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A different perspective for morbidity related to Fournier's gangrene: which scoring system is more reliable to predict requirement of skin graft and flaps in survivors of Fournier's gangrene?

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Abstract

Purpose To identify the prognostic factors that might predict morbidity related to Fournier's gangrene (FG) and particularly requirement of skin grafting and flaps. We also evaluated the validities of different severity indexes.

Methods Thirty male patients with complete data who were treated for FG between January 2012 and December 2018 were retrospectively evaluated. Fournier's Gangrene Severity Index (FGSI), Uludag Fournier Gangrene Severity Index (UFGSI) and Age-Adjusted Charlson Comorbidity Index (ACCI), Laboratory Risk Indicator for Necrotizing Fasciitis (LRINEC) score, the Combined Urology and Plastics Index (CUPI) and neutrophil–lymphocyte ratio (NLR) were calculated for 27 surviving patients. These patients were divided into two groups: Group I (14 patients with primary skin closure) and Group II (13 patients with requiring skin grafting and flaps).

Results Body temperature ($p=0.026$), heart rate ($p<0.001$), respiratory rate ($p=0.029$), creatinine ($p=0.002$), white blood cell count ($p=0.014$), hemoglobin levels ($p=0.018$), involvement of pelvic floor or beyond ($p=0.018$), length of hospital stay ($p=0.049$), previous endourologic instrumentation ($p=0.035$), requirement of cystostomy ($p=0.041$), colostomy ($p=0.046$), orchiectomy ($p=0.034$) and intensive care unit ($p=0.046$) were found to be significantly higher in Group II. All six different scoring systems were significantly higher in the patients who underwent skin grafting and flaps. In multivariate analysis, heart rate, FGSI, UFGSI, NLR, requirement of colostomy and intensive care unit were determined as independent factors for predicting requirement of skin grafting and flaps.

Conclusion FGSI, UFGSI and NLR are more reliable parameters for predicting skin reconstruction method (with the threshold values of 4.5, 5.5, and 7.87, respectively).

Keywords Fournier's gangrene · Morbidity · Scoring systems · Skin graft and flaps

Introduction

Fournier's gangrene (FG) is an acute rapidly progressive disease of the perineal, perianal and genital areas, the anterior abdominal wall or the medial aspect of the thighs, involving the subcutaneous and deep fascias. It is a special name applied to necrotizing fasciitis when caused by polymicrobial agents [1]. The male to female ratio is known to be 10:1 [2]. The most common causes are localized infections resulting from genitourinary, colorectal and dermatological factors, while other etiologic factors are genitourinary trauma, recent surgery, inadequate perineal or urogenital hygiene, urologic instrumentation, chronic alcohol usage, presence of foreign bodies and long-term indwelling catheters [3].

Emergency intervention is mandatory due to the high mortality rates. Treatment takes the form of extensive and

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repetitive surgical debridement, parenteral broad-spectrum antibiotherapy, reconstruction of the defected areas, hemodynamic stabilization and supportive intensive care, as required [4]. Despite modern intensive care techniques and medical therapies, mortality rates were, until recently, high at 30–67% [5], although these rates have seen a dramatic decrease from 50 to 10% within the last 3 decades [6].

Fournier's Gangrene Severity Index (FGSI), the Uludag Fournier Gangrene Severity Index (UFGSI) and the Age-Adjusted Charlson Comorbidity Index (ACCI) are among the most commonly used scoring systems to determine prognosis and mortality in FG [7, 8]. In recent studies, the Laboratory Risk Indicator for Necrotizing Fasciitis (LRINEC) score, the Combined Urology and Plastics Index (CUPI) and the neutrophil–lymphocyte ratio (NLR) have been used to predict mortality associated with FG as additional parameters. To the best of our knowledge, all of these indexes have been used to predict mortality related to FG [9]. That said, there have been no detailed studies to date investigating the predictive values of these indexes in determining morbidity, and there are discrepancies in the stated cut-off values of all these scoring systems in the literature. In the present study, we seek to identify any prognostic factors that may predict morbidity, and particularly a requirement for skin reconstruction. We also evaluate the validity of several severity indexes through a study of 30 patients with FG.

Materials and methods

After gaining the approval of the local ethics committee (protocol number: 77192459-050.99-E.1409, 2/16), the electronic medical records of 40 adult male patients (aged > 18 years) who were treated and followed up in our department between January 2012 and December 2018 due to FG were evaluated retrospectively. Data relating to medical history, initial symptoms, physical examination findings, vital signs and admission laboratory tests were collected from the hospital records. Patients with available data for the calculation of FGSI, UFGSI, ACCI, LRINEC, CUPI and NLR were included in the study. Among these patients, those whose data were not fully accessible, and those who died due to a general condition disorder during treatment were excluded. Patients with solitary perianal, periurethral or scrotal abscesses were also excluded.

Also recorded were the presence of additional disease; history of previous endourologic intervention; requirement for cystostomy, colostomy or orchiectomy; need for intensive care after surgical debridement; number of surgical debridement; reconstruction method of the defected areas (primary closure or skin graft and flaps); and duration of hospitalization. The patients were divided into two groups based on the reconstruction method of the defected skin areas after surgical debridement. Group I consisted of patients with a primary skin closure, while Group II consisted of patients requiring skin grafts or flaps to close the skin due to intensive tissue loss.

The G*Power (G*Power Ver. 3.0.10, Franz Faul, University Kiel, Germany, http://www.psycho.uni-duesseldorf.de/aap/projects/gpower) package program was used to determine the sample size, which was calculated as at least nine individuals in each of the two groups with a total of 18 individuals for a study with 80% power, Type I error (alpha) 0.05 and an effect size of 0.7. In our study involving 27 patients, the power was calculated as 95%.

Fournier's Gangrene Severity Index

The FGSI is one of the most commonly used scoring systems for the determination of prognosis and mortality related to FG. The parameters evaluated by the FGSI are body temperature, heart rate, respiratory rate, hematocrit level, leukocyte count, and serum sodium, potassium, creatinine and bicarbonate levels at admission [7]. Deviations from normal values for each parameter are graded from 0 to 4, and the sum of the points forms the FGSI score.

Uludag Fournier Gangrene Severity Index

The UFGSI is another commonly used scale for the prediction of mortality-related factors and disease prognosis. All parameters used in the FGSI are calculated, and deviations from normal levels are graded from 0 to 4. The body region affected by FG and the patient's age are added to these parameters in UFGSI [7]. An additional point is added if the patient is over 60 years old. One point is added if the FG is confined to the urogenital and/or anorectal region; two points are added if FG is confined to the pelvic region; and six points are added if the FG extends beyond the pelvic region [7].

Age-Adjusted Charlson Comorbidity Index

The ACCI was not developed specifically for FG but is used rather to predict 30-day mortality in cases of trauma or disease requiring immediate radical surgical intervention [8]. Scoring is based on the severity of comorbidities (mild, moderate or severe cases of cardiovascular, pulmonary, gastrointestinal, urinary, neurological, hematologic, etc., disease). Each medical disorder is weighted from 1 to 6, and the scores of each of the 19 medical conditions form the total points. For each one-point increase, another point is added to the ACCI score for each decade of life over the age of 50 [8].

Combined Urology and Plastics Index

The CUPI score is formulated to predict the length of hospital stay and to evaluate the relationship between disease severity and length of hospital stay [9]. CUPI relates to the following parameters: age; and hematocrit, calcium, alkaline phosphatase, albumin, total bilirubin, BUN, INR and serum bicarbonate levels at admission [9]. All parameters are scored individually, and the sum of the points forms the total score, which can range between 0 and 15. CUPI scores ≤ 5 predict an average length of hospital stay of 25 days, while CUPI scores > 5 predict an average length of hospital stay of 71 days [9].

Laboratory Risk Indicator for Necrotizing Fasciitis score

The LRINEC was developed primarily to distinguish between necrotizing fasciitis and soft-tissue infections. Hemoglobin, leukocyte count, serum sodium, creatinine, glucose and C-reactive protein levels at admission are used to calculate the LRINEC score [10]. All parameters are scored individually, and the sum of the points forms the total score. There is a higher probability of necrotizing soft tissue infection occurring at scores > 6 [10].

Neutrophil–lymphocyte ratio

The NLR is known as a sepsis marker, rather than being specific for FG-related prognosis. Levels above 10 are considered to be predictors of FG severity and mortality [11, 12].

Management of treatment

The aggressive surgical debridement of all necrotic tissue within 24 h of hospital admission, the administration of empirical broad-spectrum parenteral antibiotics (ceftriaxone 4 g/day or ciprofloxacin 400 mg/day plus metronidazole 1.5 g/day), daily bedside wound dressing, and repeated resections of infected and necrotic tissue, if necessary, were performed for all patients. A cystostomy, colostomy or orchiectomy was performed, depending on the severity and extent of the disease. Empirical antibiotic therapy was changed based on the results of a tissue culture. Wound reconstruction (primary closure or skin graft and flaps) was conducted after complete wound healing.

Statistical analysis

Kolmogorov–Smirnov and Shapiro–Wilk tests were used for the evaluation of normality. An independent sample *t* test or Mann–Whitney *U* test was applied for continuous variables, and a Pearson Chi-square or Fisher's exact analysis was used for categorical variables, while a Pearson test was used for the correlation analysis. Univariate and multivariate logistic regression analyses were used to determine the predictive factors for the requirement of a skin graft and flap. A receiver operating characteristic (ROC) curve analysis was performed to determine the cutoff values for each scoring system. All analyses were made using the IBM SPSS Statistics 21 (IBM, Armonk, NY, USA) software package. $P < 0.05$ was considered statistically significant.

Results

A total of 30 male patients with available data were included in the study. Of the total, three died, despite intensive care support, and the other 27 patients were discharged upon healing. Of the total, 14 (51.8%) patients underwent primary closure, 3 (11.1%) underwent a skin graft and 10 (37.1%) underwent flap reconstruction. The pedicle flap was obtained from the superomedial thigh. Among the 11 (40.7%) patients who underwent an orchiectomy, 7 (25.9%) had a unilateral and 4 (14.8%) had a bilateral orchiectomy. The mean age of the surviving patients was 62.93 ± 14.91. The 27 patients who survived were divided into 2 groups based on the applied skin reconstruction method (primary closure or skin grafting and flaps). The patients' demographic and clinical data and lab results at admission are presented in Table 1. The flowchart of the patient populations is shown in Fig. 1.

All six of the scoring systems produced significantly higher values in the patients that underwent skin graft and flaps. The predictive factors for the requirement of a skin graft and flap in the univariate analysis are shown in Table 2. In the multivariate analysis, heart rate, FGSI, UFGSI, NLR, colostomy requirement and intensive care unit accession following surgical debridement were determined as independent factors when predicting a need for reconstruction (Table 2).

Table 3 shows the cutoff values of the six different scoring systems, among which the FGSI, UFGSI and NLR were found to be more reliable. The FGSI was found to be correlated with the UFGSI ($r = 0.983$, $p < 0.001$), ACCI ($r = 0.779$, $p < 0.001$), CUPI ($r = 0.794$, $p < 0.001$) and the LRINEC ($r = 0.618$, $p < 0.001$). The NLR was found to be associated only with LRINEC ($r = 0.563$, $p = 0.002$). In an analysis of the three deceased patients, the mean cut-off levels of FGSI, UFGSI and ACCI were found to be 12.13, 15.17 and 12.11, respectively. The data required to calculate the CUPI, LRINEC and NLR in these three patients were unobtainable.

Table 1 The patients' demographic, clinical data and lab results at admission

	Grouping patients according to skin reconstruction method (*n*: 27)			
	Primary closure (*n*: 14, 51.8%)	Repair with skin grafting and flaps (*n*: 13, 48.2%)	Total (*n*: 27, 100%)	*p*
Age (years) (mean ± standard deviation)	66.00 ± 17.14	59.62 ± 11.85	62.93 ± 14.91	0.257†
Body mass index (kg/m^2) (mean ± standard deviation)	25.85 ± 1.84	26.69 ± 1.89	26.25 ± 1.88	0.253†
Body temperature (°C) (mean ± standard deviation)	37.15 ± 1.11	38.06 ± 0.86	37.58 ± 1.08	0.026*,†
Heart rate (bpm) (mean ± standard deviation)	91.29 ± 12.90	112.85 ± 9.78	101.67 ± 15.74	< 0.001*,†
Respiratory rate (mean ± standard deviation)	21.14 ± 5.11	26.15 ± 6.14	23.56 ± 6.08	0.029*,†
Sodium (mmol/L) (mean ± standard deviation)	134.93 ± 4.02	134.25 ± 3.17	134.60 ± 3.58	0.635†
Potassium (mmol/L) (mean ± standard deviation)	4.43 ± 0.61	4.12 ± 0.47	4.28 ± 0.56	0.155†
Creatinine (mg/dL) (mean ± standard deviation)	1.09 ± 0.29	1.58 ± 0.41	1.33 ± 0.43	0.002*,†
Hematocrit (%) (mean ± standard deviation)	39.61 ± 3.09	39.80 ± 5.39	39.70 ± 4.27	0.913†
White blood cell count (total/mm^3 × 10^3) (mean ± standard deviation)	11.51 ± 4.11	17.12 ± 6.65	14.21 ± 6.08	0.014*,†
HCO_3, venous (mmol/L) (mean ± standard deviation)	23.63 ± 5.64	18.94 ± 2.66	21.37 ± 4.99	0.012*,†
Calcium (mg/dL) (mean ± standard deviation)	9.49 ± 1.04	9.90 ± 1.59	9.69 ± 1.32	0.433†
Alkaline phosphatase (IU/L) (mean ± standard deviation)	90.64 ± 45.30	114.53 ± 52.02	102.14 ± 49.22	0.214†
Albumin (g/dL) (mean ± standard deviation)	4.01 ± 0.55	3.64 ± 0.48	3.83 ± 0.54	0.082†
Total bilirubin (mg/dL) (mean ± standard deviation)	1.47 ± 0.49	1.46 ± 0.55	1.47 ± 0.51	0.983†
BUN (mg/dL) (mean ± standard deviation)	18.92 ± 6.04	23.07 ± 8.23	20.92 ± 7.34	0.146†
INR (mean ± standard deviation)	1.57 ± 0.39	1.82 ± 0.47	1.69 ± 0.44	0.148†
Hemoglobin (g/dL) (mean ± standard deviation)	11.81 ± 1.49	10.40 ± 1.41	11.13 ± 1.59	0.018*,†
Glucose (mg/dL) (mean ± standard deviation)	162.50 ± 30.12	161.53 ± 23.33	162.03 ± 26.55	0.927†
C-reactive protein (mg/L) (mean ± standard deviation)	113.21 ± 36.08	139.92 ± 39.55	126.07 ± 39.47	0.078†
Polymicrobial infections detected in tissue cultures (*n*, %)				
Yes	3 (21.4)	4 (30.8)	7 (25.9)	0.678§
No	11 (78.6)	9 (69.2)	20 (74.1)	
No identified microorganisms in tissue cultures (*n*, %)				
Yes	3 (21.4)	2 (15.4)	5 (18.5)	0.538§
No	11 (78.6)	11 (84.6)	22 (81.5)	
Diabetes mellitus (*n*, %)				
Present	6 (42.9%)	7 (53.8%)	13 (48.1)	0.568‡
Absent	8 (57.1%)	6 (46.2%)	14 (51.9)	
Hypertension (*n*, %)				
Present	2 (14.3%)	4 (30.8%)	6 (22.2)	0.385§
Absent	12 (85.7%)	9 (69.2%)	21 (77.8)	
Chronic alcohol usage (*n*, %)				
Present	3 (21.4%)	5 (38.5%)	8 (29.6%)	0.420§
Absent	11 (78.6%)	8 (61.5%)	19 (70.4%)	
Paraplegia/hemiplegia and bedridden (*n*, %)				
Present	2 (14.3%)	4 (30.8%)	6 (22.2%)	0.385§
Absent	12 (85.7%)	9 (69.2%)	21 (77.8%)	
History of endourologic instrumentation (*n*, %)				
Present	4 (28.6%)	9 (69.2%)	13 (48.1%)	0.035*,‡
Absent	10 (71.4%)	4 (30.8%)	14 (51.9%)	
Diverting cystostomy (*n*, %)				
Present	9 (64.3%)	13 (100.0%)	22 (81.5%)	0.041*,§
Absent	5 (35.7%)	0 (0.0%)	5 (18.5%)	
Diverting colostomy (*n*, %)				
Present	2 (14.3%)	7 (53.8%)	9 (33.3%)	0.046*,§
Absent	12 (85.7%)	6 (46.2%)	18 (66.7%)	

Table 1 (continued)

	Grouping patients according to skin reconstruction method (*n*: 27)			
	Primary closure (*n*: 14, 51.8%)	Repair with skin grafting and flaps (*n*: 13, 48.2%)	Total (*n*: 27, 100%)	*p*
Performing orchiectomy (*n*, %)				
Present	3 (21.4%)	8 (61.5%)	11 (40.7%)	0.034*,‡
Absent	11 (78.6%)	5 (38.5%)	16 (59.3%)	
Requirement of intensive care unit (*n*, %)				
Present	2 (14.3%)	7 (53.8%)	9 (33.3%)	0.046*,§
Absent	12 (85.7%)	6 (46.2%)	18 (66.7%)	
Length of hospital stay (days) (mean ± standard deviation)	18.07 ± 6.30	22.00 ± 2.82	20.11 ± 5.17	0.049*,†
Numbers of surgical debridement (median, 25th–75th percentile)	3 (3–4)	3 (3–4)	3 (3–4)	0.793¶
The extent of disease				
Limited to urogenital, anorectal or perineal region	12 (85.7%)	5 (38.5%)	17 (62.9)	0.018*,§
Limited to pelvic floor or spread beyond these areas	2 (14.3%)	8 (61.5%)	10 (37.1)	
Affected body surface area (%) (mean ± standard deviation)	1.21 ± 0.54	1.92 ± 0.75	1.55 ± 0.73	0.011*,†
FGSI score (at admission) (mean ± standard deviation)	3.43 ± 2.95	8.15 ± 3.73	5.70 ± 4.07	0.001*,†
UFGSI score (at admission) (mean ± standard deviation)	5.07 ± 3.02	10.31 ± 4.83	7.59 ± 4.74	0.002*,†
ACCI (at admission) (mean ± standard deviation)	4.57 ± 2.47	7.31 ± 3.17	5.89 ± 3.10	0.019*,†
CUPI (at admission) (mean ± standard deviation)	5.79 ± 2.22	7.92 ± 2.84	6.81 ± 2.71	0.038*,†
LRINEC (at admission) (mean ± standard deviation)	4.21 ± 3.30	7.92 ± 3.01	6.00 ± 3.63	0.006*,†
NLR (at admission) (mean ± standard deviation)	6.99 ± 2.77	11.01 ± 4.10	8.93 ± 3.97	0.046*,†

HCO_3 serum bicarbonate, *BUN* blood urea nitrogen, *INR* international normalized ratio, *FGSI* Fournier's Gangrene Severity Index, *UFGSI* Uludag Fournier Gangrene Severity Index, *ACCI* Age-Adjusted Charlson Comorbidity Index, *CUPI* the Combined Urology and Plastics Index, *LRINEC* Laboratory Risk Indicator for Necrotizing Fasciitis score, *NLR* neutrophil/lymphocyte ratio

*$p < 0.05$. Asterisk (*) indicates statistical significance

†Independent sample *t* test

¶Mann–Whitney *U* test

‡Chi-square test

§Fisher's exact test

Discussion

FG is a rare necrotizing tissue infection. Many anaerobic and aerobic pathogens, such as *Bacteroides fragilis*, *Clostridium perfringens*, *Escherichia coli* and *Enterococcus faecalis*, thrive in this microenvironment [13]. The production of bacterial enzymes, such as collagenases and heparinases, may destroy tissue and may bring about a rapid progression of infection [2]. Inflammation and edema result in inadequate blood flow and hypoxia, thus triggering hypercoagulation, as a mechanism that is responsible for vascular thrombosis, subcutaneous tissue necrosis and skin gangrene in the perineal, genital or perianal regions [13].

Nowadays, FG is no longer considered a fatal disease, being seen today rather as a disease that is accompanied by severe morbidity [9]. The outcomes of surgical reconstruction on quality of life have become more significant due to the increased survival rates. For this reason, new scoring systems are needed for the prediction of disease severity and morbidity [9]. In our series, the mortality rate was 10%, which is consistent with the literature, with the lowest mortality rate reported in the literature (9.1%) being close to our results [11]. The low mortality rates in the present study can be attributed to modern intensive care techniques and supportive medical therapies in our tertiary care referral hospital.

Some studies have found the female sex to be associated with high mortality rates [7, 14], although others have found no such relationship [7, 15]. All the patients in the present study were male, and so no effect of gender was observed. Similar to other studies, age had no significant effect on prognosis, based on our results [7, 12, 16]. The reason for this is that FG is often seen in older ages [7]. Conversely, Yilmazlar et al. [17] added the age parameter into the UFGSI after observing that an age of ≥ 60 years increased mortality rates. Another study reported a younger prevalence with a median age of 51.8 years (range 47–63 years), unlike in the aforementioned publications [18].

There have been a number of studies showing that the presence of more than one comorbidity (chronic renal

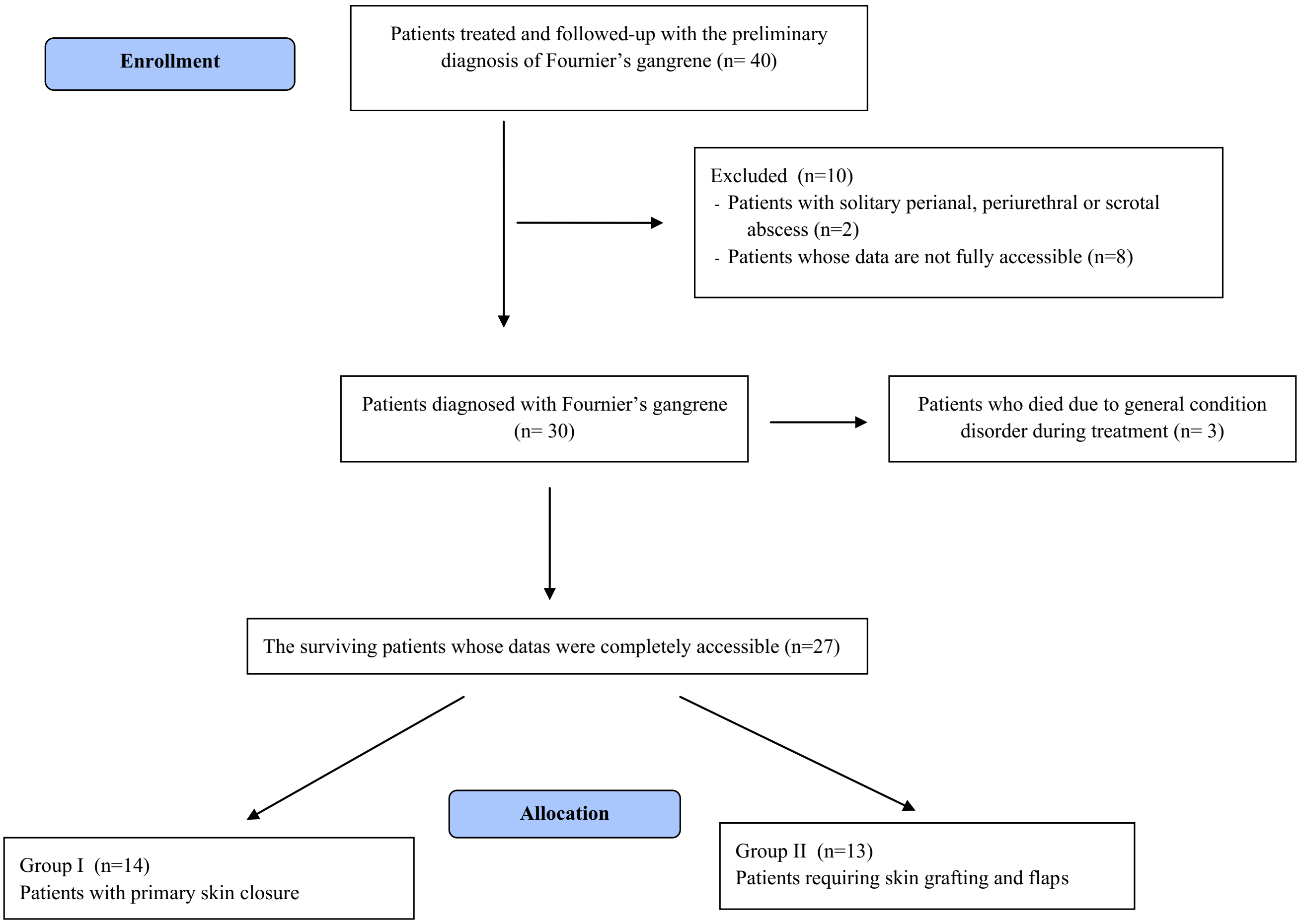

Fig. 1 Flowchart of the study population

failure, diabetes mellitus, malignancy, coronary heart disease, severe sepsis, coagulopathy, etc.) affects mortality related to FG [7, 19]. ACCI, as a general scoring system for comorbid conditions, has been used to predict mortality rates associated with FG. A high value ACCI has been shown to be associated with worse survival outcomes by Erol et al. [21], who identified a threshold value of 4 with a sensitivity of 83% and a specificity of 68%. Tuncel et al. [22], however, was unable to find any significant effect of ACCI scores on mortality. The threshold value was 5.5 in the present study predicting a skin reconstruction method. Our results show that although diabetes mellitus, hypertension, chronic alcohol usage and history of paraplegia/hemiplegia had no effects on the skin reconstruction method, previous endourologic interventions, requirements of cystostomy, colostomy and orchiectomy had significant effects on increased rates of skin grafts and flaps.

The mortality rate is estimated to be 75% for a FGSI of > 9 points, compared to 22% for a FGSI of < 9 points [16]. In different studies, it has been shown that the FGSI has a sensitivity of 65–100% and a specificity of 67–88% [7, 17]. The UFGSI has been stated to be a more powerful tool than the FGSI [23]. The UFGSI has predicted mortality with a sensitivity of 85–100% and a specificity of 67–81% for ≥ 9 points [17]. According to our results, the mean cut-off levels of the FGSI and the UFGSI for the three deceased patients were found to be 12.13 and 15.17, in accordance with the literature. A cutoff value of 4.5 for the FGSI was found to predict a requirement for skin reconstruction, with a sensitivity of 84.6% and a specificity of 71.4%, and the cutoff value for UFGSI was 5.5, with the same sensitivity and specificity. Unlike in other studies, Tuncel et al. [23] and Janane et al. [24] agreed that the extent of disease and metabolic disturbances were more accurate than the FGSI in predicting survival. In the present study, evaluating skin reconstruction methods, a multivariate analysis found the FGSI to be a more valuable predictor than the extent of disease.

The extent of disease is known to be a high-risk factor for mortality [7, 17], although in several older studies, body surface area was not associated with a poor survival prognosis [11, 25]. In our investigation of predictors for the skin reconstruction method, the involvement of the pelvic floor

Table 2 Predictive factors for requirement of skin grafting and flaps

Requirement of skin grafting and flaps	Univariate model				Multivariate model			
	HR	95% CI		*p*	HR	95% CI		*p*
		Lower	Upper			Lower	Upper	
Body temperature (°C)	2.709	1.031	7.114	**0.043**				
Heart rate (bpm)	1.143	1.045	1.250	**0.003**	1.143	1.045	1.250	**0.003**
Respiratory rate	1.174	1.005	1.372	**0.042**				
White blood cell count	1.244	1.014	1.527	**0.036**				
HCO_3	0.761	0.590	0.982	**0.036**				
Hemoglobin	0.483	0.242	0.961	**0.038**				
Creatinine	8.173	2.523	10.440	**0.009**				
FGSI	1.519	1.107	2.083	**0.010**	1.519	1.107	2.083	**0.010**
UFGSI	1.425	1.079	1.882	**0.013**	1.425	1.079	1.882	**0.013**
ACCI	1.466	1.027	2.094	**0.035**				
CUPI	1.412	0.997	2.001	**0.042**				
LRINEC	1.431	1.071	1.910	**0.015**				
NLR	1.489	1.047	2.118	**0.027**	1.567	0.932	2.635	**0.090**
The extent of disease	9.600	1.483	62.162	**0.018**				
Affected body surface area (%)	4.517	1.300	15.692	**0.018**				
Requirement of intensive care unit	7.000	1.098	44.608	**0.039**	4.824	1.396	11.374	**0.029**
History of endourologic instrumentation	5.625	1.077	29.371	**0.041**				
Colostomy requirement	7.000	1.098	44.608	**0.039**	4.824	1.396	11.374	**0.029**
Orchiectomy requirement	5.867	1.075	32.002	**0.041**				

Logistic regression

HCO_3 serum bicarbonate, *FGSI* Fournier's Gangrene Severity Index, *UFGSI* Uludag Fournier Gangrene Severity Index, *ACCI* Age-Adjusted Charlson Comorbidity Index, *CUPI* the Combined Urology and Plastics Index, *LRINEC* Laboratory Risk Indicator for Necrotizing Fasciitis score, *NLR* neutrophil/lymphocyte ratio

$p < 0.05$. Bold values indicate statistical significance

Table 3 The cutoff values of different scoring system related to Fournier's gangrene in predicting requirement of skin grafting and flaps

	FGSI	UFGSI	ACCI	CUPI	LRINEC	NLR
Cut-off value	4.5	5.5	5.5	6.5	5.0	7.87
Sensitivity (%)	84.6	84.6	69.2	76.9	84.6	84.6
Specificity (%)	71.4	71.4	71.4	64.3	71.4	71.4
PPV (%)	74.7	74.7	70.7	68.2	74.7	74.7
NPV (%)	82.2	82.2	69.8	73.5	82.2	82.2
AUC	0.846	0.824	0.777	0.739	0.791	0.799
p	0.002*	0.004*	0.014*	0.035*	0.010*	0.008*

PPV positive predictive value, *NPV* negative predictive value, *AUC* area under curve, *FGSI* Fournier's Gangrene Severity Index, *UFGSI* Uludag Fournier Gangrene Severity Index, *ACCI* Age-Adjusted Charlson Comorbidity Index, *CUPI* the Combined Urology and Plastics Index, *LRINEC* Laboratory Risk Indicator for Necrotizing Fasciitis score, *NLR* neutrophil/lymphocyte ratio

*$p < 0.05$. Asterisk (*) indicates statistical significance

or beyond was found to be an independent risk factor. There is as yet a lack of consensus in the literature on the effects of debridement numbers and colostomy requirements on mortality [7, 19]. We also found no relationship between the number of debridement and the skin reconstruction method, but did identify a colostomy requirement as an independent risk factor in a multivariate analysis.

Wetterauer et al. [12] evaluated the accuracy of the FGSI, LRINEC and NLR in predicting morbidity and mortality. The scoring systems did not find a significant correlation with mortality but were notably found to be associated with a need to perform an orchiectomy, cystostomy and penectomy. The results of these scoring systems are also indicative of the local extent of the disease. Ghodoussipour et al. [9]

found CUPI to be a predictor of the length of hospital stay, being based on the complexity of the wound closure and the requirement for a urinary or fecal diversion. FGSI, LRINEC, NLR and ACCI were not found to be predictive tools in the above study. The above studies did not determine a threshold value, although in a similar study, cut-off values of 4 for FGSI, 6 for LRINEC and 10 for NLR were obtained. Among these three parameters, NLR was significantly associated with mortality, intensive care treatment and longer hospitalization [11]. According to Pehlivanlı et al. [20], as NLR is a sign of poor immunologic and cellular inflammatory reactions, excessive numbers of surgical debridement will not improve mortality rates.

In the present study, all six scoring systems indicated a need for a cystostomy, colostomy, orchiectomy and intensive care unit treatment, and pointed to potentially longer hospitalizations and requirements for skin grafts and flaps. To the best of our knowledge, this is the most comprehensive study to date evaluating the predictive power of all known scoring systems in terms of FG-related morbidity, and especially, requirements for reconstructive surgery.

In recent years, the need for early reconstruction and quality of life have gained importance since the survival rates associated with FG have increased [6]. The timing and early management of skin grafts and flaps are important. We believe that the earlier prediction of a reconstruction requirement based on the results of scoring systems may allow for better disease management. Furthermore, early collaborations with the Plastic, Reconstructive and Aesthetic Surgery department may reduce the length of hospital stays, promoting faster healing times, good cosmetic results and a more satisfactory quality of life.

The main limitations of our study are its retrospective, non-randomized and single-center design, involving limited numbers of patients in a single center. As all of our patients were male, we could not evaluate the effect of gender on morbidity, which is another shortfall of our study. Multicenter, prospective, randomized, controlled and long-term follow-up studies with larger patient populations are needed to validate our results, although it is not easy to carry out studies with larger populations due to the rarity of FG, according to the literature.

Conclusion

Despite the increasing survival rates, FG is still an important urological condition with the potential for mortality. It can be said that all six scoring systems are able to predict FG-related morbidity, although the FGSI, UFGSI and NLR are more reliable for the prediction of the skin reconstruction method. The earlier prediction of the possibility of disfigurement from this disease through the use of scoring systems will allow us to reach more satisfactory outcomes, particularly with the collaboration of the Plastic, Reconstructive and Aesthetic Surgery department. In addition, it is important to refer patients with values above cut-off levels to tertiary health care centers, as these parameters may predict a potential need for an intensive care unit.

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Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest.

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