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Open Versus Closed Negative Pressure Wound Therapy For Contaminated and Dirty Surgical Wounds: A Quasi-Experimental Study

Saqib Hameed, Mubashir Hanif, Zaki Hussain Salamat, Sohail Ilyas, Omar Farooq, Shafqat Rehman*

Department of Surgery, Combined Military Hospital Quetta/National University of Medical Sciences (NUMS) Pakistan,
*Department of Paediatrics, Combined Military Hospital Quetta/National University of Medical Sciences (NUMS) Pakistan

ABSTRACT

Objectives: To determine the efficacy of open versus closed negative pressure wound therapy for contaminated and dirty surgical wounds in terms of time duration to full wound healing.
Study Design: Quasi-experimental study.
Place and Duration of Study: Department of General Surgery, Combined Military Hospital, Quetta Pakistan, from Oct 2021 to Apr 2022.
Methodology: A total of 96 patients with surgical wounds requiring repair were included for study. All patients underwent their respective surgery followed by grouping. Patients in Group-A received closed negative pressure wound therapy while those in Group-B received open negative pressure wound therapy. All patients were followed up till complete healing of the wound or till the occurrence of complications.
Results: Our study sample had a mean age of 44.16±12.66 years, with a slight female preponderance of 51(53.1%) participants. The mean total healing time for closed negative pressure wound therapy was 17.35±6.95 days, while it was 42.00±16.21 days with open negative pressure wound therapy, (p<0.001). There was no difference between the two groups with regards to the total complication rate, or the occurrence of individual complications, (p>0.05).
Conclusion: Closed negative pressure wound therapy results in faster wound healing, with a similar complication rate as open negative pressure wound therapy.

Keywords: Negative Pressure Wound Therapy, Surgical Wound, Wound Healing.

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INTRODUCTION

Surgical site infections (SSIs) represent one of the most common complications of surgery, with a pooled, cumulative incidence of 11% for all types of procedures.[1] However, the actual incidence is highly dependent on the classification of the surgical wound, which is based on its contamination grade at the time of the procedure: surgical incisions are classified as clean, clean contaminated, contaminated or dirty with a progressively increasing rate of incidence of SSI from clean to dirty wounds.[2] In fact, the incidence of SSI increases progressively as contamination increases with an incidence of 1% to 11% in clean wounds to 10% to 17%, and over 27% in contaminated and dirty wounds, respectively.[3] SSI are one of the most common causes of readmission, post procedure, which occurs in approximately 1.45% to 6.34% of all procedures.[4] In addition, and are associated with significant morbidity such as dehiscence (12.4%), septic complications (15.5%) and re-surgery (43.4%) as well as financial costs and mortality.[5,6]

Many authors advocate leaving the contaminated or dirty wound open to allow healing by secondary or tertiary intention, to allow for the infection to clear, however, these surgical wounds are a major handicap for the patient, and there is always the chance for the introduction of further infection.[7] Such wounds require a daily change of dressing, with or without packing with wet/medicated or dry gauze, requiring long-term monitoring.[8] Another alternative is the use of Open Negative Pressure Wound Therapy (open-NPWT), where a seal is created over an open wound and a vacuum created over it to draw out secretions, contaminated material and pus, which is associated with faster healing, however special expertise is required to change this dressing a few times a week.[9] Closed Negative Pressure Wound Therapy (closed-NPWT) involves closing the wound followed by the use of an external vacuum device to create negative pressure, which is purported to be associated with similar benefits as open-NPWT, without the requirement for closure of the wound at a later date, as well as simpler application to wounds, however,

Correspondence: Dr Saqib Hameed, Department of Surgery, Combined Military Hospital, Quetta Pakistan.
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experience with this method, especially with truncal wounds, is limited.[10]

This study was conducted with the aim of comparing open-NPWT to closed-NPWT, in an effort to determine which one was superior in terms of time to wound healing, particularly in contaminated or dirty wounds. In addition, we also studied the complications, if any, associated with each treatment modality.

METHODOLOGY

The quasi-experimental study was carried out from October 2021 to April 2022 at the Department of General Surgery, Combined Military Hospital, Quetta Pakistan, after IERB approval. The WHO sample size calculator was used to calculate the sample size with anticipated population mean of 14.52±1.011.

Inclusion Criteria: Patients with either gender, aged 18 years or more, with clean contaminated (Class III) or dirty (Class IV) wounds were included.

Exclusion Criteria: Patients with clean (Class-I) and clean/contaminated wounds (Class-II), those who were undergoing repeat procedures at the same surgical site, or had a secondary site of infection elsewhere in the body were excluded.

Final inclusion in the study was determined by per-operative examination of the surgical site to classify the wound in order to separate patients into groups. All patients were included after informed consent being sought prior to data collection.

All patients were operated on by a consultant surgical specialist with a minimum of five-years post-fellowship experience. Patients were divided into one of two groups based on the lottery method: Group-A underwent closed-NPWT, while Group-B received open-NPWT in the post-operative period (Figure). All patients received injection Ceftriaxone 1 g twice daily for three days after surgery. Drains were placed depending on the type of surgery, and the discretion of the surgeon.

In Group-A, patients received a closed-NPWT dressing at the time of closure of the wound, which remained in place for one week, after which it was removed and the wound left open. In Group-B patients received open-NPWT with a black sponge dressing attached to a negative pressure pump. This dressing was changed on alternate days and continued till complete wound healing occurred. Surgical site infection was defined as the development of redness, tenderness/swelling and purulent discharge from the wound. These were treated with antibiotics and/or debridement when required. All patients were followed-up till complete healing of wound occurred, or there were complications such as death.

Data was analyzed using Statistical Package for the Social Sciences version 26.0. Mean and SD was calculated for quantitative variables. Qualitative variables were recorded in terms of frequency and percentage. Chi-square test was applied to all qualitative variables, while the independent sample t-test was applied to quantitative variables for comparison between the groups. The p value of ≤0.05 was considered significant.

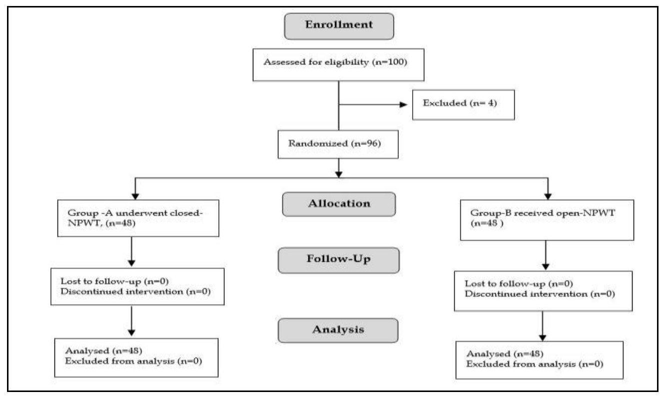

Figure: Patient Flow Diagram (n=96)

RESULTS

Our study sample was composed of 96 patients, divided into two equal groups containing 48 patients each, with a mean age of 44.16±12.66 years. Females accounted for a slight majority: 51(53.1%). Our patients had a mean body mass index of 28.30±2.52 kg/m2. A total of 63(65.6%) had some form of co-morbidity. A total of 50(52.1%) patients had wounds on the lower limbs, 27(28.1%) had wounds of the abdomen, 10(10.4%) had wounds on the upper limbs, while 6(6.2%) and 3(3.1%) had thoracic and head/neck wounds, respectively. A total of 65(67.7%) patients were classified as having contaminated wounds, while the remaining 31(32.3%) had dirty wounds. The pre-intervention characteristics of the patients are displayed in Table-I.

The mean total healing time for both groups was 29.68±17.53 days, the difference between both groups was statistically significant, (p<0.001). The total complication rate of the sample was 16.7%(n=16), while SSIs, seroma formation and wound dehiscence occurred in 7(7.3%), 4(4.2%) and 5(5.2%) cases, respectively, and there was no difference between the groups with regards to individual or total complications, (p>0.05). The post-surgical outcomes are shown in Table-II.

Table-I: Pre-Intervention Patient Characteristics (n=96)

Characteristics	Group-A (n=48) n(%)	Group-B (n=48) n(%)
Age (years) Mean±SD	42.69±12.86	45.63±12.41
Male	19(39.6%)	26(54.2%)
Female	29(60.4%)	22 (45.8%)
Body Mass Index (kg/m2) Mean±SD	28.61±2.42	27.99±2.59
Comorbid Diseases		
Diabetes Mellitus	12(25.0%)	20(41.7%)
Hypertension	18(37.5%)	21(43.8%)
Ischaemic Heart Disease	6(12.5%)	2(4.2%)
Smoking	5(10.4%)	6(12.5%)
Wound Area		
Lower Limbs	19(39.6%)	31(64.6%)
Abdomen	19(39.6%)	8(16.7%)
Upper Limbs	5(10.4%)	5(10.4%)
Thorax	3(6.3%)	3(6.3%)
Head and Neck	2(4.1%)	1(2.0%)
Wound Type		
Contaminated	34(%)	31(%)
Dirty	14(%)	17(%)

Table-II: Post-Surgical Outcomes (n=96)

Outcomes	Group-A (n=48) n(%)	Group-B (n=48) n(%)	p-value
Total Time to Healing (days) Mean±SD	17.35±6.95	42.00±16.21	<0.001
Total Complications	9(18.8%)	7(14.6%)	0.584
Surgical Site Infection	2(4.1%)	5(10.4%)	0.239
Seroma Formation	3(6.3%)	1(2.0%)	0.307
Wound Dehiscence	4(8.3%)	1(2.0%)	0.168

DISCUSSION

Since the induction of NPWT, almost twenty years ago, the management of class III and IV wounds has improved considerably.[12] Lozano *et al*. in their Randomized Controlled Trial evaluating the role of different methods of managing contaminated and dirty wounds, compared healing by primary intention with both tertiary intention and vacuum assisted secondary intention healing and demonstrated that the frequency of SSIs with the former two was 37.0% and 17.0%, will it was 0% with vacuum therapy, indicating the superiority of open-NPWT in this regard.[13] Moreover, open-NPWT was associated with a shortened time to full healing versus open healing without vacuum therapy, as demonstrated by Thomas *et al*.[14] In addition, patients treated with open-NPWT required fewer visits for change of dressing (about two to three times a week) when compared to non-vacuum assisted healing by secondary intention, where the dressing was required to be changed every day.[15] However, the application of open-NPWT and performing change-of-dressing requires a degree of technical expertise, which is not always readily available, and the equipment charges were also substantial.[16] Furthermore, open-NPWT is still based on healing by secondary intention which is a time-consuming process, which causes significant patient discomfort.[14-17]

Our study aimed to compare closed-NPWT with the open variant to determine whether this method retained the benefits of open-NPWT such as minimal side-effects with good wound healing, while also reducing the time to full healing. We studied a wide variety of different wounds, located all over the body, choosing patients who had contaminated or dirty wounds. There were no statistically significant differences between patient characteristics at baseline between the two groups. Our study showed that the time to full healing was significantly shorter with closed-NPWT versus open-NPWT: 17.35±6.95 days versus 42.00±16.21, (p<0.001). Frazee *et al*. noted a similar benefit closed-NPWT, with mean time of 14.52±13.33 days, while the open-NPWT Group had a mean time to full healing of 57.38±76.30 days.[11] To our knowledge, no other study has conducted a comparison of these treatment modalities with regards to time to healing. O'Leary *et al*. compared closed-NPWT to conventional therapy in abdominal wounds and found that the length of hospital stay was significantly reduced with closed-NPWT: with a median of 6.1 days versus 14.7 days with conventional therapy, (p=0.019).[18]

Our study showed that the frequencies of complications, specifically SSIs, wound dehiscence and seroma formation were similar in closed versus open NPWT. This was similar to Frazee *et al*. who also noted no difference between the two groups.[11] O'Leary *et al*. noted that closed-NPWT resulted in significant reduction in SSIs, which occurred in 8.3% patients, versus 32.0% with conventional sterile dressing therapy, (p=0.043).[18] An international study also noted that there was a reduction in the incidence of SSIs with closed-NPWT as compared to conventional sterile dressing therapy, and noted that the rate of readmission in these patients was also reduced, which was also the conclusion in one meta-analysis.[19,20] Ingargiola *et al*. in their systematic review comparing open-NPWT with sterile dressings noted that while SSI was significantly decreased with negative pressure dressing, the benefit in terms of wound dehiscence were less convincing, while benefits in-terms of seroma or haematoma formation were unclear.[21] Conversely, Shen *et al*. noted that there were no significant statistical difference between closed-NPWT and standard sterile dressing in-terms of the occurrence of superficial or deep SSIs.[22] We believe the difference in results is attributable to the duration for which NPWT was applied, as well as the manner in which wounds were classified as high-risk for infection, with some studies classifying wounds as high-risk based on the presence of comorbidities and immunodeficiency states.

We found that closed-NPWT is a useful dressing modality which is associated with a significantly shortened time to wound healing, with comparable outcomes to open-NPWT, and may be a useful alternative to open-NPWT and standard sterile dressings for large, open wounds in terms of complications as well. Further multi-center research, with larger sample sizes, is required before the results of this study can be generalized to the rest of the population.

LIMITATIONS OF STUDY

Our study incorporated wounds on all parts of the body, and while this gave us diversity in our sample, we were unable to establish whether the location of the wound had an effect on our outcomes. Moreover, it was difficult to perform any sort of blinding in our study as the patients' treatment group could be clearly discerned on visual examination.

CONCLUSION

Closed negative pressure wound therapy results in faster wound healing, with a similar complication rate as open negative pressure wound therapy.

Conflict of Interest: None.

Authors Contribution

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

SH, MH: Conception, study design, drafting the manuscript, approval of the final version to be published.

ZHS, SI: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

OF, SR: 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.

REFERENCES

1 Gillespie B, Harbeck E, Rattray M, Liang R, Walker R, Latimer S, et al. Worldwide incidence of surgical site infections in general surgical patients: A systematic review and meta-analysis of 488,594 patients. Int J Surg 2021; 95: 106136. https://doi.org/10.1016/j.ijsu.2021.106136

2 Onyekwelu I, Yakkanti R, Protzer L, Pinkston CM, Tucker C, Seligson D. Surgical Wound Classification and Surgical Site Infections in the Orthopaedic Patient. J Am Acad Orthop Surg Glob Res Rev 2017; 1(3): e022. https://doi.org/10.5435/JAAOSGlobal-D-17-00022

3 Ortega G, Rhee DS, Papandria DJ, Yang J, Ibrahim AM, Shore AD, et al. An evaluation of surgical site infections by wound classification system using the ACS-NSQIP. J Surg Res 2012; 174(1): 33-38. https://doi.org/10.1016/j.jss.2011.05.056

4 Shah R, Pavey E, Ju M, Merkow R, Rajaram R, Wandling MW, et al. Evaluation of readmissions due to surgical site infections: A potential target for quality improvement. Am J Surg 2017; 214(5): 773-779. https://doi.org/10.1016/j.amjsurg.2017.04.011

5 Sherrod BA, Rocque BG. Morbidity associated with 30-day surgical site infection following nonshunt pediatric neurosurgery. J Neurosurg Pediatr 2017; 19(4): 421-427. https://doi.org/10.3171/2016.11.PEDS16455

6 Koek M, van der Kooi TII, Stigter F, de Boer P, de Gier B, Hopmans T, et al. Burden of SSI Study Group. Burden of surgical site infections in the Netherlands: cost analyses and disability-adjusted life years. J Hosp Infect 2019; 103(3): 293-302. https://doi.org/10.1016/j.jhin.2019.07.010

7 Schimmel J, Belcher M, Vieira C, Lawrence N, Decker A. Incidence of Surgical Site Infections in Second Intention Healing After Dermatologic Surgery. Dermatol Surg 2020; 46(12): 1492-1497. https://doi.org/10.1097/DSS.0000000000002409

8 Britto EJ, Nezwek TA, Robins M. Wound Dressings. StatPearls Publishing; 2022.

9 Zaver V, Kankanalu P. Negative Pressure Wound Therapy. StatPearls Publishing; 2022.

10 Stannard JP, Gabriel A, Lehner B. Use of negative pressure wound therapy over clean, closed surgical incisions. Int Wound J;9 Suppl 1(Suppl 1): 32-39. https://doi.org/10.1111/j.1742-481X.2012.01017.x

11 Frazee R, Manning A, Abernathy S, Isbell C, Isbell T, Kurek S, et al. Open vs Closed Negative Pressure Wound Therapy for Contaminated and Dirty Surgical Wounds: A Prospective Randomized Comparison. J Am Coll Surg 2018; 226(4): 507-512. https://doi.org/10.1016/j.jamcollsurg.2017.12.008

12 Miller C. The History of Negative Pressure Wound Therapy (NPWT): From "Lip Service" to the Modern Vacuum System. J Am Coll Clin Wound Spec 2013; 4(3): 61-62. https://doi.org/10.1016/j.jccw.2013.11.002

13 Lozano G, Ruiz A, Díaz JA, Gómez JA, Flores E. Surgical Site Infection Rate Drops to 0% Using a Vacuum-Assisted Closure in Contaminated/Dirty Infected Laparotomy Wounds. Am Surg 2017; 83(5): 512-514. https://doi.org/10.1177/000313481708300528

14 Thomas M, Makey I, Buchanan M, Heckman M, White L, Lechtenberg B, et al. A Comparison of Negative Pressure and Conventional Therapy in Infected Open Chest Wounds. Surg Infect 2021; 22(9): 955-961. https://doi.org/10.1089/sur.2020.397

15 Sood A, Granick M, Tomaselli N. Wound Dressings and Comparative Effectiveness Data. Adv Wound Care 2014; 3(8): 511-529. https://doi.org/10.1089/wound.2012.0401

16 Hasan MY, Teo R, Nather A. Negative-pressure wound therapy for management of diabetic foot wounds: a review of the mechanism of action, clinical applications, and recent developments. Diabetes Foot Ankle 2015; 6: 27618. https://doi.org/10.3402/dfa.v6.27618

17 Iheozor Z, Newton K, Dumville JC, Costa ML, Norman G, Bruce J. Negative pressure wound therapy for open traumatic wounds. Cochrane Database Syst Rev 2018; 7(7): CD012522. https://doi.org/10.1002/14651858.CD012522.pub2

18 O'Leary D, Peirce C, Anglim B, Burton M, Concannon E, Carter M, et al. Prophylactic Negative Pressure Dressing Use in Closed Laparotomy Wounds Following Abdominal Operations: A Randomized, Controlled, Open-label Trial: The P.I.C.O. Trial. Ann Surg 2017; 265(6): 1082-1086. https://doi.org/10.1097/SLA.0000000000002098

19 Schurtz E, Differding J, Jacobson E, Maki C, Ahmeti M. Evaluation of negative pressure wound therapy to closed laparotomy incisions in acute care surgery. Am J Surg 2018; 215(1): 113-115. https://doi.org/10.1016/j.amjsurg.2017.08.009

20 Sahebally S, McKevitt K, Stephens I, Fitzpatrick F, Deasy J, Burke JP, et al. Negative Pressure Wound Therapy for Closed Laparotomy Incisions in General and Colorectal Surgery: A Systematic Review and Meta-analysis. JAMA Surg 2018; 153(11): e183467. https://doi.org/10.1001/jamasurg.2018.3467

21 Ingargiola MJ, Daniali LN, Lee ES. Does the application of incisional negative pressure therapy to high-risk wounds prevent surgical site complications? A systematic review. Eplasty 2013; 13: e49.

22 Shen P, Blackham A, Lewis S, Clark C, Howerton R, Mogal H, et al. Phase II Randomized Trial of Negative-Pressure Wound Therapy to Decrease Surgical Site Infection in Patients Undergoing Laparotomy for Gastrointestinal, Pancreatic, and Peritoneal Surface Malignancies. J Am Coll Surg 2017; 224(4): 726-737. https://doi.org/10.1016/j.jamcollsurg.2016.12.028

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