CHAPTER 21
Necrotising Fasciitis

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Introduction

The term necrotising fasciitis (NF) was first coined in 1952 by Wilson[1] to describe a rapidly progressive inflammation and necrosis of subcutaneous tissues and the deep layer of superficial fascia with sparing of the deep fascia and muscle. It had previously been described variously as haemolytic gangrene, acute streptococcal gangrene, gangrenous erysipelas, necrotising erysipelas, suppurative fasciitis, and hospital gangrene, among other names.[2,3] However, the term necrotising fasciitis is now used in a generic sense to include all diffuse necrotising soft tissue infections except gas gangrene (clostridial myonecrosis).[4] Diffuse necrotising soft tissue infections include classic gas gangrene, Meleney's haemolytic streptococcal gangrene, necrotising fasciitis as described by Wilson, and the gram-negative synergistic necrotising cellulitis of Stone. Generally, one condition cannot be distinguished from another at the time of diagnosis. Today, the orofacial form of NF is called cancrum oris (noma),[5] and the perineal form is called Fournier's gangrene. Idiopathic scrotal gangrene, however, is different in aetiology, extent, and clinical presentation from Fournier's gangrene.[4]

NF poses a serious surgical challenge not only because of its rapid and progressive nature, but also because of its attending high morbidity and mortality.[6,7]

Demographics

There is a general paucity of literature, particularly in Africa, on the exact incidence of NF, although one hospital-based report suggests two to three children are seen in most major tertiary health institutions every year; that report, however, excluded cancrum oris and Fournier's gangrene.[8] There had been reports of cases in Europe and North America, especially during World War II, but more recent reports are from the developing countries of Africa, Asia, and South America.[6,8–11] There is no gender or age preference, but studies would suggest that the trunk and the head and neck are more frequently involved in children.[8,12]

Pathology

Aetiology

Although NF may start spontaneously in apparently normal children, it is most often associated with pathological conditions related to impaired host response leading to lowered immunity.[3–8,13] Some recognised predisposing factors include:

1. *Debilitating state*, such as anaemia and malnutrition, for which protein and vitamin B deficiencies appear predominant in importance. Other conditions, such as obesity (Figure 21.1), diabetes mellitus, and cancer, play greater roles in adults than children. In recent years, human immunodeficiency virus/ acquired immune deficiency syndrome (HIV/AIDS) is becoming increasingly significant.

2. *Trauma (or specific infection)*, such as needle pricks, skin abrasions, punctures, lacerations, or friction on cheek mucosa by an abnormally positioned tooth, could sometimes be trivial and go unnoticed. Occasionally, the trauma could be severe, such as those following road traffic accidents. NF can complicate such surgical procedures as colostomy (Figure 21.2), appendectomy, herniotomy,

Figure 21.1: NF involving the anterolateral trunk and thigh in a 14-year-old obese but otherwise previously normal girl (before and after the first debridement). Note the relatively unaffected abdominal wall muscles.

Figure 21.2: Necrotising fasciitis following colostomy.

Table 21.1: Clinical (pathophysiological) stages and features of NF.

Clinical stage	Pathology	Clinical features
I	Acute inflammation	Pain and tenderness in affected area Oedema and shininess (hyeraemia in light-skinned) of affected area Systemic features (fever, anaemia)
II	Progressive necrosis of skin and subcutaneous tissue	Discharge of infected fluid/pus (may be offensive) Necrosis and sloughing of affected area, resulting in tissue defects Systemic features may appear
III	Healing and tissue repair	Disappearance of acute inflammatory features Appearance of granulation tissue Gradual healing of affected area
IV	Maturation and contraction of scar	Contractures Disfigurement

Figure 21.3: Inflammatory phase of necrotising fasciitis.

laparotomy, or dental extraction; or it can follow infections such as chicken pox, gingivitis, boil, or perineal abscess.[9,13–15]

3. *General illness* could be in the form of malaria or measles, especially in developing countries.

Microbiology

Necrotising fasciitis could result from a variety of microorganisms, particularly bacteria and occasionally fungi. Initially thought to be caused mainly by non-group-A beta-haemolytic streptococci, there is now enough evidence that NF results mostly from synergy between gram-positive cocci (such as non-group-A beta-haemolytic streptococci and staphylococci) and gram-negative organisms such as *Bacteroides fragilis*, peptostreptococci, *Proteus* sp., *Pseudomonas* sp., or *Enterobacter* sp.[3,4,16,17] Much less common is a pure group-A streptococcal infection. Anaerobic bacteria may also be involved, although often not cultured. Vincent's organisms and bacteroides are commonly isolated in noma. Recently described are new varieties of NF caused by *Photobacterium damsela*;[18] halophilic marine vibrios, especially *Vibrio fulnificus*;[19,20] and phycomycoses, especially *Rhizopus arrhizus*[21] and *Cryptococcus neophormans*.[22] Approximately 70–80% of NF is polymicrobial.

Pathophysiology

Aerobic pathogens are usually the primary tissue invaders. They destroy tissues and create an anaerobic environment conducive for anaerobic or microaerophilic organisms, which are secondary invaders.[2,3,7,13] The primary pathogens produce exotoxins, such as streptolysin, streptodornase, streptokinase, and many other proteases and cholagenases, which result in extensive tissue destruction and necrosis. The infection is commonly polymicrobial and synergistic, and the resultant damage is usually more extensive than that attributable to any individual pathogen.[2,3] Most bacteria, especially facultative gram-negative rods such as *E. coli*, produce insoluble gases whenever subjected to anaerobic metabolism.[4] Because human tissue cannot survive in an anaerobic environment, gas associated with infection implies the presence of dead tissues.

Streptococcal NF associated with toxic shock syndrome (StrepTSS) has been on the increase in the past two decades and is observed in previously normal children. Caused by a highly invasive strain of group-A streptococcus, the pathogenesis is related to streptococcal pyrogenic exotoxins (SPE) produced by specific strains of *Streptococcus pyogenes*.[23]

Natural History (Clinical Stages)

The different pathophysiological stages observed (Table 21.1) include inflammation (stage I), necrosis (stage II), repair (stage III), and sequelae (stage IV).[2,3,7,13]

Inflammation (stage I)

The prominent feature of NF is the stage of acute inflammation and results from the effects of the exotoxins, which lead to the release of cytokines, with local and systemic effects.[4,23] The local features are mainly those of hyperaemia (or shiny skin), oedema (Figure 21.3) and pain. Systemic toxaemia commonly results in death if appropriate resuscitative measures are not put in place. The process can be arrested at this stage if appropriate antibiotics are given early.

Necrosis (stage II)

Tissue destruction results either from the direct effect of the enzymes or from vascular thrombosis involving the nutrient vessels serving the area. There is enough evidence to suggest that stages I and II may occur simultaneously in most cases.[2,3] In addition, tissue oedema that results from inflammation could increase the pressure within the tight fascial compartment, further reducing blood supply to the tissues in the area. This destruction is rapidly progressive and could occur within 3–5 days. Extensive subcutaneous/fascial necrosis may proceed with minimal skin involvement, giving rise to significant undermining. Although rare in NF, true muscle necrosis occurs in patients with StrepTSS.[23] This condition, known as gangrenous streptococcal myositis, is similar to clostridial myonecrosis (gas gangrene) but differs from it in the absence of gas in the tissues.[4]

Repair (stage III)

Healing takes place by rejection of the slough, appearance of healthy granulation tissue, and, subsequently, scar tissue formation.

Sequelae (stage IV)

Disfigurement, contractures and trismus may result from tissue loss and scar formation after months to years if no appropriate preventive measures are taken.

Complications

Common complications that may be encountered include:

1. compartment syndrome, leading to Volkmann's ischaemia, Volkmann's ischaemic contracture, or gangrene;

2. septic arthritis or osteomyelitis;

3. septicaemia and multiple organ failure syndrome;

4. herniation of intraabdominal organs;

5. joint stiffness; and

6. contractures and trismus.

Clinical Presentation

A high index of suspicion is required to ensure prompt recognition and early treatment of NF. In the past, a significant number of affected children died at home at the stage of inflammation as a result of toxaemia, before getting to the hospital. With the advent of antibiotics, a significant number of these children are now seen in hospitals (Figure 21.4). Most studies report a slight male preponderance, but any age group can be affected, including neonates and older children. In some studies, up to 40% of these children have malnutrition.[8,13]

The clinical presentation depends on the stage of NF at the time of presentation (see Table 21.1). The commonly encountered symptoms include pain, swelling, and fever. Although severe local pain that is out of proportion to the size and type of wound is a hallmark of NF in older children, this might be difficult to elucidate in neonates.

At the initial stages of cellulitis (inflammation), examination will reveal features of toxaemia, including elevated temperature (or hypothermia in neonates), oedema, hyperaemia, crepitus, tachycardia, and hypotension. Blebs and blisters may precede the appearance of dark skin patches (Figures 21.1, 21.4, and 21.5) that signify tissue necrosis, usually with severe undermining. Late presentation is common in Africa, and some patients are seen when the necrotic part of the skin, subcutaneous tissues, and fascia come out together as a complete cast from a limb (Figure 21.5). This exposes the underlying muscle(s), tendon(s), or teeth and oral cavity in the case of the cheek. Occasionally, some children are seen with structural deformities as a result of improper management of the earlier stages of the disease.

The clinical presentation of *Vibrio* NF is similar to classical NF and even more similar to streptococcal gangrene, which occurs in children with minor wounds exposed to seawater or sustained while cleaning seafood. In contrast, the clinical presentation of mycotic NF is insidious. On the other extreme are patients with StrepTSS, who present with rapid progression of the disease due to the high virulence of the offending organisms.[23]

Investigations

The diagnosis of NF is mainly clinical, but the following investigations are relevant.

Microbiologic Cultures

Any discharge or swab from the wound should be cultured (aerobic and anaerobic) to help in identifying the bacteria profile of the disease. Culture of tissue taken from the wound may provide a better yield, especially for anaerobes.

In patients with systemic features, blood culture should also be done.

Imaging

It is important to emphasize that imaging studies should be undertaken only in children in whom the diagnosis of NF is not clear cut, as they may delay surgical intervention and frequently provide conflicting information.[4]

Plain radiographs may show gas within the tissues at the initial stages of the disease, but they are rarely necessary.

Magnetic resonance imaging (MRI), where readily available, could assist in defining tissue planes and the presence of microabscesses.

Figure 21.4: Necrotising fasciitis of the cheek, before (top) and after (bottom) removal of necrotic soft tissues.

Figure 21.5: Late presentation of NF in a 9-year-old boy. Here, the necrotic skin, subcutaneous fat, and fascia came off like a full cast, exposing the underlying muscles, which are relatively uninvolved.

Complete Blood Count

A haemogram should be ascertained; white cell count may indicate leucocytosis.

Exclusion of Underlying Illness

Any underlying or predisposing illness should be excluded; often, this may involve HIV testing, blood film for malaria parasites, haemoglobin electrophoresis for sickle cell disease, and blood sugar to exclude diabetes mellitus. Doing any of these tests should be guided by clinical suspicion.

Treatment

Resuscitation

Correction of depletion

It is important to correct any existing physiological derangements, such as fluid and electrolyte imbalance. Blood transfusion may be necessary to correct anaemia.

Antibiotics and antimicrobials

The initial choice of parenteral antibiotics should take cognizance of the polymicrobial nature of the disease, previous knowledge of the microbiology of NF, and local sensitivity patterns.[24] This should be broad-based and must take control of gram-negative, gram-positive, aerobic, and anaerobic microorganisms. Combinations of penicillins, aminoglycosides, and metronidazole (or cephalosporins with metronidazole) have been found useful in most studies.[2–4,6–12] Some reports have found the use of quinolones equally effective in the treatment of NF;[25] others, however, have avoided it because of the potential effect on the growth plate of bones in young children, although this risk is now considered quite minimal.[8]

In severe cases with systemic toxaemia, as in StrepTSS, intravenous human immunoglobulin has been found useful in neutralising the exotoxin already present in the system. Intravenous amphotericin B may be administered if the presence of hyphae on gram stain or on histologic section suggests phycomycotic NF.[4]

Analgesia

In the early stage and when pain is a prominent symptom, appropriate analgesics should be given. This will facilitate wound care and also help in preventing later joint stiffness.

Tetanus prophylaxis

Tetanus immunisation (both active and passive) will be necessary in most African settings.

Nutritional support

Appropriate nutritional support should be provided, especially for those patients who are malnourished.

Surgical Intervention

Fasciotomy

Even in the absence of obvious tissue necrosis, fasciotomy in the form of single or multiple linear incision(s) over the affected area may be necessary to achieve adequate compartmental decompression. Thorough wound irrigation with antiseptics such as hydrogen peroxide or cetrimide and warm normal saline, then gentle packing with gauze in EUSOL (hypochlorite solution) or natural honey helps to control local infection and halts progression of the disease. At the time of fasciotomy, partial wound approximation could be effected without tension by using sutures, rubber bands, or special devices. About 5–7 days after fasciotomy, when oedema would have subsided and infection is reasonably controlled, skin closure could be achieved directly or by skin grafting.

Debridement

Prompt, adequate and sequential debridement of all necrotic tissues (see Figure 21.1) is of utmost importance in arresting progression of tissue necrosis in NF.[2–4,6–12] Adequate arrangements for possible blood transfusion should be made during such necrosectomies, as this exercise may be attended by blood loss that could be significant to the child, especially the neonate.

Debridement may be done by the bedside in very ill patients who are poor anaesthetic risks, especially neonates.

Wound resurfacing

Significant wound contraction could occur following adequate wound care, especially on the face, trunk, and perineum; the final mode of wound closure also depends on the initial size, however. Smaller wounds may contract adequately to heal by secondary intention or require direct suturing, whereas larger but granulating wounds will require skin grafting. In the event of three-dimensional tissue loss (such as check, lip, nose), or exposure of bare surfaces (tendon, bone, nerve, or blood vessels), local, regional, or distant flap reconstruction will be required.[6,8,12,26]

Rehabilitation

Rehabilitation efforts are directed at preserving the child's physical function and supporting the child emotionally through the use of activity. The pain of the local infection may cause the patient to voluntarily immobilise affected areas of the body, so both passive and active movements should be encouraged as soon as pain and other preconditions allow.

As the wounds heal, prevention of deformity by minimising the effects of joint stiffness or scar contracture should take priority. Accordingly, appropriate splint(s) should be applied when and where indicated. The goal is to attain a position that opposes the forces of contracture, provide safe joint alignment, and maintain tendon balance without causing stretch or pressure injuries to the peripheral nerves or skin.

Role of Hyperbaric Oxygen

As in clostridial myonecrosis (gas gangrene), the use of hyperbaric oxygen in NF is still controversial. Although experimental results in animals appear promising, its usefulness is less specific in NF than gas gangrene following clinical trials in humans.[4]

Treatment of Underlying Condition

Any identified underlying or predisposing condition should be treated appropriately. This treatment must be simultaneous with treatment of the NF to avoid relentless progression of the latter.

Prognosis and Outcome

Factors that may affect outcome and prognosis are the following:

- age (neonates fare poorly);
- overall general condition of the patient at presentation;
- pre- or co-morbid conditions;
- virulence of the offending organisms versus host immunity; and
- promptness/aggressiveness of resuscitative, surgical, and supportive forms of therapy.

Despite the aggressive use of antibiotics and surgical intervention, morbidity and mortality following NF remain very high.[2–4,6–12] Mortality rates range from 20% to 80%, but are frequently between 60% and 80%. Death results commonly from overwhelming infection and multiple organ failure. Those who survive are faced with a prolonged hospital stay and multiple surgical and reconstructive procedures, with their anaesthetic and socioeconomic implications.[26]

Prevention

Necrotising fasciitis is largely a preventable disease,[26,27] but prevention will involve a multidisciplinary commitment and action by individuals, health personnel, and policy makers. Preventive measures involve:

- good oral and general body hygiene;

- prevention and control of malnutrition;

- prevention of all childhood immunisable diseases, such as measles, through national mass immunisation programmes; and

- education on early recognition and treatment of NF.

Table 21.2: Evidence-based research.

Title	Necrotising fasciitis: experience with 32 children
Authors	Legbo JN, Shehu BB
Institution	Department of Surgery, Usmanu Danfodiyo University Teaching Hospital, Sokoto, Nigeria
Reference	Ann Trop Paediatr 2005; 25:183–189
Problem	Presentation and outcome of treatment of NF in children.
Intervention	Wound debridement, direct wound suturing, skin grafting, local flap reconstruction, antibiotics.
Comparison/ control (quality of evidence)	In the four-year period of this study, 32 of 56 patients (57.1%) treated with NF were children aged 6 days to 12 years (mean, 2 years). The common presenting features were pain (84.4%), fever (78.1%), irritability (40.6%), and tissue necrosis with undermining and surrounding cellulitis/oedema (100%). Three patients (9.4%) presented with moderate to severe jaundice, and 13 (40.6%) were malnourished according to clinical, anthropometric, and laboratory measures. Precipitating factors included pustules/boils in 12 (37.5%) patients, intravenous scalp cannulation in 3 (9.4%), trauma in 2 (6.3%), and colostomy in 1 (3.2%). In 14 patients (43.8%), no factors could be identified. Duration of symptoms ranged from 3 to 19 days (mean, 6.4 days). The involved body surface area ranged from 2% to 16% (mean, 5.9%). The trunk was the most frequently involved (50%), followed by the head/neck (28.1%), upper limbs (21.9%), lower limbs (6.3%), and perineum (6.3%). Bacteria identified by aerobic culture included Staphylococcus aureus in 23 (71.9%) patients, streptococci in 19 (59.4%), Escherichia coli in 15 (46.9%), Pseudomonas aeruginosa in 12 (37.5%), and Klebsiella pneumoniae in 8 (25%). In 21 (65.6%) patients, infection was polymicrobial, and in 3 (9.4%), no organism was cultured. Anaerobic and fungal cultures were not undertaken routinely. Routine HIV screening (enzyme-linked immunosorbent assay, or ELISA) of all patients was negative.
Outcome/ effect	Septicaemia was the commonest complication, occurring in 71.9%, and mortality was 9.4%. Hospital stay was long, at a mean of 27.6 days (range, 14–96 days).
Historical significance/ comments	This is one of the occasional reports of NF in children in Africa including a large number of patients. The exclusion of children with cancrum oris and Fournier's gangrene means that the number could have been even higher. The study has shown that although NF is thought to be rare in children, it is more common than expected in the sub-Saharan African setting and carries a high morbidity and mortality. This report provides a good insight into the clinical profile of this condition in the African setting.

Evidence-Based Research

Table 21.2 presents a study of treatment of necrotising fasciitis in children in Africa during a four-year period. Table 21.3 presents a study of the advantages of early recognition and prompt treatment of NF in children.

Table 21.3: Evidence-based research.

Title	Necrotising fasciitis in children: prompt recognition and aggressive therapy improve survival
Authors	Moss LR, Musemeche CA, Kosloske AM
Institution	University of New Mexico, School of Medicine, Albuquerque, New Mexico, USA; Ohio State University School of Medicine, Columbus, Ohio, USA
Reference	J Pediatr Surg 1996; 31:1142–1146
Problem	Recognition and treatment of NF in children.
Intervention	Surgical debridement, below-knee amputation, colostomy, primary wound closure, split skin grafting.
Result	A total of 20 children with NF were treated over a period of 18 years. The disease was observed in a wide variety of clinical settings covering the entire paediatric age range. Characteristics suggestive of diagnosis included marked tissue oedema, which was uniformly present, and almost all sites had a characteristic peau d'orange appearance. Bulla, petechiae, skin necrosis, and crepitus are strongly suggestive of NF, but these were present in only a few cases. Nineteen of the 20 patients were healthy before onset of the illness. White blood cell counts were not sensitive or specific in establishing diagnosis. Bacteriology was variable, as both aerobic and anaerobic bacteria were isolated. An average of 3.8 surgical debridements were required for each patient (range, 1–15). The surgical findings were typical. The subcutaneous tissue was grey and nonbleeding, with a watery discharge. The fascia ranged from viable to necrotic, depending on the severity of infection. The skin was viable early in the course of these cases. Skin necrosis was a late sign, Failure to gain local control of the infection before systemic organ failure from sepsis proved uniformly fatal. All patients who had positive blood cultures, renal failure, adult respiratory distress syndrome, or disseminated intravascular coagulation died.
Outcome/ effect	Mortality was 25%. The 15 survivors all underwent aggressive surgical debridement within 3 hours of admission, whereas the 5 who died all had inadequate initial management.
Historical significance/ comments	This report has shown that early recognition and prompt institution of treatment gives good survival in this rapidly progressive disease. It also emphasizes the differences between NF in children as compared to adults.

Key Summary Points

1. NF is generally not common but does appear more common in children in sub-Saharan Africa than previously thought.

2. NF is frequently polymicrobial.

3. Presentation varies widely from simple cellulitis to toxic shock.

4. Success in treatment depends on prompt resuscitation, adequate surgical debridement(s), and adequate supportive therapy.

5. NF is associated with high morbidity (complications, multiple surgeries, prolonged hospital stay) and high mortality.

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