Debridement of Wounds with Ultrasound

Technological advances
have made this a superior wound healing method.

BY KAREN C. SHUM, DPM

Methods of Debridement

The term "debridement" was first coined by Desault in Paris, France referring to surgical removal of necrotic material from open wounds.[1] Debridement of foreign devitalized and contaminated tissue from traumatized or infected areas is a vital step in the wound healing process. The presence of senescent cells can leave wounds in a chronic inflammatory state stalling the wound healing process. Studies have demonstrated that wounds that have undergone serial debridement have lower infection and better healing rates than wounds that are less frequently debrided.[2,3] There have been recent innovations with respect to ultrasound debridement used in the treatment of acute and chronic wounds.

Presently, there are many methods of debridement, with sharp surgical debridement being the most widely applied. However, this method is aggressive and may result in pain, excess bleeding, and non-selective removal of viable tissue. Autolytic and enzymatic debridement are slow processes and require management of exudates and monitoring for signs of infection. A long-standing method of mechanical debridement includes wet to dry dressings. This technique is easy to perform; however, it is non-selective and requires frequent dressing changes. Biological debridement with the use of maggot therapy is a selective process but may not be aesthetically pleasing for patients. The method chosen for wound debridement should ideally be selective, efficient, and enhance the wound healing process.

Ultrasound Technology

Ultrasound technology has a variety of applications in the field of medicine. This includes diagnostic imaging and therapeutic capabilities. The use of therapeutic ultrasound has been widely reported in bone healing and muscle and tissue repair. There is now a growing body of evidence, including randomized control trials, that shows how ultrasound plays a therapeutic role in the wound healing continuum.

High intensity, low frequency ultrasound is a mode of mechanical debridement that has shown to improve wound healing. The tip of the metal alloy hand piece acts as a transducer probe, which converts electricity supplied by a power generator into ultrasound waves. A liquid solution, often saline, is used as a coupling medium that not only carries energy from the ultrasound probe directly onto the tissues, but also provides a cooling effect on the energy transferred.

The therapeutic effects of ultrasound debridement include cavitation and upregulation of cellular activity. Tissue cavitation occurs when a continuous flow of saline is emitted and the ultrasound transducer probe tip comes in contact with the wound bed. This causes production and vibration of micro-bubbles.[4] When the micro-bubbles resonate over a local area, they cause shear forces and stress to act on the tissue.[5] The energy that is released and pressure change from the cavitation loosen the targeted non-viable tissue. This hydrodynamic effect depends upon the frequency of the ultrasound wave and produces mechanical disruption, fragmentation, and emulsion of tissue. Non-viable tissue can then be removed from the wound bed through fluid irrigation.

The selective aspect of tissue debridement is essential to proper wound bed preparation because foreign material, dry crust or eschar within a wound bed acts as a physical barrier. These barriers prevent the normal course of wound contraction, and interfere with cell epithelializa-

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High intensity, low frequency contact ultrasound is a mode of selective and efficient debridement that has shown to improve wound healing.

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tion.[6,7] Additionally, the presence of necrotic material can induce the complement system resulting in ongoing inflammation and destruction of surrounding healthy tissues.

Reducing Bio-Burden, Upgrading Cellular Activity

Tissue cavitation not only removes non-viable substances, but also directly kills bacteria by disrupting their cell walls and biofilms. Regular removal of necrotic and bacterial bio-burden is necessary to reduce infection and promote healthy granulation tissue. A study by Nichter on animal models showed that there was a significant decrease in the number of Staphyloccous aureus bacteria in wounds that were debrided using ultrasound when compared to other forms of debridement.[5] In other in vitro studies, ultrasound debridement has shown effectiveness in reducing bacterial biofilms and killing Pseudomonas and Staphylococcus epidermidis as demonstrated on electron microscope images.[8] The importance of removing necrotic tissue is a key component to wound healing because the presence of it can enhance bacterial colonization and lead to an infection.[9] Ultrasound debridement can therefore control contamination and infection by bacterial organisms.

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The therapeutic benefit to using ultrasound in wound care is further demonstrated by the fact that emitted acoustic energy upregulates and increases cellular activity.[10] There is an increase in protein synthesis and permeability of cell membranes seen in the local tissue affected by ultrasound.[11] The stimulatory effect acts on cell walls by interacting with vascular endothelium through the release of nitric oxide molecules, theoretically leading to increased blood flow and local tissue perfusion. Ultrasound has also shown to interact with the inflammatory stage of wound healing by stimulating macrophages, leukocyte adhesion, fibroblast recruitment, and fibrinolysis.[12] This turns a chronic wound into an acute wound.

Improving Healing Rates

In a randomized control study, the healing rate of wounds with impaired vascular flow improved significantly with the use of low frequency ultrasound.[13] It is thought that ultrasound waves may promote angiogenesis, even in dysvascular wounds, thus augmenting wound healing. The therapeutic advantage of ultrasound in wound debridement is transient and affects the local tissue area. Studies that show the increase in rate of wound healing with high intensity, low frequency ultrasound subject patients to the routine use of the device.

There are several high intensity, low frequency contact ultrasound devices indicated for wound debridement that are available on the market today: SonicOne® (Misonix), Qoustic® (Arobella) and Sonoca® (Soring). Mist® (Celleration) is another ultrasound device used in wound debridement and it is a non-contact high intensity, low frequency device. Each device has unique properties that have variable settings on irrigation flow, intensity, and ultrasound frequency (ranging from 20-100 kHz).

With contact ultrasound devices, the option of different probe tip shapes (curette, cylindrical, cross hatched, etc.) can enable one to better debride sinus tract walls, tunnels, and narrow, deep or irregularly contoured wounds. Some probe tips also have a cutting curette edge, which is an added feature that can augment the debridement process. These different probe tips allow for targeted debridement of non-viable tissue. The ability to adjust the intensity level and selection of specific probe tips can enable one to control how aggressive the wound should be debrided. The amount of manual pressure a clinician applies to the probe tip also controls the aggressiveness of debridement. Reported levels of pain can vary depending on the device used and device settings in non-neuropathic patients. The ability to adjust settings on the ultrasound device based on the shape, size, depth, and wound base characteristics adds to the versatility of the device.

The ability to adjust the intensity level and selection of specific probe tips can affect how aggressively the wound is debrided.

Therapeutic and Economic Benefits

Ultrasound debridement is also advantageous when a definite demarcation between viable and necrotic tissue cannot be identified. The presence of liquefied tissue material can make it difficult to distinguish between necrotic and vital tissues. Additionally, soft liquefying tissue material is usually not handled well with a surgical scalpel, scissors, or forceps. The ultrasound device proves to be most useful when tissues cannot be excised easily. It functions to remove tissue material such as fibrin, slough, and eschar, controlling the amount of bleeding that is often seen with over-aggressive, sharp surgical debridement. Ultrasound debridement can successfully remove soft tissue and in some devices it is also designed to debride bone. The ability to debride thick eschar and bone makes this type of device particularly powerful.

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Setup of the device is fairly quick and simple. The probe tips are either disposable or can be reused. The ultrasound device is portable and is applicable in the outpatient setting or the operating room. This proves to be especially useful and convenient in patients who are non-surgical candidates. The design of these ultrasound units is becoming more widely available due to compact units and ease of portability.

The effectiveness of wound debridement with the use of ultrasound can reduce the total number of debridements a patient undergoes, leading to considerable cost-savings. A clinical trial by Steed revealed that regular debridement of wounds lead to improved effectiveness of the therapeutic agent used as an adjunct to promote wound healing.[14] Wounds debrided regularly have a wound base that is properly prepared, maximizing the effect of adjunctive wound care modalities. This allows the clinician to use skin graft substitutes to enhance healing or apply an autogenous skin graft for definitive wound closure. Evidence has shown improved outcomes in the proportion of wounds healed and wound volume reduction with the use of ultrasound compared to standard wound care.[15]

Ultrasound debridement can be used on wounds with various etiologies. It is indicated for use in burns, infected wounds, wounds with impaired circulation, pressure ulcers, diabetic foot ulcers, and venous ulcers. A meta-analysis of eight randomized controlled trials in ultrasonic debridement of all of the aforementioned wound types shows a short-term clinical benefit in healing and reduction in wound area.[10] The overall increase in rate of wound healing may lead to overall satisfaction of the patient.

Conclusion

Ultrasound debridement is one of many forms of debridement techniques available for use today in wound care. The therapeutic benefits of ultrasound debridement are multifactorial and go beyond just "cleaning" the wound base. There is evidence that it has bactericidal effects and enhances the wound healing process on the cellular level. In general, ultrasound has been found to be a safe way of debriding wounds. There are still questions that remain about the optimal therapeutic effect of ultrasound debridement, including the appropriate amount of time for debridement, intensity, and frequency of the ultrasound waves.

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The numerous benefits of ultrasound debridement shown thus far in clinical studies should lead a clinician to strongly consider the use of this device and incorporate it into their routine clinical practice. **PM**

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Dr. Shum is the Medical Director of the Amputation Prevention Center at Torrance Memorial Medical Center in Torrance, CA and on the teaching staff at Cedars-Sinai Medical Center in Los Angeles.