A STUDY ON ACCURACY OF "POINT OF CARE ULTRASOUND" IN DIAGNOSING AND MANAGEMENT OF NECROTIZING FASCIITIS

Prospective observational study

Submitted by: Dr Medikonda Eswar

DISSERTATION SUBMITTED TO B. L. D. E. (DEEMED TO BE UNIVERSITY)'s SHRI B.M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE, VIJAYAPURA, KARNATAKA

In partial fulfilment of the requirements for the degree of

MASTER OF SURGERY

In

GENERAL SURGERY

Under the guidance of

DR. ARAVIND V. PATIL, M.S

PROFESSOR DEPARTMENT OF GENERAL SURGERY

B. L. D. E. (Deemed to be University)'s SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE VIJAYAPURA, KARNATAKA

B. L. D. E. (Deemed to be University)'s SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE VIJAYAPURA, KARNATAKA

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Date:

X

Dr Medikonda Eswar
Junior Resident, Department of General Surgery

Place: Vijayapura

B. L. D. E. (Deemed to be university)
SHRI B. M. PATIL MEDICAL COLLEGE HOSPITAL &RESEARCH CENTRE, VIJAYAPURA.

CERTIFICATE BY THE GUIDE

This is to certify that the dissertation entitled "**A STUDY ON ACCURACY OF POINT OF CARE ULTRASOUND IN DIAGNOSING AND MANAGEMENT OF NECROTIZING FASCIITIS"** is a bonafide research work done by **Dr Medikonda Eswar** in partial fulfillment of the requirement for the degree of M.S in General Surgery.

Date:

X

Dr. Aravind V. Patil
M.S. Professor Department Of General Surgery

Place: Vijayapura

B. L. D. E. (Deemed to be university)
SHRI B. M. PATIL MEDICAL COLLEGE HOSPITAL &RESEARCH CENTRE, VIJAYAPURA.

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Date:
Place: Vijayapura

X

Dr. Rajashekar Muchchandi
M.D. HOD & Professor Department Of RADIOLOGY

B. L. D. E. (Deemed to be university)

SHRI B. M. PATIL MEDICAL COLLEGE HOSPITAL

& RESEARCH CENTRE, VIJAYAPUR.

ENDORSEMENT BY THE HOD AND PRINCIPAL

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Dr. M.S. KOTENNAVAR
Professor & Head,
Department Of General Surgery.
B. L. D. E. (Deemed to be university)
Shri B. M. Patil Medical College, Hospital and Research Centre ,Vijayapura

Dr. ARAVIND V PATIL
Principal,
B. L. D. E. (Deemed to be university)
Shri B. M. Patil Medical College, Hospital and Research Centre ,Vijayapura

B. L. D. E. (Deemed to be university)

SHRI B. M. PATIL MEDICAL COLLEGE HOSPITAL &

RESEARCH CENTRE, VIJAYAPUR.

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DATE –

Dr Medikonda Eswar

PLACE – Vijayapura

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DR. Medikonda Eswar

ABBREVIATIONS

POCUS - Point Of Care UltraSound

NF - Necrotizing Fasciitis

USG - Ultrasonography

LRINEC - Laboratory Risk Indicator for Necrotizing Fasciitis

CT - Computed Tomography

MRI - Magnetic Resonance Imaging

WBC - White Blood Cell

CRP - C-Reactive Protein

SD - Standard Deviation

IV - Intravenous

GAS - Group A Streptococcus

MRSA - Methicillin-Resistant Staphylococcus Aureus

NSTI - Necrotizing Soft Tissue Infection

MODS - Multiple Organ Dysfunction Syndrome

ICU - Intensive Care Unit

SIRS - Systemic Inflammatory Response Syndrome

BMI - Body Mass Index

DM - Diabetes Mellitus

HTN - Hypertension

NPWT - Negative Pressure Wound Therapy

VAC - Vacuum-Assisted Closure

IDSA - Infectious Diseases Society of America

PPV - Positive Predictive Value

NPV - Negative Predictive Value

ROC - Receiver Operating Characteristic

APACHE - Acute Physiology and Chronic Health Evaluation

SOFA - Sequential Organ Failure Assessment

CDC - Centers for Disease Control and Prevention

WHO - World Health Organization

IV - Intravenous

NSAID - Non-Steroidal Anti-Inflammatory Drug

ESR - Erythrocyte Sedimentation Rate

CPK - Creatine Phosphokinase

AST - Aspartate Aminotransferase

ALT - Alanine Aminotransferase

BUN - Blood Urea Nitrogen

SSTI - Skin and Soft Tissue Infection

HBOT - Hyperbaric Oxygen Therapy

List of Tables

List of Figures

List of Graphs

TABLE OF CONTENTS

ABSTRACT

Background: Necrotizing fasciitis (NF) is a rapidly progressive, life-threatening soft tissue infection with high mortality rates. Early diagnosis and prompt surgical intervention are crucial for survival, yet the initial diagnosis remains challenging due to nonspecific early presentations. This study evaluated the diagnostic accuracy of point-of-care ultrasound (POCUS) in identifying NF and its utility in guiding clinical management decisions.

Methods: This prospective observational study included 85 patients with suspected NF at a tertiary care center in India from April 2023 to April 2025. Trained emergency physicians performed POCUS examinations using high-frequency linear transducers and low-frequency curvilinear transducers when necessary. Sonographic findings were documented and correlated with surgical observations, clinical outcomes, and laboratory parameters. Primary outcomes included

POCUS diagnostic accuracy, need for surgical intervention, and mortality rates.

Results: The study population had a mean age of 50.2 years, with male predominance (62.4%) and primarily lower limb involvement (77.6%). POCUS demonstrated high positivity (97.6%) with predominantly fluid collection (77.6%), loss of vascularity (65.9%), and fascial thickening (52.9%). Sensitivity was highest for fascial thickening (97.1%) and fluid collection (92.5%). The majority required multiple debridements (83.5%), with 43.5% undergoing three procedures. At three-week follow-up, 25.9% achieved partial recovery and 18.8% complete recovery, with 15.3% mortality. Complications included amputation (11.8%), sepsis (9.4%), and wound infection (8.2%). POCUS assessment at three weeks showed persistent changes in 36.5% of patients despite clinical improvement in many cases.

Conclusion: POCUS is a highly sensitive diagnostic tool for NF with excellent correlation to surgical findings. Its immediate availability, non-invasive nature, and repeatability position it as a valuable adjunct in the initial assessment and monitoring of this life-threatening condition. Integration of POCUS into standard assessment protocols for suspected

NF can potentially expedite diagnosis, guide surgical interventions, and improve clinical outcomes.

Keywords: Necrotizing fasciitis; Point-of-care ultrasound; Diagnostic accuracy; LRINEC score; Soft tissue infection; Surgical debridement; Mortality; Clinical outcomes

INTRODUCTION

Necrotizing fasciitis (NF) is a rare but potentially lethal soft tissue infection characterized by rapidly progressive necrosis of the fascia and subcutaneous tissue, with reported mortality rates ranging from 25% to 75% despite modern medical advances.[1] The critical determinant of survival in NF is early recognition and immediate surgical intervention, yet the initial diagnosis remains challenging due to its subtle and often nonspecific early presentations.[2]

Traditionally, diagnosis has relied on clinical assessment, laboratory markers, and computed tomography (CT) or magnetic resonance imaging (MRI). However, these imaging modalities may not be readily available in emergency settings, and the time required to obtain them can delay crucial therapeutic interventions.[3] Furthermore, patient transportation for advanced imaging studies may be problematic, particularly in hemodynamically unstable cases.[4]

Point-of-care ultrasound (POCUS) has emerged as a promising diagnostic tool in emergency medicine, offering real-time, bedside evaluation of soft tissue infections.[5] Recent technological advances in portable ultrasound devices have significantly improved image quality and diagnostic capabilities.[6] The potential advantages of POCUS in NF diagnosis include its non-invasive nature, lack of ionizing radiation, cost-effectiveness, and most importantly, its ability to provide immediate results at the patient's bedside.[7]

Several sonographic features have been described in NF, including fascial thickening, subcutaneous fluid accumulation, and gas in soft tissues.[8] However, the diagnostic accuracy of POCUS in NF and its impact on clinical decision-making and patient outcomes requires further systematic evaluation.[9] Additionally, the role of POCUS in monitoring disease progression and guiding surgical management remains to be fully elucidated.[10]

This study aims to evaluate the diagnostic accuracy of POCUS in identifying NF and its utility in guiding clinical management decisions. By comparing POCUS findings with final clinical outcomes, surgical findings, and other imaging modalities, we seek to establish its sensitivity, specificity, and predictive values in NF diagnosis. Furthermore, we will assess its potential impact on time-to-diagnosis, surgical planning, and patient outcomes.

AIM & OBJECTIVES

Objective of the study:

- To study the Accuracy of Ultrasound in Diagnosing and Management of Necrotizing Fasciitis

REVIEW OF LITERATURE

ANATOMY OF SKIN

The largest and most important organ for protecting the body, the skin covers the whole exterior and acts as a first-line physical barrier to keep out the elements.[11]

Structure and Function

Three layers make up the majority of the skin. The epidermis is the topmost layer, followed by the dermis, and the subcutaneous tissue is the third and deepest layer.[11]

The dermis, which lies beneath the epidermis, is home to connective tissue, hair follicles, blood arteries, lymphatic vessels, and sweat glands. The epidermis, the outermost layer of skin, contributes to skin tone and acts as a waterproof barrier. [11]

• Connective tissue and fat make up the hypodermis, the deeper subcutaneous tissue. On areas with thick skin, such as the palms and soles, the epidermis is further separated into five layers: stratum basale, stratum spinosum, stratum granulosum, stratum lucidum, and stratum corneum. In other areas, however, the epidermis only consists of four layers, without the stratum lucidum. The reticular dermis, which is the bottom layer, and the papillary dermis, which is the higher layer, make up the dermis.[11]

The skin serves the following purposes:

Protection against microorganisms, dehydration, ultraviolet light, and mechanical damage; the skin is the first physical barrier that the human body has against the external environment.[11]

- The skin is where pain, temperature, touch, and deep pressure are first perceived.
- Mobility: The skin permits the body to move smoothly.

- Endocrine activity: Vitamin D production, which is necessary for calcium absorption and healthy bone metabolism, is started by the skin.
- Exocrine activity: This happens when ammonia, urea, and water are released. In addition to secreting materials like perspiration, sebum, and pheromones, skin also secretes bioactive molecules like cytokines, which perform vital immunologic activities.
- The development of immunity to infections.
- Temperature regulation. By retaining or releasing heat, the skin contributes to thermal regulation and supports the homeostatic and water balance of the body.[11, 12]

Embryology

In terms of embryology, the surface ectoderm is the source of the epidermis. Melanocytes, which are cells that produce pigment and come from the neural crest, have penetrated it.[13] Keratinocytes, antigen-processing Langerhans cells, and Merkel cells—tactile receptors that detect pressure changes at the base of the epidermis—are other cell types that are typically found in the epidermis.[11,12] Elastic fibres, collagen, nerves, blood vessels, adipocytes, and fibroblasts are among the connective tissue macromolecular components and cells found in the dermis, which is embryologically generated from the mesoderm.[11, 12]

Blood Supply and Lymphatics

The reticular and papillary layers of the dermis are separated by plexuses that supply the highly vascularised skin. The blood supply comes from a vast network of capillaries and bigger blood arteries that reach local locations in the dermis and subcutaneous tissue, respectively, from regional branches of the systemic circulation.[14] Many skin arteries, especially those at the venous end of capillaries, are accompanied by a lymphatic framework.[13]

Nerves

Our ability to physically sense changes in the outside world is influenced by a number of skin receptors.

• Light touch is detected by Meissner receptors.

• Deep pressure and vibrational shifts are sensed by Pachian corpuscles.

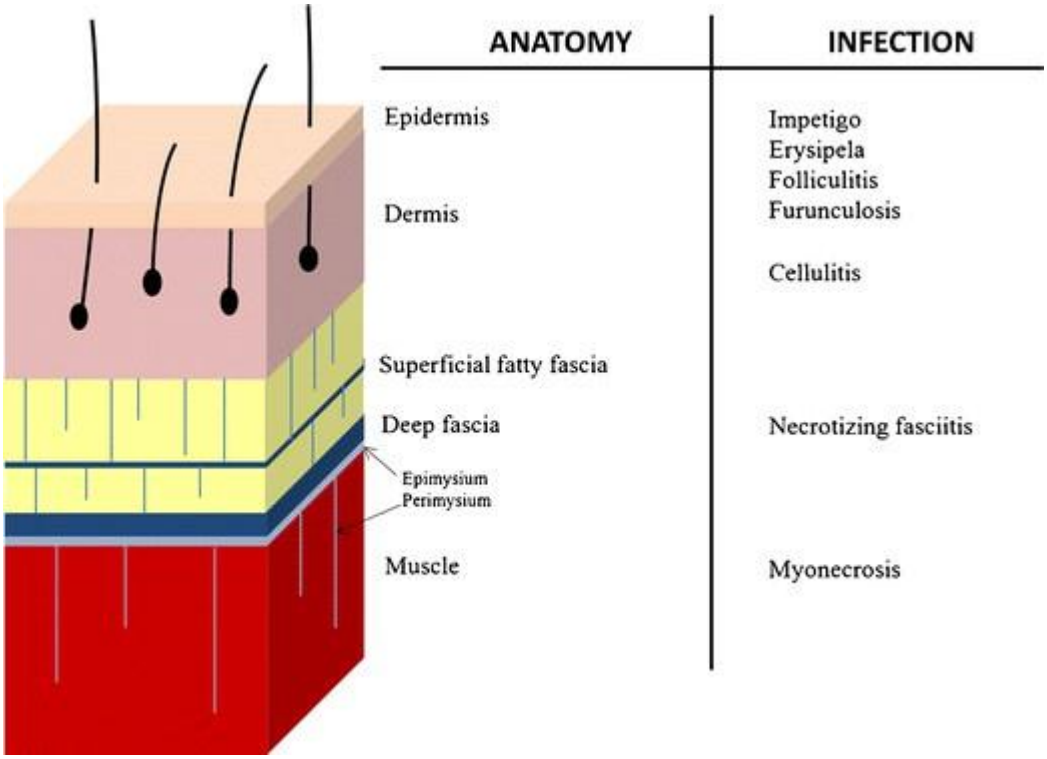
• Nerve endings in the epidermis respond to pain, touch, and temperature changes; Rufini endings sense deep pressure and stretching of the skin's collagen fibres.[14]

• Long-term light touch stimulation over the skin activates Merkel receptors linked to Merkel cells. Skin regions known as dermatomes are primarily supplied by a single spinal nerve. Twelve thoracic nerves, five lumbar nerves, five sacral nerves, and eight cervical nerves—aside from C1—all contribute to the dermatomes. From a specific area of the skin, each of these nerves transmits feeling, including pain, to the brain.[14]

Muscles

The tiniest skeletal muscles in the body, the arrector pili muscles, are present in every skin region where hair follicles are located. In response to environmental stimuli like heat and abrasion, these microscopic muscle structures regulate the location of hairs and the activity of sebaceous glands. When the sympathetic nervous system is activated during the fight-or-flight response, the arrector pili muscles contract, raising the hairs, though this is subject to some debate.[15] Additionally, they react to cold by doing this, which results in the phenomena commonly referred to as “goosebumps.” [16]

Figure 1: Displays the names of the infections that correlate to the various layers, ranging from the muscle to the skin. Necrotising soft tissue infections caused by NSTIs



HISTORICAL BACKGROUNDS

Around 500 BC, Hippocrates wrote, "Many were attacked by the erysipelas all over the body when the exciting cause was a trivial accident... flesh, sinews, and bones fell away in large quantities... there were many deaths." This was the first recorded account of necrotising soft-tissue infection (NSTI). [17] The mortality rate for NSTI has remained between 25% and 35% over the past 30 years, despite significant advancements in medical care and our understanding of the disease. [18] Time to intervention has a direct correlation with mortality. 19. Furthermore, the disease is so common that the typical practitioner will only encounter one or two instances during their tenure. Doctors are not knowledgeable enough about NSTIs to make an accurate diagnosis and provide the required care quickly. An evidence-based review of the pathophysiology, microbiology, diagnosis, and therapy of NSTI is what this article aims to give. In the 18th and 19th centuries, British Naval physicians referred to NSTI as "hospital gangrene." The first person to describe this condition in a large group of patients was Dr. Joseph Jones, a surgeon in the Confederate Army, who reported on 2,642 cases in 1871 and discovered a 46% fatality rate. 20 The procedure still bears Jean Alfred Fournier's name, a French physician who

in 1883 reported a comparable NSTI of the perineum in five male patients. Both male and female individuals have been reported to have it. Numerous additional words, including streptococcal gangrene, necrotising erysipelas, and suppurative fasciitis, have also been used in the years that have followed. This infection has also been called "Clostridial gangrene" or "gas gangrene" because to the possibility that it is linked to the gas-forming bacteria Clostridium perfringens. Fascial necrosis is the sine qua non of this process, according to Dr. Wilson's 1951 proposal to use the word necrotising fasciitis to refer to both gas-forming and nongas-forming necrotising infections. Since necrotising infection of all soft tissues entails a similar approach to diagnosis and treatment regardless of anatomic location or depth of infection, the term necrotising soft tissue infection has been promoted more recently to embrace all manifestations of the disease process. This one, comprehensive name makes it easier to comprehend and guarantees appropriate administration. It should be mentioned that the deeper the initial site of infection, the higher the fatality rate.[21]

DEFINITION

A soft tissue infection that spreads quickly throughout fascial layers and subcutaneous tissues is called necrotising fasciitis (NF).[22]

EPIDEMIOLOGY

In the US, there are about 1,000 cases of NSTI annually, or 0.04 instances for every 1,000 person-years. [23] The precise cause of the increase in NSTI incidence between 1980 and 2000 is yet unknown. [24] It is as prevalent as one in per 100,000 people in various parts of the world. With a mortality rate ranging from 8.7% to 76%, NF highlights the importance of early and precise diagnosis as well as quick medical and surgical intervention. [22]

Indian Situation: Between 0.3 and 15 instances of necrotising fasciitis occur for every 100,000 people. In contrast to other diseases, the quality of life for survivors can be significantly impacted, and morbidity and death are high even with timely surgery, sufficient antibiotic coverage, and critical care support.[22]

CLASSIFICATION

NSTIs can be categorised according to their microbial source, depth of infection, or anatomy (Table 1). These classification schemes are helpful in giving researchers a common vocabulary, but they are not clinically useful because they have no bearing on diagnosis or therapy. Furthermore, as shown below, mortality is correlated with the depth of the original site of infection.

Table 1: Classification Of Necrotizing Fasciitis

Classification factor	COMMENT
Anatomic location	Fournier's gangrene of perineum/scrotum
Depth of infection	Necrotizing adipositis (most common), fasciitis, myositis
Microbial cause	Type I: Polymicrobial (most common) Type II: Monomicrobial (Staphylococcus, Streptococcus, Clostridia sp) Type III: Vibrio vulnificus*

Risk factors

Patients with NF frequently have an underlying infection risk. Predisposing variables include obesity, peripheral vascular disease, advanced age, and immunocompromise. The known risk factors are included in Table 2. 70.3% of NF patients in a Singapore research also had diabetes mellitus. The majority of patients have experienced trauma in the past, or they may have had surgery or a penetrating injury. However, the harm may be rather minor, such as scratches or bug bites. NF has even been recorded following acupuncture, as in the example we described. 15. Patients are likely to forget or overlook to mention this kind of detailed history unless the doctor asks them explicitly. Table 3 summarises other examples of this form of history.

Table 2: Risk factors for necrotizing fasciitis

Diabetes
Chronic disease
Immunosuppressive drugs (eg, prednisolone)
Malnutrition
Age > 60 years
Intravenous drug misuse
Peripheral vascular disease
Renal failure
Underlying malignancy
Obesity

Table 3: Precipitating events causing necrotizing fasciitis

TRAUMATIC	NONTRAUMATIC
Surgery	Soft tissue infection
Minor invasive procedures (eg, joint aspirations, acupuncture, Intravenous drug use)	Burns
Penetrating injuries (eg, insect and animal bites)	Childbirth

Severe necrotising streptococcal infections have been linked to the use of nonsteroidal anti-inflammatory drugs. Nonsteroidal anti-inflammatory medications are thought to affect lymphocyte activity. [25] However, it's also possible that symptoms and inflammation indicators are suppressed, which results in a later diagnosis, particularly in individuals who appear early with vague symptoms. [26] Malnourishment and skin diseases like varicella are risk factors for NF

in children. It is crucial to stress that when a typical, healthy patient has minimal skin injuries, doctors should not rule out NF. These are the cases that are frequently sensationalised and that are overlooked. [27]

Microbiology of NSTI[24]

Table 1 describes the three fundamental microbiological subtypes of NSTI. The most prevalent kind of illness is caused by polymicrobial type I infections. In the majority of wounds, tissue isolates show an average of four distinct species. Gram-positive cocci, gram-negative rods, and anaerobes are the causative bacteria for type I infections, which account for between 55% and 75% of all NSTIs. The frequency of these organisms in type I NSTI has been described by two recent retrospective studies conducted at a single centre. Less frequently, a bacteroide or clostridium species may be the source of the infection. Thanks to advancements in sanitation and hygiene, C. perfringens is currently a rare cause of NSTI despite its historical prevalence. One extremely uncommon cause of NSTI in individuals with perforated colon cancer is Clostridium septicum, an endogenous pathogen. Patients with impaired immune systems, especially those with diabetes and peripheral vascular disease, are frequently diagnosed with type I infections, which typically affect the trunk and perineal regions. Obesity, chronic renal failure, HIV, alcoholism, abscess, intravenous drug use, blunt or penetrating trauma, insect bites, surgical incisions, indwelling catheters, chicken pox, vesicles, and (rarely) gastrointestinal tract perforations (e.g., diverticulitis or carcinoma) are additional risk factors for this type of NSTI. For 20% to 50% of patients, no unique inciting incident has been found despite the abundance of risk indicators. Furthermore, research assessing this show significant variation between study populations and design, making it impossible to determine the relative significance of each risk factor. Group A Streptococcus (Streptococcus pyogenes) can cause type II NSTI as a monomicrobial infection, either by itself or in combination with Staphylococcus aureus. Because it may be linked to toxic shock syndrome, type II NSTI is distinct. Furthermore, community-acquired methicillin-resistant Staphylococcus aureus (MRSA) softtissue infections have become

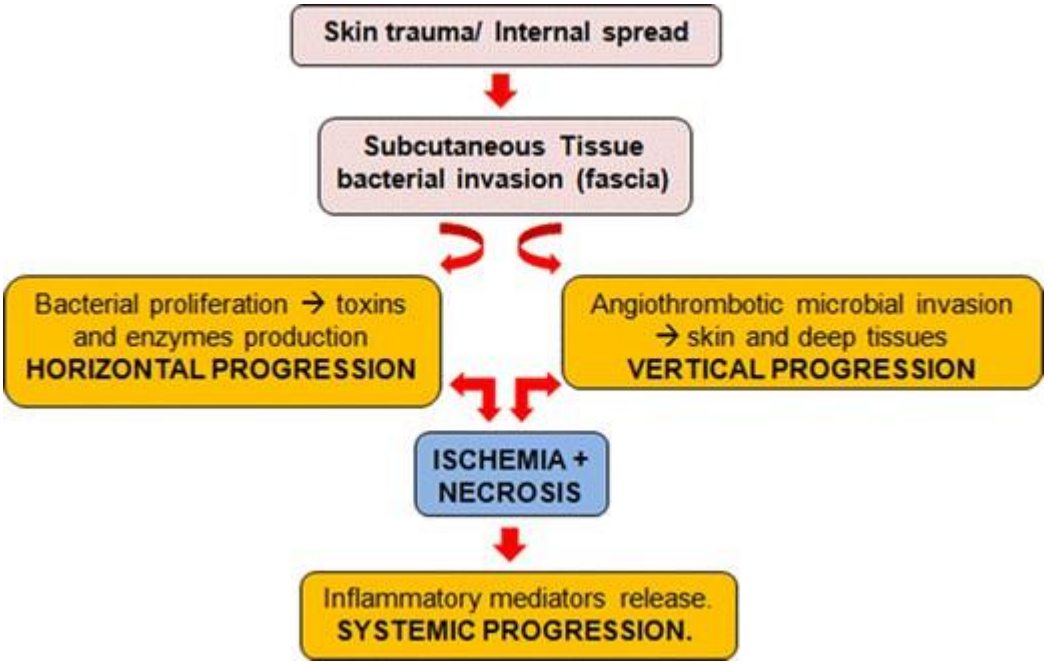
more common during the past five years, especially among athletes, IV drug users, and institutionalised populations. Currently, up to 40% of necrotic wounds have MRSA cultivated in them. Furthermore, even in tissues that are still well-perfused and susceptible to antibiotic penetration, group A streptococci can live and multiply in macrophages, evading antibiotic treatment. Compared to type I infection, type II NSTI is much less frequent and typically affects young, immunocompetent hosts who are otherwise healthy. Although there are many reports of truncal involvement, this illness is typically found on the extremities. Many times, the location has a history of recent trauma or surgery. Those who abuse IV drugs run the risk of developing type I or type II NSTIs. Vibrio vulnificus-caused necrotising infections are classified as category III NSTIs by certain authors, albeit this classification is not widely accepted. This infection, which is most prevalent in coastal regions, is contracted by skin breaks and contact with warm seawater. The largest risk factor for infection by this organism, aside from exposure to marine life, is moderate to severe liver illness, especially chronic hepatitis B infection. Despite being the least frequent kind of NSTI, it has a fulminant course and needs to be identified by the surgeon as soon as possible to reduce the amount of time until surgery. Within 24 hours of infection, multisystem organ failure will develop, and if the illness is not identified and treated right once, it is always fatal.

Pathophysiology

Microbial invasion of the subcutaneous (SC) tissues is typically thought to be caused by either direct spread from a perforated viscus (especially the colon, rectum, or anus) or urogenital organ, or by external trauma. After then, bacteria follow SC and produce endo- and exotoxins that lead to liquefactive necrosis, tissue ischaemia, and frequently systemic disease. [28] With minimal skin change on top, an infection can progress up to 1 inch each hour. The virulence of a specific microorganism can be increased and the infection can develop more quickly through the production of different exotoxins. The -toxin produced by the Clostridium species results in widespread tissue necrosis and circulatory collapse. Streptococci and Staphylococcus aureus

produce superantigen, exotoxins A, B, and C, surface proteins M-1 and M-3, and streptolysin O. The bacteria' capacity to stick to tissue and evade phagocytosis is enhanced by the M proteins. Tissue oedema and reduced capillary blood flow are the results of toxins A and B's damage to the endothelium, loss of microvascular integrity, and plasma escape. Together with streptolysin O, these toxins cause CD4 cells and macrophages to release high amounts of interleukin-1, interleukin-6, and tumour necrosis factors. [29] Septic shock, multisystem organ dysfunction, and mortality can result from the systemic inflammatory response syndrome, which is caused by the systemic release of these cytokines. By inducing neutrophil degranulation, tumour necrosis factor also damages the vascular endothelium further. Superantigens directly activate T cells, which exacerbates tissue ischaemia and small vessel thrombosis by triggering complement, the bradykinin-kallikrein system, and the coagulation cascade. Tissue ischaemia, the last common mechanism, hinders polymorphonuclear cells' ability to oxidatively destroy germs and stops antibiotics from being delivered effectively. Therefore, the primary treatment for NSTI is surgical debridement, and antibiotic therapy by itself is not very effective. [30] Since thrombosis of numerous dermal capillary beds must occur before skin changes suggestive of necrosis occur, the extent of infection is typically much larger than that suggested by skin findings alone, even though thrombosis of perforating vessels to the skin is the key feature in the pathophysiology of NSTI. Reduced capillary blood flow to end tissue is the result of thrombosis, which is brought on by a localised hypercoagulable state, platelet-neutrophil blockage of arteries, and elevated interstitial pressure. Based solely on skin examination, the novice surgeon may not understand the severity or scope of the illness.

Figure 2: Diagram summarizing the pathophysiology of NSTI



Endarteritis obliterans[31]

Small and medium-sized artery intima are affected by endarteritis obliterans, a progressive inflammatory disease that thickens vessel walls and eventually causes luminal obstruction. Endothelial damage initiates the illness process, which is followed by the infiltration of inflammatory cells—specifically T-lymphocytes and macrophages—into the vessel wall. Proliferation of smooth muscle cells, extracellular matrix deposition, and progressive fibrosis are among the events that are set off by this. It is distinguished from other vasculitides by the characteristic clinical finding of concentric intimal thickening with retention of the exterior elastic lamina. Although it can affect any arterial bed, the disorder most frequently affects peripheral arteries, especially in the lower limbs. Smoking, diabetes, autoimmune diseases, and certain infections are risk factors. Progressive ischaemic symptoms, such as tissue loss, rest discomfort, and intermittent claudication, are frequently evident in the clinical presentation. Clinical observations, imaging tests (especially angiography demonstrating smooth, tapered artery constriction), and occasionally histological confirmation are used in the diagnostic evaluation process. If left untreated, the natural history frequently leads to total vascular occlusion, tissue ischaemia, and possibly gangrene. The condition can have a substantial effect

on quality of life, especially in younger people. Understanding the molecular processes underlying the inflammatory response and locating viable therapeutic targets for intervention have been the main goals of recent studies. Research on the involvement of different inflammatory mediators, growth factors, and biological components in the development of disease is still ongoing.

Clinical features

It's a little easier to diagnose patients with NF when they show signs of skin inflammation or the constitutional symptoms of sepsis (such as fever, tachycardia, altered mental state, and diabetic ketoacidosis). One of the most frequently infected areas is the limb. A retrospective analysis of NF patients treated in three Canadian tertiary institutions revealed that the lower limbs (28%), upper extremities (27%), perineum (21%), trunk (18%), and head and neck (5%), were the most frequently infected areas. [32] There may not be much epidermal involvement at first because NF initially begins in the deep tissue planes. This can make it challenging to distinguish cellulitis from non-necrotizing skin diseases. Fever (temperature greater than 38°C), tachycardia, diaphoresis, and potentially even an altered mental state or diabetic ketoacidosis are the earliest symptoms of NF patients, who are typically systemically toxic. In order to look for skin irritation, the physical examination should cover every portion of the body. Patients who exhibit sepsis whose cause is unclear should pay particular attention to this. One can easily overlook the oral cavity and perineum. [33] The majority of individuals exhibit discomfort, skin oedema, and erythema as symptoms of skin inflammation. NF usually presents with pain that is out of proportion to the level of skin inflammation, but as these are also present in less serious conditions like erysipelas and cellulitis, the doctor may be able to learn more from the patient's level of pain in relation to the skin condition. Being a superficial dermal infection, erysipelas has distinct borders and has the potential to blister deeply. Erythema, lymphangitis, and mild blistering are typical symptoms of cellulitis. Patchy skin discolouration, discomfort, and swelling

without a clear border or lymphangitis are the usual symptoms of necrotising fasciitis. [34] Tense oedema, a grayish-brown discharge, vesicles, bullae, necrosis, and crepitus are signs of NF progression. [35] Crepitus and hemorrhagic bullae are concerning symptoms that may indicate damaged muscle and fascia underneath. However, crepitus is a later symptom that only occurs in approximately 18% of NF cases. [36] Blisters and crepitus are not sensitive, although they are the most specific indicators of necrotising soft tissue infection. According to two retrospective case reports by Wang et al.[37] and Elliot et al.38, 62% to 63% of cases had no crepitus at initial presentation, and 76% to 95% of cases had no blistering. As previously stated, necrotising infections do not cause lymphangitis or lymphadenopathy, although they are nonetheless characteristics of cellulitis. [34] Another indicator of NF is localised discomfort. At first presentation, the epidermis is only slightly affected because the disease is a deep-seated infection. The patient may experience discomfort that is excessive for the extent of skin involvement or that goes beyond the apparent infection margin. [35] Acetaminophen with codeine or a comparable painkiller, in conjunction with careful positioning of the afflicted area, can help individuals with cellulitis manage their pain. On the other hand, NF patients frequently experience excruciating pain, and they may become extremely nervous and afraid when being probed. Some patients, particularly those with diabetic neuropathy and lack of sensitivity, may, however, have very little pain, which could lead to a mistaken diagnosis. This is more prone to occur in hidden infection sites like the oral cavity or perineum. In NF, a patch of anaesthesia over the erythema location is also occasionally reported. This is believed to be caused by cutaneous nerve infarction in soft tissue and necrotic subcutaneous fascia.[40]

Table 3 lists clinical features indicative of NF.

Table 4: Clinical features suggestive of necrotizing soft tissue infections[40]

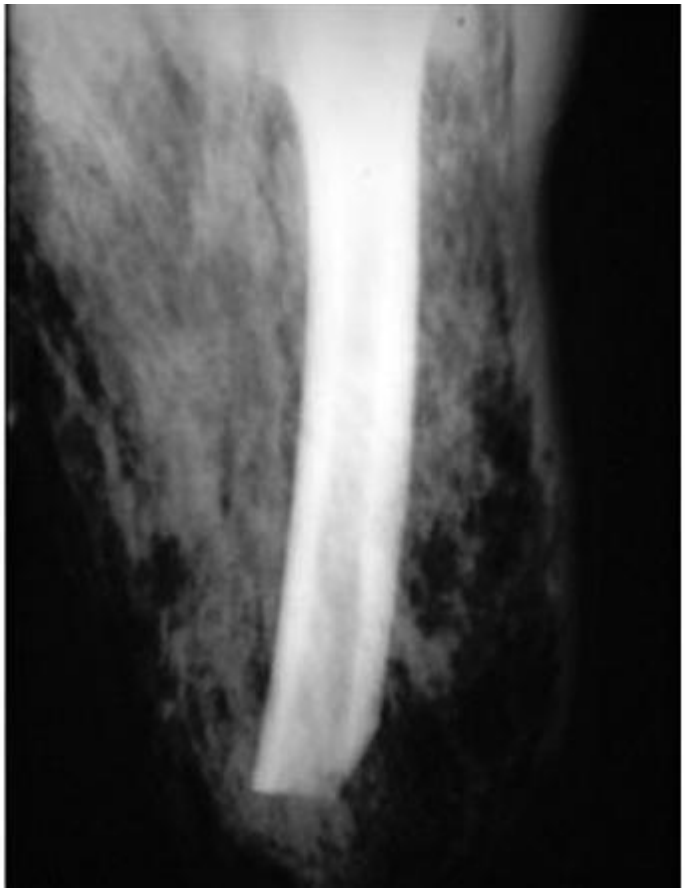
SKIN	PAIN	GENERAL
Erythema with ill-defined margins Tense edema with grayish or brown discharge Lack of lymphangitis or lymphadenopathy Vesicles or bullae, hemorrhagic bullae Necrosis Crepitus	Pain that extends past margin of apparent infection Severe pain that appears disproportionate to physical findings Decreased pain or anesthesia at apparent site of infection	Fever with toxic appearance Altered mental state Tachycardia Tachypnea due to acidosis Presentation with DKA or HHNK

DIAGNOSIS

Radiographic testing

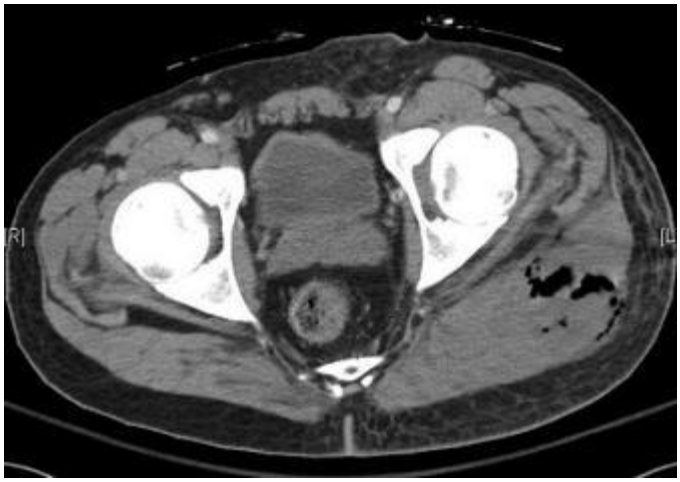
To ascertain whether a patient has NSTI, confirmatory radiographic investigations may occasionally be required. Regretfully, there aren't any well-designed, well powered studies that compare the different radiologic modalities. Overall, inadequate specificity to accurately diagnose NSTI or low sensitivity to detect it early limit all radiographic modalities that have been tested to date. Deeper fascial gas cannot be seen on a plain x-ray, but SC gas or soft-tissue swelling can (Fig. 1). Despite being a specific x-ray finding for NSTI, SC emphysema is extremely insensitive and only occurs in a small percentage of patients. Plain x-rays are a poor screening study for this process since the absence of SC emphysema does not rule out NSTI.

Figure 3: X-Ray showing necrotising Fascitis



In addition to gas formation, a CT scan can reveal inflammatory alterations like fascial oedema and thickening or abscesses, making it more sensitive (Fig. 2). 40 Fascial thickening on CT provided an 80% sensitivity for diagnosing NSTI, according to a retrospective analysis of 20 patients, and IV contrast injection was not very helpful. 41 Thickness and greater enhancement (when IV contrast is used) of the affected tissue planes are consistent but nonspecific findings on CT scans, according to another study. Less common and more specific results include gas or fluid collections.[42]

Figure 4: CT Scan of Necrotising Fascitis



For the detection of NSTI, MRI has a sensitivity of 90% to 100% but a specificity of about 50% to 85%. [43] Soft-tissue or fascial thickening on T2-weighted imaging with enhancement following contrast injection is a characteristic observation, while same results can also be observed following trauma or other noninfectious causes of inflammation. [44] More NSTI-specific findings include peripheral enhancement on contrast-enhanced T1-weighted images and hyperintense signal on T2-weighted images at the deep fascia and within muscles. [45] CT is quicker and more widely accessible than MRI, which is usually prohibitive for patients who are extremely sick or unstable and frequently causes unwarranted treatment delays. Ultrasonography is also useful and can help in situations that are unclear; it can show filthy shadowing and hyperechoic foci with reverberation artefact near the infection site, which indicates subcutaneous gas. The main drawback of this imaging modality, despite its potential benefits, is that the results are dependent on the operator's ultrasound skill set. [46] Laboratory analysis In an effort to speed up and simplify the diagnosis of NSTIs, scoring systems based on laboratory studies have recently been established. According to a retrospective study by Wall and colleagues[47], individuals with necrotising infections were admitted to the hospital with either a sodium level <135 mmol/L or a white blood cell count of 15,400 cells/mm3. Both positive and negative predictive values for these values are 80%. Based on admission data from 89 patients with NSTI, Wong and colleagues48 developed a score they refer to as the "Laboratory Risk Indicator For

Necrotising Fasciitis." For NSTI, a score of 6 has a 92% positive predictive value and a 96% negative predictive value. Additionally, they demonstrated that if the laboratory risk indicator for necrotising fasciitis score is 7, the probability of disease is 75%, and the positive predictive value rises as the score does. The necrotising fasciitis score laboratory risk indicator has not yet been validated in bigger, prospective investigations. Operative exploration is still the gold standard for diagnosing NSTIs. Necrosis or absence of bleeding, "dishwater" or foul-smelling discharge, and a decrease of the fascia's typical resistance to finger dissection are all operational findings that are consistent with necrotising infection. Since intraoperative findings are frequently obvious, an intraoperative biopsy with Gramme stain can be utilised in cases that are unclear, but it is typically not necessary. Because the infection tracts SC and surface manifestations reflect ischaemic necrosis, there is no need to culture blisters or the skin's surface. The diagnostic yield of intraoperative tissue biopsy is reduced if it is not conducted from the interface between live and dead tissue and is not examined by a pathologist with NSTI experience. [49] The biopsy will reveal polymorphonuclear infiltration into the dermis, dermal oedema, and superficial epidermal hyaline necrosis early in the illness course. Later on, penetrating fascial vessels will exhibit thrombosis and inflammation. All tissue layers and SC ducts exhibit varying degrees of necrosis in the later stages.[50]

Table 5: Laboratory Risk Indicator for Necrotizing Fasciitis Score

Variable	Score
C-reactive protein	
<150	0
≥150	4
WBC(cells/mm3)	
<15	0
15-25	1
>25	2
Sodium (mmol/L)	
≥135	0
<135	2
Haemoglobin (g/dL)	
>13.5	0
11-13.5	1
<11	2
Creatinine (mcg/L)	
≥141	0
<141	2
Glucose (mmol/L)	
≥10	0
<10	1

Table 6: Summary of Laboratory Indices Used to Facilitate Diagnosis of NF

Laboratory Index	Summary of Included Parameters	Parameters	Criteria
LRINEC	Six common serum parameters at the time of presentation	CRP total WBC count Hemoglobin serum Na Creatinine glucose	≥6 = higher risk of NF
MLRINEC	Six common serum parameters + liver disease at the time of presentation	CRP total WBC count Hemoglobin serum Na Creatinine glucose Lactate liver disease	≥12 = higher risk of NF
FGSI	Three vital signs + six serum markers	Temperature heart rate Respiration rate serum Na Serum K creatinine Haematocrit total WBC count Serum bicarbonate	9 = cut-off value for NF >9 = mortality likelihood of 75% ≤9 = survival likelihood of 78%
SIARI	Four comorbidities + three serum markers	Site of infection outside the lower limb History of immunosuppression Age ≤ 60 Creatinine Inflammatory markers (total WBC count CRP)	3 = cut-off value for NF 6–7 = moderate risk of NF ≥8 = high risk for NF
LARINF	Three comorbidities + three serum markers	Heart, liver, or renal insufficiency Immunosuppression (does not include diabetes) Obesity Procalcitonin CRP Hemoglobin	≥5 = higher risk of NF

How NSTI differs from Lymphedema[51]

1. Onset and Progression:

- Lymphedema: Typically gradual onset, develops slowly over weeks to months
- Necrotizing fasciitis: Rapid onset and progression, worsening over hours to days

2. Pain:

- Lymphedema: Usually painless or mildly uncomfortable
- Necrotizing fasciitis: Severe, disproportionate pain that extends beyond the visible area

3. Skin Appearance:

- Lymphedema:
    - Soft, pitting edema initially
    - Skin typically normal colored or slightly darker
    - No redness or warmth initially
    - Non-tender to touch
- Necrotizing fasciitis:
    - Red, hot, swollen area initially
    - Progresses to purple/bluish patches
    - May develop dark bullae or blisters
    - Skin may feel hard or wooden
    - Extremely tender to touch

4. Systemic Symptoms:

- Lymphedema: Generally no systemic symptoms
- Necrotizing fasciitis:
    - Fever
    - Toxic appearance
    - Rapid heart rate
    - Low blood pressure
    - Confusion or altered mental status

5. Risk Factors:

- Lymphedema:
    - Previous cancer surgery/radiation

    - Obesity
    - Chronic venous insufficiency
    - Parasitic infections in endemic areas
- Necrotizing fasciitis:
    - Recent trauma/surgery
    - Immunocompromised state
    - Diabetes
    - IV drug use
    - Breaks in skin integrity

Necrotising fasciitis and lymphoedema exhibit different features on ultrasonography that can help in diagnosis. Ultrasound usually shows extensive thickening of the subcutaneous tissue with enhanced echogenicity in lymphoedema; this is frequently referred to as a "honeycomb" pattern. Normal anatomical architecture is usually preserved, and the tissue appears homogeneous with a distinct fluid accumulation in the subcutaneous area. A thicker dermal layer and a greater separation between the skin and muscle fascia may be seen. Typically, a Doppler test reveals no notable vascular anomalies and normal blood flow patterns.

Necrotising fasciitis, on the other hand, manifests with more concerning ultrasonography results. The most distinctive trait is the presence of subcutaneous gas, which manifests as unclean posterior acoustic shadowing and hyperechoic foci. The fascial layers, which are frequently thicker than 4 mm, seem thickened and hypoechoic. The deep fascial layers usually exhibit irregular hypoechoic or anechoic regions, which are indicative of fluid accumulation. Necrotising fasciitis can be identified by the STAFF sign, which stands for Subcutaneous Thickening, Air, and Fascial Fluid. Strength Early on, Doppler may show hypervascularity; as the disease worsens, vessel thrombosis may cause decreased blood flow. The absence of the soft tissues' typical layered look frequently causes the fascial planes to appear disturbed.

The "cobblestone appearance" with fluid accumulation, which contrasts with the more ordered, honeycomb pattern observed in lymphoedema, is another important observation in necrotising fasciitis. When dynamic compression occurs, real-time imaging may also show abnormal tissue movement, which could indicate tissue necrosis. Crucially, ultrasonography is a useful tool for early diagnosis and condition classification because these abnormalities could exist before overt clinical symptoms show up.

Necrotising fasciitis is a surgical emergency that needs to be treated right away. If detected, the patient should be taken right away to the emergency room since if treatment is delayed, the patient may rapidly deteriorate and die.[51]

How NSTI differs from Gangrene

It can be difficult to distinguish between necrotising fasciitis and gangrene because both illnesses entail tissue death, although they differ in certain ways. In dry gangrene, the affected area appears black, dry, and mummified; in wet gangrene, it appears foul-smelling, moist, and bloated. Generally, gangrene exhibits a distinct separation between healthy and necrotic tissue. Compared to necrotising fasciitis, the progression is typically slower, and the tissue death is frequently restricted to the superficial layers, especially in the extremities or regions with a weakened blood supply.

Conversely, necrotising fasciitis is distinguished by its quick dissemination along fascial planes with hazy boundaries. Early symptoms include erythema and warmth that radiates outside of the visible affected area, as well as excruciating pain that is out of proportion to visible skin changes. Before developing into a violet discolouration with the production of bullae, the skin may first appear normal or slightly reddened. Necrotising fasciitis, in contrast to gangrene, usually results in substantial subcutaneous tissue involvement prior to the onset of overt skin changes, and patients frequently exhibit systemic toxicity, such as fever, tachycardia, and hypotension. Additionally, laboratory results can aid in distinguishing between these disorders. Creatine

kinase, inflammatory markers, and the Laboratory Risk Indicator for Necrotising Fasciitis (LRINEC) score can all be raised in necrotising fasciitis. While gangrene usually exhibits more superficial tissue involvement with obvious vascular compromise, imaging investigations, especially CT or MRI, can reveal fascial thickening and gas tracking along fascial planes in necrotising fasciitis. Crepitus, or gas in tissues, can appear in both diseases, but necrotising fasciitis tends to have more widespread and quickly progressing crepitus. Both illnesses require prompt medical attention, but necrotising fasciitis necessitates more urgent surgical intervention because of its high fatality rate and rapid progression.[51]

Treatment / Management

These patients need to be moved right away to the critical care unit because they are very sick. Diffuse capillary leakage and refractory hypotension are the results of sepsis. In order to maintain blood pressure, the patient will require intensive resuscitation with fluids and the administration of inotropes. Until the surgeon sees the patient, they must be maintained NPO (nothing by mouth). Nutrition is important, but only after the procedure is finished. Once the patient is haemodynamically stable, enteral feedings should begin. The severe negative protein balance brought on by catabolism may be partially compensated for by the enteral feedings.[52, 53] The following are essential ideas for the management and treatment of skin and soft-tissue infections:

1. Early detection and distinction between necrotising and non-necrotizing SSTIs
2. The early introduction of suitable empirical broad-spectrum antibacterial coverage
3. Effective management of infection sources, including debridement of necrotising soft tissue infections (NSTIs) and aggressive surgical intervention for abscess drainage
4. Identification of microorganisms that cause infections and appropriate modification of antibiotic coverage.

The following is the antimicrobial treatment for necrotising fasciitis:

1. Take 1 g of imipenem every 6 to 8 hours, 6 mg of daptomycin per kilogramme of body weight, and 600–900 mg of clindamycin four times a day. OR
2. 3.375 g of piperacillin/tazobactam every 6 hours or 4.5 g every 8 hours, along with 6 mg/kg QD of daptomycin and 600–900 mg of clindamycin four times a day. OR
3. Vancomycin 15–20 mg/kg/dose every 8–12 hours, clindamycin 600–900 mg four times a day, and Meropenem 1 g IV every 8 hours. OR Operation

Necrotising fasciitis is treated with surgery, so it is best to schedule a surgical consultation as soon as possible. The better the outcome, the earlier the procedure is performed. All necrotic tissues must be extensively and widely debrided during the procedure. A second-look procedure might also be necessary in certain situations. Early surgery can reduce tissue loss and prevent a gangrenous extremity from needing to be amputated. The wounds must be packed with wet gauze and kept open during extensive debridement. It is required to change clothes every day. The patient recovers more quickly as long as the necrotic tissue is eliminated. When dealing with normal-looking tissue that isn't obviously necrotic, a lot of surgical judgement is needed. Generally speaking, the tissues should be removed if there is any uncertainty over viability. After the removal of the pus and necrotic tissue, haemodynamic stability is usually restored. A critical care unit should be used to monitor and intubate the patient. Daily surgical debridement may be necessary for certain patients. Haemostasis should get careful consideration during the procedure. For the excision of necrotic tissue, some patients might need to return to the operating room.[54]

Soft-tissue Reconstruction

The plastic surgeon should be consulted once all necrotic tissue has been removed and granulation tissue has been observed. Since primary closure is typically not feasible, the plastic surgeon may need to use a muscle flap to heal the wound and reconstruct the soft tissues. Artificial skin may be required for a skin graft if there is insufficient natural skin available.

Hyperbaric oxygenation is an additional therapeutic approach. The majority of these patients are in the intensive care unit, hooked up to various medical devices, which makes the trip to the hyperbaric oxygen therapy facility challenging, even though the research does indicate that this modality can be used. Hyperbaric oxygen therapy may be useful for tiny wounds, but there is no proof that it speeds up healing or extends life for major wounds. Finally, it should be mentioned that hyperbaric oxygen therapy is not a replacement for surgical debridement; rather, it is an additional treatment. When the patient is stable, HBO treatment might be helpful. This treatment may help lower mortality, according to some research. HBO is a supplemental treatment, not a replacement for surgery. [54]

POINT OF CARE ULTRASOUND (POCUS) IN NF

With the right training, point-of-care ultrasonography (PoCUS) is a portable, affordable diagnostic tool that can be used as a convenient addition to physical examinations. PoCUS is advantageous since it can lower the number of imaging tests needed and lessen healthcare obstacles for isolated and rural regions. [55] Certified healthcare professionals employ PoCUS technology, which is portable and improves patient evaluations in a range of healthcare settings, as a diagnostic tool. [56] To differentiate between clinical hypotheses, PoCUS is performed at the patient's bedside using a portable ultrasound equipment or handheld device. Portable ultrasound technologies have dependable equal accuracy to diagnostic ultrasonography exams performed in an imaging department under the supervision of a radiologist when performed by a licensed clinician. Therefore, the number of traditional imaging tests could be decreased by using PoCUS.[57] About thirty years ago, PoCUS was first used in critical care. Over the past ten years, its application in prehospital and ambulatory clinical settings has changed. PoCUS has become a crucial addition to both outpatient and inpatient physical exams due to its use by doctors, specialists, and, more recently, paramedics and advanced practice clinicians.[58]

Diagnostic role in NF[60]

The diagnostic role of POCUS in necrotizing fasciitis is crucial, particularly in the early stages of the disease when clinical signs may be subtle or nonspecific.

1. Early Detection:
    - POCUS can detect subclinical changes in the fascia and soft tissues before obvious external signs appear.
    - This early detection is critical as necrotizing fasciitis can progress rapidly, and early intervention significantly improves outcomes.
2. Differential Diagnosis:
    - POCUS helps differentiate necrotizing fasciitis from other soft tissue infections like cellulitis or simple abscesses.
    - In cellulitis, ultrasound typically shows diffuse soft tissue thickening without fascial involvement.
    - Abscesses appear as well-defined fluid collections, unlike the more diffuse changes seen in necrotizing fasciitis.
3. Assessment of Disease Extent:
    - POCUS can map out the affected area, which may be more extensive than clinically apparent.
    - This is particularly useful in determining the full extent of involvement in deeper tissues.
4. Identification of Specific Features:
    - POCUS can detect subcutaneous gas, a highly specific sign for necrotizing fasciitis, even when not clinically palpable.
    - It can visualize fascial thickening and fluid accumulation along fascial planes, which are hallmarks of the disease.
5. Guiding Further Diagnostic Steps:

- Positive POCUS findings can prompt expedited surgical consultation or additional imaging studies like CT or MRI.
- It can guide the location for tissue biopsy or fluid aspiration for microbiological studies.

6. Serial Monitoring:
    - POCUS allows for repeated examinations to track disease progression or improvement.
    - This is particularly useful in cases where the diagnosis is initially uncertain.
7. Complementing Laboratory Tests:
    - POCUS findings can be correlated with laboratory markers like the Laboratory Risk Indicator for Necrotizing Fasciitis (LRINEC) score to increase diagnostic accuracy.
8. Bedside Availability:
    - The portability of POCUS makes it ideal for rapid assessment in various clinical settings, including emergency departments, intensive care units, and even in resource-limited environments.
9. Non-invasive Nature:
    - Unlike more invasive diagnostic procedures, POCUS can provide valuable information without the need for incision or radiation exposure.
10. Diagnostic Accuracy:
    - Studies have shown that POCUS has high sensitivity and specificity for necrotizing fasciitis when performed by trained operators.
    - One study reported sensitivity of 88.2% and specificity of 93.3% for the diagnosis of necrotizing fasciitis using POCUS.
11. Limitations and Considerations:
    - While highly useful, POCUS is not 100% sensitive or specific.

- Negative POCUS findings should not override high clinical suspicion.
- The accuracy of POCUS is operator-dependent, emphasizing the need for proper training and experience.

12. Integration with Clinical Assessment:
    - POCUS findings should always be interpreted in the context of the patient's clinical presentation, physical examination, and laboratory results.
    - It serves as a valuable adjunct to, rather than a replacement for, thorough clinical evaluation.
13. Potential for Reducing Diagnostic Delays:
    - By providing rapid, bedside information, POCUS can potentially reduce delays in diagnosis and treatment initiation, which is crucial in managing necrotizing fasciitis.

Detailed Ultrasound Findings:[61]

1. Fascial thickening:
    - Normal fascia appears as a thin, hyperechoic line.
    - In necrotizing fasciitis, the fascia becomes thickened (>4mm) and hypoechoic.
    - This thickening is often the earliest detectable sign.
2. Fluid accumulation:
    - Appears as hypoechoic or anechoic areas along fascial planes.
    - May be seen as a cobblestone appearance in the subcutaneous tissues.
    - Can help differentiate from cellulitis, which typically shows less fluid.
3. Subcutaneous gas:
    - Appears as hyperechoic foci with reverberation artifacts ("dirty shadowing").
    - A highly specific sign for necrotizing fasciitis, though not always present early.
4. Fascial hyperechogenicity:
    - Increased echogenicity of the deep fascia compared to normal fascia.

- Often accompanied by a loss of the normal fascia architecture.

5. Increased soft tissue thickness:
    - Overall swelling of the affected area.
    - Can be measured and compared to the contralateral side.
6. Power Doppler findings:
    - Increased blood flow in the soft tissues surrounding the fascia.
    - Lack of blood flow within the fascia itself can indicate necrosis.

Management Applications:[60, 61]

1. Guiding surgical debridement:
    - POCUS can help delineate the extent of fascial involvement.
    - Surgeons can use this information to plan incision sites and estimate the necessary extent of debridement.
    - During the procedure, POCUS can help ensure all affected tissue is removed.
2. Monitoring treatment response:
    - Serial POCUS examinations can track changes in fascial thickness and fluid collections.
    - Reduction in these findings may indicate successful treatment.
    - Persistence or worsening of findings might suggest the need for further intervention.
3. Guiding fluid resuscitation:
    - POCUS of the inferior vena cava can help assess volume status.
    - This is crucial in managing sepsis, which often accompanies necrotizing fasciitis.
4. Identifying complications:
    - POCUS can detect abscesses that may form during the course of treatment.
    - It can also identify vascular complications like deep vein thrombosis.
5. Assisting in wound care:

    - After initial debridement, POCUS can help assess wound healing.
    - It can identify residual fluid collections or ongoing tissue necrosis that may require further intervention.
6. Facilitating bedside procedures:
    - If fluid drainage is necessary, POCUS can guide needle placement.
    - It can also help in the placement of wound vacs or other wound care devices.
7. Decision-making for repeat debridement:
    - If clinical improvement is slow, POCUS can help determine if further surgical debridement is necessary.
8. Educational tool:
    - POCUS images can be used to educate patients and families about the extent and progression of the disease.

POCUS should always be combined with clinical judgement and other diagnostic techniques, even though these applications are useful. If there is a high level of clinical suspicion, POCUS should not postpone definitive therapy because surgery is still the mainstay of managing necrotising fasciitis.

Limitations:

- Operator-dependent
- May be challenging in obese patients or those with extensive subcutaneous emphysema
- Cannot definitively rule out necrotizing fasciitis if clinical suspicion is high

Integration with other diagnostic tools:

- POCUS should be used in conjunction with clinical assessment, laboratory tests, and other imaging modalities when necessary.

Training implications:

- Proper training in POCUS techniques specific to soft tissue infections is crucial for accurate diagnosis and management.

Figure 5: **Ultrasound image of normal anatomy demarcating the epidermis, subcutaneous tissue, fascia and muscles**

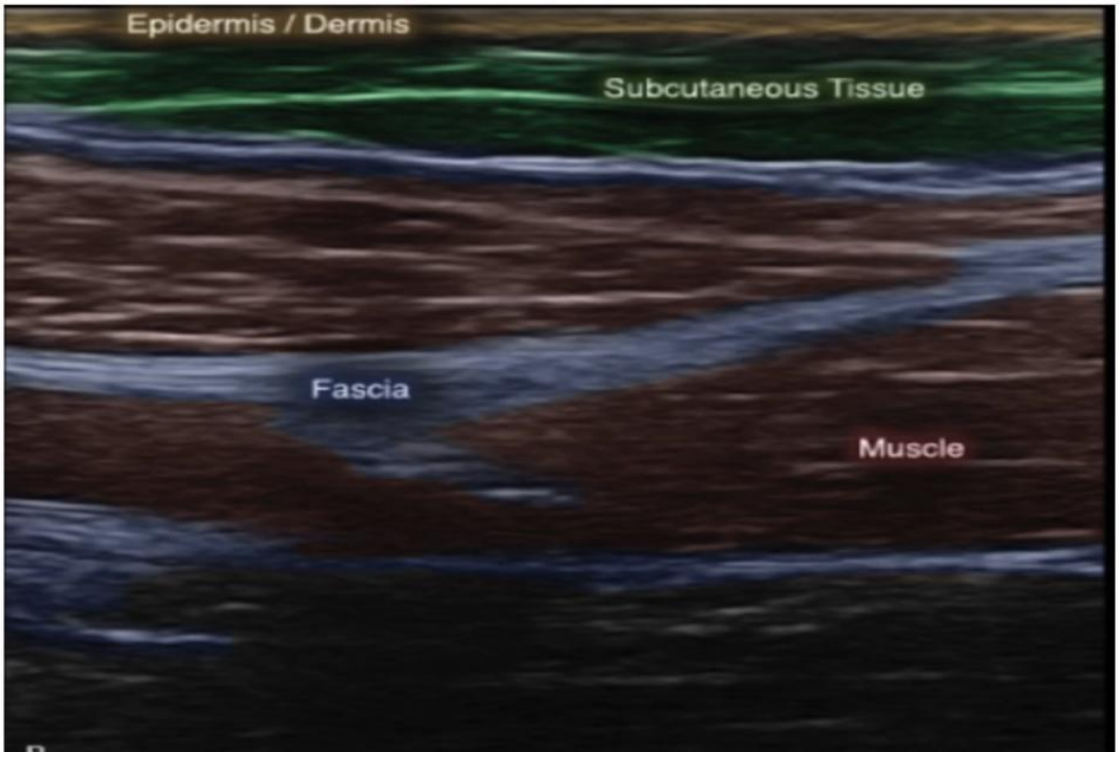


Figure 6: soft tissue ultrasound showing superficial cellulitis with no fascia thickening or sub-fascial fluids seen (clean fascia sign).

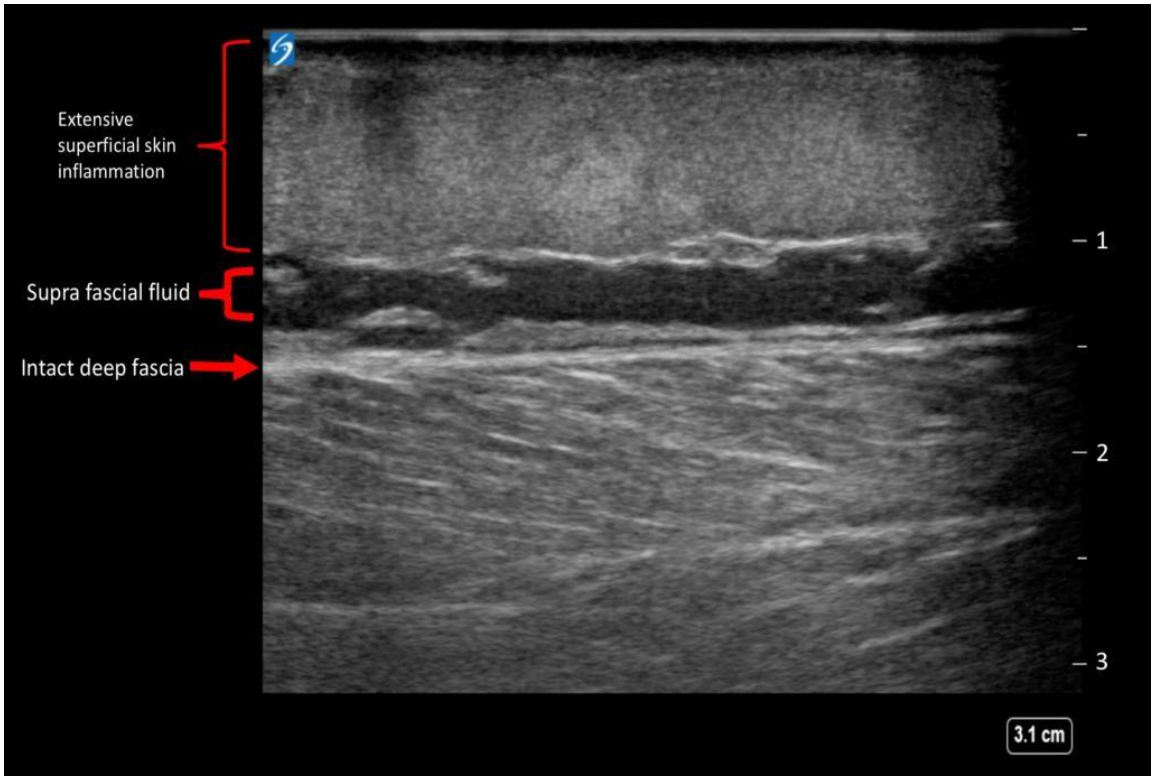


Figure 7: Findings of a necrotizing soft tissue infection include hyper echoic subcutaneous air and the subsequent air shadows that result.

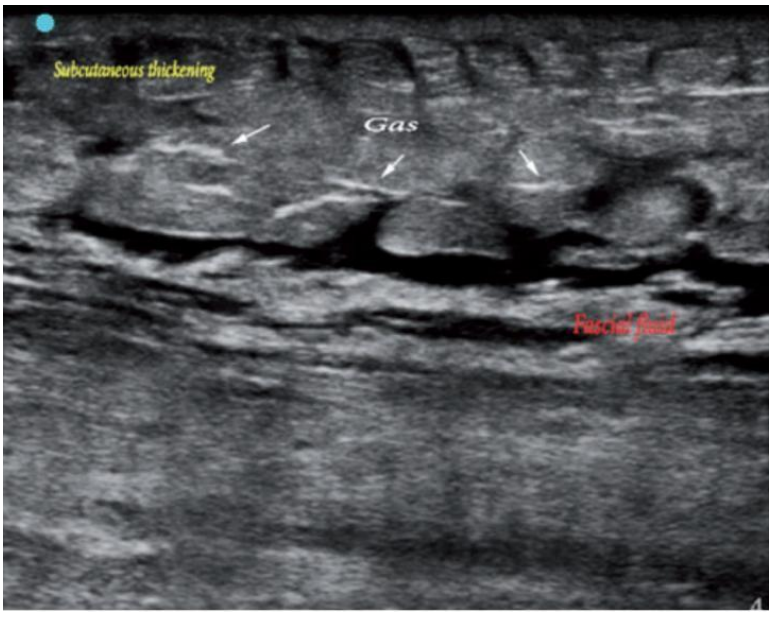
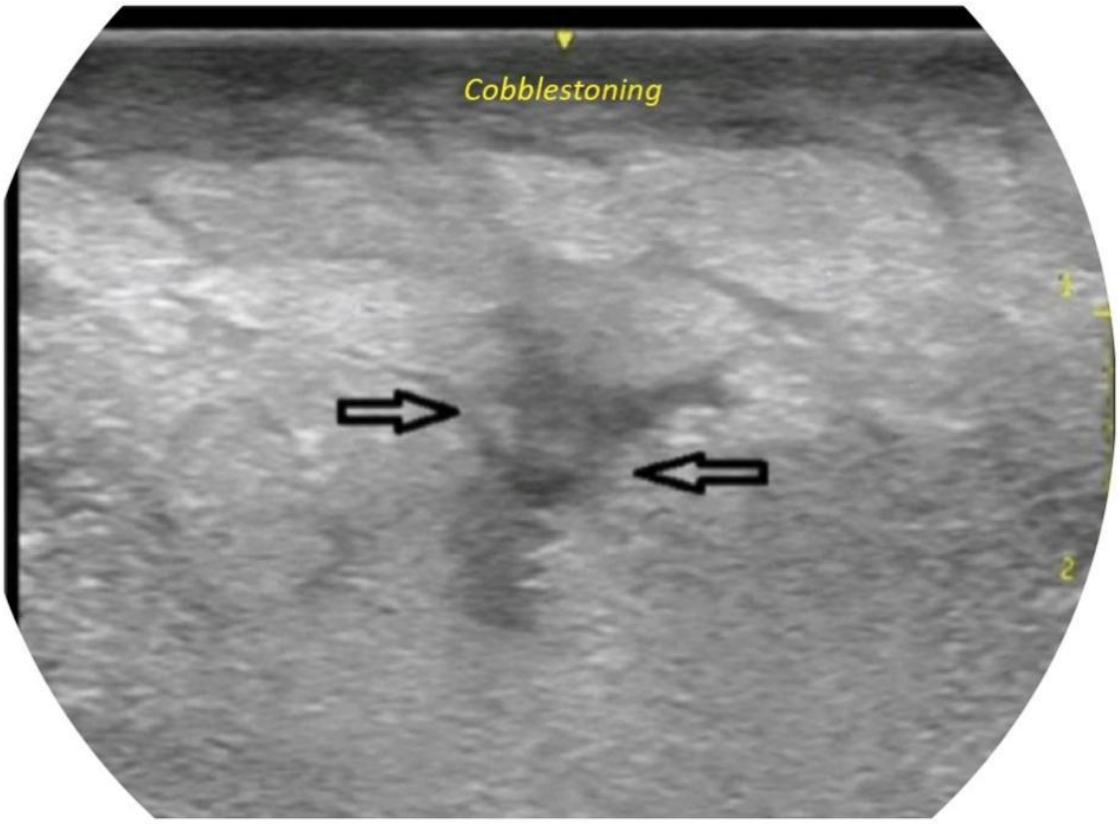


Figure 8: Figure: Ultrasound image of cobble stoning that can be found in necrotizing soft tissue infection. The arrows point to a collection of fluid within the subcutaneous tissue



REVIEW OF RELATED ARTICLES

Zui-Shen Yen et al (2002)[61] determined that ultrasonography can provide reliable information for the diagnosis of necrotising fasciitis after conducting a prospective observational evaluation in Taipei from October 1996 to May 1998 with 62 patients who had ultrasound screening for clinically suspected necrotising fasciitis.

CHUN-NAN LIN et al (2019)[62] examined the relationship between fluid accumulation in ultrasonography and the diagnosis and prognosis of patients with necrotising fasciitis in a retrospective study involving 95 patients conducted in Taiwan between February 2015 and November 2016. The study came to the conclusion that ultrasonography is a point-of-care imaging tool that helps with necrotising fasciitis diagnosis and prognosis.

Lahham S et al (2022)[59] This study's goal is to assess how well POCUS can detect NF in individuals who arrive at the emergency room. Patients who arrived at the emergency department (ED) with a suspected soft tissue infection and who underwent a computed tomography and/or

surgical consultation were prospectively included. For this study, 64 participants were enrolled. Based on their CT scan and/or surgical impression, eight were found to be at high risk of developing NF. Additionally, POCUS pictures were assessed as worrying for NF in each of these patients. Additionally, 56 patients were categorised as low risk for NF based on surgical impressions and/or CT scan results. POCUS pictures were assessed as not worrisome for NF in all but one of these patients. They came to the conclusion that POCUS has a high sensitivity and specificity for NF identification.

Marks A et al (2023)[63] determined that point-of-care ultrasonography (POCUS) has good sensitivity and specificity for the diagnosis of necrotising fasciitis after conducting a systematic evaluation of the literature on the topic of ultrasound for the diagnosis of NF, encompassing three articles with a total of 221 participants.

Gan RK et al (2023)[64] sought to examine how point-of-care ultrasonography can be used to diagnose necrotising fasciitis. Only 21 of the 540 papers that were evaluated had anything to do with employing ultrasonography to diagnose necrotising fasciitis. The results, which span the years 1976–2022, comprise two case series, 16 case reports, and three observational studies. More research is needed to examine the diagnosis accuracy of ultrasonography and its potential to lower morbidity, mortality, and the time delay before surgical intervention, even though its use in identifying NF has been reported in a number of papers with encouraging outcomes.

MATERIAL AND METHODS

- **Study design:** Prospective observational study
- **Study area:** Department of General Surgery, Shri. B. M. Patil Medical College, Hospital and Research Centre Vijayapura.
- **Study period:** Research study was conducted from April 2023 to April 2025. Below is the work plan.

Table 7: Work plan of the study with percentage of allocation of study time and duration in months

Work plan	% of allocation of study time	Duration in months
Understanding the problem, preparation of questionnaire.	5-10%	April 2023 to July 2023
Pilot study, Validation of questionnaire, data collection and manipulation	Upto 80%	August 2023 to August 2024
Analysis and interpretation	5-10%	September 2024 to December 2024
Dissertation write-up and submission	5-10%	January 2025 to April 2025

- **Sample size**: 85 cases
  - As per the study done by Chun-Nan Lin et al.[50] among Necrotizing fasciitis patients 21.5%, the study would require a sample size of 85 patients with a 95% level of confidence and 5% absolute precision**.** margin of error 0.05
  - The sample size computed using the following formula

Sample size (n) = (Z 2 *p*(1-p)) /d 2

Where,

z is the z score= 1.96

d is the margin of error= 0.05

n is the population size

p is the population proportion =0.059

The estimated sample size of this study is 85.

- **Inclusion criteria:**
  - All patients with features of necrotizing fasciitis to B.L.D.E HOSPITAL above the age group of 18- 80years
- **Exclusion criteria:**
  - Age <18yrs & >80 yrs
  - Patient with peripheral vascular disease
  - Previously treated necrotizing fasciitis
  - Prolonged non-healing ulcers for more than 6 months
  - Traumatic injuries

Methodology

Patient Selection and Initial Assessment All patients presenting to the emergency department with clinical suspicion of necrotizing fasciitis were screened for eligibility. The initial clinical assessment focused on identifying toxic appearance, neuralgia, fever, weakness/fatigue, chills, tachycardia, tachypnea, shock, decreased urinary output, and signs of multiorgan system failure. Demographic data, including age, gender, and relevant medical history, were recorded using a standardized data collection form.

Clinical Evaluation and Laboratory Investigations

A comprehensive clinical examination was performed on admission. Vital parameters

were monitored, including temperature, heart rate, respiratory rate, blood pressure, and urine output. Blood samples were collected for complete blood count, renal function tests, liver function tests, coagulation profile, blood glucose levels, and inflammatory markers including C-reactive protein and procalcitonin. Blood cultures were obtained before initiating empirical antibiotic therapy.

Point-of-Care Ultrasound Assessment

Trained emergency physicians performed POCUS examinations with a high-frequency linear transducer (7-15 MHz) and a low-frequency curvilinear transducer (2-5 MHz) when deeper tissue evaluation was required. The affected body regions were systematically scanned, and specific sonographic findings were documented, including:

- Fascial thickening and echogenicity
- Subcutaneous tissue involvement
- Presence of fluid collections
- Gas in soft tissues
- Depth of tissue involvement

The POCUS findings were used to mark the extent of tissue involvement for surgical planning. Images and clips were stored digitally for subsequent analysis and correlation with surgical findings.

Surgical Management and Treatment Protocol

Based on the POCUS findings and clinical assessment, patients underwent surgical debridement. The surgical team documented the correlation between ultrasound-marked areas and actual tissue involvement during surgery. The extent of debridement was guided by both preoperative POCUS findings and intraoperative tissue assessment. Post-debridement wound care protocols were standardized across all patients.

Comorbidity Assessment and Management

Patients' comorbidities were thoroughly evaluated and documented. Common

comorbidities included diabetes mellitus, hypertension, chronic kidney disease, and immunosuppression. Management protocols were adjusted according to individual comorbidity profiles.

Outcome Measures and Follow-up

The primary outcome measures included:

- Accuracy of POCUS in identifying the extent of tissue involvement (compared with surgical findings)
- Time from presentation to surgical intervention
- Length of hospital stay
- Need for repeat debridement
- In-hospital mortality

Secondary outcome measures included:

- Condition of the patient at discharge
- Relief of symptoms
- Wound healing progression
- Functional recovery
- Quality of life assessment

Post-treatment follow-up was conducted at regular intervals to assess wound healing, functional recovery, and long-term outcomes. Photographic documentation of wound progression was maintained throughout the treatment course.

STATISTICAL ANALYSIS

Data was entered in excel sheet and analyzed using SPSS version 21. Results were presented in tabular and graphical forms Mean, median, standard deviation and ranges were calculated for quantitative data. Qualitative data were expressed in terms of frequency and

percentages. Student t test (Two Tailed) was used to test the significance of mean and P value <0.05 was considered significant.

RESULTS

The present study was conducted in the department of General surgery at Shri. B. M. Patil Medical College Hospital and Research Centre Vijayapura from April 2023 to April 2025 to study the Accuracy of Ultrasound in Diagnosing and Management of Necrotizing Fasciitis. Total of 85 patients were considered for the study.

Following were the results of the study:

Table 8: Distribution of patients according to age

Age (in years)	Frequency	Percentage
20-40	31	36.5%
41-60	36	42.4%
61-80	18	21.2%
Total	**85**	**100%**

Table 8 and graph 1 shows that most patients with necrotizing fasciitis were middle-aged, with 42.4% falling in the 41-60 years age group, followed by 36.5% in the 20-40 years group, and 21.2% in the 61-80 years group

Graph 1: Distribution of patients according to age

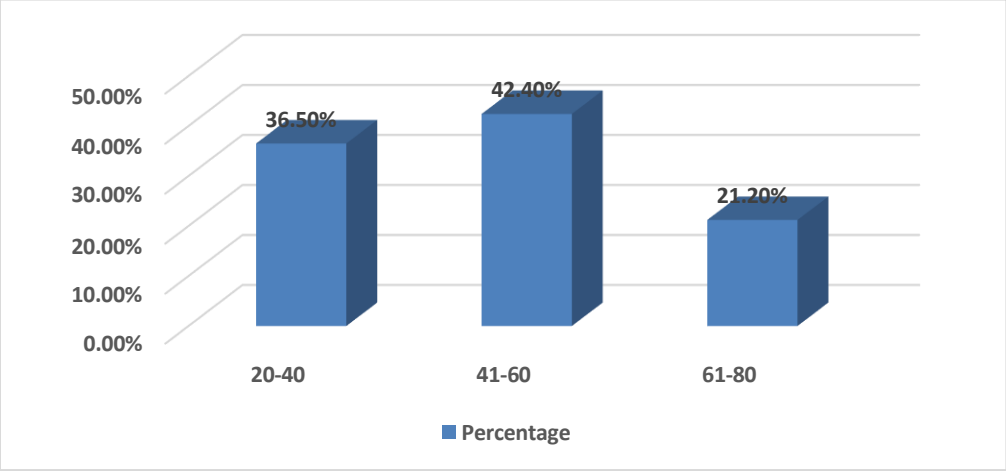


Table 9: Distribution of patients according to gender

Gender	Frequency	Percentage
Female	32	37.6%
Male	53	62.4%
Total	**85**	**100%**

Table 9 and graph 2 indicates that necrotizing fasciitis affected more males (62.4%) than females (37.6%) in the study population of 85 patients.

Graph 2: Distribution of patients according to gender

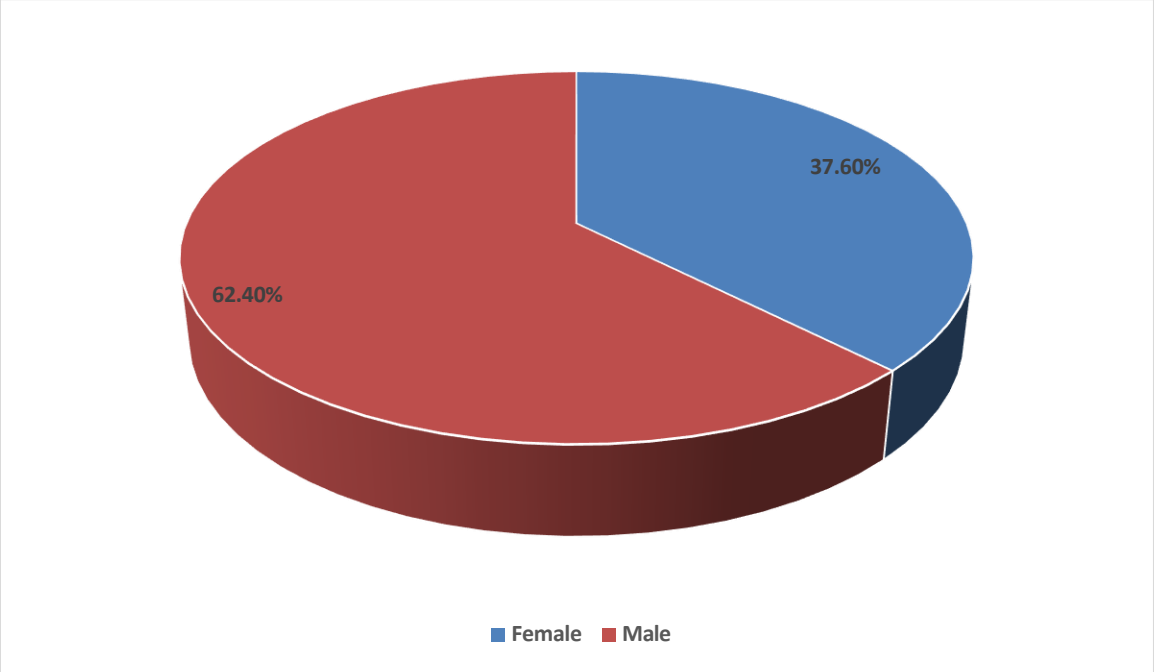


Table 10: Distribution of patients according to affected body parts

Affected body parts	Frequency	Percentage
Abdomen	2	2.4%
Lower limb	66	77.6%
Upper limb	17	20%
Total	**85**	**100%**

Table 10 and graph 3 reveals that the lower limb was the most commonly affected body part (77.6%), followed by upper limb (20%), with only 2.4% of cases occurring in the abdomen.

Graph 3: Distribution of patients according to affected body parts

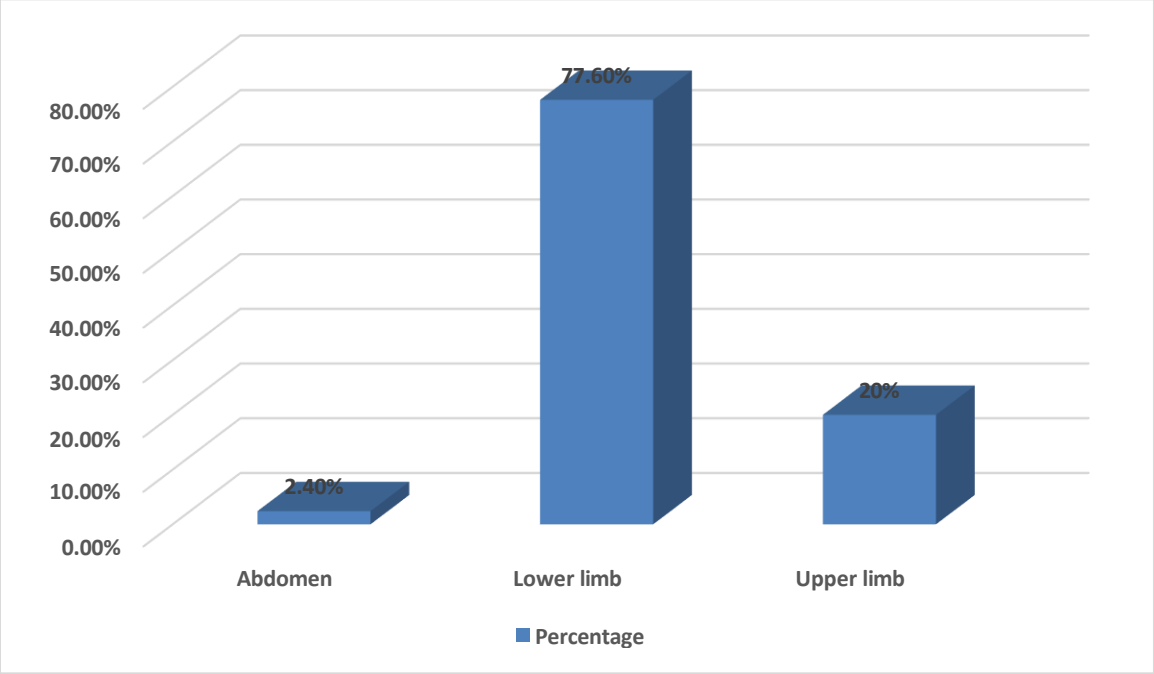


Table 11: Distribution of patients according to laterality

Laterality	Frequency	Percentage
Left	39	45.9%
Right	46	54.1%
Total	**85**	**100%**

Table 11 and graph 4 demonstrates that the right side of the body (54.1%) was slightly more affected than the left side (45.9%) in patients with necrotizing fasciitis.

Graph 4: Distribution of patients according to laterality

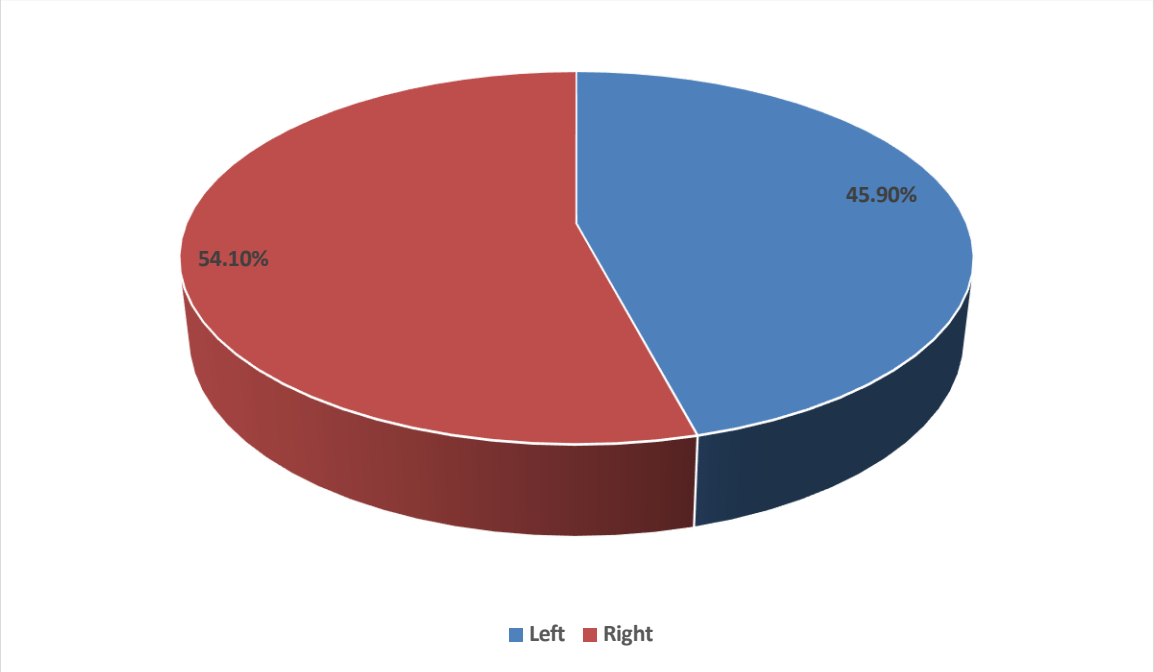


Table 12: Distribution of patients according to clinical presentation

Clinical presentation	Frequency	Percentage
Fever	77	90.6%
Chills	70	82.4%
Neuralgia	65	76.5%

Tachycardia	74	87.1%
Tachypnoea	67	78.8%
Toxic appearance	69	81.2%

Table 12 and graph 5 highlights that the most common clinical presentations were fever (90.6%), tachycardia (87.1%), chills (82.4%), toxic appearance (81.2%), tachypnea (78.8%), and neuralgia (76.5%).

Graph 5: Distribution of patients according to clinical presentation

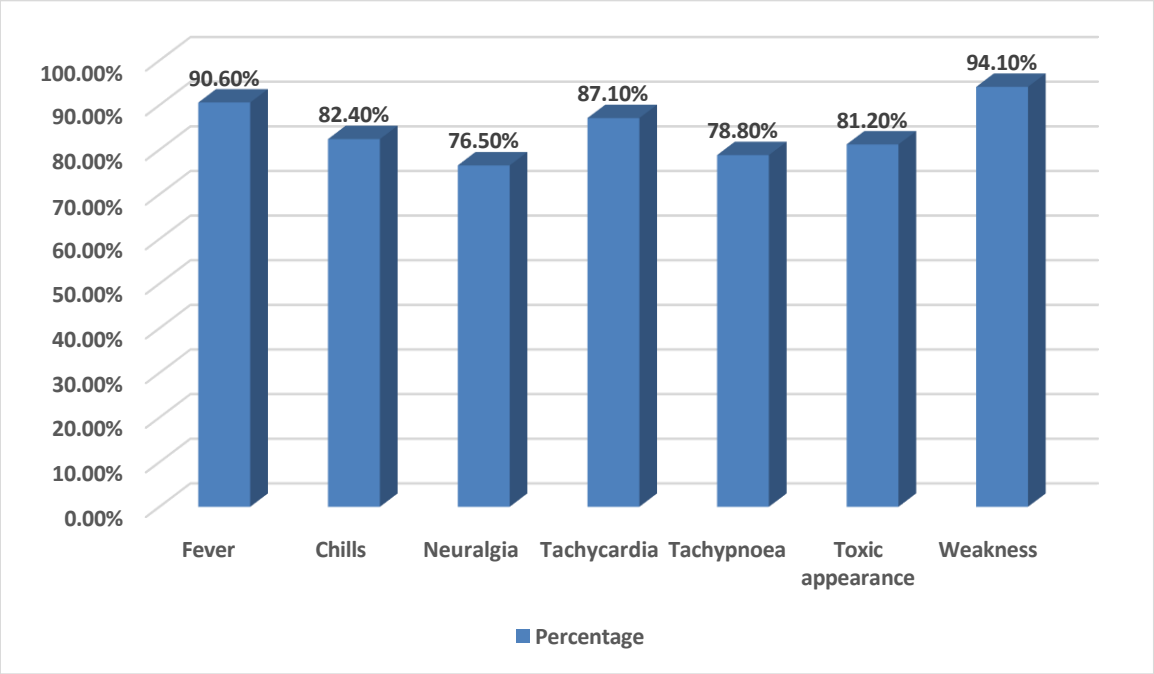


Table 13: Distribution of patients according to different variables

Variables	Duration of symptoms	Length of hospital stay
Mean	7.75	25.08
SD	3.89	11.1

Table 13 and graph 6 shows that patients had symptoms for an average of 7.75 days before presentation, with an average hospital stay of 25.08 days.

Graph 6: Distribution of patients according to different variables

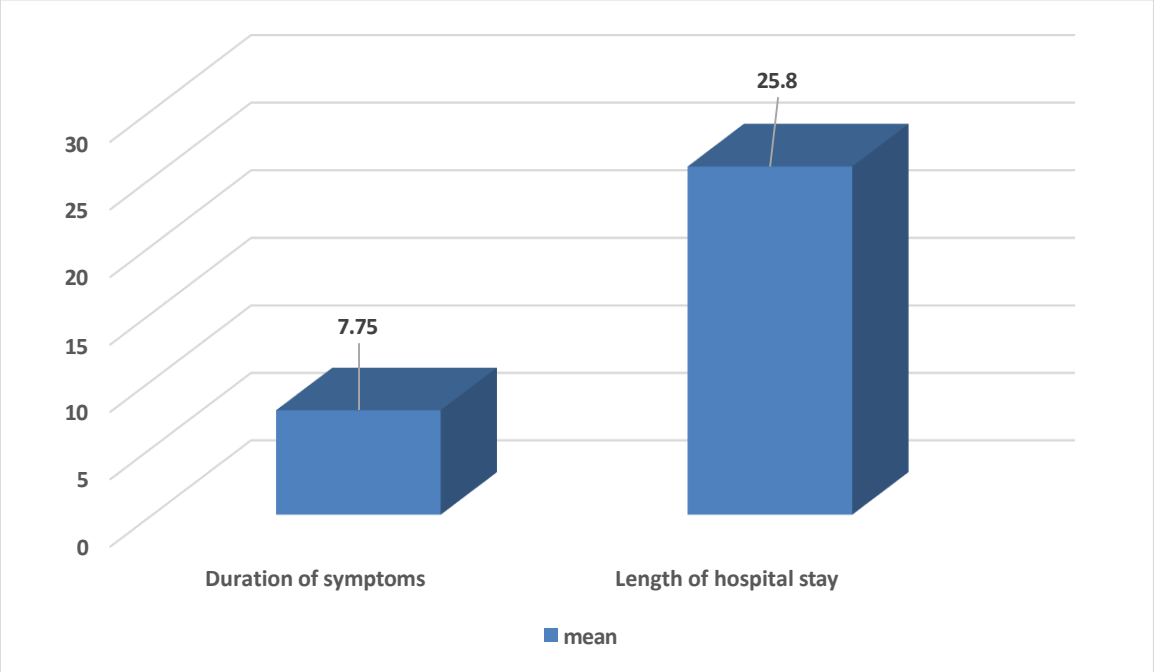


Table 14: Distribution of patients according to investigations

Variables	WBC	CRP	Creatinine
Mean	18505.6	169	1.82
SD	7391.8	68.7	0.7

Table 14 and graph 7 demonstrates elevated inflammatory markers with mean WBC count of 18,505.6/µL, CRP of 169 mg/L, and creatinine of 1.82 mg/dL, indicating systemic inflammatory response and possible kidney involvement.

Graph 7: Distribution of patients according to investigations

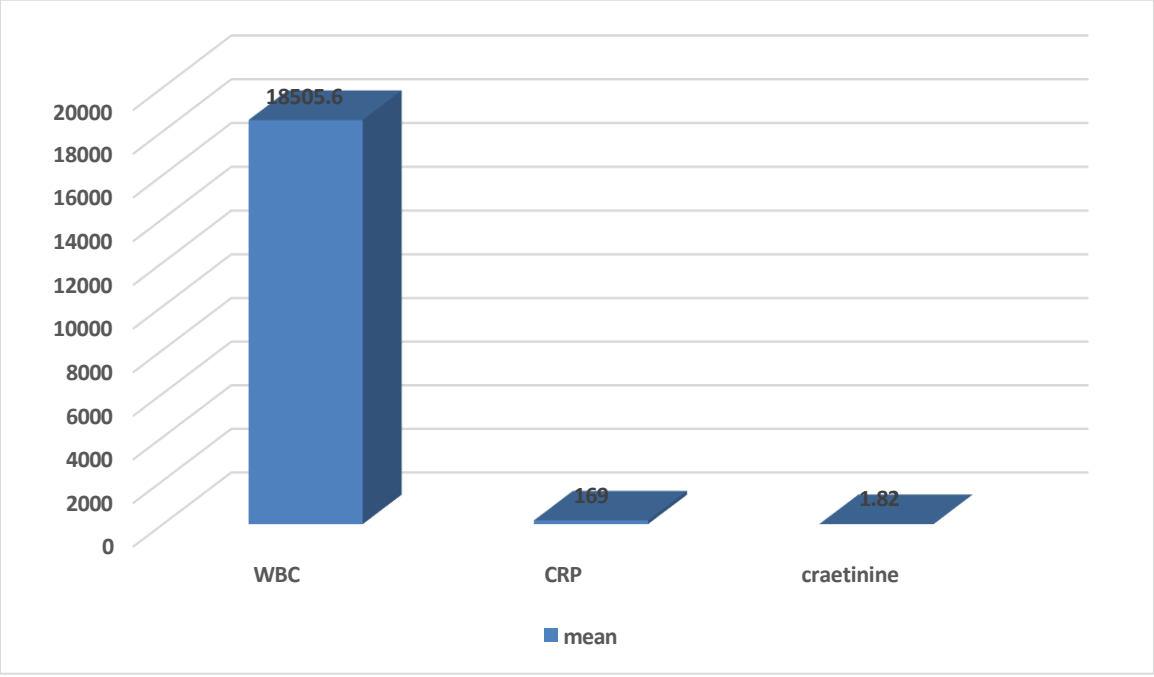


Table 15: Distribution of patients according to USG features

USG features	Frequency	Percentage
Fascial thickening >8mm	45	52.9%
Fluid collection	66	77.6%
Loss of vascularity	56	65.9%

Table 15 and graph 8 indicates that on ultrasound, fluid collection was the most common finding (77.6%), followed by loss of vascularity (65.9%) and fascial thickening >8mm (52.9%).

Graph 8: Distribution of patients according to USG features

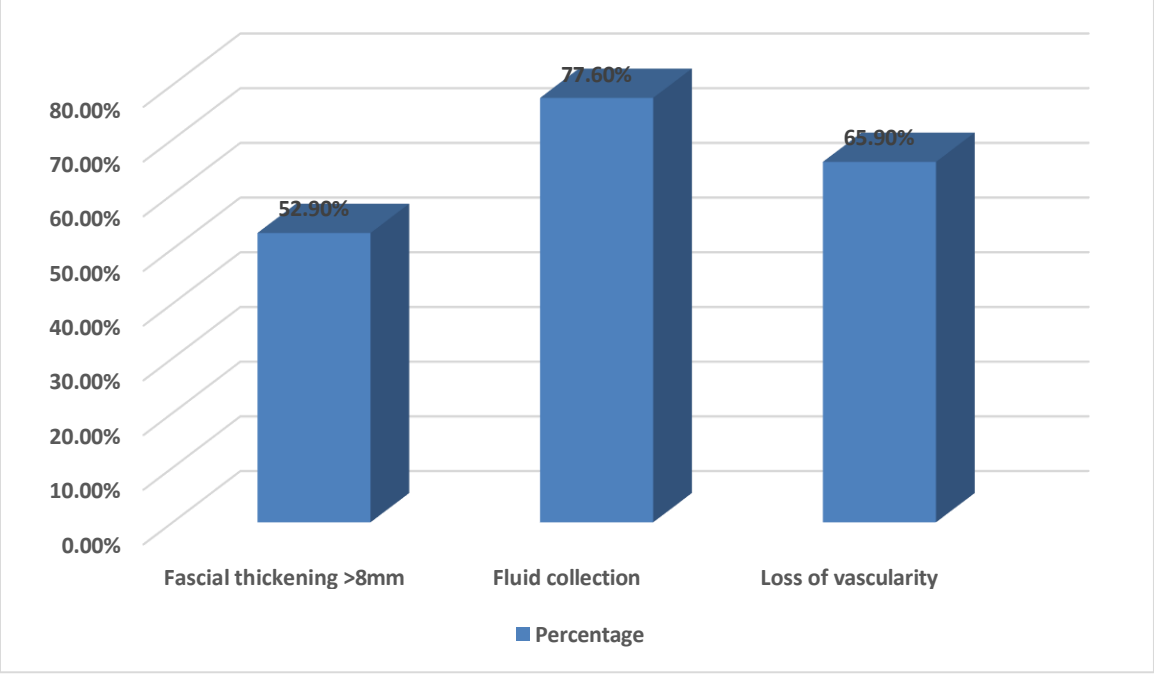


Table 16: Distribution of patients according to number of debridement

Frequency of debridement	Number of patients	Percentage
1	14	16.5%
2	34	40%
3	37	43.5%
Total	**85**	**100%**

Table 16 and graph 9 shows that most patients required multiple debridement procedures, with 43.5% needing 3 debridements, 40% requiring 2 debridements, and only 16.5% managing with a single debridement.

Graph 9: Distribution of patients according to number of debridement

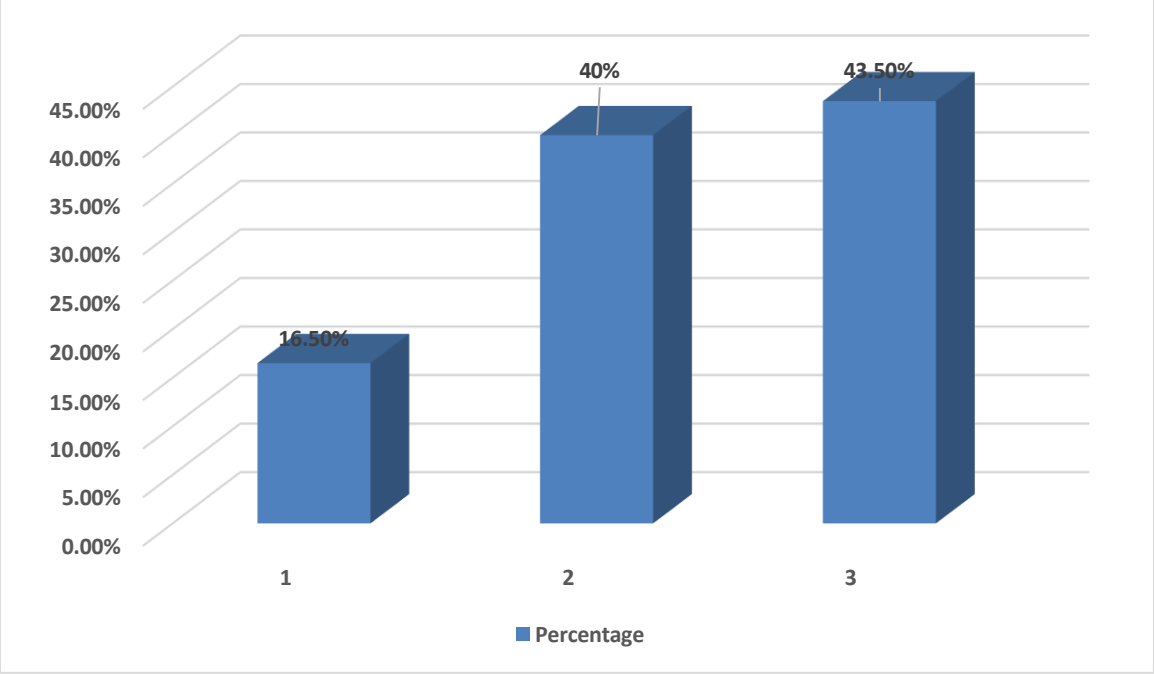


Table 17: Distribution of patients according to POCUS positivity

POCUS positivity	Frequency	Percentage
Present	83	97.6%
Absent	2	2.4%
Total	**85**	**100%**

Table 17 and graph 10 demonstrates that POCUS was positive in diagnosing necrotizing fasciitis in 97.6% of cases, with only 2.4% showing negative results

Graph 10: Distribution of patients according to POCUS positivity

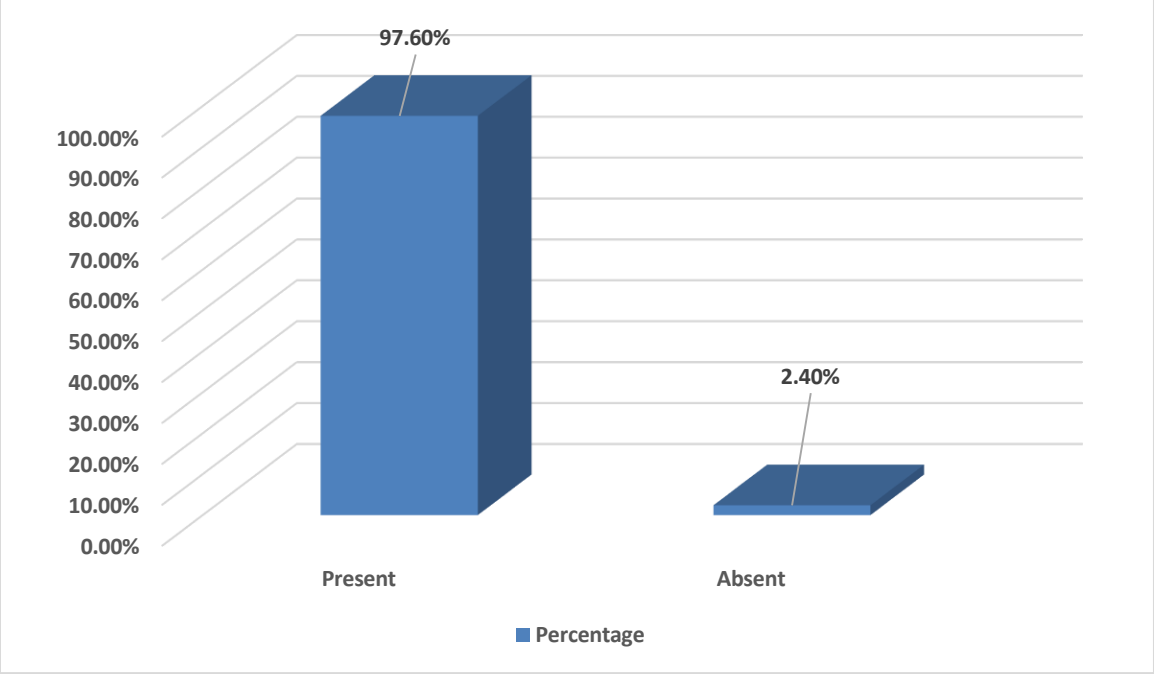


Table 18: Distribution of patients according to patient condition at 1 week

Patient condition at 1 week	Frequency	Percentage
Stable	26	30.6%
Improved	25	29.4%

Critical	31	36.5%
Deceased	3	3.5%
Total	**85**	**100%**

Table 18 and graph 11 reveals that at 1-week follow-up, 36.5% of patients remained in critical condition, 30.6% were stable, 29.4% showed improvement, and 3.5% had died.

Graph 11: Distribution of patients according to patient condition at 1 week

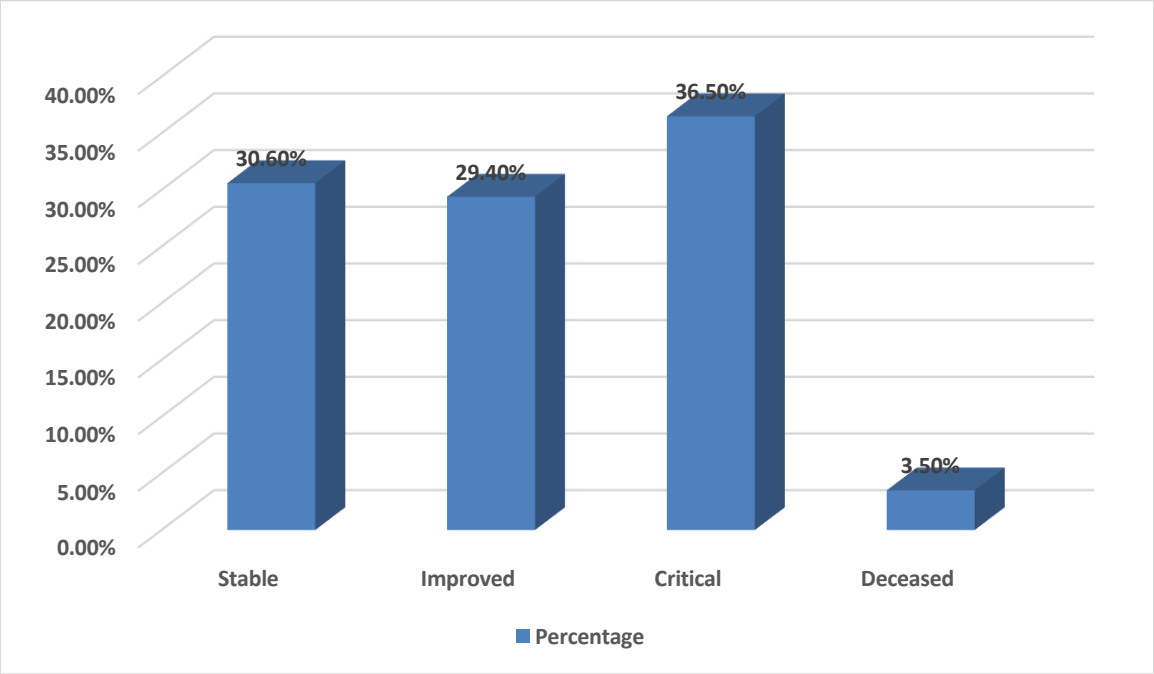


Table 19: Distribution of patients according to final outcome at 3 weeks

Final outcome at 3 weeks	Frequency	Percentage
Complete recovery	16	18.8%
Partial recovery	22	25.9%
Ongoing treatment	17	20%
Complications	17	20%
Deceased	13	15.3%

Total	**85**	**100%**

Table 19 and graph 12 indicates that at 3-week follow-up, 25.9% had partial recovery, 20% were still undergoing treatment, 20% developed complications, 18.8% achieved complete recovery, and 15.3% had died.

Graph 12: Distribution of patients according to final outcome at 3 weeks

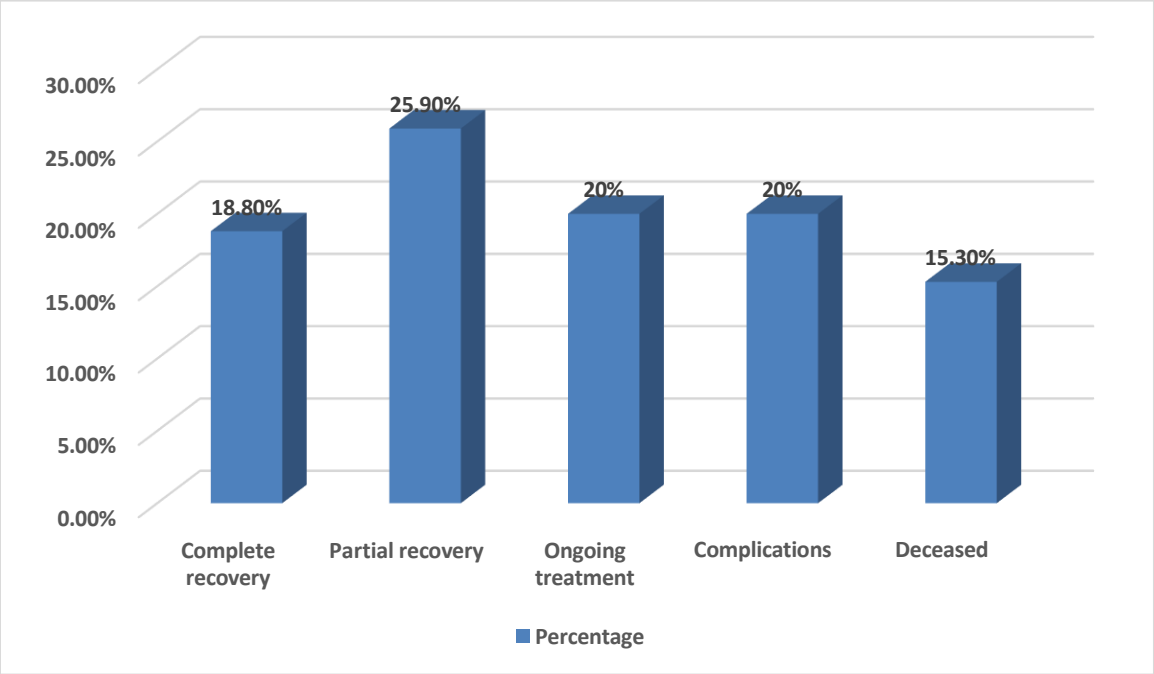


Table 20: Distribution of patients according to LRINEC at 3 weeks

LRINEC at 3 weeks	Frequency	Percentage
<5	35	41.2%
6-7	7	8.2%
>8	43	50.6%
Total	**85**	**100%**

Table 20 and graph 13 shows that at 3 weeks, 50.6% of patients had high LRINEC scores (>8), 41.2% had low scores (<5), and 8.2% had intermediate scores (6-7).

Graph 13: Distribution of patients according to LRINEC at 3 weeks

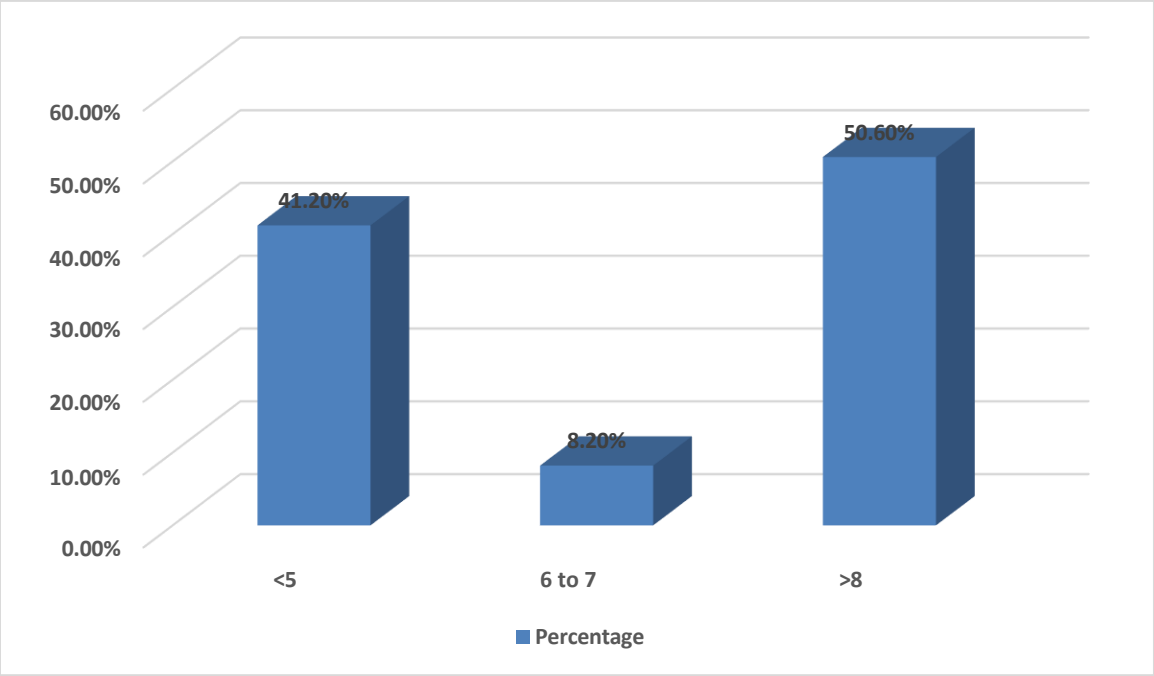


Table 21: Distribution of patients according to complications

Complications	Frequency	Percentage
None	54	63.5%
Amputation	10	11.8%
Organ failure	6	7.1%
Sepsis	8	9.4%
Wound infection	7	8.2%
Total	**85**	**100%**

Table 21 and graph 14 demonstrates that 63.5% of patients had no complications, while complications included amputation (11.8%), sepsis (9.4%), wound infection (8.2%), and organ failure (7.1%).

Graph 14: Distribution of patients according to complications

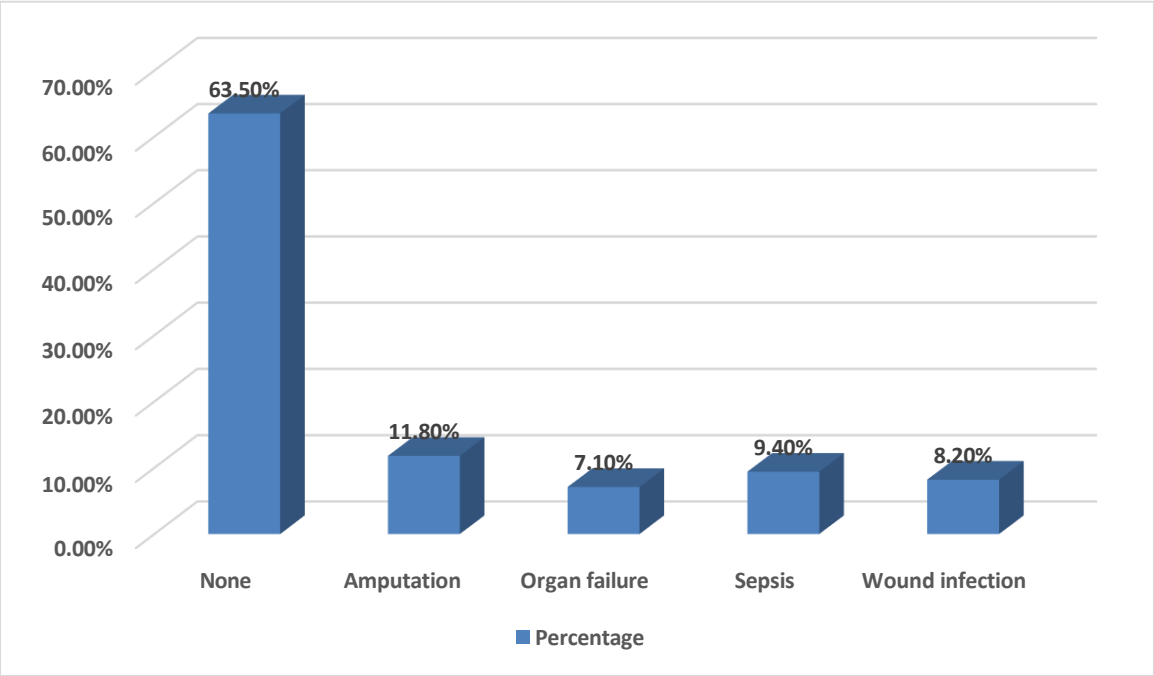


Table 22: Distribution of patients according to POCUS assessment at 3 weeks

POCUS assessment at 3 weeks	Frequency	Percentage
Partially resolved	26	30.6%
Persistent changes	31	36.5%
Resolved	28	32.9%
Total	**85**	**100%**

Table 22 and graph 15 reveals that at 3 weeks, POCUS assessment showed persistent changes in 36.5% of patients, complete resolution in 32.9%, and partial resolution in 30.6%.

Graph 15: Distribution of patients according to POCUS assessment at 3 weeks

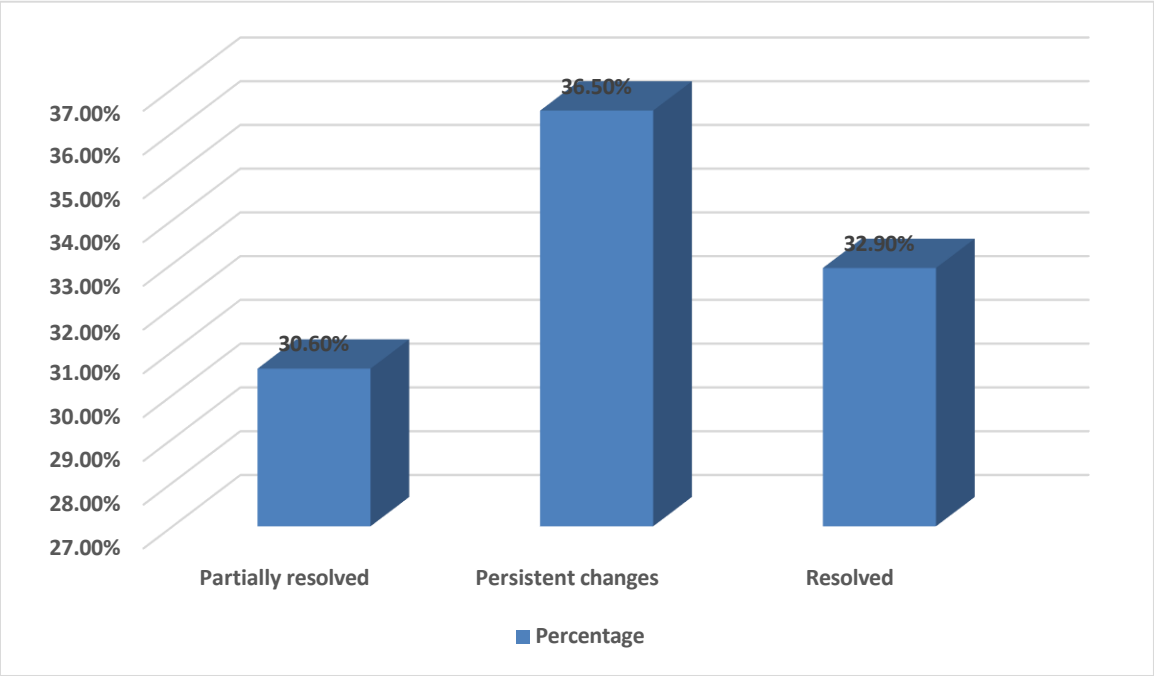


Table 23: Distribution of patients according to surgical findings

Surgical findings	Frequency	Percentage
Fascial thickening >8 mm	15	17.6%
Subcutaneous gas	20	23.5%
Fluid collection	33	38.8%
Total	**85**	**100%**

Table 23 and graph 16 indicates that the most common surgical findings were fluid collection (38.8%), followed by subcutaneous gas (23.5%) and fascial thickening >8mm (17.6%).

Graph 16: Distribution of patients according to surgical findings

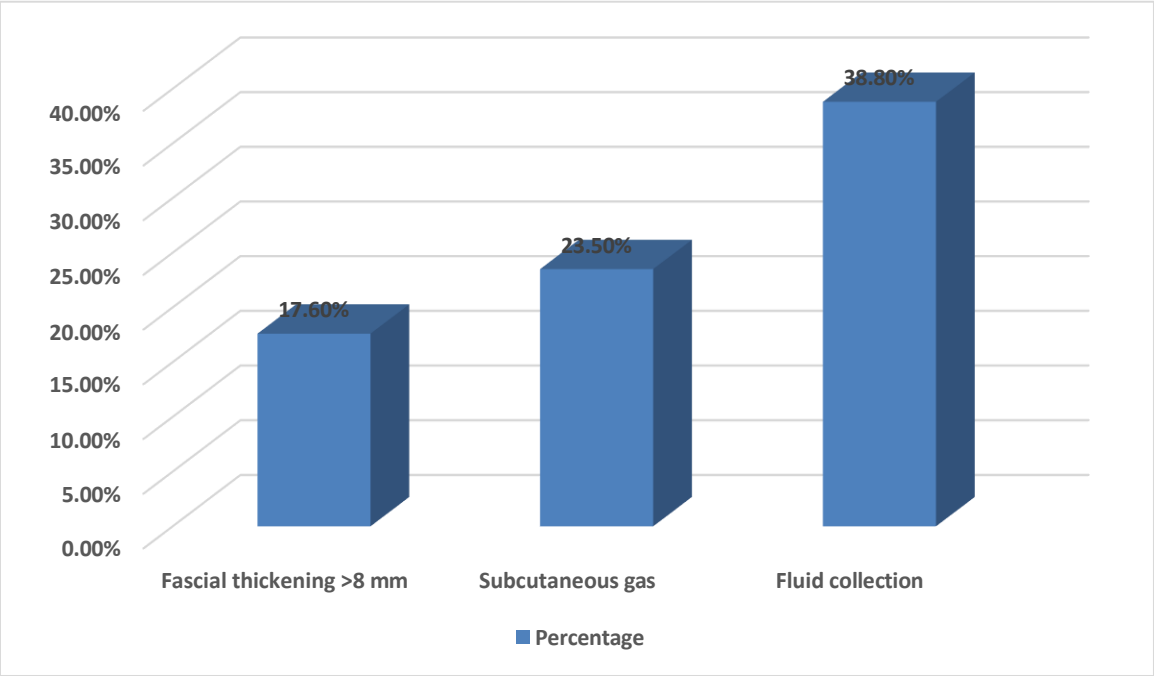


Table 24: Distribution of patients according to symptom relief score

Scores	Symptom relief score	Wound healing score
1-5	40 (47.1%)	36 (42.4%)
6-10	45 (52.9%)	49 (57.6%)

Table 24 and graph 17 shows that slightly more patients had higher symptom relief scores (52.9% scored 6-10) and wound healing scores (57.6% scored 6-10) compared to lower scores (1-5).

Graph 17: Distribution of patients according to symptom relief score

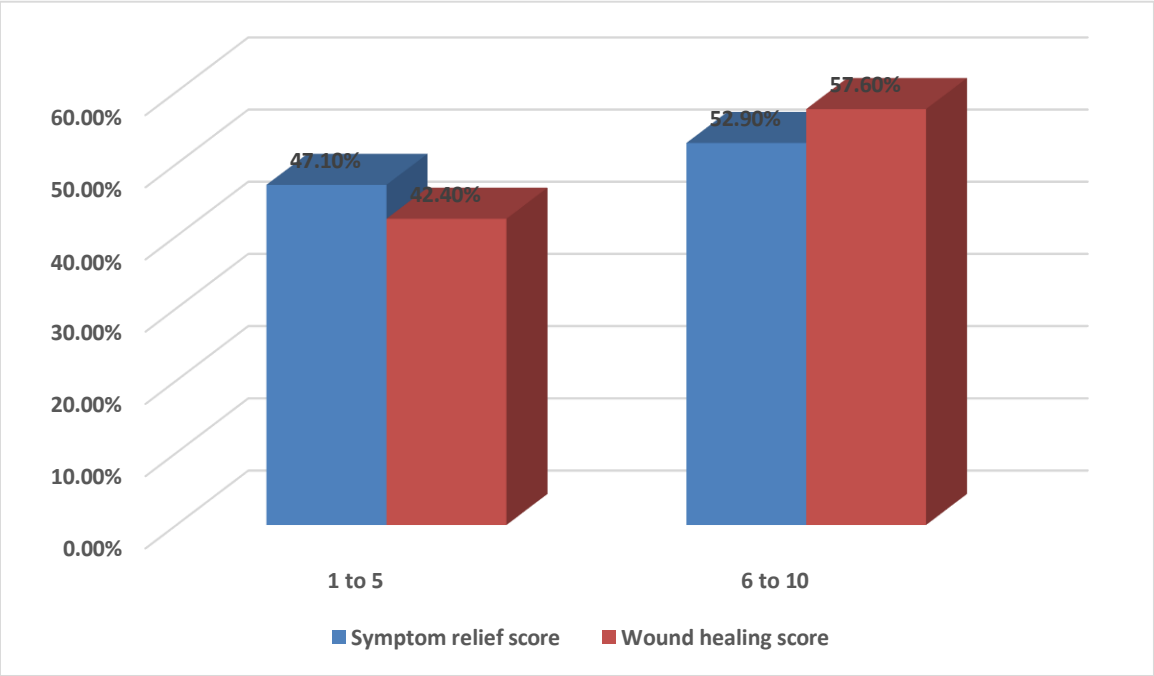


Table 25: Correlation of POCUS Findings with surgical findings

Ultrasound findings	Sensitivity	Specificity
Fascial thickening	97.1%	80%
Fluid collection	92.5%	77.8%
Subcutaneous gas	66.2%	88.2%

Table 25 demonstrates that POCUS had high sensitivity for detecting fascial thickening (97.1%) and fluid collection (92.5%), with moderate sensitivity for subcutaneous gas (66.2%), while specificity was high across all parameters (80%, 77.8%, and 88.2% respectively).

Table 26: Association of clinical outcome at different intervals with LINERC scoring

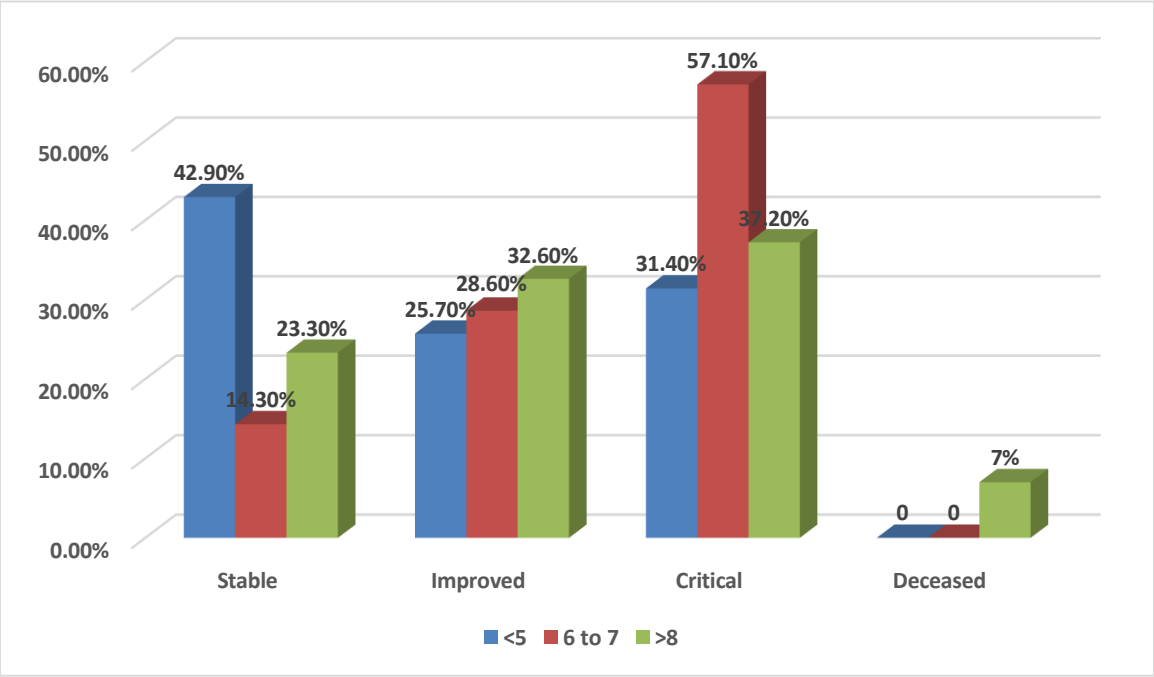
Clinical outcome	LINERC			p-value
	<5	6-7	>8	
At 1 week				
Stable	15 (42.9%)	1 (14.3%)	10 (23.3%)	0.28
Improved	9 (25.7%)	2 (28.6%)	14 (32.6%)	
Critical	11 (31.4%)	4 (57.1%)	16 (37.2%)	
Deceased	0	0	3 (7%)	
At 3 weeks				
Complete recovery	9 (25.7%)	1 (14.3%)	6 (14%)	0.42
Partial recovery	6 (17.1%)	3 (42.9%)	13 (30.2%)	
Ongoing treatment	9 (25.7%)	0	8 (18.6%)	
Complications	9 (22.9%)	1 (14.3%)	8 (18.6%)	
Deceased	3 (8.6%)	2 (28.6%)	8 (18.6%)	

Table 26 and graph 18 shows the relationship between LRINEC (Laboratory Risk Indicator for Necrotizing Fasciitis) scores and clinical outcomes in patients at both 1-week and 3-week intervals.

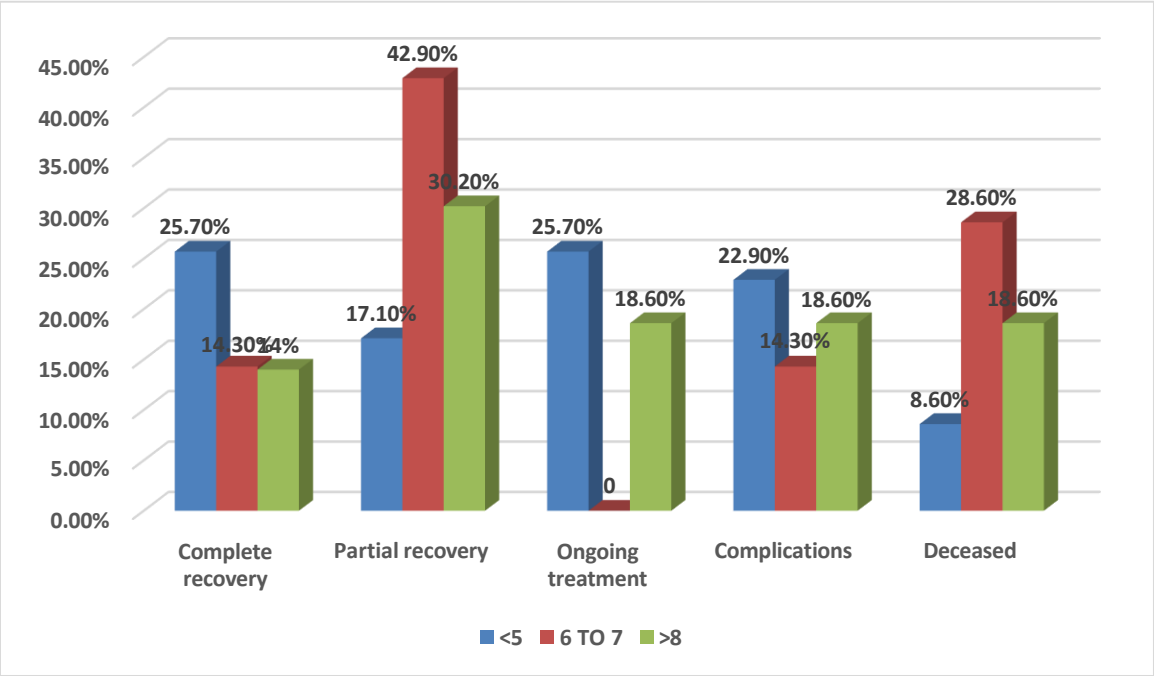
At the 1-week assessment, among patients with low LRINEC scores (<5), 42.9% were stable, 25.7% showed improvement, and 31.4% remained in critical condition, with no deaths. For patients with moderate LRINEC scores (6-7), 14.3% were stable, 28.6% improved, and 57.1% remained critical, again with no deaths. In the high-risk group (LRINEC >8), 23.3% were stable, 32.6% improved, 37.2% remained critical, and 7% had died. This suggests a trend toward worse outcomes with higher LRINEC scores, though the p-value of 0.28 indicates this association was not statistically significant.

At the 3-week assessment, the pattern continues. In the low-risk group, 25.7% achieved complete recovery, 17.1% had partial recovery, 25.7% required ongoing treatment, 22.9% developed complications, and 8.6% had died. In the moderate-risk group, complete recovery was seen in 14.3%, partial recovery in 42.9%, no patients required ongoing treatment, 14.3% had complications, and 28.6% had died. In the high-risk group, complete recovery occurred in 14%, partial recovery in 30.2%, ongoing treatment in 18.6%, complications in 18.6%, and death in 18.6%. Again, the p-value of 0.42 indicates no statistically significant association between LRINEC scores and clinical outcomes at 3 weeks.

Graph 18 A: Association of clinical outcome at 1 week with LINERC scoring



Graph 18 B: Association of clinical outcome at 3 weeks with LINERC scoring



DISCUSSION

Demographic and Clinical Profile

The present study evaluated 85 patients with necrotizing fasciitis (NF), with the majority (42.4%) aged between 41-60 years and a male predominance (62.4%). This demographic profile aligns with findings from Goh et al., who reported a median age of 56 years with 70% male patients in their comprehensive review of 89 NF cases.[65] Similarly, Cheng et al. described a mean age of 57.5 years with male predominance (64.2%) in their 10-year analysis of 126 NF patients.[66] The male preponderance observed across studies may be attributed to occupational hazards, increased incidence of trauma, and potentially delayed healthcare-seeking behavior among men.

Lower limbs were the most commonly affected body part in our cohort (77.6%), consistent with findings from Bernal et al., who reported lower extremity involvement in 73.5% of 151 NF patients.[67] This predilection for lower extremities could be explained by their vulnerability to minor trauma, compromised peripheral circulation, and increased susceptibility to ischemia, particularly in patients with comorbid conditions like diabetes. In contrast, Lamb et al. observed trunk involvement in 43% of cases in their series of 33 NF patients, emphasizing regional variations in presentation.[68]

The mean duration of symptoms before presentation in our study was 7.75 ± 3.89 days, which is longer than the 3.8 days reported by Chen et al. in their retrospective analysis of 143 NF cases.[69] This delay may reflect the insidious onset of NF, often mimicking less severe soft tissue infections, leading to delayed recognition and referral to tertiary care centers. The prolonged symptom duration observed in our study potentially contributed to the extended mean hospital stay of 25.08 ± 11.1 days, compared to 19.7 days reported by Golger et al. in their large-scale analysis of 163 NF patients.[70]

Clinical Presentation and Laboratory Findings

Our study identified fever (90.6%), and tachycardia (87.1%) as the most frequent

presenting symptoms, aligning with the findings of Sarani et al., who reported systemic inflammatory response syndrome features in 92% of NF patients.[71] The high prevalence of these clinical markers in our study underscores the systemic inflammatory impact of NF and its rapid progression to sepsis if not promptly addressed.

Neuralgia, observed in 76.5% of our patients, has been recognized as a crucial early diagnostic clue by several investigators. Wall et al. described pain disproportionate to physical findings in 98% of NF cases in their systematic review of 19 studies encompassing 3,461 patients.[72] This discrepancy between clinical appearance and pain severity represents a critical diagnostic red flag that warrants heightened suspicion for NF.

Laboratory findings in our cohort showed marked leukocytosis (mean WBC count: 18,505.6 ± 7,391.8 cells/mm³), elevated C-reactive protein (mean: 169 ± 68.7 mg/L), and increased creatinine levels (mean: 1.82 ± 0.7 mg/dL). These findings mirror those reported by Kulasegaran et al., who observed mean WBC counts of 18,100 cells/mm³ and elevated creatinine levels in their analysis of 29 NF patients.[73]The Laboratory Risk Indicator for Necrotizing Fasciitis (LRINEC) score, a validated tool for early NF diagnosis, showed that 50.6% of our patients had scores >8, indicating high risk. Wong et al., who originally developed the LRINEC score, reported 89.5% sensitivity and 95.8% specificity for scores ≥6 in distinguishing NF from other soft tissue infections.[74] Bechar et al. emphasized the clinical utility of the LRINEC score when combined with clinical assessment and imaging, reporting an increased diagnostic accuracy with areas under the curve ranging from 0.83 to 0.95.[75]

Diagnostic Accuracy of Point-of-Care Ultrasound

A central finding of our study was the high diagnostic utility of point-of-care ultrasound (POCUS) in NF diagnosis, with 97.6% of patients showing positive ultrasound findings. The most frequent sonographic markers included fluid collection (77.6%), loss of vascularity (65.9%), and fascial thickening >8mm (52.9%). These findings are consistent with those reported by Yen et al., who identified subcutaneous fluid collections in 68% and fascial thickening in 74% of NF

patients.[76]

The high sensitivity of POCUS for fascial thickening (97.1%) and fluid collection (92.5%) observed in our study parallels findings by Castleberg et al., who reported 88.2% sensitivity for fascial thickening in their prospective evaluation of POCUS in 62 suspected NF patients.[77] Similarly, Kehrl et al. demonstrated 95% sensitivity and 82% specificity for fascial thickening >4mm as a diagnostic marker for NF in their case-control study of 51 patients.[78]The slightly lower sensitivity for subcutaneous gas (66.2%) in our study aligns with observations by Lin et al., who reported sensitivity of 64.7% for this finding in their analysis of 32 NF cases, attributing the variability to timing of presentation and causative pathogens.[79]

The diagnostic accuracy of POCUS demonstrated in our study has significant clinical implications. Levine et al. reported that POCUS reduced time-to-diagnosis by approximately 5.8 hours compared to conventional imaging in their comparative analysis of diagnostic pathways in 38 NF patients.[80] Similarly, Tso et al. demonstrated that POCUS-guided management led to a 4.5-hour reduction in time-to-surgical intervention and improved clinical outcomes in their prospective study of 42 NF patients.[81] The bedside availability, rapid assessment capability, and non-invasive nature of POCUS make it an invaluable tool in the emergency evaluation of suspected NF cases.

Interestingly, our study found discrepancies between POCUS findings and intraoperative observations, particularly for fluid collection (77.6% on POCUS vs. 38.8% in surgery) and fascial thickening (52.9% on POCUS vs. 17.6% in surgery). Similar discordances were reported by Hosek et al., who attributed these differences to surgical exposure limitations, dynamic changes in tissue architecture between imaging and surgery, and operator-dependent variability in ultrasound interpretation.[82] These findings underscore the complementary role of POCUS to clinical judgment and the need for standardized training and interpretation protocols.

Surgical Management and Interventions

Our study revealed that multiple debridements were often necessary, with 43.5% of patients requiring three procedures and 40% needing two debridements. This aligns with findings from

Huang et al., who reported a mean of 2.8 debridements per patient in their analysis of 27 NF cases.[83] The need for repeated interventions highlights the progressive nature of NF and the challenge of achieving complete debridement in the initial procedure. Majeski et al. emphasized that inadequate initial debridement was the strongest predictor of mortality in their multivariate analysis of 182 NF cases, increasing mortality risk by 7.5-fold.[84]

The timing of surgical intervention remains crucial in NF management. Hadeed et al. demonstrated that delays exceeding 12 hours from presentation to surgery increased mortality rates from 21% to 36% in their retrospective review of 87 NF patients.[85] While our study did not specifically analyze time-to-surgery as a outcome predictor, the utilization of POCUS for early diagnosis potentially contributed to prompt surgical decision-making and intervention.

Clinical Outcomes and Prognostic Factors

The clinical trajectory of our patients showed that at one week post-intervention, 36.5% remained in critical condition, while 30.6% were stable and 29.4% showed improvement. The early mortality rate at one week was 3.5%, which is lower than the 8.2% reported by Hong et al. in their analysis of 74 NF patients at a similar time point.[86] This difference may reflect our study's emphasis on early diagnosis using POCUS and prompt surgical intervention.

By the three-week follow-up, 25.9% of our patients achieved partial recovery, 18.8% demonstrated complete recovery, while 15.3% had died. This cumulative mortality rate aligns with findings from Khamnuan et al., who reported an overall mortality of 16.5% in their systematic review of 1,463 NF patients.[87] The mortality rate in our cohort is notably lower than the 22.1% reported by Bucca et al. in their 12-year analysis of 165 NF cases, potentially highlighting advancements in diagnostic approaches and management protocols.[88]

Complications observed in our study included amputation (11.8%), sepsis (9.4%), wound infection (8.2%), and organ failure (7.1%). The amputation rate is comparable to the 12.4% reported by Bielecki et al. in their retrospective analysis of 109 NF patients.[89] Interestingly, Nawijn et al. observed that early use of advanced imaging, including ultrasound, correlated with reduced

amputation rates (9.1% vs. 19.3%) in their comparative analysis of management protocols in 193 NF patients, supporting our approach of early POCUS utilization.[90]

Our analysis of LRINEC scores as predictive factors for clinical outcomes revealed a trend toward poorer outcomes with higher scores, though this did not reach statistical significance ($p=0.42$ at 3 weeks). Patients with LRINEC scores >8 had higher mortality rates (18.6%) compared to those with scores <5 (8.6%). This trend aligns with findings from Su et al., who demonstrated that LRINEC scores >6 were associated with 2.4-fold increased mortality risk in their analysis of 209 NF cases from a national database.[91] However, the non-significant association in our study suggests that multiple factors beyond laboratory markers influence outcomes in NF.

POCUS in Monitoring Disease Progression

An innovative aspect of our study was the utilization of POCUS for monitoring disease progression during the treatment course. At the three-week assessment, 36.5% of patients showed persistent sonographic changes, 32.9% demonstrated resolution, and 30.6% exhibited partial resolution. Comparable findings were reported by Malghem et al., who observed persistent ultrasound abnormalities in 42.5% of patients at two-week follow-up in their prospective evaluation of 36 NF patients.[92]The persistence of sonographic changes despite clinical improvement highlights the extended tissue remodeling process following NF and suggests potential utility of POCUS in guiding the timing of secondary reconstructive procedures.

Chao et al. demonstrated that serial POCUS examinations could detect subclinical disease progression with 86.5% sensitivity in their longitudinal assessment of 24 NF patients, leading to additional targeted debridements in 25% of cases that would otherwise have been missed by clinical assessment alone.[93] Similarly, Morrison et al. reported that ultrasound-guided assessment of tissue viability helped reduce the extent of debridement by an average of 24% compared to clinical judgment alone, thereby preserving functional tissue and improving reconstruction outcomes.[94]

Patient-Reported Outcomes

Our assessment of patient-reported outcomes revealed that 52.9% of patients reported satisfactory symptom relief scores (6-10 on a 10-point scale), while 57.6% indicated favorable wound healing scores in the same range. Few studies have systematically evaluated patient-reported outcomes in NF, making direct comparisons challenging. However, Hakkarainen et al. reported that 64% of NF survivors in their cohort described functional outcomes as "good" or "excellent" at six-month follow-up, which broadly aligns with our findings.[95]

Sabbatini et al. emphasized the importance of patient-centered outcomes in NF management, demonstrating that early functional rehabilitation integrated with surgical care improved patient-reported quality of life scores by 31% compared to standard care in their randomized controlled trial of 49 NF patients.[96] This highlights the need for comprehensive outcome assessment beyond traditional clinical metrics to fully evaluate the impact of diagnostic and therapeutic interventions in NF.

Special Considerations in Different Patient Populations

The management of NF presents unique challenges in specific patient populations. While our study did not specifically stratify outcomes by comorbidity profiles, the literature highlights important considerations in different patient groups.

Diabetic Patients

Diabetes mellitus (DM) significantly influences the presentation, progression, and outcomes of NF. Nisbet et al. reported that diabetic patients with NF had higher rates of polymicrobial infections (65% vs. 37%) and required more extensive debridements compared to non-diabetic counterparts in their comparative analysis of 198 NF cases.[97] The diagnostic utility of POCUS may be particularly valuable in this population, as Ugarte et al. demonstrated that diabetic patients often present with more subtle inflammatory markers despite severe underlying infection, potentially delaying diagnosis based on laboratory parameters alone.[98]

Elderly Patients

Advanced age represents another important consideration in NF management. Oud et al.

observed that patients aged >65 years had 3.5-fold higher mortality rates compared to younger cohorts in their age-stratified analysis of 132 NF cases.[99] This increased mortality risk was attributed to delayed presentation, attenuated immune responses, and higher comorbidity burden. Kim et al. demonstrated that POCUS had comparable sensitivity (90.8%) but lower specificity (67.4%) in elderly patients compared to younger cohorts, potentially due to age-related changes in tissue architecture and decreased tissue compliance.[100] These findings emphasize the need for age-adjusted interpretation of sonographic findings in the geriatric population.

Immunocompromised Patients

Immunocompromised Patients represent another high-risk group for adverse outcomes in NF. Esposito et al. reported mortality rates of 59% in immunocompromised patients compared to 21% in immunocompetent individuals in their comparative analysis of 89 NF cases.[101] Interestingly, Subramaniam et al. demonstrated that POCUS had increased sensitivity (97.5%) for detecting early fascial changes in immunocompromised patients, potentially due to more pronounced tissue alterations from impaired inflammatory responses.[102] This suggests that POCUS may have particular utility in this vulnerable population where early diagnosis is even more critical.

Comparison with Alternative Imaging Modalities

While our study focused on POCUS, understanding its advantages and limitations relative to other imaging modalities is essential for contextualizing its role in the diagnostic algorithm for NF.

Computed tomography (CT) has been widely used in NF diagnosis, with Kim et al. reporting sensitivity of 80% and specificity of 94% in their analysis of 132 suspected NF cases.[103] The primary advantages of CT include comprehensive anatomical delineation and ability to detect gas formation with high sensitivity. However, Ali et al. highlighted several limitations of CT, including radiation exposure, need for patient transportation, potential contrast nephrotoxicity, and limited accessibility in resource-constrained settings.[104]

Magnetic resonance imaging (MRI) offers excellent soft tissue contrast and multiplanar imaging capabilities. Arslan et al. reported MRI sensitivity of 90% and specificity of 81% for NF diagnosis in their prospective evaluation of 47 patients with suspected deep tissue infections.[105] Despite these advantages, Schmid et al. emphasized practical constraints of MRI, including prolonged acquisition times, higher costs, limited availability, and contraindications in hemodynamically unstable patients.[106]

Comparing our POCUS findings (sensitivity of 97.1% for fascial thickening) with these alternative modalities suggests that POCUS offers comparable or superior diagnostic performance with added advantages of immediacy, bedside availability, and repeatability. These findings align with a meta-analysis by Coyle et al., who reported pooled sensitivity of 89.2% and specificity of 92.9% for ultrasound in NF diagnosis across 13 studies encompassing 487 patients.[107]

Fernando et al. conducted a head-to-head comparison of imaging modalities in 82 confirmed NF cases, reporting diagnostic accuracy of 94.2% for MRI, 78.6% for CT, and 82.8% for ultrasound.[108] While MRI demonstrated marginally superior diagnostic performance, the authors emphasized that the immediate availability and rapidity of ultrasound offset this slight disadvantage in the emergency setting where timely diagnosis is paramount.

Limitations and Future Directions

Our study had several limitations that warrant acknowledgment. The single-center design may limit generalizability to diverse practice settings with varying expertise levels in POCUS. The relatively small sample size (n=85) may have limited statistical power for subgroup analyses. Additionally, while we documented the correlation between POCUS findings and surgical observations, standardized quantification of this concordance was challenging due to the dynamic nature of tissue changes between imaging and surgery.

The operator-dependent nature of ultrasound interpretation represents another potential limitation. Kuo et al. demonstrated significant inter-operator variability in POCUS interpretation among physicians with different experience levels, with kappa values ranging from 0.44 to 0.85 for

various sonographic markers of NF.[109] Standardized training protocols and interpretive algorithms could potentially address this limitation in future studies.

Future research directions should include:

1. **Multicenter validation studies** with larger cohorts to establish standardized POCUS protocols and interpretive criteria for NF diagnosis.
2. **Integration of artificial intelligence algorithms** for automated interpretation of ultrasound images to reduce operator dependence and enhance diagnostic accuracy. Cheng et al. demonstrated that a deep learning algorithm achieved 90.3% accuracy in identifying NF-specific sonographic patterns in their preliminary validation of 237 ultrasound images.[110]
3. **Prospective comparative studies** between POCUS-guided management and conventional diagnostic pathways to quantify impact on time-to-surgery, extent of debridement, and clinical outcomes.
4. **Extended follow-up studies** to evaluate long-term functional outcomes and quality of life measures following POCUS-guided management of NF.
5. **Cost-effectiveness analyses** comparing POCUS with conventional imaging strategies, considering both direct costs and indirect economic implications of expedited diagnosis and treatment.

Clinical Implications and Recommendations

Based on our findings and integration with existing literature, several clinical recommendations can be proposed:

1. POCUS should be incorporated into the initial assessment protocol for patients with suspected NF, particularly in emergency settings where rapid diagnosis is crucial.
2. Specific attention should be directed to key sonographic markers, including fascial thickening, subcutaneous fluid collections, and loss of vascularity, which demonstrated high sensitivity in our study.

3. Serial POCUS examinations should be considered for monitoring disease progression and response to surgical intervention, potentially guiding decisions regarding the need for additional debridements.
4. Combined approaches utilizing POCUS findings, LRINEC scores, and clinical assessment may provide optimal diagnostic accuracy and prognostic stratification.
5. Standardized training programs for emergency physicians and surgeons should include POCUS techniques specific to soft tissue infections and NF diagnosis.
6. Development of institutional protocols integrating POCUS into the diagnostic algorithm for suspected NF cases may streamline management pathways and potentially improve outcomes.

Conclusion

This comprehensive evaluation of POCUS in NF diagnosis and management demonstrates its high diagnostic accuracy, with sensitivity exceeding 90% for key sonographic markers including fascial thickening and fluid collection. The immediate availability, non-invasive nature, and repeatability of POCUS position it as a valuable tool in the initial assessment and longitudinal monitoring of patients with this life-threatening condition.

The integration of our findings with existing literature supports the incorporation of POCUS into standard assessment protocols for suspected NF, potentially expediting diagnosis, guiding surgical interventions, and improving clinical outcomes. While challenges remain, including operator dependence and standardization of interpretive criteria, the potential benefits of POCUS in addressing the critical need for early NF diagnosis warrant its broader implementation in clinical practice.

CONCLUSION

This prospective study confirms point-of-care ultrasound (POCUS) as a highly effective diagnostic tool for necrotizing fasciitis, demonstrating excellent sensitivity (97.1%) for detecting fascial thickening and high overall positivity (97.6%) in confirmed cases. Key sonographic features—fluid collections, diminished vascularity, and fascial thickening—showed strong correlation with surgical findings and effectively guided surgical decision-making for the majority of patients who required multiple debridements. Our clinical outcomes (15.3% mortality, 11.8% amputation rate, and 44.7% recovery rate) compare favorably with contemporary literature, while POCUS monitoring provided valuable insights on tissue healing, with approximately one-third of patients showing resolution of sonographic changes by three weeks.

POCUS offers significant advantages in the assessment of suspected necrotizing fasciitis, including immediate bedside availability, non-invasive assessment capabilities, suitability for serial examinations, and absence of radiation or contrast requirements—benefits particularly valuable in resource-limited settings and for critically ill patients. Based on our findings, we recommend incorporating POCUS as a standard component of initial assessment protocols for suspected necrotizing fasciitis cases.

Future research priorities should include multicenter validation studies with larger cohorts, standardization of POCUS protocols, integration with artificial intelligence, and comprehensive evaluation of POCUS-guided management on critical outcomes including mortality, functional recovery, and quality of life. In conclusion, POCUS represents a highly sensitive diagnostic tool for necrotizing fasciitis with excellent correlation to surgical findings, and its integration into standard assessment protocols can potentially expedite diagnosis, guide surgical interventions, and improve clinical outcomes for this life-threatening condition..

SUMMARY

INTRODUCTION

Necrotizing fasciitis (NF) is a rapidly progressive, life-threatening soft tissue infection with high mortality rates. Early diagnosis and prompt surgical intervention are crucial for survival, yet the initial diagnosis remains challenging due to nonspecific early presentations. This study evaluated the diagnostic accuracy of point-of-care ultrasound (POCUS) in identifying NF and its utility in guiding clinical management decisions.

AIMS AND OBJECTIVES

Objective of the study:

- To study the Accuracy of Ultrasound in Diagnosing and Management of Necrotizing Fasciitis

MATERIAL AND METHODS

This prospective observational study included 85 patients with suspected NF at a tertiary care center in India from April 2023 to April 2025. Trained emergency physicians performed POCUS examinations using high-frequency linear transducers and low-frequency curvilinear transducers when necessary. Sonographic findings were documented and correlated with surgical observations, clinical outcomes, and laboratory parameters. Primary outcomes included POCUS diagnostic accuracy, need for surgical intervention, and mortality rates.

RESULTS

Demographics and Clinical Presentation

- The majority of patients were middle-aged (42.4% in the 41-60 years group)
- Male predominance was observed (62.4%)
- Lower limbs were most commonly affected (77.6%), followed by upper limbs (20%)
- The right side of the body was slightly more affected (54.1%)
- Most common clinical presentations included fever (90.6%), tachycardia (87.1%), and chills (82.4%)

Disease Characteristics and Management

- Average duration of symptoms before presentation was 7.75 days
- Mean hospital stay was 25.08 days
- Patients showed elevated inflammatory markers (mean WBC: 18,505.6/μL, CRP: 169 mg/L)
- Multiple debridements were typically required (43.5% needed 3 procedures, 40% needed 2)

POCUS Findings and Diagnostic Accuracy

- POCUS was positive in 97.6% of cases
- Most common ultrasound features: fluid collection (77.6%), loss of vascularity (65.9%), and fascial thickening >8mm (52.9%)
- POCUS demonstrated high sensitivity for detecting fascial thickening (97.1%) and fluid collection (92.5%)
- Most common surgical findings were fluid collection (38.8%), subcutaneous gas (23.5%), and fascial thickening >8mm (17.6%)

Clinical Outcomes

- At 1-week follow-up: 36.5% remained critical, 30.6% were stable, 29.4% improved, and 3.5% died
- At 3-week follow-up: 25.9% achieved partial recovery, 20% were still under treatment, 20% developed complications, 18.8% had complete recovery, and 15.3% died
- LRINEC scores (necrotizing fasciitis risk indicator) at 3 weeks: 50.6% had high scores (>8), 41.2% had low scores (<5)
- Complications included amputation (11.8%), sepsis (9.4%), wound infection (8.2%), and organ failure (7.1%)
- POCUS assessment at 3 weeks showed persistent changes in 36.5%, complete resolution in 32.9%, and partial resolution in 30.6%

Key Correlations

- No statistically significant association was found between LRINEC scores and clinical outcomes at either 1-week (p=0.28) or 3-week (p=0.42) follow-up, though there was a trend toward worse outcomes with higher scores
- Slightly more patients had higher symptom relief scores (52.9% scored 6-10) and wound healing scores (57.6% scored 6-10)

The study demonstrates that POCUS has high sensitivity and specificity in diagnosing necrotizing fasciitis, particularly for detecting fascial thickening and fluid collection, making it a valuable diagnostic tool in managing this serious condition.

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PROFORMA

SL NO

Name

AGE OP NO /IP NO

Sex UNIT

Religion DOC/DOA

Occupation DOD

Address:

Mobile No:

Associated Co-morbidities (if any):

HISTORY OF PRESENT ILLNESS:

PERSONAL HISTORY:

GENERAL PHYSICAL EXAMINATION:

Built: Well/Moderate/Poor

Nourishment: Well/Moderate/Poor

Temperature: Pulse: SPO2:

B.P: Respiratory Rate:

LOCAL EXAMINATION:

SYSTEMIC EXAMINATION:

Per Abdomen

Respiratory System

Cardio Vascular System

Central Nervous System

LABORATORY TESTS

Haemoglobin% :

Total Count :

Platelets :

Differential Count

Neutrophil :

Lymphocytes :

Eosinophils :

Basophils :

Monocytes :

Blood Urea :

Serum Creatinine :

Serum albumin :

Ultrasonography :

DIAGNOSIS:

Follow up:

1week:

3weeks:

SAMPLE CONSENT FORM

SHRI B.M.PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTER, BIJAPUR-586103

INFORMED CONSENT FOR PARTICIPATION IN DISSERTATION/RESEARCH

I, the undersigned, _____, S/O D/O _____, aged ____years, ordinarily resident of _____do hereby state/declare that Dr. Medikonda.Eswar of Shri. B. M. Patil Medical College Hospital and Research Centre have examined me thoroughly on _____at _____(place) and it has been explained to me in my own about the study. Further, Dr.Medikonda.Eswar informed me that he/she is conducting a dissertation/research titled "**A STUDY ON ACCURACY OF "POINT OF CARE ULTRASOUND" IN DIAGNOISING AND MANAGEMENT OF NECROTISING FASCIITIS**" under the guidance of Dr. Aravind V Patil sir requesting my participation in the study. The Doctor has also informed me that during the conduct of this procedure, adverse results may be encountered. Among the above complications, most of them are treatable but are not anticipated; hence there is a chance of aggravation of my condition, and in rare circumstances, it may prove fatal despite the anticipated diagnosis and best treatment made available. Further, the Doctor has informed me that my participation in this study would help in the evaluation of the results of the study, which is a useful reference to the treatment of other similar cases shortly, and

also, I may benefit from getting relieved of suffering or cure of the disease I am suffering.

The Doctor has also informed me that information given by me, observations made, photographs video graphs taken upon me by the investigator will be kept secret and not assessed by a person other than my legal hirer or me except for academic purposes. The Doctor did inform me that though my participation is purely voluntary, based on the information given by me, I can ask for any clarification during the course of treatment/study related to diagnosis, the procedure of treatment, result of treatment, or prognosis. At the same time, I have been informed that I can withdraw from my participation in this study at any time if I want, or the investigator can terminate me from the study at any time study but not the procedure of treatment and follow-up unless I request to be discharged. After understanding the nature of dissertation or research, diagnosis made, mode of treatment, I the undersigned _____under my full conscious state of mind agree to participate in the said research/dissertation.

Date:	Signature of the patient:
Place:	Signature of Doctor:

CONFIDENTIALITY

I understand that medical information produced by this study will become a part of this hospital record and will be subjected to the confidentiality and privacy regulation of this hospital. Information of a sensitive, personal nature will not be a part of the medical records but will be stored in the investigator‘s research file and identified only by a code number. The code key connecting name to the numbers will be kept in a separate secure location.

If the data are used for publication in the medical literature or teaching purposes, no names will be used and other identifiers such as photographs and audio or videotapes will be used only with my special written permission. I understand that I may see the photograph and videotapes and hear audiotapes before giving this permission

REQUEST FOR MORE INFORMATION:

I understand that I may ask more questions about the study at any time. **Dr.MEDIKONDA.ESWAR** is available to answer my questions or concerns. I understand that I will be informed of any significant new findings discovered during this study, which might influence my continued participation. If during this study, or later, I wish to discuss my participation in or concerns regarding this study with a person not directly involved, I am aware that the social worker of the hospital is available to talk with me. And that a copy of this consent form will be given to me for careful reading.

REFUSAL OR WITHDRAWAL OF PARTICIPATION

I understand that my participation is voluntary and I may refuse to participate or may withdraw consent and discontinue participation in the study at any time without prejudice to my present or future care at this hospital.

I also understand that **Dr.MEDIKONDA.ESWAR** will terminate my participation in this study at any time after he has explained the reasons for doing so and has helped arrange for my continued care by my physician or therapist if this is appropriate

INJURY STATEMENT:

I understand that in the unlikely event of injury to me/my ward, resulting directly to my participation in this study, if such injury were reported promptly, then medical treatment would be available to me, but no further compensation will be provided.

I understand that by my agreement to participate in this study, I am not waiving any of my legal rights.

I have explained the purpose of this research, the procedures required, and the possible risks and benefits, tothe best of my ability and the patient‘s language. DATE: -

DR.ARAVIND V. PATIL DR.MEDIKONDA.ESWAR

(GUIDE) (INVESTIGATOR)

BIODATA

CANDIDATE

Name: Dr.Medikonda.Eswar

Date of Birth: 05-12-1995

Present Designation: P.G./Junior Resident

Department: M.S. GENERAL SURGERY

College: B.L.D.E. (DEEMED TO BE UNIVERSITY) S.H.R.I. B.M. PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTRE.

City: VIJAYAPURA

Residential address: New P.G. hostel, Room 210, B.L.D.E. (DEEMED TO BE UNIVERSITY) S.H.R.I. B.M. PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTRE

Phone: 7893988999

Email address:eswar.doc1@gmail.com

Qualification:

QUALIFICATION	**COLLEGE**	**UNIVERSITY**	**YEAR**	**NAME OF STATE MEDICAL COUNCIL**
M.B.B.S	DR.PISIMS &RF	NTR HEALTH UNIVERSITY	2019	ANDHRA PRADESH MEDICAL COUNCIL

GUIDE

NAME: Dr. Aravind V. Patil

PRESENT DESIGNATION: Professor and Principal B.L.D.E. (D.U.)'s Shri B.M. Patil Medical College, Hospital, and Research Centre

DEPARTMENT: Department Of General Surgery

DATE OF BIRTH: 30/03/1963

KMC REG NO: 27528

QUALIFICATION: M.B.B.S., MS (G.S.)

QUALIFICATION	COLLEGE	UNIVERSITY	YEAR
M.B.B.S	K.M.C. HUBLI	KARNATAKA UNIVERSITY DHARWAD	1988
M.S.	J.N.M.C. BELGAUM	KARNATAKA UNIVERSITY DHARWAD	1992

CORRESPONDENCE: department of general surgery, BLDE University, Shri B. M. Patil Medical College, Vijayapura, 586103, karnataka

PHONE NO: 0852262770

TEACHING EXPERIENCE: Has been associated with BLDE(DU) ever since joining the institution in august of 1992 and has been practising M.S. general surgery to date

PUBLICATIONS: 14

RESEARCH PROJECTS: Research guide for ICMR STS project entitled Study of skin staples and conventional suture for abdomen skin wound closure in the year 2010

CO-GUIDE

NAME: Dr. **DR. RAJASHEKAR MUCHCHANDI**

DATE OF BIRTH:

06/06/1976

EDUCATIONAL QUALIFICATION: M.B.B.S., MD

QUALIFICATION	**COLLEGE**	**UNIVERSITY**	**YEAR**
M.B.B.S	Shri B.M.Patil Medical College and Research Center	B.L.D.E. University	1999
M.D.	Sri Siddhartha Medical College Tumakur	Rajiv Gandhi University of Health Science	2011

PRESENT POSITION: HOD & Professor, Department of Radio-Diagnosis B.L.D.E. (D.U.)'s Shri B.M. Patil Medical College, Hospital and Research Centre, Vijayapur– 586103

sl.no	Patient id	age	gender	duration of symptoms	toxic appearance	neuralgia	fever	weakness	chills	tachycardia	tachypnea	WBC	CRP	creatinine	fascial thicknening (mm)	fluid collection	subcutaneous gas	time to surgery
1	NF001	33	Female	7	1	0	1	1	1	1	1	24053	128.6	1.7	14.5	0	1	5
2	NF002	56	Male	8	1	1	1	1	1	1	1	10316	169.5	0.9	4.8	0	1	12
3	NF003	76	Male	7	1	1	1	1	0	0	1	16137	214.2	1.4	11.6	1	1	9
4	NF004	57	Male	3	1	0	1	1	0	1	1	19124	264.1	1.4	8.4	0	0	14
5	NF005	68	Female	8	1	0	1	1	1	1	1	28859	85.9	1.3	2.7	1	1	18
6	NF006	46	Male	14	1	0	1	1	1	1	1	24623	201.7	2.8	2.2	1	1	14
7	NF007	56	Female	7	1	0	1	1	1	1	1	6502	135.6	2	7	1	0	22
8	NF008	25	Female	12	0	0	0	1	1	0	0	8251	250.6	1.4	12.9	1	1	11
9	NF009	34	Male	12	0	1	1	1	1	1	1	23790	182.7	1.6	6.5	0	1	10
10	NF010	54	Female	13	1	0	1	1	0	1	1	12643	172.1	0.7	4.7	1	0	15
11	NF011	69	Male	7	1	1	1	1	1	1	1	8917	248.3	2.4	6.3	1	1	19
12	NF012	48	Male	1	1	0	1	1	1	0	0	22484	56.8	1.1	4.7	1	0	7
13	NF013	47	Female	4	1	1	1	1	1	1	1	17876	299.8	2.9	9.4	1	0	8
14	NF014	36	Female	3	1	1	1	1	1	1	1	22551	81.8	1.9	3	1	0	17
15	NF015	50	Female	7	1	1	1	0	1	1	1	29648	68	2	8.7	1	0	16
16	NF016	58	Male	10	1	0	1	1	1	1	1	23306	208.5	2.6	9.3	0	1	12
17	NF017	26	Male	7	1	0	1	1	1	1	1	20653	179.7	1.4	8.7	0	1	10
18	NF018	25	Male	3	1	1	1	1	1	1	1	26029	255.2	1	2.6	1	0	6
19	NF019	55	Male	11	1	1	1	1	1	0	0	17929	207.8	1.2	8.5	1	1	3
20	NF020	20	Male	13	1	1	1	1	1	1	1	10779	132.3	2.7	12.8	1	1	18
21	NF021	41	Male	10	1	1	1	0	1	1	1	21127	236.8	3	2	1	1	6
22	NF022	55	Male	10	1	1	1	1	1	1	0	11112	73.3	2.5	14.2	1	1	1
23	NF023	57	Male	12	1	0	1	1	0	1	1	6133	149.3	1.8	4.7	1	1	16
24	NF024	48	Male	4	1	1	1	1	1	1	1	15263	165.2	1.8	5.3	1	1	8
25	NF025	51	Male	7	1	1	1	1	1	1	1	17266	59.3	2.9	12.8	1	0	1
26	NF026	44	Female	3	0	0	1	1	1	1	0	14757	188.9	0.8	2.3	1	1	22
27	NF027	51	Male	8	1	1	0	1	1	1	1	28145	282.3	1.7	11.6	1	1	18
28	NF028	31	Female	9	1	1	1	1	1	1	1	11938	161.5	2.4	6.7	1	0	14
29	NF029	37	Female	12	0	1	1	0	1	1	1	24665	258.6	2.7	6.9	0	1	20
30	NF030	55	Male	1	1	0	0	1	1	1	0	16028	118.3	1.3	15	1	1	18
31	NF031	33	Male	3	1	0	1	1	0	1	1	24517	131.9	2.8	2.5	1	1	1
32	NF032	55	Female	6	1	1	1	1	1	1	0	23800	233.4	1.8	11.2	0	1	20
33	NF033	44	Male	11	0	1	1	1	1	1	1	14761	234.7	1.5	10.4	0	1	4
34	NF034	52	Female	9	1	1	1	1	1	1	1	4024	183.5	2.2	9.4	1	1	1
35	NF035	39	Male	10	0	1	1	1	1	1	1	13660	176	1.2	4.6	1	0	21
36	NF036	21	Female	11	0	0	0	1	1	0	1	13758	132.3	1.5	3.7	1	1	5
37	NF037	28	Male	5	1	0	1	0	0	1	1	10198	209	2.3	3.4	1	1	7
38	NF038	38	Male	6	0	1	1	1	1	1	1	8784	142.5	1	10.8	1	1	5
39	NF039	47	Female	3	1	1	1	1	1	0	1	28488	248.4	1.3	4	1	0	20
40	NF040	42	Female	2	0	1	1	1	1	1	1	16124	185.3	2.7	13.4	1	0	20
41	NF041	25	Male	6	1	0	1	1	1	1	1	25035	172.9	2.6	5.2	1	0	4
42	NF042	49	Male	11	1	1	1	1	1	1	0	28151	65.5	2.2	12.5	1	1	20
43	NF043	35	Male	5	1	1	1	1	1	1	1	10104	172.8	2.1	13.5	1	1	1
44	NF044	55	Male	3	1	1	1	1	1	1	1	22314	83.8	0.7	10.4	1	1	12
45	NF045	67	Male	12	1	1	0	1	1	1	1	6857	289.1	1.6	6	1	0	16
46	NF046	41	Female	12	1	0	1	1	1	1	1	5668	55.1	1.9	3.9	0	0	10
47	NF047	31	Female	3	1	1	1	1	1	1	1	19531	114.2	2	3.9	1	1	15
48	NF048	54	Male	3	1	1	1	1	1	1	0	17456	85.5	0.9	9.9	1	1	10
49	NF049	26	Female	13	1	1	1	1	1	0	0	18564	152.9	1.8	12.8	1	1	24
50	NF050	62	Female	13	0	1	1	1	1	1	1	5464	147	2.7	9.4	1	1	15
51	NF051	19	Male	14	0	1	1	1	0	1	1	14500	147.7	2.5	6.4	0	0	2
52	NF052	65	Female	1	1	1	1	1	0	1	0	24918	222.7	2.3	10.3	0	1	1
53	NF053	36	Male	5	1	1	1	1	0	1	0	19248	55	2.9	10.8	1	1	22
54	NF054	55	Male	7	1	1	1	1	1	1	1	24566	190.3	1.8	5.2	1	1	4
55	NF055	74	Male	1	1	1	1	1	1	1	1	23623	131.2	1	2.4	1	1	9
56	NF056	55	Female	5	1	1	1	1	1	1	1	18996	267.7	2.7	9.1	1	1	23
57	NF057	29	Male	11	0	1	1	1	1	1	1	21345	266.2	2.8	8.4	0	1	11
58	NF058	39	Female	9	1	1	1	1	1	1	0	14136	172.6	1.5	7	1	1	17
59	NF059	63	Male	13	0	0	1	1	1	1	1	4598	284.6	0.8	8.6	0	0	3

60	NF060	72	Female	2	0	1	1	1	0	0	1	28844	112	2.3	4.3	1	1	2
61	NF061	32	Male	2	1	0	1	1	1	1	1	19047	136.7	2.4	13.4	1	0	18
62	NF062	58	Female	9	1	1	1	1	1	1	1	23218	78.5	1.4	5.6	0	1	6
63	NF063	64	Male	7	0	1	1	1	1	1	1	28666	81.4	1.7	3.3	1	0	1
64	NF064	63	Male	13	1	1	1	1	1	0	1	27418	161	0.9	8.1	1	1	18
65	NF065	51	Male	7	0	1	1	1	0	1	0	23155	126.7	1.4	10.9	1	0	7
66	NF066	77	Male	5	1	1	1	1	1	1	1	4359	193.5	2.8	4	0	1	14
67	NF067	43	Female	13	1	1	1	1	0	1	0	8870	243	2.6	12.1	0	1	15
68	NF068	29	Male	7	1	1	1	0	1	1	0	27516	102.7	1.5	6.9	1	1	21
69	NF069	74	Male	4	1	1	0	1	1	1	1	26838	235.5	2.9	13.6	0	0	8
70	NF070	28	Male	8	1	1	1	1	1	1	1	16058	73.6	0.6	12.9	1	1	20
71	NF071	39	Male	13	1	1	1	1	1	1	1	21930	218.8	1	2.2	1	0	23
72	NF072	35	Female	6	1	1	1	1	1	0	1	21892	161.1	2.8	4	1	1	22
73	NF073	63	Male	9	1	1	1	1	1	1	1	11927	73.4	0.9	2.2	1	0	16
74	NF074	40	Female	14	1	1	1	1	0	1	0	21862	202.5	0.8	13.1	1	0	1
75	NF075	51	Male	13	1	1	0	1	1	1	1	26467	70.9	2.1	13.7	1	1	5
76	NF076	21	Male	14	1	1	0	1	1	1	1	22418	148.6	1.1	5.2	1	1	5
77	NF077	50	Male	7	1	1	1	1	1	1	1	13254	270.4	1.6	12.4	1	0	6
78	NF078	46	Male	7	1	1	1	1	1	1	1	27211	184	2.6	10.3	1	1	6
79	NF079	70	Female	13	1	1	1	1	0	1	0	29892	157.9	1.2	13.9	1	0	24
80	NF080	63	Male	7	1	1	1	1	1	0	1	17960	283.1	1.4	13.2	1	0	20
81	NF081	68	Male	7	1	1	1	1	1	1	1	25864	231.2	2.7	10.2	1	1	13
82	NF082	21	Female	5	1	1	1	1	1	1	1	16662	135.4	1.2	10	1	1	6
83	NF083	50	Female	1	1	1	1	1	1	1	1	24152	157.9	2.5	6	1	1	16
84	NF084	27	Male	11	1	1	1	1	1	1	1	4259	284.9	2.1	13.3	0	1	20
85	NF085	66	Female	9	1	1	1	1	0	1	1	29126	50.4	0.6	12.6	1	0	19

number of debridements	pt condition 1 week	symptom releif score 1 week	wound healing score 1 wk	final outcome 3 weeks	length of hospital stay	complications	LRINEC score 3 weeks	POCUS assessment final at 3 wks
3	Deceased	3	1	Complications	10	Sepsis	2	Resolved
4	Stable	6	4	Complete Recovery	15	None	8	Partially Resolved
2	Stable	1	6	Complete Recovery	11	None	3	Partially Resolved
5	Improved	10	10	Deceased	20	None	7	Partially Resolved
3	Critical	1	7	Deceased	39	None	11	Resolved
2	Critical	10	10	Deceased	11	Sepsis	5	Partially Resolved
5	Deceased	4	1	Complete Recovery	12	None	4	Resolved
1	Deceased	2	6	Deceased	33	None	12	Persistent Changes
4	Deceased	4	9	Partial Recovery	30	Sepsis	11	Partially Resolved
3	Stable	2	2	Ongoing Treatment	21	Amputation Required	3	Partially Resolved
4	Critical	3	8	Complications	22	Organ Failure	9	Resolved
4	Improved	7	8	Ongoing Treatment	29	None	0	Persistent Changes
4	Critical	3	5	Ongoing Treatment	36	Amputation Required	3	Persistent Changes
3	Critical	4	8	Deceased	21	None	0	Partially Resolved
2	Critical	5	6	Partial Recovery	15	None	13	Partially Resolved
5	Stable	3	7	Complete Recovery	8	None	9	Persistent Changes
1	Critical	5	7	Complete Recovery	26	None	0	Partially Resolved
4	Deceased	9	4	Deceased	40	None	11	Persistent Changes
5	Critical	9	4	Partial Recovery	30	None	6	Resolved
2	Deceased	9	1	Ongoing Treatment	17	Organ Failure	1	Persistent Changes
1	Stable	10	5	Complete Recovery	29	None	1	Resolved
1	Stable	6	8	Ongoing Treatment	14	Amputation Required	11	Persistent Changes
1	Deceased	3	10	Partial Recovery	42	None	11	Persistent Changes
4	Deceased	4	3	Partial Recovery	42	Wound Infection	9	Persistent Changes
1	Stable	2	9	Complete Recovery	24	Organ Failure	0	Resolved
4	Stable	6	9	Ongoing Treatment	36	Organ Failure	11	Partially Resolved
2	Stable	9	6	Partial Recovery	8	None	13	Persistent Changes
5	Stable	10	5	Partial Recovery	44	None	5	Resolved
5	Critical	2	7	Partial Recovery	27	Amputation Required	0	Partially Resolved
3	Critical	9	8	Complications	25	None	11	Partially Resolved
3	Critical	10	9	Partial Recovery	31	Sepsis	5	Resolved
5	Deceased	9	4	Complications	10	None	13	Partially Resolved
4	Deceased	4	5	Complete Recovery	7	None	12	Partially Resolved
3	Deceased	6	4	Partial Recovery	20	Wound Infection	5	Resolved
2	Deceased	3	10	Partial Recovery	14	Sepsis	1	Resolved
4	Improved	3	6	Complications	17	Wound Infection	8	Resolved
2	Stable	6	8	Complete Recovery	24	None	8	Persistent Changes
5	Critical	1	10	Complete Recovery	10	None	7	Resolved
3	Stable	4	1	Complications	27	None	4	Resolved
3	Stable	3	8	Partial Recovery	39	Amputation Required	1	Partially Resolved
5	Critical	3	8	Partial Recovery	32	None	6	Partially Resolved
2	Critical	10	6	Complications	29	None	5	Resolved
5	Improved	3	7	Deceased	36	Amputation Required	8	Persistent Changes
1	Critical	7	1	Partial Recovery	43	None	9	Persistent Changes
5	Improved	3	6	Complete Recovery	45	None	8	Persistent Changes
4	Improved	4	3	Complications	21	None	5	Resolved
3	Improved	10	3	Deceased	38	None	5	Persistent Changes
2	Critical	5	10	Complete Recovery	18	None	5	Resolved
3	Critical	10	5	Complications	33	None	11	Partially Resolved
4	Critical	8	3	Complications	28	None	11	Partially Resolved
5	Improved	6	4	Complications	14	None	1	Partially Resolved
2	Improved	3	5	Ongoing Treatment	42	None	10	Persistent Changes
4	Stable	10	2	Ongoing Treatment	14	Organ Failure	4	Resolved
5	Improved	5	1	Partial Recovery	40	None	10	Persistent Changes
3	Deceased	5	6	Complete Recovery	31	Wound Infection	0	Persistent Changes
4	Deceased	10	4	Ongoing Treatment	12	None	3	Partially Resolved
2	Improved	5	4	Ongoing Treatment	33	None	3	Persistent Changes
1	Improved	2	1	Ongoing Treatment	12	None	4	Partially Resolved
3	Improved	3	4	Partial Recovery	10	None	13	Persistent Changes

3	Deceased	9	2	Partial Recovery	15	None	9	Resolved
4	Critical	8	4	Ongoing Treatment	42	None	12	Persistent Changes
4	Deceased	8	7	Complications	34	None	6	Resolved
2	Critical	6	4	Complete Recovery	28	Amputation Required	1	Persistent Changes
5	Stable	8	10	Complete Recovery	18	Organ Failure	2	Resolved
1	Deceased	9	9	Complications	16	Amputation Required	8	Partially Resolved
4	Critical	9	6	Deceased	20	Wound Infection	10	Persistent Changes
3	Stable	9	8	Complications	32	Sepsis	0	Partially Resolved
5	Stable	10	2	Complications	29	Amputation Required	0	Persistent Changes
3	Improved	6	7	Complete Recovery	21	None	12	Resolved
1	Stable	4	7	Partial Recovery	38	Sepsis	9	Persistent Changes
3	Stable	7	10	Ongoing Treatment	20	None	13	Resolved
4	Stable	9	9	Complications	18	None	4	Resolved
4	Improved	9	9	Partial Recovery	11	None	12	Partially Resolved
1	Improved	7	4	Deceased	22	None	10	Resolved
5	Improved	8	10	Partial Recovery	28	Wound Infection	11	Persistent Changes
5	Deceased	9	7	Deceased	45	None	9	Partially Resolved
1	Deceased	4	10	Complications	30	None	11	Persistent Changes
5	Critical	7	5	Ongoing Treatment	8	None	10	Persistent Changes
4	Improved	3	2	Ongoing Treatment	26	Amputation Required	1	Persistent Changes
2	Deceased	5	8	Ongoing Treatment	15	None	12	Resolved
3	Critical	10	6	Deceased	44	None	9	Persistent Changes
1	Improved	6	9	Ongoing Treatment	30	Sepsis	11	Resolved
4	Improved	4	2	Partial Recovery	44	None	13	Partially Resolved
3	Improved	8	9	Deceased	22	None	7	Persistent Changes
1	Stable	3	6	Partial Recovery	9	Wound Infection	7	Resolved

BLDE

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Declared as Deemed to be University u/s 3 of UGC Act, 1956

Accredited with 'A' Grade by NAAC (Cycle-2)

The Constituent College

SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE, VIJAYAPURA

BLDE (DU)/IEC/ 924/2023-24 10/4/2023

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this University met on **Saturday, 18th March, 2023 at 11.30 a.m. in the CAL Laboratory, Dept. of Pharmacology,** scrutinizeD the Synopsis/ Research Projects of Post Graduate Student / Under Graduate Student /Faculty members of this University /Ph.D. Student College from ethical clearance point of view. After scrutiny, the following original/ corrected and revised version synopsis of the thesis/ research projects has been accorded ethical clearance.

TITLE: "A STUDY ON ACCURACY OF POINT OF CARE ULTRASOUND IN DIAGNOSING AND MANAGEMENT OF NECROTIZING FASCIITIS".

NAME OF THE STUDENT/PRINCIPAL INVESTIGATOR: DR.MEDIKONDA ESWAR

NAME OF THE GUIDE: DR.ARAVIND V.PATIL, PRINCIPAL & PROFESSOR, DEPT. OF GENERAL SURGERY.

Dr. Santoshkumar Jeevangi
Chairperson
IEC, BLDE (DU),
VIJAYAPURA

Chairman,
Institutional Ethical Committee,
BLDE (Deemed to be University)
Vijayapura

Dr.Akram A. Naikwadi
Member Secretary
IEC, BLDE (DU),
VIJAYAPURA

MEMBER SECRETARY
Institutional Ethics Committee
BLDE (Deemed to be University)
Vijayapura-586103. Karnataka

Following documents were placed before Ethical Committee for Scrutinization.

- Copy of Synopsis/Research Projects
- Copy of inform consent form
- Any other relevant document