The Use of Negative Pressure Wound Therapy for Treatment Surgical Wound Arthroplasty 
A Systematic Review

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Abstract: As the increasing of arthroplasty surgery, the number of complications resulting from this procedure also rises, including delayed surgical wound healing and infection. Revision surgeries are often needed due to wound healing complications. Recently, a dressing technique that uses a vacuum dressing (Negative Pressure Wound Therapy) to promote healing, has been widely used as therapy for many different indications wounds. This study aimed to present the use of negative pressure wound therapy (NPWT) in surgical wound healing after arthroplasty surgery. Scopus, ScienceDirect, and PubMed databases were systematically searched from 2009 to 2018 of the use NPWT to treatment wounds after arthroplasty surgery. Ten articles that met the inclusion criteria, NPWT used for wound treatment after TAA (total ankle arthroplasty), TKA (total knee arthroplasty), THA (total hip arthroplasty) surgery, were eventually included. We found 8 reports stated that NPWT accelerated wound healing and reduced surgical site infection compared to conventional dressing. The results 5 of 10 studies had lower complication of prolonged wound healing when used NPWT for treatment. The other studies showed NPWT shortened the duration of hospitalization, had no further surgery, decreased area of infection, and concise inflammation process. All the articles included in the review indicated that NPWT have positive effect on wound healing process.

1 BACKGROUND

Periprosthetic infection is the most common complication and the main problem of arthroplasty. According to Sukeik and Haddad, “infection after total hip replacement is a devastating complication with significant sequelae both for patients and for the healthcare system”. Wound problems after arthroplasty not only impair postoperative physical therapy, clinical outcomes, and patient satisfaction but also notably increase the risk for implant infection, which can lead to dire consequences such as amputation. The development of infectious process can result in sepsis, and the removal of the infected prosthesis leads to loss of function and to significant reduction in quality of life. (Obolenskiy et al., 2013; Matsumoto and Parekh, 2015).

The management of the infectious process in some cases can be possible without removing endoprosthesis or endocorrector, if a combined treatment includes local negative pressure – negative pressure wound therapy, NPWT, or vacuum-assisted closure, VAC1-therapy. NPWT is an adjunctive healing method for selected surgical wounds at high risk for complications, acute wounds, and certain chronic wounds after failure of primary intention healing and recently, has been applied to closed incisions following trauma or clean surgery and has demonstrated notable clinical effects (Matsumoto and Parekh, 2015; Robert, 2017).

The surgical wound healing process often causes a decrease in the physical and psychological condition of the patient. Conventional wound care requires a long healing time, especially for chronic wounds and complicated complications. Visits by medics and paramedics are also needed. This has an impact on the cost. Therefore, more effective and efficient wound care management is required.

Long-term surgical wound healing processes that occur in patients with arthroplasty are the most common cause of compliaction. Patients who receive arthritis therapy belong to the elderly with joint problems such as arthritis due to degeneration and others, which in the case of treatment is usually performed arthroplasty surgery several times due to prolonged wound healing process.

Recent management associated with chronic wounds or post-operative arthroplasty wounds include the use of hyperbaric oxygen and negative pressure techniques (Negative Pressure Wound Therapy / Vacuum Assisted Closure (VAC)). This negative pressure technique has grown rapidly and is now widely used in many countries, especially in Western Europe (Germany) and the United States.

Negative pressure wound therapy (NPWT) system has been used and developed since more than 25 years to deal with complex wounds. Even other
sources mention that this system has been found 50 years ago. Various researches continued to develop until in 1995 a pharmaceutical company promoted it commercially in Ukraine.

Currently, NPWT has been used in the treatment of various injuries such as orthopedic trauma, soft tissue trauma, skin graft, diabetic ulcers, venous varicose ulcers, burns, postoperative wound infections, and other types of acute and chronic wounds.

This review is aimed to explain the effectiveness of NPWT use in patients who had undergone arthroplasty surgery.

2 METHODS

The scope of the source is the use of Negative Pressure Wound Therapy either using an incision, by cover or not as an intervention. This use is a negative pressure vacuum device that uses electric power and usually uses a certain wound cover that is connected to the device. The sources studied are from international journals scopus indexed. Journal search engines used are Scopus, Sciencedirect, PubMed, by providing "Negative Pressure Wound Therapy" and "arthroplasty" keyword limits with the year 2009-2018.

Data Extraction and Appraisal

Data extraction is designed using the main criteria of the Greenhalgh framework. The components taken are objectives, research design, population (sample size, characteristics and sampling method), interventions of wound care using Negative Pressure Wound Therapy, measured results, data collection methods, and yield analysis. Articles that meet the criteria are evaluated regarding quality and validity with focus of sample size, client allocation and needs and bias factors. Data extraction was performed by one reviewer and examined by a second reviewer.

3 RESULTS

Characteristic of Included Trials

Research articles obtained as many as 18 journals published from 2009 to 2018 with the most compositions published in 2011-2018. All research journals are conducted in various countries with experimental methods. The research designs were found in the research of Randomized Controlled
Trial (n = 5), Retrospective cohort study (n = 1), Prospective cohort study (n = 4). The most widely used research design is the prospective cohort study.

**Negative Pressure Wound Therapy (NPWT)**

NPWT, a dressing technique that uses a vacuum dressing to promote healing, has been demonstrated that NPWT can accelerate wound healing by advancing angiogenesis, increasing microvascular blood flow, stimulating granulation tissue formation, and reducing edema. It has been used mainly for open wounds but recently, this therapy has been applied to closed incisions following trauma or clean surgery and has demonstrated notable clinical effects. NPWT enhances granulation tissue formation over previously healed wounds, by stimulating local angiogenesis, thereby improving the local blood supply. This local increase in vascularity results in an influx of fibroblasts, which diminish the surface area of the wound by approximating its margins (Robert, 2017).

**Mecanisms of Action NPWT/ VAC**

The mechanism of NPWT in the postoperative wound healing process is to keep the wound environment moist, remove fluids and infectious material, decrease bacterial colonization, increase tissue granulation formation, faster cell growth, increase local blood flow, decrease bacterial count, and remove proteases that harm the wound healing process (Santy, 2015).

Research conducted by Blume et al. (2008) says that the use of NPWT (V.A.C) can improve the process of wound healing through efforts to create a humid wound environment and reduce edema. In general, Andros et al. (2005) states that the advantages of NPWT method compared with other methods is that this method can provide a moist environment, so that wound healing becomes optimal, remove the exudate from the wound so that protease enzymes inside the exudate are also made, this enzyme known to interfere with the wound healing process. Besides other advantages are infection control, where on day 4 and 5 wound that does not use NPWT bacterial count and bacterial colonisation increase. While on the use of NPWT this is not visible. Another advantage is that NPWT can stimulate cell growth physically by increasing angiogenesis, so that new cell growth will be maximal. The results of this study are not fully supported by Mouësa et al. (2006) which states that in patients receiving NPWT therapy, the wound does become more rapidly healed and the wound surface area also decreases rapidly compared to conventional therapy (Santy, 2015).

**4 RESULT**

**Post Operative Wound Healing Using NPWT**

NPWT proved to accelerate the healing process of surgical wound in patients post-arthroplasty surgery with mechanisms of absence of dehydrogen on the wound, the presence of good scar and drainage and reduce the problem of wound healing compared with conventional dressings (Matsumoto & Parekh, 2015, Redfern et al., 2017).

Dehiscence associated with infection demonstrated closure of the wound and control of the infectious process without the need for surgical intervention, and the six patients who underwent surgery to treat infection showed clinical improvement in infection and good healing (Helito et al., 2017).

There is evidence in the use of NPWT in orthopedic trauma with good results but limited literature assessing the use of NPWT on post arthroplasty incision care. Suzuki et al. assessed application of NPWT directly to high-risk surgical wounds associated with open fractures. Early studies have indicated though, that NPWT has been associated with decreased seroma size as well as earlier resolution in hip arthroplasty patients (Manoharan et al., 2016).

The incidence of surgical wound infections as a form of postoperative complication also proved to be low in wound care performed using NPWT. In addition, the use of NPWT has also been shown to decrease the incidence of surgical wound complications by narrowing the wound and improving wound characteristics (Pelham et al., 2006; Stannard et al., 2009, 2012; Pachowsky et al., 2012; Suzuki et al., 2014; Matsumoto and Parekh, 2015; Redfern et al., 2017), improving quality of life for accelerating wound healing (Manoharan et al., 2016), does not require the replacement of repeated dressings (Mendame Ehya et al., 2017), does not cause pain in the sufferer (Mendame Ehya et al., 2017), accelerates the return of motion function (Stannard et al., 2009; Mendame Ehya et al., 2017), preventing the occurrence of fistula and purulent inflammation (Pachowsky et al., 2012; Obolenskiy et al., 2013), shortening the patient’s LOS in the hospital (Hansen et al., 2013), decrease the amount of exudate (Hansen et al., 2013), is quite efficient in the use of cost (Hansen et al., 2013), does not require re-operation (Karlakki et al., 2016), prevent colonization that may cause infection (Stannard et al., 2009, 2012; Zhang et al., 2016; Helito et al., 2017),
Clinical evidence from case study and cohort study results, the majority of the results indicate that the effect of NPWT use can reduce the size of the wound and help the wound healing process. The prospective randomized trial of patients with chronic post-arthroplasty, non-healing injury by comparing NPWT use showed that 64% of patients treated with NPWT (VAC system) showed good tissue granulation while 81% of patients treated with conventional dressings showed inflammation and fibrosis in the wound tissues. (Pelham et al., 2006; Stannard et al., 2009, 2012; Pachowsky et al., 2012; Suzuki et al., 2014; Matsumoto and Parekh, 2015; Redfern et al., 2017).

5 DISCUSSION

Arthroplasty has the most wound healing problem after surgery compared to other surgical techniques such as implants. Many post-operative wound healing events are elongated. Many factors that affect the wound healing process include an incision, decreased vascular perfusion, diabetes mellitus, kidney disease, immunocom-promised (Matsumoto & Parekh, 2015; PRedfern et al., 2017; Stannard et al., 2012; Stannard, Volgas, Stewart, McGwin, & Alonso, 2009; Suzuki, Minehara, Matsuura, Kawamura, & Soma, 2014).

In terms of financing, the use of NPWT and Conventional Therapy (moist gauze) also showed no significant difference. The results of the Dutch study conducted by Manoharan (2016) show that there are differences but not significant between NPWT and Conventional Therapy, ie for NPWT the required cost is Australian $ 48.70 and for Conventional Therapy is Australian dollar $ 43.51 (Manoharan et al., 2016).

However, consideration in the application of this method is the result of Randomized Controlled Trial (RCT) research on the safety and effect of NPWT on pressure ulcer wounds, diabetic foot ulcers, miscellaneous chronic wounds indicates that of the many studies it states that NPWT is safe and serious side effects rarely reported and also more effective than the usual standard therapy.

Nursing Implication and Recommendation

Nurses need to be aware of the following issues including infections, potential bleeding, use of anticoagulant therapy, malignancy, patient compliance, offloading and ambulation at home. If there is an infection in the wound area, then debridement therapy and antibiotics are the main therapies. NPWT is merely an adjuvant therapy. Potential bleeding may occur, so strict monitoring of the drainage of fluid out of the container is required. If excessive bleeding occurs, the use of this method should be discontinued.

Use of NPWT in patients receiving anticoagulant therapy should be of concern to doctors and caregivers. If bleeding occurs, negative pressure should be lowered and if the bleeding continues after a drop in pressure, treatment should be discontinued. In the case of malignancy, this therapy is not indicated because it can increase the growth of cancer cells. In addition, patient compliance during the use of the tool in this therapy is very important, because the patient must still do the ambulation well, and much rest. In diabetic ulcers patients who have dementia therapy is also very effective but must be supervised.

6 CONCLUSION

The use of NPWT for the treatment of chronic wounds such as postoperative wounds that require a long healing process, very effective if done using NPWT with the latest modifications such as the use of PHMB, Instillation, closed incise, and others. However, it should be underlined that the cost will be spent on the use of NPWT is more expensive than normal dressing. On the other hand it accelerates the healing process of the wound, if the wound heal quickly then it will also cut the cost of prolonged care. The nurse in this case plays a role to provide an offer to the client regarding the choice of intervention that suits his needs and abilities.

REFERENCES


Table 1. Characteristic of included articles

<table>
<thead>
<tr>
<th>No</th>
<th>Author</th>
<th>Study Design</th>
<th>Sample</th>
<th>Intervention</th>
<th>Control/Comparison</th>
<th>Outcome measured</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Matsumoto &amp; Parekh (2015)</td>
<td>Retrospective cohort study</td>
<td>N=74 participants with TKA</td>
<td>continuous -80 mm Hg negative pressure for 6 days postoperatively</td>
<td>conventional nonadherent gauzedressing</td>
<td>Wound healing (dehiscence, eschar, drainage) and surgical site infection menurut criteria Center for Disease Control and Prevention</td>
<td>On 9 patients (24%) experience in wound healing problems in the control group and 1 (3%) in the incisional NPWT group. Incisional NPWT was found to reduce wound healing problems with an odds ratio of 0.10 (95% CI 0.01-0.50; P = .004).</td>
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<td>2</td>
<td>Redfen et al (2017)</td>
<td>Prospective cohort study</td>
<td>N = 400 post operative patients</td>
<td>Closed incision negative pressure therapy (ciNPT)</td>
<td>Traditional gauze dressing</td>
<td>Surgical site complication</td>
<td>The rate of deep infection was unchanged in the ciNPT group compared with control (1.0% vs 1.25%); however, the overall rate of infection (including superficial wound infection) decreased significantly (3.5% vs 1.0%, P = .04). Overall complication rate was lower in the ciNPT group than controls (1.5% vs 5.5%, P = .02).</td>
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<td>3</td>
<td>Manoharan et al (2016)</td>
<td>Prospective cohort study</td>
<td>N = 33 patients who done knee arthroplasty</td>
<td>Negative pressure wound therapy (NPWT)</td>
<td>Conventional dry dressing (CDD)</td>
<td>Quality of Life, Wound complications, and total cost</td>
<td>There was no wound complications in the intervention group, and wound protection was more favorable in the intervention group than in the control group. More costs were spent when using NPWT than CDD and there was no significant difference in quality of life in both groups.</td>
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<td>4</td>
<td>Ehya et al (2017)</td>
<td>Prospective and randomized study</td>
<td>N = 51 patients 17 dan 34 patients randomly divide to two groups intervention and control group.</td>
<td>VAC combined perforator flap technique</td>
<td>Conventional wound dressing (CWD)</td>
<td>Time of the first post-operative dressing change, pain visual analopical scale VAS, perforator flap infection rate, 95% perforator flap healing time and percentage of survived perforator flap.</td>
<td>There was no exudate at the opening of the first dressing in the VAC group, and the 2 participants’ surface exudate in the control group.</td>
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<td>5</td>
<td>Obolenskiy et al (2013)</td>
<td>Quasi experimental- one group study</td>
<td>N = 58 patients who experience wound complication after</td>
<td>Negative pressure wound therapy (NPWT)</td>
<td>-</td>
<td>Recurrent fistula and purulent inflammatory process</td>
<td>Out of a total of 58 patients only 7 people were given NPWT and 3 of them had no recurrent fistula within 2-8 weeks.</td>
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<td>No</td>
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<td>6</td>
<td>Karlakki et al</td>
<td>Non-blind RCT</td>
<td>N = 220 patients who done TKA or THA</td>
<td>Incisional negative pressure wound therapy dressings (iNPWTd)</td>
<td>Conventional dressing</td>
<td>Wound complication, wound exudates, LOS, dressing change, cost effectiveness</td>
<td>LOS reduction was not significant in both groups. Wound exudates decreased significantly in the control group, and significantly decreased in the intervention group. More dressing changes were performed in the control group than in the intervention group (NPWT).</td>
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<td>7</td>
<td>Hansen et al</td>
<td>Prospective cohort study</td>
<td>N = 109 post operative arthroplasty patients</td>
<td>Negative pressure wound therapy (NPWT)</td>
<td>-</td>
<td>Rate of wound Complications, further surgery</td>
<td>Eighty-three patients (76%) had no further surgery and 26 patients (24%) had subsequent surgery: 11 had superficial irrigation and debridement (I&amp;D), 12 had deep I&amp;D with none requiring further surgery, and three ultimately had component removal.</td>
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<td>8</td>
<td>Pachowsky et al</td>
<td>Prospective randomized</td>
<td>N = 19 patients randomly divide to two groups intervention and control group.</td>
<td>Negative pressure wound therapy (NPWT) group B</td>
<td>Standard dressing group A</td>
<td>Postoperative seromas on the fifth and tenth postoperative days using ultrasound</td>
<td>Ten days after surgery, group A (ten patients, 70.5 ± 11.01 years of age) developed seromas with an average size of 5.08 ml and group B (nine patients, 66.22 ± 17.83 years of age) 1.97 ml. The difference was significant (p=0.021).</td>
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<td>9</td>
<td>Helito et al</td>
<td>Long-term randomized prospective study</td>
<td>N = 10 patients TKA infection with or without dehiscence and post operative patients with infection risk factor</td>
<td>Negative pressure wound therapy (NPWT) Pico device</td>
<td>-</td>
<td>Wound infection and complications</td>
<td>The wounds experienced by all patients have no infections or complications, all showing the healing process.</td>
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<td>10</td>
<td>Suzuki et al</td>
<td>Restropective study</td>
<td>N = 10 men and 4 women who done open fracture fixation</td>
<td>Negative pressure wound therapy (NPWT) 125 mmHg</td>
<td>-</td>
<td>Outcome dari NPWT terhadap luka operasi</td>
<td>The average use of NPWT is 9 days for surgical wound healing, maceration of the skin can sometimes appear as a side effect although not every time</td>
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