10 years of Negative Pressure Wound Therapy [NPWT]: Evolution of Indications for its Use

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Abstract - Negative Pressure Wound Therapy [NPWT], or Vacuum-assisted closure therapy [VAC therapy], is a therapeutic method using a special sponge or gauze dressing with a vacuum device to promote wound healing. Aim of the study was to assess changes in indications for use of NPWT as well as evaluation of results of its use during the last ten years by comparing the literature published in the years 2002 and 2012. An analysis made of peer-reviewed publications [Pubmed] chosen on the basis of inclusion of the term negative pressure wound therapy [NPWT]. We compared numbers and issues of papers published in the years 2002 and 2012. Number of papers concerning NPWT increased from 16 in 2002 to 249 in 2012. Indications for its use were also evaluated from healing wounds after sternotomy, diabetic foot, pressure ulcers to laparostomy wounds, infected by-pass, infected mesh after hernioplasty and many others. NPWT, when used on for right indication and especially by experienced healthcare professionals [e.g. surgeons], is an excellent tool to support wound healing, but further prospective studies are needed to understand the exact mechanism of its action.

Keywords — diabetic foot, Negative Pressure Wound Therapy [NPWT], open abdomen, Vacuum-assisted closure therapy [VAC therapy], wound healing.

I. INTRODUCTION

Negative Pressure Wound Therapy [NPWT], or Vacuum-assisted closure therapy [VAC therapy], is a therapeutic method using a special sponge or gauze dressing with a vacuum device to promote wound healing. Negative pressure is applied to the wound through a special sealed dressing in a continuous or intermittent manner. The vacuum facilitates wound drainage, reduces oedema and increases blood flow to the area. This improves the reduction of exudate and bacterial load, simplifies tissue granulation and accelerates wound healing.

This novel technology was introduced for medical practices approximately 20 years ago by Argenta and Morykwas [1,2] which was based on the work of Chariker nad Fleischmann in the late 1980’s and early 1990’s. [3,4] Nowadays NPWT has been widely spread throughout North America and Europe and is becoming more and more available in other parts of the world. In a few years it will most likely become the gold standard for treatment of hard-to-heal wounds especially those with increased amounts of exudation.

Development of NPWT has become especially apparent in the last ten years, when it began to be used by physicians of different specialties and the range of indications for its use is suspected to increase progressively.

The aim of this review was to check what changed during last ten years by comparing the literature published in the years 2002 and 2012, we also focused on assessing changes in indications for the use of NPWT including evaluation of the results obtained.

II. METHODS

An analysis made of peer-reviewed publications [Pubmed] chosen on the basis of inclusion of the term negative pressure wound therapy [NPWT]. We compared numbers and issues of papers published in the years 2002 and 2012.

Many commercial sets for NPWT are available on the market but comparison of their results for their use was not an objective of this review.

III. RESULTS

A database search for full text articles published in English concerning NPWT was performed. Papers not relating directly to NPWT were excluded from the review [Table 1].

From January 1st 2002 to December 31st 2002 total number of 16 articles matched inclusion criteria. Three of the articles described important role of NPWT in cardio surgery where it was used for the treatment of hard to heal deep wounds after sternotomy especially when infected [5,6,7].
Two papers presented use of VAC in a number of orthopedic pathologies such as treatment of lower limbs injury after trauma or surgical complications. [8, 9] Other authors characterized wide use of NPWT in the treatment of hard to heal wounds like diabetic foot, pressure ulcer and others. [10, 11, 12, 13]

NPWT was also used in the treatment of mediastinal abscesses, not responsive to antibiotics, thanks to NPWT the patient avoided a thoracic surgery disorder [28] and vacuum-assisted closure of pleural empyema was also possible without classic open-window thoracostomy [29].

Publications from multiple centers mention orthopedic indications of VAC in cases of trauma, fractures, and poor healing wounds [30, 31, 32, 33, 34, 35, 36]. Research shows that NPWT may act advantageously in the treatment of bone, which is still very difficult to treat [37]. Beneficial effects of NPWT are also found for use in patients, whose wounds were formed as a result of exotic animal bites, particularly spiders [38].

Extensive infections, cellulitis, purulent perineum infections, along with abscess and Fournier’s necrosis also responded positively to VAC treatment [39, 40]. With this therapy, cosmetic results were much better than traditionally treated patients, patients did not require multiple surgeries and their hospitalization was shorter. Interesting results of NPWT used in pigs as a hemostatic adjunct for control of coagulopathic hemorrhages in large soft tissue wounds proved that it is able to stop lethal bleeding. [41]

In vascular surgery VAC is used in the treatment of infected wounds after by-pass procedures and infected vascular prostheses, becoming an indispensable outfitting for every referenced department of vascular surgery [42, 43, 44].

In gastrointestinal surgery VAC found a very wide application, and as such was is associated with many publications. Treatment of patients with an open abdomen [laparostomy] due to various reasons amongst which ranks first place is acute pancreatitis gave very promising results [45, 46, 47, 48, 49, 50, 51]. Furthermore, treatment of intestinal fistulas especially with wound complication is a very common indication. Reports of usage of VAC in diverticulitis were also observed [52].

A new indication for the use of NPWT, particularly its portable version, is treatment of the pilonidal cyst. This disease has a high rate of recurrence after surgery and patients are at risk of long-lasting healing of wounds and frequent local purulent lesions and inflammation, which causes discomfort and frequent halting from the active professional life. Portable VAC allows for it to be used in an outpatient setting thereby allowing quicker and more effective healing of the operating site [53].

VAC is also used in the treatment of penis and scrotum wounds caused by bacterial infections [54, 55].

Large wound surfaces with large amounts of mucus observed in skin burns prompted the use of NPWT which resulted in a significant acceleration in the time taken for patient healing and rehabilitation. After the application of NPWT, wounds healed better, were less likely to become infected, skin is also more elastic and looks better. [56, 57]

In plastic surgery VAC is used in patients who expe-

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Table 1

NPWT 2002 vs 2012

<table>
<thead>
<tr>
<th>Indications</th>
<th>2002 [number of papers]</th>
<th>2012 [number of papers]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wounds after sternotomy</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Hard to heal orthopedics wounds</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Diabetic foot</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Pressure ulcer</td>
<td>2</td>
<td>23</td>
</tr>
<tr>
<td>Infected by-pass or graft</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Wounds after fasciotomy</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Gunshot wounds</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Methodology of NPWT</td>
<td>2</td>
<td>23</td>
</tr>
<tr>
<td>Reviews</td>
<td>2</td>
<td>44</td>
</tr>
<tr>
<td>Open abdomen</td>
<td>0</td>
<td>26</td>
</tr>
<tr>
<td>Spiders bite</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Open abdomen children</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Infected mesh</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Burns</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Scrotum wounds</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Pyoderma gangrenosa</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Plastic surgery with skin grafts</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Hand surgery</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Abscess of mediastinum</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>
rienced complications associated with skin graft rejection, its partial necrosis and also after excision of large scalp flaps due to injuries and lack of opportunities to cover it with their own skin. NPWT resulted in faster healing of wounds, its reduction in size as well as granulation [58, 59, 60, 61, 62, 63].

One of the most dangerous complications of limb injuries and fractures is compartment syndrome, patients after decompression or impingement are often exposed to a long stay in the hospital with problems associated with hard to heal wounds with large amounts of secreted necrotic tissue. In such situations, the use of VAC also improved wound healing, accelerated patients rehabilitation, discharge from hospital and reduction in the costs for treatment. [64].

Diabetic foot is a disease that causes patients to stay for long periods of time in the hospital, treatment is complicated because of ineffective antibiotic therapy and infected wounds which often required frequent surgical treatment and sometimes amputations. In such situations, NPWT also turned out very effective in improving the results of treatment [65, 66, 67, 68, 69, 70].

Pressure ulcers are a serious concern in patients with different causes of bed immobilization, a conservative form of treatment for this condition is ineffective and often results in treatment being finished with surgery, which also yield unsatisfactory results. VAC creates opportunities for better wounds healing. [71, 72, 73, 74, 75].

Large abdominal wall defects in children after surgery without safe abdominal wall closure or with compartment syndrome is a significant therapeutic problem [76, 77, 78]. The use of VAC in such situations has enabled the effective healing of wounds and the achievement of therapeutical success.

Palm and digits wounds associated with skin loss have a prolonged healing time and with little success because of the small volume of skin that can cover the loss. Certain modifications of the use of NPWT with irrigation resulted in effective wound healing although the exact mechanism of healing in not clearly understood [79].

Large ENT oncology treatments, such as laryngectomy in patients after radio-chemotherapy, are exposed to numerous local complications, for example: neck dehiscence, great vessel exposure, fistula formation or cervical skin necrosis results in complex wounds that can often be treated initially with negative pressure dressings followed by definitive reconstruction [80, 81, 82].

In all neurosurgical cases involving open cranial wounds, the VAC device promoted granulation tissue formation over the dural substitute, prevented CSF leakage, and kept the wounds free from local infection. The VAC dressings applied to a tissue matrix or other barrier over the brain tissue in extensive cranial wounds are safe and well tolerated, providing a functional barrier and preventing infection [83].

Abdominal hernia surgery is very often performed on surgical wards. The risk of septic complications in these operations is small but the occurrence of surgical site infection heals very poorly, biofilm formation in the mesh is hard to heal and even targeted antibiotic therapy is ineffective. In such situations, the role of NPWT is invaluable because it works by removing bacteria from the biofilm [14], cleans the operated site from purulent secretions, increases local blood circulation to facilitate migration of macrophages and lymphocytes as well as antibiotics [84, 85].

Traumatic heart wounds especially after gunshots are frequently lethal because of uncontrolled critical bleeding from the heart muscle. A case of a patient with suicide attempt showed that the vacuum device applied to the wound in the right ventricle stabilized and controlled the bleeding [86]. It also proved that portable vacuum devices can be a simple and efficient method for the control of critical bleedings. This type of device can be useful in military missions or in emergency units, where it can provide the time necessary to prepare the operating room or call for additional specialized help to manage the bleeding.

IV. DISCUSSION

VAC therapy after ten years has become more and more popular. Despite the lack of understanding into its mechanisms of action, positive effects of treatment and increase fields of its application have been observed VAC therapy can reduce the overall cost of treating patients, which in turn is related to shortened hospitalizations. The use of NPWT in an outpatient setting results in accelerated wound healing and total reductions in treatment costs by reducing the number of dressing, visits to specialists, topically active drugs compared with the same vacuum therapy costs. [87, 88, 89, 90].

It has also been proven that NPWT has significant antibacterial effects by reducing in vitro bacterial biofilm formation [14], it also reduces subcutaneous edema which can be assessed by ultrasound [91].

On the other hand, experiments checking bacteria’s on the VAC foam revealed that bacterium might be solely identified on the NPWT foam or differ to those isolated in the tissue; whether this is a contamination, bacterial switch or the results on the NPWT foam or differ to those isolated in the tissue; whether this is a contamination, bacterial switch or the results of insufficient microbiological diagnostics prior to NPWT is no know. NPWT is still a very young therapeutic method and very plastic to various changes and modifications of facilities such as digits irrigation system mentioned before.

It should not be forgotten that even though many positive pressure effects are produced by VAC, negative side effects such as decreased blood flow and microvascular response in the intestinal wall may also occur, on the other hand a reduction in flow is observed only in small vessels, no such observations were made in the major vascular trunks such as mesenteric vessels [92, 93, 94]. This valuable knowledge gives conscious choice of therapy, evaluation of its benefits and risk of potential side effects. It also forces modifications of the system and
stimulate experiments to reduce side effects, such as the porcine model study, evaluating the system using protective insulating disc intestine from direct VAC resulting in better blood supply to the intestine with preserved antibacterial and suction activity [95, 96]. Similar studies used protective discs to evaluate its protective action on a large vessel in the groin [97]. Some modifications such as the placement of the dressing Jelonet proved to be ineffective and did not improve the circulatory vessels supplying the gut [98].

In some situations, VAC may cause worsening of bleeding from the site of its implantation, and sometimes this action will be opposite from that intended, the literature describes cases of acute bleeding from wounds after sternotomy [99].

The gradual development of VAC and its wide range of applications will allow for better learning of the VAC system and its operation in different surgical situations. For example, in intestinal anastomosis, which has been proven that NPWT has no acute adverse effect on intestinal anastomosis performed by manual stapling or suture [100].

NPWT also affects the deeper layers of tissue acting as an anti-inflammatory [chronic inflammation] and thereby stabilizing the tissue [101].

In some situations that require usage of VAC therapy, it is possible to use the standard suction system, which works on the basis of suction from the wall, which is not just cheaper than conventional VAC but also shows promising treatment results. [102].

V. CONCLUSION

NPWT can be a useful source for cutting down costs of chronic wound managements and saving money by its effect on expediting wound healing. There should be a national standard for the availability and indication of this tool to assure equal opportunities for different patients in different areas in the country [103].

Although NPWT appears effective and its superiority to conventional techniques has been demonstrated, there are still some critical concerns concerning its efficacy. Because its mechanisms of action remain partly unclear and because there are still some gaps between evidence-based data and the excellent clinical results, further prospective, randomized, ideally blinded studies are needed. Even so, we may conclude that NPWT, when used for the right indication, especially by experienced healthcare professionals [e.g. surgeons], is an excellent tool to support wound healing and save lives [104].

References


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