Management of Skin Grafts Using Negative Pressure Therapy: The Effect of Varied Pressure on Skin Graft Incorporation

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Abstract: Introduction. Optimal pressure settings have been suggested in the use of negative pressure wound therapy (NPWT) in wound dressings. When used as a bolster for skin grafting, an NPWT setting of 125 mm Hg was initially suggested, but not validated through studies. The objective of this study is to report findings on the effect of varied pressure settings on the incorporation of split thickness skin grafts when using an NPWT bolster. Methods. From 2007 to 2010, 48 inpatients underwent split thickness skin grafting using a negative pressure system as a bolster under the care of 2 surgeons at 2 academic institutions. Twenty-two patients were evaluated retrospectively who were treated using NPWT bolsters at 75 mm Hg and 125 mm Hg based on the surgeon’s discretion. Twenty-six patients were evaluated prospectively and were randomized to 50 mm Hg, 75 mm Hg, 100 mm Hg, and 125 mm Hg pressure settings. Graft incorporation was assessed at time of bolster removal, 2 weeks, and 4 weeks, per standard protocol. Results. At each assessment point, incorporation of each skin graft was > 95% in all study subjects, at all pressure settings. Conclusion. Whereas initially postulated to be 125 mm Hg, ideal pressure settings for NPWT, when used as a bolster for split thickness skin grafts, may be lower. This study suggests that pressures as low as 50 mm Hg can be tolerated without compromise of skin graft incorporation. Study findings were presented at the Plastic Surgery Research Council Meeting in San Francisco, CA in April of 2010.
sters will achieve optimal incorporation at pressures lower than the standard pressure of 125 mm Hg commonly used in open wounds.

Materials and Methods

All patients undergoing STSG who were treated by the 2 senior authors, Wirth and Evans, between 2007 and 2010, were considered for this study. Outpatients, patients for whom NPWT was contraindicated, and patients who declined participation were excluded. All pathologies and wound locations were included. Institutional Review Board approval was obtained at each participating institution (University of California at Irvine and Long Beach Memorial) prior to initiating the study. All prospective patients signed informed consent prior to participation.

Patients undergoing STSG with NPWT bolster prior to December 2008 were assessed by retrospective chart review. Patients after December 2008 were assessed prospectively and randomized to 4 treatment arms: 50 mm Hg, 75 mm Hg, 100 mm Hg, and 125 mm Hg. Randomization was determined by computer algorithm prior to patient enrollment. Thickness of STSG, method of fixation, and decision for meshing or “piecrusting” were left to the surgeon’s discretion.

A negative pressure wound therapy bolster using a vacuum-assisted closure device (V.A.C., Kinetic Concepts, Inc, San Antonio, TX) was used in all patients. The bolster was applied with a single layer petrolatum gauze interface between the STSG and the NPWT dressing. Length of time with NPWT dressing was left to the surgeons’ discretion, but was primarily based on maximum reduction of fluid exudate. Epithelialization was visually estimated as a percent of incorporation by attending surgeons and resident surgeons at time of bolster removal, at 2 weeks, and at 4 weeks. Pictures were taken at each visit and findings were recorded.

Results

Forty-eight patients, 32 males and 16 females, were included in the study. Average age was 49 (range 13-89). The retrospective pool contained 22 patients, with 3 patients in the 75 mm Hg group and 19 patients in the 125 mm Hg group. The prospective pool contained 26 patients, with 2, 8, 4, and 12 patients in 50 mm Hg, 75 mm Hg, 100 mm Hg, and 125 mm Hg groups, respectively. Given similar demographic and wound profiles, retrospective and prospective data were pooled for assessment. Statistical significance was not calculated due to the small study population.

Across all patients, average number of comorbidities was 1 (range 0-5). Average wound size was 151 cm² (range 28 cm² - 561 cm²). Most common pathologies were trauma, 44%; oncology, 23%; and infection, 12.5%. The negative pressure wound therapy bolster was kept in place for an average of 5 days (range 3 days - 8 days). Estimation of skin graft incorporation was > 95% in all patients and at
all time points. Across all patients, average wound size was 70 cm², 171 cm², 125 cm², and 167 cm², in the 50 mm Hg, 75 mm Hg, 100 mm Hg, and 125 mm Hg groups, respectively. The distribution of patients and wound size across these pressure settings is summarized in Figure 1 and Figure 2. A summary of demographic data and comorbidities associated with these groups is shown in Table 1.

No significant complications were encountered in the study. One patient was treated with 3 skin grafts at nearby sites on the lower extremity after the patient suffered compartment syndrome on the right lower extremity. In this patient, each surgery was > 1 year apart and due to new open wounds related to comorbidities of diabetes, peripheral vascular disease, and collagen disorder. This patient had a pressure setting of 125 mm Hg on his NPWT bolster.

A second patient showed evidence of hypertrophic

| Table 1. Summary of demographic data and comorbidities in various pressure groups. |
|---------------------------------|---------|---------|---------|---------|
| 50 mm Hg | 75 mm Hg | 100 mm Hg | 125 mm Hg |
| Number of patients | 2 | 11 | 4 | 31 |
| Average age | 71 | 53 | 53 | 46 |
| Percentage female | 50% | 36% | 0% | 35% |
| Average wound size | 70 | 171 | 125 | 167 |
| Percentage smokers | 0% | 18% | 25% | 13% |
| Percentage diabetes mellitus | 0% | 9% | 0% | 6% |
| Percentage myocardial infarction, cerebrovascular accident or stroke, or peripheral vascular disease | 100% | 0% | 0% | 10% |
| Percentage take at 0 weeks | 98% | 98% | 98% | 95% |
| Percentage take at 2 weeks | 98% | 98% | 100% | 95% |
| Percentage take at 6 weeks | 100% | 100% | 100% | 98% |

Figure 3. Hypertrophic scarring in a postradiation wound after skin grafting with negative pressure bolster dressing at 50 mm Hg.

Figure 4. Postoperative results of skin grafting with negative pressure bolster at 50 mm Hg on postoperative day 5, at time of bolster removal.
scarring at the STSG site after treatment with NPWT at 50 mm Hg. This was thought to be related to prior radiation therapy to the wound bed. Figure 3 shows the results on skin grafting in this patient. Figure 4, Figure 5, and Figure 6 show results of other patients at the various pressure settings.

**Discussion**

Negative pressure wound therapy is an established option in the bolstering of STSG. It seems to offer particular benefits in large and irregularly contoured wounds. In their clinical practice, senior authors Wirth and Evans have found that pressure settings of 125 mm Hg are not necessary to achieve good skin graft epithelialization. This observation prompted review and further study of data, the findings of which suggest that pressure settings as low as 50 mm Hg can be used without compromise to STSG incorporation.

Lower pressure settings may create potential benefits to patients and providers. The authors have noticed less pain and less secondary skin reaction at the STSG cutaneous borders when lower pressure is used. Surgical concerns of venous occlusion and nerve compression, particularly in the pediatric population, may be obviated. These findings follow the physiologic rationale that any pressure above normal capillary pressure, approximately 25 mm Hg, should improve angiogenesis and epithelialization.

**KEYPOINTS**
- Across all patients, average number of comorbidities was 1 (range 0-5). Average wound size was 151 cm² (range 28 cm² - 561 cm²).
- Most common pathologies were trauma, 44%; oncology, 23%; and infection, 12.5%. The negative pressure wound therapy bolster was kept in place for an average of 5 days (range 3 days - 8 days).
- Estimation of skin graft incorporation was > 95% in all patients and at all time points.
- No significant complications were encountered in the study.
Limitations
This study is limited in its population size and subjective measurements. The 50 mm Hg group, for instance, had only 2 patients and wound sizes were smaller than in other groups. These factors make it difficult to exclude other reasons for successful take of the skin graft. Measuring endpoints by visual estimation also creates some inaccuracy in this study's results. Further analysis with computer-based estimation, or histologic analysis, may help to validate results. Finally, the benefit of NPWT at lower pressure settings and in smaller wounds is not clearly superior to that of a traditional bolster, and may represent a higher cost that is not clearly beneficial to patients. Further study in larger patient populations with larger wound sizes will be necessary.

Conclusions
Negative pressure wound therapy offers established benefits to STSG epithelialization. The findings in this study suggest that pressure settings as low as 50 mm Hg may be tolerated without compromise to epithelialization. Given there are few patients and data points at this time, the observations outlined serve as a proof of concept rather than concrete clinical evidence. Further studies, in larger study populations, larger wounds, wider spectra of pressure settings, and with more objective microscopic and macroscopic measurement tools, are needed for better understanding of the effect of pressure on epithelialization.

Keypoints
• In their clinical practice, senior authors Wirth and Evans have found that pressure settings of 125 mm Hg are not necessary to achieve good skin graft epithelialization. This observation prompted review and further study of data, the findings of which suggest that pressure settings as low as 50 mm Hg can be used without compromise to split thickness skin graft incorporation.

Reference