Modified Negative Pressure Wound Therapy (NPWT): An Experience of 106 cases at Philippine General Hospital

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ABSTRACT

We studied 106 cases of Negative Pressure Wound Therapy (NPWT) or Vacuum Assisted Closure (VAC) from 2000-2004 on open wounds. Our modification using packing foam, infant feeding tube, wall suction set at 60-70 mmHg and Glad® or Saran® wrap showed similar good results.

Key Words: Negative Pressure Wound Therapy (NPWT) / Vacuum Assisted Closure (VAC) / Open Wounds

Background

Back in 2000, a technique popularized by Wake Forest group North California, utilizing vacuum to hasten wound healing was introduced in UP-PGH (University of Philippines, Philippines General Hospital). Patented as Vacuum Assisted Closure (VAC), also known as Negative Pressure Wound Therapy (NPWT), it was marketed by Kinetic Concepts Inc. (San Antonio Texas). It has a portable suction machine costing PhP 15,000 and disposable tubing and foam amounting to PhP 5,000 per VAC change. So, depending on length of time used and number of dressing change required the total cost may be from 20,000 to 30,000 pesos per patient. Its main attraction was its portability and comfort to the patient as this machine was quiet and could be operated from any readily available wall socket. Since cost was an issue to our generally poor population and infection control locally a big factor in healing, we decided to collect cases from trauma admissions, formulating a protocol for which all large wounds and open fractures with or without an external fixator or not would be included in this study. We also had referrals with large wounds neglected from the start as well as large decubitus ulcers from prolonged recumbency secondary to spinal cord injuries and a few cases of fasciotomies to which we applied the VAC. We modified the portable suction machine using our in-hospital bedside suction, hospital wall suction or Gomco® suction machine. Our disposables were made up of Ioban® (iodine laced barrier drapes) or Saran® wrap, regular packing foam and nasogastric or infant feeding tube gauge 18-25. Saran® wrap and foam were gas sterilized in the hospital. The total cost of our modified VAC system ranged from PhP 500-1,000 per patient, which was much too cheap as compared to the original VAC system.

This report is an accumulation of our NPWT or VAC experience from 2000-2004. Only those patients with complete data in our charts could be included.

Description of technique / modification

All VAC were applied and changed in a sterile condition in an operating room. The patient is brought to the operating room for debridement of the wound and the affected limb is prepped and draped. A thorough debridement of all devitalized tissues is done. A complete excisional debridement is performed using knife, scissor followed by copious wash. Intraoperative cultures are obtained during the debridement. The wound is now prepared for the application of our modified VAC.

Pre-sterilized foam is taken and shaped according to the wound to be closed. A tunnel is made at the centre of the foam using a metz scissor. An infant feeding tube or a nasogastric tube is taken and additional holes made by cutting the round tip and along the length of the tube inside the foam. The tube is then embedded inside the foam tunnel (Figure 1). Sometimes over a graft, a vaselinized gauze is applied

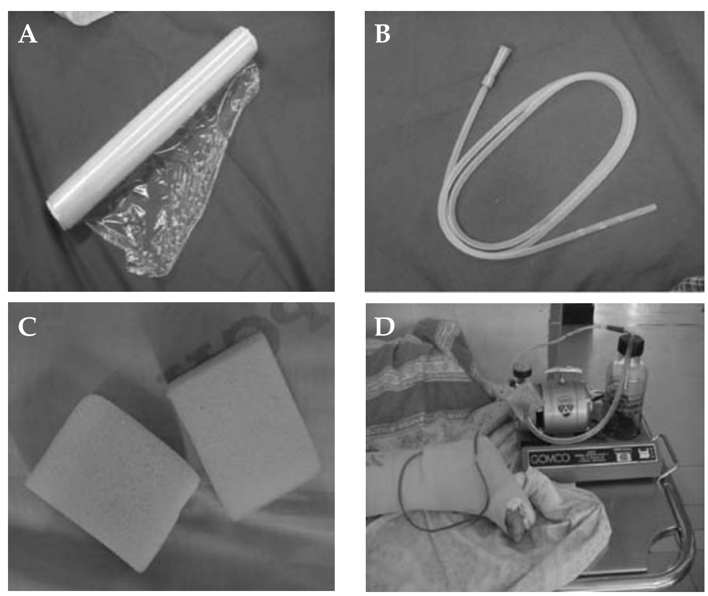

Figure 1. Our components used in VAC. (A) Saran® wrap, (B) Nasogastric or infant feeding tube gauge 18-25, (C) extra holes are made as needed in the foam, a tunnel is created at its centre and (D) Gomco® suction machine, portable and creates 60-70 mmHg of negative pressure

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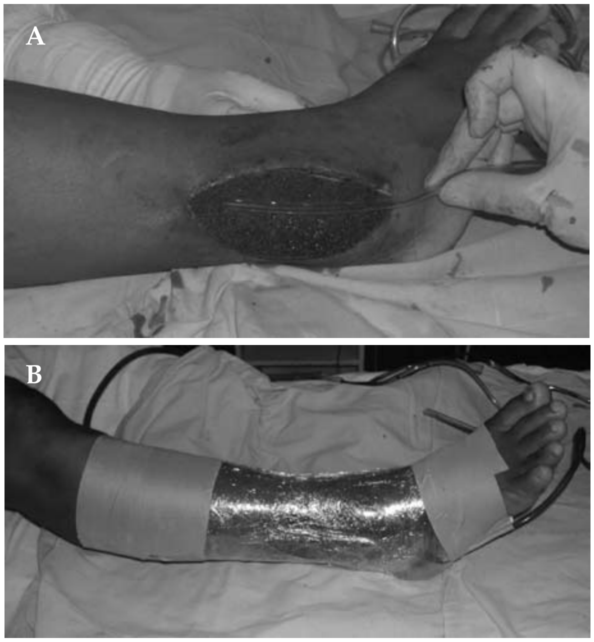

Figure 2. (A) Foam is cut with a metz scissor in the shape of the wound. A Nasogastric tube or an infant feeding tube is placed in a tunnel of the foam. (B)It is then wrapped by Saran® wraps. The edges are obliterated by using Leukoplast® plaster tapes thus making it a sealed dressing

Figure 3. Applying VAC around an external fixator requires an extra effort. The Saran® wrap are slit cut around the pins. Leukoplast® plaster tapes has to be properly applied around the pins so as to make it a sealed dressing.

on the wound and the foam is placed on this wet gauze to decrease chance of adhesions. A pre-sterilized Saran® wrap or Glad® wrap (Ioban®, Steridrap® or any brand of barrier drape) is wrapped around the area. The ends of this seal are then obliterated by applying Leukoplast® plaster tapes thus making it an air tight seal. (Figure 2) The tube is now connected to the suction to check if the foam collapses, if not then we look for any unsealed area then seal it with more plaster tapes. In cases of external fixators, slit cuts on the Saran® wraps are made to seal pin sites, and tapes around the pin sites seals the area adequately (Figure.3). Around five layers of Saran® wrapping is usually adequate to seal the system.

Once in the recovery room negative pressure is applied. Suction machine is set to 60 to 70 mmHg of atmospheric pressure turned on for 30 to 60 minutes and then turned off for the next 30 to 60 minutes creating an intermittent suction as this was found to be better than continuous suction.[12] Dressing change is done in operating room every third to fifth day as there are often delays in our institution in bringing our patients for repeat debridement to the operating room. Once a clean wound bed is obtained, the wound is covered definitively with a split-thickness skin graft or flap as in sacral decubitus ulcers. (Figure 4)

Results

From 2000-2004, we had 106 patients who underwent the VAC procedure. There were 89 males and 17 females. There were 12 pediatric patients (up to 18 years) (11.3%), 90 adults less than 65 years (85%) and four adults more than 65 years (3.7%). The upper extremity alone was involved in 18%, lower extremity alone in 72.6%, combined extremity in 5.7% and back in 3.7%. (Table 1)

Table 1. Demographic, Injury, and Treatment Data of 106 Patients treated with VAC

Age, years	Pediatric	12 (11.3%)
	Working age 18-65	90 (85%)
	Adult beyond 65	4 (3.7%)
Gender	Male	89 (84%)
	Female	17 (16%)
Types of wound	Trauma	82 (77.4%)
	Diabetic wounds/ulcers	14 (13.2%)
	Peri-operative infection	5 (4.7%)
	Decubitus ulcers	3 (2.8%)
	Fasciotomy wounds	2 (1.9%)
Involvement of area	Upper extremity	19 (18%)
	Lower extremity	77 (72.6%)
	Combined	6 (5.7%)
	Back	4 (3.7%)
Mechanism of injury	Motorcycle accidents	19 (18%)
	Auto pedestrian accidents	19 (18%)
	Vehicular crash	21 (19.8%)
	Others (falls, labor accidents,	47 (44.2%)
	mauling, gunshot wounds)	32 (30.2%)
Size of wound	<6cm	74 (69.8%)
	>6 cm	61 (57.5%)
Number of VAC change	1-3 changes	39 (36.8%)
	4-6 changes	6 (5.7%)
	7-9 changes	66 (62.3%)
Time to consult since injury	<12 hours	28 (26.4%)
	12-24 hours	12 (11.3%)
	>24hours (1-13 days)	

The majority of our cases were from open fractures. Eighty-two cases of large soft tissue wounds with or without external fixator including two cases of fasciotomies for compartment syndrome were included. Five cases of perioperative trauma infections (qualified as infections as problem within 30 days of operation), 14 cases of diabetic wounds were also included. Three decubitus ulcers with large sacral lesions were also treated with VAC, prior

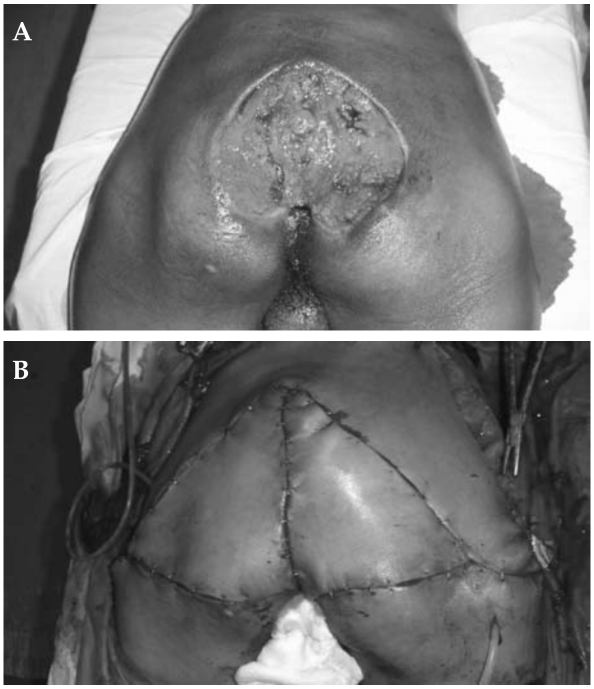

Figure 4. (A) Decubitus ulcer in a 78 year old man. Good granulation tissue bed was achieved after 3 VAC changes. (B) The soft tissue defect was covered using bilateral V-Y Gluteal advancement flaps.

to swinging a V-Y gluteal advancement flap, as a way to control infection and stimulate graft bed. (Figure 4)

Since infection management was also a purpose of this study, we looked at initial organisms cultured and interestingly found *Staphylococcus aureus* only three times. The rest being various gram negative organisms such as *Enterobacter*, *Enterococcus*, *Klebsiella*, *Proteus*, *E. coli*, *Hafnia* and *Pseudomonas*. Subsequent culture from repeat debridement yielded only *Staphylococcus aureus* two times, the rest being gram negative organisms, again mostly *E. coli*, *Enterobacter* and *Pseudomonas*, indicating microbacterial flora in our hospital to be predominantly gram negative.

We often delay our closure of open fractures for various reasons: often they come more than six hours after injury. Thus, during repeat debridement (second look) more necrosis and dead tissues are often found, requiring enlarging the injured area. VAC's advantage is that it causes less tissue loss, decreases bacterial load (wound does not smell and doesn't have discharge) with less oedema overall, helps in controlling tough nosocomial infection. Subsequent debridements show granulation buds which progressively thicken in next changes of dressing.

Our results showed that out of 106 cases, the average number of VAC changes is three to four, average number of days between VAC changes is 3 to 5 days, length of time VAC applied before closure is 14 to 21 days. Most frequent mode of coverage is Split Thickness Skin Graft (STSG) obviating the need of more complex flaps and microvascular reconstructive procedures.

Complication

We did not have true failures from VAC. One patient complained of the noise of the suction machine. She was a patient with type II open fractures but with large lacerated wound and requested for earlier discontinuation of VAC.

Another patient had 16 VAC changes before closure with STSG. This was because of poorly nourished, persistently anaemic status and poor antibiotic compliance for his infected wounds. He stayed in the hospital for more than three months.

Next patient was an open type III distal femoral fracture with popliteal artery bypass grafting and associated tibia and fibula fracture. VAC was set up over the external fixator, extremity developed gangrene due to failure of the popliteal artery bypass after three weeks. But healthy granulation tissue was observed. This demonstrated the VAC's ability to stimulate regeneration therefore not truly a failure of VAC (Figure 5).

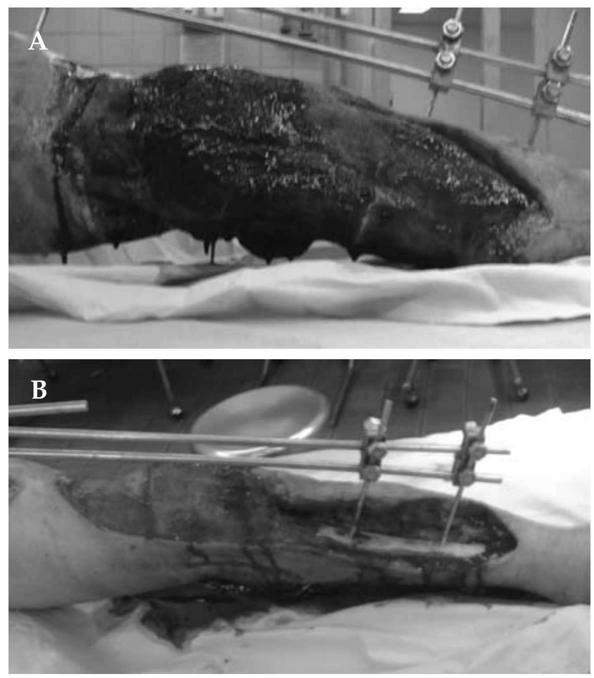

Figure 5. (A) (B) Patient with Open III-C Distal Femur Fracture who underwent Popliteal Artery Bypass Grafting – note large leg avulsion with exposed tibia. Healthy granulation tissue allowed successful Skin Grafting. However, it was the Popliteal Artery Bypass Graft that failed at 3 weeks, resulting in amputation.

Two patients with diabetic gangrene with uncontrolled blood sugar had to have definitive amputation to control the infections. This demonstrates that poorer vascularity in diabetes may not be good candidates for VAC but this technique can be used to temporize the care of these wounds while optimizing the patients before definitive treatment, that is, awaiting wound delineation and control of infection.

Discussion

Thorough surgical debridement still remains the primary option for all open wounds without which no other adjunctive procedure will work. VAC just helps us surgeons with the effect of continuous negative pressure on wound healing by removing fluid, increasing circulation, stimulating granulation tissue and regeneration.[1,2,3,4]

There are currently two main theories regarding the mechanism of action of VAC therapy. The first is based on the stimulatory effect of microstrain on cellular mitogenesis, angiogenesis, and elaboration of growth factors. This is the same mechanism that is operational in controlled Ilizarovian distraction or in tissue expansion. The second is based on the enhancement of the dynamics of microcirculation by active evacuation of excess interstitial fluid in the form of edema.[5,6] I also feel vacuum alters the micro organism's capacity to proliferate.

The basis for VAC is based on various animal and human studies.[7,8] An ICL lecture on VAC in open tibial fractures in AAOS meeting in 2004 (Gouler[9] from University of Michigan) reported 44 patients; randomized to standard wound protocol vs VAC found the following. Drainage was lessened with VAC 3.1 days vs 1.6 days (p=.003). Infection 16% vs 8% in patients with VAC. De Frenzo[10] reported 10^7 bacterial count down to 10^2-10^3 per gram of tissue at fourth and fifth days with VAC treatment, but emphasized that this does not obviate need for adequate debridement of traumatized soft tissues. Furthermore, it simplified the care of complex soft tissue wounds as it required less dressing change and more complex flaps to cover soft tissues became less frequently used.

Wackenfors[11] (2004) noted increased tissue O_2 perfusion using 125 mmHg a few cm from wound edge but included hypoperfusion in immediate vicinity to wound edge thus, intermittent makes more sense in that ebb-flow mechanism allows recovery and recommended 75 to 100 mmHg as optimum. In our study we used 60 to 70 mmHg and found no negative effect of VAC with this pressure setting, furthermore patients are generally comfortable and did not report any pain while the suction was on.

Recent literature has favored the use of VAC for patients with open infected wounds. Herscovici et al.[12] have used the VAC to decrease the size of traumatic wounds in 21 patients with high-energy soft tissue injuries. In selected patients, they were able to preclude free tissue transfer with VAC or regional muscle transfer. DeFranzo et al.[10] describe using the VAC to assist wound closure in 75 patients with severe lower extremity wounds with exposed bone. Our experience also confirmed the usefulness of this technique.

Leininger et al.[13] reported on 77 Iraqi patients who sustained 88 wounds secondary to missile injuries. NPWT or VAC was used in conjunction with repeated irrigation and debridement. They reported decreased hospital stay, simplified ward nursing, ability to effectively use NPWT in the field and no infections.

The advantages of VAC was further emphasized by a review article by Schlatterer and Hirshorn[14] as a method of reducing bacterial counts in wounds, as a bridge until definitive bony coverage, for treating infections, and as an adjunct to wound bed preparation and for bolstering split-thickness skin grafts, dermal replacement grafts, and muscle flaps. The article states that NPWT or VAC has been shown to be an adjunct to the mainstays of wound management. No significant complications have been noted in the categories of NPWT discussed in this review. In addition, evidence supports a decrease in complex soft tissue procedures in grade III B open fractures when NPWT is employed. NPWT appears to provide clinical benefit for the treatment of these complex lower extremity wounds.[15,16,17]

Parett[18] reviewed 290 open tibia-fibula fractures Gustilo grade III, from 1992 till 2003. His results demonstrated a change in practice, with a trend down the reconstructive ladder, currently using fewer free flaps (20% from 1992-1995, 11% from 1996-1999 to 5% from 2000-2003) and more delayed closures and skin grafts with frequent use of the vacuum-assisted closure sponge which he started using from 1997.

There are two papers which emphasizes statistically significant decrease in median time required to complete healing of acute and chronic wounds.[19,20] Braakenburg and colleagues[19] found a median time to complete healing of 16 days with VAC versus 20 days in the control group (P = 0·32). Vuerstaek and co-workers[20] reported a quicker median time to complete healing of 29 days with VAC versus 45 days in the control group (P = 0·001, as reported by the authors).

Two studies described changes in wound surface area.[19,21] Braakenburg and colleagues[19] reported a median reduction in wound surface area of 0·3 cm^2 per day with VAC versus 0·1 cm^2 per day in the control group (P = 0·83, as reported by the authors). Moues and coworkers[21] reported that, in 28 patients of 54 initially recruited, after 30 days, reduction in wound surface area had occurred in all 15 patients treated with VAC versus 13 of those in a gauze treatment group. The mean(s.d.) reduction in wound surface area was 3.8 per cent per day with VAC and 1.7 per cent per day with gauze (difference in means 2.10 per cent). Unfortunately in our study, we were not able to measure the surface area and depth of the wound prior to VAC application. Thus, we recommend a prospective study measuring the size and depth of the wound prior to VAC application and measuring the difference in size after VAC application and comparing it to a control group.

Vuerstaek and colleagues[20] reported a median time for the wound bed to be ready for surgery of seven days with VAC versus 17 days in the control group. Moues and co-workers[20] reported a median time to being ready for surgery of 6 days for the VAC group versus 7 days for the gauze-treated group (P = 0.19, as reported by the authors). In our study 14 to 21 days was required before we could definitely close the wound. We attribute this to the delay of VAC changes that usually occurs in our hospital because of unavailability of operating room time when we need it. Thus, our modifications are not inferior to the original VAC but works just as well. The costs of our modifications are much less than the original VAC, which is good for our setting.

Question if VAC causes anemia is frequently asked, my opinion is that monitoring VAC drainage over three to five days does not show appreciable blood losses. Primary cause of the anemia is the debridement with ensuing blood loss.

Recommendation

We recommend using this technique for open fractures with large soft tissue defects and wounds secondary to fasciotomies, peri-operative infections, diabetic and decubitus ulcers. Our modifications of VAC system did not show detrimental effects and works as well as the original VAC system. Beside, the components are readily available and cheap as compared to the original VAC system.

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