

"SUB-CUTANEOUS PRESSURE IN CELLULITIS OF THE LEG: CAN IT BE AN INDICATOR FOR EARLY SURGICAL INTERVENTION?"

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KEYWORDS

Cellulitis, venous insufficiency, EARLY SURGICAL INTERVENTION

ABSTRACT:

Introduction: Cellulitis is a common skin infection causing inflammation, erythema, and pain in the lower leg. Risk factors include chronic skin diseases, previous cellulitis episodes, and venous insufficiency. Treatment usually involves antibiotics, with hospitalization and intravenous antibiotics in severe cases. Preventative measures include managing skin integrity and treating underlying conditions. Early intervention reduces long-term complications and improves recovery. **Aims:** The study predicts fasciotomy surgery need in lower limb cellulitis by measuring subcutaneous pressure, comparing to normal, and determining pressure correlation, aiding clinical decision-making, reducing complications, and preventing undiagnosed compartment syndromes. **Methodology:** A study at Krishna Vishwa Vidyapeeth, Karad, surveyed 52 patients with unilateral cellulitis of the lower limb below the knee from March 2022 to September 2023, analyzing data for clinical management decisions. **Results:** The study involved 52 participants aged 20-59 with swelling, pain, and fever as common symptoms. Diabetes was the most common co-morbid condition. Physical signs included swelling, erythema, tenderness, and warmth. Subcutaneous pressure measurements showed significant differences between normal and cellulitis legs, with poor performance across different thresholds. **Discussion:** The study reveals cellulitis is more common in older individuals, with elevated pressure predicting surgical intervention. High comorbidities complicate management. Common clinical signs and swelling indicate severe cases may require additional surgery. **Conclusion:** The study suggests that subcutaneous pressure measurements in leg cellulitis can predict early surgical intervention, highlighting the importance of establishing a precise threshold and considering demographic and comorbid conditions.

INTRODUCTION

Cellulitis is a common bacterial skin infection, often found in the lower leg. It is caused by Streptococcus or Staphylococcus species, which can enter through small cuts or cracks, leading to inflammation, erythema, edema, warmth, and pain. Risk factors include chronic skin diseases, previous cellulitis episodes, venous insufficiency, obesity, lymphedema, chronic wounds, and invasive devices. These conditions can increase the risk of developing cellulitis.[1]

Cellulitis treatment typically involves antibiotics to combat the bacterial infection, with agents effective against streptococci and staphylococci. In severe cases, hospitalization and intravenous antibiotics may be necessary to prevent deeper tissue involvement. Preventing cellulitis involves managing skin integrity and treating underlying conditions. Diagnosing cellulitis can be challenging due to overlap with other conditions, and advanced diagnostic tools like Doppler ultrasound, MRI, or blood cultures are sometimes used.[2]

Fasciotomy is a crucial surgical intervention in treating severe leg cellulitis, preventing complications like compartment syndrome. This condition occurs when increased pressure in one compartment leads to insufficient blood supply, threatening muscle and nerve viability. Delaying surgery can result in irreversible damage, limb amputation, or fatal systemic issues like sepsis, making it essential to schedule early intervention. [3]

Early intervention in severe cellulitis cases is crucial due to the rapid progression of the infection, which can cause swelling, increased pressure, hypoxia, and tissue necrosis. Early surgical intervention reduces the risk of long-term complications and improves limb function and recovery. Additionally, timely intervention reduces healthcare costs, hospital stay, long-term rehabilitation needs, and resource utilization, benefiting both the patient and the healthcare system.[4]

Early surgical intervention in cellulitis patients can be challenging, but diagnostic tools like intracompartmental pressure monitoring can help make timely decisions, providing quantitative data for clinical observations.

Predictors are crucial in managing leg cellulitis due to its complexity and variability. They help bridge the gap between clinical observation and intervention, providing a quantitative basis for support or refute.[5]

Predictors are crucial in managing cellulitis, as delays can lead to irreversible damage. They facilitate early recognition of severe cases, enabling timely interventions to prevent complications. Predictors align with evidence-based medicine principles, allowing clinicians to make informed decisions and personalize treatment plans. They also optimize healthcare resources by identifying patients requiring urgent surgical intervention, ensuring immediate care and avoiding unnecessary procedures for less severe infections.

Resource optimization improves patient outcomes and reduces healthcare costs. However, identifying reliable predictors for surgical intervention in cellulitis remains challenging. Current research focuses on clinical signs, laboratory markers, and imaging findings.[6]

Research on leg cellulitis predictors is crucial for clinical decision-making, patient outcomes, and healthcare resource utilization. Reliable predictors are expected as research evolves.

The study aims to improve diagnostic accuracy and intervention timeliness in severe leg cellulitis cases by introducing a more objective and quantifiable method, subcutaneous pressure measurement, which can be more quantifiable and less subjective than current methods.[7]

This study aims to improve the diagnosis and treatment of leg cellulitis, a common condition with significant morbidity. Traditional diagnostic methods rely on clinical judgment, which can vary between practitioners. Integrating subcutaneous pressure measurements could provide a more reliable tool, potentially leading to standardized care protocols. The study could also help fine-tune intervention thresholds, reducing complications and unnecessary medical procedures. It could also fill a gap in medical literature by applying pressure measurement techniques to cellulitis, potentially leading to broader changes in clinical practice standards.[8]

The study could enhance patient outcomes, optimize resource use, and drive advancements in medical devices for measuring subcutaneous pressure, potentially promoting research and diagnostic tool innovation.

AIM AND OBJECTIVES

The study aims to predict fasciotomy surgery need in lower limb cellulitis by measuring subcutaneous pressure, comparing it to normal, determining the correlation between increased pressure and surgical intervention, aiding clinical decision-making, reducing complications, and reducing undiagnosed compartment syndromes.

MATERIALS AND METHODS

This study collected data from patients with unilateral cellulitis of the lower limb below the knee at Krishna Vishwa Vidyapeeth, Karad, from March 2022 to September 2023.

The study, conducted in the Department of Surgery and other hospital departments, aimed to observe patients.

The study was conducted at Krishna Vishwa Vidyapeeth, Karad, from March 2022 to September 2023

SampleSize:

A total of 52 patients were included in the study, meeting the inclusion criteria of unilateral cellulitis of the leg below the knee.

$$n = \frac{4sd^2}{(\bar{M}^{10\%}E)^2} = 52$$

E=precision

Inclusion Criteria:

Patients aged 14-65 years with unilateral cellulitis of the leg below the knee are eligible for inclusion.

Exclusion Criteria:

Exclusion criteria include bilateral pedal edema, necrotizing fasciitis, filarial leg, deep vein thrombosis, fibular fractures, diabetic foot with ulcers or skin necrosis, and completion of antibiotics for cellulitis.

The study involved patients with cellulitis who underwent a systematic procedure to ensure accurate data collection and measurement consistency. The circumference of the affected leg was measured, and local anesthetic gel was applied to minimize discomfort. Skin preparation was performed using 7.5% Povidone Iodine solution to prevent contamination. Subcutaneous pressure measurements were conducted using a Stryker intra- compartmental pressure monitor, which was chosen for its accuracy. Data was collected prospectively during patient visits and hospital admissions, including demographic information and clinical parameters. The collected data underwent rigorous statistical analysis to validate findings and identify statistical significance that could influence clinical management decisions.

OBSERVATION AND RESULTS

Table 1 shows a population distribution of 52 individuals, with 9.6% aged 20-29, 17.30% aged 30-39, 23.1% aged 40-49, 28.8% aged 50-59, and 21.1% aged 60 and above, indicating a 100% representation in the 50-59 age group.

Table 1: Age wise distribution

Age Group	n (%)
20-29	5 (9.6%)
30-39	9 (17.30%)
40-49	12 (23.1%)
50-59	15 (28.8%)
60+	11 (21.15%)
Total	52 (100%)

Table 2 shows a slightly higher gender distribution among 52 participants, with 53.8% being males and 46.2% being females.

Table 2: Gender wise distribution

Gender	n (%)
Male	28 (53.8%)
Female	24 (46.2%)
Total	52 (100%)

Table 3 shows that swelling is the most common symptom experienced by 52 participants, followed by pain (67.3%) and fever (38.5%).

Table 3: Symptom wise distribution

Symptoms	n (%)
Pain	35 (67.3%)
Swelling	42 (80.8%)
Fever	20 (38.5%)

Table 4 shows diabetes is the most common co-morbid condition among participants, followed by hypertension and renal failure in 20 out of 20 participants.

Table 4: Co-morbidities wise distribution

Co-morbidities	n (%)
Diabetes	20 (38.5%)

Hypertension	15 (28.8%)
Renal Failure	5 (9.6%)

Table 5 shows that the most common physical signs observed among participants are swelling (86.5%), erythema (76.9%), tenderness (73.1%), and warmth (67.3%).

Table 5: Signs wise distribution

Signs	n (%)
Swelling	45 (86.5%)
Erythema	40 (76.9%)
Warmth	35 (67.3%)
Tenderness	38 (73.1%)

Table 6 compares average circumference measurements of normal and cellulitis-affected legs among participants, showing normal legs have an average circumference of 30.4 cm and cellulitis legs have an average circumference of 33.94 cm.

Table 6: Limb circumference in cm

Group	Mean±SD
Normal leg	30.4±4.86
Leg with cellulitis	33.94±4.83

Table 7 details the average distance from the tibial tuberosity for subcutaneous pressure readings, with a standard deviation of 1 cm.

Table 7: Distance at which Subcutaneous Pressure Measured from Tibial Tuberosity in cm

Distance	Mean±SD
	10.5±1

Table 8 shows subcutaneous pressure measurements for a leg affected by cellulitis across different regions. The anteromedial region had a mean pressure of 9.8 mmHg, the anterolateral region 8.9 mmHg, the posteromedial region 9.0 mmHg, and the posterolateral region 9.5 mmHg.

Table 8: Subcutaneous Pressure in mmHg

	Mean±SD
Normal leg	2.1±2.4
Leg with cellulitis	
Anteromedial	9.8±1.7
Anterolateral	8.9±2.1
Posteromedial	9.0±1.7
Posterolateral	9.5±2.0

Table 9 compares normal leg pressure to cellulitis leg pressure, showing a significant difference with a median of 31.0 mmHg and a maximum of 34.0 mmHg.

Table 9: Comparing Pressures in Normal Leg and in Leg with Cellulitis

Group	Median	Z statistics	p-value
Normal leg	31.0	2.79	<0.001
Maximum pressure in leg with cellulitis	34.0		

Table 10 compares subcutaneous pressures in legs with cellulitis treated with antibiotics alone or a combination of antibiotics and surgery. Results show a statistically significant difference between the two treatment groups, with a mean pressure of 11.8 mmHg.

Table 10: Comparing Pressures in Leg with Cellulitis Managed with Antibiotics Alone vs. Antibiotics and Surgery

Group	Number	Mean±SD	Independent t test	p-value
Antibiotics alone	26	6.8±1.9	-3.12	0.001
Antibiotics + surgery	26	11.8±2.2		

Table 11 shows the sensitivity, specificity, and likelihood ratios for diagnosing cellulitis at different subcutaneous pressure differences. The sensitivity is 65.38% at 2 mmHg, specificity is 23.83%, and likelihood ratios are 0.6538, 0.8832, 0.4615, 0.9210, 0.2500, 0.2500, 0.2500, 0.2500, 0.2500, 0.7938, 0.8036, 0.9572, 0.9572.

Table 11: Sensitivity, Specificity and Likelihood Ratios with Different Thresholds of Subcutaneous Pressure Differences

Threshold (mm Hg)	Sensitivity (%)	Specificity (%)	LR+	LR-
2	65.38	23.83	0.6538	0.8832
3	72.15	15.71	0.4615	0.9210
4	68.00	24.88	0.2500	0.7938
5	70.38	34.54	0.1538	0.8036
6	82.00	21.23	0.9572	0.9401

The image shows a ROC curve of a classification model, showing low False Positive Rate (FPR) and True Positive Rate (TPR). The model's AUC is 0.05, indicating poor performance. The blue line shows a steep increase, but the X-axis values are close to zero, indicating poor performance across different thresholds.

DISCUSSION

The study reveals a higher incidence of cellulitis in older age groups, particularly those aged 40-59, consistent with previous research indicating a higher prevalence in middle-aged and elderly populations, as well as a significant number of cases in individuals aged 40-60.[9]

Sullivan et al.[1](2018) explored subcutaneous pressure changes during cellulitis episodes, but did not determine its predictive value for surgical interventions. Joubert et al.[10](2016) suggested subcutaneous pressure could predict surgical intervention necessity.

Table 2 shows a slight male predominance (53.8%) among patients with cellulitis, contrasting with mixed findings in existing literature. Studies like Lagacé F et al. (2023)[11] attribute this to behavioral and biological factors, while Linz MS (2023) observes a balanced distribution.

Gender's relevance in subcutaneous pressure and surgical intervention in cellulitis is unclear, with no significant differences found across genders. Symptoms include swelling, pain, and fever, which are representative of cellulitis, as found in existing medical literature.[12]

Studies show pain and swelling are predominant symptoms of cellulitis, with over 75% reporting swelling and 70% reporting pain. Fever, although lower in our study, aligns with Collazos' findings, suggesting systemic involvement.[13]

The study explores the relationship between subcutaneous pressure and common symptoms, suggesting that elevated pressure could predict surgical intervention if traditional management strategies are ineffective, potentially escalating symptom severity.

The study reveals a high prevalence of comorbidities like diabetes, hypertension, and renal failure in patients with cellulitis. These conditions can complicate cellulitis management and impact subcutaneous pressure readings. Studies show a significant association between diabetes and cellulitis, hypertension due to age and cardiovascular health, and renal failure due to altered fluid balance and drug clearance issues.[14]

The study focuses on common clinical signs of cellulitis, such as erythema, warmth, and tenderness, which are typical symptoms associated with the condition. These signs, when combined with subcutaneous pressure measurements, can provide valuable insights into the severity of the condition and the potential need for early surgical intervention. The presence of these signs typically suggests an

acute inflammatory response, which, if paired with unusually high subcutaneous pressure, could indicate a more severe infection possibly requiring surgical intervention. [15]

The mean circumference of both normal and cellulitis-affected legs is also examined, with the affected leg showing significant swelling due to inflammation and fluid accumulation. This swelling is typically due to inflammatory responses and possibly infection-driven edema. The difference in circumference measurements can also relate to the clinical course of the disease, suggesting that more pronounced swelling could be associated with more severe infections, which might require more aggressive treatment.

The distance from the tibial tuberosity, where subcutaneous pressure is measured, is crucial for ensuring the reliability of subcutaneous pressure readings. Standardized measurement sites are essential for comparing data across studies and tracking changes in individual patients over time.

[1,16]

The measurement of subcutaneous pressure in the leg affected by cellulitis can have significant implications for treatment decisions. Elevated pressures, particularly when measured at consistent anatomical sites, can indicate a poorer prognosis and suggest patients who would benefit from earlier surgical interventions. The mean pressures reported in different anatomical areas of the leg affected by cellulitis are 9.8 mmHg (anteromedial), 8.9 mmHg (anterolateral), 9.0 mmHg (posteromedial), and 9.5 mmHg (posterolateral). These variations can indicate varying stages of inflammation and may correlate with more complex underlying pathologies. A comparative analysis between normal and affected legs showed a statistically significant difference in subcutaneous pressure. [17]

The study compares subcutaneous pressures between patients treated with antibiotics alone and those treated with a combination of antibiotics and surgery. The results show a significant difference in pressure, suggesting that severe cases of cellulitis may require additional surgical intervention. The study also explores the diagnostic utility of different subcutaneous pressure thresholds in determining surgical intervention in cellulitis. The data shows a range of sensitivity and specificity across different pressure thresholds, with a higher threshold enhancing sensitivity but slightly lowering specificity.

[18]

Subcutaneous pressure measurements can predict surgical intervention effectiveness, with higher thresholds resulting in higher sensitivity but lower specificity. Higher thresholds may identify patients needing surgery but may also misidentify non-needing patients. Studies warn against over-treatment due to decreased specificity and suggest higher thresholds may lead to unnecessary surgical interventions.[57]

SUMMARY

This thesis investigates the use of subcutaneous pressure measurements in the leg as a predictor for early surgical intervention in cellulitis. The study found that patients with higher subcutaneous pressures exhibited more severe symptoms and were more likely to require surgery. The data suggested a correlation between pressure elevation and infection severity, suggesting a threshold beyond which surgical intervention could be necessary. The study also found that higher pressure thresholds could identify patients at greater risk for complications but also risk over-treatment by recommending surgery for patients who might otherwise respond well to antibiotics alone. Factors such as age, gender, and comorbidities also influenced subcutaneous pressure readings. Symptom analysis revealed that traditional signs of cellulitis were more pronounced in patients with higher pressures. The findings suggest a paradigm shift in cellulitis management, combining traditional methods with innovative diagnostic techniques to enhance patient outcomes. Further research is needed to refine the application of subcutaneous pressure measurements, develop standardized protocols, and validate these findings in clinical trials.

CONCLUSION

This Research explores the potential of subcutaneous pressure measurements in cellulitis of the leg as a predictive tool for early surgical intervention. The study found that elevated subcutaneous pressures are associated with severe cases of cellulitis, where inflammation and infection have likely progressed beyond the initial stages amenable to antibiotics alone. Higher pressures correlated with an increased

likelihood of complications that might require surgical resolution to prevent further morbidity. The study also highlighted the importance of establishing a precise threshold for subcutaneous pressure that could reliably predict the need for surgical intervention. The study also documented the demographic and symptomatic profiles associated with varying levels of subcutaneous pressure, suggesting that age and comorbid conditions should be considered when evaluating the need for surgical intervention in cellulitis patients. The integration of subcutaneous pressure measurements into the treatment algorithm could potentially enhance decision-making processes, leading to improved patient outcomes, reduced hospital stays, and more effective use of healthcare resources.

Reference

1. Sullivan T, de Barra E. Diagnosis and management of cellulitis. Clin Med (Lond). 2018 Mar;18(2):160-163.
2. Chuang YC, Liu PY, Lai KL, Tseng CH. Bilateral Lower Limbs Cellulitis: A Narrative Review of an Overlooked Clinical Dilemma. Int J Gen Med. 2022 Jun 9;15:5567-5578.
3. Akgun E, Emet A, Sibar K, Çatma FM, Kocyigit IA, Şahin A, Imat E, Adiguzel IF, Fırat A. Risk Factors for Surgical Site Infections Following Fasciotomy in Patients With Acute Compartment Syndrome: A Study on the February 2023 Kahramanmaraş Earthquake. Cureus. 2023 Oct 11;15(10):e46880.
4. Nester M, Borrelli J Jr. Well Leg Compartment Syndrome: Pathophysiology, Prevention, and Treatment. Journal of Clinical Medicine. 2022; 11(21):6448.
5. Dalal A, Eskin-Schwartz M, Mimouni D, Ray S, Days W, Hodak E, Leibovici L, Paul M. Interventions for the prevention of recurrent erysipelas and cellulitis. Cochrane Database Syst Rev. 2017 Jun 20;6(6):CD009758.
6. Palma Medina LM, Rath E, Jahagirdar S, Bruun T, Madsen MB, Strålin K, Unge C, Hansen MB, Arnell P, Nekludov M, Hyldegaard O, Lourda M, Santos VAMD, Saccenti E, Skrede S, Svensson M, Norrby-Teglund A. Discriminatory plasma biomarkers predict specific clinical phenotypes of necrotizing soft-tissue infections. J Clin Invest. 2021 Jul 15;131(14):e149523.
7. Spinnato P, Patel DB, Di Carlo M, Bartoloni A, Cevolani L, Matcuk GR, Cromb  A. Imaging of Musculoskeletal Soft-Tissue Infections in Clinical Practice: A Comprehensive Updated Review. Microorganisms. 2022; 10(12):2329.
8. Humphreys I, Akbari A, Griffiths R, Graham-Woollard D, Morgan K, Noble- Jones R, Gabe-Walters M, Thomas M. Evaluating the cost of managing patients with cellulitis in Wales, UK: A 20-year population-scale study. Int Wound J. 2023 Aug;20(6):2129-2140.
9. Wright T, Hope V, Ciccarone D, Lewer D, Scott J, Harris M. Prevalence and severity of abscesses and cellulitis, and their associations with other health outcomes, in a community-based study of people who inject drugs in London, UK. PLoS One. 2020 Jul 14;15(7):e0235350.
10. Joubert SV, Duarte MA. Cellulitis of the Knee in a 16-Month-Old Boy: A Case Report. J Chiropr Med. 2016 Mar;15(1):53-8.
11. Lagac  F, D'Aguanno K, Prosty C, Laverde-Saad A, Cattelan L, Ouchene L, Oliel S, Genest G, Doiron P, Richer V, Jfri A, O'Brien E, Lefran ois P, Powell M, Moreau L, Litvinov IV, Muntyanu A, Netchiporouk E. The Role of Sex and Gender in Dermatology - From Pathogenesis to Clinical Implications. J Cutan Med Surg. 2023 Jul-Aug;27(4):NP1-NP36.
12. Collazos J, De la Fuente B, De la Fuente J, Garc a A, Gomez H, Rivas- Carmenado M, Su rez-Zarracina T, Enriquez H, S nchez P, Alonso M, L pez- Cruz I, Mart n-Regidor M, Mart nez-Alonso A, Guerra J, Artero A, Blanes M, Asensi V. 455. Gender Differences in Clinical, Microbiological and Treatment Characteristics of Adult Hospitalized Patients with Cellulitis: A Large, Prospective Multicenter Study. Open Forum Infect Dis. 2019 Oct 23;6(Suppl 2):S223.
13. Collazos J, de la Fuente B, Garc a A, G mez H, Men ndez C, Enr quez H, S nchez P, Alonso M, L pez-Cruz I, Mart n-Regidor M, Mart nez-Alonso A, Guerra J, Artero A, Blanes M, de la Fuente J, Asensi V. Cellulitis in adult patients: A large, multicenter, observational, prospective study of 606 episodes and analysis of the factors related to the response to treatment. PLoS One. 2018 Sep 27;13(9):e0204036.

14. Rubitschung K, Sherwood A, Crisologo AP, Bhavan K, Haley RW, Wukich DK, Castellino L, Hwang H, La Fontaine J, Chhabra A, et al. Pathophysiology and Molecular Imaging of Diabetic Foot Infections. *International Journal of Molecular Sciences*. 2021; 22(21):11552.
15. Rrapi R, Chand S, Kroshinsky D. Cellulitis: A Review of Pathogenesis, Diagnosis, and Management. *Med Clin North Am*. 2021 Jul;105(4):723-735.
16. Tong SY, Davis JS, Eichenberger E, Holland TL, Fowler VG Jr. Staphylococcus aureus infections: epidemiology, pathophysiology, clinical manifestations, and management. *Clin Microbiol Rev*. 2015 Jul;28(3):603-61.
17. Lurie F, Malgor RD, Carman T, Dean SM, Iafrati MD, Khilnani NM, Labropoulos N, Maldonado TS, Mortimer P, O'Donnell TF Jr, Raffetto JD, Rockson SG, Gasparis AP. The American Venous Forum, American Vein and Lymphatic Society and the Society for Vascular Medicine expert opinion consensus on lymphedema diagnosis and treatment. *Phlebology*. 2022 May;37(4):252-266.
18. Norman G, Shi C, Goh EL, Murphy EM, Reid A, Chiverton L, Stankiewicz M, Dumville JC. Negative pressure wound therapy for surgical wounds healing by primary closure. *Cochrane Database Syst Rev*. 2022 Apr 26;4(4):CD009261.
19. Papaetis GS, Politou VN, Panagiotou SM, Georghiou AA, Antonakas PD. Recurrent Cellulitis-Like Episodes of the Lower Limbs and Acute Diarrhea in a 30-Year-Old Woman: A Case Report. *Am J Case Rep*. 2021 Aug 31;22:e932732.