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Article

Improved wound bed preparation using a mono-use disposable hydrodebridement tool - case studies

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Abstract. *Background*: Wound preparation and cleanliness represent the first steps towards effective healing. Debridement can be the most traumatic procedure for the patient when wound dressing is being carried out. It is important to choose appropriate techniques that aid the selective removal of non-viable tissue thereby reducing patients' physical and psychological trauma. Hydrodebridement with oxygenated saline solution is a selective mechanical debridement procedure, that exploits oxygen pressure in order to deliver a micro jet of solution which cleanses the wound bed and removes devitalized tissue.
Subjects and Methods: The Jetox™-HDC® system was teamed with a sterile saline solution (0.9%) and compressed medical oxygen with adjustable flow (9-15 L/min). The device is sterile, latex free, and simultaneously sucks up tissue residues. Three skin lesions with different etiology in two clinical cases were treated: Case 1 (male, age 55, diabetic) with one (1) ischemic lesion (20x11cm); Case 2 (female, age 87, diabetic, and bedridden) with two(2) pressure ulcers, (10x10cm and 4x7cm). We gauged any improvement in tissue oxygenation locally around the wound by monitoring the trans-cutaneous tissue oxygen pressure ($TcPO_2$) before and during hydro-debridement. *Conclusions:* The procedure was easy to use and generally well tolerated by patients. The device was suitable for outpatient treatment as well as for homecare. The debridement was capable of selectively removing of non-viable tissue and did not cause other vital tissue damage. In addition to improved wound bed preparation and better overall decongestion of the injured area, the use of the system was associated with an overall improvement in tissue oxygenation in the surrounding wound area. ($TcPO_2$-30mmHg, start of hydro-debridement – $TcPO_2$-44mmHg, end of hydro-debridement). This technique could be advantageous in the treatment of both ischemic wounds and pressure ulcers. The extent of tissue oxygenation produced by this procedure deserves further investigation in a statistically more relevant number of studies.

Keywords: Debridement, Hydro-debridement, Détersion mécanique, Desbridación mecánica, Desbridamiento de herida, Wound bed preparation.

Introduction

Wound bed preparation is the first step towards healing. It is important to proceed systematically by initially removing devitalized tissue, and collecting fluid secretions, and residues in order favor bacterial decapsulation and promote the expansion of granulation tissue.

Debridement, however, can represent the most traumatic procedure for the patient when the wound is cleaned and dressed and if it isn't carried out with due care or too invasively, may induce psychological trauma that can afflict the patient for years after[1]. With numerous technological and pharmacological wound-care alternatives available nowadays, it is essential to choose the most appropriate debridement technique in consideration of the clinical condition, whilst also taking into account the needs of the patient and the condition of the lesion. Those methods which also favor the selective removal of devitalized tissue should be preferred in order to reduce trauma for the patient.

Given its acceptable cost-effectiveness, this study evaluated the performance of the hydro-debridement tool Jetox™ - HDC® on three skin lesions with different etiology in two clinical cases.

Rationale

The presence of devitalized tissue in wounds, in addition to impeding cell regeneration, also promotes the development of bio-burden that can lead to infection, often chronic. The process of removing this bioburden and non-viable tissue is called debridement. This procedure can be direct (mechanical, enzymatic, autolytic) or indirect (negative pressure wound therapy, low frequency ultrasound, laser therapy) and it is one of the most important stages of wound care and healing[2,3].

The most rapid and effective of these methods is thought to be mechanical debridement or those devices which take advantage of new technologies (e.g. low frequency ultrasound)[4-6], but their use is limited not only by the high costs involved, but also because they are impossible to use in outpatient treatment or in homecare, and cause pain to the patient during treatment.

In the development of new techniques, attention is more frequently directed towards the removal of non-viable or compromised tissue, the effective removal of biofilm, and its ease of use.

The term *biofilm* was coined by Bill Costerton[7] in 1978, who defined it as a slimy extracellular matrix that is composed of extracellular polymeric substances[8]. Biofilm is a thick layer of prokaryotic organisms that have aggregated to form a colony. The colony attaches to a surface with a slime layer which aids in protecting the microorganisms. Its presence has an important role in bacterial infections associated with chronic wounds[9,10], it starts forming within a few hours, achieves maturation some 2-4 days after the first colonisation[11], and is difficult to diagnose using instrumental methods[12]. Aside from its protective action through various mechanisms (physical-chemical, structural architecture)[13] the bacterial load in wound environments hostile to the action of antibiotics, biocides and immune-competent cells, biofilm can sometimes make it difficult to identify the germ colony in traditional bacterial culture[14].

Biopsy is often considered as one of the most effective methods for identifying the pathogen responsible for infection in patients with chronic skin lesions In fact, biopsy is considered as the gold standard when identifying bacterial strains thought to be responsible for infection, and is often the preferred route taken when choosing the most appropriate or targeted antibiotic treatment[12,15].

Another method to evaluate the pathogenic germ is represented by the superficial buffer or swab, but this method can produce incorrect indications for the choice of antibiotic therapy due to possible colonization and contamination[16, 17] of the cutaneous flora.

Routine bacterial cultures, even if accompanied by MIC (Minimum Inhibitory Concentration) [12,13,18], may not reflect the resistance of the pathogen enhanced by the biofilm matrix, . Many studies have suggested that the presence of biofilm is 60-100% in chronic lesions[19,20] but because it is so difficult

to sample, it is thought that biofilm can be present in 100% of the samples in this study. Biofilm has proved to be more difficult to remove in the presence of infections with *Pseudomonas aeruginosa* and *Staphyloccocus aureus* [21,22].

The presence of biofilm can contribute to rendering lesions chronic, through its ability to create low localized oxygen stresses[23] making it one of the main causes of antibiotic resistance, a topic which has now become a global healthcare issue.

For this reason, in our search for a cost-effective non-invasive debridement technique, and one which is easy to use by the nursing staff both in out-patient and homecare environments, we chose to evaluate the performance of the Jetox™ –HDC® hydro-debridement tool.

Subjects And Methods

Device

The Jetox™-HDC® system (Photo 1.) for wound cleansing was used, teamed with a standard sterile saline solution (0.9%) and compressed medical oxygen with adjustable flow (delivered at 9-15 L/min). Hydro-debridement with oxygenated solution is a selective mechanical debridement technique, that exploits oxygen pressure (4 psi–12 psi) in order to deliver a micro jet of saline solution which becomes oxygenated when it meets the cool jet stream of oxygen.

The system simultaneously sucks up tissue residues, thus reducing or preventing contamination of the working environment, of the healthcare operators present, and of the patient. The device is latex free, sterile, mono-use disposable and it does not does cause any additional trauma to the wound.

Photo 1. – Jetox™- HDC® system

Previous studies [24-28] have shown that Jetox™ - HDC® is very effective in the removal of devitalized tissue, and that it doesn't cause trauma to granulation tissue [29-31]. In addition, it doesn't cause pain during the procedure for the patient[32,33] and vaporization problems were never observed[24-33].

For our debridement procedure, 13-14L/min oxygen was used which corresponded to an irrigation of 9-12L/min. The duration of treatments lasted, on average, 30-40 minutes per application to wound.

Patient Assessment

Before initiating treatment, a full nursing evaluation was carried out according to the *Toven* method[34,35]. The *Toven* method provides a global assessment of the patient (clinical disease, nutritional state, autonomy status, risk of pressure lesion onset). In addition, an assessment of the state of the lesion (measurement, peri-lesional skin condition, wound border and margin, the state of the wound bed, and the presence of fluid exudation, emission of-foul odour or pain) was also

undertaken. We also wanted to evaluate the nature of any improvement in tissue oxygen levels, by monitoring transcutaneous tissue oxygen pressure ($TcPO_2$) before and during hydrodebridement of lesions of the lower limbs. A sensor was applied roughly 30 minutes before the start of treatment at a distance of 10 cm from the wound margins and was protected with adhesive transparent film to prevent accidental penetration of any oxygenated solution which could alter oxygenation values undergoing measurement .

CLINICAL CASE 1 (CC1) – A Hydro-debridement outpatient treatment

Clinical Condition: A 55-year-old, male, suffering from type 2 diabetes diagnosed at age 22, presenting an unaltered state of consciousness though showing arterial insufficiency in the lower limbs, with no blood flow in the right anterior tibial artery. The patient had an excavated and gangrenous lesion in the lower third of his leg, with an abscess of the Achilles tendon.

Principal Nursing Diagnosis (NANDA-II International): Impaired skin and tissue Integrity in the lower third of the right leg (00044-46), impaired physical mobility (00085).

Nursing Assessment:

BMI (Body Mass Index) - 28,6 kg/m^2;
MNA (Mini Nutritional Assessment) - 24/30;
Barthel index- 80/100;
Braden index – 20/23;
$TcPO_2$ - 30mmHg before treatment.

Lesion prior to commencement of treatment * (Photo 2)***:***

- located on the lower posterior third of the right lower limb;
- a damaged area measuring 20x11cm;
- a peri-lesional erythematous halo of 3cm;
- tissue necrosis at the lateral border;
- fibrin present at the wound bad;
- minimal amount of fluid exudation, an Odour rating of 4/5on the Teler Scale;

Pain at rest – NRS (Numeric Rating Scale) 7/10 – in treatment by appointment with intramuscular dose of ketorolac tromethamine.

Duration of treatment: 40 minutes (Photo 3).

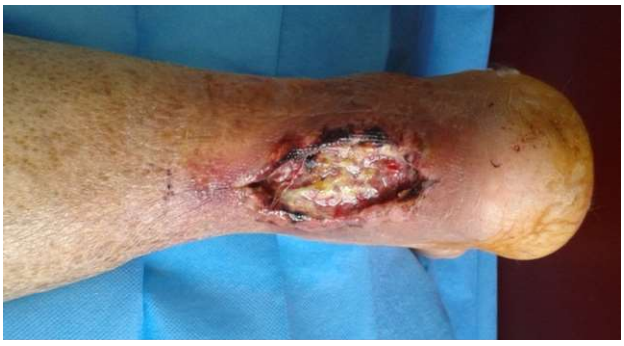

Photo 2. - CC1, Lesion at the beginning of treatment

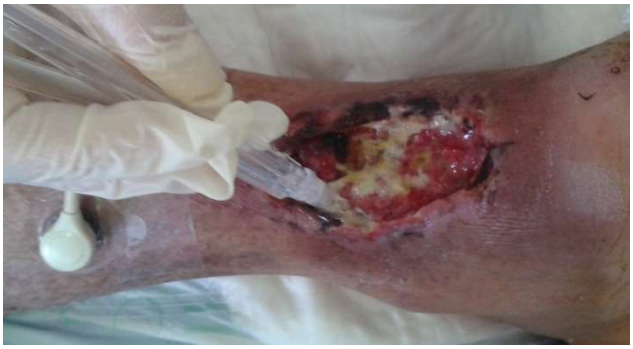

Photo 3. - CC1, Hydrodebridement

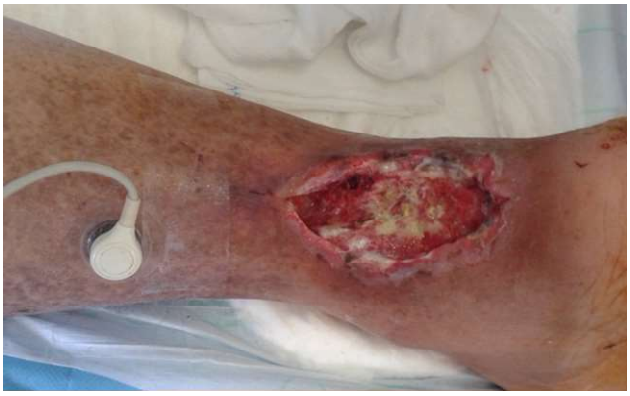

Photo 4. – CC1, wound at the end of hydrodebridement

End of treatment: (Photo 4.) - After hydrodebridement, a cleansed wound bed, and an improved tissue oxygenation ($TcPO_2$: 44mmHg) was seen. Peri-lesional decongestion was also observed. Pain was evaluated during treatment, by the NRS score of 5/10 and a good compliance of the patient was noted.

(* -Permission to capture the photos of the lesions during the procedure was kindly granted by Dr. Fabrizia Toscanella)

CLINICAL CASE 2 (CC2) – Hydro-debridement in homecare

Clinical Condition: An 87-year-old female with type 2 diabetes and advanced Alzheimer's disease. She appeared in a vigil state of consciousness but had deficits in attention orientation, and was bedridden.

Principal Nursing Diagnosis (NANDA-II International): impaired skin and tissue integrity in the lower third of the right leg, a pressure sore in the sacral area (00044-46), and impaired physical mobility (00085).

Nursing Assessment:

BMI (Body Mass Index)- 22,2kg/m^2;
MNA (Mini Nutritional Assessment) - 20/30;
Barthel index- 0/100;
Braden index– 14/23;
Urinary catheter in-situ.

Wound assessment CC2 : on initiation of treatment (Table 1.)

Wound 1 (W1)	**Wound 2 (W2)**
- lower right limb measuring 7X4cm;	- sacral area, with a damaged area of 10x10 cm,
- 7 days from onset;	- 14 days from onset,
- a peri-lesional erythematous halo of 2,5 cm;	- peri-lesional maceration and satellite lesions;
- planted wound edges;	- planted wound edges;
- necrotic wound bed;	- fibrin on the wound bed with traces of necrotic area;
- minimal amount of fluid exudation, an Odour rating of 3/5 on the Teler Scale	- large amount of fluid exudation, an Odour rating of 4/5 on the Teler Scale.
Pain Evaluation: PAINAD (Pain Assessment In Advance Dementia) - 6/10 during the night (not continuous) - 3/10 during the day	

Table 1. - CC2, lesion at the beginning of treatment

WOUND 1 (W1): first hydrodebridement session (Photo 5,6):

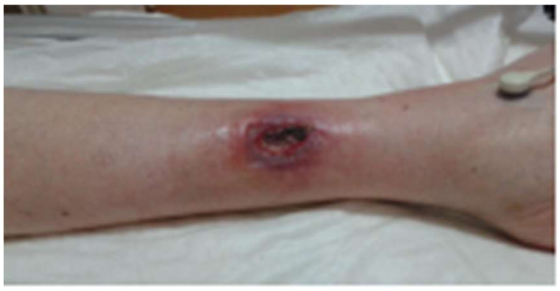

Photo 5. – CC2,W1, lesion at the beginning of the first hydrodebridement sesion

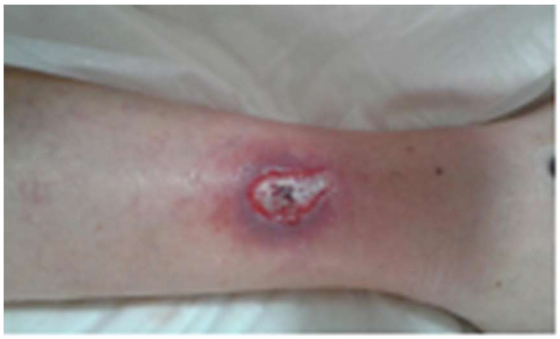

Photo 6. – CC2,W1, lesion at the end of first hydrodebridement session

W1: Second hydrodebridement session, 2 days later (Photo 7,8)

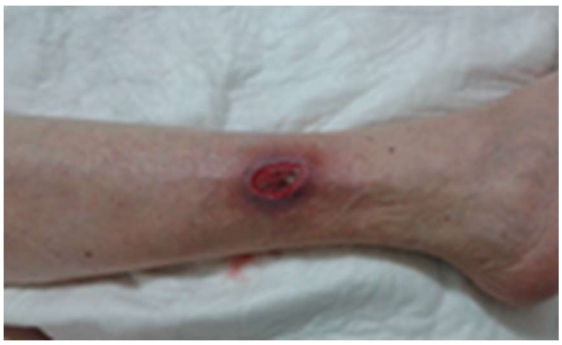

Photo 7. – CC2,W1, 2 days after first hydrodebridement

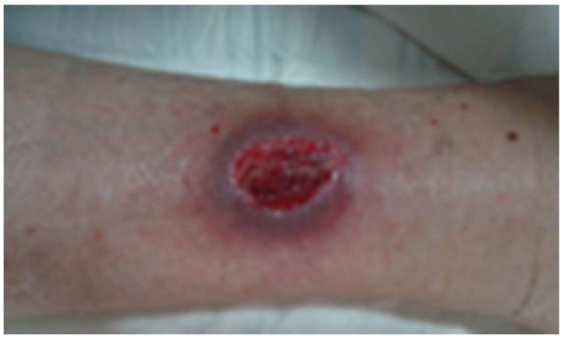

Photo 8. – CC2,W1, Lesion after second hydrodebridement session

End of treatment: Following two consecutive treatments we observed a marked improvement in the state of the lesion, as represented by a more cleansed appearance of wound bed, and granular edges evolving towards healing. A non-significant improvement in $TcPO_2$ from an initial 60mmHg to 64mmHg after first session (lasting 30 minutes), and from an initial 63mmHg to 66mmHg after the second session (same duration) was also observed. A good compliance during the procedure was noted, and there were no visible signs of increased pain. No local anaesthetic was used.

WOUND 2 (W2): Before and after hydrodebridement (Photo 9,10)

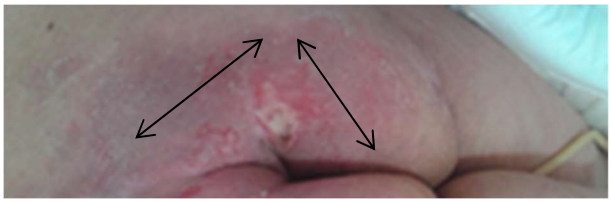

Photo 9. – CC2, W2 at the beginning of hydrodebridement

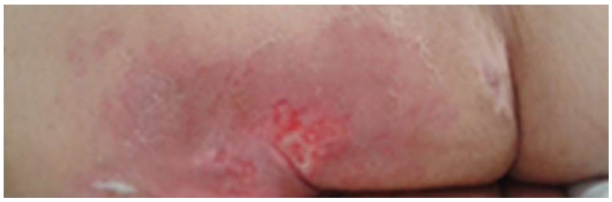

Photo 10. – CC2,W2, at the end of hydrodebridement

After the procedure, it was possible to note an improvement in the necrotic area and a general decongestion of the peri-wound area. The Duration of treatment was 20 minutes, and no local anaesthetic was used.

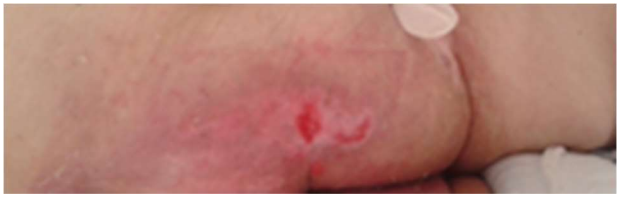

Photo 11. – CC2, W2, 3 days after the hydrodebrydement

On removal of the first dressing, 3 days after the first hydrodebridement (Photo 11.), it was possible to observe an overall improvement in the appearance of the lesion, and an expansion of epithelial tissue. The wound was healing.

In both lesions , CC2's immediate result at the end of the first hydrodebridement session was less surprising than the state of the wound when the first dressing was removed from W1 on day 2 and from W2 on day 3.

The medication applied to the wound area following the procedure was the same as that which had been used during the week previous to the first hydrodebridement session (a silver- based hydrofiber dressing). Not only was there an increase in granulation tissue noted, but an epithelial tissue expansion was also observed. This suggests that the device was highly capable of mechanically removing any biofilm present.

Conclusion

The procedure was easy to use and generally well tolerated by patients. The Jetox™-HDC® device was suitable for use both in outpatient treatment and in a home-care setting. The debridement was shown to be selective and did not cause any damage to vital tissue.

Aside from the better cleanliness and general appearance of the wound, the strengths of hydrodebridement are represented by a decongestion of the injured area and an improved oxygenation of local tissue. Furthermore, we observed an improvement in tissue oxygenation in a widened wound area ($TcPO_2$ - 30mmHg start of hydrodebridement; $TcPO_2$ - 44mmHg end of hydrodebridement session). ***This technique could be advantageous in the treatment of ischemic and pressure injuries and the reliability of this tissue oxygenation warrants further investigation in a greater sample size.***

In CC2, not only was it possible to observe an increase in granulation tissue, but an epithelial tissue expansion within 2-3 days after procedure was also noted. In this instance, the procedure provided a probable mechanical removal of most if not all of the bacterial biofilm encountered.

The results from these case studies are encouraging and imply the need to further investigate the effectiveness of this hydro-debridement method in a more widespread clinical setting, with an increased number of patients, and using an array of medical observational instruments.

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