Negative Pressure Wound Therapy with instillation in the management of a patient with a stage IV pressure injury



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Objective: To evaluate the efficacy of integrated Negative Pressure Wound Therapy with instillation (NPWTi) on a stage IV pressure injury for a patient with a 10-year history of diabetes mellitus. **Methods:** A patient with diabetes mellitus and a stage IV pressure injury was admitted to the medical department. The TIME concept was followed to assess the wound. An automated volumetric wound cleansing solution integrated with NPWTi was applied post-op after debridement. **Results:** Visible granulation of the wound bed was seen. Undermining, tunneling, bone and tendons were sealed as the granulation tissues proliferated. Sloughs and necrotic tissues were reduced, the wound bed appeared beefy red, moist and the wound edges progressively became smaller at each cycle of dressing change. After 6 weeks of continuous efforts, the wound had granulated well enough for skin grafting. **Conclusion:** The use of NPWTi quickens the process of wound healing and enhances patients' quality of life.

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Diabetes is a major cause of morbidity for patients undergoing surgery and can increase the incidence of some postoperative complications such as pressure injury (Liang et al, 2017). Pressure injury, also known as pressure ulcer, is a common cause of a prolonged length of hospital stay for patients with surgery. It has been reported that the length of hospital stay of surgical patients could increase by 3.5–5 days on average when a pressure injury occurs (Suzman et al, 2015; World Health Organization, 2016). For some severe cases, the length of stay for pressure injuries could even be longer than 15 days (Flacker, 2003), which can add a tremendous financial burden for the patient and healthcare facility.

In the US, pressure injuries are one of the most prevalent health conditions. Annually, the Agency for Healthcare Research & Quality (AHRQ) projected that more than 2.5 million people in the US will develop pressure injuries. This will, subsequently, elevate the cost of the medical management for pressure injury to the US healthcare system from $9.1 billion to $11.6 billion per year. A single hospital stay due to pressure ulcer may incur additional annual charges of up to $700,000 (AHRQ, 2015). Cost of treatment for stage III pressure injury may range between $5,900 and $14,840; while for stage IV pressure injury, it ranges from $18,730 to $21,410 (Leaf Healthcare, 2016).

A handful of risk factors and aetiologies have been postulated to contribute to the development of pressure injuries during the perioperative period, including patients who are advanced in age, suffer from malnutrition (lower levels of haematocrit or albumin) or poor circulation or smoke (Lindgren et al, 2004; Theou et al, 2013; Jaul, 2010; 2014). Other factors such as anaesthesia and type of surgery, length of surgery, patient position during the surgery, warming or moisture devices used, and padding type the patients used (Inouye et al, 2007; Vanderwee et al, 2007; Lyder and Ayello, 2009; Black et al, 2011) could also contribute in the development of pressure injury.

Numerous studies have explored the role of patients with pre-existing diabetes on the development of pressure injury (Liang et al, 2017). Despite the fact that some studies have reported significant association between diabetes and risk of surgery-related pressure injury, some others have reported varying results on this association. It was noted in several studies that surgical patients with diabetes had higher risk of pressure injury than those without diabetes (Allman et al, 1999; Bouten et al, 2003; Bennett et al, 2004; VanGilder et al, 2009; Coleman et al, 2014; Thomas et al, 2013; Buttorff et al, 2017), while still others showed null association (Davis and Caseby, 2001; Margolis et al, 2003; Kaitani et al, 2010; Lyder et al, 2012; Jaul and Calderon-Margalit, 2013). Although two previous meta-analyses have explored this topic and found significant association between diabetes and surgery-related pressure injury (Cox, 2017; Komici et al, 2017), limited sample size and significant heterogeneity, which was not sufficiently examined, made the results less reliable. Therefore, there is an urgent need to update the evidence of association between pre-existing diabetes and surgery-related pressure injury.

Much of the current focus regarding this public health issue is centred on the importance of prevention. Prevention and management of pressure ulcers require an interdisciplinary approach (AHRQ, 2015). As the AHRQ pressure ulcer toolkit exemplifies, many healthcare systems are implementing improved care plans to deliver coordinated, high-quality care to patients with or at risk of developing pressure injury (AHRQ, 2015).

Negative pressure wound therapy

Fleischmann et al (1998) introduced NPWTi for septic wounds that failed to respond to conventional therapy. Over the last decade, vacuum-assisted closure (VAC) has been established as an effective wound care modality for managing complex acute and chronic wounds. The therapy has been widely used by clinicians to treat many other wound type. The therapy is currently being used to manage infected and critically colonized, difficult-to-treat wounds. This growing interest, coupled with practitioner uncertainty in using the therapy in the presence of infection, prompted the convening of an interprofessional expert advisory panel to determine appropriate use of the different modalities of NPWT and different dressings (Gabriel et al, 2009).

NPWT is intended to create an environment that promotes wound healing by secondary or tertiary (delayed primary) intention by preparing the wound bed for closure, reducing oedema, promoting granulation tissue formation and perfusion, and by removing exudate and infectious material. Instillation therapy is indicated for patients who would benefit from vacuum-assisted drainage and controlled delivery of topical wound treatment solutions and suspensions over the wound bed.

Adjunct with the benefits of NPWT, introduction of topical wound solutions assists in wound cleansing, i.e. removal of debris, exudates, infectious agent and bioburden. With the repetitive cycle of NPWT and automated instillation of topical wound solutions into the wound bed, it is shown that this mechanism of action promotes granulation tissue formation while providing a moist wound healing environment. During the instillation phase, antiseptic solution is slowly introduced to the crevices of the wound and remains in the wound bed for a defined period of time before the negative pressure phase is initiated. Instillation helps with wound cleansing by loosening soluble contaminants in the wound bed, followed by subsequent removal of infectious material during NPWT. As a result, soluble bacterial burden can be decreased, contaminants and biofilms removed and the wound cleansed. It also improves pain management through delivery of analgesic solutions directly to the wound bed.

The V.A.C.Ulta™ NPWT system (KCI Licensing, Inc, San Antonio, TX) is an integrated wound management system that provides VAC therapy with the added option of delivering instillation using V.A.C. VeraFlo™ Therapy. It is indicated for patients with chronic, acute, traumatic, subacute and dehisced wounds, partial-thickness burns, ulcers (caused by diabetes, pressure and venous insufficiency), flaps and grafts. The V.A.C.Ulta™ NPWT system provides a variety of therapeutic options to allow for wound healing customization and a flexible approach to wound care.

Objective

To evaluate the efficacy of integrating NPWTi on stage IV pressure injury for a patient with a 10-year history of diabetes mellitus.

Case study

A 64-year-old lady with a 10-year history of diabetes mellitus was admitted due to a stage IV pressure injury. A series of wound debridement and all advanced wound dressings were tried but the wound continued to deteriorate. Wound assessment was performed, following the TIME concept. The patient was brought to the operation theatre as there is hardened slough and necrotic tissues present on the wound *[Figure 1]*. The patient's wound was cleansed and soaked with a wound cleansing solution containing polyhexanidemethyle biguanide (PHMB) and betaine for the first week; and normal saline for the second week. Desloughing and sharp debridement were done by the wound care team. The dressing foam was then applied directly onto the wound bed. The setting of the pressure was -125 mmHg. Dressings were changed every 5 days. After more than a month's cycle of NWPTi, the wound was visibly much better in terms of wound bed preparation *[Figure 2]*.

Results

Visible granulation of the wound bed was seen *[Figure 3]*. Undermining, tunneling, bone and tendons were sealed as the granulation tissues proliferated. Sloughs and necrotic tissues were reduced, the wound bed appeared beefy red, moist and the wound edges progressively became smaller at each cycle of dressing change *[Figure 4]*. An X-ray was done and showed no signs of osteomyelitis.

Figure 1. 02.06.2019 Post-Operation Day 1

Figure 2. 19.07.2019 Wound presented for NPWTi

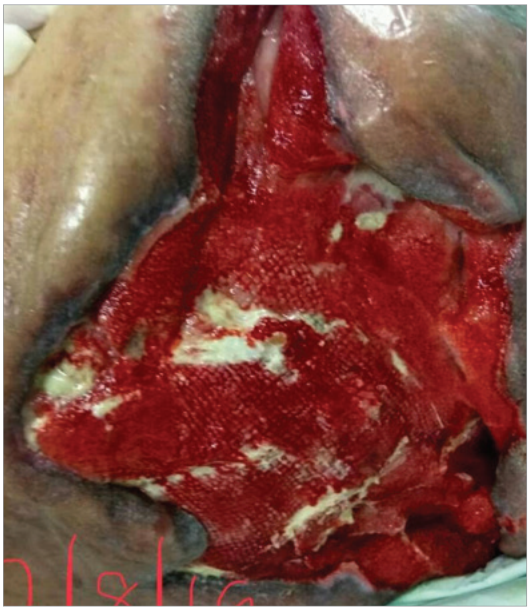

Figure 3. 12.08.2019 Wound inspection

Figure 4. 31.08.2019 Wound inspection

Discussion

Wound cleansing is performed on a regular basis by many healthcare professionals. However, the modern concept of cleansing has not always been a priority in wound management. There are many questions which challenge those responsible for cleaning wounds such as how often a wound should be cleaned and which techniques should be used (Williams, 1999).

NPWTi is increasingly used as an adjunct therapy for a wide variety of infected wounds. However, the effect of NPWTi on mature biofilm in wounds has not been determined. This case study assessed the effects of NPWTi using saline or various antimicrobial solutions on mature *Pseudomonas aeruginosa* biofilm using an *ex-vivo* porcine skin explant biofilm model. The treatment consisted of six cycles with 10-minute exposure to instillation solution followed by 4 hours of negative pressure at -125 mm Hg over a 24-hour period. NPWTi using saline reduced bacterial levels by 1-log (logarithmic) of 7-log total colony-forming units (CFUs). In contrast, instillation of 1% povidone iodine (2-log), L-solution (3-log), 0·05% chlorhexidine gluconate (3-log), 0·1% polyhexamethylene biguanide (4-log), 0·2% polydiallyldimethylammonium chloride (4-log) and 10% povidone iodine (5-log), all significantly reduced ($p<0{\cdot}001$) total CFUs. Scanning electron micrographs showed disrupted exopolymeric matrix of biofilms and damaged bacterial cells that correlated with CFU levels. Compared with previous case studies assessing microbicidal effects of topical antimicrobial dressings on biofilms cultured on porcine skin explants, these ex vivo model data suggest that NPWTi with delivery of active antimicrobial agents enhances the reduction of CFUs by increasing destruction and removal of biofilm bacteria (Schultz et al, 2010).

The use of lavage was compared to NPWTi to assess the extent of soft tissue damage, debris removal and environmental cross-contamination susceptibility in three distinct models. Scanning electron microscopy in an *ex-vivo* model showed increased visible tissue trauma from lavage treatment at low and high pressures versus NPWTi, with the degree of trauma relative to the pressure of the irrigant. These results were corroborated in granulating full-thickness excisional swine wounds coated with dextran solution to simulate wound debris. Both low-pressure lavage and NPWTi demonstrated effective cleansing in this model, reducing debris by >90%. However, using three-dimensional photography to evaluate tissue damage by measuring immediate tissue swelling (changes in wound volume and depth) showed significantly greater (p <0.05) swelling in low-pressure lavage-treated wounds compared with NPWTi-treated wounds. Lastly, benchtop wound models were inoculated with fluorescent bacterial particles to assess environmental cross-contamination potential and collected at measured distances after treatment with low-pressure lavage and NPWTi. No evidence of cross-contamination was found with NPWTi, whereas one-half of the particles became 'aerosolized' during low-pressure lavage (p <0.05). Collectively, these studies demonstrate the effective wound cleansing capabilities of NPWTi without the tissue damage and environmental contamination associated with lavage (Allen et al, 2010).

Conclusion

NPWTi is able to clean the wound with topical wound cleansers and remove infectious materials during the negative pressure cycle, thus preparing the wound for secondary closure and supporting the wound healing process. Because it is an enclosed system, the wound is protected from external contamination. NPWTi is an effective wound management therapy when used in conjunction with good wound healing management (e.g. debridement and antibiotics). WAS

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