JIDC | THE JOURNAL OF INFECTION IN DEVELOPING COUNTRIES

Original Article

A prediction model for admission to the intensive care unit in patients with perianal necrotizing fasciitis

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Abstract

Introduction: Patients with perianal necrotizing fasciitis (PNF) frequently require admission to the intensive care unit (ICU). The study aimed to develop a novel scoring system to predict ICU admission in PNF patients.

Methodology: This cohort study retrospectively recruited patients in the Nanjing Hospital of Chinese Medicine. The outcome was the admission to the ICU. Random forest was used to select variables for the development of a new scoring system, whose performance was assessed using the area under the curve (AUC) with a 95% confidence interval (CI). Integrated discrimination improvement (IDI) and net reclassification improvement (NRI) were applied to assess the performance improvement of Sequential Organ Failure Assessment (SOFA) score and Fournier's Gangrene Severity Index (FGSI) compared to the new scoring system.

Results: Totally 106 eligible individuals with PNF were enrolled. SOFA, age, course of disease, and extent of disease were selected to develop the new scoring system, which was named "modified SOFA" (mSOFA). The AUC of the mSOFA was 0.974 (95% CI: 0.931-1.000). SOFA (NRI: -0.72, $p = 0.010$; IDI = -0.05, $p = 0.002$) and FGSI (NRI: -1.50, $p < 0.001$; IDI = -0.55, $p < 0.001$) demonstrated a decreased predictive performance for the ICU admission compared to mSOFA.

Conclusions: The mSOFA scoring system had a better predictive performance for the ICU admission than SOFA and FGSI, indicating that mSOFA may be a reliable tool for the prediction of ICU admission in PNF patients.

Key words: Perianal necrotizing fasciitis; ICU admission; modified SOFA; FGSI; SOFA.

J Infect Dev Ctries 2025; 19(10):1519-1526. doi:10.3855/jidc.21446

(Received 10 February 2025 – Accepted 23 April 2025)

Introduction

Perianal necrotizing fasciitis (PNF) is a serious infectious disease that affects the tissues surrounding the anal and perineal regions [1]. It is characterized by purulent necrosis of the skin and soft tissue, resulting from the synergistic action of multiple bacterial pathogens [1]. PNF progresses rapidly and can cause multiple organ failure, septic shock, and high mortality [2,3]. It has a high rate of intensive care unit (ICU) admission, which causes the aggravation of disease burden [4].

Although numerous scoring systems have been developed to predict mortality, the application of ICU admission prediction in clinical practice has not received enough attention. Early prediction of ICU admission can help clinicians identify critically ill patients in a timely manner and optimize treatment decisions, thereby improving patient survival, shortening ICU stay, and effectively allocating medical resources. Therefore, the development of an effective ICU admission prediction model has important clinical value. Previous studies have shown that early prediction of ICU admission enhances clinical outcomes by enabling timely intervention and appropriate resource deployment, which is crucial to improving patient survival and optimizing clinical management [5,6]. Unlike mortality prediction systems, ICU admission prediction focuses more on intervening before the patient's condition deteriorates to prevent unnecessary delays [7].

Multiple scoring systems have been proposed for assessing the severity of PNF and predicting mortality risk [8]. The Fournier's Gangrene Severity Index (FGSI), that modified from the Acute Physiology and Chronic Health Evaluation (APACHE) II score, is the commonly adopted system to evaluate the decision of treatment and predict outcome for PNF patients [9]. Yilmazlar *et al.* reported that the Uludag Fournier's Gangrene Severity Index (UFGSI) improved the predictive ability of death [10]. However, the impact of time factors on death events was not considered when constructing UFGSI. A prospective cohort study

including 44 PNF patients found no significant difference between FGSI and UFGSI in predicting 30-day mortality [11]. Quick-Sequential Organ Failure Assessment (qSOFA) and SOFA are common prognostic scoring systems for infectious diseases, including sepsis [12,13]. A recent study including 69 PNF patients has shown that qSOFA was significantly correlated with FGSI, and had a comparable predictive ability of mortality risk to FGSI [8]. In PNF patients admitted to the ICU, SOFA did not show significant predictive value in mortality [4].

The sample size of currently reported studies is small. Moreover, the prognostic factors involved in each scoring system are not comprehensive, and the predictive performance varies. In addition, the scoring systems in predicting ICU admission are also unknown. Therefore, we aim to construct a novel scoring system to predict the ICU admission of PNF patients and to compare its predictive performance with existing scores, to more accurately identify high-risk individuals and serve as a reference for clinical decision making and risk control.

Methodology

Study design

This cohort study retrospectively recruited patients in the Nanjing Hospital of Chinese Medicine from 2019 to 2022. The study received approval from the Ethics Committee of Nanjing Hospital of Chinese Medicine (No. KY2021109). Adult patients diagnosed with PNF who underwent surgical debridement were included. Patients with cancers and missing data on the ICU admission were excluded. Each patient had a written informed consent. All patients met the diagnostic criteria for PNF. Then, the patients were randomly assigned to the training set (n = 63) and the test set (n = 43). During the allocation process, we ensured that there were no significant differences in the basic clinical characteristics between the two groups (p > 0.05), except for differences in the distribution of hyperuricemia (Supplementary Table 1).

Outcome variable

The outcome variable was admission to the ICU.

Data collection

Variables including age, gender, course of disease, number of debridement before hospitalization, number of comorbidities (including diabetes, hypertension, hyperlipidemia, hyperuricemia, coronary heart disease, kidney disease, liver disease, blood and immune system diseases), trauma or surgeries (Number of debridement surgeries prior to referral to our hospital, including pelvic fractures, perianal surgeries, etc.), FGSI, SOFA, extent of disease (Y-area only or beyond Y-area), and number of debridement after hospitalization were collected.

The extent of disease was divided into grade I (Y-area only) and grade II (beyond Y-area). Y-area was defined as the area of the perineum, scrotum, and penis, vulva, perianal or inguinal region [14].

SOFA score was constructed based on partial pressure of oxygen/fraction of inspired oxygen (PaO_2/FIO_2), platelets, bilirubin, mean arterial pressure (MAP), dopamine, epinephrine, norepinephrine, dobutamine, Glasgow Coma Scale (GCS) score, creatinine, and urine output [12].

FGSI was calculated based on temperature, heart rate, respiratory rate, serum sodium, potassium, bicarbonate, creatinine, hematocrit, and white blood cell count [11].

Development and validation of a new scoring system

Patients were divided 6:4 into training and test groups. Collected variables were run through random forest, and variables with contribution ratio > 5% in the training set were selected to construct a new scoring system, with area under the curve (AUC) with 95% confidence interval (CI) calculated. The model's performance was validated using the data from the testing set. A nomogram was used to visualize the prediction results of the new scoring system.

Statistical analysis

The test of normality for continuous variables was carried out using the Kolmogorov-Smirnov test. Continuous variables with a normal distribution were displayed as mean ± standard deviation (Mean ± SD), with differences between the two groups compared using an independent samples t-test. Continuous variables without a normal distribution were presented as median and interquartile range [M (Q1, Q3)], with differences between the two groups compared using the Mann-Whitney U rank sum test. Categorical variables were indicated as numbers and percentages [n (%)], with differences between the two groups compared using the chi-square test.

Integrated discrimination improvement (IDI) and net reclassification improvement (NRI) were applied to assess the performance improvement of the SOFA score and FGSI compared to the new scoring system. Negative values of NRI and IDI indicated a decreased performance of the model compared to the reference model. All analyses were conducted with SAS 9.4 (SAS

Institute Inc., Cary, NC, USA) and Python 3.9 (Python Software Foundation, Delaware, USA). The nomogram was generated using R 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was defined as $p < 0.05$.

Results

Patient characteristics

Totally 117 individuals diagnosed as PNF and undergoing surgical debridement were selected. After excluding patients with cancers (n = 10) and missing data on the ICU admission (n = 1), 106 subjects were eligible (Supplementary Figure 1). There were 58 patients admitted to the ICU. We found statistical significance in age, FGSI, respiratory rate, serum potassium, hematocrit, serum bicarbonate, SOFA, PaO_2/FIO_2, platelets, bilirubin, MAP, creatinine, urine output, and extent of disease between ICU patients and non-ICU patients (Supplementary Table 2).

Model development and performance

The eligible patients in this study were separated into a training set (n = 63) and a testing set (n = 43). Baseline characteristics between the two groups did not differ significantly ($p > 0.05$), except for hyperuricemia (Supplementary Table 2).

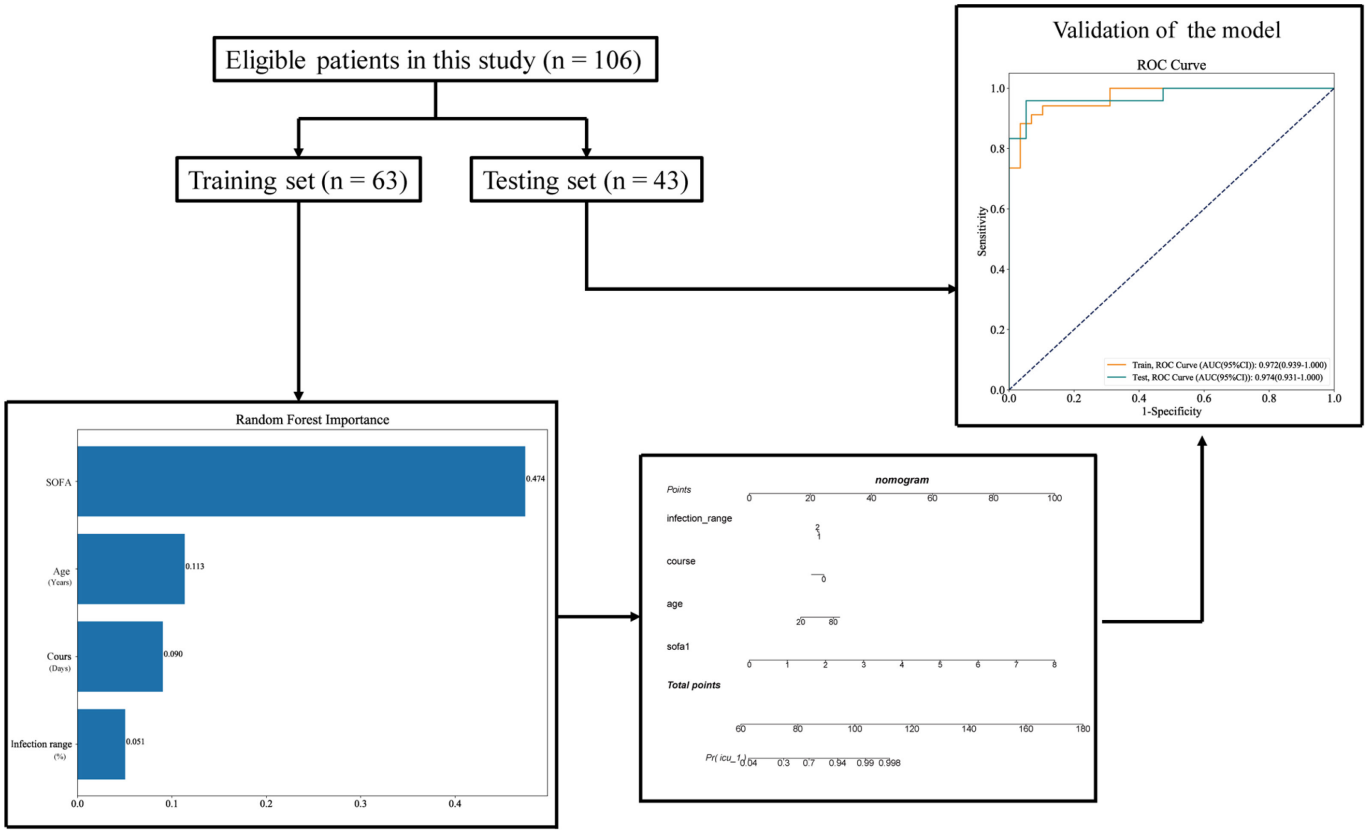
Table 1 shows the comparison of characteristics between patients admitted to ICU and those not admitted to ICU in the training set. Results displayed that a significant difference was found in blood and immune system diseases, FGSI, SOFA, and extent of disease between patients admitted to the ICU and those

Table 1. Comparison of baseline information between patients admitting to ICU and patients not admitting to ICU in the training set.

Variables	Total (n = 63)	ICU admission		Statistics	*p*
		No (n = 29)	Yes (n = 34)		
Age, years, Mean ± SD	53.52 ± 16.99	50.38 ± 15.85	56.21 ± 17.70	t = -1.37	0.177
Gender, n (%)				χ^2 = 0.96	0.327
Male	51 (80.95)	25 (86.21)	26 (76.47)		
Female	12 (19.05)	4 (13.79)	8 (23.53)		
Course of disease, days, M (Q_1, Q_3)	7.00 (5.00, 10.00)	6.00 (4.00, 11.00)	7.00 (6.00, 10.00)	Z = -1.21	0.227
Number of debridement before hospitalization, M (Q_1, Q_3)	0.00 (0.00, 1.00)	0.00 (0.00, 1.00)	0.00 (0.00, 1.00)	Z = 1.28	0.202
Number of comorbidities, n (%)				χ^2 = 0.17	0.917
0	17 (26.98)	8 (27.59)	9 (26.47)		
1	27 (42.86)	13 (44.83)	14 (41.18)		
> 1	19 (30.16)	8 (27.59)	11 (32.35)		
Diabetes, n (%)				χ^2 = 0.36	0.547
No	33 (52.38)	14 (48.28)	19 (55.88)		
Yes	30 (47.62)	15 (51.72)	15 (44.12)		
Hypertension, n (%)				χ^2 = 0.03	0.858
No	42 (66.67)	19 (65.52)	23 (67.65)		
Yes	21 (33.33)	10 (34.48)	11 (32.35)		
Hyperlipidemia, n (%)				-	0.460
No	62 (98.41)	28 (96.55)	34 (100.00)		
Yes	1 (1.59)	1 (3.45)	0 (0.00)		
Hyperuricemia, n (%)					
No	63 (100.00)	29 (100.00)	34 (100.00)		
Coronary heart disease, n (%)				-	0.590
No	60 (95.24)	27 (93.10)	33 (97.06)		
Yes	3 (4.76)	2 (6.90)	1 (2.94)		
Kidney diseases, n (%)				-	1.000
No	60 (95.24)	28 (96.55)	32 (94.12)		
Yes	3 (4.76)	1 (3.45)	2 (5.88)		
Liver diseases, n (%)				-	1.000
No	59 (93.65)	27 (93.10)	32 (94.12)		
Yes	4 (6.35)	2 (6.90)	2 (5.88)		
Blood and immune system diseases, n (%)				-	0.027
No	57 (90.48)	29 (100.00)	28 (82.35)		
Yes	6 (9.52)	0 (0.00)	6 (17.65)		
Trauma or surgeries, n (%)				-	0.495
No	61 (96.83)	29 (100.00)	32 (94.12)		
Yes	2 (3.17)	0 (0.00)	2 (5.88)		
FGSI, M (Q_1, Q_3)	3.00 (1.00, 7.00)	2.00 (1.00, 3.00)	5.00 (2.00, 7.00)	Z = -3.23	0.001
SOFA, M (Q_1, Q_3)	1.00 (0.00, 3.00)	0.00 (0.00, 0.00)	3.00 (2.00, 4.00)	Z = -6.41	< 0.001
Extent of disease, n (%)				χ^2 = 5.40	0.020
Y-area only	21 (33.33)	14 (48.28)	7 (20.59)		
Beyond Y-area	42 (66.67)	15 (51.72)	27 (79.41)		
Number of debridement after hospitalization, M (Q_1, Q_3)	1.10 ± 0.30	1.07 ± 0.26	1.12 ± 0.33	t = -0.65	0.520

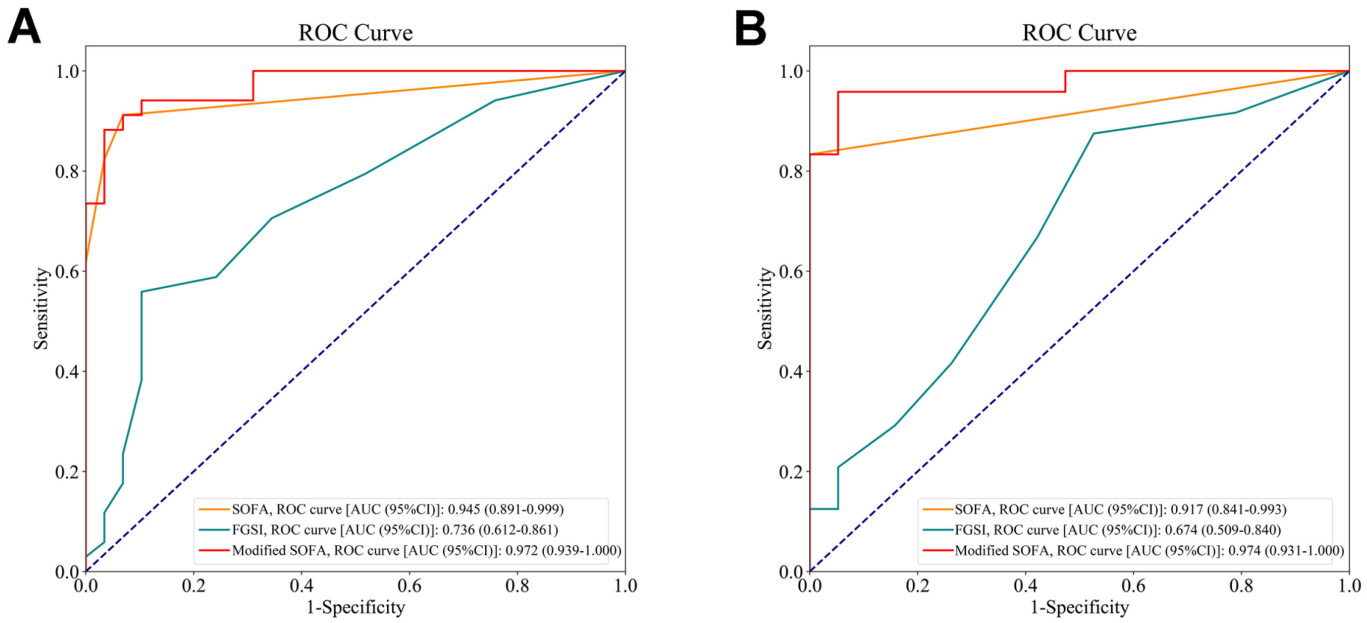
ICU: intensive care unit; Mean ± SD: mean ± standard deviation; FGSI: Fournier's Gangrene Severity Index; SOFA: Sequential Organ Failure Assessment.

Figure 1. The development and validation of modified SOFA.



SOFA: Sequential Organ Failure Assessment.

Figure 2. Comparison of predictive performance of SOFA, FGSI, and mSOFA. A. Comparison of predictive performance of SOFA, FGSI, and modified SOFA in the training set; B. Comparison of predictive performance of SOFA, FGSI, and modified SOFA in the testing set.



SOFA: Sequential Organ Failure Assessment; FGSI: Fournier's Gangrene Severity Index; mSOFA: modified SOFA.

not admitted to the ICU. Supplementary Table 3 shows the comparison of variables in the FGSI and SOFA between patients admitted to the ICU and not admitted to the ICU, and results displayed that respiratory rate, hematocrit, PaO_2/FIO_2, platelets, bilirubin, and MAP were significantly different.

Random forest was used to select SOFA, age, course of disease, lesion extent, and other indicators to establish a model, named "modified SOFA" (mSOFA), with an AUC of 0.972 (95% CI: 0.939-1.000). The performance of mSOFA was validated using the testing set [AUC: 0.974 (95% CI: 0.931-1.000)], indicating a good performance of mSOFA in predicting admission to the ICU in PNF patients. The model based on mSOFA: Logit(P) = -3.603 + 0.034 × age + 2.375 × SOFA - 0.039 × course of disease - 0.081 × (extent of disease = beyond Y area). The processes of the model development and validation were shown in Figure 1.

Comparison of predictive performance of SOFA, FGSI, and mSOFA

Figure 2A shows the performance of SOFA [AUC: 0.945 (95%CI: 0.891-0.999)] and FGSI [AUC: 0.736 (95%CI: 0.612-0.861)] in predicting ICU admission in the training set. Figure 2B shows the predictive performance of SOFA [AUC: 0.917 (95%CI: 0.841-0.993)]and FGSI [AUC: 0.674 (95%CI: 0.509-0.840)] for the ICU admission in the testing set. Compared to mSOFA, SOFA had a comparable re-classification power (NRI: -0.30, p = 0.227) and integrated discrimination (IDI = -0.01, p = 0.408), and FGSI had a significant decrease in re-classification power (NRI: -1.71, $p < 0.001$) and integrated discrimination (IDI = -0.52, $p < 0.001$) in the training set. SOFA (NRI: -0.72, p = 0.010; IDI = -0.05, p = 0.002) and FGSI (NRI: -1.50, $p < 0.001$; IDI = -0.55, $p < 0.001$) showed a decreased predictive performance for the ICU admission compared to the mSOFA model (Table 2) in the testing set. These findings indicated that mSOFA had a better predictive performance for the ICU admission than SOFA and FGSI.

Discussion

This study found a novel scoring system (mSOFA) based on SOFA, age, course of disease, and extent of disease. The mSOFA showed excellent performance in predicting ICU admission. The predictive performance of mSOFA for ICU admission was superior to that of SOFA and FGSI.

PNF usually originates from the genitourinary system and can cause a fulminant progression, leading to multiple organ failure, septic shock, and death [15,16]. Although PNF is rare, it remains a disease with high mortality despite that medical options and intensive care conditions have improved [16,17]. PNF patients often require intensive care unit admission, and about half of these patients experience septic shock upon admission to the ICU, with a mortality rate up to 80% [18]. Age is associated with necrotizing fasciitis, and patients with advanced age adversely affect the survival [16]. PNF is more common in elderly patients, as are other necrotizing soft tissue infections [19,20]. Yilmazlar *et al.* identified age as an independently prognostic variable for patients with PNF [10]. The extent of disease affected the outcome of people with necrotizing soft tissue infections [20]. Similarly, Yilmazlar *et al.* noted that disease severity was independently associated with mortality in PNF subjects [10]. In addition, the duration of symptoms at first admission was considerably longer in patients who died than in those who survived [21]. In this study, age, extent of disease, and course of disease were identified as the important predictors for the ICU admission of patients with PNF. Specifically, older age was associated with a higher risk of ICU admission, as elderly patients are more likely to develop severe complications, such as septic shock and organ failure. The extent of disease, particularly when it involved areas beyond the Y-area (perineum, scrotum, vulva, perianal, and inguinal regions), was a critical factor, as a wider spread of necrosis correlates with more severe disease and a higher likelihood of requiring intensive care. Furthermore, the course of disease-the duration from symptom onset to first medical intervention-also

Table 2. Comparing predictive performance of Modified SOFA, SOFA, and FGSI.

Scoring systems	AUC (95%CI)	NRI (95%CI)	*p*	IDI (95%CI)	*p*
Training set					
Modified SOFA	0.972 (0.939-1.000)	Ref		Ref	
SOFA	0.945 (0.891-0.999)	-0.30 (-0.79, 0.19)	0.227	-0.01 (-0.04, 0.02)	0.408
FGSI	0.736 (0.612-0.861)	-1.71 (-1.94, -1.47)	< 0.001	-0.52 (-0.64, -0.39)	< 0.001
Testing set					
Modified SOFA	0.974 (0.931-1.000)	Ref		Ref	
SOFA	0.917 (0.841-0.993)	-0.72 (-1.28, -0.17)	0.010	-0.05 (-0.08, -0.02)	0.002
FGSI	0.674 (0.509-0.840)	-1.50 (-1.85, -1.15)	< 0.001	-0.55 (-0.67, -0.42)	< 0.001

SOFA: Sequential Organ Failure Assessment; FGSI: Fournier's Gangrene Severity Index; AUC: area under the curve; NRI: net reclassification improvement; IDI: integrated discrimination improvement; CI: confidence interval.

significantly influenced ICU admission; patients with a longer duration of symptoms were more likely to experience systemic complications, requiring intensive monitoring and treatment. These factors, when combined, were incorporated into the mSOFA scoring system to improve the prediction of ICU admission.

A study has reported that the SOFA score on admission to the ICU impacted the length of stay in the ICU and healthcare resource use during the first two days in emergency patients [22]. In addition, SOFA has been demonstrated as a reliable prognostic indicator in patients with life-threatening conditions, such as infection, sepsis, and acute heart failure [23-25]. In line with these findings, our study identified SOFA as a significant predictor for ICU admission in patients with PNF. A higher SOFA score, which reflects the degree of organ dysfunction, was strongly associated with the need for ICU care. This supports the existing literature that highlights the critical role of SOFA in predicting adverse outcomes in critically ill patients. Although few studies have specifically investigated SOFA in PNF patients, Usta *et al.* found a significantly higher SOFA score in patients who died than in those who survived [26]. In a larger series study assessing 168 PNF patients, Lauerman *et al*. reported a significant association between the primary wound closure and a low SOFA score, indicating that SOFA was a good predictor of primary wound closure in patients with PNF [27]. SOFA in this study was determined to be a predictor for ICU admission in patients with PNF. According to our findings, the mSOFA scoring system based on age, extent of disease, course of disease, and SOFA was constructed. The mSOFA scoring system showed a good performance for the prediction of ICU stay (AUC: 0.974).

FGSI was developed to classify risky cases and predict mortality in PNF patients [9]. Noegroho *et al*. evaluated FGSI in 83 PNF patients and found that FGSI was a good tool to predict the severity of the disease and the mortality risk of the patients [28]. Arora *et al*. included 50 patients with PNF to check the power of the FGSI for the prediction of mortality, and found that the FGSI score was associated with mortality [29], indicating that the FGSI at admission should be used to identify patients with a serious prognosis. In this study, we found the superior predictive performance of mSOFA to SOFA (AUC: 0.974 vs. 0.917) and FGSI (AUC: 0.974 vs. 0.674) in the prediction of ICU admission. Our findings indicated that mSOFA may be a reliable scoring system to predict ICU admission in patients with PNF, which may be used to direct patient management. We recommended that hospitalized PNF patients should be immediately assessed with the mSOFA scoring system to make an early decision on whether aggressive treatment should be given to decrease the risk of ICU admission.

There are two limitations in this study. First, due to the rare incidence of PNF and the high survival rate of our center, it is unable to explore the performance of various scoring systems in predicting mortality. Second, selection bias is inevitable in a study conducted in a single center. The mSOFA scoring system for identifying patients with a high risk of ICU admission needs to be further validated by multicenter studies. Therefore, future studies will include validating the mSOFA scoring system in a wider patient population, especially to further evaluate its generalizability in different medical institutions and multi-center studies. Additionally, we plan to explore the application of mSOFA in other critically ill patients, such as patients with acute sepsis and acute heart failure.

Conclusions

This study found that the mSOFA scoring system, based on age, extent of disease, course of disease, and SOFA, showed a good predictive performance for ICU admission in PNF patients, indicating that mSOFA may be a reliable tool used to predict the risk of ICU admission for PNF patients.

Ethics approval and consent to participate

This study was conducted in accordance with the declaration of Helsinki. This study has been approved by the Ethics Committee of Nanjing Hospital of Chinese Medicine (No. KY2021109). Written informed consent was obtained from the participants.

Consent for publication

Written informed consent was obtained from the participants.

Availability of data and materials

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

Authors' Contributions

Yan Ding and Xiaofeng Wang conceived and designed the study; Yan Ding, Yahong Xue, Huiting Zhu, Xingbao Wang, Hao Ma, Haoyue Zhang, and Yaqiu Miao collected the data; Yan Ding, Yahong Xue, Huiting Zhu, Xingbao Wang, Hao Ma, Haoyue Zhang, and Yaqiu Miao analyzed and interpreted the data; Yan Ding wrote the manuscript; Xiaofeng Wang provided critical revisions that are important for the intellectual content; All authors approved the final version of the manuscript.

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Conflict of interest
No conflict of interest is declared.

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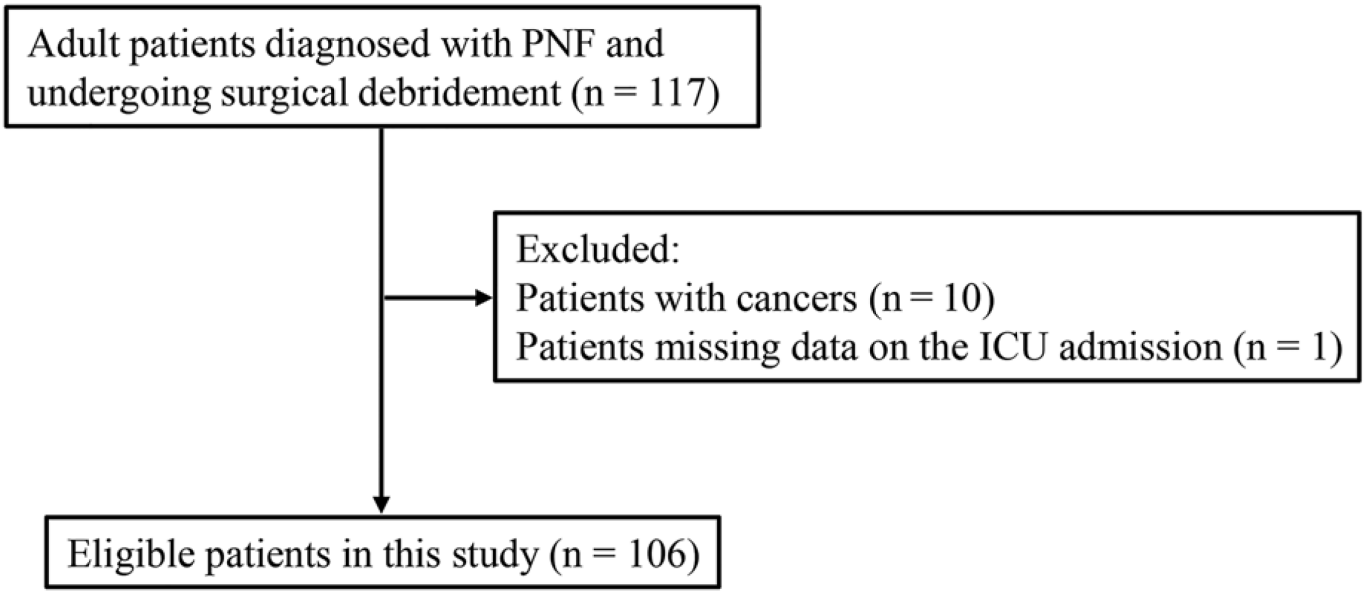
Annex – Supplementary Items

Supplementary Figure 1. Patients' selection funnel.



Supplementary Table 1. The baseline information of patients admitting to ICU or not.

Variables	Total (n = 106)	ICU admission		Statistics	*p*
		No (n = 48)	Yes (n = 58)		
Age, years, Mean ± SD	52.92 ± 16.20	48.15 ± 15.26	56.88 ± 16.01	t = -2.86	0.005
Gender, n (%)				χ^2 = 1.01	0.316
Male	91 (85.85)	43 (89.58)	48 (82.76)		
Female	15 (14.15)	5 (10.42)	10 (17.24)		
Course of disease, days, M (Q_1, Q_3)	7.00 (5.00, 10.00)	7.00 (4.00, 10.00)	7.00 (5.00, 10.00)	Z = 0.08	0.934
Number of debridement before hospitalization, M (Q_1, Q_3)	0.00 (0.00, 1.00)	0.00 (0.00, 1.00)	0.00 (0.00, 1.00)	Z = 0.22	0.824
Number of comorbidities, n (%)				χ^2 = 3.21	0.201
0	31 (29.25)	18 (37.50)	13 (22.41)		
1	43 (40.57)	16 (33.33)	27 (46.55)		
> 1	32 (30.19)	14 (29.17)	18 (31.03)		
Diabetes, n (%)				χ^2 = 1.24	0.265
No	60 (56.60)	30 (62.50)	30 (51.72)		
Yes	46 (43.40)	18 (37.50)	28 (48.28)		
Hypertension, n (%)				χ^2 = 0.52	0.473
No	69 (65.09)	33 (68.75)	36 (62.07)		
Yes	37 (34.91)	15 (31.25)	22 (37.93)		
Hyperlipidemia, n (%)				-	0.589
No	103 (97.17)	46 (95.83)	57 (98.28)		
Yes	3 (2.83)	2 (4.17)	1 (1.72)		
Hyperuricemia, n (%)				-	1.000
No	102 (96.23)	46 (95.83)	56 (96.55)		
Yes	4 (3.77)	2 (4.17)	2 (3.45)		
Coronary heart disease, n (%)				-	0.657
No	101 (95.28)	45 (93.75)	56 (96.55)		
Yes	5 (4.72)	3 (6.25)	2 (3.45)		
Kidney diseases, n (%)				-	1.000
No	100 (94.34)	45 (93.75)	55 (94.83)		
Yes	6 (5.66)	3 (6.25)	3 (5.17)		
Liver diseases, n (%)				-	0.699
No	99 (93.40)	44 (91.67)	55 (94.83)		
Yes	7 (6.60)	4 (8.33)	3 (5.17)		
Blood and immune system diseases, n (%)				-	0.124
No	99 (93.40)	47 (97.92)	52 (89.66)		
Yes	7 (6.60)	1 (2.08)	6 (10.34)		
Trauma or surgeries, n (%)				-	0.500
No	104 (98.11)	48 (100.00)	56 (96.55)		

Yes	2 (1.89)	0 (0.00)	2 (3.45)		
FGSI, M (Q_1, Q_3)	3.00 (1.00, 6.00)	2.00 (1.00, 4.00)	4.50 (2.00, 7.00)	Z = -3.82	< 0.001
Temperature, ℃ n (%)				-	0.117
0 point	91 (85.85)	45 (93.75)	46 (79.31)		
1 point	6 (5.66)	1 (2.08)	5 (8.62)		
3 points	9 (8.49)	2 (4.17)	7 (12.07)		
Heart rate, beats/min, n (%)				-	1.000
0 point	93 (87.74)	42 (87.50)	51 (87.93)		
2 points	11 (10.38)	5 (10.42)	6 (10.34)		
3 points	2 (1.89)	1 (2.08)	1 (1.72)		
Respiratory rate, breaths/min, n (%)				χ^2 = 5.35	0.021
0 point	93 (87.74)	46 (95.83)	47 (81.03)		
1 point	13 (12.26)	2 (4.17)	11 (18.97)		
Serum sodium, mmol/L, n (%)				-	0.854
0 point	94 (88.68)	43 (89.58)	51 (87.93)		
1 point	1 (0.94)	1 (2.08)	0 (0.00)		
2 points	10 (9.43)	4 (8.33)	6 (10.34)		
3 points	1 (0.94)	0 (0.00)	1 (1.72)		
Serum potassium, mmol/L, n (%)				χ^2 = 8.48	0.014
0 point	52 (49.06)	31 (64.58)	21 (36.21)		
1 point	31 (29.25)	10 (20.83)	21 (36.21)		
2 points	23 (21.70)	7 (14.58)	16 (27.59)		
Serum creatinine, mg/100 mL (× 2 for acute renal failure), n (%)				-	0.555
0 point	80 (75.47)	38 (79.17)	42 (72.41)		
2 points	20 (18.87)	9 (18.75)	11 (18.97)		
3 points	3 (2.83)	1 (2.08)	2 (3.45)		
4 points	3 (2.83)	0 (0.00)	3 (5.17)		
Hematocrit, %, n (%)				-	0.002
0 point	85 (80.19)	45 (93.75)	40 (68.97)		
1 point	2 (1.89)	1 (2.08)	1 (1.72)		
2 points	17 (16.04)	2 (4.17)	15 (25.86)		
4 points	2 (1.89)	0 (0.00)	2 (3.45)		
White blood cell count, total/mm × 1000, n (%)				χ^2 = 2.09	0.351
0 point	53 (50.00)	26 (54.17)	27 (46.55)		
1 point	26 (24.53)	13 (27.08)	13 (22.41)		
2 points	27 (25.47)	9 (18.75)	18 (31.03)		
Serum bicarbonate (venous), mmol/L				χ^2 = 10.13	0.006
0 point	87 (82.08)	44 (91.67)	43 (74.14)		
2 points	12 (11.32)	4 (8.33)	8 (13.79)		
3 points	7 (6.60)	0 (0.00)	7 (12.07)		
SOFA, M (Q_1, Q_3)	0.50 (0.00, 3.00)	0.00 (0.00, 0.00)	3.00 (2.00, 4.00)	Z = -8.17	< 0.001
PaO_2/FIO_2, mmHg (kPa), n (%)				χ^2 = 72.94	< 0.001
0 point	61 (57.55)	47 (97.92)	14 (24.14)		
1 point	15 (14.15)	1 (2.08)	14 (24.14)		
2 points	24 (22.64)	0 (0.00)	24 (41.38)		
3 points	6 (5.66)	0 (0.00)	6 (10.34)		
Platelets, $\times 10^3/\mu L$, n (%)				-	< 0.001
0 point	90 (84.91)	48 (100.00)	42 (72.41)		
1 point	5 (4.72)	0 (0.00)	5 (8.62)		
2 points	8 (7.55)	0 (0.00)	8 (13.79)		
3 points	3 (2.83)	0 (0.00)	3 (5.17)		
Bilirubin, mg/dL (μmol/L), n (%)				-	< 0.001
0 point	89 (83.96)	48 (100.00)	41 (70.69)		
1 point	11 (10.38)	0 (0.00)	11 (18.97)		
2 points	6 (5.66)	0 (0.00)	6 (10.34)		
MAP, mm Hg, n (%)				χ^2 = 13.35	< 0.001
0 point	92 (86.79)	48 (100.00)	44 (75.86)		
1 point	14 (13.21)	0 (0.00)	14 (24.14)		
Dopamine, n (%)				-	1.000
0 point	105 (99.06)	48 (100.00)	57 (98.28)		
4 points	1 (0.94)	0 (0.00)	1 (1.72)		
Epinephrine, n (%)				-	1.000
0 point	105 (99.06)	48 (100.00)	57 (98.28)		
3 points	1 (0.94)	0 (0.00)	1 (1.72)		
Norepinephrine, n (%)				-	1.000
0 point	105 (99.06)	48 (100.00)	57 (98.28)		
3 points	1 (0.94)	0 (0.00)	1 (1.72)		
Dobutamine, n (%)				-	1.000
0 point	106 (100.00)	48 (100.00)	58 (100.00)		
Glasgow Coma Scale, M (Q_1, Q_3)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	Z = -0.83	0.408

Creatinine, mg/dL, n (%)				-	0.001
0 point	92 (86.79)	48 (100.00)	44 (75.86)		
1 point	7 (6.60)	0 (0.00)	7 (12.07)		
2 points	2 (1.89)	0 (0.00)	2 (3.45)		
3 points	2 (1.89)	0 (0.00)	2 (3.45)		
4 points	3 (2.83)	0 (0.00)	3 (5.17)		
Urine output, mL/d, n (%)				-	0.001
0 point	106 (100.00)	48 (100.00)	58 (100.00)		
Extent of disease, n (%)				$\chi^2 = 14.29$	< 0.001
Y-area only	41 (38.68)	28 (58.33)	13 (22.41)		
Beyond Y-area	65 (61.32)	20 (41.67)	45 (77.59)		
Number of debridement after hospitalization, M (Q_1, Q_3)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	Z = -1.08	0.279

ICU: intensive care unit; Mean ± SD: mean ± standard deviation; FGSI: Fournier's Gangrene Severity Index; SOFA: Sequential Organ Failure Assessment; PaO_2/FIO_2: partial pressure of oxygen/fraction of inspired oxygen; MAP: mean arterial pressure.

Supplementary Table 2. Comparison of characteristics between training set and testing set.

Variables	Total (n = 106)	Training set (n = 63)	Testing set (n = 43)	Statistics	*p*
Age, years, Mean ± SD	52.92 ± 16.20	53.52 ± 16.99	52.05 ± 15.11	t = 0.46	0.647
Gender, n (%)				$\chi^2 = 3.07$	0.080
Male	91 (85.85)	51 (80.95)	40 (93.02)		
Female	15 (14.15)	12 (19.05)	3 (6.98)		
Course of disease, days, M (Q_1, Q_3)	7.00 (5.00, 10.00)	7.00 (5.00, 10.00)	7.00 (4.00, 10.00)	Z = -0.57	0.571
Number of debridement before hospitalization, M (Q_1, Q_3)	0.00 (0.00, 1.00)	0.00 (0.00, 1.00)	0.00 (0.00, 1.00)	Z = -0.27	0.788
Number of comorbidities, n (%)				$\chi^2 = 0.47$	0.790
0	31 (29.25)	17 (26.98)	14 (32.56)		
1	43 (40.57)	27 (42.86)	16 (37.21)		
> 1	32 (30.19)	19 (30.16)	13 (30.23)		
Diabetes, n (%)				$\chi^2 = 1.13$	0.288
No	60 (56.60)	33 (52.38)	27 (62.79)		
Yes	46 (43.40)	30 (47.62)	16 (37.21)		
Hypertension, n (%)				$\chi^2 = 0.17$	0.681
No	69 (65.09)	42 (66.67)	27 (62.79)		
Yes	37 (34.91)	21 (33.33)	16 (37.21)		
Hyperlipidemia, n (%)				-	0.565
No	103 (97.17)	62 (98.41)	41 (95.35)		
Yes	3 (2.83)	1 (1.59)	2 (4.65)		
Hyperuricemia, n (%)				-	0.025
No	102 (96.23)	63 (100.00)	39 (90.70)		
Yes	4 (3.77)	0 (0.00)	4 (9.30)		
Coronary heart disease, n (%)				-	1.000
No	101 (95.28)	60 (95.24)	41 (95.35)		
Yes	5 (4.72)	3 (4.76)	2 (4.65)		
Kidney diseases, n (%)				-	0.685
No	100 (94.34)	60 (95.24)	40 (93.02)		
Yes	6 (5.66)	3 (4.76)	3 (6.98)		
Liver diseases, n (%)				-	1.000
No	99 (93.40)	59 (93.65)	40 (93.02)		
Yes	7 (6.60)	4 (6.35)	3 (6.98)		
Blood and immune system diseases, n (%)				-	0.237
No	99 (93.40)	57 (90.48)	42 (97.67)		
Yes	7 (6.60)	6 (9.52)	1 (2.33)		
Trauma or surgeries, n (%)				-	0.513
No	104 (98.11)	61 (96.83)	43 (100.00)		
Yes	2 (1.89)	2 (3.17)	0 (0.00)		
FGSI, M (Q_1, Q_3)	3.00 (1.00, 6.00)	3.00 (1.00, 7.00)	3.00 (1.00, 5.00)	Z = 0.06	0.953
SOFA, M (Q_1, Q_3)	0.50 (0.00, 3.00)	1.00 (0.00, 3.00)	0.00 (0.00, 3.00)	Z = -0.49	0.624
Extent of disease, n (%)				$\chi^2 = 1.87$	0.171
Y-area only	41 (38.68)	21 (33.33)	20 (46.51)		
Beyond Y-area	65 (61.32)	42 (66.67)	23 (53.49)		
Number of debridement after hospitalization, M (Q_1, Q_3)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	Z = 1.10	0.273
ICU admission, n (%)				$\chi^2 = 0.04$	0.851
No	48 (45.28)	29 (46.03)	19 (44.19)		
Yes	58 (54.72)	34 (53.97)	24 (55.81)		

Mean ± SD: mean ± standard deviation; FGSI: Fournier's Gangrene Severity Index; SOFA: Sequential Organ Failure Assessment; ICU: intensive care unit.

Supplementary Table 3. Comparison of variables in the FGSI and SOFA between patients admitting to ICU and patients not admitting to ICU in the training set.

Variables	Total (n=63)	ICU admission		Statistics	*p*
		No (n = 29)	Yes (n = 34)		
FGSI					
Temperature, °C, n (%)				-	0.094
0 point	51 (80.95)	27 (93.10)	24 (70.59)		
1 point	5 (7.94)	1 (3.45)	4 (11.76)		
3 points	7 (11.11)	1 (3.45)	6 (17.65)		
Heart rate, beats/min, n (%)				-	0.577
0 point	54 (85.71)	25 (86.21)	29 (85.29)		
2 points	8 (12.70)	3 (10.34)	5 (14.71)		
3 points	1 (1.59)	1 (3.45)	0 (0.00)		
Respiratory rate, breaths/min, n (%)				-	0.016
0 point	53 (84.13)	28 (96.55)	25 (73.53)		
1 point	10 (15.87)	1 (3.45)	9 (26.47)		
Serum sodium, mmol/L, n (%)				-	0.264
0 point	57 (90.48)	27 (93.10)	30 (88.24)		
1 point	1 (1.59)	1 (3.45)	0 (0.00)		
2 points	5 (7.94)	1 (3.45)	4 (11.76)		
Serum potassium, mmol/L, n (%)				$\chi^2 = 3.47$	0.176
0 point	29 (46.03)	17 (58.62)	12 (35.29)		
1 point	19 (30.16)	7 (24.14)	12 (35.29)		
2 points	15 (23.81)	5 (17.24)	10 (29.41)		
Serum creatinine, mg/100 mL (× 2 for acute renal failure), n (%)				-	1.000
0 point	51 (80.95)	24 (82.76)	27 (79.41)		
2 points	10 (15.87)	5 (17.24)	5 (14.71)		
3 points	1 (1.59)	0 (0.00)	1 (2.94)		
4 points	1 (1.59)	0 (0.00)	1 (2.94)		
Hematocrit, %, n (%)				-	0.012
0 point	49 (77.78)	27 (93.10)	22 (64.71)		
1 point	2 (3.17)	1 (3.45)	1 (2.94)		
2 points	10 (15.87)	1 (3.45)	9 (26.47)		
4 points	2 (3.17)	0 (0.00)	2 (5.88)		
White blood cell count, total/mm × 1000, n (%)				$\chi^2 = 1.28$	0.528
0 point	36 (57.14)	18 (62.07)	18 (52.94)		
1 point	12 (19.05)	6 (20.69)	6 (17.65)		
2 points	15 (23.81)	5 (17.24)	10 (29.41)		
Serum bicarbonate (venous), mmol/L				-	0.210
0 point	52 (82.54)	26 (89.66)	26 (76.47)		
2 points	7 (11.11)	3 (10.34)	4 (11.76)		
3 points	4 (6.35)	0 (0.00)	4 (11.76)		
SOFA					
PaO_2/FIO_2, mm Hg (kPa), n (%)				-	< 0.001
0 point	35 (55.56)	28 (96.55)	7 (20.59)		
1 point	10 (15.87)	1 (3.45)	9 (26.47)		
2 points	15 (23.81)	0 (0.00)	15 (44.12)		
3 points	3 (4.76)	0 (0.00)	3 (8.82)		
Platelets, ×103/μL, n (%)				-	< 0.001
0 point	51 (80.95)	29 (100.00)	22 (64.71)		
1 point	4 (6.35)	0 (0.00)	4 (11.76)		
2 points	6 (9.52)	0 (0.00)	6 (17.65)		
3 points	2 (3.17)	0 (0.00)	2 (5.88)		
Bilirubin, mg/dL (μmol/L), n (%)				-	0.003
0 point	53 (84.13)	29 (100.00)	24 (70.59)		
1 point	5 (7.94)	0 (0.00)	5 (14.71)		
2 points	5 (7.94)	0 (0.00)	5 (14.71)		
MAP, mm Hg, n (%)				-	0.006
0 point	55 (87.30)	29 (100.00)	26 (76.47)		
1 point	8 (12.70)	0 (0.00)	8 (23.53)		
Dopamine, n (%)					
0 point	63 (100.00)	29 (100.00)	34 (100.00)		
Epinephrine, n (%)					
0 point	63 (100.00)	29 (100.00)	34 (100.00)		
Norepinephrine, n (%)				-	1.000
0 point	62 (98.41)	29 (100.00)	33 (97.06)		
3 points	1 (1.59)	0 (0.00)	1 (2.94)		
Dobutamine, n (%)					
0 point	63 (100.00)	29 (100.00)	34 (100.00)		
Glasgow Coma Scale, M (Q_1, Q_3)	0.00	0.00 (0.00,0.00)	0.00 (0.00,0.00)	Z = 0.07	0.946

	(0.00,0.00)				
Creatinine, mg/dL, n (%)				-	0.057
0 point	56 (88.89)	29 (100.00)	27 (79.41)		
1 point	4 (6.35)	0 (0.00)	4 (11.76)		
2 points	2 (3.17)	0 (0.00)	2 (5.88)		
4 points	1 (1.59)	0 (0.00)	1 (2.94)		
Urine output, mL/d, n (%)					
0 point	63 (100.00)	29 (100.00)	34 (100.00)		

FGSI: Fournier's Gangrene Severity Index; SOFA: Sequential Organ Failure Assessment; ICU: intensive care unit; PaO_2/FIO_2: partial pressure of oxygen/fraction of inspired oxygen; MAP: mean arterial pressure.