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Prognostic factors and clinical outcomes in Fournier's Gangrene: a retrospective study of 35 patients

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Abstract

Background Fournier's gangrene is a severe form of infectious necrotizing fasciitis affecting the perineum, perianal, and genital areas; it is associated with substantial morbidity and mortality. Hence, it is important to identify prognostic factors that can predict clinical outcomes and guide treatment strategies. Thus, our study aimed to analyze patient characteristics and determine prognostic factors affecting clinical outcomes in Fournier's gangrene.

Methods This retrospective study involved examining medical records spanning 18 years for patients with Fournier's gangrene at our institution. Considering the exclusion criteria, data from 35 patients were included in this study.

Results A total of 35 patients were included in the analysis. The mean age of the patients showed no statistically significant difference between the survivor and non-survivor groups. The Charlson Comorbidity Index, American Society of Anesthesiologists score, and Acute Physiology and Chronic Health Evaluation II score were not significantly different between the two groups. Notably, the initial Sequential Organ Failure Assessment score was significantly higher in the non-survivor group than that in the survivor group. The overall in-hospital mortality rate was 17.1%. Moreover, the prevalence of multidrug resistant bacterial infection was markedly higher in the non-survivor group than that in the survivor group. Coagulation dysfunction was significantly more prevalent in the non-survivor group than that in the survivor group, and had the most significant impact on in-hospital mortality. A multivariable logistic regression analysis identified multidrug resistant bacterial infection to be independently associated with high in-hospital mortality.

Conclusions Coagulation dysfunction and multidrug resistant bacterial infection were identified as independent negative prognostic factors, highlighting the need for prompt monitoring and proactive strategies against Fournier's gangrene.

Keywords Fournier's gangrene, Multidrug resistance, Necrotizing fasciitis, Organ dysfunction, Prognosis

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Background

Fournier's gangrene is a life-threatening infection that primarily affects the perineum and external genitalia [1]. It is a form of necrotizing fasciitis characterized by rapid spread of infection along the fascial plane and necrosis of the skin, subcutaneous tissue, and fascia, with a high risk of multiple organ failure and septic shock, leading to death [2]. It was first documented by Baurienne in 1764 as scrotal gangrene and was later named after the French dermatologist Jean Alfred Fournier who reported a series of five young men experiencing spontaneous fulminant gangrene of the penis and scrotum in 1883 [3]. Fournier's gangrene can occur in both sexes and across various age groups. However, global epidemiological data are limited. It is generally considered a rare disease, affecting individuals between 50 and 70 years, with a higher incidence in males than that in females, estimated at approximately 1.6 cases per 100,000 males annually [4].

Several factors, including diabetes mellitus, chronic alcoholism, poor personal hygiene, immunosuppression, obesity, liver cirrhosis, malignancy, chemotherapy, steroid use, and trauma, predispose individuals to Fournier's gangrene. However, there are no identifiable risk factors in approximately 10% of the cases [5]. The primary causes of Fournier's gangrene are commonly reported in the following order: gastrointestinal tract-related infections (perianal abscess, perirectal abscess), genitourinary tract infections, and cutaneous injuries in the perineal area due to local trauma [1]. However, accurately determining the origin of severe Fournier's gangrene clinically is often challenging.

The treatments for Fournier's gangrene focus on early recognition, use of broad-spectrum antibiotics, resuscitation, and aggressive debridement [6]. However, in rare cases, early diagnosis before the exacerbation of necrosis and gangrene is difficult. Late detection and inappropriate treatment ultimately lead to high mortality rates [2, 5]. Factors influencing such outcomes include the extent and severity of the infection, presence of comorbidities, timely diagnosis and treatment, and the effectiveness of surgical debridement and antibiotic therapy, which is further exacerbated by the complicated features of polymicrobial infections [7–9]. Despite advances in medical and surgical interventions, this condition remains challenging to manage, with reported mortality rates ranging from 20 to 88%, averaging approximately 40% [4, 10].

Considering the complexity and severity of Fournier's gangrene, it is important to identify prognostic factors that can predict clinical outcomes and guide treatment strategies. This study aimed to analyze the characteristics of patients with Fournier's gangrene and to elucidate the prognostic factors influencing clinical outcomes.

Methods

Ethical considerations

This study was approved by the Institutional Review Board (IRB) of Keimyung University Dongsan Hospital (approval number: DSMC 2023-05-033). Considering the noninterventional and observational nature of this study, the requirement for obtaining informed consent was waived by the IRB of Keimyung University Dongsan Hospital (approval number: DSMC 2023-05-033). Data were collected and analyzed in accordance with ethical guidelines, protecting the privacy rights of the participants.

Study description and definitions

This retrospective cohort study involved analyzing the medical records of patients admitted to our institution between January 1, 2005, and December 31, 2022. Our study focused on 50 patients aged>18 years who were admitted for Fournier's gangrene. Fifteen patients who provided do not resuscitate orders and received palliative care, were initially treated at another hospital, or had incomplete medical records were excluded from the study. This study ultimately included 35 patients admitted for Fournier's gangrene (Figs. 1 and 2). All patients underwent aggressive debridement and were administered broad-spectrum antibiotics. Although the treatment physicians changed over an 18-year period, we mostly used a consistent treatment strategy, since we enrolled physicians receiving training from the same institution.

Fournier's gangrene was classified using the International Statistical Classification of Diseases and Related Health Problems codes and diagnosed based on the patients' medical record review and computer tomography (CT) scan records. Fournier's gangrene is defined as a polymicrobial necrotizing fasciitis affecting the genital, perineal, perianal, and adjacent areas. The diagnosis is primarily clinical, and is based on the identification of signs such as severe pain, erythema, edema, and crepitus in the affected regions. Key findings on CT scans include subcutaneous emphysema, fascial thickening, and fluid collection [11, 12]. Information and scores were based on data obtained in the first 24 h after admission to the emergency room (ER).

As defined by the Clinical Criteria of the Third International Consensus Definition (Sepsis-3), sepsis is a life-threatening organ dysfunction resulting from an uncontrolled host response to infection [13]. Organ dysfunction was included in the definition of sepsis and the presence or absence of organ dysfunction was determined using Sequential Organ Failure Assessment (SOFA) scores. The Fournier's Gangrene Severity Index (FGSI) is a numerical score calculated using a combination of clinical and laboratory assessments, including temperature, heart rate, respiratory rate, blood

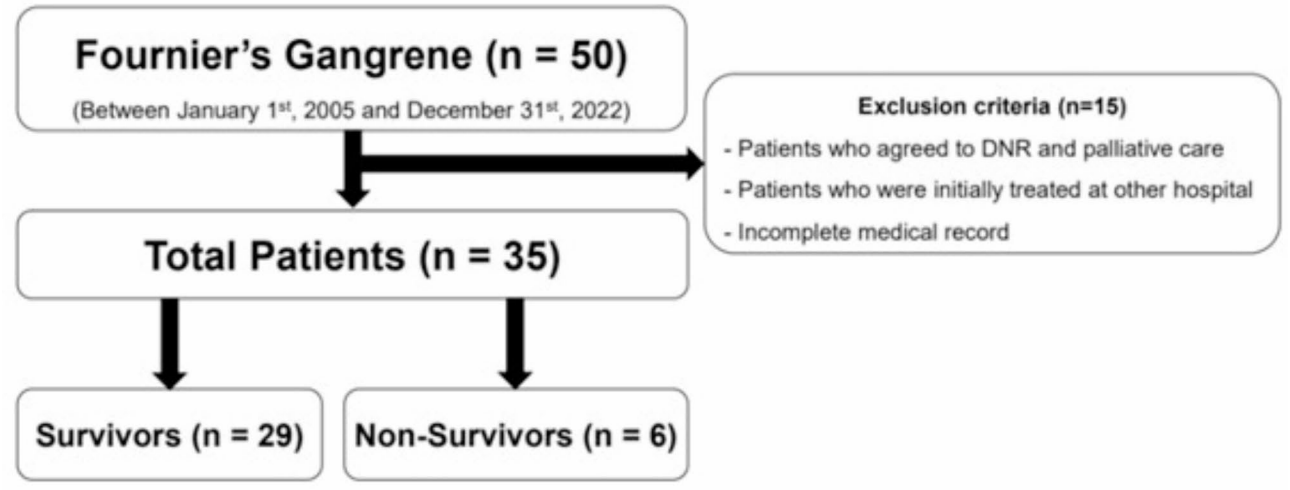

Fig. 1 Flow chart of patients' enrollment. DNR, do not resuscitate

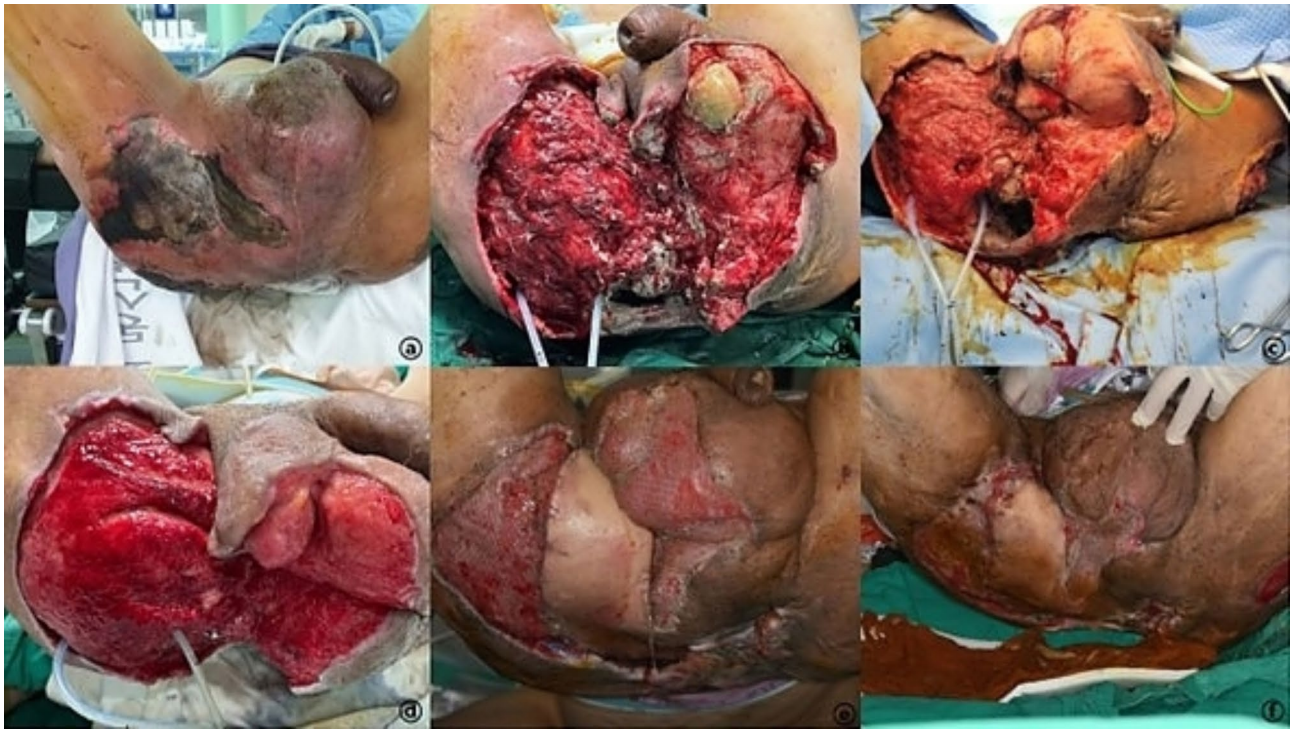

Fig. 2 A case of Fournier's gangrene. A 55-year-old male with paraplegia due to a history of falling down. Necrotizing fasciitis spread to the perianal area, scrotum, and both hip and thigh area. ⓐ: Status before debridement and at the time of admission. ⓑ, ⓒ: After debridement, testicles were exposed. ⓓ: A photograph obtained two weeks postoperatively. ⓔ: Reconstruction with split thickness skin graft. ⓕ: A photograph after vacuum assisted dressing two weeks after reconstruction

electrolytes, creatinine level, and hematocrit. The study established a score > 9 as a sensitive and specific mortality predictor in patients with perineal gangrene [14]. The Charlson comorbidity index (CCI) and Acute Physiology and Chronic Health Evaluation (APACHE) II scores were calculated to evaluate the severity of underlying medical conditions in the patients. Source control was defined as surgical debridement at the bedside or operating theatre. Multidrug resistant (MDR) bacterial infection is defined as the resistance of microorganisms to three or more distinct categories of antibiotics [15]. The pathogens under consideration were those identified in the preliminary culture conducted during source control.

Data collection

The data collected retrospectively were as follows: [1] patient characteristics, including age, sex, body mass index (BMI), CCI, American Society of Anesthesiologists (ASA) score, APACHE II score, SOFA score, FGSI, and medical history; [2] clinical data, including laboratory data at the admitted ER, presence of sepsis and septic shock, extent of disease, length of hospital stay, length of intensive care unit (ICU) stay, the duration from admitted time to antibiotic administration, and duration from admitted time to source control implementation; [3] infection and microbiological data, including the type of isolated bacteria and fungi, and occurrence of bacteremia and MDR bacterial infection; and [4] organ dysfunction data, including the type, number, and occurrence ratio of organ dysfunction results.

Statistical analyses

Continuous data are expressed as the mean ± standard deviation. Categorical data are expressed as frequencies and percentages. Data normality was assessed using the Kolmogorov–Smirnov test and confirmed by visual inspection of the histograms. Continuous variables were analyzed using Student's t-test or Mann–Whitney U test, whereas categorical variables were analyzed using the chi-square or Fisher's exact test. Multivariate logistic regression analysis was used to estimate the association between organ dysfunction and in-hospital mortality with unadjusted and adjusted (for age, BMI, and CCI and FGSI scores) for evaluations. Odds ratios (ORs) were used to determine the effects of organ dysfunction on in-hospital mortality. Univariable and multivariable logistic regression analyses were performed to identify the risk factors associated with in-hospital mortality, with the degree of association presented as ORs and their corresponding 95% confidence intervals. Logistic regression performance was evaluated using C-statistics and Hosmer–Lemeshow tests. Statistical significance was set at a p-value < 0.05. The IBM Corporation's SPSS (version 28.0; Armonk, NY, USA) was used for all the analyses.

Results

Patient characteristics, clinical data, and operative outcomes

The in-hospital mortality rate of the enrolled patients with Fournier's gangrene was 17.1% (n = 6/35). The patient characteristics and clinical data at the time of Fournier's gangrene diagnosis are summarized in Tables 1 and 2.

The mean age of the patients was 57.9 ± 13.1 years, with a higher mean age observed in the non-survivor group. The CCI and APACHE II scores were non-significantly higher in the non-survivor group than those in the survivor group. Even the FGSI score, which is used globally

Table 1 Patient characteristics

	All patients (n = 35)	Survivors (n = 29)	Non-survivors (n = 6)	p-value
Age (years)	57.9 ± 13.1	56.6 ± 13.2	64.8 ± 10.9	0.161
Sex				0.143
Male	30 (85.7)	26 (89.7)	4 (66.7)	
Female	5 (14.3)	3 (10.3)	2 (33.3)	
BMI (kg/m^2)	24.8 ± 3.3	24.9 ± 3.4	24.2 ± 2.8	0.628
Charlson comorbidity index	3.5 ± 2.2	3.2 ± 2.2	4.7 ± 2.1	0.139
ASA score	2.7 ± 0.9	2.6 ± 0.9	3.2 ± 0.8	0.193
APACHE II score	14.9 ± 6.9	14.1 ± 7.2	18.5 ± 4.9	0.166
Initial SOFA score	2.5 ± 2.9	2.0 ± 2.8	5.0 ± 2.3	0.018
FGSI	6.9 ± 4.4	6.8 ± 4.6	7.5 ± 3.6	0.724
Medical History				
HTN	15 (42.9)	10 (34.5)	5 (83.3)	0.028
DM	20 (57.1)	16 (55.2)	4 (66.7)	0.605
CKD	9 (25.7)	6 (20.7)	3 (50.0)	0.135
Chronic liver disease	4 (11.4)	3 (10.3)	1 (16.7)	0.658
Anorectal surgery history	7 (20.0)	6 (20.7)	1 (16.7)	0.823
Malignancy	6 (17.1)	4 (13.8)	2 (33.3)	0.248
Immune deficiency	1 (5.7)	0 (0)	2 (33.3)	< 0.001
Smoker	23 (65.7)	21 (72.4)	2 (33.3)	0.066
Bedridden state	6 (17.1)	5 (17.2)	1 (16.7)	0.973
Sanatorium stay	4 (11.4)	3 (10.3)	1 (16.7)	0.658

Data are shown as mean ± standard deviation or number (percentage)

SD, standard deviation; BMI, body mass index; ASA, American Society of Anesthesiologists; APACHE, Acute Physiology and Chronic Health Evaluation; SOFA, Sequential Organ Failure Assessment; FGSI, Fournier's gangrene scoring index; HTN, hypertension; DM, diabetes mellitus; CKD, chronic kidney disease

Table 2 Patient clinical data

	All patients (*n* = 35)	**Survivors (*n* = 29)**	**Non-survivors (*n* = 6)**	***p*-value**
Sepsis	18 (51.4)	13 (44.8)	5 (83.3)	0.086
Septic shock	12 (34.3)	8 (27.6)	4 (66.7)	0.066
Initial laboratory results				
WBC	18157.1 ± 11811.2	18080.0 ± 11833.7	18260.0 ± 7129.4	0.518
Hb (g/dL)	10.3 ± 2.6	10.7 ± 2.7	9.1 ± 1.9	0.146
Platelet count (10^3/μL)	261.2 ± 165.2	271.2 ± 147.2	180.2 ± 72.6	0.073
Initial lactate level (mmol/L)	2.3 ± 0.9	2.5 ± 0.9	1.3 ± 0.4	0.062
BUN	38.7 ± 27.2	40.3 ± 28.6	43.6 ± 22.2	0.859
Creatinine level (mg/dL)	2.6 ± 3.0	2.4 ± 2.8	4.5 ± 4.1	0.247
Total bilirubin level (mg/dL)	1.1 ± 1.5	1.1 ± 1.6	0.8 ± 0.7	0.962
AST	27.2 ± 16.8	25.2 ± 13.4	40.4 ± 30.6	0.404
ALT	23.6 ± 22.4	19.6 ± 12.3	40.2 ± 50.9	0.486
Albumin	2.9 ± 0.6	3.0 ± 0.7	3.1 ± 0.4	0.760
INR	1.3 ± 0.2	1.3 ± 0.2	1.3 ± 0.1	0.589
CRP level (mg/dL)	23.2 ± 12.2	23.7 ± 12.3	18.4 ± 13.3	0.590
Procalcitonin level (ng/ml)	15.8 ± 20.7	16.4 ± 22.4	11.3 ± 9.5	0.913
BNP level (pg/mL)	8173.8 ± 12239.9	9778.0 ± 12340.0	9661.8 ± 16906.1	0.996
Extent of Disease				0.373
Y area only	23 (65.7)	20 (69.0)	3 (50.0)	
Beyond Y area	12 (34.3)	9 (31.0)	3 (50.0)	
Time to administration of antibiotics (mins)	206.3 ± 178.6	195.5 ± 189.6	258.67 ± 108.8	0.438
Time to Source control (mins)	476.6 ± 387.5	499.9 ± 402.5	364.0 ± 309.1	0.443
Length of ICU (days)	25.4 ± 28.9	22.2 ± 29.4	43.2 ± 21.5	0.258
Length of hospital (days)	45.3 ± 36.6	46.9 ± 38.3	37.5 ± 28.3	0.573
Number of organ dysfunction	1.0 ± 0.9	0.9 ± 0.9	1.5 ± 1.0	0.138
Operation type				
Incision and drainage	35 (100)	29 (100)	6 (100)	.
Surgical diversion	9 (25.7)	8 (27.6)	1 (16.7)	0.577
Local flap surgery	8 (22.9)	7 (24.1)	1 (16.7)	0.692
Skin graft	3 (8.6)	2 (6.9)	1 (16.7)	0.436
Orchiectomy	2 (5.7)	1 (3.4)	1 (16.7)	0.204
Number of Operation	3.9 ± 3.9	3.5 ± 3.0	6.2 ± 6.9	0.400

as a prognostic factor, showed no significant difference between the two groups (7.5±3.6 vs. 6.8±4.6, $p=0.724$). Notably, the initial SOFA scores at arrival to the ER were significantly higher in the non-survivor group than those in the survivor group (5.0±2.3 vs. 2.0±2.8; $p=0.018$).

Incidences of hypertension and immune deficiency were significantly higher in the non-survivor group than those in the survivor group. Other comorbidities, including diabetes mellitus, chronic kidney disease, chronic liver disease, and malignancy, were higher in the non-survivor group; however, the difference was not significant. The proportion of patients who underwent anorectal surgery was 20% ($n=7/35$), and the types of surgeries performed included incision and debridement for perianal abscess, hemorrhoidectomy, and low anterior resection for rectal cancer. However, there was no significant difference between the non-survivor and survivor groups (16.7% vs. 20.7%; $p=0.823$).

The ratio of patients in a bedridden state and sanatorium stay were similar between the two groups (Table 1).

In the patient clinical data, the evaluation of sepsis and septic shock was based solely on the initial assessment that occurred at the time of ER admission. Sepsis (83.3% vs. 44.8%; $p=0.086$) and septic shock (66.7% vs. 27.6%; $p=0.066$) were more frequent in the non-survivor group compared to the survivor group, although this difference was not statistically significant. In the initial laboratory test, platelet levels were non-significantly lower in the non-survivor group than those in the survivor group. There was no difference in the extent of disease between the two groups, including in the Y area, which is a known prognostic factor [16]. The time from admission to the administration of antibiotics, time to source control measures, length of ICU stay, length of hospital stay, number of organ dysfunctions, operation type, and number of operations were not significantly different between the two groups (Table 2).

Data are shown as mean ± standard deviation or number (percentage).

SD, standard deviation; WBC, white blood cell; Hb, hemoglobin; BUN, blood urea nitrogen; AST, aspartate aminotransferase; ALT, alanine aminotransferase; INR, International Normalized Ratio; CRP, C-reactive protein; BNP, brain natriuretic peptide; ICU, intensive care unit.

Microbiological spectrum and characteristics

Among the 35 patients, 34 were identified to be infected with causative pathogens. Bacteremia occurred in 14.3% of all patients and did not differ significantly between the non-survivor and survivor groups. Gram-positive bacteria, gram-negative bacteria, and fungi were isolated from the patients and were not significantly different between the two groups. Mixed growth was defined as the detection of more than one type of gram-positive, gram-negative, or fungal pathogen. Samples from 20.0% of the patients infected with causative pathogens showed mixed growth in the culture. The overall rate of infection with MDR pathogens was significantly higher in the non-survivor group than that in the survivor group. The most common MDR pathogens were *Escherichia coli*, followed by *Klebsiella pneumoniae*, *Acinetobacter* spp., *Staphylococcus aureus*, *Staphylococcus epidermidis*, and *Enterococcus faecalis*. (Table 3).

Table 4 shows the distribution of the isolated microbiological pathogens, expressed as the percentage of bacteria and fungi per species, in patients with Fournier's gangrene. Among the isolated causative pathogens, the most common were *Escherichia coli* (48.6%), *Klebsiella pneumoniae* (20.0%), and *Streptococcus anginosus* (11.4%). *Candida tropicalis* was the only causative fungus identified (2.9%).

Organ dysfunction

The most common type of organ dysfunction in patients with Fournier's gangrene was renal dysfunction, followed by liver, respiratory, cardiovascular, coagulation, and central nervous system dysfunctions. The incidence of coagulation dysfunction was significantly higher in the non-survivor group than that in the survivor group. The incidence of renal dysfunction was higher in the non-survivor group than that in the survivor group, but this difference was not statistically significant (Table 5). Multivariate logistic regression analysis was performed to determine the association between organ dysfunction and in-hospital mortality. Results showed that the in-hospital mortality rate was significantly affected only by coagulation dysfunction. Furthermore, we adjusted for previously known risk factors for Fournier's gangrene, including age, BMI, CCI, and FGSI. Among all the organ dysfunctions, only coagulation dysfunction had the most significant impact on in-hospital mortality (Table 6).

Values were adjusted for age, body mass index, Charlson Comorbidity Index, Fournier's gangrene severity index.

Predictive factors for in-hospital mortality

Table 7 shows the results of multivariate logistic regression analysis for in-hospital mortality in patients with Fournier's gangrene. After accounting for individual risk and confounding factors, only MDR bacterial infection was independently associated with significantly high in-hospital mortality.

Table 3 Microbiological profile of survivors and non-survivors

	All patients (*n* = 35)	Survivors (*n* = 29)	Non-survivors (*n* = 6)	*p*-value
Identified pathogens	34 (97.1)	28 (96.6)	6 (100.0)	0.644
Bacteremia	5 (14.3)	4 (13.8)	1 (16.7)	0.855
Type of bacteria				
Gram-positive	17 (48.6)	14 (48.3)	3 (50.0)	0.939
Gram-negative	23 (65.7)	19 (65.5)	4 (66.7)	0.957
Fungus	1 (2.9)	1 (3.4)	0 (0)	0.644
Mixed growth	7 (20.0)	6 (20.7)	1 (16.7)	0.823
MDR	8 (22.9)	4 (13.8)	4 (66.7)	0.005
Escherichia coli	5 (62.5)	2 (50.0)	3 (75.0)	
Klebsiella pneumoniae	2 (25.0)	2 (50.0)	0 (0)	
Acinetobacter spp.	1 (12.5)	1 (25.5)	0 (0)	
Staphylococcus aureus	1 (12.5)	1 (25.5)	0 (0)	
Staphylococcus epidermidis	1 (12.5)	0 (0)	1 (33.3)	
Enterococcus faecalis	1 (12.5)	0 (0)	1 (33.3)	

Data are shown as number (percentage)

MDR, multidrug resistant

Table 4 Distribution of microbiological pathogens isolated from cultures in patients with Fournier's gangrene

	All patients (*n* = 35)	% Total
Gram-positive	17	48.6
Enterococcus faecium	2	5.7
Enterococcus faecalis	2	5.7
Enterococcus gallinarum	1	2.9
Enterococcus avium	1	2.9
Staphylococcus lugdunensis	1	2.9
Staphylococcus warneri	1	2.9
Staphylococcus aureus	2	5.7
Staphylococcus hemolyticus	1	2.9
Staphylococcus epidermidis	2	5.7
Streptococcus anginosus	4	11.4
Streptococcus a-hemolyticus	2	5.7
Streptococcus agalactiae	1	2.9
Corynebacterium striatum	1	2.9
Leuconostoc lactis	1	2.9
Bacillus licheniformis	1	2.9
Gram-negative	23	65.7
Escherichia coli	17	48.6
Klebsiella pneumoniae	7	20.0
Acinetobacter baumannii	2	5.7
Proteus mirabilis	1	2.9
Proteus vulgaris	2	5.7
Enterobacter aerogenes	1	2.9
Fungus	1	2.9
Candida tropicalis	1	2.9

Table 5 Organ dysfunction analysis data in sepsis due to Fournier's gangrene

	All patients (*n* = 35)	Survivors (*n* = 29)	Non-survivors (*n* = 6)	*p*-value
Organ dysfunction				
Respiratory	7 (20.0)	5 (17.2)	2 (33.3)	0.370
Coagulation	5 (14.3)	1 (3.4)	4 (66.7)	< 0.001
Liver	8 (22.9)	6 (20.7)	2 (33.3)	0.502
Cardiovascular	7 (20.0)	5 (17.2)	2 (33.3)	0.370
CNS	2 (5.7)	1 (3.4)	1 (16.7)	0.204
Renal	20 (57.1)	16 (55.2)	4 (66.7)	0.605

Data are shown as number (percentage)

CNS, central nervous system

Table 6 Multivariable logistic regression analysis of organ dysfunction and in-hospital mortality in patients with Fournier's gangrene

Variable	Crude		Adjusted	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Respiratory	2.4 (0.34–16.9)	0.379	1.1 (0.11–10.94)	0.946
Coagulation	56.0 (4.1–768.5)	0.003	1044.21 (1.70–642865.0)	0.034
Liver	1.92 (0.28–13.08)	0.507	1.99 (0.23–17.17)	0.532
Cardiovascular	2.4 (0.34–16.9)	0.379	1.03 (0.09–11.49)	0.983
CNS	5.6 (0.3–104.94)	0.249	2.88 (0.13–64.17)	0.505
Renal	1.63 (0.26–10.32)	0.607	0.53 (0.03–8.91)	0.661

OR, odds ratio; CI, confidence interval; CNS, central nervous system;

Table 7 Multivariable logistic regression analysis for in-hospital mortality in patients with Fournier's gangrene

Variable	Univariable		Multivariable	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Age (years)	1.05(0.98–1.13)	0.165	1.01(0.89–1.13)	0.921
Sex	4.33(0.54–34.54)	0.166		
Charlson comorbidity index	1.38(0.89–2.13)	0.148	1.72(0.79–3.75)	0.171
ASA score	2.22(0.66–7.46)	0.198		
APACHE II score	1.10(0.96–1.26)	0.171		
FGSI	1.04(0.85–1.27)	0.715	0.94(0.68–1.31)	0.727
Septic shock	5.25(0.80–34.50)	0.084	8.61(0.34–217.58)	0.191
Extent of Disease	2.22(0.37–13.22)	0.380		
Time to administration of antibiotics (mins)	1.00(0.99–1.01)	0.435		
Time to Source control (mins)	0.99(0.99–1.00)	0.436		
MDR	12.5(1.69–92.25)	0.013	45.14(1.66–1225.88)	0.024
Initial lactate level (mmol/L)	0.29(0.08–1.13)	0.075		
Bacteremia	1.25(0.11–13.68)	0.855		

OR, odds ratio; CI, confidence interval; ASA, American Society of Anesthesiologists; APACHE, Acute Physiology and Chronic Health Evaluation; FGSI, Fournier's gangrene scoring index; MDR, multidrug resistant

Discussion

Notably, our results underscore the critical impact of coagulation dysfunction on in-hospital mortality, and independently identify MDR bacterial infections as a significant predictive factor, shedding light on crucial considerations for managing Fournier's gangrene.

Fournier's gangrene is associated with a high mortality rate, necessitating prompt diagnosis and robust treatment [9]. Therefore, understanding the factors related to adverse prognoses and mortality is crucial, as it can enhance survival rates, making the research of prognostic indicators significantly important. Overall, various underlying disease factors, including age, ASA score, and the CCI, have been established as significant determinants of clinical outcomes and prognosis in critically ill patients [17–19]. Additionally, the SOFA scoring system is particularly useful for predicting clinical outcomes, particularly mortality, in critically ill patients [13, 14, 20–22]. Parameters such as the FGSI, a multi-factor prognostic indicator specifically designed for patients with Fournier's gangrene, proved to be a significant prognostic tool, as corroborated by recent literature [22–25]. Specifically, the FGSI showed a consistent correlation with increased mortality and complications across multiple studies, with scores above 9 being associated with a marked rise in mortality rates [26–28]. However, contrary to previous studies, our analysis revealed no significant differences in age ($p=0.161$), CCI ($p=0.139$), ASA score ($p=0.193$), or FGSI ($p=0.724$) between the survivor and non-survivor groups. This will be elaborated upon in the limitations section; however, we posit that the discrepancies in our results compared to those of other studies may stem from the relatively small sample size in our research. Conversely, the initial SOFA score emerged as a notably significant differentiator between these groups. This finding suggests that the degree of organ dysfunction may play a more crucial role than existing comorbidities at the time of presentation in determining the clinical trajectory and prognosis of Fournier's gangrene. The markedly higher initial SOFA score in the non-survivor group (5.0 ± 2.3 vs. 2.0 ± 2.8; $p=0.018$) underscores its potential utility as an early predictor of poor outcomes in patients with Fournier's gangrene. This highlights the critical need for promptly assessing organ dysfunction upon patient presentation and implementing swift interventions to address any identified organ dysfunction. Additionally, early identification and aggressive surgical debridement, alongside appropriate antibiotic therapy, are paramount for improving survival rates [9, 29]. Strategies focused on the early management of organ dysfunction, supported by a thorough understanding of the patient's overall clinical condition through SOFA and FGSI scoring, can significantly improve clinical decision-making. As such, the integration of these scoring systems into routine practice may provide valuable insight into patient prognosis, ultimately guiding therapeutic strategies, and enhancing survival outcomes.

The contribution of coagulation dysfunction to the negative impact on mortality in necrotizing soft tissue infections is well established, with declining platelet counts indicating severity in critically ill patients, and coagulopathy correlating with high mortality rates [30, 31]. Bleeding or disseminated intravascular coagulation events from coagulopathy complicate the treatment of critically ill patients and adversely affect their clinical outcomes [32, 33]. Our study suggests that coagulation dysfunction with reduced platelet count, as a prognostic factor for Fournier's gangrene, is an independent negative prognostic factor for survival. The significantly higher prevalence of coagulation dysfunction in the non-survivor group compared to that in the survivor group demonstrates its association with adverse clinical outcomes. The OR value

indicated a significant impact of coagulation dysfunction on in-hospital mortality, and this robust association persisted even after adjusting for demographic and clinical factors. These findings suggest the importance of monitoring coagulation abnormalities in patients with Fournier's gangrene. Proactive strategies for addressing coagulopathy may be crucial for improving survival rates.

The detection of MDR bacterial infections in critically ill patients is a notable predictor of poor prognosis [34]. MDR bacterial infections in ICUs correlate with poor clinical outcomes, extended hospitalization, and high mortality, presenting challenges owing to high antimicrobial therapy failure rates [35, 36]. Clinicians and institutions are actively researching antibiotics and exploring various strategies for treating MDR bacterial infections [37, 38]. In one notable study of 40 patients with Fournier's gangrene, MDR bacterial infections were reported in 25% of the patients, with a significantly higher rate of MDR bacterial infection in the non-survivor group (62.5% vs. 15.6%; $p<0.05$) [25]. Similarly, our study detected MDR bacterial infections in 22.9% of the patients, revealing a significant association between MDR bacterial infections and in-hospital mortality. This finding highlights the issue of antibiotic resistance in the community, although the underlying disease or nursing home residence status were similar among patients with MDR bacterial infections detected in the initial culture in this study. Although the exact reason for this remains unclear, strategies such as developing an antimicrobial stewardship program to reduce the occurrence of MDR bacterial infection and active and judicious use of antibiotics in the early stages may precede efforts to improve the clinical outcomes of patients.

This study has several limitations. First, it includes selection and confirmation biases, similar to other retrospective studies. Second, this study was conducted at a single institution and had a relatively small sample size. Therefore, unlike other studies, the non-significant results observed in the non-survivor group for sepsis, septic shock, and some scoring systems such as FGSI can be attributed to the limitations stemming from the relatively small sample size of the study [22–25]. Furthermore, with a limited number of cases, treatment modalities and techniques varied slightly among patients, although similar strategies and methods had been employed in patient treatment. To overcome these limitations, it is essential to validate these findings through meticulous interpretations of data from subsequent multicenter cohort studies.

Conclusion

Our study highlights the intricate nature of Fournier's gangrene and emphasizes the pivotal role of the initial SOFA score in predicting clinical outcomes. Notably, coagulation dysfunction and MDR bacterial infections are independent negative prognostic factors, highlighting the importance of prompt monitoring and proactive strategies. These findings provide crucial insights into the challenging landscape of Fournier's gangrene, calling for ongoing research and multicenter studies to validate and enhance our understanding, and ultimately improve patient care and survival rates.

Abbreviations

ALT	Alanine aminotransferase
APACHE	Acute Physiology and Chronic Health Evaluation
ASA	American Society of Anesthesiologists
AST	Aspartate aminotransferase
BMI	Body mass index
BNP	Brain natriuretic peptide
BUN	Blood urea nitrogen
CI	Confidence interval
CKD	Chronic kidney disease
CNS	Central nervous system
CRP	C-reactive protein
DM	Diabetes mellitus
FGSI	Fournier's gangrene scoring index
Hb	Hemoglobin
HTN	Hypertension
ICU	Intensive care unit
INR	International Normalized Ratio
IRB	Institutional Review Board
MDR	Multidrug resistant
OR	Odds ratio
SD	Standard deviation
SD	Standard deviation
SOFA	Sequential Organ Failure Assessment
WBC	White blood cell

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Author contributions

HB analyzed and interpreted the patient data regarding Fournier's gangrene patients. CH and JW reviewed the literature and contributed to manuscript drafting. All authors read and approved the final manuscript.

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted according to the guidelines of the Declaration of Helsinki. The study was approved by the Institutional Review Board of Keimyung University Dongsan Hospital (approval number: DSMC 2023-05-033).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

1. Eke N. Fournier's gangrene: a review of 1726 cases. Br J Surg. 2000;87:718–28.
2. Thwaini A, Khan A, Malik A, Cherian J, Barua J, Shergill I, et al. Fournier's gangrene and its emergency management. Postgrad Med J. 2006;82:516–9.
3. Fournier JA, Fournier JA. Gangrène foudroyante de la verge (overwhelming gangrene). Dis Colon Rectum. 1988;31:984–8.
4. Sorensen MD, Krieger JN, Rivara FP, Broghammer JA, Klein MB, Mack CD, et al. Fournier's gangrene: population based epidemiology and outcomes. J Urol. 2009;181:2120–6.
5. Singh A, Ahmed K, Aydin A, Khan MS, Dasgupta P. Fournier's gangrene. A clinical review. Arch Ital Urol Androl. 2016;88:157–64.
6. Tuncel A, Aydin O, Tekdogan U, Nalcacioglu V, Capar Y, Atan A. Fournier's gangrene: three years of experience with 20 patients and validity of the Fournier's gangrene Severity Index score. Eur Urol. 2006;50:838–43.
7. Yeniyol CO, Suelozgen T, Arslan M, Ayder AR. Fournier's gangrene: experience with 25 patients and use of Fournier's gangrene severity index score. Urology. 2004;64:218–22.
8. Czymek R, Hildebrand P, Kleemann M, Roblick U, Hoffmann M, Jungbluth T, et al. New insights into the epidemiology and etiology of Fournier's gangrene: a review of 33 patients. Infection. 2009;37:306–12.
9. Huayllani MT, Cheema AS, McGuire MJ, Janis JE. Practical review of the current management of Fournier's gangrene. Plast Reconstr Surg Glob Open. 2022;10:e4191.
10. Sroczyński M, Sebastian M, Rudnicki J, Sebastian A, Agrawal AK. A complex approach to the treatment of Fournier's gangrene. Adv Clin Exp Med. 2013;22:131–5.
11. Ballard DH, Mazaheri P, Raptis CA, Lubner MG, Menias CO, Pickhardt PJ, et al. Fournier gangrene in men and women: appearance on CT, ultrasound, and MRI and what the surgeon wants to know. Can Assoc Radiol J. 2020;71:30–9.
12. Leslie SW, Rad J, Foreman J. Fournier gangrene. Treasure Island (FL): StatPearls Publishing; 2024.
13. Singer M, Deutschman CS, Seymour CW, Shankar-Hari M, Annane D, Bauer M, et al. The third international consensus definitions for sepsis and septic shock (Sepsis-3). JAMA. 2016;315:801–10.
14. Vincent JL, de Mendonça A, Cantraine F, Moreno R, Takala J, Suter PM, et al. Use of the SOFA score to assess the incidence of organ dysfunction/failure in intensive care units: results of a multicenter, prospective study. Working group on sepsis-related problems of the European Society of Intensive Care Medicine. Crit Care Med. 1998;26:1793–800.
15. Magiorakos AP, Srinivasan A, Carey RB, Carmeli Y, Falagas ME, Giske CG, et al. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. Clin Microbiol Infect. 2012;18:268–81.
16. Hahn HM, Jeong KS, Park DH, Park MC, Lee IJ. Analysis of prognostic factors affecting poor outcomes in 41 cases of Fournier gangrene. Ann Surg Treat Res. 2018;95:324–32.
17. Lupei MI, Chipman JG, Beilman GJ, Oancea SC, Konia MR. The association between ASA status and other risk stratification models on postoperative intensive care unit outcomes. Anesth Analg. 2014;118:989–94.
18. Charlson ME, Carrozzino D, Guidi J, Patierno C. Charlson comorbidity index: a critical review of clinimetric properties. Psychother Psychosom. 2022;91:8–35.
19. Vallet H, Guidet B, Boumendil A, De Lange DW, Leaver S, Szczeklik W, et al. The impact of age-related syndromes on ICU process and outcomes in very old patients. Ann Intensive Care. 2023;13:68.
20. Ferreira FL, Bota DP, Bross A, Mélot C, Vincent JL. Serial evaluation of the SOFA score to predict outcome in critically ill patients. JAMA. 2001;286:1754–8.
21. Raith EP, Udy AA, Bailey M, McGloughlin S, MacIsaac C, Bellomo R, et al. Prognostic accuracy of the SOFA score, SIRS criteria, and qSOFA score for in-hospital mortality among adults with suspected infection admitted to the Intensive Care Unit. JAMA. 2017;317:290–300.
22. Azmi YA, Alkaff FF, Renaldo J, Wirjopranoto S, Prasetiyanti R, Soetanto KM, et al. Comparison of different scoring systems for predicting in-hospital mortality for patients with Fournier gangrene. World J Urol. 2023;41:2751–7.
23. Doluoğlu ÖG, Karagöz MA, Kılınç MF, Karakan T, Yücetürk CN, Sarıcı H, et al. Overview of different scoring systems in Fournier's gangrene and assessment of prognostic factors. Turk J Urol. 2016;42:190–6.
24. Sparenborg JD, Brems JA, Wood AM, Hwang JJ, Venkatesan K. Fournier's gangrene: a modern analysis of predictors of outcomes. Transl Androl Urol. 2019;8:374–8.
25. Seong WS, Kang BJ, Kim AR, Kim KH, Ha HK. Fournier's gangrene: a 10-year clinical experience at a tertiary Academic Medical Center. Urogenit Tract Infect. 2023;18:64–9.
26. Corcoran AT, Smaldone MC, Gibbons EP, Walsh TJ, Davies BJ. Validation of the Fournier's gangrene severity index in a large contemporary series. J Urol. 2008;180:944–8.
27. Unalp HR, Kamer E, Derici H, Atahan K, Balci U, Demirdoven C, et al. Fournier's gangrene: evaluation of 68 patients and analysis of prognostic variables. J Postgrad Med. 2008;54:102–5.
28. Yilmazlar T, Ozturk E, Ozguc H, Ercan I, Vuruskan H, Oktay B. Fournier's gangrene: an analysis of 80 patients and a novel scoring system. Tech Coloproctol. 2010;14:217–23.
29. Garg G, Singh V, Sinha RJ, Sharma A, Pandey S, Aggarwal A. Outcomes of patients with Fournier's gangrene: 12-year experience from a tertiary care referral center. Turk J Urol. 2019;45(Suppl 1):S111–6.
30. Vanderschueren S, De Weerdt A, Malbrain M, Vankersschaever D, Frans E, Wilmer A, et al. Thrombocytopenia and prognosis in intensive care. Crit Care Med. 2000;28:1871–6.
31. Chen YC, Liou YT, Tsai WH, Chen LW. Prognostic role of subsequent thrombocytopenia in necrotizing fasciitis without liver disease. Ann Plast Surg. 2022;88(1s Suppl 1):S99–105.
32. Gafter-Gvili A, Mansur N, Bivas A, Zemer-Wassercug N, Bishara J, Leibovici L, et al. Thrombocytopenia in Staphylococcus aureus bacteremia: risk factors and prognostic importance. Mayo Clin Proc. 2011;86:389–96.
33. Assinger A, Schrottmaier WC, Salzmann M, Rayes J. Platelets in sepsis: an update on experimental models and clinical data. Front Immunol. 2019;10:1687.
34. GiViTI S, Committee, Bertolini G, Nattino G, Tascini C, Poole D, Viaggi B, et al. Mortality attributable to different Klebsiella susceptibility patterns and to the coverage of empirical antibiotic therapy: a cohort study on patients admitted to the ICU with infection. Intensive Care Med. 2018;44:1709–19.
35. Campion M, Scully G. Antibiotic use in the Intensive Care Unit: optimization and de-escalation. J Intensive Care Med. 2018;33:647–55.
36. Maia MO, da Silveira CDG, Gomes M, Fernandes SES, Bezerra de Santana R, de Oliveira DQ, et al. Multidrug-resistant bacteria on critically ill patients with sepsis at hospital admission: risk factors and effects on hospital mortality. Infect Drug Resist. 2023;16:1693–704.
37. Cassini A, Högberg LD, Plachouras D, Quattrocchi A, Hoxha A, Simonsen GS, et al. Attributable deaths and disability-adjusted life-years caused by infections with antibiotic-resistant bacteria in the EU and the European Economic Area in 2015: a population-level modelling analysis. Lancet Infect Dis. 2019;19:56–66.
38. Antimicrobial Resistance Collaborators. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. Lancet. 2022;399:629–55.

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