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Negative Pressure Wound Therapy in Lower Limb Reconstruction

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ABSTRACT

Objective: To access the efficacy of negative pressure wound therapy and, its potential outcomes in lower limb reconstruction.
Study Design: Prospective observational study.
Place and Duration of Study: Department of Plastic Surgery, Combined Military Hospital, Rawalpindi Pakistan, from Dec 2019 to Dec 2020.
Methodology: We evaluated negative pressure wound therapy on 56 patients meeting exclusion and inclusion criteria. Dressing kept for 03 to 04 days on continuous suction pressure at -125 mmHg. Outcomes measured in term of wound size reduction, type of tissue requirement for wound coverage and complications after negative pressure wound therapy.
Result: Wound size reduction after negative pressure wound therapy was 24.10% with average number of dressings 02.39±1.07 (range 01 to 06) Wound covered with Partial Thickness Skin Graft in 38(67.9%) patients. Flap coverage required in 15(26.8%) in lower limb. No major complication noted in 56 patients.
Conclusion: Negative pressure wound therapy has evolved management algorithm of complex and complicated wounds in lower extremities. It optimizes wound bed, significantly reduces duration of wound healing and lessen soft tissue defect coverage with secondary procedures.

Keywords: Lower Limb Reconstruction, Negative Pressure Wound Therapy (Npwt), Wound Outcomes of Negative Pressure, Wound Therapy in Lower Limb Reconstruction.

How to Cite This Article: *Ayub A, Choudhary SH, Majid A, Mansoor P, Qureshi MU, Faisal S. Negative Pressure Wound Therapy in Lower Limb Reconstruction. Pak Armed Forces Med J 2025; 75(Suppl-2): S321-S326. DOI: https://doi.org/10.51253/pafmj.v75iSUPPL-2.7235*

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INTRODUCTION

Advent of new technology in various fields like transport, armor, medical science, or increased incidence of diseases like diabetes, obesity has resulted in the increased frequency of complex and chronic wounds. Reconstructive ladder provides spectrum of options for wound reconstruction from secondary intention wound healing to technically challenging techniques like microsurgical tissue transfer. Now, negative pressure wound therapy(NPWT) is one of the adjunctive option in reconstructive ladder. Indications for this dressing are acute or chronic wounds like trauma or wound dehiscense and diabetic foot, pressure sore and venous ulcers respectively. It provides temporary wound coverage and helps to step down the reconstructive ladder for wound management. Before negative pressure wound therapy era, mostly dressings for wounds management were based on the principle of moist environment for wound healing.[1] Its mechanism is tissue hypoxia and mechanical stress leads to angiogenesis and vasodilation in wound bed, and helps in healthy granulation tissue formation, increase tissue perfusion, and mechanical wound contracture.[2] It has attained popularity day by day because it helps in healthy granulation tissue formation, homeostasis of wound, microdeformation and macrodeformation of wound.[3] However, role of this therapy regarding infection rate reduction is conflicting. Recent evidence showed that negative pressure wound therapy reduced a statistically significant amount of negative rod, non-fermenting bacterial count in the wound and has no statistical difference noted for the bacterial count of gram positive cocci.[4]

It is noninvasive, pretty straightforward technique. Prerequisites are adequate wound debridement, proper hemostasis and coverage of anatomically critical structures such as neurovascular bundle or body organs.[1,5] Continuous or intermittent suction pressure applied to interface material including antibacterial gauze or open pore polyurethane foam that is sealed in sterile transparent adhesive dressing.[5] Contraindications for the application of negative pressure wound therapy are exposed neurovascular bundles, malignant tissues and exposed organs or tissue anastomotic site in wound bed.[6] It ought to be used with caution in infected

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Received: 13 Aug 2021; revision received: 30 Nov 2021; accepted: 05 Dec 2021

wounds, high risk patients for hemorrhage and over enteric fistula.[6]

There has been a growing number of evidence which enlightened its efficacy, mechanism of action for wound healing and evolution of management strategies of complex and complicated wounds in multiple centers globally. This study will help us to understand the affects and benefits of negative pressure wound therapy in lower limb reconstruction in patients admitted to Combined Military Hospital, Rawalpindi.

METHODOLOGY

We conducted Prospective observational study in department of Plastic Surgery, Combined Military Hospital Rawalpindi for the period of 01 year from Dec 2019 to Dec 2020. Ethical approval was taken from hospital ethical committee (IERB no:176/6/21) and informed written consent from the participants. The sample size was calculated by using the WHO sample size calculator 7.2a with level of significance (α) of 10%, power of the test (1–β) of 80%, population standard deviation (σ) of 9.7, population variance (σ2) of 94.09, test value of the population mean of 61.95 and anticipated population mean of 59.00.[7] Sampling technique was non-probability consecutive sampling. Study was conducted on 56 patients sample size. Study included basic demographics, wound etiology, site of wound, wound size before and after negative pressure wound therapy, total number of dressings, wound score before and after negative pressure wound therapy, post therapy complications and mode of wound closure. We classified the wound in lower limb into 05 groups for wound scoring as described by Lee *et al*., for Negative Pressure Wound Therapy for soft tissue injuries around foot and ankle named open wound scoring system.[8] 0 Score for closed wound, Score 01 for skin and soft tissue defect, Score 02 for exposure of bone, tendon or implant (any one), Score 03 for exposure of 02 or more structures including bone, tendon or implant and Score 04 for associated or residual infection in wound located in lower limb.

Inclusion Criteria: Both genders; all age groups; wounds resultant of trauma, burn, diabetic foot, pressure sore and on partial thickness skin graft (PTSG) in lower limb.

Exclusion Criteria: Participants on anticoagulant or platelets aggregation inhibitors medication; malignancies; grossly infected wounds; necrotic slough with presence of eschar.

In all participants, wounds in lower limb were evaluated and scored according to open wound system classification. Under spinal or general anesthesia, wound bed was prepared by adequate debridement. Hemostasis secured and wound surroundings were cleaned and dried. Wound bed covered with layered dressing, first applied paraffin gauze, than sterilized gauze and kept fenestrated evacuation tube in it than we applied Tincture iodine in periwound area. It was sealed by sterile transparent adhesive film (Opsite dressing) including 2 to 3 cm surrounding area of wound. Tube was always connected to continuous suction at 125 mmHg for 03 - 04 days. Negative pressure suction was confirmed by presence of collapsed gauze and absence of gushing sounds due to air leak. Wound was reevaluated on 3rd or 4th post-operative day for wound progress and to plan either for continue Negative Pressure Wound therapy or further wound debridement or wound coverage with partial thickness skin graft (PTSG) or flap. Follow up maintained in all participants until wound healed (Figure-1 and 2).

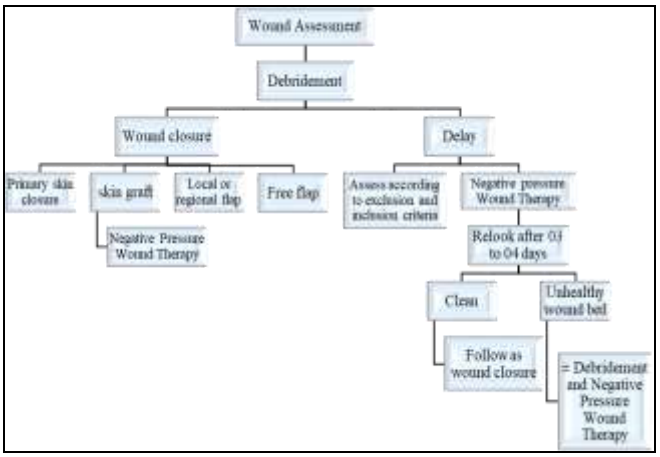

Figure-1: Flow chart Showing Algorithm of Wound Management

Data was analyzed using SPSS version 25.0. Mean±SD was calculated for quantitative variables like age, wound size before and after negative pressure wound therapy, wound score before and after wound therapy and number of dressings. Qualitative variables like gender, wound etiology, location of wound, type of tissue utilize for wound coverage and complications were recorded in terms of frequency percentage. Pre and post negative pressure wound therapy effects were assessed using paired t-test. *p*-value of ≤0.05 was considered as significant.

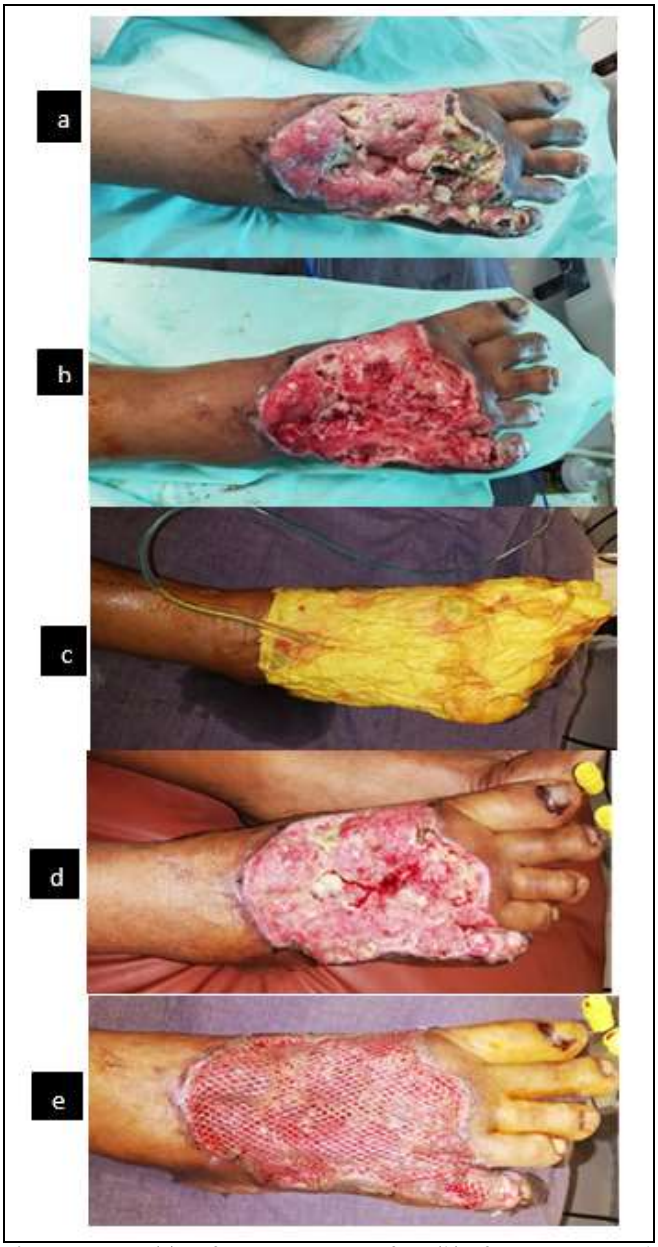

Figure-2: (a)Defect on foot.(b)After Wound Debridement.(c)Negative Pressure Wound Therapy (d)First Change of Dressing. (e) Skin Graft on foot

RESULTS

A total of 56 patients included 17(30.4%) females and 39(69.6%) males were treated. Mean age of patients was 37±20.85 years (range 01 to 78 years). Most common etiology of wound in lower limb was trauma which affected 32(57.1%) patients followed by diabetic foot 11(19.6%), burn 9(16.1%), and pressure sore 4(7.1%). Most common wound site in lower limb was leg in 26(46.4%) patients then foot in 12(21.4%), thigh in 10(17.9%), and knee in 8(14.3%).

The mean of wound size at the time of initial treatment was 113 cm 2±128.42 (12 to 665 cm^2) and mean wound score before negative pressure wound therapy was 02.12±0.87. According to open wound scoring system, most common presentation of wound on examination was Score 2 in 25(44.6%) than Score 3 in 13(23.2%), Score 1 in 14(25%) and Score 4 in 4(7.1%) patients.

The average number of dressing in patients was 02.39±1.07 (range 01 to 06). Mean wound size at the time of wound coverage was 85.76±111.89 cm2 (08 to 612 cm^2) and wound score was 1.32±0.57. In 41(73.2%) patients wound score was 1, score 2 in 12(21.4%) and remaining 03(5.4%) had score 3.

Wound score before negative pressure wound therapy based on wound etiology is shown in Table-I.

Table-I: Wound Score Before Negative Pressure Wound Therapy

Etiology	Wound Score				
	0	1	2	3	4
Trauma	0(0.00%)	2(3.57%)	15(26.78%)	13(23.21%)	2(3.57%)
Burn	0(0.00%)	8(14.28%)	1(1.78%)	0(0.00%)	0(0.00%)
Diabetic foot	0(0.00%)	2(3.57%)	7(12.5%)	0(0.00%)	2(3.57%)
Pressure Sore	0(0.00%)	2(3.57%)	2(3.57%)	0(0.00%)	0(0.00%)

Wound score after negative pressure wound therapy based on wound etiology is shown in Table-II.

Table-II: Wound Score after Negative Pressure Wound Therapy

Etiology	Wound Score				
	0	1	2	3	4
Trauma	0(0.00%)	20(35.71%)	11(19.64%)	1(1.78%)	0(0.00%)
Burn	0(0.00%)	9(16.07%)	0(0.00%)	0(0.00%)	0(0.00%)
Diabetic foot	0(0.00%)	9(16.07%)	0(0.00%)	2(3.57%)	0(0.00%)
Pressure Sore	0(0.00%)	3(3.57%)	1(1.78%)	0(0.00%)	0(0.00%)

Overall Wound reduction was noted at the end of negative pressure wound therapy in lower extremities was 24.10%. There was a statistically significant difference in wounds size and score before and after the negative pressure wound therapy in the two groups (p=<0·05). Wound covered with skin graft (PTSG) in 38(67.9%) on healthy granulation wound bed and flap was used for coverage of exposed bone and tendon in 15(26.8%). 03(5.45%) Pressure Sore wound healed with secondary intention. Overall success rate was 100% and no complication observed in 56 patients.

DISCUSSION

Lower limb trauma is a difficult task for reconstructive surgeon and about 15% to 55% infection rate noted in open tibial fracture.[9] Parrett *et al*., applied negative pressure wound therapy (NPWT) in 50% cases of open fracture most commonly Gustilo type 3 of lower extremities and found that it has significantly reduced the requirement of free tissue transfer (42%).[10] De Franzeo *et al*., used it for the management of lower limb wounds with exposed bone and he noted bacterial load decrease from 107 to 103 or 102/ gram within 04 to 05 days.[11] In our study, most common etiology of wound in lower limb was trauma about 55.4%.[13] patients presented with wound on lower limb with wound score 3 (exposed 02 or more structures including bone, tendon or implant) and 02 with score 4 (residual infection). After negative Pressure wound therapy, only 01 patient had score 03 and no patient had score 04. Wound covered with skin graft in 20 patients and in remaining 12 patients wound coverage provided with local flap. Besides trauma, one of common cause of amputation of lower limb is diabetic foot. Indication of negative pressure wound therapy in diabetic foot is post wound debridement or non-healing stump. Lavery *et al*., noted 15% reduction of wound surface area in first week after application of wound therapy and 60% reduction noted after 04 weeks in diabetic foot.[12] It has remarkably reduced the amputation rate (35%).[13] In our study, 02 patients with wound score 04 improved to score 03 and patients with wound score 02 improved to score 01 after negative pressure wound therapy. Most of wounds covered with skin graft (PTSG).

It has excellent outcomes on partial thickness skin graft (PTSG) in burned Patients. It helps to minimize the motion and shearing forces on graft by firmly skin graft adherence onto the wound and regular drainage of seroma or hematoma.[14] Petkar *et al*., reported partial thickness skin graft uptake was about 96.7% with negative pressure wound therapy and 87.5% with conventional dressing.[15] We applied negative pressure wound therapy after excision and grafting on 09 deep dermal burned patients. We noted excellent outcomes in term of graft uptake and none of them required regrafting.

Indication of negative pressure wound therapy in pressure sore is grade 03 or grade 04 wound.[1] Baheresteni *et al*., reported early application of negative pressure wound therapy in pressure sore reduced wound healing time (within 30 days) and most of wound healed with secondary intention. It was cost effective as compared to conventional dressing as in our study.[16]

Negative pressure wound therapy comprises of interface material (open cell foam or antibacterial gauze), evacuation tube, adhesive semi occlusive dressing and vacuum source. The role of interface material is to disseminate vacuum throughout the wound and helps in wound contraction and healthy granulation tissue formation by microdeformation at wound surface. Dorafshar *et al*., found no significant difference between gauze vs foam dressing in outcomes in term of healthy wound bed or wound size reduction. Gauze dressing reduces pain and also cost effective.[17] We used antibacterial gauze dressing as interface material in all patients because it is more biological and conforming dressing in complex wound geometry.

In our study, evacuation tube was connected to continuous suction at -125mmHg. Continuous suction has better outcomes noted in wound detersion phase while intermittent suction is found better option for formation of healthy granulation formation on wound bed.[18] Desai *et al*., described that -125mmHg is most appropriate suction pressure for granulation tissue formation.[19]

It helped to maintain the biochemical environment of the wound by providing a moist healing environment, removal of exudate, improve capillary microcirculation, tissue hypoxia resulting in angiogenesis over the wound bed and reduction of wound size.[1] Due to less frequent change of dressing, it reduces the bacterial colonization, requirement of analgesics which in turn reduces the burden of nursing staff.[20] Khurram *et al*., applied dressing in paediatric lower limb trauma found 26% wound size reduction rate and average number of dressing was 2.68.[21] Lee *et al*., found wound score before and after dressing for soft tissue defects in lower limb was 2.69 and 1.1.3 respectively and average wound size reduction was 24% as comparable with our study.[8]

Rentea *et al*., conducted study on 290 patients of negative pressure wound therapy in infant and children and most common location of wound was lower limb secondary to trauma. He performed delayed primary closure of wound in 35.1% and remaining wounds were covered with skin graft or flap.[22] in our study, we applied skin graft in 67.9% patients and flap coverage in 26.8% in lower limb.

Complications of negative pressure wound therapy are pain, bleeding, maceration of surrounding skin tissue necrosis and wound infection. Oreja *et al*., reported most common complication associated with negative pressure wound therapy is Periwound maceration (49%) followed by hemorrhage (14%), tissue necrosis (12%), wound infection (7%) and pain (2%).[23] Rasool *et al*., found no complication associated with dressing as in our study.[24]

Over the past 3 decades, advances in negative pressure wound therapy included modification in type of dressing (gauze vs foam), suction pressure (continues vs intermittent), instillation and suction machines (portable vs in hospital machines) has aided to improve outcomes and facilitate the patients

CONCLUSION

Negative pressure wound therapy is now an asset in reconstructive ladder for wound management. It is cost effective, adjuvant technique provides temporary substitute for wound coverage and facilities to improve wound bed and reduced duration of wound healing. It has remarkably reduced the requirement of microsurgical tissue transfer for wound reconstruction in extremities. It also reduces the hospital stay and helps in early rehabilitation of patients.

Conflict of Interest: None

Funding Source: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

AA & SHC: Data acquisition, data analysis, critical review, approval of the final version to be published.

AM & PM: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

MUQ & SF: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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