

Clinical Study of Risk Factors, Clinical Presentation and for Surgical Management of Cellulitis

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Abstract

Background: Lower limb cellulitis is a common bacterial infection of the skin and subcutaneous tissues and may range from localized inflammation to severe infection with deep tissue involvement, systemic toxicity, and limb-threatening complications. Diabetes mellitus, renal dysfunction, vascular insufficiency, and delayed presentation may contribute to increased severity and the need for surgical intervention.

Aim: To assess the risk factors, etiopathogenesis, clinical presentation, severity, need for surgical management, recurrence, and outcomes of patients with lower limb cellulitis.

Materials and Methods: This prospective cohort study was conducted over 18 months from June 2024 to November 2025 in the Department of General Surgery, Narayana Medical College and Hospital, Nellore. A total of 100 patients aged more than 25 years with clinically diagnosed lower limb cellulitis requiring hospital admission were included. Detailed history, clinical examination, laboratory investigations, Doppler studies, radiological evaluation, and microbiological investigations were performed as indicated. Disease severity was assessed using the Clinical Resource Efficiency Support Team (CREST) classification. Patients were managed conservatively or surgically depending on disease severity and clinical response. Outcomes assessed included healing, complications, recurrence, amputation, mortality, and duration of hospital stay.

Results: The study population comprised 60% males and 40% females, with the highest proportion of patients in the 51–60-year age group (27%), followed by 71–80 years (26%). The right lower limb was involved in 54% of cases, the left in 45%, and bilateral involvement in 1%. According to CREST classification, 67% were Grade II, 30% Grade III, and 3% Grade IV. Diabetes mellitus was the most common comorbidity (54%), followed by chronic kidney disease (22%) and acute kidney injury (17%). Among Grade III patients, diabetes was present in 63% and chronic kidney disease in 33%. Osteomyelitic changes were observed in 9% of patients. Doppler abnormalities suggestive of arterial insufficiency were identified in several patients. Microbiological cultures showed no growth in 45%, while *Escherichia coli* and *Klebsiella* were each isolated in 6%. Surgical management included fasciotomy (32%), fasciotomy with wound debridement (47%), and wound debridement alone (20%). Overall, 68% achieved healing, while recurrence, amputation, and mortality occurred in a subset of patients. The mean duration of hospital stay was 7.23 ± 4.53 days. Infective counts significantly decreased following treatment (16.24 ± 7.51 before treatment versus 10.64 ± 6.57 after treatment; $p < 0.001$).

Conclusion: Lower limb cellulitis predominantly affects middle-aged and elderly individuals and is strongly associated with diabetes mellitus and renal dysfunction. Severe disease, vascular insufficiency, and deeper tissue involvement may necessitate surgical intervention. Early diagnosis, appropriate antimicrobial therapy, control of comorbidities, vascular assessment, and timely surgical management are essential to reduce complications, recurrence, and mortality and to improve overall patient outcomes.

Keywords: Lower Limb Cellulitis; Diabetes Mellitus; Surgical Management; CREST Classification.

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Introduction

Cellulitis is an acute, spreading bacterial infection involving the skin and subcutaneous tissues, clinically characterized by erythema, warmth,

edema, tenderness, and pain. Among skin and soft tissue infections, lower limb cellulitis constitutes the most common presentation requiring hospital

admission. The lower extremities are particularly vulnerable due to frequent exposure to trauma, fissures, ulcers, venous stasis, and impaired lymphatic drainage. The disease spectrum varies from mild localized inflammation to severe, rapidly progressive infection associated with limb-threatening and life-threatening complications. [1,2]

Lower limb cellulitis represents a significant cause of morbidity, prolonged hospitalization, and healthcare expenditure worldwide. Elderly patients and those with underlying comorbidities are more likely to develop severe disease requiring inpatient care. Recurrent episodes are common and often result in chronic edema, residual wounds, functional impairment, and reduced quality of life. Several studies have demonstrated that lower limb cellulitis accounts for a substantial proportion of emergency surgical admissions, especially in tertiary care hospitals. [3]

The etiopathogenesis of lower limb cellulitis involves bacterial entry through breaches in the skin barrier such as traumatic wounds, surgical incisions, diabetic foot ulcers, venous stasis ulcers, intertrigo, and fissures in the web spaces. *Streptococcus* species and *Staphylococcus aureus* are the most frequently implicated organisms. Host factors such as diabetes mellitus, chronic venous insufficiency, lymphedema, obesity, renal failure, and immunocompromised states significantly influence susceptibility, severity, and recurrence of infection. Diabetes mellitus remains the most important predisposing factor due to associated neuropathy, vasculopathy, impaired wound healing, and altered immune response. [4]

Clinically, lower limb cellulitis presents along a continuum of severity. Early or mild disease may be managed conservatively with antimicrobial therapy, limb elevation, and supportive measures. However, advanced disease is often complicated by blistering, subcutaneous abscess formation, necrosis, and systemic toxicity. Progressive infection may extend to deeper tissues resulting in fasciitis, myositis, compartment syndrome, or bacteremia, necessitating urgent surgical intervention. [5]

Necrotizing soft tissue infections of the lower limb represent the most severe form of cellulitis and are associated with high morbidity and mortality if not recognized and treated promptly. These infections require early and aggressive surgical debridement in addition to broad-spectrum antimicrobial therapy and intensive supportive care. Evidence suggests that delay in surgical intervention is a major determinant of poor outcome, emphasizing the importance of timely identification of patients requiring operative management. [6] Despite advances in antimicrobial therapy, the decision

regarding the need, timing, and extent of surgical intervention in lower limb cellulitis remains a clinical challenge. Factors such as severity of presentation, presence of comorbidities, vascular status, microbiological profile, and response to initial medical management influence surgical decision-making. Variability in presentation and lack of uniform criteria often result in delayed or inadequate intervention. [7]

In the Indian context, lower limb cellulitis is particularly prevalent due to high rates of diabetes mellitus, barefoot walking, poor foot hygiene, delayed presentation, and limited access to early healthcare. Regional data evaluating the relationship between risk factors, clinical presentation, and surgical outcomes in lower limb cellulitis remain limited. Most existing studies focus predominantly on medical management, with fewer addressing the surgical aspects in detail. [8]

Therefore, the present study was undertaken to evaluate the risk factors, clinical presentation, and need for surgical management in patients with lower limb cellulitis admitted to a tertiary care teaching hospital. By analyzing disease patterns, indications for surgery, and outcomes, this study aims to contribute clinically relevant data that may aid in early diagnosis, appropriate intervention, prevention of complications, and improvement of patient outcomes.

Aim: The aim of the study is to access the risk factors, etiopathogenesis, clinical presentation and need for surgical management. **Objectives:** To analyze various causes and risk factors for cellulitis in the lower limb, to study the grades of disease, to study the need for surgical management and to assess the recurrences of condition and finally to assess the multiple surgical interventions.

Materials and Methods

This was a Prospective cohort study done for 18 months from June 2024 to November 2025 in 100 cases diagnosed with lower limb cellulitis admitted to Narayana Medical College and Hospital, Nellore.

Inclusion criteria: Patients aged more than 25 years clinically diagnosed with lower limb cellulitis.

Exclusion criteria: Patients treated on an outpatient basis and managed conservatively without admission.

After obtaining informed consent, all eligible patients were evaluated using a pre-designed proforma. Detailed history, clinical examination, and relevant investigations were carried out. Patients were graded according to the CREST classification and managed conservatively or surgically based on severity.

Clinical Assessment: Patients were assessed for: Local signs such as erythema, warmth, swelling, tenderness, and discharge, Systemic signs such as fever and tachycardia. The severity of cellulitis was graded according to the Clinical Resource Efficiency Support Team (CREST) classification.

Investigations: All patients underwent routine laboratory investigations. Additional investigations were performed whenever clinically indicated: Complete blood count, Renal function tests, Blood glucose levels, Doppler Studies, X-rays, Microbiological culture.

Management Protocol: Patients were managed based on the severity of disease.

Patients with mild to moderate cellulitis were treated with appropriate antibiotics, limb elevation, analgesics, and supportive care. Antibiotic therapy was modified according to culture and sensitivity reports when available. Patients with severe cellulitis, abscess formation, failure of medical management, necrotizing soft tissue infection, or compartment syndrome underwent surgical

intervention such as incision and drainage, wound debridement, or fasciotomy, as indicated.

Outcome Assessment: The outcome was assessed based on: Resolution of cellulitis with conservative management, Requirement of surgical intervention, Development of complications such as abscess, necrotizing fasciitis, compartment syndrome, or septicemia, Duration of hospital stay, Recurrence of cellulitis.

Statistical Analysis: The collected data will be entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.0. Descriptive statistics will be used to summarize the data and will be expressed as frequencies, percentages, mean, and standard deviation wherever applicable. Appropriate statistical tests, such as the Chi-square test or Fisher's exact test, will be employed to assess the association between risk factors and categorical variables. A p-value of less than 0.05 will be considered statistically significant.

Results

Table 1: Age and Gender-Wise Distribution of Study Population

Age Group (Years)	Frequency	Percentage
20–30	5	5%
31–40	4	4%
41–50	17	17%
51–60	27	27%
61–70	16	16%
71–80	26	26%
81–90	5	5%
Female	40	40%
Male	60	60%

Table 2: Patient Characteristics in Study Population

Lower Limb Involved	Frequency	Percentage
Left Lower Limb	45	45%
Right Lower Limb	54	54%
Both	1	1%
CREST Classification	Frequency	Percentage
Grade II	67	67%
Grade III	30	30%
Grade IV	3	3%
Associated Comorbidities	Frequency	Percentage
Diabetes	54	54%
Chronic Kidney Disease	22	22%
Acute Kidney Injury	17	17%
Septic Shock	8	8%
Chronic Liver Diseases	9	9%
Others	7	7%
Nil	23	23%

Table 3: Distribution of Diseases among Grade III Patients

Diabetes Mellitus	Frequency	Percentage
Present	19	63%
Absent	11	37%
Chronic Kidney Disease	Frequency	Percentage
Present	10	33%
Absent	20	67%
Osteomyelitic Changes	Frequency	Percentage
Absent	91	91%
Present	9	9%

Table 4: Doppler Study Findings in Study Population

Doppler Findings	Frequency	Percentage
Normal Study	37	37%
Not Done	43	43%
Monophasic in Dorsalis Pedis Artery	8	8%
Monophasic in Anterior Tibial Artery	3	3%
Monophasic in Popliteal Artery	3	3%
Monophasic in Posterior Tibial Artery	1	1%
Monophasic in Anterior Tibial + Dorsalis Pedis	1	1%
Monophasic in Anterior Tibial + Posterior Tibial	1	1%
Monophasic in Dorsalis Pedis + Posterior Tibial	1	1%
Biphasic in Anterior Tibial + Monophasic in Dorsalis Pedis	1	1%
Deep Vein Thrombosis	1	1%
Total	100	100%

Table 5: Bacterial Growth in Study Population

Organism	Frequency	Percentage
No Growth	45	45%
Escherichia coli	6	6%
Klebsiella	6	6%
Staphylococcus aureus	3	3%
Staphylococcus haemolyticus	2	2%
Pseudomonas aeruginosa	2	2%
Others	7	7%
Not Sent	29	29%
Total	100	100%

Table 6: Procedures Performed In Study Population

Procedure Done	Frequency	Percentage
Fasciotomy	32	32%
Fasciotomy with Wound Debridement	47	47%
Wound Debridement	20	20%
Closure	1	1%
Total	100	100%

Table 7: Outcome of Study Population

Outcome	Frequency	Percentage
Healed	68	68.0%
Resultant Wound	14	14.0%
Below Knee Amputation	1	1.0%
Healed by Secondary Intention	1	1.0%
Recurrence	5	5.0%
Re Recurrence	3	3.0%
Recurrence + Amputation	1	1.0%
Below Knee Amputation + Expired	1	1.0%
Expired	7	7.0%
Lost Follow-up	1	1.0%
Total	100	100%

In the present study, the duration of hospital stay ranged from 1 to 22 days, with a mean stay of 7.23 ± 4.53 days.

Table 8: Comparison of Infective Counts before and After Treatment

Infective Counts	Mean	Std. Deviation	Std. Error Mean	p-value
Before Treatment	16.24	7.51	0.75	0.000*
After Treatment	10.64	6.57	0.66	

Paired t test

Discussion

Lower limb cellulitis is a common and potentially serious infection of the skin and subcutaneous tissues, which continues to be a major cause of morbidity and hospital admissions worldwide. In developing countries like India, the burden of lower limb cellulitis is particularly high due to a combination of socioeconomic, environmental, and clinical factors such as poor hygiene, barefoot walking, high prevalence of diabetes mellitus, delayed healthcare access, and lack of awareness regarding early symptoms. The present study was undertaken to analyze the clinical profile, risk factors, microbiological characteristics, and management outcomes of patients presenting with lower limb cellulitis in a tertiary care setting, with particular emphasis on factors influencing severity and need for surgical intervention.

The age distribution observed in the present study shows that the majority of patients belonged to the 51–60 years age group, followed closely by those aged 71–80 years. This pattern indicates that lower limb cellulitis predominantly affects middle-aged and elderly individuals. Aging is associated with several physiological changes including decreased immune function, reduced skin integrity, impaired vascular supply, and delayed wound healing, all of which predispose to infection and its progression. Elderly individuals are also more likely to have associated comorbid conditions such as diabetes mellitus, chronic kidney disease, and peripheral vascular disease, which further increase susceptibility to infection and complicate its course. These findings are consistent with those reported by Raff and Kroshinsky¹, who highlighted the increased incidence of cellulitis among older adults, and Gunderson², who emphasized the role of advancing age as a significant risk factor for severe infection.

The present study demonstrated a clear male predominance, with males accounting for 60% of the study population. This observation can be attributed to increased occupational exposure, higher likelihood of trauma, and environmental factors such as barefoot walking, especially in rural and semi-urban populations. Males are more frequently involved in outdoor activities and manual labor, which increases the risk of minor injuries that may act as portals of entry for bacteria. In addition, lack of proper foot care practices further contributes to the risk. Similar findings have

been reported by Badipatla et al. [8], who observed a higher incidence of cellulitis among males, supporting the role of environmental and behavioral factors in disease occurrence.

The pattern of limb involvement in the present study revealed that the right lower limb was more commonly affected than the left, with bilateral involvement being rare. This finding is in accordance with the typical presentation of cellulitis, which usually results from localized breaches in the skin barrier such as cuts, ulcers, fissures, or traumatic injuries. The predominance of unilateral involvement reflects the localized nature of infection, although systemic factors may influence its severity. The slight predominance of right-sided involvement may be incidental or related to limb dominance and increased exposure to trauma.

Assessment of disease severity using the CREST classification showed that the majority of patients presented with Grade II cellulitis, followed by Grade III and a small proportion of Grade IV cases. This indicates that most patients presented with moderate disease requiring hospitalization, while a significant number had severe disease with systemic involvement. The presence of a considerable proportion of Grade III and IV cases suggests delayed presentation and inadequate early management, which are common in resource-limited settings. Stevens et al. [9] emphasized that early recognition of severe cellulitis is essential to prevent progression to life-threatening complications such as necrotizing fasciitis. The findings of the present study highlight the need for increased awareness and early intervention to reduce disease severity.

Comorbid conditions were found to play a pivotal role in the development and progression of cellulitis. Diabetes mellitus was the most common comorbidity observed in this study, followed by chronic kidney disease and acute kidney injury. Diabetes mellitus is a well-established risk factor for cellulitis due to its multiple effects on host defense mechanisms. Hyperglycemia impairs neutrophil function, reduces chemotaxis, and compromises phagocytic activity, leading to increased susceptibility to infection. In addition, diabetic neuropathy results in loss of protective sensation, making patients unaware of minor injuries, while microvascular disease leads to poor tissue perfusion and delayed healing. Björnsdóttir

et al. [4] identified diabetes as a major risk factor for cellulitis, and Lipsky et al. [10] further emphasized its role in increasing severity and complications. The high prevalence of diabetes in the present study underscores its importance in the pathogenesis of lower limb cellulitis.

Renal dysfunction, including chronic kidney disease and acute kidney injury, was also commonly observed in the present study. Renal impairment is associated with immune dysfunction, accumulation of metabolic toxins, and fluid imbalance, all of which contribute to increased susceptibility to infection and poor outcomes. Patients with renal disease often have multiple comorbidities and require careful management. The coexistence of diabetes and renal disease further increases the risk of severe infection, as observed in this study.

The analysis of comorbidities among Grade III patients revealed that diabetes mellitus and chronic kidney disease were significantly associated with severe disease. This finding highlights the importance of these conditions as predictors of disease severity. Rrapi et al. [3] reported that host-related factors such as diabetes and renal disease significantly influence the severity and progression of cellulitis. Cranendonk et al. [11] explained that the inflammatory response in such patients is often exaggerated, leading to tissue damage and rapid spread of infection. These observations emphasize the need for early identification and aggressive management of high-risk patients.

Osteomyelitis was observed in a subset of patients, indicating advanced disease and delayed presentation. The development of osteomyelitis suggests that infection has extended beyond the soft tissues to involve underlying bone. This is more commonly seen in diabetic patients due to neuropathy and vascular insufficiency. Stevens and Bryant [5] reported that untreated cellulitis may progress to deeper infections, including osteomyelitis and necrotizing fasciitis, which are associated with high morbidity and mortality.

The evaluation of vascular status using Doppler studies revealed that a significant proportion of patients either did not undergo vascular assessment or had abnormal findings. Monophasic flow patterns, which indicate arterial insufficiency, were observed in several patients. Adequate blood supply is essential for delivery of oxygen, nutrients, immune cells, and antibiotics to the site of infection. Reduced perfusion leads to tissue hypoxia, impaired healing, and increased risk of necrosis. Sartelli et al. [12] emphasized that vascular compromise is a critical factor in determining disease severity and outcome. The findings of the present study highlight the importance of routine vascular assessment,

particularly in patients with diabetes and peripheral vascular disease. The microbiological profile observed in this study showed a predominance of Gram-negative organisms such as *Escherichia coli* and *Klebsiella*, while a large proportion of cases showed no growth. This differs from classical literature, which reports *Streptococcus* and *Staphylococcus* species as the most common causative organisms. Ki and Rotstein [13] reported that Gram-positive organisms are the predominant pathogens in cellulitis. The variation observed in the present study may be due to prior antibiotic use, hospital-acquired infections, and regional microbial patterns. The high proportion of negative cultures may also be attributed to inadequate sampling or early initiation of antibiotics before culture collection.

Antibiotic sensitivity testing was not available in a majority of cases, which represents a limitation in management. Empirical antibiotic therapy is often necessary in acute settings; however, it may not always be appropriate and can contribute to antimicrobial resistance. Lipsky et al. [10] emphasized the importance of culture-based antibiotic therapy in improving outcomes and reducing resistance. The findings of the present study suggest the need for improved microbiological evaluation and rational antibiotic use.

A significant proportion of patients in the present study required surgical intervention, with fasciotomy and wound debridement being the most commonly performed procedures. This indicates that many patients presented with advanced disease involving deeper tissues and increased compartmental pressure. Surgical intervention plays a crucial role in the management of severe cellulitis by removing necrotic tissue, reducing bacterial load, and improving tissue perfusion. Stevens et al. [9] emphasized that early surgical intervention is essential to prevent progression to necrotizing infections and sepsis. The high rate of surgical procedures in this study reflects delayed presentation and severity of disease.

The outcome analysis revealed that the majority of patients achieved complete healing, while a subset experienced complications such as recurrence, amputation, and mortality. The observed mortality rate highlights the potential severity of cellulitis, particularly in patients with systemic involvement and multiple comorbidities. Badipatla et al. [8] reported similar findings, emphasizing the role of delayed presentation and underlying conditions in poor outcomes.

Recurrence of cellulitis is a significant concern, as it leads to chronic edema, skin changes, and functional impairment. Chlebicki and Oh [14] reported that recurrent cellulitis is common in

patients with persistent risk factors and lymphatic damage. The duration of hospital stay in the present study varied widely, with a mean of approximately one week. Prolonged hospital stay was associated with severe disease, presence of comorbidities, and need for surgical intervention. This reflects the increased healthcare burden associated with cellulitis and highlights the importance of early management to reduce hospital stay and costs.

The statistically significant reduction in infective counts observed after treatment indicates the effectiveness of the management strategies employed. Appropriate use of antibiotics, along with timely surgical intervention when required, plays a crucial role in improving outcomes. From a public health perspective, lower limb cellulitis represents a significant challenge, particularly in developing countries. The high prevalence of diabetes, poor hygiene practices, and limited access to healthcare contribute to increased incidence and severity. Preventive measures such as health education, early diagnosis, proper foot care, and management of comorbidities are essential to reduce disease burden.

The present study has several strengths, including its prospective design, adequate sample size, and comprehensive evaluation of clinical and microbiological parameters. However, certain limitations must be acknowledged. The study was conducted in a single center, which may limit generalizability. Microbiological data were incomplete in some cases, and Doppler studies were not performed in all patients. Additionally, long-term follow-up was not included, limiting the assessment of recurrence and long-term outcomes.

The findings of the present study highlight that lower limb cellulitis is a multifactorial disease influenced by host factors, microbial profile, and healthcare access. Early diagnosis, appropriate antibiotic therapy, control of comorbidities, and timely surgical intervention are essential to reduce morbidity and mortality.

Further research is required to evaluate long-term outcomes, recurrence patterns, and effectiveness of preventive strategies. Multicentric studies with larger sample sizes may provide more comprehensive insights and help in developing standardized treatment protocols.

Conclusion:

Lower limb cellulitis is a common and potentially serious condition associated with significant morbidity and occasional mortality. It predominantly affects middle-aged and elderly individuals, with a higher incidence observed among males. Diabetes mellitus was identified as the most common predisposing factor, followed by chronic kidney disease and acute kidney injury.

The majority of patients presented with moderate disease; however, a considerable proportion had severe disease due to delayed presentation and presence of comorbidities. Conditions such as diabetes and renal dysfunction were strongly associated with increased disease severity and complications. A subset of patients showed evidence of osteomyelitis and vascular insufficiency, indicating advanced disease. The microbiological profile demonstrated variation from classical patterns, with a higher prevalence of Gram-negative organisms. A significant number of patients required surgical intervention, reflecting the severity of presentation. Although most patients responded well to appropriate medical and surgical management, recurrence and mortality were observed in a small proportion. Early diagnosis, strict control of comorbidities, appropriate antibiotic therapy, and timely surgical intervention are essential to reduce complications and improve patient outcomes.

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