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Technology Review

ULTRASOUND ASSISTED WOUND CARE

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1. BACKGROUND

The Director General of Health, Ministry of Health requested the Health Technology Assessment Unit to carry out a technology review on the safety and effectiveness of "Sonoca 180" in wound healing.

2. INTRODUCTION

Today there are hundreds of devices and products marketed actively for the prevention and treatment of wounds ranging from pressure relieving beds, mattresses and cushions which are universally used as measures for prevention and treatment of pressure sores; compression therapy in a variety of forms widely used for venous leg ulcer. Currently there is a whole range of novel devices involving laser, ultrasound and electricity that are also being applied for wound healing (Cullum , 2001).

Wounds are classified either as acute or chronic wounds. Most acute wounds heal by direct union whereas chronic wounds are open wounds that persist for an extended period of time. A wound is considered chronic when it does not appear to follow the normal healing pattern that is approximately four weeks duration (Hass, 1995).

Venous leg ulcers and diabetic foot ulcers, pressure ulcers are examples of chronic wounds that result from impaired healing. An infected surgical wound is also considered a chronic wound.

In medical practice, ultrasound (US) is used both for diagnosis and in therapy. High-frequency (1-4 MHz) and low-frequency (20-120 KHz) therapeutic ultrasound are relevant to wound healing.

The Sonaca 180 is a low frequency ultrasound and operates at 25kHz. Therefore this technology review focuses on wound healing of chronic wounds using low frequency ultrasound.

3. TECHNOLOGY FEATURES

The Sonaca 180 (Ultrasonic/ Dissector) is a device that combines both low frequency ultrasound together with a wound treatment solution in the process of wound healing.

Ultrasound treatment uses mechanical vibration delivered at a frequency above the range of human hearing. Physical therapists report that covering the wound area with a hydrogel film and applying ultrasound during the inflammatory and proliferative stages stimulates the cells involved in wound healing and also warms the tissue, enhancing healing by improving circulation (Weichenthal , 1997).

Therapeutic ultrasound is a physical modality in which nonionizing radiation, in the form of sound, is transferred to the body's tissues and absorbed as heat. The therapeutic efficacy of US depends on dose (W/cm^2 time) and dosage (frequency of application, series) (Uhlemann, 2003).

It is applied at frequencies of 1.0 MHz and 3.0 MHz and is the most commonly used deep-heating modality, capable of reaching depths of five centimeters and more below body surface. Ultrasound, like short-wave diathermy, may be applied in a continuous method or in pulsed waves to apply therapeutic heat and non-thermal effects (McCulloch, 1997).

How does ultrasound benefit wound healing?

(i) Inflammatory Phase – the non-thermal effects of ultrasound causes degranulation of mast cells. Histamine and other chemical mediators are released from the mast cell and play a role in attracting neutrophils and monocytes to the injured site. These and other events appear to accelerate the acute inflammatory phase and promote wound healing (Young & Dyson, 1987).

(ii) Proliferative Phase - ultrasound also has been noted to effect fibroblasts which secrete collagen. Continuous ultrasounds at higher therapeutic intensities provide an effective means of heating deeper tissue prior to stretch. As with other methods of therapeutic heat, the use of ultrasound in this capacity is thought to increase collagen extensibility, circulation, pain threshold, enzymatic activity, cell membrane permeability, and nerve conduction velocity (Gostishchev et al 1984).

4. OBJECTIVE

To assess the effectiveness, safety and cost effectiveness of low frequency ultrasound assisted in wound care.

5. METHODOLOGY

Retrieval of evidence

Literature search were carried out in several databases namely Cochrane Systematic Review, DARE, NHS EED, HTA, MEDLINE, NCCAM and even general search engine like GOOGLE. There were no limits applied when performing the search. The key words used singly or in combination during the search were “therapeutic ultrasound”; “ultrasound assisted wound care”; “wound healing”; “wound therapy”; “low frequency ultrasound”; “chronic wound” AND safety/ efficacy/ effectiveness OR cost effectiveness.

Inclusion criteria

Clinical studies of chronic wound which includes the leg ulcers, diabetic foot ulcers and pressure sores that use therapeutic ultrasound of low frequency range as an adjunctive treatment to enhance the wound healing process.

Exclusion criteria
High frequency ultrasound for wound healing and in soft tissue or musculoskeletal injuries.

6. RESULT AND DISCUSSION

6.1 SAFETY

Ultrasound is now used in a wide range of applications which can lead to exposure of human tissues to ultrasonic fields. Therefore the safety of ultrasonic fields may be assessed in term of its ability to produce a potentially harmful effect in tissues.

Adverse bio-effects may occur on some equipment that are capable of warming the tissue to a certain level .The magnitude of the temperature rise increases with the length of exposure and with the ultrasound output. In addition, it is known that tissues can be damaged close to any gas bodies exposed to high amplitude pulses of ultrasound, for example at the lung surface or with micro-bubble contrast agents. A further aspect of safety management is the inherent sensitivity of each type of tissue and the long-term relevance of any adverse bio-effects (British Medical Ultrasound Society Final Draft 2002).

A study by Hautarzt et al (2003) indicated that the ultrasound system is safe and easy to handle. In another study by Ferrel et al (1999), suggested further RCT studies to be conducted to indicate the safety aspect of the therapeutic ultrasound system. Lack of randomized clinical trial may cause unsafe outcome of the safety and the cost effectiveness of therapeutic ultrasound system.

In a placebo- controlled parallel group single blind RCT, 24 patients with chronic ulcerations of the leg due to chronic venous insufficiency were randomised to receive ultrasound therapy for wound healing.. In this study, patients recorded only minor side-effects such as tingling feeling and occasionally pinhead-sized bleeding in the ulcer area (Pescan , 1997).

6.2 EFFECTIVENESS

6.2.1 Experimental studies

Wound healing- angiogenesis

An in vitro study which studied the tunneling or undermining wounds and surface model found that ultrasound was found to be effective in the elimination of resistant bacterial organisms. Organisms such as Vancomycin-resistant *Enterococcus* and resistant *Pseudomonas auriginosa* in vivo were cultured and treated with differing ultrasound outputs and exposure time (Jeffry, 2003).

In vitro effects revealed that therapeutic ultrasound induces in vitro cell proliferation, collagen/ NCP production, bone formation,and angiogenesis (Doan, 1999; Bye, 1992). Another study evaluated different ultrasound machines and the outcome of the experiments demonstrated similar findings with the above two studies (Speed , 2001).

Rehr et al (1999) carried out a study evaluating a "traditional" (1 MHz, pulsed 1:4, tested at four intensities), and a "long wave" machine (45 kHz, continuous, also tested at four intensities). The study results showed that both ultrasound machines produced similar results, and the optimum intensities were 0.1 to 0. 4 W/cm2 (SATA) with 1 MHz ultrasound, and 15 to 30 mW/cm2 (SATA) with 45 kHz ultrasound. The therapeutic ultrasound stimulates the production of angiogenic factors such as IL-8, bFGF and VEGF which may be one of the mechanisms through which therapeutic ultrasound induces angiogenesis and healing.

6.2.2 CHRONIC WOUNDS

(i) Cutaneous wound

There is good evidence to say that ultrasound therapy is useful for the healing of cutaneous wounds. Three systematic reviews in general agreed that this technology has beneficial effects in the wound healing process (Ernst, 1995; Flemming, 2004; Dissemond, 2003).

A systematic review of 5 studies that used ultrasound therapy for cutaneous wound in patients with leg ulcers, chronic leg ulcers and pressure sores demonstrated that low – dose ultrasound was an effective complimentary therapy for wound healing (Ernst, 1995). In another recent systematic review of seven RCTs, the benefits of ultrasound in the wound healing of venous ulcers was also demonstrated (Flemming, 2004). Dissemond et al (2003) found in his review that the use of different low dose ultrasound systems was an effective alternative strategy in the treatment of chronic wounds. This review also found that the ultrasonic system was easy to handle, safe and there is little additional equipment required using this intervention.

In a meta-analysis carried out by Johanson et al (1998), ultrasound therapy on chronic leg ulcers (arterial, venous, rheumatoid, diabetic and post traumatic ulcers), found that ultrasound had the best effect when delivered in low doses around the edges of the wound. However the author concluded that further studies are required to confirm and evaluate the possible dose-effect relationship of therapeutic ultrasound.

Similarly a small randomized controlled trial involving 24 patients with chronic leg ulceration showed that all the patients responded to the treatment of low frequency ultrasound (30 kHz) and low dose ultrasound (Pescan et al, 1997).

Several case studies demonstrated that the low frequency ultrasound was a useful tool in the management of chronic wounds, not only for healing but also for pain, pigmentation and odour reduction (Johnson et al, 2003).

However, there are also literatures which reported that the ultrasound therapy has no beneficial effects in wound healing. A systematic review of wound care management which assessed the effectiveness and cost effectiveness of various modalities concluded that there were insufficient evidence to support the use of therapeutic ultrasound in chronic wounds (Cullum , 2001).

Two controlled studies reported the effects of ultrasound on chronic leg ulceration in 38 patients. It was observed that there was no difference found in proportion of healed ulcers or ulcer area in ultrasound group (1.0 watt/cm 2 at 1 MHz for 10 minutes) (Scand, 1991; Eriksson, 1991).

(ii) Pressure ulcers and pressure sores

Low frequency ultrasound is also being used in the treatment of pressure sores. To date there was only one study namely a case study that demonstrated a beneficial effect of ultrasound in treatment of pressure ulcers (Jeffry et al, 2003).

A systematic review concluded that there is no evidence of effectiveness of ultrasound in the treatment of pressure sores due to flaws in the study methodology and the small number of participants in the studies reviewed (Flemming et al, 2004).

Similarly two randomized controlled trials of patients with pressure ulcers found no significant differences between treatment groups (David et al 1996, Riet et al 1995).

There was a case report of a patient with Stage III pressure ulcers over the coccyx area which did not demonstrate any benefits of undergoing therapeutic ultrasound (Selowitz et al 2002).

(iii) Purulent wounds.

A case series of 42 patients with purulent wounds who underwent ultrasonic treatment had good granulation effects and the wound healed quickly in these patients (Vestnik et al, 1982). Similarly another case series reviewed the effectiveness of the combination of low frequency ultrasound together with gentamycin solution in 17 patients. This study observed that there was a decrease in the purulent septic complications from 35.7% to 5.9% (Komrakov et al 1990).

A cross sectional study of 112 patients with diabetes mellitus and purulent surgical wound who were treated with low frequency ultrasound and laser radiation demonstrated that therapeutic ultrasound had an advantage in the first and second phase of wound healing process (Kuliev et al 1992).

Another study reported that an ultrasound surgical device “SUGA -21f.02” was used in 76 patients and an intensification of diffusion of the medical preparation into the tissues was shown among the deep layers of the wound channel (Sedov et al 1998).

However, in a study which evaluated the impact of ultrasound at two power densities of the range of 0.5W/ cm2 and 1 W/cm2 in the healing of crural ulceration found that there was no satistically significant difference in terms of granulation development rate and debridement of the wound.

(iv) Trophic ulcers

Gostishchev et al (1984) reviewed the treatment of trophic ulcers by the low frequency ultrasound through clinical, morphological investigations and by measurement of the medium pH and demonstrated growth of granulation tissue which allows fulfilling autodermatoplasty.

7. COST IMPLICATIONS

Proceedings from a paper presented in the Annual Symposium on Advanced Wound Care suggested that the use of UAV device may enhance the clinical outcomes while maintaining cost efficiency. Therapeutic ultrasound which is performed at the bedside without sedation is less costly than surgical intervention (Mary et al, 2003) .

However there were no clinical studies found from the search of literature, evaluating the cost-effectiveness of using low frequency ultrasound for wound healing.

8. CONCLUSION

This review has limited evidence on routine use of therapeutic ultrasound in practice. Most of the knowledge on the efficacy of ultrasound on living tissue has been gained through in vitro studies. The available evidences marginally suggest and support the use of low frequency ultrasound in wound healing especially in chronic wounds. Thus, there is insufficient good quality evidence to recommend the use of low frequency therapeutic ultrasound in assisting wound healing.

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