring in 2, necrotizing enterocolitis, immunodeficiency, bullous impetigo, and maternal mastitis in 1 patient each. The most common site of the initial involvement was the abdominal wall (n = 53), followed by the thorax (n = 7), back (n = 2), scalp (n = 2), and extremity (n = 2). The initial skin presentation ranged from minimal rash to erythema, edema, induration or cellulitis. The lesions subsequently spread rapidly. The overlying skin might later develop a violaceous discoloration, peau d'orange appearance, bullae, or necrosis. Crepitus was uncommon. Fever and tachycardia were frequent but not uniformly present. The leukocyte count of the peripheral blood was usually elevated with a shift to the left. Thrombocytopenia was noted in half of the cases. Hypercalcemia was rarely reported. Of the 53 wound cultures available for bacteriologic evaluation, 39 were polymicrobial, 13 were monomicrobial, and 1 was sterile. Blood culture was positive in only 20 cases (50%). Treatment modalities included the use of antibiotics, supportive care, surgical debridement, and drainage of the affected fascial planes. Two of the 6 cases who received hyperbaric oxygen therapy died. The overall mortality rate was 59% (39/66). In 12 cases, skin grafting was required because of poor granulation formation or large postoperative skin defects among the survivors.

Conclusion. Neonatal NF is an uncommon but often fatal bacterial infection of the skin, subcutaneous fat, superficial fascia, and deep fascia. It is characterized by marked tissue edema, rapid spread of inflammation, and signs of systemic toxicity. The wound cultures are predominantly polymicrobial and the location of initial involvement depends on the underlying etiologic factor. High index of suspicion, prompt aggressive surgery, appropriate antibiotics, and supportive care are the mainstays of management in the newborn infant with NF. Pediatrics 0;103(4). URL: http://www.pediatrics.org/cgi/content/full/103/4/e53; necrotizing fasciitis, neonate.
performed 2 weeks later. She was discharged well with good eschar formation from the hospital 25 days after admission.

Case 3

A full-term, female infant, weighing 3500 g, was delivered at term after an uneventful delivery. She was admitted to our hospital at 7 days of age because of fever, poor feeding, and a large erythematous, indurated area in the lumbar region. The leukocyte count was 17,700/mm³ with a differential count of 1% metamyelocytes, 20% bands, 59% segmented neutrophils, 13% monocytes, and 7% lymphocytes. The serum electrolyte values and the platelet count were normal. The C-reactive protein level was 128 mg/L. Ultrasonography of the affected area on the back revealed fascial thickening and echolucent band (similar to Case 1). Fasciotomy with debridement of necrotic subcutaneous tissue and fascia was performed within 9 hours after admission. The wound culture yielded oxacillin-resistant Staphylococcus aureus and the blood culture was sterile. Oxacillin, gentamicin, and metronidazole were given initially, and were changed to vancomycin when the wound cultures results were available. She was discharged on the 29th hospital day in good condition. The skin healed well without skin grafting.

Fig 1. Parts A and B. Case 1. An extensive erythematous area over the lower back initially (A), and extended rapidly to both flanks and developed a violaceous discoloration (B).

REVIEW OF LITERATURE

Our literature review yielded 66 cases of NF for analysis (Table 1). Only 3 cases were premature. There was no sex predilection and the condition rarely recurred. Several underlying conditions were identified that might have contributed to the development of necrotizing NF. These
included omphalitis in 47,1–9 mammitis in 5,1,11 balanitis in 4,1,8,10 fetal scalp monitoring in 2,15 postoperative complications in 2,13,14 septicemia in 2,17,18 and necrotizing enterocolitis,12 immunodeficiency,16 bullous impetigo,19 and maternal mastitis20 in 1 patient each.

The most common site of the initial involvement was the abdominal wall (n = 53), followed by the thorax (n = 7), back (n = 2), scalp (n = 2), and extremity (n = 2). The initial skin presentation ranged from minimal rash to erythema, edema, induration or cellulitis. The lesions subsequently spread rapidly. The overlying skin might later develop a violaceous discoloration, peau d’orange appearance, bullae, or necrosis. Crepitus was uncommon.20 Fever and tachycardia were frequent but not uniformly present. The leukocyte count of the peripheral blood was usually elevated with a shift to the left. Thrombocytopenia was noted in half of the cases. Hypocalcemia was rarely reported.20

Of the 53 wound cultures available for bacteriologic evaluation, 39 were polymicrobial, 13 were monomicrobial, and 1 was sterile. Among the 39 specimens with polymicrobial infections, the predominant aerobic bacteria were Staphylococcus aureus, Escherichia coli and enterococcus, whereas the predominant anaerobic bacteria were Clostridium spp and Bacteroides spp. Staphylococcus aureus was the most common organism recovered from the wound cultures with monomicrobial infections. Blood culture was positive in 20 cases (50%) including 5 polymicrobial and 15 monomicrobial bacteremia, and sterile in 20 cases. Bacteremia caused by organisms identical to those found in the wound cultures.

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* Other associated factors included necrotizing enterocolitis, postoperative complication, fetal scalp monitoring, immunodeficiency, septicemia, bullous impetigo, and maternal mastitis.
† Three other patients were included in an earlier report.
‡ The location of initial involvement included both of the lower abdomen and groin area in 4 cases after circumcision.
occurred in 13 instances. Two blood cultures and one wound culture grew Candida species.\textsuperscript{5,16}

Treatment modalities included the use of antibiotics, supportive care, surgical debridement, and drainage of affected fascial planes. Two of the 6 cases who received hyperbaric oxygen therapy died.\textsuperscript{8,10} The overall mortality rate was 59\% (39/66). Death usually occurred before surgery or shortly after surgical intervention as a result of bacterial infection with septic shock, disseminated intravascular coagulation, and/or multiple-organ failure. In 12 cases, skin grafting was required because of poor granulation formation or large postoperative skin defects among the survivors.\textsuperscript{3,5–10,12,15–20}

DISCUSSION

NF is primarily an adult disease. It was first described in detail in 1924 by Meleny.\textsuperscript{21} The term “necrotizing fasciitis” was introduced by Wilson in 1952 when he observed a rapidly progressive inflammation and necrosis of subcutaneous tissue, superficial fascia, and superficial part of the deep fascia with variable presence of cutaneous gangrene.\textsuperscript{22}

Among neonates, NF frequently was attributable to secondary infection, such as omphalitis,\textsuperscript{1–9} mamilitis,\textsuperscript{1,11} balanitis,\textsuperscript{8,10} postoperative complications,\textsuperscript{13,14} fetal scalp monitoring,\textsuperscript{15} and bullous impetigo.\textsuperscript{16} Other associations of NF included necrotizing enterocolitis,\textsuperscript{12} immunodeficiency,\textsuperscript{16} and sepsisemia.\textsuperscript{17,18} Primary NF, which implies lack of a known causative factor or any identifiable portal of entry for bacteria, is rarely reported in the neonate. Although there were no known causative factors in our patients, there may be unrecognized infections in the epidermis with systemic bacterial invasion in these relatively immunocompromised neonates. Thus, we cannot be certain that our cases are primary necrotizing fasciitis.

In the neonate, the site of involvement is usually dependent on the etiologic factor. For instance, when the causative factors are omphalitis and balanitis, the site of involvement is usually the abdominal wall. In cases of mamilitis and fetal monitoring, the thorax and the scalp are sites involved, respectively. In 5 cases, including our 3, the inflammation began in the lumbar regions.

It is important that early diagnosis is made for NF because immediate surgical debridement offers the best chance for survival. Because of the variable changes of skin presentation and nonspecific laboratory findings in the early stage of the disease, prompt diagnosis is often difficult and relies on a high index of suspicion. Marked tissue edema, rapid progression of inflammation, and signs of systemic toxicity are the diagnostic clues. Ultrasonography,\textsuperscript{23} computed tomography,\textsuperscript{24} and magnetic resonance imaging\textsuperscript{25} have been very useful in the diagnosis of NF. Stamenkovic and Lew\textsuperscript{26} had suggested that immediate surgical exploration with frozen section biopsy may provide definite and life-saving diagnosis in questionable cases. However, because necrosis is present at the junction between the subcutaneous tissue and fascia, definite diagnosis is usually made at surgery by demonstration of a lack of resistance of normally adherent fascia to gentle finger pressure or blunt probe dissection.\textsuperscript{27,28}

Because wound cultures were predominantly polymicrobial (39 cases, 73.6\% in our review), Moss et al\textsuperscript{29} had recommended that the antibiotic therapy should be a combination of penicillin or a cephalosporin for Gram-positive, an aminoglycoside for Gram-negative, and clindamycin or metronidazole for anaerobic organism. However, because some cases are monomicrobial such as ours, it is important to retrieve wound cultures results as promptly as possible so that appropriate antibiotic therapy can be instituted. McHenry et al\textsuperscript{29} demonstrated that a prolonged lapse time between hospital admission and operative debridement was the only potential determinant associated with an unfavorable outcome in NF. It is important that prompt adequate surgery be performed. The procedure should include early debridement of all necrotic tissue and drainage of affected fascial plane by extensive fasciotomy until viable bleeding tissue is encountered.\textsuperscript{1,27,29}

Supportive care consists of aggressive fluid resuscitation and pain control.\textsuperscript{27} Hyperbaric oxygen therapy has been used, however, Brown et al\textsuperscript{30} in a retrospective review showed that this therapy did not reduce mortality or the number of surgical debridement in the treatment of major truncal NF. A prospective study of hyperbaric oxygen therapy is mandatory to clarify the role of this therapy as an adjunctive measure in the management of NF.

CONCLUSION

Neonatal NF is an uncommon but often fatal bacterial infection of the skin, subcutaneous fat, superficial fascia, and deep fascia. Clinically, it is characterized by marked tissue edema, rapid spread of inflammation, and signs of systemic toxicity. It is usually a polymicrobial infection in secondary NF and the location of initial involvement depends on the underlying etiologic factor. High index of suspicion, prompt aggressive surgery, appropriate antibiotics, and supportive care are the main stays of management in the newborn infant with NF.

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REFERENCES


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NEONATAL NECROTIZING FASCIITIS

**Neonatal Necrotizing Fasciitis: A Report of Three Cases and Review of the Literature**

Wu-Shiun Hsieh, Peng-Hong Yang, Hsun-Chin Chao and Jin-Yao Lai

*Pediatrics* 1999;103;e53

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