Section: General Surgery

Original Research Article

# WHEN TO CUT – SUBCUTANEOUS AND INTRACOMPARTMENTAL PRESSURE AS SURGICAL INDICATORS IN LOWER LIMB CELLULITIS

**K Mrithula[1], SP Gayathre[2], T Babu Antony[3], G Chandrasekar[4], T Jeyalakshmi[5], M Durai Raj[6]**

[1]Junior Resident, Department of General Surgery, Government Stanley Medical College and Hospital, Chennai, India.
[2]Head of Department, Department of General Surgery, Government Stanley Medical College and Hospital, Chennai, India.
[3]Professor of Surgery, Department of General Surgery, Government Stanley Medical College and Hospital, Chennai, India.
[4]Assistant Professor, Department of General Surgery, Government Stanley Medical College and Hospital, Chennai, India.
[5]Assistant Professor, Department of General Surgery, Government Stanley Medical College and Hospital, Chennai, India.
[6]Assistant Professor, Department of General Surgery, Government Stanley Medical College and Hospital, Chennai, India.

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Corresponding Author:
**Dr. K. Mrithula,**
Email: drmrithums98@gmail.com

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## ABSTRACT

**Background:** Cellulitis of the lower limb is a prevalent soft tissue infection with a risk of progression to compartment syndrome. Cellulitis is frequently mismanaged due to subjective assessment. Prior research has linked subcutaneous pressure (SCP) to disease severity in cellulitis and the role of intracompartmental pressure (ICP) in acute compartmental syndrome in orthopedic trauma but the objective framework to guide timely surgical intervention based on the measured pressure values in cellulitis remains unexplored. **Materials and Methods:** A retrospective observational study of 120 patients with lower limb cellulitis was conducted. SCP and ICP were measured using Stryker Pressure manometer 295 -1, and patients were managed conservatively or surgically based on clinical evaluation. ROC (Receiver Operator Curve) analysis confirmed diagnostic utility with high AUCs (Area Under Curve). ROC curves were used to derive optimal pressure thresholds. The Youden Index was applied to determine the pressure thresholds that maximized diagnostic accuracy, balancing sensitivity and specificity. The high AUC values further validate the discriminative strength of SCP and ICP in stratifying surgical risk. **Result:** Among 120 patients with unilateral lower limb cellulitis, 78 patients were managed conservatively and the 42 patients who underwent surgery had significantly higher SCP and ICP values. ROC curve analysis identified optimal cut-offs of >11mmHg for SCP (AUC = 0.82) and >28 mmHg for ICP (AUC = 0.93). **Conclusion:** Pressure monitoring thus provides an additional objective framework to guide timely intervention and prevent mismanagement based on clinical judgment alone.

## INTRODUCTION

According to the global epidemiological estimates, the annual incidence of cellulitis ranges from 16 to 24 per 1,000 individuals in high-income countries. Lower limb cellulitis is a common cause of hospital admissions, particularly in diabetic and immunocompromised patients. It can range from mild inflammation to limb-threatening complications like compartment syndrome and necrotizing fasciitis. The average hospital stay for cellulitis in India ranges from 7 to 12 days, often extended due to comorbidities and slow wound healing. Clinical judgment alone may lead to delays in surgical intervention or overtreatment with fasciotomy. Hence, timely objective differentiation between cases requiring surgical (fasciotomy, debridement, Incision and drainage) versus conservative treatment (antibiotics, glycerine magsulfate dressing, lower limb elevation) becomes crucial.[1-3]

While prior research has linked elevated subcutaneous pressure to disease severity, the utility of simultaneous subcutaneous and intracompartmental pressure measurement as a guide


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to treatment protocol remains underexplored. There are various techniques like saline infusion technique, slit catheter, wick catheter, Whiteside's technique and near infrared spectroscopy to measure intracompartmental pressure (ICP).[4]

This study shows the measurement of subcutaneous pressure and intracompartmental pressures with Stryker pressure manometer 295-1 and establishes clinically relevant pressure thresholds in cellulitis assessment to guide timely and objective surgical decision-making.

## MATERIALS AND METHODS

This retrospective observational study was conducted at Government Stanley Medical College and Hospital, Chennai, from January 2024 to January 2025. A total of 120 patients with unilateral lower limb cellulitis were enrolled in the study. The circumference of the limb at the point of maximal swelling was measured in reference to tibial tuberosity. Following the application of Prilocaine gel and sterile preparation, needle port of Stryker pressure manometer 295-1 was placed into the subcutaneous plane at a 45-degree angle and advanced half a centimetre. 0.5ml of saline was injected and the steady reading achieved was recorded as the subcutaneous pressure. Then, the needle was inserted further into the gap between the compartments and the intracompartmental pressure was measured. No one from the surgical team was aware of the pressure readings since only the investigator took them.

The treating team relied only on their clinical judgement to decide whether the patient needed surgical intervention (fasciotomy [9], incision and drainage, or debridement) or conservative management. On day 14, data was collected on the procedure and clinical result, and patients were followed up until discharge.

Management outcomes (conservative vs. surgical) were recorded from case records and correlated with the recorded pressure values. Statistical analysis was conducted using Mann-Whitney U test, ROC curve analysis, and chi-square test. Cut-off values were derived using the Youden Index.


## RESULTS

Of the 120 patients, 78 (65%) were managed conservatively while 42 (35%) required surgical intervention (fasciotomy, debridement, or I&D).

The normal SCP of lower limb is usually -1 to 4mm Hg and that of ICP between 0 to 8 mm Hg. From the study, it is noted that both SCP and ICP were increased in all patients with cellulitis (both conservative and surgical). However, SCP and ICP values above the proposed threshold was noted in the surgical group ($p < 0.00001$).

| Group | Raised SCP (>11 mmHg) - n (%) | Raised ICP (>28 mmHg) - n (%) | Both SCP & ICP Raised - n (%) |
|---|---|---|---|
| Surgical | 36 (92.9%) | 36 (85.7%) | 36 (85.7%) |
| Conservative | 22 (28.2%) | 15 (19.2%) | 14 (17.9%) |

**ROC curve analysis revealed:**

- SCP >11 mmHg (AUC = 0.82)
- ICP >28 mmHg (AUC = 0.93)

The pressure thresholds are not arbitrary but statistically derived using ROC analysis combined with Youden index, providing an objective basis for clinical decision making in cellulitis management.

- These thresholds demonstrated high sensitivity (97.6% for SCP, 95.1% for ICP) and acceptable specificity (57.0% for SCP, 75.9% for ICP).
- Chi-square analysis confirmed the statistical significance of these cut-offs in predicting surgical need ($p < 0.00001$).

## DISCUSSION

Subcutaneous pressure measurement has recently gained clinical attention as an adjunct to intracompartmental monitoring. Cellulitis is characterised by a slow and earlier increase in subcutaneous pressure, which often occurs before significant intracompartmental elevations. Unlike ICP, which represents localized ischemic risk, SCP reflects the overall tissue fluid load and inflammatory burden. Moreover, the continuity of the subcutaneous space makes it ideal for early detection of disease progression — and potentially for guiding early surgical decisions, especially before compartment syndrome develops.

New research reveals that SCP often increases before ICP does in cellulitis, and it correlates better with oedema of soft tissues, lymphatic blockage, and inflammatory dissemination. In order to better anticipate which patients may need surgical intervention, recent comparative studies have shown that SCP and ICP assessments should be administered together.

An evidence-based cut-off value for subcutaneous and intracompartmental pressures is being increasingly prioritized in light of these results. Decisions on surgical intervention may be made


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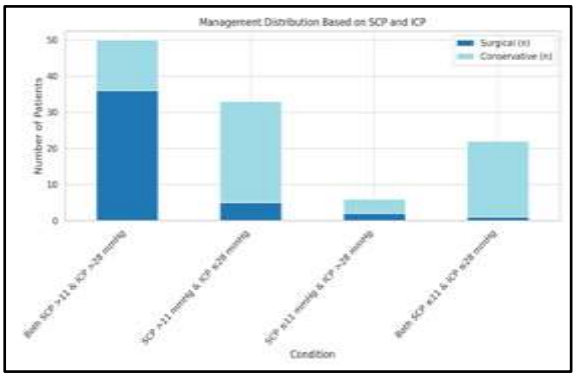
quickly, objectively, and reproducibly with a well-defined threshold, rather than depending solely on subjective clinical judgement.

| Condition | Surgical (n, %) | Conservative (n, %) |
|---|---|---|
| Both SCP >11 & ICP >28 mmHg | 36 (72.0%) | 14 (28.0%) |
| SCP >11 mmHg & ICP ≤28 mmHg | 5 (15.2%) | 28 (84.8%) |
| SCP ≤11 mmHg & ICP >28 mmHg | 2 (33.3%) | 4 (66.7%) |
| Both SCP ≤11 & ICP ≤28 mmHg | 1 (4.5%) | 21 (95.5%) |




SCP and ICP are valuable diagnostic tools in assessing cellulitis severity. SCP >11 mmHg and ICP >28 mmHg are effective thresholds for predicting surgical need. The integration of SCP and ICP measurements offers valuable adjunct to clinical judgment in cellulitis management. Most patients above the pressure cut-offs required surgery, supporting their use in early triage. However, a subset of patients deviated from this trend, which can be attributed to several clinical factors.

Interestingly, not all patients with elevated SCP had elevated ICP, suggesting that SCP may be an earlier or more diffuse marker of inflammation, while ICP becomes elevated only when compartmental involvement is significant. Conversely, 5 patients had elevated ICP (>28 mmHg) with normal SCP (≤11 mmHg), highlighting the possibility of localized deep compartmental pathology not reflected in the subcutaneous layer.

**Explaining the Exceptions:**

1. Early Antibiotic Response (False Positives): Some patients with SCP >11 mmHg or ICP >28 mmHg showed rapid clinical improvement with antibiotics and supportive care, indicating that elevated pressures were due to early-stage edema rather than impending compartment syndrome.
2. Comorbidities and Clinical Red Flags (False Negatives): A few patients with SCP ≤11 mmHg or ICP ≤28 mmHg underwent fasciotomy due to severe localized pain, neurovascular signs, or rapid progression. These findings may represent localized pressure spikes not captured during measurement or pressure elevation between readings.
3. Clinical Judgment Overrides Numeric Algorithms: Surgeons may still choose surgery based on imaging findings (e.g., deep abscess), immune status, or overt systemic signs, even when measured pressures are low. This reflects the importance of integrating pressure monitoring with comprehensive clinical assessment.

**Additional Insights from Internal Data Correlation**

1. SCP as an Early Marker: 10 patients had SCP >11 mmHg but normal ICP, suggesting SCP may rise earlier and reflect superficial inflammation before deeper compartment involvement.
2. ICP as a Specific Surgical Predictor: ICP showed higher specificity and AUC than SCP, indicating its superior correlation with surgical outcomes. This supports SCP as a screening tool and ICP as a decision-making tool.
3. Gray Zone of Overlap: Borderline patients with pressures near the threshold underscore a diagnostic gray zone where clinical context and serial assessment are essential.
4. Avoiding Overtreatment: Some patients with elevated pressures improved without surgery, reinforcing that pressure values should be interpreted alongside clinical response.
5. Complementary Role of SCP and ICP: Simultaneous assessment of both pressures provides a fuller picture of the inflammatory depth and tissue threat, strengthening clinical decisions.

**Comparison with Existing Guidelines**

Current cellulitis management guidelines—such as those from NICE (UK), IDSA (USA), and ICMR (India)—primarily focus on antimicrobial stewardship, symptom monitoring, and referral based on subjective clinical indicators. While they provide clear antibiotic protocols and escalation strategies, none incorporate objective criteria like subcutaneous or intracompartmental pressure measurements to guide surgical intervention. This study addresses that critical gap by introducing validated pressure thresholds (SCP >11 mmHg, ICP >28 mmHg) that correlate with clinical outcomes. By integrating quantifiable parameters into cellulitis triage, our findings support a more reproducible and earlier decision-making framework—one that could complement existing protocols and reduce both overtreatment and delayed intervention.

**Support from Compartment Syndrome Literature**

Although existing protocols for acute compartment syndrome in trauma recommend fasciotomy at ICP around 30 mmHg or delta pressure ≤30 mmHg, no such objective criteria currently exist for cellulitis. Our study bridges this gap by validating SCP and ICP thresholds that align with pathophysiological benchmarks from trauma literature, thus supporting objective, pressure-driven decision-making in cellulitis management. This aligns with established compartment syndrome recommendations, where pressures above 30 mmHg or a delta pressure (diastolic – ICP) below 30 mmHg are considered surgical indicators (Matsen FA, Krugmire RB.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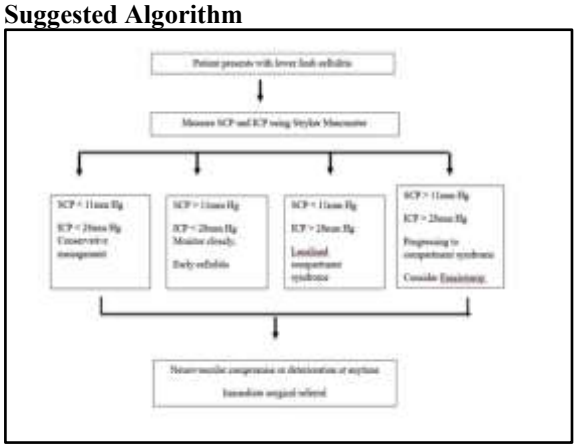
Compartmental syndromes. Surg Gynecol Obstet. 1978).

**Limitations**

This study has few limitations. First, it is a single-center retrospective analysis, which may limit generalizability. Second, pressures were measured at a single time point without serial tracking, potentially missing dynamic changes. Third, pressure readings could be subject to operator-dependent variability despite use of standard equipment. Finally, while this study introduces validated cut-offs, external validation across diverse patient populations is needed before universal adoption.

**Suggested Algorithm**



## CONCLUSION

Incorporating bedside pressure monitoring into routine evaluation of cellulitis can supplement clinical decision-making, reduce delays in fasciotomy, and avoid unnecessary surgeries. Being a portable tool, pressure manometers such as Stryker can be used as a bedside tool as an extended part of clinical examination to decide the treatment protocol. Considering the exceptions noted in the study, Pressure manometers can only be used as an additional tool to clinical examination and treatment should not be tailored solely based on the pressure measurements.

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