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Original Article

The Effectiveness of Vacuum Assisted Closure (VAC) for Securing of Skin Graft: A Prospective Study in a Rural Hospital

Samart Phuwapraisirisan, MD
Phukieo Hospital, Chaiyaphum, Thailand

Abstract

Objective: **To determine the effectiveness of vacuum-assisted closure (VAC) by modified simple-to-use VAC system over the skin graft.**

Materials and Methods: **A prospective study was carried out to include twenty-four consecutive patients who underwent partial thickness skin grafting for lower and upper limb, trunk, chest wall and abdominal wall defects at the surgical ward in the Phukieo Rural Hospital, Thailand, from July 2007 to January 2012. The dressing comprised cut foam sheet, a modified portable closed system-suction drain connected to naso-gastric tube and covered by an adhesive film. Graft-take rate and cost per case were evaluated.**

Result: **Graft-take was 100% in 15 of 24 patients (63%) and 9 patients (17%) had partial graft loss. No serious complications were encountered. Cost analysis demonstrated a minimum treatment cost of 2,355 baht over 5 days compared with commercial VAC dressing (20,900baht/5 days),and it was more convenient than other methods of skin graft dressing.**

Conclusions: **The use of negative pressure dressing by modified simple-to-use VAC system is an effective and safe alternative method to secure the skin graft on the wound bed for the treatment soft tissue defect.**

Keywords: **skin graft, vacuum-assisted closure, wound dressing**

Introduction

A skin grafting procedure is a method of wound coverage when the wound cannot be closed by direct suture. The optimal wound therapy after skin grafting has been extensively investigated. The tie-over bolster dressing (Figure 1) has been widely implemented, incorporating a bolster dressing made of foam and/or cotton applied over the graft, and fixed in place either by sutures or an elastic rubber bandage (or both)[1-4]. The graft is immobilized by the tie-over bolster dressing to prevent shearing in plane between graft and wound bed, which is critical for graft survival[3]. This had been a mainstay of graft dressing until it was recently replaced by the incorporation of negative pressure into graft dressing.

Application of negative pressure wound therapy (NPWT) over a split-thickness skin graft (STSG) can result in a reduced incidence of graft failure or re-graft procedures compared with standard bolster techniques[5-10]. The use of negative pressure in the dressing of skin graft has been shown to promote healing beyond that of immobilization dressing by

Correspondence address : *Samart Phuwapraisirisan, MD, Phukieo Hospital, 149 Phukieo District, Chaiyaphum 36110, Thailand; Telephone: +66 4486 1700-4; Fax: +66 4484 4742; E- mail: ph_samart@hotmail.com*

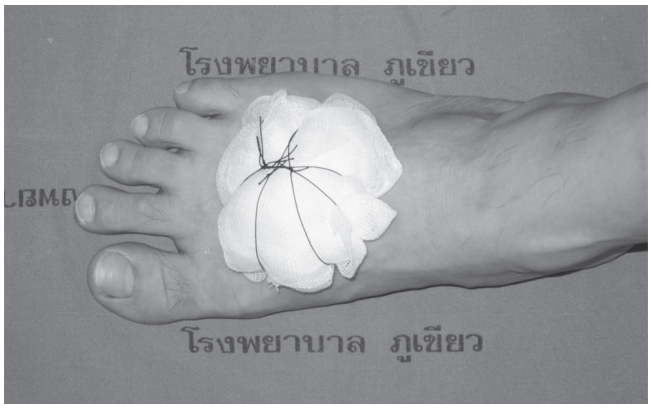

Figure 1 The tie-over bolster is a dressing made of cotton and/or applied over the graft, and fixed by sutures.

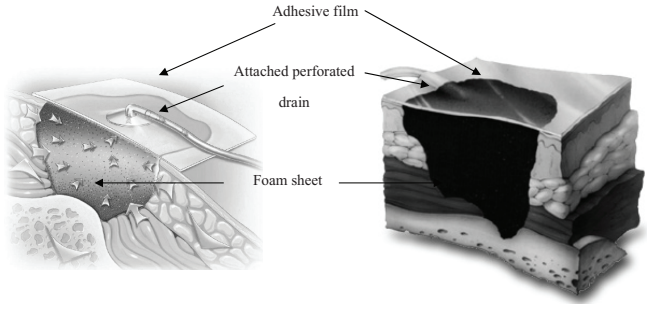

Figure 2 The vacuum-assisted closure (VAC) compose of foam sheet placed over the wound, attached perforated drain connected to the negative pressure system and adhesive film cover the foam sheet and surrounding skin to made them become closed system.

variety of mechanisms[4,10]. These included decreasing interstitial edema, increasing dermal perfusion, decreasing bacterial colonization and stabilization of the graft[11-15]. All of these mechanisms decrease the incidence of seroma and infection which are the main causes of graft failure and promote the increase in graft taking rate.

The negative pressure dressing, as the method of wound healing promotion, was firstly described by Fleischmann et al. in 1993[15,17]. This was subsequently widely used and investigated. The negative pressure system known as vacuum-assisted closure (VAC) dressing became commercially available in 1995 and was first reported in the literature by Morykwas et al. in 1997[15]. The system consisted of a foam dressing with an attached perforated drain, which connected to a vacuum unit maintaining appropriate negative pressure (Figure 2). The negative pressure system contributed

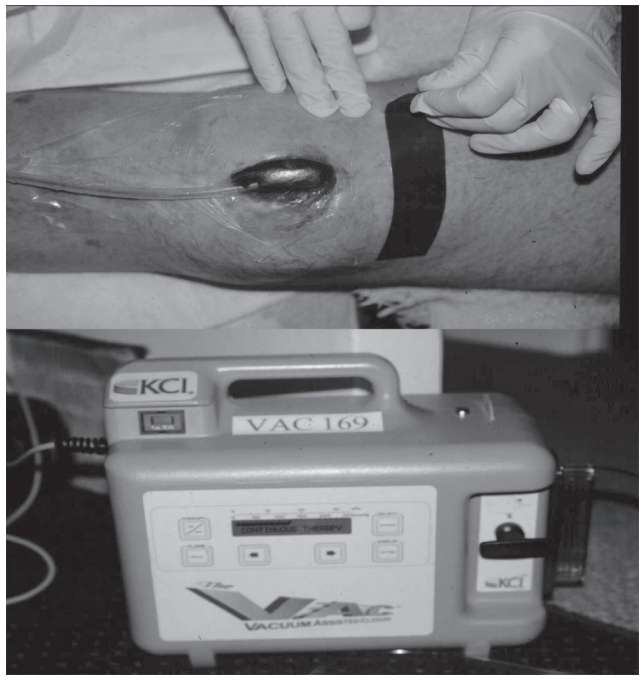

Figure 3 The commercial KCI and portable VAC.

to the good outcome initially achieved by commercial VAC[16,17] (Figure 3).

There were, however, limitations of VAC which precluded its universal adoption in the appropriate clinical settings. The prolonged hospital admission, causing decreased patient mobility during application of dressing and the cost of treatment (comprising the cost of both the dressing itself and cost relating to a prolonged hospital admission) were the most significant precluding factors. A major improvement has been the portable VAC, but the commercial portable VAC is still associated with significantly high costs. A new portable suction system, local-made using modified foam sheets and naso-gastric tubes used as the attached perforated drain in the present study, should lower the cost of treatment compared with commercial VAC.

Materials and Methods

A prospective trial was carried out on 24 consecutive patients whose age ranged from 29 to 84 years (Table1). The split thickness skin grafts were harvested using Watson's knife and Air-Dermatome (Zimmer®). Multiple holes in the graft were made by surgical blade and Mesh-graft (Zimmer®). The grafts

Table 1 Comparison between full taking and partial loss of skin graft group

	Full taking N = 15	Partial loss N = 9	Total N = 24
Age (yrs)	59.1	51	56.04
Sex			
M (%)	9 (60)	4 (44)	13 (54)
F (%)	6 (40)	5 (56)	11 (46)
Co-morbid disease			
DM, HT (%)	4 (27)	1 (11)	5 (21)
DM, HT, CKD (%)	3 (20)	2 (22)	5 (21)
DM, HT, CKD, CA breast (%)	-	1 (11)	1 (4)
DM, CKD, Cirrhosis (%)	1 (7)	-`	1 (4)
HT (%)	1 (7)	-	1 (4)
HT, CKD (%)	1 (7)	-	1 (4)
HT, CHF (%)	-	1 (11)	1 (4)
Adrenal insufficiency (%)	1 (7)	-	1 (4)
Leprosy (%)	-	1 (11)	1 (4)
Multiple trauma &burn (%)	1 (7)	1 (11)	2 (8)
Nil (%)	3 (20)	2 (22)	5 (21)
Site of wound			
Extremities (%)	14 (93)	7 (78)	21 (88)
Chest wall &Trunk (%)	1 (7)	2 (22)	3 (12)
Average area of defect (cm^2)	118.07	100.4	110.71
Complication			
Nil (%)	15	7	22 (92)
Seroma (%)	0	2	2 (8)
Graft taking rate (%)	100	87	95

were transplanted on the recipient sites and fixed by absorbable sutures. A sterilized sponge, and local-made foam which was approved by Nation Metal and Materials Technology Center (MTEC) for its physical and chemical properties that were substantially equivalent to the original KCI foam, was cut slightly larger than the graft size to fit the appropriate contour of the wound defect[18]. The naso-gastric tube was inserted through the foam. A thin porous barrier, non-adherent dressing layer, such as Bactigras^R or Sofra-tulle^R was placed between the graft and the sponge to prevent adherence between the graft and the foam. It also prevented the peeling off of the graft when removing the VAC. The adhesive film was applied to cover the whole sponge and intact skin surrounding the graft. The outside end of the naso-gastric tube was connected to a portable suction system that provided appropriate continuous negative pressure (at 100 to 125 mmHg) causing the sponge to completely collapse in the closed environment. Additional adhesive film might be necessary to cover the leaked area if the sponge would not collapse. This would make the dressing airtight and create the vacuum effect. The sponge would contour the graft to the wound bed, thus completing the contact between the graft and the recipient bed. Any fluid collection either beneath or over the graft wound be sucked out to the reservoir of the suction-drainage system. The VAC dressing also helped to immobilize the graft on the wound bed.

The VAC dressing was applied to the graft for a period of four to seven days, without using additional materials to immobilize the joint area as was usually done in a traditional skin grafting procedure[19]. The graft survival area and total graft area were measured and calculated as percent graft-take. After the VAC was removed from the graft (usually five days after the application), a simple dry dressing was applied and the wound was examined every two to three weeks until the wound was completely healed, usually within four to six weeks after grafting (Figure 4).

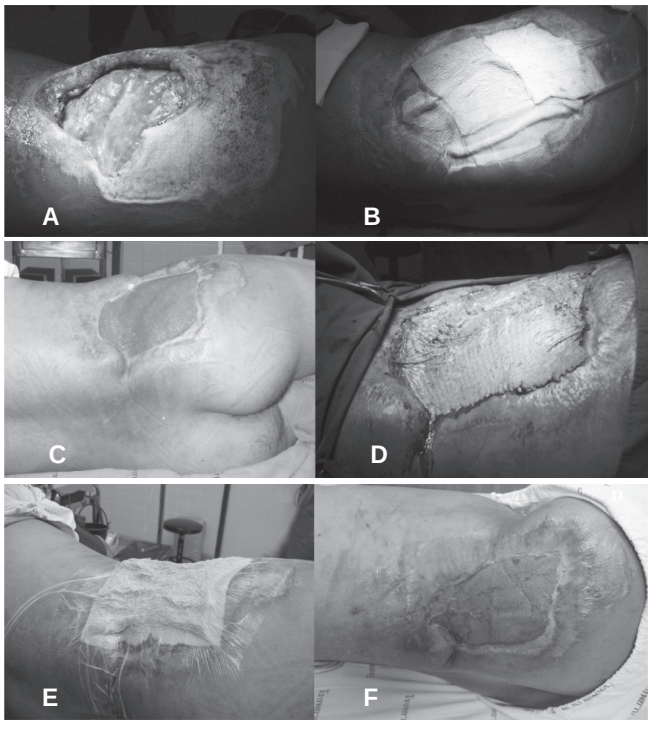

Figure 4 Example of a patient who was treated by modified simple-use VAC system.
A. The wound before treatment; B. Wound bed preparation by VAC; C. Healthy wound bed ready for D. STSG procedure, the graft fixed STSG by absorbable sutures; E. VAC application for secure; F. Complete graft taking STSG

Figure 5 Wall suction negative pressure system made the patient immobilized compared with modified portable VAC which patient can move out from bed.

Figure 6 The modified portable VAC made the patient comfort from out bed activities.

Table 2 Cost analysis for modified VAC compared with commercial VAC

Dressing	Maximum total cost (baht)	Minimum total cost (baht)	Cost per dressing (baht)	5 day cost (baht)
Modified VAC	439,004	13,126	471	2,355
KCI foam VAC	No available data	No available data	4,180	20,900

Results

During the nearly five-year period of the study, this method was used to secure the graft in 24 patients. More than half were male (54%), and the average age was 56 years. Eighty percent of patients have co-morbid diseases, including hypertension (58%) and diabetes (50%). The graft sites included 21 (88%) in the extremities and 3 in the trunk and chest wall (12%). There were 21 chronic wounds and 3 acute wounds (2 were burn wounds). The sizes of the wounds measured between 50 cm^2 to 330 cm^2 (average 110.71 cm^2). Sixty to 100% of the grafted areas survived in all wounds in the first week after graft taking and nearly all wounds completely healed within six weeks. The average graft taking rate in this study was 95.2% which was comparable to 96.7% in a previous study in burn patients[20].

Seroma occurred in two patients due to inadequate negative pressure dressing from leakage of the system during the first two to three days. Patients in both full-take and partial loss groups had comparable demographic data, similar graft sites, co-morbid diseases and area of defect. The graft taking rates of the two groups were not statistically different (100% vs. 87%). The cost of using the local-made, modified portable VAC compared with the commercial VAC was

significantly less (2,355 baht over five days for modified portable VAC compared with 20,900 baht over five days for commercial VAC) (Table 2).

Discussion

Skin graft take and healing consist of four phases: adherence, plasma imbibition, revascularization and remodeling. A critical factor causing graft loss is the shearing force in plane between the graft and wound bed. The aim of a skin graft site dressing is to splint and hold the graft in place such that adherence and imbibition occur, and that both shearing and hematoma are prevented. The graft will usually be glued or sutured to the wound edges. A "bolster" or "tie-over" dressing usually is often applied. More recent reports use topical negative pressure therapy device to provide sub-atmospheric pressure over large areas of the wound. Several comparative studies have demonstrated high graft taking rate of VAC securing graft compared to standard tie-over bolster dressing [4,6-8]. The present study also showed the effectiveness of VAC securing skin graft for various graft sites and wound types, but did not directly compare with tie-over dressing.

The main result of the present study is the high average graft taking rate of 95.2% which was comparable to a previous study[20]. Patients with complete graft-take and those with partial loss were similar in terms of demographics and co-morbidities. Most of patients (79%) have at least one co-morbid disease. Although hypertension and DM can affect both macro- and micro-circulation which may result in poor graft taking, and a negative correlation of graft success in patients suffering from diabetes mellitus or dermato-liposclerosis was described in one study[23], a high graft taking rate was achieved in the present study.

Some non-comparative case series have also reported better than expected outcomes in patients exhibiting certain co-morbidities, for example arterial disease, when treated with NPWT[21]. One hypothesis suggests that placement of NPWT as the post-graft bolster improves the distal circulation of the involved extremity compared with conventional splinting/bolstering[21,22]. This remains to be rigorously evaluated but is an interesting hypothesis. However, two patients in the present study had partial loss of the graft due to the development of a seroma after loss of negative pressure.

The second result of the present study was the much lower cost of the local-made, modified VAC system. To avoid the costs of the expensive commercially-available technology, one study used locally-developed wall-suction unit systems on split thickness skin grafts as well as a homemade negative pressure suction system. This trial was methodologically of high quality, and the new intervention proved to be effective, and the costs of the new technology were very low[4]. In other study, which also used a homemade NPWT system but with serious methodological problems, a positive effect of the NPWT system on wound healing was seen as well[24].

The NPWT provides a more stable bolstering of the wound compared to the standard tie-over type dressings, and the graft site can tolerate more movement from the patient without compromising graft outcomes. The use of NPWT to allow earlier patient mobilization, possibly leading to earlier hospital discharge of patients undergoing STSG, also results in significant cost savings. The present study is only one of several clinical trials with a small number of skin graft patients successfully managed by low-cost, modified simple-to-use VAC system, which can readily be used in small rural hospitals. In all of these studies, NPWT was compared with conventional tie-over bolster dressings. It is possible that the use of alternative advanced fixation techniques may also yield better results than conventional bolster methods and could perform equally well as NPWT. In the absence of studies comparing other advanced fixation techniques with conventional bolster and/or NPWT it is not possible to state that NPWT is the only graft fixation method that encourages optimal graft take[25]. Well-designed RCTs comparing other advanced fixation techniques, conventional tie-over methods, and NPWT are required to definitively settle the question of the best graft securing method.

Conclusion

The benefits of negative pressure dressing or VAC for skin graft dressing include an improved graft take due to the removal of fluid collection beneath the graft and the decreased or absence of the shearing forces. The VAC has become popular, but is associated with high costs if commercial VAC is used. In this study a modified VAC, local-made from simple materials with a portable suction drain system that is generally

available in hospitals, were implemented as an alternative method. The modified VAC can save costs, and seems to be as effective as the commercially available VAC.

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