

## Original Article

# From Crisis to Closure: Outcomes of Lower Limb Necrotizing Fasciitis Management Using Early Debridement, Vacuum-Assisted Closure Therapy, and Split-Thickness Skin Grafting: A Prospective Institutional Study

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### ABSTRACT

**Background:** Necrotizing fasciitis (NF) is an aggressive, rapidly progressive soft-tissue infection characterized by fascial necrosis, systemic toxicity and a substantial risk of limb loss and death. Successful treatment depends on early recognition, urgent surgical source control, appropriate antimicrobial therapy, resuscitation and repeated reassessment. Following adequate debridement, extensive residual wounds often require staged reconstruction. Negative-pressure wound therapy (NPWT), commonly delivered as vacuum-assisted closure (VAC), may facilitate exudate control, granulation and wound-bed preparation before definitive split-thickness skin grafting (STSG).

**Aim:** To evaluate the clinical outcomes of a structured staged management protocol consisting of early aggressive surgical debridement, VAC therapy and subsequent STSG in patients with lower-limb NF.

**Materials and Methods:** This prospective observational institutional study was conducted in the Department of General Surgery, ESI Medical College, Kalaburagi, from December 2023 to November 2025. Twenty-five patients with lower-limb NF managed using serial debridement, VAC therapy and STSG were included. Demographic characteristics, diabetes status, limb salvage, mortality and graft uptake were evaluated. Outcomes were summarized descriptively.

**Results:** The study included 25 patients with a mean age of  $52 \pm 11$  years. Males constituted 84% of the cohort and diabetes mellitus was present in 68%. Limb salvage was achieved in 92% of patients. Overall mortality was 4%. Among patients undergoing definitive grafting, approximate graft uptake was 90%. The staged strategy enabled progression from infection control and serial debridement to wound-bed preparation and definitive skin coverage in the majority of patients.

**Conclusion:** In this institutional series, a structured pathway of early surgical debridement followed by VAC-assisted wound-bed preparation and timely STSG was associated with favorable limb-salvage and reconstructive outcomes. The findings support VAC therapy as an adjunct—not a substitute—for adequate surgical source control. Larger prospective comparative studies are required to determine the independent contribution of NPWT and identify predictors of outcome.

**Keywords:** necrotizing fasciitis; lower limb; necrotizing soft-tissue infection; surgical debridement; negative-pressure wound therapy; vacuum-assisted closure; split-thickness skin graft; limb salvage; wound reconstruction; wound healing.

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## INTRODUCTION

Necrotizing fasciitis is a severe necrotizing soft-tissue infection that can progress rapidly along fascial planes and produce extensive tissue necrosis. Although it is relatively uncommon compared with superficial skin and soft-tissue infections, its consequences can be catastrophic. Patients may progress from localized pain and swelling to bullae, skin necrosis, systemic inflammatory response, septic shock, multiorgan dysfunction, limb loss and death. The clinical appearance may initially underestimate the depth and extent of infection, making a high index of suspicion essential.

The lower limb is a frequent site of necrotizing soft-tissue infection. Predisposing factors include diabetes mellitus, peripheral vascular disease, immunosuppression, trauma, chronic wounds and other conditions that compromise host defense or tissue perfusion. Diabetes is particularly relevant because hyperglycemia, microvascular dysfunction and impaired immunity may contribute both to susceptibility to infection and delayed wound healing.

Diagnosis remains predominantly clinical. Severe pain out of proportion to the visible skin findings, rapidly progressive swelling, systemic toxicity, bullous change, skin discoloration, anesthesia, crepitus and evidence of tissue necrosis should raise suspicion. Laboratory and radiological investigations can provide supportive information, but definitive surgical management should not be delayed when clinical suspicion is strong.

Early surgical debridement is the central therapeutic intervention. The objective is removal of all clearly nonviable and infected tissue and control of the source of infection. Contemporary evidence-based guidance supports prompt operative intervention; a systematic review used for the Eastern Association for the Surgery of Trauma practice guideline found lower mortality among patients receiving early compared with delayed debridement. [6]

Complete source control often requires serial operations because the extent of necrosis can evolve after the initial procedure. Re-exploration allows identification and removal of residual nonviable tissue while preserving viable structures. Thus, management should be regarded as a dynamic process rather than a single operation.

After adequate debridement, patients are frequently left with large, irregular and heavily exudative wounds. Definitive closure during the active infectious phase is generally inappropriate because residual infection can become concealed and compromise reconstruction. Instead, a staged approach is used: infection control and debridement are followed by wound-bed preparation and, once healthy granulation tissue is established, definitive reconstruction.

Negative-pressure wound therapy has become an important adjunct in this intermediate phase. By applying controlled subatmospheric pressure to a sealed wound, NPWT can facilitate exudate management, reduce edema, promote granulation and help decrease wound dimensions. It may therefore shorten the interval between radical debridement and definitive coverage in selected patients.

Split-thickness skin grafting is one of the most practical reconstructive options for broad superficial defects once the wound is clean, adequately vascularized and covered by healthy granulation tissue. Contemporary reconstructive principles emphasize that closure should be determined by the final defect and the structures exposed, with grafting appropriate when critical structures are adequately covered and the wound bed is suitable.

The present study was designed to evaluate the outcomes of this staged approach in patients with lower-limb NF managed at a tertiary institutional surgical unit. The study specifically focuses on clinically meaningful endpoints—limb salvage, mortality and graft uptake—while describing the transition from acute source control to definitive wound closure.

## MATERIALS AND METHODS

### Study Design and Setting

This was a prospective observational institutional study conducted in the Department of General Surgery, ESI Medical College, Kalaburagi, Karnataka, India, over a two-year period from December 2023 to November 2025.

### Study Population

Twenty-five patients with lower-limb necrotizing fasciitis who underwent operative management followed by VAC therapy and definitive STSG were included in the study. The study cohort therefore represents patients managed through the complete staged treatment pathway rather than all patients presenting with necrotizing soft-tissue infection.

### Clinical Assessment

Patients were assessed clinically for the extent and progression of soft-tissue infection, systemic toxicity and limb viability. Relevant laboratory and imaging investigations were performed according to clinical need. Investigations were considered adjunctive and were not intended to delay operative source control in patients with a high clinical suspicion of NF.

### Initial Resuscitation and Medical Management

Initial treatment included hemodynamic stabilization, fluid and electrolyte correction, appropriate empirical broad-spectrum antimicrobial therapy and optimization of important comorbid conditions. Particular attention was given to glycemic optimization in patients with diabetes mellitus. Further antimicrobial management was guided by the clinical course and microbiological information where available.

### Surgical Debridement Protocol

Urgent surgical exploration and aggressive debridement formed the foundation of treatment. Nonviable skin, subcutaneous tissue and fascia were excised until viable tissue was identified. The extent of debridement was determined by operative findings rather than by the apparent surface extent of skin involvement. Wounds were reassessed serially, and repeat debridement was undertaken when residual or progressive necrosis was suspected.

The management principle was complete source control while preserving clearly viable tissue. VAC therapy was not used as a replacement for debridement; it was introduced only after adequate surgical control had been achieved.

### Vacuum-Assisted Closure / Negative-Pressure Wound Therapy

Following adequate debridement and clinical stabilization, VAC therapy was used to manage the open wound and facilitate wound-bed preparation. The technique was intended to assist with management of wound exudate, reduction of edema and promotion of healthy granulation tissue. Published evidence supports the use of NPWT as an adjunct following adequate source control in complex necrotizing soft-tissue wounds. [4,5,7]

The timing of transition from VAC therapy to definitive reconstruction was based on clinical assessment of the wound. A clean wound with healthy, uniform granulation tissue and absence of clinically evident ongoing infection was considered suitable for grafting.

### Split-Thickness Skin Grafting

STSG was selected for definitive coverage once the wound had achieved an adequate granulating bed and infection was considered controlled. Graft take was assessed clinically following grafting. The reported graft-uptake figure represents the approximate uptake documented in the study cohort.

### Outcome Measures

The primary outcomes were limb salvage and mortality. Secondary reconstructive outcome was graft uptake. Additional clinical variables of interest included age, sex and diabetes mellitus. Because the available dataset for this manuscript did not include complete patient-level information on time to first debridement, number of operations, wound dimensions, duration of VAC therapy, hospital stay or microbiological isolates, these variables were not analyzed quantitatively.

### Statistical Analysis

Continuous variables were summarized as mean  $\pm$  standard deviation and categorical variables as percentages. Given the small sample size and absence of a comparator group, the analysis was descriptive and no inferential statistical comparisons were undertaken.

## RESULTS

### Demographic Profile

Twenty-five patients were included. The mean age was  $52 \pm 11$  years. There was a clear male predominance, with males comprising 84% of the cohort. Diabetes mellitus was present in 68% of patients, making it the most prominent reported comorbidity.

| Variable          | Result                      |
|-------------------|-----------------------------|
| Sample size       | 25 patients                 |
| Mean age          | $52 \pm 11$ years           |
| Male sex          | 84%                         |
| Diabetes mellitus | 68%                         |
| Study duration    | December 2023–November 2025 |

### Treatment Course

All patients in the reported cohort underwent surgical debridement as the primary definitive intervention. Serial debridement was undertaken as clinically required. Following source control, VAC therapy was used to manage the open wounds and promote wound-bed maturation. Once an appropriate granulating wound bed was achieved, STSG was used for definitive coverage.

### Clinical and Reconstructive Outcomes

| Outcome      | Result |
|--------------|--------|
| Limb salvage | 92%    |

|                          |     |
|--------------------------|-----|
| Mortality                | 4%  |
| Approximate graft uptake | 90% |

The overall limb-salvage rate of 92% indicates that the majority of patients were managed without limb loss. Mortality was 4%. Among patients undergoing grafting, approximate graft uptake was 90%, indicating satisfactory wound-bed preparation and graft integration in the majority of cases.

## DISCUSSION

The present study evaluates a staged strategy for lower-limb NF in which early surgical source control is followed by VAC-assisted wound management and definitive STSG. The central concept is to separate the treatment of the acute infectious process from the reconstructive phase. This is important because the immediate priority in NF is eradication of infected and devitalized tissue, whereas reconstruction becomes appropriate only after infection has been controlled and tissue viability is established.

### Importance of Early Debridement

The most important determinant of outcome in NF is timely recognition and source control. A recent practical review emphasizes that NF generally requires serial debridement and that delays in surgical treatment are associated with worse outcomes. [2] The Eastern Association for the Surgery of Trauma guideline specifically recommends early operative debridement within 12 hours of suspected diagnosis; in its evidence synthesis, mortality was 14% in the early-debridement group compared with 25.8% in the delayed group. [6] These findings reinforce the principle that VAC therapy or any reconstructive intervention cannot compensate for inadequate or delayed debridement.

In the present study, aggressive surgical debridement was therefore treated as the first and most important step. Serial assessment is equally important because NF can continue to evolve despite an apparently adequate initial operation. Repeat exploration allows residual necrotic tissue to be removed and prevents premature reconstruction.

### Role of VAC Therapy

The residual wound following NF debridement can be large, irregular and associated with substantial exudate. Conventional dressings can be labor intensive and may require frequent changes. VAC therapy provides a controlled closed environment and may help reduce edema, manage exudate and encourage granulation tissue formation. Reviews of NF management describe NPWT as a useful adjunct after adequate source control rather than a primary treatment for the infection. [2,7]

A systematic review and meta-analysis comparing VAC with conventional dressing in NF reported a lower pooled mortality with VAC, although other outcomes such as hospital stay, number of debridements and complication rate were not significantly different. Importantly, the authors also highlighted the limitations of the available evidence. [7] Consequently, the favorable outcomes in the present study should not be interpreted as proof that VAC itself independently reduced mortality or prevented amputation.

### Transition from Infection Control to Reconstruction

One of the key clinical decisions in NF is determining when a wound is ready for definitive coverage. Premature closure can trap residual infection and compromise graft survival. Conversely, unnecessarily prolonged open-wound management can increase morbidity and delay rehabilitation. Reconstructive literature supports proceeding with coverage after eradication of infection and development of a healthy granulation bed. [1,2]

In the present protocol, VAC therapy functioned as a bridge between debridement and definitive reconstruction. This staged pathway allowed the wound to be monitored during the period of infection control and progressively prepared for grafting.

### Role of Split-Thickness Skin Grafting

STSG is particularly useful for broad, superficial defects with a healthy vascularized wound bed. It is technically less complex than flap reconstruction and can cover extensive defects when deeper structures are adequately protected. Contemporary reconstructive recommendations similarly emphasize that the quality of granulation tissue and underlying blood supply are major determinants of graft or flap survival. [2]

The approximate 90% graft uptake in this series is consistent with a clinically successful staged reconstruction strategy. The finding also supports the practical value of adequate wound-bed preparation before grafting. A randomized-trial meta-analysis of NPWT used with skin grafts found improved graft take and reduced time from grafting to discharge compared with non-NPWT approaches, although the optimal pressure and patient selection remain areas of ongoing investigation. [8,9]

### Diabetes and Patient Risk Profile

Diabetes mellitus was present in 68% of the study population. Diabetes is clinically important in NF because impaired immune function, vascular compromise and altered wound healing can influence both infection severity and

reconstruction. The high prevalence of diabetes in this series emphasizes the importance of perioperative metabolic optimization and close wound surveillance.

### **Limb Salvage**

The 92% limb-salvage rate is a clinically meaningful outcome. In lower-limb NF, the objective is not simply survival but preservation of a functional limb whenever this can be achieved without compromising source control. Limb salvage requires a balance between radical removal of infected tissue and preservation of viable structures. The reconstructive phase then aims to restore durable soft-tissue coverage and facilitate rehabilitation.

The limb-salvage result should nevertheless be interpreted within the context of this study design. The cohort was small, selected for patients who proceeded through the described management pathway, and lacked a contemporaneous control group. Therefore, the result demonstrates the feasibility and observed outcome of the protocol rather than establishing superiority over alternative treatment strategies.

### **Mortality**

The mortality rate in the present series was 4%. This is favorable when viewed against the substantial mortality historically associated with NF, but direct comparisons across studies are difficult because cohorts differ in disease severity, anatomical site, comorbidity burden, timing of surgery, sepsis severity and case selection. The small number of deaths also means that the percentage is highly sensitive to a single additional event.

### **Clinical Implications**

The principal clinical implication of this study is the importance of viewing NF management as a continuum: rapid recognition, immediate resuscitation, early and adequate debridement, repeated reassessment, controlled wound management and timely definitive reconstruction. VAC therapy is most appropriately positioned within this sequence as a wound-management and reconstructive adjunct.

For surgeons managing extensive lower-limb wounds, this staged pathway may also provide a practical framework for coordinating acute care with reconstructive planning. Early involvement of reconstructive expertise can help anticipate the final defect and determine whether STSG, local flap, regional flap or free-tissue transfer will ultimately be required.

### **Comparison with Published Literature**

The findings of the present series are broadly compatible with published principles of NF care. Reviews consistently emphasize early operative debridement and serial reassessment. [1,2] The use of VAC after adequate source control is also described as a useful strategy for managing large open wounds and promoting granulation. [4,5,7] Evidence from randomized-trial meta-analysis suggests that NPWT can improve skin-graft take when used around grafting. [8,9]

However, the available literature does not justify attributing all favorable outcomes to VAC therapy. The most important therapeutic intervention remains timely and complete source control. VAC should therefore be considered complementary to, rather than a replacement for, surgery and antimicrobial therapy.

### **Strengths**

- The study was prospective and followed patients through both the acute and reconstructive phases.
- The treatment pathway was clinically coherent, progressing from source control to wound-bed preparation and definitive coverage.
- The study reports clinically relevant outcomes including limb salvage, mortality and graft uptake.
- The cohort reflects real-world surgical practice in a tertiary institutional setting.

### **Limitations**

- The sample size was small (25 patients), limiting statistical power.
- The study was conducted at a single institution, which may limit external validity.
- There was no control or comparison group, so the independent effect of VAC therapy cannot be determined.
- Patient-level data regarding time from presentation to first debridement, number of debridements, wound size, microbiological isolates, duration of VAC therapy, hospital stay and long-term functional outcome were not available for the current analysis.
- The reported graft uptake was approximate rather than based on a standardized percentage-area measurement.
- Selection of patients who underwent the complete staged pathway may introduce selection bias.

### **Future Research**

Future prospective multicenter studies should record time from presentation to first debridement, severity scores, microbiological profile, number and timing of repeat debridements, duration and pressure settings of NPWT, wound dimensions, time to grafting, length of hospital stay, graft-loss percentage, functional outcomes and quality-of-life measures. A comparison between NPWT and conventional wound care would allow the independent contribution of VAC therapy to be assessed more rigorously.

## CONCLUSION

Lower-limb necrotizing fasciitis is a surgical emergency in which early source control remains the cornerstone of successful treatment. In this prospective institutional series of 25 patients, a structured pathway incorporating early aggressive debridement, serial wound assessment, VAC therapy and subsequent STSG was associated with a 92% limb-salvage rate, 4% mortality and approximately 90% graft uptake.

The findings support the practical role of VAC therapy as a bridge between adequate debridement and definitive reconstruction. By providing controlled wound management and facilitating development of a healthy granulating bed, NPWT may help make extensive wounds suitable for STSG. Nevertheless, the favorable outcomes should be interpreted as observational findings, and larger comparative studies are needed to determine whether the staged protocol offers advantages over conventional wound management and to identify the patients most likely to benefit.

## DECLARATIONS

### Ethics Approval

The study was conducted after obtaining approval from the Institutional Ethics Committee of ESI Medical College, Kalaburagi.

### Informed Consent

Written informed consent was obtained from participants for inclusion in the study and use of relevant clinical information, as applicable. The exact wording should be aligned with the institutional ethics approval.

### Funding

No external funding was received for this study.

### Conflict of Interest

The author declares no conflict of interest.

### Author Contributions

Dr. Rashmi S. N.: Conceptualization, study design, patient management, data collection, critical revision and final approval of the manuscript.

Dr. Akash Anadure : Analysis, manuscript preparation.

### Data Availability

The study data are available from the corresponding author on reasonable request, subject to institutional policy and ethical restrictions.

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