Negative Pressure Wound Therapy (VAC®) for the Treatment of Spinal Surgical Site Infections

Basak Caner Topkoru¹, Tuncay Kaner²
¹Department of Neurosurgery, Goztepe Education and Research Hospital, Istanbul, Turkey
²Department of Neurosurgery, Medeniyet University School of Medicine, Goztepe Education and Research Hospital, Istanbul, Turkey

ABSTRACT
Postoperative wound infections remain a challenge to manage after spinal operations. Negative pressure wound therapy (NPWT), commercially known as VAC® (vacuum assisted closure), has emerged as an alternative to conventional gauze closure. The main principle of the system involves placing an open-cell foam dressing into the wound and applying a controlled sub-atmospheric pressure to promote wound healing. The main mechanism of action of VAC therapy consists of macro- and microdeformation, fluid removal and environmental control of the wound.

To date, a randomized clinical trial in spinal infections comparing conventional therapy to VAC therapy is lacking. However, there is a growing body of evidence in other disciplines about the priority of VAC therapy over conventional therapy, especially in complex wounds.

The purpose of this review is to gain insight into VAC therapy with all its aspects such as features of the technique, mechanisms of action, complications and contraindications in spinal surgical site infections.

KEY WORDS: Negative pressure wound therapy, surgical site infection, spinal infection, vacuum assisted closure

INTRODUCTION
The incidence of postoperative spinal wound infections ranges from 0.4 to 12% in different series (15, 21, 27, 31). The management of these infections remains a significant challenge especially if the operations involve spinal instrumentation.

Patient age, obesity, diabetes, urinary incontinence, smoking, nutrition deficiency, non-steroidal anti-inflammatory drug usage, massive blood loss, and prolonged surgical time have been found to be risk factors for surgical site infections by several studies (31).

In the pediatric population, wound healing can be compromised by protein-calorie malnutrition, hypotension requiring inotropic therapy, impaired perfusion, edema, infection and physiological instability that prevents safe redistribution of pressure (2, 8). With the advances in instrumentation and anesthesia, the number of spinal deformity correction surgeries in the pediatric population has increased recently. Despite the use of prophylactic antibiotics and the advances in surgical technique and postoperative care, infections continue to be a serious problem postoperatively. The infection rate is much higher in children with neuromuscular scoliosis such as cerebral palsy and myelomeningocele and in idiopathic scoliosis (6, 36).

The standard clinical interventions to reduce the risk of wound complications are prophylactic antibiotics (3), drain placement (4, 28), copious irrigation (7) and careful attention to wound closure. Early detection of spinal wound infection is the key factor to prevent superficial infection from deteriorating to deep infection (27).
Once postoperative infections are encountered after spinal surgery, they can be treated successfully with multiple irrigations and debridements, with or without the use of a VAC device and prolonged intravenous antibiotics, which leads to increased hospital stays recovery times and cost for the patient and the health care system.

Negative pressure wound therapy (V.A.C.*) consists of an open-pore polyurethane foam placed in the wound, covered by a semi-occlusive dressing and connected by a tube to the vacuum source (1). Others have marketed similar devices with alternative materials but the system developed by Argenta et al is the most common device used in acute care settings (25).

Since the first appearance, it has been used successfully in treating open wounds of extremities, sternum, abdominal wall and also pressure and diabetic ulcers in adult and pediatric population (15).

**History:**

In 1962 Winter reported that the wounds that are kept moist heal faster than those exposed to air (38).

Later Chariker et al described a suction drainage system for the management of incisional and cutaneous fistulae. They used a gauze-filled dressing connected to walled suction at pressures of 60-80 mm Hg. They speculated that the system promotes fluid drainage, reduces skin damage and therefore helps the formation of granulation tissue (16).

A more familiar version of NPWT was described by Fleischmann et al in 1993. They used a polyurethane sponge instead of gauze-filled dressing connected to a suction (11).

Negative pressure wound therapy (NPWT) was introduced as a commercial product (V.A.C. Therapy, KCL USA, Inc.; San Antonio,TX) in 1997. The authors subjected 300 wounds of varying chronicity to their vacuum assisted closure technique until the wounds were either completely closed or covered by a split thickness skin graft or local flap. They reported that 296 of the wounds responded favourably stating that the technique led to the elimination of chronic edema, increased blood flow and increased granulation tissue (1).

**The Molecular Mechanism of Action of NPWT**

The wound healing mechanism by NPWT still remains unclear. Several mechanisms have been speculated. NPWT has been shown to remove the third space fluid from the wound area as a result of a decrease in tissue turgidity and capillary afterload, which promotes improved capillary circulation and local oxygenation (29) Morykas et al demonstrated in their experimental study an increase in local blood flow and that NPWT reduces the bacterial load and potential for bacterial colonization (22).

NPWT wound healing occurs via a mechanical effect on the wound bed. It causes the wound dressing to collapse transferring the force toward the wound edges called macrodeformation (26), thus drawing them closer together enabling cells stretching in the microscopic level, facilitating division, angiogenesis and proliferation called as microdeformation (32 35). Another main effect of NPWT is the environmental control of the wound; which is providing an insulated, warm and moist environment (33).

Secondary effects of the aforementioned mechanism are granulation tissue formation, cell proliferation, modulation of inflammation and upregulation of the neurotransmitters (25).

Increased granulation is thought to be a response to angiogenesis with upregulation of the HIF-1α-VEGF pathway (10). Inflammation is a critical response to injury and essential for the effects of NPWT. In mast cell deficient mice granulation tissue, the response has been shown to be muted (39). Additionally systemic cytokine and growth factor expressions have been found increased after VAC therapy (13, 18, 19).

**VAC in Spinal Surgical Site Infections:**

Published reports about VAC in spinal surgical site infections are limited to small retrospective and case studies, with no reports of NPWT being used as prophylactic treatment. To date, a randomized clinical trial in spinal infections comparing conventional therapy to VAC therapy is lacking. However, there are existing randomized clinical trials in other disciplines such as orthopedic (34) and abdominal surgery (20) with conflicting results, where they used VAC therapy as prophylaxis after closure. Masden randomized 93 patients with comorbidity either to VAC or standard dry closing group at the conclusion of the surgery. There was no statistical difference in the rates of surgical site infection in the standard dressing group and the VAC group. In contrast, Stannard et al reported in a series of 249 patients that the rate of surgical site infection is significantly lower in the VAC group after high risk traumas in orthopedic patients for prophylactic wound treatment (34).
In a prospective randomized clinical trial of different wound types where the authors compared the VAC system to conventional wound therapy, a tendency towards a shorter duration of therapy was found, especially in the late treated wounds. Additionally, they found that the wound surface area reduced significantly faster with VAC (23).

Ousey et al has reviewed the literature for VAC therapy in spinal wounds recently (27). They found that in most of the studies the NPWT dressing was placed in the operating theater after irrigation and debridement. Wound healing was assessed every 2-3 days and generally completed between 7 days and 16 months (15, 17, 21, 30, 40). The length of time for NPWT in situ ranged from 3 to 186 days (6, 17, 37).

The general consensus was that NPWT dressings were changed 2 and 3 days, although manufacturers’ instructions suggest that NPWT could be kept in place for 7 days (6, 14, 27).

The publications in the literature report generally (mainly for non-spinal wounds) a negative pressure of -50 to -75 mmHg to be used in children aged 2 years or younger, -75 to -125 mmHg for children aged above 2 years and -100 to -125 mmHg in adult patients (8). Some manufacturers of NPWT recommend reducing the pressure settings to between -40 and -80 mmHg for patients who have pain until the pain is relieved (27).

Complications and Contraindications:

Although the VAC treatment has been considered generally as a safe treatment modality in the literature it is not without complications. There is only one death in the literature due to hemorrhage caused by VAC treatment. In this case the patient refused blood transfusion because of religious reasons and died 2 days after the VAC dressing was placed (15). Non-healing wounds due to persistent infections caused by foam pieces left in the wound has also been reported (12, 15). Other complications are cerebrospinal fluid leakage and non-healing granulation tissue requiring skin grafts (27).

Negative pressure wound therapy is contraindicated in the presence of active cerebrospinal fluid leak, metastatic or neoplastic disease in the wound or in the patients with an allergy to the NPWT dressing and in those with a bleeding diathesis (15, 25).

Cost-effectiveness:

The cost of medical care of a lumbar fusion complicated with an infection may be three or four times higher than the cost of an uncomplicated fusion (5). Several studies have been conducted to analyze the cost-effectiveness of NPWT over traditional wound dressings and they all argue that even though the unit cost may be high, the VAC treatment is cost-effective since with its effects on promoting the wound healing it reduces the length of stay in the hospital, the rate of complications and further surgical interventions (9, 24).

CONCLUSION

Despite the lack of prospective randomized clinical trials of VAC therapy in spinal wounds the limited literature to retrospective and case studies indicates the usefulness of NPWT in complex spinal surgical site infections.

REFERENCES


