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ABSTRACT: Complex wounds management has represented a challenge for healthcare physicians, specifically for surgeons. Conventional techniques have long been in use for its proper management, however, the desired results are not always achieved. The use of sub atmospheric pressure dressings, commercially available as the vacuum-assisted closure (VAC) device, has proven to be an effective way to accelerate the recovery of hard-to-heal wounds.
In this brief review, it is highlighted the importance of the VAC system in successful wound healing.

Keywords:
Vacuum-assisted closure, Wound, Wound closure.

Review

General Surgery

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Introduction

Wound healing remains a challenging clinical issue and a correct as well as an efficient wound management is essential. Primary goal of practicing physicians is to achieve a high success rate in wound healing. The scientific community has always sought new wound care techniques, especially with emphasis on new therapeutic approaches and the development of technologies for the management of acute and chronic wounds (1).

For the first time in 1993 Fleischmann et al. (2) described the concept of using controlled subatmospheric pressure to treat open and/or infected wounds using a vacuum-sealed dressing to treat open fracture wounds in trauma patients. Subsequently in 1997 Argenta et al. (3) developed the VAC device (Kinetic Concepts, Inc., San Antonio, TX, USA) at Wake Forest University as a method to accelerate healing by secondary intention, particularly in compromised and debilitated patients.

The use of controlled levels of negative pressure application has been shown to accelerate debridement and promote healing in various types of wounds (4). This brief review points out the importance of the negative pressure wound device (VAC) in successful wound healing.

Acute wounds undergo a complex series of both biochemical and cellular events, such as hemostasis, inflammation, proliferation and maturation.

There are certain factors, both local and systemic, that can negatively affect this process (5):

- Local factors: desiccation, tissue edema, exudate (6), infection, etc.
- Systemic factors: ischemia, poor nutrition, diabetes, radiation, etc.

Chronic wounds do not make an orderly progression between the four main phases of healing, including a decrease in the proliferative response, which makes it a priority to improve their local and systemic conditions to accelerate their healing.

Four primary mechanisms of action of the negative pressure system to aid wound closure have been described.

1. Wound contraction
   Skin and soft tissues have a natural tension in their normal state. When an incision is made, the tissue separates. Keeping these tissues in approximation allows for early first or second intention closure.
   Open pore dressings allow pressure to pass to the wound edges while evacuating exudate (which in excess also slows wound closure) and contract up to 80% at a pressure of 125 mmHg.

Received on April 13, 2022. Accepted on April 17, 2022. Published on April 21, 2022.

DOI 10.5281/zenodo.6476767

Figure 1. A) Contaminated wound with devitalized tissue. **B)** Clean wound after lavage and debridement. **C)** Sponge measurement according to the size of the wound.

2. Stabilization of the wound environment
   The VAC system uses a semi-occlusive polyurethane cover that allows the passage of gases such as water vapor as well as maintaining proteins and microorganisms. This covering is normally changed every 2 to 5 days. It allows maintaining a humid and warm environment which promotes angiogenesis and debridement of necrotic tissue; (7) as well as a stable osmotic and oncotic gradient by allowing the passage of fluid with electrolytes and proteins. (8).
   To fulfill its functions, the dressing has an average pore size of 423 picometers and decreases its space by up to 97% when compressed.

3. Decrease of edema and evacuation of exudate from the wound:
   One of the main characteristics is to promote the extraction of exudate which improves wound closure by removing harmful matter (metalloperoxidase 2 and 9), in addition to increasing blood flow by evacuating exudate from small blood vessels. (9)
   The movement of ions anchored to glycoproteins generates electric fields that stimulate the cellular response. (10)(11)

4. Microdeformation
   It has been theorized that microdeformations of the wound surface promote cell proliferation through mechanotransduction pathways. Mechanical signals promote cell proliferation and migration , as well increase the expression of extracellular matrix components, contractile elements and growth factors which are necessary for wound healing. (12)

Indications

The application of negative therapy for wound closure has evidence since 1992 (13), where it was used to treat open fractures with proven benefits especially with greater amount of granulation tissue, lower infection rates and shorter recovery time.

Advantages

1. Wound closure in a shorter time even in patients with local (infection) or systemic (diabetes) complications.

2. Wound coverage is easier to change and maintain, even in difficult to access anatomical positions such as skin folds or circumferences.

Figure 2. A) Sponge placed on the wound without exceeding its edges. **B)** Placement of adhesive on the wound and removal the first sheet (number 1). **C)** Removal of adhesive sheet number 2 and removal of blue flange.

DOI 10.5281/zenodo.6476767

Figure 3. Cutout on adhesive cloth on which the suction hose is connected.

3. Traditional coverings must be changed several times a day, but with the negative pressure system it can last from 2 to 5 days, thus reducing the discomfort caused by the changes (14).

Disadvantages

1. From the point of view of mobilization, the main disadvantage is having to mobilize the pump that generates the negative pressure.

2. Currently, both dressings and negative pressure pumps have a high cost, in addition to the need for trained personnel to handle them.

Contraindications

Its use is restricted in tissue with suspected or confirmed malignancy, since when negative therapy is applied the tissue grows in an accelerated manner, in addition this tissue has the characteristic of being more friable and more likely to bleed. (15)

A relative contraindication is its use in exposed vital organs, blood vessels or vascular grafts, its use is postponed until it contains granulation tissue to avoid erosion, damage and bleeding. (16)

In ischemic wounds, no benefit has been demonstrated and it may even worsen ischemia, since the therapy itself assumes that there is controlled ischemia. In the case of a wound with baseline ischemia, the risk is greater than the benefit. (17)

Figure 4. Placement of suction hose and its collapse, checking that it is airtight.

In patients with fragile skin, either due to advanced age, collagen diseases or chronic use of corticosteroid can generate damage and even necrosis especially at the margins of the wound, so its use with caution is recommended.

Mode of application

1. Once the patient meets the criteria for VAC system placement, the wound is mechanically washed with antiseptic agents, as well as mechanical debridement. (Figure 1 and 2)
2. Measurement of the sponge to be used,
3. There are different types and sizes of dressings that can be used for the negative pressure system, the appropriate size should be used so that it does not protrude more than 20% of the edges of the wound. It is also necessary to avoid the cover directly on the skin since it can injure it. (Figure 3 and 4)
4. It is fixed with the adhesive included with the sponge. It is divided into three sections which should be placed in this order:
    a) Tighten evenly to avoid the presence of bubbles and thus generate an airtight seal. Proceed to remove cover number one. (Figure 5)
    b) While the tension is maintained, proceed to remove the label with the number two keeping firm pressure to avoid separating the part already adhered to the skin and the sponge. (Figure 6)
    c) Finally, remove part number three (blue label) (Figure 6).
5. A cut is made on the adhesive fabric, previously measured on the sponge, for the connection with the drainage, it is important to mention that through this incision the negative

DOI 10.5281/zenodo.6476767

pressure is going to be transmitted from the generator to the wound. (Figure 7)

6. Proceed to place the suction hose and check the tightness of the seal by programming the negative pressure generator, the sponge and wound collapse will be generated. (Figure 8)
7. The negative pressure therapy indicated for each particular patient will be started.

The VAC system has certain advantages such as the fact of being easy to handle, hospital admission is not essential, good compliance and patient satisfaction requires minimal training to maintain the vacuum at home, it can be applied to multiple cases at the same time and give adequate mobility to the patient (18), and it will reduce the total length of in-hospital stay and this is ideal for hospitals with high demand (19).

Conclusion

The VAC system is a reliable therapy for treating wounds of different types, reduces bacterial counts aiding healing and increases the rate of granulation tissue formation. It has the advantage of being used as a definitive treatment for non-surgical wounds or as a temporary dressing for optimal wound preparation prior to surgical closure.

The VAC device is well tolerated with minimal complications and/or contraindications so it is increasingly being used in different clinical settings playing a growing role in wound management.

Conflicts of Interests

The authors declare no conflict of interest.

Acknowledgements

None.

References

1 Velnar T, Bailey T, Smrkolj V. The Wound Healing Process: an Overview of the Cellular and Molecular Mechanisms. *The Journal of International Medical Research.* 2009;37(5):1528–1542.

2 Hopf HW, Humphrey L, Puzziferri N, et al. Adjuncts to preparing wounds for closure: hyperbaric oxygen, growth factors, skin substitutes, negative pressure wound therapy (vacuum-assisted closure). Foot Ankle Clin. 2001 Dec; 6 (4): 661–82

3 Argenta LC, Morykwas MJ. Vacuum-assisted closure: a new method for wound control and treatment: clinical experience. Ann Plast Surg. 1997; 38 (6): 563–77

4 Moues CM, van den Bemd GJ, Meerding WJ, Hovius SE. An economic evaluation of the use of TNP on full thickness wounds. *J Wound Care.* 2005;14(5):224–227.

5 Hunt TK. The physiology of wound healing. Ann Emerg Med. 1988 Dec;17(12):1265-73. doi: 10.1016/s0196-0644(88)80351-2. PMID: 3057943.

6 Wysocki AB, Staiano-Coico L, Grinnell F. Wound fluid from chronic leg ulcers contains elevated levels of metalloproteinases MMP-2 and MMP-9. J Invest Dermatol. 1993 Jul;101(1):64-8. doi: 10.1111/1523-1747.ep12359590. PMID: 8392530.

7 Winter GD. Effect of air exposure and occlusion on experimental human skin wounds. Nature 1963;200:378-9

8 Morykwas MJ, Simpson J, Punger K, Argenta A, Kremers L, Argenta J. Vacuum-assisted closure: state of basic research and physiologic foundation. Plast Reconstr Surg 2006; (Suppl. 121):126.

9 Yang ML, Chang DS, Webb LX. Vacuum-assisted closure for fasciotomy wounds following compartment syndrome of the leg. J Surg Orthop Adv 2006;15:19-23.

10 Lee RC, Frank EH, Grodzinsky AJ, Reliance DK. Oscillatory compressional behavior of articular cartilage and its associated electromechanical properties. J Biomech Eng 1981; 103:280.

11 Folkman J, Moscon A. Role of cell shape in growth control. Nature 1978;273:345-9.

12 Cornelia Wiegand; Richard White. Microdeformation in wound healing. Wound Rep Reg (2013) 21 793–799. DOI:10.1111/wrr.12111

13 Fleischmann W, Strecker W, Bombelli M, Kinzl L. Vakuumversiegelung zur Behandlung des Weichteilschadens bei offenen Frakturen [Vacuum sealing as treatment of soft tissue damage in open fractures]. Unfallchirurg. 1993

14 Joseph E, Hamori CA, Berman S, et al A prospective randomized trial of vacuum-assisted closure versus standard therapy of chronic non-healing wounds, Wounds. 2000;12:60.

15 Venturi ML, Attinger CE, Mesbahi AN, Hess CL, Graw KS. Mechanisms and clinical applications of the vacuum-assisted closure (VAC) Device: a review. Am J Clin Dermatol. 2005;6(3):185-94. doi: 10.2165/00128071-200506030-00005. PMID: 15943495.

16 White RA, Miki RA, Kazmier P, Anglen JO. Vacuum-assisted closure complicated by erosion and hemorrhage of the anterior tibial artery. J Orthop Trauma. 2005 Jan;19(1):56-9. doi: 10.1097/00005131-200501000-00011. PMID: 15668586.

17 Orgill DP, Manders EK, Sumpio BE, Lee RC, Attinger CE, Gurtner GC, Ehrlich HP. The mechanisms of action of vacuum assisted closure: more to learn. Surgery. 2009 Jul;146(1):40-51. doi: 10.1016/j.surg.2009.02.002. Epub 2009 Apr 19. PMID: 19541009.

18 Hussain A, Singh K, Singh M. Cost Effectiveness of Vacuum-Assisted Closure and its modifications: a review. *ISRN Plastic Surgery.* 2013;2013(595789):5.

19 Yadav S, Rawal G. Healthcare information for all-Is it achievable? *Int J Sci Res Rev.* 2015;4(1):101–105.

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 DOI 10.5281/zenodo.6476767