

Unusual cases of necrotizing fasciitis: a clinical experience from Turkey

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Abstract

Background Necrotizing fasciitis is a rare, destructive soft tissue infection which starts on the skin and subcutaneous tissue, and spreads quickly towards the deeper tissues. Its etiology includes trauma, surgical intervention, perineal abscess, soft tissue infection, minor invasive procedures, abrasion, contusion, burn, laceration, bite, and penetrating injuries. The mortality of the disease can increase in the presence of predisposing factors such as diabetes, hypertension, immunodeficiency, self-care insufficiency, alcoholism, and advanced age. The clinical presentation of necrotizing fasciitis may vary. It is often observed in the abdominal region, the lower extremity, the perineal, perianal, scrotal and genital regions.

Methods Between December 2011 and September 2016, a retrospective study of all patients admitted due to necrotic wounds and/or tissue defects was undertaken. Their clinical records were reviewed with respect to age, sex, associated morbidities, defect localization, treatment, and outcomes.

Results Thirteen cases were admitted to the emergency department. There were 10 female and 3 male patients. The defects were located in the gluteal (one), trochanteric (one), thoracic (two), upper extremity (three), lower extremity (two) and perineal region (four). Pressure sores, insect bites, trauma, diabetes mellitus and perineal infections were detected in the etiology of the cases. As observed in our study, NF can present with very different etiological, demographical and clinical findings.

Conclusions The cases presented some rarely observed characteristics in terms of age, sex, etiology, and infection localization. Therefore, it should be kept in mind that necrotizing fasciitis can exhibit extraordinary characteristics causing confusion with other soft tissue infections, and a detailed and meticulous evaluation must be performed for diagnosis.

Level of Evidence: Level IV, therapeutic study.

Keywords Fournier's gangrene · Necrotizing fasciitis · Unusual cases · Review

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Introduction

Necrotizing fasciitis (NF) is a rare, progressive, severely necrotizing soft tissue infection that effects the skin, subcutaneous tissues, superficial and deep fasciae, and even the muscles [1–11]. The disease often affects individuals of middle and advanced age (particularly over 50 years of age) [6]. It is very rare in children³. Male to female ratio is 10/1 [6, 12, 13]. NF generally involves a triggering event such as a trauma, surgery or soft tissue infection [7–9]. The infection can become quite dramatic in the presence of a predisposing factor [7]. These factors include some co-morbid conditions such as immune system insufficiency, malnutrition, smoking, diabetes, obesity, peripheral vascular disease, chronic alcoholism, liver and renal failure, advanced age, and debility [1–5, 8–12, 14–18]. The disease

Table 1 Demographic features of the patients and the anatomical localizations of the disease

Case number	Gender	Age (year)	Aetiology	Predisposing factor	Anatomic localization
1	F	66	Pressure sore	Malnutrition, debility (related to paraplegia)	Gluteal
2	F	70	Pressure sore	Malnutrition, debility (related to paraplegia)	Trochanteric
3	M	59	Insect bite	Smoking, alcohol consumption	Thoracic
4	M	12	Insect bite	None	Lower extremity
5	F	52	Insect bite	Smoking, NSAID	Lower extremity
6	F	22	Bartholin abscess	Hygiene insufficiency, NSAID	Vulva, perineum
7	F	60	Perineal abscess	DM	Perineum
8	F	41	Vulvar infection	Malnutrition, debility (sequelae of measles), immune deficiency	Perineum
9	F	48	Vulvar infection	DM, renal failure, immune deficiency	Perineum
10	F	53	Trauma	None	Upper extremity
11	M	55	Trauma	None	Upper extremity
12	F	56	Soft tissue infection, sepsis	Autoimmune hepatitis	Upper extremity
13	F	60	Postsurgical wound infection	DM	Thoracic

M male, *F* female, *NSAID* non-steroidal antiinflammatory drug, *DM* diabetes mellitus

does not have specific clinical features and the aetiology, clinical manifestation, and anatomic location may vary widely [4].

NF often affects the lower abdominal region, the genital area, the perineal area (known as fournier gangrene), and the lower extremities [1–3, 6, 9, 12, 19]. Less often, the retroperitoneal area, the anterior chest wall, the upper extremity, the neck, and the scalp can be involved [1, 9, 12]. Surgeons can come across some rarer presentations of NF. This study evaluates unusual clinical presentations in an attempt to lower suspicion threshold for necrotizing fasciitis and encourage rapid intervention.

Patients and methods

Thirteen patients admitted to the Departments of Plastic, Reconstructive and Aesthetic Surgery at Adana State Hospital

and Adana Numune Research and Training Hospital due to necrotic wounds and/or tissue defects during the period from December 2011 to September 2016 were included in the study (Table 1). There were ten females and three male patients. Patients were aged between 12 and 70 years (average 50.3 years). Regarding aetiology, two patients had pressure sores, three patients had history of insect bites, four patients had perineal infections, two patients had trauma, one patient had sepsis, and one patient had postsurgical wound infection. Pressure sore cases had stage-III defects with discharge, with cavitary tissue defects extending over to the fascia, the muscular, and deep tissue layers (Fig. 1). An analysis of their medical records revealed that they had both undergone spinal surgery resulting in paraplegia and had been malnourished for a long time. Patient had suffered from

Fig. 1 View of the NF case with trochanteric pressure sore (case 2)

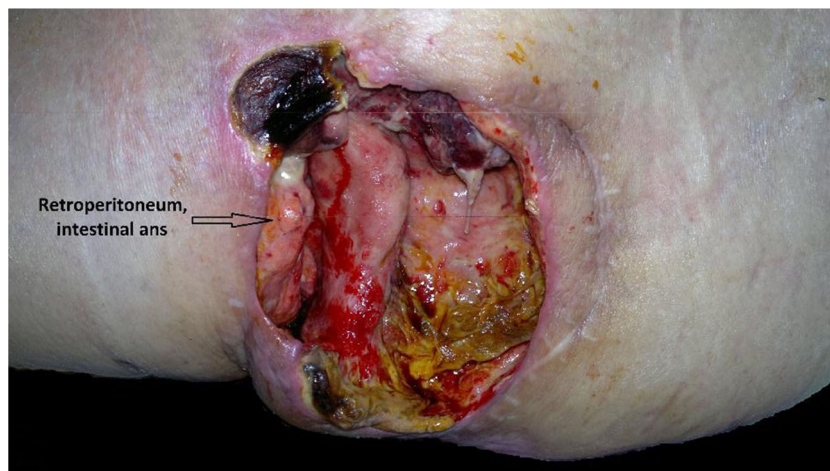




Fig. 2 View of the NF case with wide necrotic defects in the thoracic area (case 3)

insect bite on the thoracic region who had been followed up in another medical centre for a while due to a necrotic defect in the abdomino-thoracic area, and whose general condition deteriorated because of rapid expansion of tissue necrosis was transferred to the intensive care unit (ICU) from the emergency department. An analysis of her clinical record revealed that erythema and pain had started on the anterior chest wall after an insect bite of an unknown species, which was followed by a necrotizing wound of the skin. There was a wide, full-thickness tissue defect on the patient's anterior abdomino-thoracic wall, which also involved the pectoral muscles (Fig. 2). Paediatric patient had bullous, epidermolytic skin lesions with irregular borders on the lower extremity that developed after an insect bite (Fig. 3). Case 5, who was a chronic smoker, had a circular, progressive, fibrotic, infected, malodorous, necrotic defect on



Fig. 3 View of the bullous epidermolytic lesions induced by an insect bite in the posterior aspect of the lower extremity (case 4)



Fig. 4 View of the necrotic tissue defect extending to the deep tissue in the perineal area (case 9)

the lower extremity. The patient was bitten by an insect of an unknown species. The lesions had first started as erythema and then spread and became painful, causing full thickness tissue loss. Patients with defects on the vulva and perineum had deep, fibrotic, necrotic infected wounds with discharge and irregular borders extending to the deep tissue layer (Fig. 4). Patients with defects on the upper extremities had necrotic wounds with irregular borders extending to the fascial layers (Fig. 5). Case 13: with necrotic wound covering her anterior chest wall, she noticed a mass in the medial part of her right breast. Surgery was performed at another medical centre. On physical examination, she had surgery areas in the right thoracic region with skin defect of the anterior thoracic and neck region (Fig. 6). Medical histories, physical examination findings, and clinical manifestations of these patients were compatible with NF diagnosis.

Wound site cultures and biopsies for histopathological examination were taken prior to surgical intervention from all patients. The cases were all subjected to debridement and wound care was initiated. Vacuum assisted closure [VAC, KCI International, San Antonio, TX] therapy was applied to cavitory defects and those with discharge were to take the infection under control and to increase granulation formation in the wound site (Fig. 7). All patients were started on a prophylactic broad-spectrum antibiotic regimen covering anaerobic and aerobic bacteria. Laboratory risk



Fig. 5 View of the case with an upper extremity necrotic defect (case 10)



Fig. 6 View of the case with a necrotic thoracic defect (case 13)

indicator for necrotizing fasciitis (LRINEC) scoring system was used to determine the diagnosis and prognosis (Table 2) [20].

Results

Edematous enlargements, inflammatory cell (plasma cell, lymphocyte, neutrophil, a trace of eosinophil) infiltration, fibroblastic proliferation, vascular micro-thrombosis, and vasculitis were detected in the inter- and intrafascicular fibrous septa of the skeletal muscles in the cross-sections of the histopathological examinations (Fig. 8). The NF diagnoses were confirmed based on histopathological findings.

The antibiotic treatments administered according to the results of the wound site cultures, and the antibiograms, are listed in Table 3. The serum biomarkers measured are



Fig. 7 View of the case with a thoracic defect who received VAC therapy

Table 2 The laboratory risk indicator for necrotizing fasciitis (LRINEC) [20]

Serum parameter	Range	Score
Hb (g/dl)	>13.5	0
	11–13.5	1
	<11	2
WBC ($\times 10^3/\mu\text{l}$)	<15	0
	15–25	1
	>25	2
Sodium (mmol/l)	≥ 135	0
	<135	2
Creatinine (mg/dl)	≤ 1.6	0
	>1.6	2
Glucose (mg/dl)	≤ 180	0
	>180	1
CRP (mg/dl)	<150	0
	≥ 150	4

The glucose value was multiplied by 18.015 and the creatinine value by 0.01131 to convert them into mg/dl unit

Hb haemoglobin, WBC white blood cell CRP C-reactive protein

Total scores ≤ 5 ; low risk of necrotizing fasciitis (<50% risk)

6–7; intermediate risk of necrotizing fasciitis

≥ 8 ; high risk of necrotizing fasciitis (>75% risk)

summarized in Table 4. The LRINEC scores of the patients are summarized in Table 5.

Under antibiotic treatment, the discharge in the wound site continued to increase in case 1. The patient was taken to the operating room, and an exploration was conducted under general anaesthesia. Necrotizing wounds were observed in deeper layers, spreading towards the thoracic region on the fascia along the spinal tract. Debridement was performed on the wound site once again (Fig. 9). The defect was left open after debridement to continue wound care. The patient was monitored closely in the ICU. However, exitus occurred due to sepsis and vascular thrombosis, which was consequently followed by multiple organ failure.

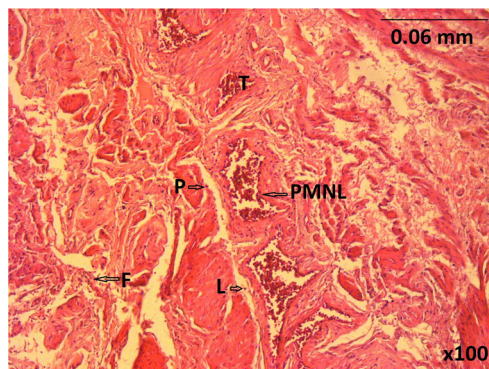


Fig. 8 View of the histopathological detected in the sample case (case 5) *E* edema, *P* plasma cell, *L* lymphocyte, *PMNL* polymorphonuclear leukocyte, *F* fibroblast, *T* thrombosis. (haematoxylin-eosin, original magnification $\times 100$)

Table 3 Results of the wound site cultures and antibiograms, types of NF (Society of Infectious Disease [8, 13]) and the list of the antibiotic treatments administered

Case number	Detected microorganisms	Type of NF	Antibiotic treatment
1	<i>Escherichia coli</i> + <i>Enterobacter</i>	1	Seftriaxone
2	<i>Acinetobacter</i> + <i>Pseudomonas</i>	1	Meropenem + amikacyne
3	<i>Acinetobacter</i> + MRSA	1	Tygacilline + vancomycine
4	<i>Streptococcus pyogenes</i>	2	Ampicilline + sulbactam
5	MRSA	2	Vancomycine
6	<i>Pseudomonas</i>	1	Ciprofloxacine
7	<i>Escherichia coli</i> + <i>Enterobacter</i>	1	Seftriaxone
8	<i>Pseudomonas</i> + MRSA	1	Piperacilline + tazobactam + vancomycine
9	<i>Escherichia coli</i> , <i>Enterobacter</i>	1	Seftriaxone
10	<i>Acinetobacter</i>	2	Meropenem + amikacyne
11	MRSA	2	Vancomycine
12	<i>Acinetobacter</i>	2	Meropenem + amikacyne
13	<i>Proteus mirabilis</i> + <i>Pseudomonas</i> + <i>Acinetobacter</i>	1	Teicoplanin + imipenem + cilastatin sodium

MRSA meticilline resistant *Staphylococcus aureus*

In case 2, the infection, which had spread to the retroperitoneal area, was taken under control following serial debridement and wound care. The posterior thigh flap was performed for reconstruction (Fig. 10). No complications were observed and the patient was discharged with full recovery.

The necrosis on the anterior thoracic wall of case 3 had spread rather rapidly, covering the entire anterior thoracic area and a major part of the anterior abdominal wall. The case was subjected to serial debridements and VAC therapy. However, pyothorax developed due to progressive necrosis and bilateral chest tubes were inserted (Fig. 11). The patient was monitored in the ICU with a mechanical ventilator. Exitus occurred due to sepsis and multiple organ failure.

Debridement and repair with a split thickness skin graft (STSG) was performed on cases that had NF located in the upper (Fig. 12) and lower extremity (Fig. 13). The defect on the vulva-perineum of the female patients was repaired with a full thickness skin graft, local flap or by secondary healing

after VAC therapy (Fig. 14). The defect on the thoracic and neck region (case 13) was debrided serially and repaired (Fig. 15).

Table 6 is a summary of the surgical treatments performed on patients and the progression of disease. The hospitalization period varied between 18 and 28 days (average 19.6 days).

Discussion

NF is a potentially lethal infectious disease that requires immediate medical and surgical intervention [5]. Progressing rapidly, this disease causes necroses that spread to the subcutaneous tissue and fascia [4]. The disease is characterized by its ability to cause systemic toxicity in the early stage [9]. The most frequent causes of death are sepsis, systemic inflammatory response syndrome (SIRS), acute respiratory distress syndrome (ARDS), disseminated intravascular coagulation

Table 4 List of the serum parameters measured in the patients in the study

Case number	Serum parameters					
	Hb (g/dl)	WBC ($\times 10^3/\mu\text{l}$)	Sodium (mmol/l)	Creatinine (mg/dl)	Glucose (mg/dl)	CRP (mg/dl)
1	10.5	26.8	131	1.8	79	158.8
2	13.2	17.5	139	1.1	107	152.5
3	9.1	40.4	130	1.9	198	163.4
4	10.0	16.7	134	0.7	198	43.4
5	10.1	18.7	140	1.1	112	162.3
6	10.3	16.8	134	0.9	189	53.1
7	10.1	18.9	133	1.6	128	79.6
8	9.2	18.6	134	1.8	79	156.2
9	10.4	15.8	132	3.2	135	193.1
10	10.9	16.2	133	1.7	119	68
11	9.7	13.5	137	1.2	121	178
12	9.8	14.9	133	1.9	123	121
13	10.2	25.2	139	1.8	107	189

Normal values: Hb 12–18, WBC 4–10, Sodium 135–145, Creatinine 0.5–1.3, Glucose 70–110, CRP 0–5

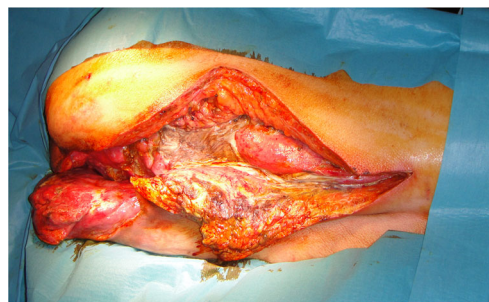
Hb haemoglobine, WBC white blood cell, CRP C-reactive protein

Table 5 List of the LRINEC score values detected in the cases

Case number	LRINEC score	Risk
1	12	High
2	6	Intermediate
3	13	High
4	6	Intermediate
5	7	Intermediate
6	6	Intermediate
7	6	Intermediate
8	11	High
9	8	High
10	6	Intermediate
11	6	Intermediate
12	6	Intermediate
13	10	High

(DIC), septic shock, acute renal failure, liver, and multiple organ failures [1, 2, 5, 18, 21–24].

The aetiology of NF includes factors such as complicated wounds, pressure sores, perineal abscess, skin incision, local trauma, abrasion, contusion, burn, laceration, surgery, soft tissue infection, minor invasive procedures (joint aspiration, acupuncture), bite, penetrating damage (insect or animal bite), injection, and folliculitis [2, 6, 10, 23]. NF is observed particularly in cases with comorbidities [7, 12]. Among the predisposing factors are advanced age, poor tissue perfusion, lack of education, renal failure, trauma, primary anorectal infection, diabetes, hypertension, smoking, alcohol consuming, cirrhosis, malnutrition, insufficient personal care and poor hygiene, HIV-AIDS, immunosuppression, intravenous drug use, drug addiction, non-steroidal anti-inflammatory drug (NSAID) use, post-transplantation, malignancy, cases of post-chemotherapy, morbid obesity, spinal cord injury, paraplegia, peripheral vascular disease, and varicella infection [2, 4, 6, 7, 10, 12, 14, 18, 21, 23, 25]. Some idiopathic cases with no additional predisposing factors have also been reported [1, 10]. Fustes-Morales et al. have stated that half of the cases did not have any predisposing factors [26]. As a matter of fact, NF developed in one of our cases despite his young age, and without any evident predisposing factors. Palmer et al. have reported that infectious conditions in patients with debility would result in NF, and that the gangrenous process could start more easily, and that debility on its own could have an adverse effect on the survival [27]. Malnutrition and debility were thought to have paved the way for NF in the two bedridden female cases with pressure sores in our study. However, it is not always possible to make an exact comment on which one of these factors was more influential. History of alcohol use and smoking in case 3, who developed abdomino-thoracic NF, was thought to have impaired liver function by creating an immune system defect, facilitating the spread of the infection. In general, we think that predisposing factors affect the disease cumulatively. Cases

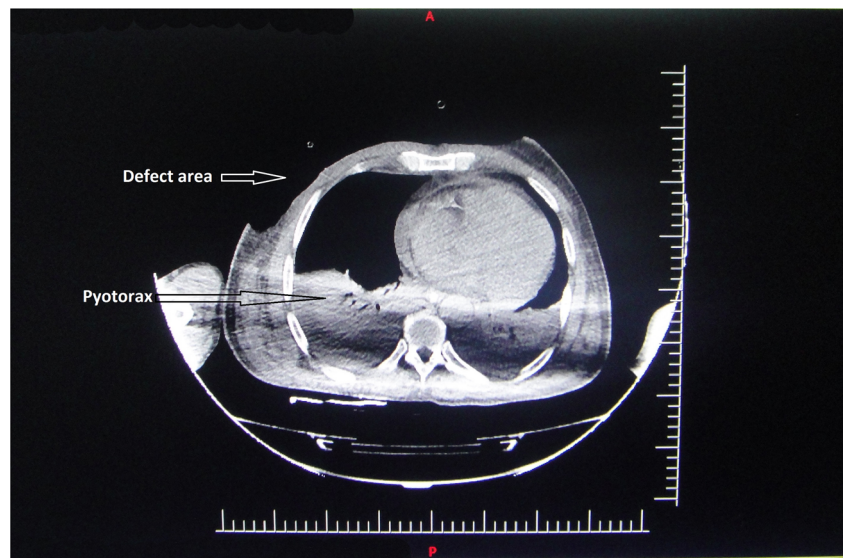
**Fig. 9** Intraoperative view of the NF case induced by a gluteal pressure sore spreading to the posterior thoracic deep fascia

developing NF due to insect bite are also quite rare in the literature [28, 29]. In our series, three patients, who lived in rural areas, had a history of insect bite where one developed thoracic NF leading a mortal progression.

Although NF was originally described as gangrene observed in the scrotum area in men, later, the disease was reported in the perineal area of women as well [6, 23]. Kuo et al. described five female cases out of 44 with NF [30]. Sorensen et al. reported 39 female cases out of 1680 NF cases [31]. Kim reported that the man/woman ratio was approximately 10/1 in the study he conducted [32]. Eke et al. have stated that NF diagnosis is overlooked in women and that the ratio of women with NF is lower because certain clinicians fail to diagnose the disease [29]. It is stated that the etiological factors in women are often septic abortus, hysterectomy, episiotomy, and vulvar or Bartholin gland abscesses [6, 32]. Certain studies showing a significant relation between mortality and gender can be found in the literature. Khamnuan et al. have reported that the disease has a more fatal course in women and attributed this to the fact that women have more subcutaneous fatty tissues and are more susceptible to infections [5]. Elliott et al. have stated that female gender is an independent factor affecting mortality rate in their series of 198 cases [33]. Czymek et al. have also stated that NF has a more fatal course in women compared to men (50% in women, 7.7% in men) [34]. However, there are also reports demonstrating that a statistically significant difference between female and male mortality rate has not been observed [5, 35]. There are controversial results on this issue in the literature. Since atypical cases were addressed in the study, the female cases were relatively dominant. There is a need for comparative studies with large

**Fig. 10** Postoperative view of the case with a decubitus ulcer who was repaired with posterior thigh flap

Fig. 11 Computerized tomography (CT) image of the thoracic NF case that developed pyothorax



series with similar etiological and predisposing factors to investigate the relationship between mortality and gender.

NF can emerge at various localizations in the body. Anaya et al. have reported that lower extremities are the most frequently involved area in NF [19]. Similarly, Fustes-Morales et al. have reported that the most frequent anatomic localization in their 39-case series was lower extremity [26]. The lower abdominal region and the perineal area are also among those areas where NF is frequently localized [7, 23]. Hodgins et al. treated NF observed in the lower extremity most frequently and then in the inguinal and perineal area, the abdomen, the upper extremity, and the head-neck region, respectively, in the study they conducted [14]. The reason NF is frequently seen in the lower extremity is that bacterial passage is easier in this localization [14]. NF case series with atypical localizations are quite few in the literature. Bozkurt et al. have reported an NF case observed in the upper extremity [7], while Seyhan et al. have reported a NF case seen on the thoracic wall [1]. The risk of NF development on the chest wall is quite low because this area is well perfused [1]. NF developing on the chest wall can be caused by thoracic wall trauma, surgical intervention, lung tumour resection,

oesophageal operation, radiation treatment, and thoracic catheter application [6, 9, 21]. Other cases in which development of NF on the thoracic wall through retropharyngeal spread of infection was observed have also been reported [21]. The thoracic NF case in our study, to our knowledge, is the only case with a history of insect bite in this anatomic location leading a fatal course.



Fig. 12 The view of the case with a defect on the upper extremity after the grafting operation



Fig. 13 The view of the case with a defect on the cruris after the STSG operation



Fig. 14 The view of the case with vulvar defect after the secondary healing

The aetiology and anatomic localization of NF is also related to age. While NF is often observed in the lower extremity in adults, it is most often observed in the trunk in children. Truncal NF is often seen in cases below 1 year of age. The most common etiological cause in this age group is omphalitis [21]. Differently from the data in the literature, although no predisposing factor was present in the paediatric case in our study, insect-



Fig. 15 The view of the case with thoracic defect after the STSG operation

bite-induced NF developed in the lower extremity. The insect might have caused a toxic skin reaction. No clear pathophysiological mechanism could be put forth on this subject because the insect species could not be identified.

According to Society of Infectious Diseases, NF has been categorized into two types based on the localization and effective microorganisms [8, 13, 22, 23, 36]. In type 1 NF cases, polymicrobial aerobic and anaerobic mixed infection factors are isolated [1, 2, 4, 23, 36–38]. There are predisposing factors such as DM, peripheral vascular disease, alcoholism, malignancy, immunodeficiency, and previous surgical operation [8]. In type 1 NF, the disease starts in the trunk, the genital, perianal or perineal area and spreads through the fascial planes to the abdominal wall via gluteal muscles [2, 10, 13]. The disease progressed similarly in case 3 in the present study, spreading to the thoracic fascia with a fatal course. In type 2 NF, there is no significant comorbidity and the infection is monomicrobial [10, 13]. It is seen in the extremities [13]. The aetiology includes factors such as penetrating or blunt trauma, surgical operation, varicella zoster, intravenous drug use, burn, and NSAID use [2, 8, 10]. The effective microorganisms and clinical course identified in our cases were similar to those in the literature.

Diversity of clinical findings can bring difficulties and delay the diagnosis [4–6, 8–14, 16]. This is caused by the fact that the disease is rarely seen and that it can appear with atypical presentations and variations as seen in our series. An infection in the deep fascia can spread easier than it would subcutaneously [6]. This could cause an invasive wound infection in deep tissues going unrecognized in the early period due to milder findings in the superficial tissues. A similar presentation occurred in our case with gluteal pressure sore. While the clinical observation of the wound surface demonstrated mild progression, the disease had a fast and fulminant course, causing widespread fasciitis on the thoracic and spinal fascia causing mortality.

Certain scoring systems are used for the diagnosis of the disease [4, 5, 10, 14, 39]. Wong et al. used LRINEC scoring system (Table 2) [5, 6, 20, 21]. We used this scoring system to confirm the diagnosis because of atypical presentations. This scoring system is also quite a supportive parameter in determining the prognosis [20]. Although some studies have expressed controversial opinions concerning the specificity and sensitivity of LRINEC scoring, Hodgins et al. have stated that LRINEC scoring, which they applied in their series, has reached sensitivity and specificity rates as high as 90% [14]. In our opinion, as the parameters analysed are parameters whose levels directly change in the event of an inflammatory process and infection, this scoring systems can be thought to be convenient. As a matter of fact, the LRINEC scores that we obtained in our study were totally coherent with the progression of the disease.

Imaging methods have a limited role in NF diagnosis [8, 10, 17]. Direct radiography, ultrasonography (USG),

Table 6 A summary of the surgical treatments performed and progress

Case number	Treatment	Progress	Hospital stay (day)
1	Debridement + VAC	Sepsis, multiorgan failure, Exitus	18
2	Debridement + VAC + posterior thigh flap	Full recovery	28
3	Debridement + VAC	Sepsis, multiorgan failure, Exitus	13
4	Debridement + STSG	Full recovery	17
5	Debridement + VAC + STSG	Full recovery	22
6	Debridement + FTSG	Full recovery	14
7	Debridement + rotation flap	Full recovery	16
8	Debridement + VAC	Secondary healing	25
9	Debridement + VAC + FTSG	Full recovery	19
10	Debridement + STSG	Full recovery	17
11	Debridement + STSG	Full recovery	19
12	Debridement + STSG	Full recovery	21
13	Debridement + STSG	Full recovery	26

VAC vacuum assisted closure, STSG split thickness skin graft, FTSG full thickness skin graft

computerized tomography (CT), and magnetic resonance imaging (MRI) can be used; however, these are non-specific [10, 21]. These analyses provide useful information about effusion, inflammation, gas accumulation within the tissue, and the boundaries of the affected tissues [8, 10, 21]. They also may become quite important in differentiating some diseases that are frequently confused with NF. For instance, empyema necessitates, which causes effusion and empyema in the chest wall, is frequently confused with NF [25]. In our study, we used CT in order to identify the tissue damage and follow up the pleural effusion in the case that developed NF on the chest wall. No additional imaging method was needed in the other cases as the depth of the wound was directly observed during surgery, and live tissues were seen during debridement.

The final diagnosis of NF is established histopathologically [7]. Fisher et al. identified certain histological criteria for the diagnosis of NF [40]. Accordingly, they set forth that NF diagnosis could be established if there is intense polymorphonuclear leukocyte infiltration, inflammation, edema, extensive fascial necrosis, microvascular thrombosis, or vasculitis [2, 9, 40, 41]. The diagnosis can be made in the early phase by sending rapid frozen section and tissue biopsies with debridement materials [10, 16]. Necrosis is expected to develop in tissues with microvascular thrombosis and vasculitis even if the tissues seem macroscopically normal [9]. Since the cases in our study had atypical clinical presentations, they were all subjected to histopathological examination in the early stage, and the final diagnosis was established by interpreting the clinical and histopathological findings.

There are very different results in the literature reporting on the mortality rates of the disease [5, 6, 23]. The mortality rate range is between 4 and 80% in NF despite optimal and appropriate approaches [2, 3, 6, 12, 16, 42–46]. There are a limited number of studies establishing a correlation between NF's anatomic localization and mortality. NF observed in extremities is stated to have a less mortal course

than those observed in the trunk and perineum [1, 6]. Safran et al. have reported that the mortality rate in NF observed on the thoracic wall was 77% [47] and Losanoff et al. 66% [48]. Cases with thoracic involvement had a mortal course while those on extremity localization were cured in our study as well. However, large-series with atypical presentations of NF, including comparative data should be conducted in order to obtain more precise data.

Conclusion

An increase in mortality can be observed caused by delays in diagnosis and treatment as NF presentations cases may vary. As observed in our study, NF can present with very different etiological, demographical, and clinical findings. This diagnosis should always be kept in mind, and all necessary interventions should be initiated as soon as there is a suspicion of NF. As far as we are concerned, the number of studies evaluating cases of unusual types of NF is quite limited in the literature. We believe that this study will provide some data that will shed light particularly on the characterization and management of NF cases with atypical presentations and make a positive contribution to the literature.

Compliance with ethical standards

Conflict of Interest Emin Kapi, Zeynep Deniz Akdeniz Dogan, Tamer Seyhan, and Nihal Kilinc declare that they have no conflict of interest.

Funding None

Ethical approval For this type of study, formal consent is not required.

Informed consent Informed consent was obtained from all individual participants or family members included in the study.

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