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Early Predictors Related with Mortality in Suspected Patients of Necrotizing Fasciitis

Časné indikátory související s mortalitou u pacientů s podezřením na nekrotizující fasciitis

S.-M. CHOI, K.-B. LEE

Department of Orthopaedic Surgery, Chonbuk National University Medical School, Research Institute of Clinical Medicine of Chonbuk National University-Biomedical Research Institute of Chonbuk National University Hospital, Jeonju, South Korea

ABSTRACT

PURPOSE OF THE STUDY

There are little reports about criteria or predictors for evaluation of the severity of necrotizing fasciitis (NF) leading to death. The purpose of this study is to evaluate the risk factors to predict mortality through analysis of historical, clinical, laboratory and radiographic findings in the patients suspected NF in emergency room and assist surgeons in taking preventative measures or appropriate treatment to increase survival rates on the basis of the early predictor related mortality.

MATERIAL AND METHODS

67 consecutive patients who received a fasciotomy under the impression of NF in emergency room were divided into two groups on the basis of the result of treatment; Death (D) and survival (S) groups which were compared as follows: demographics, cause of death, number of surgical procedures, surgical period, intensive care unit period, hospital period, causes of NF, underlying disease, infected site, duration from symptom appearance to surgical day, vital sign (blood pressure, pulse and respiration rates, fever, peripheral O2 saturation), wound appearance, physical examination, laboratory study (vein and artery blood), radiologic findings and microorganism cultivation (blood and infected site culture) were evaluated for analysis.

RESULTS

The mortality rate was 21% (n = 14) and the survival rate was 79% (n = 53). Most common causes of death was septic shock (85%, n = 12). Mortality of patient with NF were increased with statistically significant difference when no open wound at involved site ($p = 0.05$), cold skin sensation compared to other site ($p = 0.04$), frank cutaneous gangrene with skin sloughing ($p = 0.009$), vascular insufficiency ($p = 0.04$) and motor dysfunction (motor grade < 3) ($p = 0.01$). Air formation along the fascial plane have statistically significantly difference ($p = 0.004$). Most involved sites in death group were proximal area such as hip and thigh (65%), in sequence knee (11%) and calf (24%). While distal portion of extremities such as calf (31%), ankle and foot (25%) or forearm (30%) and hand (54%) were more common in survival group. The ratio between single and multi-organisms in each group had no statistically significant difference: respectively 67% and 33% in survival and 58% and 42% in death group.

CONCLUSIONS

Recognition of several risk factors (cold skin sensation, gangrene, vascular insufficiency, motor dysfunction, air formation, and proximal involvement) associated with toxicity and mortality could help surgeon to determine the necessity of further evaluation, proper selection of drug and operative timing, and those could improve the referral service in suspected cases of necrotizing fasciitis and avoid unnecessary delays in treatment

Level of evidence: IV, retrospective cohort study.

Key words: necrotizing fascitis; emergency room; survival, predictors.

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INTRODUCTION

Necrotizing fasciitis (NF) is any necrotizing soft tissue infection spreading along fascial planes with or without overlying cellulitis (1). The clinical features of NF include a rapidly progressing necrotizing process, beginning in the superficial fascial planes and progresses into the deep fascial layers causing necrosis by microvascular occlusion, accompanied by severe systemic toxicity (17). Causative infectious agents tend to be either a single organism or more frequently by a variety of microbes, both aerobic and anaerobic (6). The reported mortality rates ranged from 5.9% to 36% with common causes of death including sepsis or respiratory, renal, or multisystem organ failure (28). Early diagnosis of NF and treatment is the most important factors associated with mortality of NF; however, necrotizing fasciitis is often indistinguishable from cellulitis due to the nonspecific symptoms and signs, laboratory and radiologic findings on initial presentation in the emergency room. Delayed recognition and treatment can cause the disease to progress and increases the risk of poor outcomes, so it is crucial to diagnose the disease at an early stage and treat rapidly. But, there are little reports about criteria or predictors for evaluation of the severity of NF leading to death. The purpose of this study is to evaluate the risk factors to predict mortality through analysis of historical, clinical, laboratory and radiographic findings in the patients suspected NF in emergency room and assist surgeons in taking preventative measures or appropriate treatment to increase survival rates on the basis of the early predictor related mortality.

MATERIAL AND METHODS

We retrospectively reviewed the medical records of 67 consecutive patients who received a fasciotomy under the impression of NF in emergency room between 2003 and 2014. All the patients were finally confirmed to NF on the basis of in intraoperative and histopathologic findings. All patients were promptly treated with broad-spectrum antibiotics in emergency room and had a surgical treatment including incision, debridement of necrotic soft tissue and/or amputation as early as possible if the patients' condition were permitted. Tissue cultures by some of dissected fascia in all case were performed. Patients were divided into two groups on the basis of the result of treatment; death (D) and survival (S) groups which were compared as follows: the demographics, cause of death, number of surgical procedures, surgical period, intensive unit care period, hospital period, causes of NF, underlying disease, infected site, duration from symptom appearance to surgical day, vital sign (blood pressure, pulse and respiration rates, fever, peripheral O_2 saturation), wound appearance, physical examination, laboratory study (vein and artery blood), radiologic findings and microorganism cultivation(blood and infected site culture) were evaluated for analysis. All data were collected from medical results conducted within 24 hours from visiting to the emergency room. But data on the causal microorganisms were determined by reviewing the microbiological reports of wound and/or blood culture samples that were taken before or at the time of operation. Aerobic and anaerobic cultures and gram stained smears were made immediately of the fluid aspirated and the tissue debrided from the center of the lesion.

Statistical analyses were performed using Microsoft-Excel and Sigma Plot Version 11.1 (System Software Inc. San Jose , CA) for Windows. Categorical variables were compared using the Chi-square statistic and continuous variables using Student's t test (when normally distributed) or Mann-Whitney U test. Results are presented as means ± standard deviation (SD) or medians with range. A two-tailed p value < 0.05 was considered to be statistically significant.

RESULTS

3.1. Demographic data between survival and death groups

Total 67 patients diagnosed with NF had undergone emergent fasciotomy and/or amputation. The mortality rate was 21% (n = 14) and the survival rate was 79% (n = 53). Most common causes of Death was septic shock (85%, n = 12) and the following was cardiac arrest (15%, n = 2). Death group have preponderance in Female, while survival group is a distinct male preponderance.(p = 0.05), but age has no significant difference between two groups. Surgical period (S: 27.6 ± 1.54, D: 7.4 ± 4.06, day, p = 0.03), the mean duration for Intensive care unit (S: 1.69 ± 0.49 D: 8.26 ± 2.2, day, p = 0.01), and the mean duration of hospitalization (S: 59.67 ± 4.6, D: 24.14 ± 7.7, day, p = 0.001) between two groups were statically significant difference. (Table 1).

3.2. Comparison between survival and death groups on causes, comorbidities and vital signs of NF

Causes of NF in survival group were more various such as spontaneous occurrence (54%, n = 29), eating raw foods (5% n = 3), trauma (39%, n = 20) and athlete's foot (2% n = 1). But, spontaneous occurrence in death group was most common (85%, n = 12) and second was to eat raw foods (15%, n = 2) (Table2). The

Table 1. Demographic analysis

	Survival	Death	p value
Total Number(N)	53 (79%)	14 (21%)	
Sex = F: M	1 : 1.8	1.8 : 1	0.05
Age (year)	57	57	
Infected site			
lower : upper extremity	9 : 1	9 : 1	
Causes of death			
septic shock		12 (85%)	
cardiac arrest		2 (15%)	
Number of surgical procedures	4.1 ± 0.6	2.2 ± 0.9	0.152
Surgical period	27.6 ± 1.54	7.4 ± 4.06	0.031
Intensive Care Unit periods	1.69 ± 0.49	8.26 ± 2.2	0.011
Hospital periods	59.67 ± 4.6	24.14 ± 7.7	0.001

Table 2. Causes of necrotizing fasciitis between two groups

	Survival	Death
Spontaneously	29 (54%)	12 (85%)
Eating raw foods	3 (5%)	2 (15%)
Trauma	20 (39%)	–
Athlete's foot	1 (2%)	–

Table 3. Co-existing disease of the patients with necrotizing fasciitis within 24 hours from visiting to the emergency room between two groups

	Survival	Death	p value
Chronic renal failure	4	6	0.004
Hepatic disease	7	9	0.01
Taking immunosuppressive agent	7	5	0.03
Hypertension	21	3	0.34
Diabetes	23	8	0.35
Cardiovascular disease	7	3	0.45
Pulmonary disease	4	2	0.45
Cerebrovascular disease	6	1	1.00
Hematologic disease	2	0	1.00
Osteomyelitis	2	0	1.00

Table 4. Vital sign of patients with necrotizing fasciitis within 24 hours from visiting to the emergency room

	Survival	Death	p value
Systolic Blood Pressure (SBP) mm Hg	117.4 ± 3.8	102.8 ± 7.9	0.09
Diastolic blood pressure (DBP) mm Hg	70.1 ± 2.3	62.5 ± 5.4	0.16
Pulse rates (PR)	84.2 ± 1.8	104.7 ± 9.8	0.046
Respiration rates (RR)	17.0 ± 0.1	20.7 ± 0.5	0.007
Fever	36.8 ± 0.1	36.9 ± 0.2	0.862
Peripheral O2 saturation (%)	97.9 ± 0.0	95.4 ± 2.8	0.402

Table 5. Wound appearance and physical examination with necrotizing fasciitis within 24 hours from visiting to the emergency room

	Survival	Death	p value
Direct tenderness	28	7	0.753
Swelling	55	17	1.000
Open wound	10	0	0.05
Pus-discharge	8	0	0.189
Redness	23	4	0.242
Heatness	20	3	0.222
Coolness	2	2	0.04
Gangrene	10	7	0.009
Motor function	3	3	0.01
Sensory function	6	2	0.669
Circulation	7	5	0.03

Table 6. Laboratory data of patients with necrotizing fasciitis within 24 hours from visiting to the emergency room

	Survival	Death	p value
WBC	14.56 ± 0.96	15.05 ± 3.02	0.840
Segment neutrophil	82.06 ± 1.54	84.71 ± 4.06	0.470
ESR	73.94 ± 5.2	47.64 ± 9.4	0.052
CRP	178.3 ± 13.9	170.3 ± 27.5	0.079
SaO2 (ABGA)	95.1 ± 1.1	95.0 ± 2.0	0.975
CO2 (ABGA)	30.1 ± 0.8	26.4 ± 2.3	0.045
Ph (ABGA)	7.44 ± 0.0	7.37 ± 0.0	0.027
Lactate (ABGA)	1.96 ± 0.2	4.10 ± 1.4	0.02
HbA1c	7.72 ± 0.42	6.65 ± 0.69	0.226

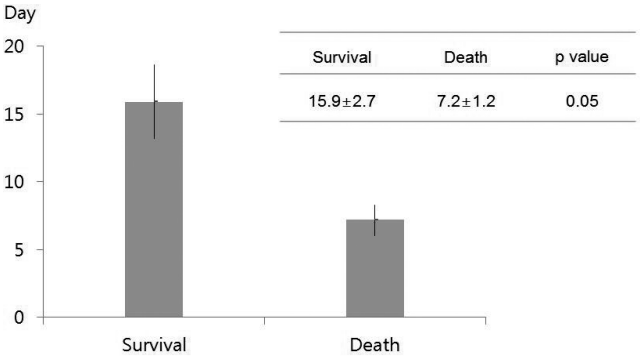

Fig. 1. The time interval between onset of illness (symptom appearance) and surgical day were longer in survival group than death group with statistically significant difference.

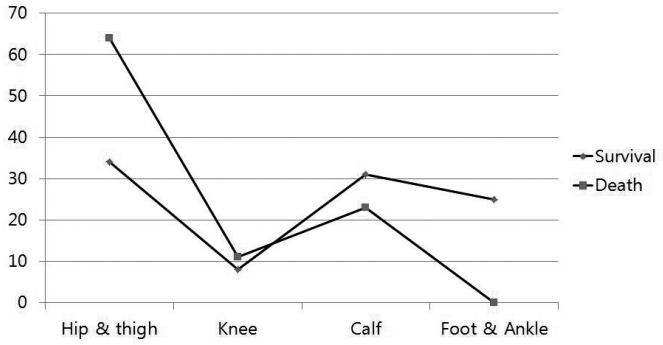

Fig. 2. Involved site of patients with necrotizing fasciitis had influence on the prognosis. Central portion of body was higher rate of death than peripheral portion.

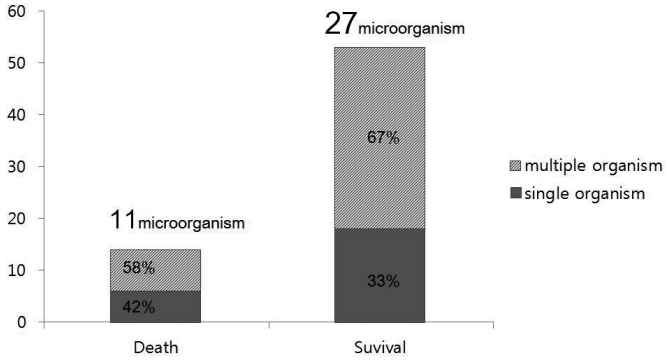

Fig. 3. There was no statistically significant difference in the incidence of mono- or multi-microorganisms between two groups.

time interval between onset of illness (symptom appearance) and surgical day were more longer in survival group (15.9 ± 2.7 days) than death group (7.2 ± 1.2 days) with statistically significant difference (p = 0.05). (Fig. 1). we evaluated co-existing disease of the patients between two groups; Renal disease, hepatic disease, taking immunosuppressive agent, hypertension, diabetes, cardiovascular disease, pulmonary disease, cerebrovascular disease, hematologic disease and osteomyelitis. Of these underlying disease, chronic renal failure (CRF) (p = 0.004),

hepatic disease (p = 0.01) and taking immunosuppressive agent (p = 0.03) have been identified as pre-disposing factors of mortality in patients with NF (Table 3). Vital sign within 24hours in emergency showed that both systolic and diastolic blood pressure were lower in death group than survival group but no statistically significant difference.(p = 0.09 and p = 0.16) But, pulse rate and respiration rates were higher in death group than survival group with statistically significant difference (p = 0.046 and p = 0.007). The mean temperature were normal in both group, peripheral O_2 saturation using pulse oximeter was slightly lower in death group, as shown in (Table 4).

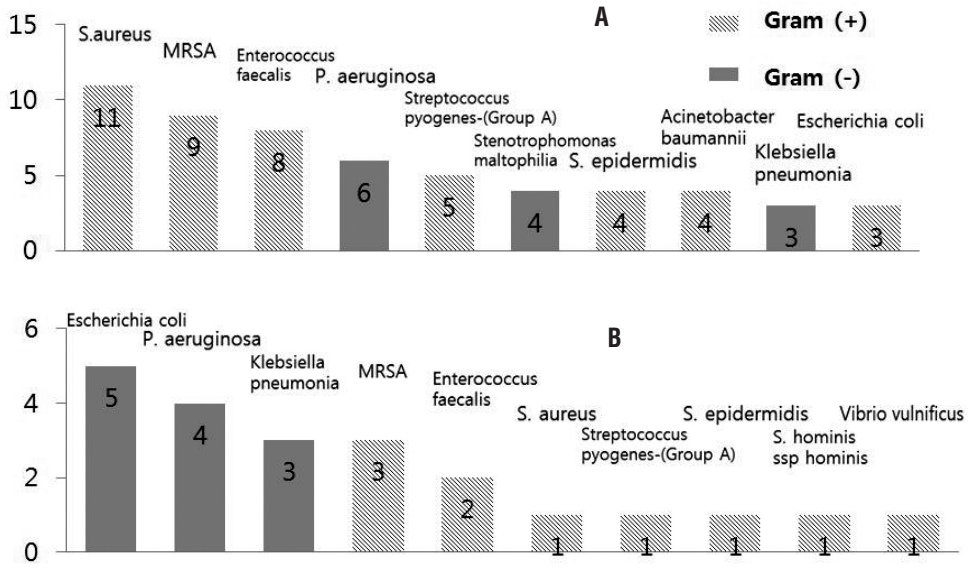

Fig. 4. The incidence of cultured microorganisms of the patients with necrotizing fasciitis gram stain between two groups (A: survival group, B: death group) show that gram-negative bacterium in necrotizing fasciitis progress more severe course resulting in death.

3.3. Comparison between survival and death groups on wound appearance, physical examination and laboratory data

Wound appearance such as swelling, open wound existence, pus-discharge, redness, hotness, coolness, gangrene and physical examination including direct tenderness, circulation, motor and sensory dysfunction were evaluated. Especially, mortality of patient with NF were increased with statistically meaningful difference when no open wound at involved site (p = 0.05), cold skin sensation compared to other site (p = 0.04), frank cutaneous gangrene with skin sloughing (p = 0.009), vascular insufficiency (p = 0.04) and motor dysfunction (motor grade < 3) (p = 0.01) (Table 5).

Laboratory data including WBC, segmental neutrophil, ESR, CRP and HbA1c from venous blood showed no difference between two group, but, CO_2 (p = 0.045), Ph (p = 0.02) and lactate (p = 0.02) except SaO_2 (p = 0.97) from arterial blood gas analysis have statically significant difference (Table 6).

Table 7. Radiologic findings using magnetic resonance imaging and computed tomography

	Survival	Death	P value
Osteomyelitis	6	0	0.33
Muscle involvement	18	5	0.902
Deep fascia involvement	15	4	1.000
Air along the fascial plane	4	6	0.004
Abscess	15	4	1.000
Necrosis	9	2	1.000
Compartment syndrome	1	1	0.377
Joint	4	1	1.000

Table 8. Involved site of patients with NF

	Survival	Death
Hip	6	3
Thigh	17	8
Knee	6	2
Calf	21	4
Ankle	4	–
Foot	13	–
Shoulder	1	1
Upper arm	-	1
Elbow	1	–
Forearm	4	–
Hand	3	–

3.4. Radiologic findings using magnetic resonance imaging and computed tomography between survival and death groups

We compared radiological finding from plain radiograph, computed tomography (CT) and magnetic resonance imaging (MRI) between two groups; involved soft tissue layer (skin, subcutaneous, fascia, muscle) osteomyelitis, joint infection, air and fluid collection, abscess, necrosis, compartment syndrome. Only air along the fascial plane have statistically significantly difference (p = 0.004) (Table 7).

3.5. Involved site of patients with NF

NF mainly occurred at lower limb in both groups, but significant difference existed between the two groups with respect to proximity of affected sites. Most Involved sites in death group were proximal area such as hip and thigh (65%), in sequence knee (11%) and calf (24%) without distal portion including foot and ankle in lower extremity. All 2 case of upper extremity in death group were also proximal portion including shoulder (50%) and upper arm (50%). While distal portion of extremities such as calf (31%), ankle and foot (25%) or forearm (30%) and hand (54%) were more common in survival group (Table 8, Fig. 2).

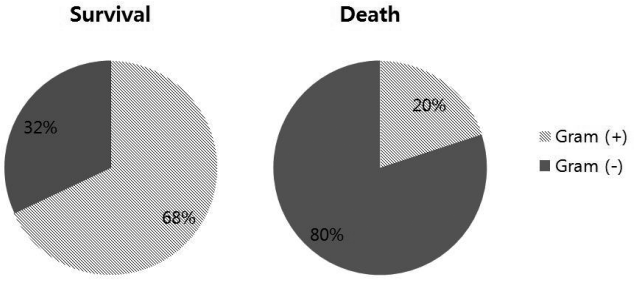

Fig. 5. The incidence of cultured microorganisms of the patients with necrotizing fasciitis gram stain between two groups show that gram-negative bacterium in necrotizing fasciitis progress more severe course resulting in death.

3.6. The incidence of cultured micro-organisms of the patients with necrotizing fasciitis gram stain between two groups

Total 27 types of microorganisms including aerobe and anaerobe were cultured in death group compared to 11 types in survival group. The ratio between single and multi-organisms in each group had no statistically significant difference: respectively 67% and 33% in survival and 58% and 42% in death group. Of pathogens which were identified in single and polymicrobial infections in survival group, *Staphylococcus aureus* (11) was the most common, in sequence, Methicillin-resistant *Staphylococcus aureus* (9), *Enterococcus faecalis* (8), *Pseudomonas aeruginosa* (6), *Streptococcus pyogenes* (Group A) (5) followed. In death group, *Escherichia coli* (5) was cultured most commonly and *Pseudomonas aeruginosa* (4), Methicillin-resistant *Staphylococcus aureus* (3), *Klebsiella pneumonia* (3) followed. Gram-negative bacterium was 80% in death group, in contrast, gram-positive bacterium was 68% in survival group, which have statistically significant difference ($p = 0.007$) (Figs. 3, 4, 5).

DISCUSSION

In this study, sex had influence on the outcome of treatment and could predict mortality. Females were at greater risk for mortality. Elliott et al. (10) reviewed 198 patients between March 1985 and June 1993, and also found that being female was an independent predictor of death. Khamnuan et al. report that females have a greater amount of subcutaneous fat (BMI > 30) than men and are more easily prone to infection. However, some authors have reports that sex has no correlation with the mortality of NF (7, 8, 15, 19). In previous several studies, advanced age was associated with an increased risk of mortality (2, 3, 8, 11, 12, 16, 18) but in our series, age had no effect on mortality.

The most important consideration to predict the possibility of mortality in the patients suspected NF is to assess what stage the patient were in progression of NF. Thus, surgeon should understand the characteristics of NF and evaluate the severity of NF on the authority of clinical, radiological, laboratory clues correlated to the characteristics. Generally, progression of disease is known to be rapid with skin changing from red and purple to pathognomic blue-grey ill-defined patches as early as 36 hours after onset, but occasionally after third to fifth days (17). By fourth or fifth day, frank cutaneous gangrene develops in patients with skin sloughing caused by thrombosis of nutrient vessels. Bullae filled with clear, thick, pink, and deep purple fluid may develop, often showing the appearance of a partial or full thickness burn (1, 16). Although at first extremely painful, involved areas become insensible secondary to cutaneous nerve destruction (13, 14). This may occur before the onset of gangrene, providing a clue that the process is indeed necrotizing fasciitis (16). Subcutaneous fat and fascia become edematous, dull gray and necrotic with serosanguinous exudations and extensive underming of skin (18). Skin death is subsequent to subcutaneous necrosis. Far advanced instances reveal muscles and tendons "standing out almost as an anatomic dissection" (17). Pink, viable muscle can be seen beneath grossly gangrenous fascia, fat and necrotic skin (6). Several physical examinations having statistically meaning in this study, such as coolness, gangrene, vascular dysfunction and motor deficits in mortality group were late signs in the progression of patients with NF (Table 5). Thus, we can postulate that the patients with these symptoms are not only high risk of mortality but also imply to being the advanced stage of NF.

The degree of rapid progression through the duration from onset of illness to surgery also reflect the severity of NF as a risk factor presenting that early recognition and prompt aggressive debridement of all necrotic tissue is critical for survival. Wong et al. have reported that a delay from admission to operation of more than twenty-four hours influence survival for patients with NF (4) (Fig. 1). Another risk factor to develop advanced NF is the proximity of affected area in both lower and upper extremity. There are more likely to deteriorate with rapid progression when infected sites are close to central portion with more soft tissue and larger vessel (Fig. 2). The following two cases with each different involved site of NF shows different prognosis resulting that the patinets with NF at central area of body like hip and pelvis was expired, while one with peripheral area like calf was survived (Figs. 6, 7).

The most common cause of death by NF was a septic shock. That is, assessment of what condition the patients with NF were in a series of process from systemic inflammatory response syndrome(SIRS) to septic shock help to predict the possibility of mortality. In 1992, the American College of Chest Physicians (ACCP) and the Society of Critical Care Medicine (SCCM) jointly published the consensus definitions of sepsis (Table 9). There are many different ways to predict the risk of dying for patients with sepsis. The most facile approach may be to accurately classify the patient according to their stage of sepsis. Applying the consensus conference definition, rough estimates of fatality rates (the percentage of patients who die) are as follows: (22)

• Sepsis: 10–20%

• Severe sepsis: 20–50%
• Septic shock: 40–80%.

In our study, there are several statistical meaningful factors of high mortality, associated with the criteria of septic condition. Vital sign including heart rate(HR) and respiratory rate(RR), Ph, PCO_2 and lactate on arterial blood gas analysis, tissue hypoxic state presented discoloration or blanching of soft tissue on physical examination and organic failure related circulatory dysfunction such as liver and kidney are one of the septic criteria respectively. These factors are important clues to predict high mortality by rapid assessment in emergency room (Tables 4, 5).

This study showed that there was no significant difference in conjunction with mono- or polymicrobal organism infection between two groups, but mortality was higher in NF with gram negative organism than gram positive infection. Lee et al. reported that Patients with gram-negative monobacterial necrotizing fasciitis present with more fulminant sepsis. Identification of gram-negative organism like *Escherichia coli Pseudomonas aeruginosa*, and *Klebsiella pneumoniae* from blood or tissue culture help surgeon to predict the severe forward progression and decide appropriate treatment (Figs. 4, 5). Thus, intravenous antibiotics should be initiated immediately after having established the diagnosis and be changed according to sensitivities. Appropriate selection of antibiotics is crucial for in ameliorating systemic sepsis and bacterial spread in company with surgical procedures. Historically, an empiric regimen using high-dose penicillin and clindamycin was recommended to cover gram-positive and aerobic organisms. This particular combination was also shown to be synergistic against clostridia species. A third agent was used for additional empiric coverage of gram-negative organisms. Today, the recommended initial antibiotics regimen has changed because of the emergence of resistant microbes and relative decrease in the incidence of clostridial infection. Vancomycin, linezolid, daptomycin, or quinurpristin/ dalfopristin are recommended for empiric coverage of gram-positive organisms because of

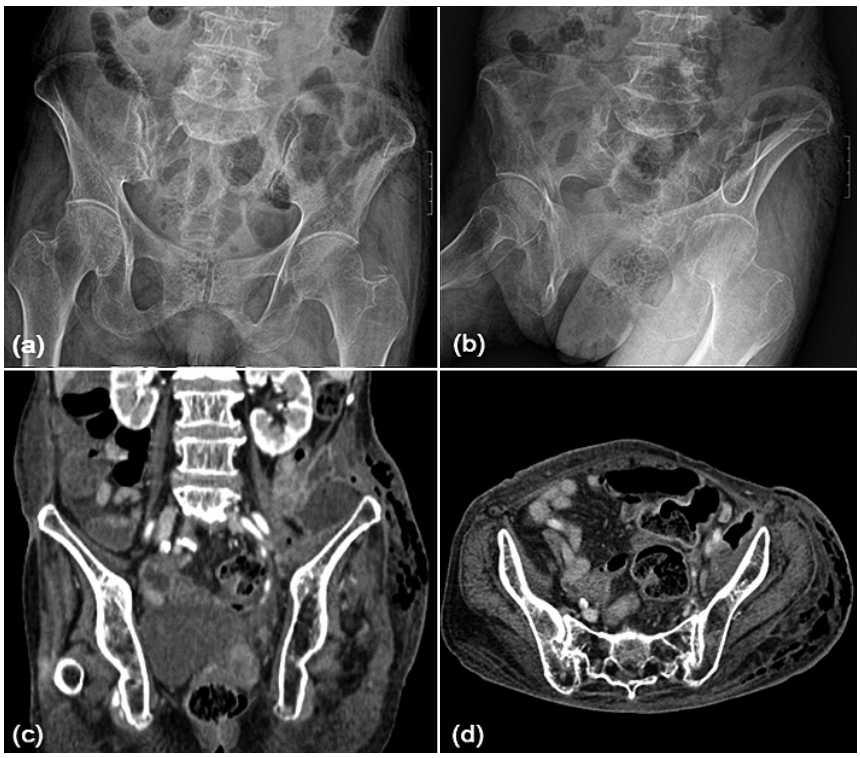

Fig. 6. Expired 68-year-old woman with necrotizing fasciitis and history of remote chemo-therapy with surgery due to sigmoid cancer. The time from onset of illness to surgery was 3 days. AP (a), internal oblique (b) radiograph and coronal (c) and axial (d) CT images of hip and pelvis show dermal thickening, fascial edema and gas tracking along superficial and deep fascial planes, consistent with necrotizing fasciitis.

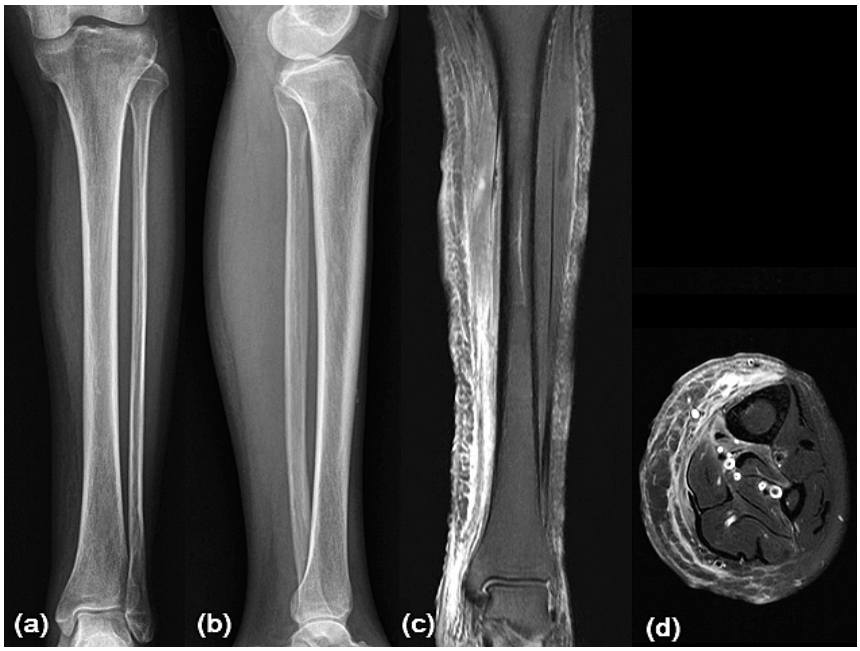

Fig. 7. Survived 53-year-old woman with early necrotizing fasciitis. The time from onset of illness to surgery was 8 days. AP (a) and lateral (b) radiograph of lower leg show dermal thickening, fascial edema without gas formation. Coronal (a) and axial (b) T2-weighted fat suppressed images show diffuse marked edema (increased T2 signal intensity) of soft tissues and superficial fascia of lower leg. No definitive muscle edema or enhancement is yet appreciated.

Table 9. Defining criteria of ACCP/SCCM named conditions.

ACCP/SCCM named condition	Defining criteria
SIRS	Core body temperature > 38 °C or < 36 °C HR ≥ 90 bpm
	Respiration 20/min (or PaCO2 < 32 mm Hg) WBC ≥ 12,000/l or ≤ 4,000/l or >10% immature forms
Sepsis	At least two SIRS criteria caused by known or suspected infections
Severe sepsis	Sepsis with acute organ dysfunction (including hypoperfusion and hypotension) caused by sepsis
Septic shock	Sepsis with persistent or refractory hypotension or tissue hypoperfusion despite adequate fluid resuscitation
MODS	The presence of organ dysfunction in an acutely ill patient such that homeostasis cannot be maintained without intervention

ACCP: American College of Chest Physicians; HR: heart rate; MODS: multiple organ dysfunction syndrome; Pa_{CO2}: Partial pressure of carbon dioxide in the blood; SCCM: Society of Critical Care Medicine; SIRS: systemic inflammatory response syndrome; WBC: white blood cell.

concern for MRSA infection. Especially, in IV drug users (20, 21, 23). The incidence of clindamycin-resistant MRSA prohibits use of this drug alone for coverage of gram-positive organisms in severe infections. Clindamycin remains a useful agent because it covers anaerobic organisms well and inhibits M protein and exotoxin synthesis by group A *Streptococcus.* Quinolones offer excellent soft-tissue penetration and can be used to cover gram-negative organisms. Thus, initial antibiotics should have effective for both aerobic and anaerobic microbes and especially, deliberate selection of IV antibiotics for gram-negative organisms are necessary for initial treatment to increase mortality (24).

NF remains a clinical diagnosis, and although it can be useful to grasp disease extent to plan the surgical approach and margins, the utility of imaging is limited. Radiographic findings in the early stage of NF are similar to those of cellulitis including increased soft-tissue opacity and thickness. Radiographs can also be normal until the infection and necrosis are advanced and manifest as soft-tissue emphysema tracking along fascial planes (4, 26). CT characteristics usually show pathologic findings of soft-tissue inflammation or liquefactive necrosis and thus may feature dermal thickening, increased soft-tissue attenuation, inflammatory fat stranding, and possible superficial or deep crescentic fluid or air in the subfascial planes (5, 11, 26, 27, 29, 30). But, soft-tissue air with deep fascial fluid collections is not always seen, and its absence does not mean prompt exclusion of NF from the differential diagnosis because the patient may have early disease in which gas has not yet formed or reached detectable levels (27). MRI of necrotizing fasciitis shows circumferential dermal and soft-tissue thickening that have variable signal intensity on T1-weighted sequences and increased signal intensity on fluid-sensitive sequences (9, 25, 27). However subcutaneous edema being typically a less-prominent feature than in patients with cellulitis and fascial thickening being hyperintense on fluid-sensitive sequences are nonspecific and difficult to distinguish from nonnecrotizing fasciitis, eventually, clinical correlation is crucial. Patients with negative or nonspecific imaging findings and a high clinical suspicion of necrotizing fasciitis should be promptly treated. Late-stage gas collections dissecting superficial or deep fascia are seen as punctate or curvilinear T1- and T2-hypointense foci. In our study, of these radiographic finding in CT and MRI, only the air collection in the subfascial planes have had a statistical significance between two groups (Table 7). That is, surgeon often cannot only get a lot of information for the diagnosis of NF, but also is difficult to grasp the severity of patients through radiologic evaluation except the finding of gas collection. Importantly, in patients whose cases are severely toxic, treatment should not be delayed for the performance of imaging. Especially, MRI is the modality of choice for detailed evaluation of soft-tissue infection but is often not performed for necrotizing fasciitis evaluation because its acquisition is time consuming and will delay treatment (9, 27). Thus, further detailed evaluation using radiologic mortality can be performed in relatively stable patients who have changing clinical status to assess for possible progression to necrosis. CT is the most sensitive modality for soft-tissue gas detection, and compared with radiography, CT is superior to evaluate the extent of tissue or osseous involvement, show an underlying (and potentially more remote) infectious source, and reveal serious complications such as vascular rupture complicating tissue necrosis (4,5,11,22,26,29,30). Therefore, the rapidity of CT compared with MRI would rather be advantageous to predict the mortality of NF for an emergent necrotizing fasciitis evaluation.

CONCLUSIONS

Prompt diagnosis of NF is crucial to a favorable outcome because of its potential fatal course. Although laboratory and radiologic diagnostic tests may be useful adjuncts, the diagnosis is still primarily a clinical one. Thus suspicion alone could be justified to early surgical referral. When a patient visiting to emergency room is suspected to NF, even though it is difficult to confirm diagnosis, assessing what the stage of NF is into objective standard affect to decide the direction of management. Recognition of several risk factors (cold skin sensation, gangrene, vascular insufficiency, motor dysfunction, air formation, and proximal involvement) associated with toxicity and mortality could help surgeon to determine the necessity of further evaluation, proper selection of medical drug and operative timing and those could improve the referral service in suspected cases of necrotizing fasciitis and avoid unnecessary delays in treatment.

Disclosure of interest

The authors declare that they have no competing interest.

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Corresponding author:
Kwang-Bok Lee MD, PhD
Department of Orthopaedic Surgery,
Chonbuk National University Medical School
Chonbuk National University Hospital
634-18, Keumam-dong, Jeonju-shi
Chonbuk, South Korea
E-mail: osdr2815@naver.com