Review

The Effectiveness of NPWT on Burns in Children: A Literature Review

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ABSTRACT
Burns is a global public health problem, and it is estimated that burns cause 180,000 deaths every year. There are many known wound care techniques, especially in the world of health, which are now constantly developing better by technological developments, consumer demands, and the development of related diseases. Negative Pressure Wound Therapy (NPWT) is a non-invasive therapy that promotes granulation and wound closure. This study aimed to prove the effectiveness of NPWT against burns in children. This study used a literature study approach with a descriptive review type. Based on the search results, seven articles were obtained using keywords, and papers were received from science direct, PubMed, and google scholar. The seven articles were published between 2014-2020, with the research method of each article being a randomized controlled trial and a retrospective study. Based on the results of several research articles, it was found that NPWT (Negative Pressure Wound Therapy) has been proven to be effective in treating burns in children.

Introduction

Burns is a global public health problem, and it is estimated that burns cause 180,000 deaths every year. Most of these occur in low to middle-income countries, and nearly two-thirds occur in the Africa and Southeast Asia region (WHO, 2018). Burns can occur at home and work. Surveys conducted in Bangladesh and Ethiopia show that 80-90% of burns occur at home. Children and women usually experience burns while in the kitchen, exposed to hot liquids and flames or explosions from stoves (WHO, 2018). Based on data from RSCM (Cipto Mangunkusumo Hospital) in 2012-2016, the highest causes of burns were fire (53.1%), hot water (191%), electricity (14%), chemistry (3%), most children occur because of hot water (52%), fire (26%), electricity (6%), chemistry (1%) (Ministry of Health, 2019). Burns is the fifth most common cause of childhood injury. As many as 17% of the total incidence of burns occurred in children (ABA, 2018). The leading causes of burns in children are improper adult supervision and child abuse (WHO, 2018). Children have thinner skin than adults, so it is easier to lose fluids and electrolytes, so there is a greater likelihood of hypothermia (Azizah, 2017). According to the research of Toon et al., The mortality rate for children aged ≤four years is relatively high in burns due to immature immunity, high fluid requirements, so that they are at risk of experiencing sepsis and hypovolemic shock (Cindy et al., 2018).

Generally, there are many known wound care techniques, especially in the world of health, which are now constantly developing better by technological developments, consumer demands, and related diseases. In Indonesia, one of the commonly used wound care techniques is conventional wound care. Still, traditional wound care has several drawbacks, including the length of time for revitalization, compared to wound care with NPWT (Rohman et al., 2015).

The development of this technology can be in the form of advances in medical devices with a technological context or medical devices that are not in a technical context but are raised because of the development of technology itself, for example, Negative Pressure Wound Therapy / Vacuum-Assisted Closure (VAC). This negative pressure technique has developed rapidly and is now widely used in various countries, especially in Western European countries (Germany) and the United States (Santy, 2013).

Negative Pressure Wound Therapy (NPWT) is a non-invasive therapy that promotes granulation and wound closure. Since its first application in 1995, NPWT has been shown to improve wound closure by creating a vacuum through a sterilized occlusive dressing over the wound site. Negative pressure is usually maintained between -50 mmHg and -125 mmHg based on wound conditions. The vacuum maintains a pressure gradient that increases blood flow and immune cell recruitment. Antibiotics and salts can be applied therapeutically under certain circumstances. NPWT has been used for acute and chronic wounds, including chronic ulcers. Compared to conventional treatment with moist wound therapy, negative pressure therapy shows a higher rate of wound closure and a lower risk of bacterial infection (Yen, Chang, and Sheridan, 2017). This study aimed to prove the effectiveness of NPWT against burns in children.

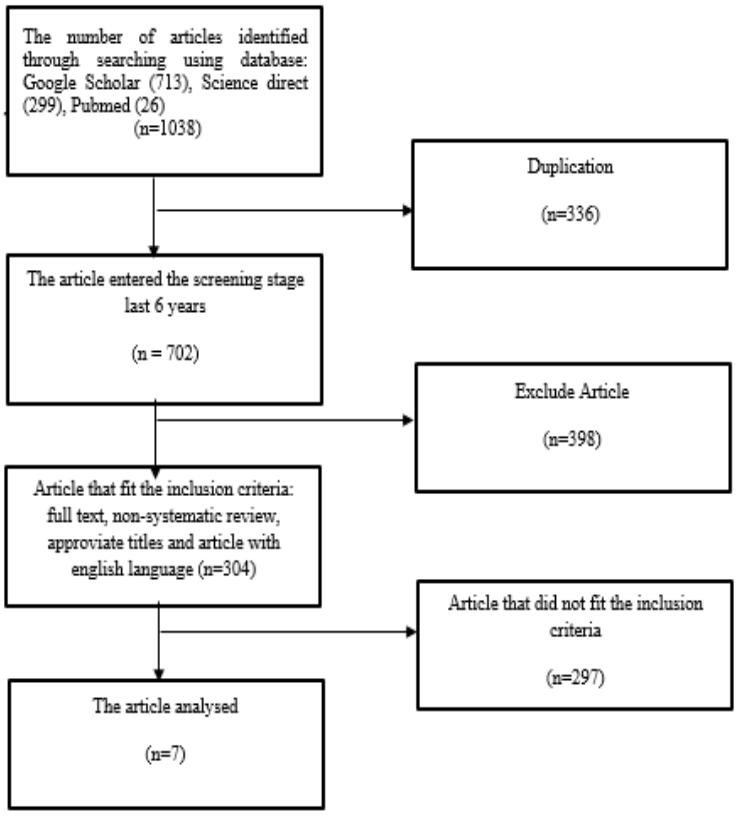
Method

This study used a literature study approach with a descriptive review type. The articles used were of international origin with a span of years from 2014-2020. The databases used were Google Scholar, PubMed, and Science Direct. The strategy used to search the literature was by

using the keywords "NPWT" AND "burn injury" AND "pediatric". The inclusion criteria in this study were full text and articles on the effectiveness of NPWT on burns in children. In contrast, the exclusion criteria are articles with the type of systematic review. Filtering the literature used keywords, namely "NPWT, burn injury, pediatric", spanning the years 2014-2020, with the type of full text and articles in English so that the results are seven articles.

Results

The researchers obtained articles from Science Direct, Pubmed, and Google Scholar based on the search results using keywords. After that, the authors selected papers using inclusion and exclusion criteria and obtained seven articles. Of the seven articles chosen for this literature review, the research method of each study was a randomized controlled trial and a retrospective study. The seven papers were published between 2014-2020, conducted in various countries: America, Australia, Austria, Brazil, the United States of America (Hawaii and Missouri), and France. The authors read carefully from the abstract, objectives, research methods, samples, and research results.



No	Article	Purpose	Method design	Population and sample	Results
1	Treatment of burned children using dermal regeneration template with or without negative pressure	Evaluating the results obtained from burns treatment with the Dermal Regeneration Template (DRT) combined or not with Negative Pressure Wound Therapy (NPWT) for the management of pediatric patients who are victims of burns.	Retrospective study	**Population:** Children with burns, treated with DRT, with or without NPWT **Sample:** 40 pediatric patients with burns	- In the group that only used DRT, the average DRT take rate was 85% with an average maturation time of 17.65 days and an average skin graft take of 85.2%. - In the group using DRT plus NPWT, the mean DRT take rate was 99.8%, with a mean maturation time of 16.68 days and an average skin graft rate of 89.1%. - NPWT in combination with DRT offers a higher success rate in the treatment of complex wounds caused by burns, increases the DRT Take Rate, increases the maturation time of the DRT, and increases the speed of skin graft integration.
2	Negative wound pressure therapy is safe and useful in pediatric burn patients	Knowing the effectiveness of NPWT in children with burns or soft tissue trauma	Retrospective Review	**Population :** Child with burns **Sample :** 29 children, 12 girls and 17 boys	- The average percentage of total burned area is 28% and the percentage of 3rd degree burns is 20% - NPWT is able to speed up the wound granulation process and reduce the number of dressing changes. Of all the children, no bleeding occurred and all the patient's wound granules were successfully grafted and all survived.
3	A retrospective analysis of securing autologous split-thickness skin grafts with negative pressure wound therapy in paediatric burn patients	Provides an overview of autologous split-thickness skin grafts (ASTSGs) fixation in burns with negative pressure wound therapy (NPWT) in pediatric patients.	A retrospective review	**Population:** 458 children with superficial burns to full thickness **Sample:** 53 pediatric patients with burns	- TBSA from deep skin thickness to full thickness burns (IIb-III8) was an average of 4.0% (2.0-6.0%). - TBSA treated with ASTSG and NPWT was med 3.5% (2.0-6.0%). - The main advantages of NPWT over conventional fixation methods for pediatric patients are speed of skin graft collection and early mobilization. Especially in the age group of children who are less cooperative in administering the procedure, a strong and safe skin graft fixation is the safest thing to do.
4	Randomized clinical trial of negative pressure wound therapy as an adjunctive	Comparing Acticoat and Mepitel with dressings that combined Acticoat, Mepithelial and continuous NPWT on	Randomized Controlled Trial	**Population :** Child with burns **Sample:** 114 samples of children.	- The mean length of time to reepithelise wounds was 8 days in the intervention group and 10 days in the control group. However, the addition of additional dressings also increases the cost of treatment.

	treatment for small-area thermal burns in children	burn epithelialization in children.		With inclusion criteria aged less than 17 years with TBSA <5%	
5	Judul : Inpatient Versus Outpatient Management of Negative Pressure Wound Therapy in Pediatric Patients	To improve the population-level approach to comparing the indications for NPWT, pre-existing adverse conditions and incident complications after the initiation of NPWT, use of health care after NPWT, and the cost profile of using NPWT in pediatric patients who are treated primarily as outpatients.	A Retrospective Analysis	**Population :** Inpatients or outpatients aged 0-18 years with a condition requiring wound care **Sample :** 3184 children and infants	- After 30 days of observation, it was found that the incidence rate of complications in outpatients had a lower complication rate (2.4%) after the initiation of NPWT in children
6	Negative Pressure Wound Therapy in children: A 25 cases series	To clarify the indications for NPWT in children through 25 series of cases.	Retrospective study	**Population :** 25 children between 2004 and 2019. **Sample :** all children with wounds treated with Negative Pressure Wound Therapy	- Mean age is 8.8 years. The context of the occurrence of injuries was mainly on the road (44%) or household accidents (36%). - Substance loss was mainly in the lower limbs (84%). - Depression applied is 90 mmHg. - The healing time is 18.4 days. - Thin skin grafting was the main method of choice (88%). - There are no complications associated with NPWT equipment. - NPWT is a simple and effective technique for children
7	Negative pressure dressing assisted healing in pediatric burn patient	To provide a related review of the use of NPWT on children's burns	Retrospective study	**Population :** Hospitalized pediatric burns patient **Sample :** 22 patients	- The mean patient was 3.5 years (range 8 months to 10 years) with partial thickness burns covering 8.5% (range 3-18%) of body surface area. The median treatment regimen was 3.5 dressing changes over 6.6 days, with a mean hospital stay of 9.6 days. On average the children received 9.4 total doses of narcotics administered during hospitalization. - NPD is a viable option for partial and full thickness burns in pediatric patients who do not require transfer to a burn unit.

Discussion

Negative Pressure Wound Therapy (NPWT) refers to the application of negative pressure to wound care. This technology appeared around 1980 and consisted of applying a dressing (usually foam or gauze) to the wound, then sent through a hose to a vacuum pump. The area is covered with an adhesive film and a pump that applies controlled negative pressure to the entire area of the wound bed. The Centers for Medicare and Medicaid Services (CMS) define NPWT as applying subatmospheric pressure toward wounds to remove exudate and dirt and through an integrated system consisting of a suction pump, separate exudate space, and dressings specific wounds. The goals of NPWT are to heal wounds, improve wound bed granulation, and assist surgical closure of wounds (Rhee et al., 2014).

Before installing the NPWT, the wound area must be cleaned and rinsed with normal saline, and the skin around the wound is made dry. Sterile foam is used for dressings because it provides an even distribution of negative pressure over the entire wound bed. Two types of foam are commonly used black and white foam. Black (Polyurethane ether, larger porous, hydrophobic with a pore size 400–600mm) is used for chest and abdominal wounds; meanwhile, white foam (polyvinyl alcohol, solid porous, hydrophilic with a pore size of 250 mm) is used for superficial surface wounds. An evacuation tube is attached to the foam then to the vacuum pump. The wound is then covered with an adhesive protective bandage. The protective bandage must cover the foam and pipe and at least 3–5 cm of healthy tissue around it to ensure an airtight/airtight seal. The dressings are usually changed on the 3rd day.

Negative pressure resistance for adults (−125 mmHg) is commonly used for children ≥four years of age. But for preterm infants, neonates, children ≤three years, and open wounds subjected to lower negative pressure. A pressure of −50 mmHg is given to preterm infants and −75 mmHg for neonates and children aged ≤three years; this has been accepted empirically (de Jesus et al., 2018). Negative pressure mode can be continuous or intermittent. The intermittent method consists of cycles 5 minutes on and 2 minutes off phase. They were keeping pressure settings in low pressure, especially for chronic, painful wounds. Higher pressure is used for large wounds and exudative wounds (Argawal et al., 2019). After the NPWT is placed on the injured limb, nurses should palpate the distal pulse to confirm circulatory patency and check whether the patient feels tingling or numbness. If any pus or bleeding underdressing or in the tube, there is a problem with the protective coating.

Based on the search for articles, there were six articles on the effectiveness of NPWT therapy in healing wounds in children. The authors found two components in seven articles, namely NPWT without and NPWT with combination therapy. A total of 5 articles use NPWT without a combination (Pouzt, 2020; Ren, 2017; Santosa, 2020; Koehler, 2014; Hoeller, 2014), and two articles use NPWT in combination (Frear, 2020; Pereima, 2019). From 2 NPWT articles with a combination of acticoat mepithelial dressings and Dermal Regeneration Template installation.

Santosa (2020) conducted a study on 3,184 children and infants who needed wound care was designed with a retrospective analysis study design. Mentioning that NPWT in children who need outpatient wound care impacted the low complications caused. The intervention was carried out in 2 groups for 30 days of treatment. The inpatient group at the hospital was given NPWT with a combination of sedation and anesthesia. In that group, there were several who had complications compared to the outpatient

group. They did it in a large sample size that explained the NPWT intervention provided, not a detailed study.

Research conducted by Ren (2017) showed that NPWT could accelerate the wound healing process and reduce dressing changes. The intervention was first to clean all necrotic wounds, and then the NPWT could be installed by applying a negative pressure of 50-125 mmHg. Dressing changes are done every 5-7 days. The study was conducted based on authentic specialties and with a severe case rate in children and was carried out safely and effectively, but the sample used in this study was still small.

Another study conducted by Pouzt (2020) states that NPWT therapy in children with wounds accelerates healing time and minimizes complications. The intervention was carried out by cleaning the wound until it was clean, then installing an NPWT with a pressure of 90 mmHg. Change of dressings every three days. The results of this study indicated that the average wound healing rate was 18.4 days and without complications.

A retrospective study by Koehler et al. (2014) analyzed the medical records of 22 children who experienced partial-thickness burns, showed that the NPWT affected the average treatment regimen, dressing changes during, and the length of hospitalization. In this study, the pressure applied was -120-125mmHg for most of the patients. One was set to 120mmHg intermittent suction for the remaining three patients, and two were set to continuous -70-75mmHg. Dressing changes occur every 2-4 days. No data were available retrospectively on the reasons behind choosing a negative pressure setting. Patients were classified as a whole based on the thickness of their burns (partial or complete) and whether they required further skin grafting. Negative Pressure Dressing is a viable option for partial and full-thickness burns in pediatric patients who do not require transfer to a burn unit.

Furthermore, Hoeller et al. (2014) researched 53 pediatric patients with burns or wounds associated with burns who were given NPWT therapy with a continuous negative pressure mode of 70–125 mmHg. This study shows that NPWT therapy has developed into a constant, well-applied, and valuable tool in securing ASTSG to the wound bed. The main advantages of NPWT over conventional fixation methods for pediatric patients are speed of skin graft collection and early mobilization. Particularly in age groups where adherence difficulties are desirable, such as in infants and toddlers, firm and safe skin graft fixation and high likelihood of patient mobility are of the utmost importance for the overall treatment outcome.

In addition to providing NPWT therapy independently, NPWT therapy can also be combined with other interventions, and it is proven that NPWT has a good effect when combined with other interventions. Frear et al. (2020) conducted a randomized controlled trial study of 114 children with burns degrees 2A and 2B. That study showed that giving NPWT combined with acticoat and mepithelial to children who experienced burns could accelerate the average length of time for wound reepithelialization compared to those who did not receive NPWT therapy. In this study, the sample was divided into two groups (control and intervention). In the control group, standard dressing intervention was performed, while in the intervention group, the wound dressing was combined with acticoat and mepithelial. Wearing For burns in the extremity area of children <12 years of age, it is 40mmHg. The sample re-treated the burn every 3-5 days until closure occurred in the wound area.

A retrospective study conducted by Pereima et al. (2019) analyzed the medical records of 44 children in partial-thickness burns (3 people), total thickness (40 people), and total deep thickness (1 person). That study showed that the Dermal Regeneration Template grafting combined with the administration of NPWT with pressures ranging from 80-125mmHg has a higher success rate in treating complex wounds. Those complex wounds caused by burns, increasing the DRT Take Rate, accelerates the maturation time of DRT, and increases the speed of skin graft integration compared to children who have only Dermal grafting Regeneration Template without NPWT combination.

Based on the article search results, seven articles regarding the effectiveness of NPWT therapy in healing partial-thickness burns in children. The seven articles state that NPWT therapy is effective in healing wounds in children, one of which is burns (Frear, 2020; Pereima, 2019; Pouzt, 2020; Ren, 2017; Santosa, 2020; Koehler, 2014; Hoeller, 2014). The standard of the effectiveness of NPWT therapy is seen based on the duration of wound healing, the period of dressing changes, the time of hospitalization, and the complications that arise.

Partial-thickness burns are always accompanied by excess fluid buildup and microcirculation disorders. This condition is ideal for being a medium for microbial colonization. NPWT on burns can remove excess fluid containing pathogenic mediators and microorganisms, reduce edema and increase tissue perfusion, which aids wound healing and stops the expansion of necrosis. Another thing is when compared with conventional dressings, which have a frequent dressing change frequency, especially when the amount of exudate in the wound is large, plus the pain that arises from changing dressings. The use of NPWT can minimize dressing changes so that NPWT can reduce the incidence of pain. It makes NPWT suitable for children. In 2003, the US Food and Drug Administration approved the use of the NPWT system in the treatment of partial-thickness burns (Nagy & Juhász, 2015).

Based on the results of research conducted by Hoeller et al. (2014), children with burns who use NPWT therapy are faster in subsequent recovery procedures, namely skin grafts, and early mobilization. In addition, Pereima et al. (2019) showed the success rate of healing burn patients with the use of NPWT is higher. It can increase the DRT Take Rate rate, accelerate the maturation time of the DRT, and increase the speed of skin graft integration compared to children who only have Dermal Regeneration Template grafting without the NPWT combination. NPWT therapy has also been shown to create a moist wound environment while reducing edema, encouraging blood flow to the wound, increasing granulation tissue formation, and stimulating angiogenesis, thereby decreasing the wound surface area (Nuutila, 2019).

Another advantage of NPWT is that it can stimulate physical cell growth by increasing angiogenesis. Angiogenesis and matrix deposition that occur after injury are seen as granulation tissue in new capillary formation. The matrix will be formed by molecules whose structure is produced by fibroblasts and will provide support in the formation of granulation tissue, and this will maximize the growth of new cells. NPWT also makes wound healing more optimal. It works by providing a moist environment, removing exudate that comes out of the wound so that excess protease enzymes in the exudate are also wasted (Santy, 2013). The balance of protease activity plays an essential role in wound healing. It works by having a vital role for vasoconstriction, increased membrane permeability, increased coagulation, leukocyte

adhesion, chemotaxis, migration, killing bacteria, eliminating tissue debris, stimulating inflammatory responses, and increasing growth factor activity. In acute wounds, protease inhibitors play a role in regulating protease activity so that there is a balance of protease activity in wound healing. Still, there is an excess of oxidants in chronic wounds, which will create an increase in protease. The results of excessive protease enzyme activity can cause the degradation of collagen, proteoglycans, and hyaluronan. It delays wound healing (Arief & Widodo, 2018).

NPWT is also considered to have a minimal risk of complications or infection in the patient (Pouzt, 2020). Because the wound care system using NPWT therapy reduces the frequency of clothing, the wound site will not be exposed. Besides that, NPWT can provide a positive wound environment by removing metalloproteinases in wound exudates and cleaning microorganisms to reduce infection rates; NPWT also improves microvascular circulation better to reduce bacterial colonization (Lin, 2020).

Conclusions

Based on the results of several research articles, this study found that NPWT (Negative Pressure Wound Therapy) has been proven to be effective in treating burns in children. The effect of using NPWT on the healing process of burns in children is accelerating the maturation time of DRT (Dermal Regeneration Template), reducing complications that arise, accelerating the wound healing process. NPWT is safe for children related to the mobilization of children who are not obedient during wound care. The data found that the effect of pressure exerted and the frequency of changing wound dressings also greatly influenced the effectiveness of NPWT. The article found that the average use of pressure started from 50-125 mmHg with an average frequency of changing wound dressings of 2-7 days until the wound closure process occurred. In addition, the use of other combinations with NPWT is proven to increase the work effectiveness of NPWT, one of which is the combination with acticoat mepithelial; this combination will accelerate the average length of time for wound revitalization.

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