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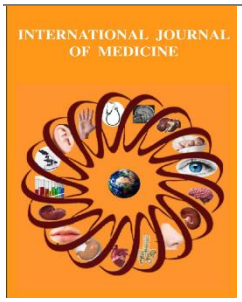

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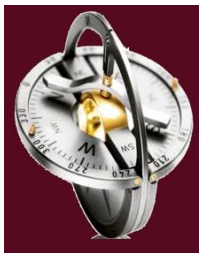

Research Article

Role of Modified LRINEC Score in Early Diagnosis and Prognosis of Necrotising Soft Tissue Infections: A Prospective Observational Study

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Abstract

Objective: Necrotising soft tissue infections (NSTIs) are rapidly progressive, life-threatening infections with high morbidity and mortality if diagnosis is delayed. This study aimed to evaluate the role of the modified Laboratory Risk Indicator for Necrotising Fasciitis (LRINEC) score in differentiating NSTI from non-necrotising soft tissue infections (NNSTIs) and to assess its prognostic significance with respect to morbidity, mortality, and length of hospital stay. ***Methodology:*** A prospective observational study was conducted at a tertiary care centre in Northern India, enrolling 65 patients with clinically suspected soft tissue infections. Patients were stratified into three categories based on modified LRINEC score: low risk (<6), intermediate risk (6-8), and high risk (>8). Demographic characteristics, comorbidities, clinical presentation, and outcomes were recorded. Statistical analysis included Chi-square test, Student's t-test, Pearson correlation, regression analysis, and ROC curve to assess diagnostic accuracy. ***Results***: Among 65 patients, 22 (34%) were confirmed as NSTI and 43 (66%) as NNSTI. Type 2 diabetes mellitus (45%) was the most common comorbidity among NSTI patients. Surgical intervention was required in 86% of NSTI cases, with procedures including fasciotomy with serial debridement, skin grafting, and delayed closure. Two patients underwent amputations, and two succumbed to disease-related complications. The mean hospital stay was significantly longer in patients with high LRINEC scores (19.1 ± 8.3 days vs. 6.5 ± 3.9 days; p<0.001). ICU admission also correlated positively with increasing LRINEC score (p=0.002). ROC analysis revealed an AUC of 0.611 for mortality prediction. Modified LRINEC score ≥8 demonstrated sensitivity of 81.8% and specificity of 80.6% for diagnosing NSTI. ***Conclusion***: The modified LRINEC score is a useful adjunct in early diagnosis and prognostic stratification of NSTIs. While its role in predicting mortality is limited, higher scores correlate strongly with increased morbidity, hospital stay, and ICU admission. Clinical judgment remains essential, and combining LRINEC with bedside evaluation offers optimal accuracy for timely management.

Keywords: Amputation, Diagnosis, Hospital Stay, Laboratory Risk Indicator for Necrotising Fasciitis, Morbidity, Necrotising Fasciitis, Prognosis, Sepsis, Soft Tissue Infections, Surgical Debridement

INTRODUCTION

Necrotising soft tissue infections (NSTI) are a heterogenous group of rapidly progressive infections involving skin, subcutaneous tissue, fascia, or muscle, characterised by fulminant necrosis, systemic toxicity, and high mortality if diagnosis is delayed [1]. The diagnosis is typically confirmed at surgical exploration, with findings of fascial necrosis, thrombosed superficial veins, and deliquescent tissue [2]. However, clinical presentation is often nonspecific, with pain out of proportion to examination as the only early clue, leading to frequent diagnostic delays [3]. Extremity infections are often monomicrobial and caused by group A streptococcus, whereas perineal infections such as Fournier's gangrene are frequently polymicrobial [4,5].

Epidemiologically, NSTI remains rare but life-threatening. The reported annual incidence is 0.4 per 100,000 in the United States and 1 per 100,000 in Western Europe [6]. In the United Kingdom, Public Health England estimates approximately 500 new cases annually [7]. Indian data are limited, but available reports suggest fewer than 100 cases are reported each year [8]. Mortality remains high, ranging between 20–50%, and can reach nearly 100% without timely surgical debridement [9]. The burden is higher in patients with diabetes, obesity, peripheral vascular disease, chronic liver disease, or immunocompromised states [10,11]. Even healthy adults may occasionally be affected [12].

Necrotising fasciitis (NF) represents the most severe form of NSTI, characterised by bacterial invasion and toxin release causing vascular thrombosis, ischemia, and rapid spread along fascial planes [13]. Mortality has remained largely unchanged over the past three decades despite advances in critical care [14]. Early diagnosis and aggressive surgical intervention are critical; however, distinguishing NSTI from severe cellulitis or abscess remains difficult, as initial signs are often indistinguishable [15].

In 2004, Wong et al.16 proposed the Laboratory Risk Indicator for Necrotising Fasciitis (LRINEC) score, a simple diagnostic tool based on six routine laboratory parameters—CRP, WBC count, hemoglobin, sodium, creatinine, and glucose [16]. A score ≥6 suggested a high probability of NF. Subsequent studies reported mixed results. While several validated its usefulness [17–20], others questioned its sensitivity and specificity, especially in emergency settings [21–24]. Recognising these limitations, Borschitz et al. (2015) [13] modified the score by incorporating additional clinical parameters such as "pain out of proportion," erythrocyte count, and fibrinogen levels, improving predictive performance [13].

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Despite these developments, there is limited regional data from India regarding the diagnostic performance and prognostic value of the modified LRINEC score, particularly in northern regions such as Lucknow. Most studies have focused on treatment outcomes, while few have assessed diagnostic tools that could facilitate early recognition and stratification of patients.
Therefore, the present study was designed to evaluate the role of the modified LRINEC score in the early diagnosis and prognostic assessment of necrotising soft tissue infections, and to assess its applicability in differentiating NSTI from non-necrotising infections in our regional patient population.

Objective:
To assess the diagnostic utility and prognostic value of modified LRINEC (Laboratory Risk Indicator for Necrotizing Fasciitis) scores in necrotising soft tissue infections, with a focus on reducing diagnostic delays and evaluating patient outcomes in terms of morbidity, mortality, and hospital stay.

MATERIALS & METHODS

Study Design and Setting
This was a prospective observational study conducted in the Department of General Surgery at Era's Lucknow Medical College and Hospital, Lucknow, Uttar Pradesh, India, a tertiary care teaching hospital with a capacity of 842 beds and 24×7 trauma and emergency services. The hospital is equipped with advanced diagnostic and surgical facilities, and postgraduate trainees actively participate in patient management under supervision. The study was approved by the Institutional Ethics Committee of Era's Lucknow Medical College and Hospital, and informed consent was obtained from all participants prior to enrolment.

Study Population
All patients admitted with clinical suspicion of superficial soft tissue infections during the study period were screened. Those meeting inclusion criteria were enrolled consecutively. Patients were classified into three groups according to their modified LRINEC score at presentation:

- Low risk: score < 6
- Intermediate risk: score 6–8
- High risk: score > 8

Clinical characteristics, comorbidities, laboratory values, surgical interventions, hospital course, and outcomes were recorded. For ROC analysis, patients were dichotomised into ≤8 (low/intermediate risk) and ≥8 (high risk) groups.

Calculation of Modified LRINEC Score
The modified LRINEC score was calculated for each patient using points assigned to six laboratory parameters obtained at admission:

- C-reactive protein (CRP)
- Total white cell count (WBC)
- Hemoglobin
- Serum sodium
- Serum creatinine
- Serum fibrinogen

Points were assigned as per the modified scoring system described by Borschitz et al. [13].

Clinical and Laboratory Evaluation
All patients underwent thorough history taking and physical examination. Pain was assessed using a visual analogue scale. Temperature was recorded using a digital thermometer. Signs of dehydration and renal dysfunction were documented (oliguria, elevated serum urea/creatinine, altered corticomedullary differentiation on imaging).

Routine investigations performed at admission included:

- Complete hemogram (haemoglobin, total leukocyte count, erythrocyte count) using a Sysmax 5-part haematology analyser.
- Serum creatinine using a standard kidney function test.
- Serum fibrinogen and CRP estimated by fully automated chemiluminescence (Vitros platform).
- Additional baseline tests for operative fitness: liver function tests, random blood sugar, PT/INR, viral markers, ECG, and chest X-ray (PA view).

Sample Size Calculation
The sample size was calculated based on the sensitivity of the modified LRINEC score for detecting necrotising fasciitis, assumed to be 72% [Reference: Borschitz et al.[13]]. Using the formula:
n = Z2aSn(100 – Sn) / p e2
Where:

- Sn = 72% (sensitivity)
- p = 32.9% (prevalence of NF among suspected cases)
- e = 20% (error factor)
- α = 0.05, Power = 90%

The minimum sample size required was calculated as 59, which was increased to 65 to account for 10% potential data loss.

Statistical Analysis
Data were entered in Microsoft Excel and analysed using descriptive and inferential statistics. Categorical variables were expressed as frequencies and percentages, while continuous variables were expressed as mean ± standard deviation. Between-group comparisons were performed using the unpaired Student's t-test for continuous variables and the Chi-square test for categorical variables. Pearson's correlation was applied for associations between LRINEC score, hospital stay, and ICU stay. Linear regression was performed to assess LRINEC as a predictor of hospital and ICU stay. Receiver operating characteristic (ROC) curve analysis was used to determine the diagnostic performance of the modified LRINEC score in predicting necrotising infections and outcomes. A p-value < 0.05 was considered statistically significant..

RESULT
Statistical analysis was carried out using descriptive and inferential methods, including Chi-square test, t-test, correlation, regression, and ROC curve analysis, to evaluate the diagnostic and prognostic utility of the modified LRINEC score. A total of 65 patients with soft tissue infections were studied, of whom 22 (34%) had necrotising soft tissue infections (NSTI) and 43 (66%) had non-necrotising infections (NNSTI). Based on modified LRINEC scoring, 26 patients (40%) were classified as low risk (all NNSTI), 24 (37%) as moderate risk (7 NSTI and 17 NNSTI), and 15 (23%) as high risk (all NSTI). The cohort comprised 43 males (66%) and 22 females (34%), with mean ages of 39 and 35 years, respectively, and the highest incidence was seen at extremes of age. Comorbidities were common, present in 80% of patients, with type 2 diabetes mellitus (38%) and hypertension (21%) being most frequent, particularly in NSTI cases. On admission, 58 patients (89%) required operative management, predominantly fasciotomy with serial debridement (63%), followed by skin grafting and delayed primary closure, while only 7 (11%) were managed conservatively. Definitive outcomes included skin grafting in 41%, delayed closure in 31%, and

secondary healing in 27%. Overall, 61 patients (89.7%) had favorable outcomes, whereas 7 (10.3%) had poor outcomes, including 2 deaths. ICU admissions strongly correlated with LRINEC score, with none in the low-risk group, 8 in the moderate group, and 14 in the high-risk group, confirming its prognostic value in predicting morbidity and intensive care requirement.

Table 1. Baseline Clinical and Outcome Characteristics of Patients with Soft Tissue Infections (n = 68)

Variable	Category / Value	n (%)	Mean ± SD (Range)
Type of infection	NNSTI	46 (67.6)	–
	NSTI	22 (32.4)	–
Management outcome	Conservative	7 (10.3)	–
	Operative	61 (89.7)	–
Patient outcome	Negative (death/poor outcome)	7 (10.3)	–
	Positive (survived/favorable outcome)	61 (89.7)	–
Hospital stay (days)	–	–	13.93 ± 9.21 (2–35)
ICU stay (days)	–	–	1.63 ± 3.27 (0–20)
Modified LRINEC score	–	–	6.93 ± 4.22 (0–16)

A total of 68 patients with soft tissue infections were included in the study. Among them, non-necrotising soft tissue infections (NNSTI) were more common (46 cases, 67.6%), while necrotising soft tissue infections (NSTI) accounted for 22 cases (32.4%). With respect to management outcomes, the majority of patients (61 cases, 89.7%) underwent operative management, whereas only 7 patients (10.3%) were managed conservatively. In terms of overall survival, 61 patients (89.7%) had favorable outcomes, while 7 patients (10.3%) had poor outcomes, including mortality. The mean duration of hospital stay was 13.93 ± 9.21 days (range 2–35), while the mean ICU stay was 1.63 ± 3.27 days (range 0–20). The mean modified LRINEC score in the cohort was 6.93 ± 4.22 (range 0–16) (Table 1).

Table 2. Comparison of Hospital and ICU Stay Between Low and High LRINEC Score Groups

Outcome Variable	LRINEC Group	n	Mean ± SD	Mean Difference	t (df)	p-value	95% CI of Difference
Hospital stay (days)	Low (<6)	28	6.54 ± 3.86	–12.56	–7.47 (66)	<0.001	–15.92 to –9.20
	High (≥6)	40	19.10 ± 8.28				
ICU stay (days)	Low (<6)	28	0.21 ± 1.13	–2.41	–3.19 (66)	0.002	–3.92 to –0.90
	High (≥6)	40	2.63 ± 3.88				

When patients were stratified by LRINEC score, those with high LRINEC scores (≥6) had significantly longer hospital and ICU stays compared to those with low LRINEC scores (<6). The mean hospital stay was 19.1 ± 8.28 days in the high LRINEC group versus 6.54 ± 3.86 days in the low LRINEC group, with a mean difference of –12.56 days ($p < 0.001$). Similarly, the mean ICU stay was significantly higher in the high LRINEC group (2.63 ± 3.88 days) compared to the low LRINEC group (0.21 ± 1.13 days) ($p = 0.002$). These findings indicate that a higher LRINEC score is strongly associated with prolonged hospitalization and greater ICU utilization (Table 2).

Table 3. Association Between LRINEC Score Group and Patient Management Outcome

Management Outcome	Low LRINEC (n=28)	High LRINEC (n=40)	Total (n=68)	χ^2, p
Conservative management	4 (14.3%)	3 (7.5%)	7 (10.3%)	χ^2=0.821
Operative management	24 (85.7%)	37 (92.5%)	61 (89.7%)	p-0.36
Total	28 (100%)	40 (100%)	68 (100%)	

Crosstabulation of LRINEC groups with management outcomes revealed that operative management was the predominant approach in both groups, accounting for 85.7% of patients in the low LRINEC group and 92.5% in the high LRINEC group. Conservative management was observed more frequently in the low LRINEC group (14.3%) compared to the high LRINEC group (7.5%). However, this association was not statistically significant ($\chi^2 = 0.821$, $p = 0.365$; Fisher's Exact Test $p = 0.435$). This suggests that management decisions were largely guided by clinical condition and severity rather than LRINEC score alone (Table 3).

Table 4. Association Between LRINEC Score Group and Patient Outcome

Patient Outcome	Low LRINEC (n=28)	High LRINEC (n=40)	Total (n=68)	χ^2, p
Poor outcome (0)	4 (14.3%)	3 (7.5%)	7 (10.3%)	χ^2=0.821
Favorable outcome (1)	24 (85.7%)	37 (92.5%)	61 (89.7%)	p-0.36
Total	28 (100%)	40 (100%)	68 (100%)	

The majority of patients in both LRINEC groups had favorable outcomes, with survival rates of 85.7% in the low LRINEC group and 92.5% in the high LRINEC group. Poor outcomes were slightly more frequent among patients with low LRINEC scores (14.3%) compared to high LRINEC scores (7.5%). However, the difference was not statistically significant ($\chi^2 = 0.8$, $p = 0.37$). This finding indicates that LRINEC score did not significantly predict survival or overall patient outcome in this cohort, although higher scores were associated with longer hospital and ICU stays (Table 4).

Table 5. Correlation Between LRINEC Score, Hospital Stay, and ICU Stay (n = 68)

Variables	Mod. LRINEC Score	Hospital Stay (days)	ICU Stay (days)
Mod. LRINEC score	1	0.665 ($p < 0.001$)	0.472 ($p < 0.001$)
Hospital stay (days)	0.665 ($p < 0.001$)	1	0.679 ($p < 0.001$)
ICU stay (days)	0.472 ($p < 0.001$)	0.679 ($p < 0.001$)	1

Note: Pearson correlation coefficient (r) values shown; all significant at $p < 0.01$.
There was a strong positive correlation between the modified LRINEC score and hospital stay ($r = 0.665$, $p < 0.001$), indicating that patients with higher LRINEC scores tended to have longer hospitalizations. A moderate positive correlation was also observed between LRINEC score and ICU stay ($r = 0.472$, $p < 0.001$), suggesting that higher scores were associated with increased ICU utilization. Additionally, a strong positive correlation existed between hospital stay and ICU stay ($r = 0.679$, $p < 0.001$). These findings support the prognostic value of the LRINEC score in predicting both length of hospital stay and ICU requirement.[Table 5]

Tables 6 and 7. ROC Curve Analysis of Modified LRINEC Score for Predicting Patient Outcome

Parameter	Value
Area under the curve (AUC)	0.611
Standard error	0.064
95% Confidence Interval	0.485 – 0.738
p-value (Asymptotic Sig.)	0.338 (NS)

Table 7: Coordinates of the Curve (Selected Cut-off Points)

Cut-off (≥)	Sensitivity	1 – Specificity
2.5	0.869	1.000
4.5	0.656	0.714
5.5	0.607	0.429
6.5	0.525	0.143
7.5	0.426	0.000

ROC analysis demonstrated that the modified LRINEC score had limited discriminative ability in predicting patient outcome, with an AUC of 0.611 (95% CI: 0.485–0.738, p = 0.338). This suggests that the score performed only slightly better than chance. [Table 6]
At lower cut-off values (≥2.5), the sensitivity was high (86.9%), but specificity was poor (no false-positive discrimination). At higher cut-off points (≥6.5 and above), specificity improved modestly but sensitivity dropped sharply. This trade-off indicates that while LRINEC may be useful for identifying patients at risk of prolonged hospital/ICU stay (as shown in Tables 2 and 5), its predictive accuracy for overall patient survival outcome is limited in this dataset. [Table 7, Fig 1]

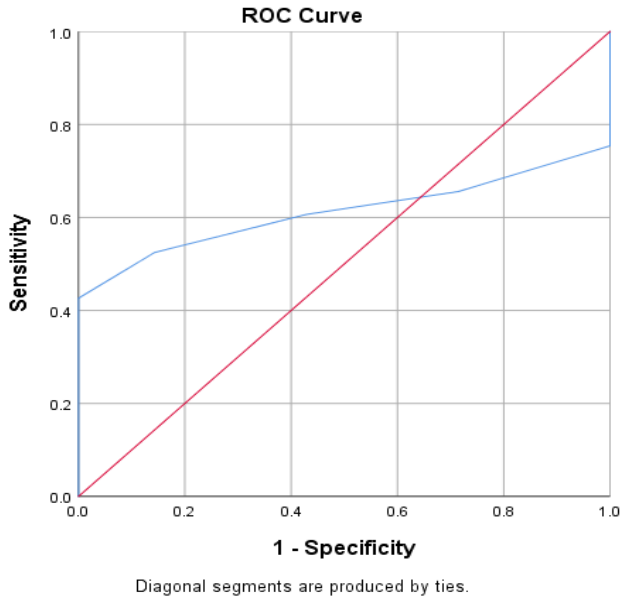

Figure 1: ROC Curve Analysis of Modified LRINEC Score for Predicting Patient Outcome

Table 8. Linear Regression Analysis of Modified LRINEC Score with Hospital and ICU Stay

Dependent Variable	Predictor	β Coefficient (B)	SE	t	p-value	95% CI for B	R^2	F-statistic (p)
Hospital stay (days)	Mod. LRINEC score	1.37	0.19	7.24	<0.001	0.99 – 1.75	0.442	F(1,66) = 52.36, p < 0.001
ICU stay (days)	Mod. LRINEC score	0.35	0.08	4.34	<0.001	0.19 – 0.50	0.222	F(1,66) = 18.88, p < 0.001

Hospital stay: The regression model showed that the modified LRINEC score significantly predicted length of hospital stay (R^2 = 0.442, p < 0.001). For every 1-point increase in LRINEC score, hospital stay increased by approximately 1.37 days. This indicates that nearly 44% of the variability in hospital stay could be explained by LRINEC score.
ICU stay: Similarly, LRINEC score was a significant predictor of ICU stay (R^2 = 0.222, p < 0.001). Each 1-point increase in LRINEC score was associated with a 0.35 day increase in ICU stay. Although the effect size was smaller compared to hospital stay, the association remained statistically significant.[Table 8]
These findings confirm that LRINEC score has prognostic value, particularly in predicting prolonged hospitalisation and ICU requirement, supporting its use as a clinical tool for risk stratification in NSTI.
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Discussion:
Necrotising soft tissue infections (NSTIs) continue to pose a diagnostic and therapeutic challenge due to their rapid progression and high mortality if not treated promptly. Delay in diagnosis and surgical intervention has been shown to significantly worsen outcomes [Su et al., 2008][3]. To aid clinicians, Wong et al. (2004) [16]introduced the LRINEC score, a diagnostic tool based on simple laboratory parameters, for distinguishing NSTI from non-necrotising soft tissue infections (NNSTI). Since its introduction, several studies have evaluated its diagnostic and prognostic accuracy with mixed results.
In the present study, which included 65 patients (22 NSTI, 43 NNSTI), we found that the modified LRINEC score ≥8 demonstrated a sensitivity of 81.8% and specificity of 80.6% for predicting NSTI, with a positive predictive value of 54.2% and a negative predictive value of 68.4%. Our results are in agreement with previous reports suggesting that higher LRINEC scores correlate with greater disease severity and worse outcomes [Abdulla et al., 2019;[17] Bechar et al., 2017;[18] El-Menyar et al., 2017;[19] Narasimham et al., 2018 [20]]. We observed that ICU admissions, need for surgical intervention, and poor outcomes increased proportionally with higher LRINEC scores, highlighting its prognostic

value.

Our findings are also consistent with the observations of Borschitz et al. (2015),[13] who demonstrated that NSTI patients had significantly higher LRINEC scores compared with severe non-necrotising infections like cellulitis. They further proposed modifications to the score, adding clinical parameters such as “pain out of proportion” and laboratory markers like fibrinogen, which improved predictive accuracy. Similarly, Schroder et al. (2019) [25] emphasized the need for combining LRINEC with careful clinical assessment, noting that clinical suspicion remains paramount. In our cohort, the incorporation of LRINEC alongside clinical judgment allowed for timely differentiation between NNSTI and NSTI, supporting this combined approach.

When comparing our findings with Indian studies, we observed parallels. Vijay et al., (2018) [26] studied 50 patients with NSTI and reported diabetes mellitus as the most common comorbidity (38%), similar to our finding of T2DM in 45% of NSTI patients. In Vijay’s series, 56% of patients required limb amputations, especially those with peripheral vascular disease, while in our study, only 2 patients (9%) required amputations.[26] This difference could be attributed to earlier diagnosis and intervention facilitated by LRINEC scoring in our setting. Nedunchezhian et al. (2020) [27] also validated the modified LRINEC score, concluding that it was significantly correlated with prognosis, particularly hospital stay, ICU stay, and need for surgical intervention—findings mirrored in our analysis, where higher scores predicted prolonged hospitalisation and ICU requirement.

Despite these encouraging results, it is noteworthy that some studies have challenged the diagnostic accuracy of LRINEC. For example, Al-Hindawi et al. (2007) [21], Neeki et al. (2017) [23], Hsiao et al. (2020) [22], and Syed et al. (2017) [24] found that LRINEC was not sufficiently reliable in differentiating NSTI from severe cellulitis in emergency settings. Our study partially supports this limitation, as although LRINEC correlated strongly with morbidity measures (hospital stay, ICU admission, operative needs), its discriminative ability for mortality prediction was modest, with an AUC of 0.611 ($p = 0.338$).

Overall, our findings support the use of the modified LRINEC score as a useful adjunct tool in the early diagnosis and risk stratification of NSTI, particularly for predicting morbidity outcomes such as ICU stay, hospital stay, and surgical interventions. However, it should not replace clinical judgment, as mortality prediction remains limited. Combining clinical features with modified LRINEC scoring, as suggested by Borschitz et al. (2015) [13] and Schroder et al. (2019) [25], may offer the most reliable approach for early recognition and improved outcomes

Conclusion:

In this study of 68 patients with soft tissue infections, NNSTI was more common (67.6%) than NSTI (32.4%). The majority required operative management (89.7%) and survival was high (89.7%). The mean hospital stay was 13.9 days, mean ICU stay 1.6 days, and mean modified LRINEC score 6.9. Patients with high LRINEC scores had significantly longer hospital stays (19.1 vs. 6.5 days, $p < 0.001$) and ICU stays (2.6 vs. 0.2 days, $p = 0.002$) compared to low scores. Correlation analysis showed LRINEC was positively associated with both hospital stay ($r = 0.665$, $p < 0.001$) and ICU stay ($r = 0.472$, $p < 0.001$). Regression confirmed LRINEC as a significant predictor of hospital stay ($R^2 = 0.44$, $p < 0.001$) and ICU stay ($R^2 = 0.22$, $p < 0.001$). However, ROC analysis for predicting survival outcome yielded a modest AUC of 0.611 ($p = 0.338$), suggesting limited discriminative ability. Chi-square tests showed no significant association between LRINEC score and either management approach or survival outcome.

The modified LRINEC score demonstrates strong prognostic value for predicting morbidity in necrotising soft tissue infections, as reflected by longer hospitalisation and ICU requirement, but has limited accuracy in predicting overall survival outcomes. Early use of LRINEC scoring can therefore aid in timely risk stratification and resource planning, though clinical judgment remains essential for guiding definitive management and predicting mortality

Conflict of interest: Nil:

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