Thirty-Day Mortality and Morbidity Outcomes in Abdominal Wall Necrotising Soft Tissue Infections: The STANMORE Study

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Running title: The STANMORE Study

Keywords: Necrotising Soft Tissue Infection. Morbidity. Mortality. LRINEC score.

Funding Statement: This study received no funding

Conflict of interest: The Authors declare no conflict of interest.

Word Count: 3439 words

Abstract

Background:

Necrotising soft tissue infection is a rapidly progressive soft tissue infection with a high mortality rate. Limited contemporary data exist on abdominal wall necrotising soft tissue infections. This study aimed to assess 30-day mortality and morbidity and identify associated clinical factors.

Methods:

This was a prospective, multinational, multicenter audit of adult patients (≥18 years) with abdominal wall necrotising soft tissue infection presenting between January 1 and June 30, 2022. Data on demographics, comorbidities, clinical features, treatment, and outcomes were collected. Univariate and multivariate regression analysis were performed to identify independent risk factors for morbidity and mortality.

Results:

A total of 331 patients were included from 63 centres in 27 countries. Thirty-day morbidity and mortality occurred in 200 patients (60.4%), with 47 deaths (14.2%). A LRINEC score ≥6 was observed in 134 out of 263 (51.0%) of cases. Common presenting signs were skin changes in 287 out of 327 cases (87.8%), pain out of proportion to clinical findings in 236 out of 311 cases(75.9%), and gas in soft tissue on imaging 210 out of 329 cases (63.8%). The median time to first antibiotics was 2 hours (Range 0-240 hours) . The median time to surgery was 6 hours (Range 1-384 hours). In the mortality group, 29 out of 47 (61.7%) had diabetes, 33 out of 47 (70.2%) had hypertension, and 25 out of 47 (53.2%) had obesity. Bowel resection (38.3%, 18 out of 47), stoma formation (44.7%, 21 out of 47) and ICU admission

(89.4%, 42 out of 47) were more common in the mortality group ($p < 0.05$, OR 7.47). On multivariable analysis, polymicrobial infection (OR 1.73 CI 1.01-2.95) and bowel resection (OR 3.10 CI 1.22-7.88) were independently associated with morbidity, while increasing age (OR 1.04 CI 1.01-1.07), elevated creatinine(OR1 CI 1.00-1.01), bowel resection (OR 7.47 CI 2.99-18.62), and longer time to antibiotics (OR 1.02, CI 1.00-1.04) were independently associated with mortality ($p < 0.05$).

Conclusion:

Abdominal wall necrotising soft tissue infection is associated with high early morbidity and mortality. Delays in recognition and treatment remain critical contributors. Risk stratification may assist early identification and management.

Introduction

Necrotising soft tissue infection (NSTI) is a rare but life-threatening surgical emergency characterised by rapidly progressive necrosis of the subcutaneous tissue and fascia. Although incidence is low, estimated at 0.3-5 cases per 100,000 population (1,2) it is associated with mortality rates of 20-30% despite advances in antimicrobial therapy, diagnostic imaging and critical care (1,3). Early diagnosis is challenging because initial features can mimic cellulitis or abscesses, while the extent of underlying fascial necrosis may exceed the overlying skin changes. Although scoring tools like the Laboratory Risk Indicator for Necrotising Fasciitis (LRINEC) have been devised to aid differentiation between NSTI and other soft tissue infections the diagnostic accuracy remains variable. Prompt recognition and immediate surgical debridement remain the cornerstone of effective management, with survival rates significantly influenced by the timing of operative intervention.

Abdominal wall NSTI is a relatively uncommon and poorly characterised subtype of NSTI. Unlike infections involving the extremities or the perineum, abdominal wall NSTI frequently occurs secondary to intra-abdominal pathology including bowel perforation or surgical site infections. Findings from studies of NSTIs at other anatomical sites may not be directly applicable to abdominal wall disease. This study aimed to characterise the clinical presentation, management, and 30-day outcomes of patients with abdominal wall necrotising soft tissue infection. Specifically, it aimed to assess mortality and morbidity rates within 30 days of diagnosis and to identify clinical and treatment-related factors associated with these outcomes.

Methods

Study Design and Setting

This study was conducted and is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for cohort studies, and the completed checklist is provided as Supplementary Material 1. The STANMORE Study was a prospective, multicentre, international audit conducted to evaluate 30-day morbidity and mortality outcomes in patients diagnosed with NSTI involving the abdominal wall. Collaborators were recruited through professional networks, social media platforms, and surgical societies. The study was registered as a multinational clinical audit in Forth Valley Royal Hospital, Larbert, United Kingdom, with no alteration to standard patient care or clinical pathways required by participating centres.

Study Period and Population

Patients were enrolled over six months, from January 1, 2022, to June 30, 2022. All adult patients (≥18 years) with a clinical diagnosis of NSTI involving the abdominal wall who underwent surgical intervention within the study period were eligible. Inclusion criteria permitted cases where the abdominal wall was the primary or a component site of infection, including those with concurrent involvement of the perineum, groin, or intra-abdominal viscera. Patients were excluded if NSTI was confined to the extremities or scrotum without involvement of the abdominal wall, or if the date of diagnosis or the date of first surgery fell outside the study period.

Data Collection

Collaborators prospectively identified consecutive eligible patients during the study period and entered data using a standardised electronic spreadsheet provided by the study team. The dataset included variables relating to:

- Demographics: age, sex, ethnicity, smoking status, and comorbidities (diabetes, hypertension, obesity, ischaemic heart disease [IHD], cerebrovascular accident [CVA], autoimmune disease).
- Clinical presentation: signs and symptoms at admission (pain out of proportion, skin changes, fever, crepitus, radiological evidence of gas).
- Laboratory results: C-reactive protein (CRP), white cell count (WBC), haemoglobin (Hb), serum sodium, creatinine, and glucose.
- LRINEC score: calculated using standard criteria (CRP ≥150 mg/L = 4; WBC >25×10⁹/L = 2; Hb <11 g/dL = 2; Na <135 mmol/L = 2; Creatinine >141 µmol/L = 2; Glucose >10 mmol/L = 1).

- Treatment variables: time to antibiotics, time to first surgery, need for bowel resection, stoma, or relook laparotomy.
- Microbiology: categorised as polymicrobial, Group A Streptococcus, or Clostridium species.
- Outcomes: Complications within 30 days of diagnosis. Chest complications here refers specifically to respiratory complications.
- Morbidity: Defined as all complications, including mortality (Clavien-Dindo 1-5).
- Country Classification: Countries were classified as Developed or Developing based on the World Bank database. Low- to Upper-Middle income countries were classed as Developing. Developed countries were limited to high income countries.

Data Management and Statistical Analysis

Data were pooled centrally and cleaned for completeness and internal consistency. Clarification was sought from collaborators where discrepancies were identified. Missing data were not imputed and were handled by case-wise exclusion, and denominators are reported for each variable. Completeness exceeded 98% for demographic, comorbidity, presenting sign and operative variables. The LRINEC score was calculable in 263 of 331 patients (20.5% missing), reflecting its requirement for all six laboratory components and variation between centres in the availability of the full admission panel. Because missingness in this variable differed between outcome groups, LRINEC analyses are presented as applying to the subgroup with complete admission laboratory data rather than to the whole cohort. Descriptive statistics were used to summarise baseline characteristics and outcomes. Categorical variables were presented

as frequencies and percentages, while continuous variables were summarised using means with standard deviations or medians with ranges, as appropriate. Univariate and multivariate regression analyses were conducted to evaluate factors associated with morbidity and mortality. Variables considered clinically relevant were initially assessed using univariate analysis, and those with *p*-values <0.20 were subsequently included in the multivariate regression model. For the morbidity model, all variables meeting this threshold were entered. Due to the large number of univariate analyses performed, a Bonferroni correction was applied to the significance threshold within each outcome family. Each family comprised 20 comparisons, giving a corrected threshold of 0.0025. Bonferroni-adjusted P values are reported alongside unadjusted values, and the confidence intervals reported are unadjusted 95% intervals. Associations reaching $P < 0.05$ but not retaining significance after correction are described as nominally significant and are interpreted as hypothesis-generating. For the mortality analysis, given the limited number of events (n = 47), the number of predictors in the multivariate model was restricted to five to minimise the risk of overfitting. The five predictors entered were age, serum creatinine, multi-site involvement, bowel resection and time to first antibiotic administration, selected on the basis of univariate strength of association and prior clinical plausibility. Hypertension was not entered despite a strong univariate association. Results are presented as odds ratios (ORs) with corresponding confidence intervals (CIs) and *p*-values. Statistical analyses were performed using IBM SPSS Statistics version 26.

Ethics and Governance

As a service evaluation audit, ethical approval was not mandated centrally. Each participating site was responsible for obtaining appropriate local approvals in accordance with institutional governance policies. Patients were informed that anonymised data would be entered into a UK-

based registry, and this discussion was recorded in the medical record. No patient-identifiable data were collected.

Results

A total of 331 patients with abdominal wall necrotising soft tissue infection were included from 63 centres across 27 countries. The median number of entries per centre was 3 (range 1-24). Data were submitted by 153 collaborators. Table 1 describes the patient demographics. The mean age of the cohort was 52.4 years (SD 15.6), and 176 (53.2%) were male. Common comorbidities included diabetes in 180 patients (55.2%), hypertension in 151 patients (45.8%), and obesity in 151 patients(45.8%). Overall, 200 patients (60.4%) developed 30-day morbidity, and 47 patients (14.2%) suffered mortality.

Compared with patients without complications, those who developed morbidity were more frequently female (p=0.02, OR 1.7 CI 1.09-2.66), obese (p=0.025, OR 1.44 CI 0.82-2.55), and had cerebrovascular disease (p=0.043, OR 1.22 CI 0.49-3.05). Mortality comparisons were performed between patients who died and survivors. Patients who passed away had a higher mean age (58.8 years, p=0.002, OR1.04 CI 1.01-1.07), and hypertension (p<0.001, OR 3.30 CI 1.70-6.43), ischaemic heart disease (p=0.016, OR 2.25 CI 1.15-4.41), cerebrovascular disease (p=0.002, OR 3.02, CI 1.47-6.19), and autoimmune disease (p=0.037) were more common in this group.

Table 2 describes the presenting features. Associations reported from Tables 1 to 4 are unadjusted for multiplicity, and those reaching $P < 0.05$ without retaining significance after Bonferroni correction are described as nominally significant and interpreted as hypothesis-generating. Pain out of proportion, skin changes, and radiological gas in soft tissue were

common presenting features. Skin changes (p=0.016), fever (p=0.003), clinical crepitus (p<0.001), and radiological gas (p=0.015) were more frequently observed among patients with morbidity. Pain out of proportion (p=0.014), crepitus (p<0.001), and radiological gas (p<0.001) were more frequent among patients in the mortality group. Having abdominal wall necrotising soft tissue infection in more than one site was more common in the morbidity and mortality group. LRINEC scores were available for 263 patients, of whom 134 (51.0%) had a score ≥6. These analyses therefore apply to the subgroup with complete admission laboratory data rather than to the whole cohort. LRINEC data were missing more often among patients who developed morbidity (50 of 200, 25.0%) than among those who did not (18 of 131, 13.7%). LRINEC ≥6 was more frequent among patients with morbidity (p=0.017) and in the mortality group compared with survivors (p=0.029). The median time to antibiotics was 2 hours, and the median time to surgery was 6 hours, with no differences between groups.

Table 3 describes postoperative outcomes. Patients with morbidity more frequently required bowel resection (p<0.001), stoma formation (p=0.004), re-look surgery (p=0.013), and ICU admission (p<0.001). Among patients with morbidity, wound-related complications were the most common in 121 out of 199 patients(60.8%), followed by chest complications in 32 out of 199 (16.1%) and bleeding in 15 out of 199 (7.5%). The morbidity subgroup also had a high prevalence of Group A Streptococcus (47/196, 24.0%) and polymicrobial infections (133/196, 67.9%). Complication rates by Clavien-Dindo classification, including grade IIIb or higher, were 45.9% in patients with complications . Bowel resection, stoma and ICU admission were statistically more common in the mortality group. There was no statistically significant difference in microbiological results between the mortality and survivor groups.

Table 4 compares developing and developed countries. Among 331 patients, 85 were treated in developed countries and 246 in developing countries. Morbidity (52.9% vs 63.0%, p=0.10) and mortality (16.5% vs 13.4%, p=0.48) did not differ between groups.

Tables 5 and 6 describe the univariate and multivariate regression models for morbidity and mortality. Due to the large number of univariate analyses, a Bonferroni correction was also applied to correct the significance threshold. Hypertension showed the strongest univariate association with mortality (OR 3.30, 95% CI 1.70 to 6.43, P < 0.001) but was not among the five predictors entered into the multivariate model, which was constrained by the number of events. On multivariable analysis, polymicrobial infection (OR 1.73, p=0.04) and bowel resection (OR 3.10, p=0.02) were independently associated with morbidity. For mortality, age (OR 1.04, p=0.01), higher creatinine (p=0.004), bowel resection (OR 7.47, p<0.001), and longer time to antibiotics (p=0.02) were independently associated with death.

Discussion

Our data confirm that classical features of NSTI, such as pain out of proportion to examination findings (236/311, 75.9%), skin changes (287/327, 87.8%), and systemic symptoms including fever (234/330, 70.9%), were frequently observed. These findings are consistent with prior literature, including historical series reporting similar frequencies of pain (72%), erythema (72%), and soft tissue oedema (75%), supporting the reliability of these clinical indicators in identifying NSTI (4). Despite this, diagnostic uncertainty persists. The presence of gas in soft tissue, a hallmark radiological feature, had a sensitivity of only 48.9% on plain X-ray. In contrast, CT demonstrated improved diagnostic performance with a sensitivity of 88.5% and specificity of 93.3% (5). These findings highlight the importance of

maintaining a high index of suspicion and utilising appropriate imaging modalities to reduce diagnostic delay and improve patient outcomes.

The LRINEC score was first described by Wong (6) as a clinical tool for identifying patients with suspected NSTI. A threshold of ≥6 was proposed for raising clinical suspicion, with a score of ≥8 indicating a high likelihood of disease. In our study, 51% of the total cohort of patients had a LRINEC score ≥6. The percentage of patients with a score of ≥6 was statistically significantly higher in both the morbidity (57.3%) and mortality (64.9%) groups ($p < 0.05$). These findings highlight that although LRINEC may be useful in supporting diagnostic decision-making, it has limited discriminatory power and cannot be relied upon in isolation. Notably, a proportion of patients with NSTI in our cohort had a score of 0, reinforcing the need for clinical vigilance and a low threshold for initiating treatment when suspicion remains high. However, it is worth noting that the blood parameters used in the LRINEC score were obtained at admission, and not all patients developed NSTI at admission, as mentioned earlier.

The cornerstone of effective NSTI management is prompt antibiotic therapy combined with timely surgical debridement. In the current study, the time to first antibiotic administration in the mortality group varied widely, ranging from 0.2 to 240 hours, while the interval to first surgery extended from 1 to 267 hours. Time to first antibiotic administration was independently associated with mortality. Our study found that polymicrobial infection was the most common microbiological isolate, followed by Group A Streptococcus and Clostridium species. This distribution is consistent with the classification of NSTI into Type 1 and Type 2, based on microbiological profile (7). The predominance of polymicrobial infections in our cohort likely reflects the abdominal origin of many cases, in which

contamination from gastrointestinal flora is more likely. Notably, polymicrobial infection was independently associated with morbidity on multivariable analysis. This has implications for empirical antibiotic coverage, underscoring the need for broad-spectrum regimens that target both aerobic and anaerobic organisms at the time of presentation.

Time to surgery was not identified as a significant predictor. This discrepancy may be explained by the limited statistical power to detect an effect of surgical delay. Factors contributing to operative delay in our cohort included misdiagnosis at presentation, secondary development of abdominal wall NSTI from intra-abdominal pathology or postoperative complications, institutional logistical constraints, and inter-hospital transfers. Moreover, as the data collected was the time to antibiotic or surgery from admission, the delayed time gathered does not necessarily reflect the time from when NSTI was suspected. These findings reinforce the need for heightened clinical vigilance and early intervention, particularly in atypical or postoperative presentations. Importantly, they should not be interpreted as diminishing the role of early surgical debridement, which remains a fundamental principle in the management of necrotising soft tissue infections.

Our study reported a 30-day mortality rate of 14.2%, consistent with previously reported figures in the literature. Al-Qurayshi (8) reported an overall mortality risk of 12.6%, while Khamnuan (9) documented a higher rate of 19.3%, with 92.8% of deaths occurring in hospital and the remainder within 28 days of surgery. Among patients who died in our cohort, common comorbidities included diabetes (29 out of 47, 61.7%), hypertension (33 out of 47, 70.2%), and obesity (25 out of 47, 53.2%), with a predominance of male patients (27 out of 47, 57.4%). Compared with survivors, hypertension, ischaemic heart disease, cerebrovascular

disease, and autoimmune disease were more common among patients who passed away, suggesting a higher burden of cardiovascular and systemic comorbidity in this group.

Wound-related complications were the most frequent in this group, and myocardial infarction occurred more frequently in patients who died compared with survivors. Similarly, in the morbidity group, diabetes (110/195, 56.4%), hypertension (99/199, 49.7%), and obesity (101/199, 50.8%) were prevalent, with wound-related issues again representing the most common complication. These findings are consistent with those of Light (10), who identified diabetes and cardiovascular disease, including hypertension, as the most frequent comorbidities in patients with NSTI. Tan (11) further showed that diabetic patients often presented atypically, with hypotension and tenderness, contributing to delayed diagnosis, prolonged time to surgery, and extended hospitalisation. However, mortality rates were similar between diabetic and non-diabetic patients, a pattern that was also observed in our cohort, where the proportion of diabetic patients did not differ substantially between those with and without complications.

Furthermore, a higher percentage of patients with morbidity and mortality underwent bowel resection and stoma formation. On multivariable analysis, bowel resection was independently associated with mortality, likely reflecting more advanced disease and extensive tissue involvement. Indications for stoma creation in our study included extensive involvement of the abdominal wall, groin, and perineum requiring wide debridement and defunctioning, as well as bowel perforation. In several cases, bowel perforation was the primary pathology, subsequently leading to secondary abdominal wall necrotising soft tissue infection. This aligns with findings from a review by Kumar (12), which identified the abdominal wall

(43%), the thigh and lower extremities (50%), and the flank/retroperitoneum (32%) as common sites involved in NSTI secondary to bowel perforation.

Our multivariable regression analysis identified age, serum creatinine, bowel resection, and time to first antibiotic administration as independent predictors of mortality, while polymicrobial infection and the need for bowel resection were independently associated with morbidity. Beyond these findings, the overall results of this study provide clinically relevant insights that may support decision-making in necrotising soft tissue infections. Increasing age and elevated creatinine likely reflect reduced physiological reserve and the presence of systemic organ dysfunction at presentation, identifying patients at particularly high risk of adverse outcomes. For surgeons, particularly those with less experience managing necrotising infections, these findings should not be viewed in isolation but rather used alongside clinical judgement to guide early escalation, prompt antibiotic therapy, and a low threshold for urgent and aggressive surgical debridement.

A key strength of this study is its prospective, multinational design, which enabled the recruitment of a large, diverse cohort of patients with an uncommon, clinically severe condition. The collaborative audit model allowed for real-world insights into current practice patterns and outcomes across a wide range of healthcare settings.

Limitations

This study, conducted as a multinational clinical audit, is subject to several limitations that may affect the interpretation and generalisability of its findings. The reliance on voluntary data submission introduces the potential for selection bias, as centres with greater interest or capacity for audit participation may be overrepresented. This is represented in the fact that

the range of cases collected from the 63 centres is between 1 and 24 cases. Moreover, outcomes based on individual centres was not calculated therefore we are unable to ascertain if any of these centres were outliers that affected the distribution of our data and consequent associations. However, the study aimed to identify outcomes in real-world practical settings which will always have a degree of variability as discussed below.

Variability in local diagnostic criteria, treatment protocols, and resource availability across participating sites likely contributed to clinical heterogeneity, limiting the ability to make standardised comparisons. As these were not discrete data points that we collected objective data for, we were unable to consider the effect of these variables. Site-level characteristics, including bed numbers, referral or trauma centre status and the proportion of cases arriving as transfers, were not collected, and between-centre variation therefore cannot be characterised or adjusted for. Inter-hospital transfer was not recorded as a discrete variable. Time to first antibiotic and time to first surgery were measured from admission to the reporting centre rather than from first presentation to any hospital, so both intervals are likely to understate total delay in transferred patients, which is a plausible contributor to the wide ranges observed. LRINEC data were missing in 13.7% of patients without complications and in 25.0% of patients with morbidity, and this differential missingness may bias the observed association between LRINEC score and morbidity, most plausibly towards the null. Finally, associations identified in the univariate analyses that did not retain significance after Bonferroni correction should be regarded as hypothesis-generating rather than confirmatory.

Furthermore, the absence of detailed physiological severity scores, timing of escalation decisions, and uniform microbiological profiling and antibiotic regimen restricts the capacity

to adjust for key confounders. While the audit design reflects real-world practice, these methodological constraints should be considered when interpreting the observed associations.

Conclusion

Abdominal wall necrotising soft tissue infection is associated with high morbidity and a 30-day mortality of 14.2%, with over half of patients developing complications. Increasing age, elevated creatinine, bowel resection, and delayed antibiotic administration were independently associated with mortality, while polymicrobial infection and bowel resection were associated with morbidity. These findings identify patients at particularly high risk of adverse outcomes and highlight the significant surgical burden associated with this condition. Early recognition, prompt antibiotic therapy, and timely, aggressive surgical intervention, supported by multidisciplinary care, remain essential to improving outcomes.

Funding Statement: This study received no funding

Conflict of interest: The Authors declare no conflict of interest.

List of Abbreviations: Necrotising Soft Tissue Infections (NSTIs)

Acknowledgment: STANMORE Study Collaborative group

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