Section: General Surgery

Original Research Article

BACTERIOLOGICAL PROFILE AND CLINICAL OUTCOMES OF NECROTIZING FASCIITIS: A PROSPECTIVE OBSERVATIONAL STUDY FROM A TERTIARY CARE CENTER IN EASTERN INDIA

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ABSTRACT

Background: Necrotizing fasciitis (NF) is a rapidly progressive soft tissue infection associated with extensive fascial necrosis, systemic toxicity, and high mortality. Early identification of the causative organisms and institution of appropriate antimicrobial therapy, together with prompt surgical debridement, are essential for improving clinical outcomes. This study aimed to evaluate the bacteriological profile of NF and its association with clinical outcomes in patients managed at a tertiary care centre.

Materials and Methods: A prospective observational study was conducted among 50 consecutive patients with surgically confirmed NF admitted to the Department of General Surgery at a tertiary care hospital. Deep tissue specimens obtained during the initial surgical debridement were subjected to Gram staining, aerobic and anaerobic culture, and antimicrobial susceptibility testing. Demographic characteristics, comorbidities, microbiological findings, empirical antibiotic therapy, surgical management, and clinical outcomes were recorded and analyzed using descriptive and inferential statistics. A p-value of <0.05 was considered statistically significant.

Results: The mean age of the patients was 48.2 ± 11.3 years, with males accounting for 70% of the study population. Diabetes mellitus was the most common comorbidity (64%), and the lower limb was the most frequently affected site (60%). Tissue cultures were positive in 45 (90%) patients, of whom 38 (76%) had polymicrobial infections and seven (14%) had monomicrobial infections, while five (10%) had sterile cultures. *Escherichia coli* was the predominant isolate (44%), followed by *Streptococcus* spp. (36%), *Staphylococcus aureus* (20%), and *Pseudomonas aeruginosa* (16%). All patients underwent emergency surgical debridement, with 50% subsequently requiring split-thickness skin grafting. The overall in-hospital mortality was 18%. Mortality was higher among patients with monomicrobial infections than polymicrobial infections (28.6% vs. 18.4%); however, the difference was not statistically significant (p=0.349).

Conclusions: NF is predominantly a polymicrobial infection, with Gram-negative organisms, particularly *Escherichia coli*, being the most common pathogens in our setting. Early surgical debridement combined with broad-spectrum empirical antibiotics followed by culture-guided antimicrobial therapy remains essential for successful management. Knowledge of local bacteriological patterns may facilitate appropriate empirical antibiotic selection and improve patient outcomes.

Keywords: Necrotizing fasciitis; bacteriological profile; polymicrobial infection; tissue culture; Escherichia coli; surgical debridement; antimicrobial susceptibility.

INTRODUCTION

Necrotizing fasciitis (NF) is a rapidly progressive, fulminant soft tissue infection characterized by extensive necrosis of the superficial fascia and subcutaneous tissues, with secondary involvement of the overlying skin and occasionally the underlying muscle. Despite significant advances in antimicrobial therapy, intensive care, and surgical management, NF continues to be associated with high morbidity and mortality because of its aggressive nature and the potential for rapid progression to septic shock and multiorgan dysfunction.[1,2]

The incidence of NF has increased over the past two decades, partly because of the rising prevalence of diabetes mellitus, chronic kidney disease, peripheral vascular disease, immunosuppressive conditions, and an aging population.[2,3] Mortality rates reported in the literature range from 15% to 35%, although early diagnosis, prompt surgical debridement, and aggressive resuscitation have significantly improved patient survival in recent years.[2,4]

NF is broadly classified into four microbiological subtypes. Type I disease, the commonest form, is polymicrobial and typically involves a combination of aerobic and anaerobic organisms. Type II disease is usually caused by Group A Streptococcus, either alone or in association with Staphylococcus aureus. Type III infections are predominantly caused by Gram-negative organisms such as Vibrio vulnificus or Aeromonas hydrophila, whereas Type IV infections are fungal in origin and occur mainly in immunocompromised patients.[2,5]

The microbiological spectrum of NF varies considerably across different geographical regions and healthcare settings. Recent studies from Asia have demonstrated a predominance of Gram-negative bacilli, particularly Escherichia coli, Klebsiella pneumoniae, and Pseudomonas aeruginosa, whereas streptococci and staphylococci continue to predominate in many Western populations.[6,7] This evolving bacteriological profile has important implications for empirical antibiotic therapy because inappropriate initial antimicrobial treatment has been associated with increased mortality.

Diabetes mellitus remains the most frequently reported comorbidity among patients with NF, being present in nearly 40%–70% of affected individuals. Other important risk factors include chronic kidney disease, peripheral vascular disease, liver disease, alcoholism, malignancy, HIV infection, and other causes of immunosuppression.[2,8] In developing countries, delayed presentation, poor personal hygiene, low socioeconomic status, and limited access to healthcare may further contribute to disease severity and poorer outcomes.

Although the diagnosis of NF is primarily clinical and requires a high index of suspicion, microbiological examination of deep tissue specimens obtained during surgical debridement plays a pivotal role in identifying the causative organisms and guiding definitive antimicrobial therapy. Deep tissue cultures provide a more reliable representation of the infecting organisms than superficial wound swabs and remain the gold standard for microbiological diagnosis [5,9].

Several studies have evaluated the bacteriological profile and antimicrobial susceptibility patterns in NF; however, regional data from eastern India remain limited. Local epidemiological information is essential because microbial flora and resistance patterns differ across institutions and directly influence empirical antibiotic policies. Understanding the prevailing bacteriological spectrum and its relationship with clinical outcomes may facilitate earlier institution of appropriate antimicrobial therapy and improve patient survival.

Therefore, this study was done to evaluate the bacteriological profile of patients with NF treated at a tertiary care teaching hospital in eastern India and to assess the association between microbiological findings and clinical outcomes.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of General Surgery, Hi-Tech Medical College and Hospital, Bhubaneswar, Odisha, India, in a time of 24 months after approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants or their legally authorized representatives before enrolment.

Fifty consecutive adult patients with clinically suspected and intraoperatively confirmed NF, including Fournier's gangrene, were recruited prospectively. The diagnosis was established on the basis of clinical findings and confirmed by operative findings, which remain the diagnostic gold standard for NF.[1,2]

Inclusion Criteria

Patients were included if they:

- were aged ≥18 years;
- had clinically diagnosed NF requiring emergency surgical exploration;
- had Fournier's gangrene or NF following trauma, insect bite, postoperative infection, intravenous drug abuse, or spontaneous onset;
- provided written informed consent.

Exclusion Criteria

Patients were excluded if they:

- were younger than 18 years;
- had cellulitis or abscess without fascial involvement;
- had received antibiotic therapy for more than 72 hours before presentation;
- refused surgical intervention or participation.

A detailed clinical history, physical examination, and laboratory investigations were performed at admission. Demographic variables, comorbid

illnesses, addiction history, duration of symptoms, and clinical signs were documented using a structured proforma. The Laboratory Risk Indicator for Necrotizing Fasciitis (LRINEC) score was calculated using admission laboratory parameters as originally described by Wong et al.[10]

Deep tissue specimens were obtained aseptically during the first surgical debridement before administration of subsequent antibiotic doses. Tissue cultures are considered superior to superficial wound swabs because they better represent organisms invading the fascial plane.[1,9]

Specimens underwent Gram staining, aerobic culture, anaerobic culture, fungal culture (when clinically indicated), and antimicrobial susceptibility testing according to the **Clinical and Laboratory Standards Institute (CLSI)** recommendations.[11]

Statistical analysis was done using **IBM SPSS Statistics version 29.0**. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were summarized as frequencies and percentages. The Chi-square test or Fisher's exact test was used to compare categorical variables. Continuous variables were compared using Student's *t*-test or the Mann-Whitney *U* test depending on data distribution. A p value of <0.05 was considered statistically significant.

RESULTS

Study Population

A total of **50 patients** with surgically confirmed necrotizing fasciitis were included in the study. The mean age of the study population was **48.2 ± 11.3 years**, with a male predominance (**70%**). Diabetes mellitus was the most common associated comorbidity (64%), followed by hypertension (24%) and chronic kidney disease (18%). The lower limb was the most frequently affected anatomical site (60%), followed by the scrotum/perineum (20%).

Table 1: Baseline Characteristics of the Study Population

Variable	Value
Number of patients	50
Mean age (years)	48.2 ± 11.3
Male sex	35 (70%)
Diabetes mellitus	32 (64%)
Hypertension	12 (24%)
Chronic kidney disease	9 (18%)
Lower limb involvement	30 (60%)
Perineal/Fournier's gangrene	10 (20%)
Mean duration of symptoms	5.8 ± 2.6 days

Culture Characteristics

Deep tissue cultures yielded bacterial growth in **45 (90%)** patients. Among culture-positive patients, **polymicrobial infection predominated (76%)**, while **14%** had monomicrobial infection. Sterile cultures were observed in five patients (10%).

Microbiological Profile

Gram-negative bacilli were the predominant isolates. *Escherichia coli* was the commonest isolated organism (44%), followed by *Streptococcus* spp. (36%), *Staphylococcus aureus* (20%), and *Pseudomonas aeruginosa* (16%). Anaerobic organisms, predominantly *Bacteroides* spp., were isolated in 14% of patients.

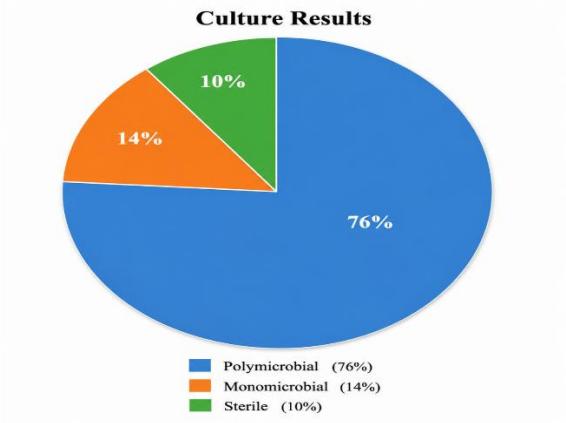

Figure 1: Distribution of Tissue Culture Results

Table 2: Frequency of Bacterial Isolates

Organism	n	%
E. coli	22	44
Streptococcus spp.	18	36
Staphylococcus aureus	10	20
Pseudomonas	8	16
Proteus	6	12
Klebsiella	3	6
Enterobacter	2	4
Bacteroides	7	14

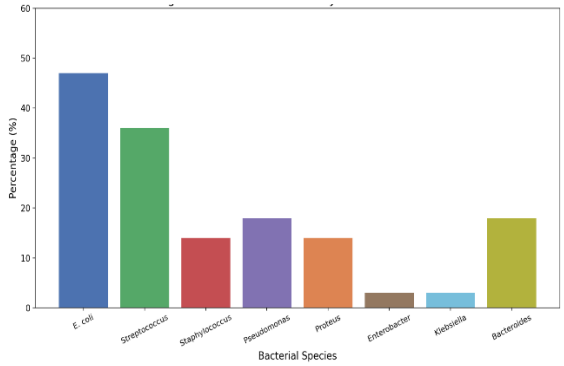

Figure 3

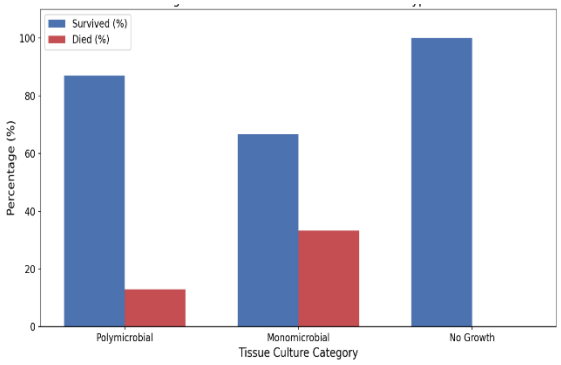

Figure 4: Outcome According to Culture Pattern

Gram Stain Pattern

Gram-negative bacilli were identified in 70% of tissue specimens, whereas Gram-positive cocci were detected in 44% of patients. Gram-positive bacilli were isolated in only three patients. No Gram-negative cocci were isolated.

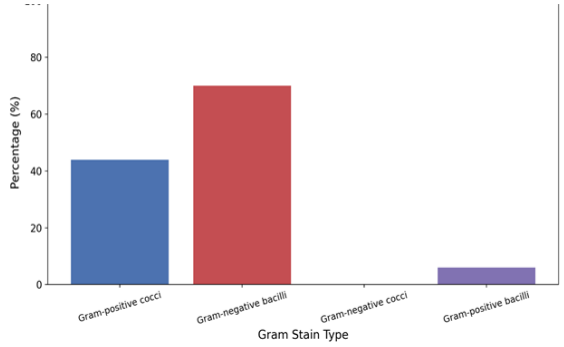

Figure 3: Gram Stain Pattern

Association Between Microbiological Pattern and Clinical Outcome

The overall in-hospital mortality was **18% (9/50)**. Mortality was numerically higher among patients with monomicrobial infection (28.6%) than among those with polymicrobial infection (18.4%); however, the difference did not reach statistical significance (p=0.349).

Empirical Antibiotic Therapy

The most commonly prescribed empirical antibiotic regimen was ceftriaxone, metronidazole, and amikacin (36%), followed by piperacillin-tazobactam, clindamycin, and amikacin (16%). Antibiotic therapy was subsequently modified according to culture sensitivity reports.

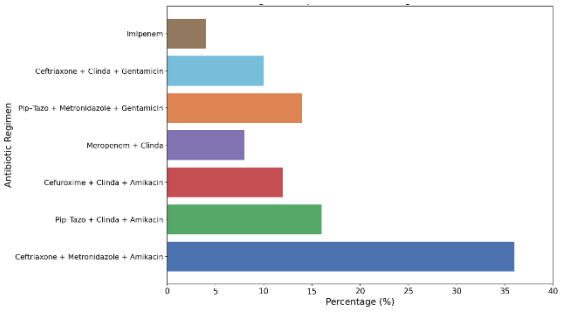

Figure 5: Initial Empirical Antibiotic Regimens

Surgical Management and Outcome

All patients underwent emergency surgical debridement. Twenty-five patients (50%) subsequently required split-thickness skin grafting, while 16 (32%) underwent delayed wound closure by mobilization and suturing. Nine patients (18%) died before definitive reconstruction could be performed.

Table 3: Definitive Surgical Procedure and Clinical Outcome

Procedure	Survived	Died	Total	p value
Mobilization and suturing	16	0	16	**<0.001**
Split-thickness skin graft	23	2	25	
No definitive surgery	2	7	9	

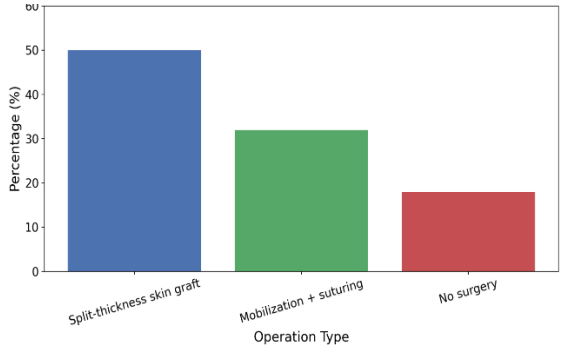

Figure 6: Types of Operations

Overall Outcome

The mean hospital stay was 34.2 ± 9.8 days (range: 7–52 days). Overall survival was 82%, whereas 18% of patients died during hospitalization, primarily because of septic shock and multiorgan dysfunction.

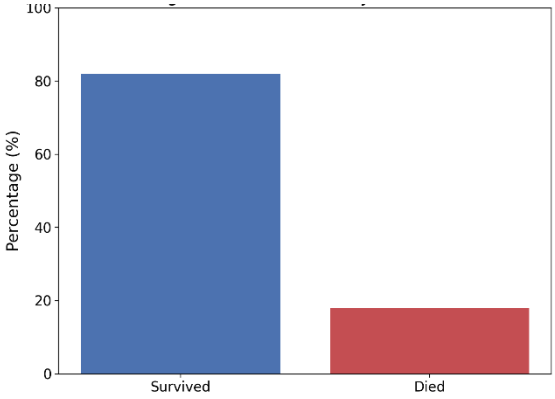

Figure 7: Final Clinical Outcome

DISCUSSION

The present prospective study evaluated the bacteriological profile and clinical outcomes of 50 patients with surgically confirmed necrotizing fasciitis (NF) managed at a tertiary care centre. Tissue cultures were positive in 90% of patients, with polymicrobial infection accounting for 76% of cases. Escherichia coli was the most frequently isolated organism, followed by Streptococcus spp., Staphylococcus aureus, and Pseudomonas aeruginosa. Despite aggressive surgical debridement and broad-spectrum antimicrobial therapy, the overall mortality was 18%. These findings reinforce the polymicrobial nature of NF and emphasize that early diagnosis, prompt surgical debridement, and culture-directed antibiotic therapy remain the cornerstones of management, as consistently highlighted in contemporary literature.[1,3,12,13]

The demographic profile observed in our study is comparable with previous reports, with a predominance of middle-aged males and diabetes mellitus as the most frequent underlying comorbidity. Diabetes has consistently been recognized as the most important predisposing factor for necrotizing fasciitis because hyperglycaemia impairs neutrophil function, delays wound healing, and promotes rapid bacterial proliferation.[2,5,6,14,15] Similar observations were reported by Halbhavi et al., who identified diabetes as the commonest associated illness in Indian patients with NF.[6] Chronic kidney disease and hypertension were the next most frequent comorbidities in our study, findings that agree with previous reports identifying chronic systemic illnesses as significant contributors to disease severity and poor outcomes.[2,5,15] The lower extremity was the commonest site of involvement, followed by the perineum, which is comparable to the distribution described by Hembram et al. and other contemporary studies.[2,5]

A major finding of the present study was the predominance of polymicrobial infection, accounting for more than three-fourths of all culture-positive cases. This finding supports the classical concept of Type I NF, where synergistic interactions between aerobic and anaerobic organisms accelerate tissue destruction through toxin production, enzymatic degradation, and microvascular thrombosis.[5,13,16] Halbhavi et al. reported polymicrobial growth in approximately 63% of patients,[6] while Giuliano et al. first established the polymicrobial nature of NF in their landmark microbiological study.[17] The higher proportion observed in our study may be explained by the predominance of diabetic patients and infections involving the lower limb and perineum, where mixed enteric flora are commonly encountered.

Escherichia coli was the commonest organism isolated, followed by Streptococcus spp., Staphylococcus aureus, and Pseudomonas aeruginosa. This microbiological profile differs from many Western studies that identify Group A Streptococcus as the principal pathogen but closely resembles reports from developing countries where Gram-negative enteric organisms predominate.[1,6,18] Alasi et al. similarly reported E. coli as the most common isolate in a prospective Nigerian study,[18] whereas Halbhavi et al. identified Staphylococcus aureus and Pseudomonas aeruginosa as the predominant Gram-positive and Gram-negative organisms, respectively.[6] These geographical differences probably reflect variations in patient demographics, prevalence of diabetes mellitus, healthcare-associated infections, antimicrobial prescribing practices, and institutional microbial flora. Isolation of anaerobic organisms such as Bacteroides species in our study further supports the need for empirical antibiotic regimens that provide comprehensive aerobic and anaerobic coverage.[5,12]

Although mortality was numerically higher among patients with monomicrobial infection than among those with polymicrobial infection, the difference was not statistically significant. Similar observations were seen in studies by Khamnuan et al. and Jabbour et al., who demonstrated that mortality is influenced more by haemodynamic instability, organ dysfunction, and delayed surgical intervention than by microbiological classification alone.[3,19] Nevertheless, previous studies have shown that monomicrobial infections caused by highly virulent pathogens such as Group A Streptococcus and Vibrio vulnificus may progress rapidly and are associated with significantly higher mortality.[20] The relatively small number of monomicrobial infections in our cohort may have limited the statistical power to detect significant differences.

Broad-spectrum empirical antimicrobial therapy was initiated in all patients and later modified according to culture and antimicrobial susceptibility reports. The most frequently used regimens included ceftriaxone or piperacillin-tazobactam combined with metronidazole, clindamycin, and aminoglycosides. These treatment strategies are consistent with current recommendations advocating immediate antimicrobial coverage against Gram-positive cocci, Gram-negative bacilli, and

anaerobes, with clindamycin included because of its inhibitory effect on streptococcal toxin production.[21-23] Culture-guided modification remains essential for optimizing therapy and minimizing antimicrobial resistance.

Emergency surgical debridement remains the cornerstone of successful management. All patients in the present study underwent urgent surgical exploration, and many required repeated debridement procedures before definitive wound closure. Split-thickness skin grafting was the most common reconstructive procedure, reflecting the extensive soft tissue loss following adequate debridement. Although mortality was higher among patients undergoing delayed surgery, the difference was not statistically significant, probably because of the relatively small number of delayed cases. Larger studies have consistently demonstrated that early debridement significantly reduces mortality and remains the most important modifiable determinant of survival.[24-26]

The overall mortality rate of 18% observed in our study falls within the range reported in previous literature.[3,5] Most deaths occurred in patients presenting with septic shock and multiorgan dysfunction. Similar findingswere shown by Khamnuan et al., Kjaldgaard et al., and Megas et al., who identified shock, acute kidney injury, and delayed surgery as independent predictors of mortality.[3,15,27] Patients who underwent definitive wound reconstruction had significantly better outcomes, emphasizing that successful reconstruction is generally achievable only after adequate infection control and physiological stabilization.

The strengths of the present study include its prospective design, standardized deep tissue microbiological sampling, and complete in-hospital follow-up. However, it was conducted at a single tertiary care centre with a relatively small sample size, limiting the generalizability of the findings. In addition, advanced molecular diagnostic techniques and comprehensive antimicrobial resistance profiling were not routinely available. Future multicentre studies involving larger patient populations are required to validate regional bacteriological trends, evaluate evolving resistance patterns, and identify independent predictors of mortality.

CONCLUSION

Necrotizing fasciitis remains a life-threatening surgical emergency requiring prompt diagnosis and multidisciplinary management. In the present study, polymicrobial infection was the predominant microbiological pattern, with Escherichia coli being the commonest isolated organism, followed by Streptococcus spp., Staphylococcus aureus, and Pseudomonas aeruginosa. These findings highlight the polymicrobial nature of the disease and support the use of broad-spectrum empirical antibiotic therapy with subsequent modification based on culture and antimicrobial susceptibility results.

Diabetes mellitus was the most common associated comorbidity, and lower limb was the most frequently affected anatomical site. Although monomicrobial infections showed a higher numerical mortality, microbiological pattern alone was not significantly associated with clinical outcome. Instead, severe systemic illness and delayed clinical presentation appeared to have a greater impact on patient survival.

Early recognition, prompt radical surgical debridement, repeated wound exploration when required, and culture-guided antimicrobial therapy remain the key determinants of successful management. Knowledge of regional bacteriological profiles and antimicrobial susceptibility patterns is essential for selecting appropriate empirical antibiotics and improving clinical outcomes. Larger multicentre studies should be done to monitor changing microbiological trends, antimicrobial resistance patterns, and predictors of mortality in patients with necrotizing fasciitis.

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