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ORIGINAL ARTICLE

The Bagautdinov dressing method: negative pressure wound therapy in a patient with an allergy to acrylate adhesive

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Abstract

Current embodiments of negative pressure wound therapy (NPWT) create a hermetically sealed chamber at the surface of the body using polyurethane foam connected to a vacuum pump, which is then covered by a flexible adhesive drape. Commercially available NPWT systems routinely use flexible polyethylene films that have a sticky side, coated with the same acrylate adhesives used in other medical devices such as ECG leads and grounding pads. Severe reactions to the acrylate adhesives in these other devices, although uncommon, have been reported. We describe the case of a 63-year-old woman with an intractable leg ulcer resulting from external-beam radiotherapy (XRT). Treatment with a standard commercial NPWT system induced severe inflammation of the skin in direct contact with drape adhesive. We successfully administered prolonged, outpatient NPWT to the patient using an alternative method (first described by Bagautdinov in 1986), using plain polyethylene film and petrolatum. The necessary hermetic seal is achieved by smearing the skin with petrolatum before applying the polyethylene film and activating the vacuum pump. The Bagautdinov method is a practical solution to the problem of adapting NPWT to patients with contact sensitivity or skin tears related to the adhesive compounds in the flexible drapes. Its use of a circumferential elastic wrap to maintain constant pressure on the seal probably limits the Bagautdinov technique to the extremities.

Introduction

The past two decades have seen negative pressure wound therapy (NPWT) (also known as subatmospheric pressure therapy) develop into a reliable method of local wound care that delivers subatmospheric pressure via connection of a vacuum pump to a chamber that is hermetically sealed to the body surface via the use of flexible plastic drapes that typically have an adhesive layer on one side. Inside the chamber created by the adhesive drape and the walls of the wound cavity, either cotton gauze (1) or open-cell polyurethane foam is placed to distribute the vacuum and wick fluid from the wound into a collection canister in series with the vacuum source.

Early studies at Wake Forest University by Morykwas and Argenta (2,3) showed NPWT using polyurethane foam to be markedly effective in both animal studies and clinical trials for promoting new granulation tissue formation and controlling exudates and transudates, which promotes more rapid healing than traditional wound therapy. The subsequent commercialisation of the Wake Forest system by Kinetic

Key Messages

- negative pressure wound therapy via the WoundVAC® can accelerate post-external-beam radiotherapy wound healing in the preparation for therapeutic reconstruction
- negative pressure wound therapy with commercially available systems are contraindicated in patients with a significant acrylate allergy
- the Bagautdinov dressing method cited in Russian literature can serve as a viable option for wound patients with an allergy to the WoundVAC adhesive drape

Concepts Incorporated (KCI) of San Antonio, Texas (now Acelity) sparked an exponential growth in the employment of NPWT in a wide variety of wounds. It has had a major impact on wound management in many specialties, including Plastic, Thoracic, Orthopaedic, Podiatric and General Surgery as well as at many wound centres.

The proposed physiological mechanisms underlying the beneficial effects of NPWT include removing wound fluid and reducing tissue oedema, thereby facilitating wound contraction. It also facilitates direct stimulation of cell proliferation via the exposure of cells to tensile forces created at the wound surface by contact with foam struts, which exert positive pressures greater than atmospheric when subatmospheric pressure is exerted in the hermetic chamber (microdeformation hypothesis) (2–6). Other proposed mechanisms hypothesised to explain the effects of NPWT include stimulation of higher levels of wound tissue perfusion and increased clearance of bacteria from the wound, but the available clinical and animal data relevant to both of these latter hypotheses is mixed and inconclusive. Nonetheless, NPWT has been shown to be superior to most alternative methods of wound management in several clinical trials, particularly in diabetic foot problems (7,8), and currently remains one of the most effective advanced methods of managing wounds.

An unusual problem that apparently is rarely encountered with NPWT systems is skin reaction to the adhesive drapes. Both KCI (Acelity, San Antonio, TX) and other commercial NPWT systems use acrylate compounds in the sticky side of the drapes to promote adhesion to periwound skin (9,10). Acrylates are derivatives of acrylic acid and include ethyl acrylate, hydroxyethyl acrylate and methyl methacrylate. These and other acrylates are capable of causing significant skin irritation or allergy, with nail lacquers and artificial nails, dental materials and medical adhesives accounting for most of the reported problems not associated with occupational exposure (11). Acrylate adhesives have been reported to induce severe skin reactions to ECG leads and electrosurgical grounding pads (11–15).

It might be assumed that a patient with contact sensitivity to the flexible drapes in commercial systems could not be treated with NPWT. The first reports, however, of NPWT systems using flexible drapes and a porous foam wound filler did not use films with an adhesive layer. In 1986, Bagautdinov published two short, but seminal, papers in the Russian medical literature describing subatmospheric wound therapy (16,17). In addition to the polyurethane foam and a tube connected to suction, the Bagautdinov method created a hermetic seal by smearing the skin surrounding the wound with sterile petrolatum and an antiseptic. The entire wound surface and neighbouring skin was fully covered with polyethylene film. As this method foregoes the need for adhesive, it is a practical option for NPWT in patients with contact sensitivity to the drape adhesive.

We describe the use of the original Bagautdinov method for subatmospheric pressure wound therapy in a patient with a non-healing, radiation-induced ulcer who also had a severe allergy to skin adhesives. It was ascertained that NPWT was needed to prepare the site for a microvascular free flap. As far as we know, this is the first report of the Bagautdinov method being used outside Russia.

Case report

A 63-year-old woman with an extensive history of multiple squamous cell carcinomas (SCC) presented with a $6 \times 4{\cdot}5$ cm^2, non-healing ulcerated wound on the anterolateral surface of her left leg at the junction of the middle and distal third. The patient previously had a left leg SCC lesion treated with multiple Mohs' surgeries and attempted reconstructions. Six months prior to presentation, the patient received external-beam radiation therapy (XRT), which was discontinued because of bleeding and poor wound healing. Two months later, the patient's wound was debrided at another hospital followed by topical therapy with enzymatic debridement using collagenase.

The patient then came under our care and underwent an operative debridement with placement of a collagen/glycosaminoglycan dermal substitute (Integra®, LifeSciences Corp., Plainsboro, NJ) covered by a silver impregnated mesh (Acticoat®, Smith & Nephew PLC, London, UK) and a portable KCI WoundVac® (Acelity, San Antonio, TX) to apply subatmospheric pressure. A visiting nurse performed the first dressing changes, but she did not inform us of any surrounding skin problems. When the patient returned to clinic 1 week later, she had marked erythema, rash, oedema, pain and pruritis involving all the skin in direct contact with the adhesive drape of the WoundVac (Acelity, San Antonio, TX) (Figure 1). Further inquiry at that time showed that the patient had been previously treated for a brief period with NPWT with the same result – a severe skin reaction leading to the discontinuation of therapy. After we observed her skin reaction, we discontinued the use of the drapes and switched to the Bagautdinov method to create a hermetic seal over the wound with the same vacuum system and collection canisters (Figure 2). Her skin symptoms persisted for over a week but gradually resolved. The severity of her symptoms and the slow resolution suggested an allergic dermatitis rather than an irritant dermatitis, which was subsequently confirmed by a positive patch test.

Initially, we used hydrocortisone ointment (white petrolatum containing 1% hydrocortisone) as the vehicle to secure a hermetic seal with liberal application to the surrounding skin and placed non-sterile polyethylene film (Glad Wrap®, Glad, Oakland, CA, USA) over the wound and adjacent skin in the amount necessary to create an adequate seal. A small incision was made in the film to allow for the placement of a tube, which was then connected to a vacuum set at at 50 mm Hg(Figure 3). Later, after her skin condition resolved, petrolatum was substituted for hydrocortisone ointment. For the next 8 months, the patient had twice-weekly NPWT dressing changes using the Bagautdinov method. During this interval, she had 40 treatments of hyperbaric oxygen therapy over a 2-month period, leading to marked improvement of the wound such that it became completely granulated but never re-epithelialised. The wound stabilised at a size of $5 \times 4{\cdot}75$ cm^2 with granulation tissue covering the wound base even on the periosteum of the medial border of the tibia. Plastic surgery reconstruction with a flap was considered in the strategic planning for the patient but was deferred because of the need to manage a stenosis of the superficial femoral artery.

After the revascularisation, the patient had a latissimus dorsi microvascular free muscle flap with a split-thickness skin graft

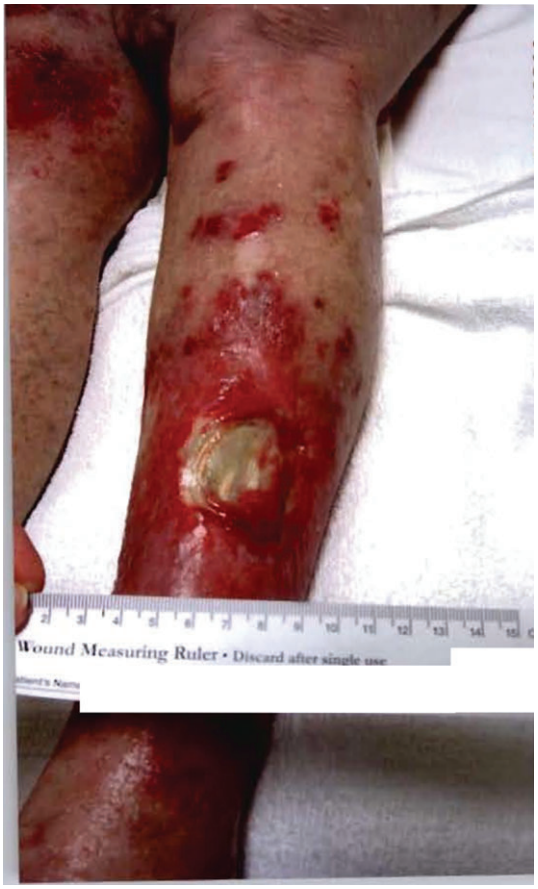

Figure 1 Wound with acute allergic contact dermatitis to adhesive dressing.

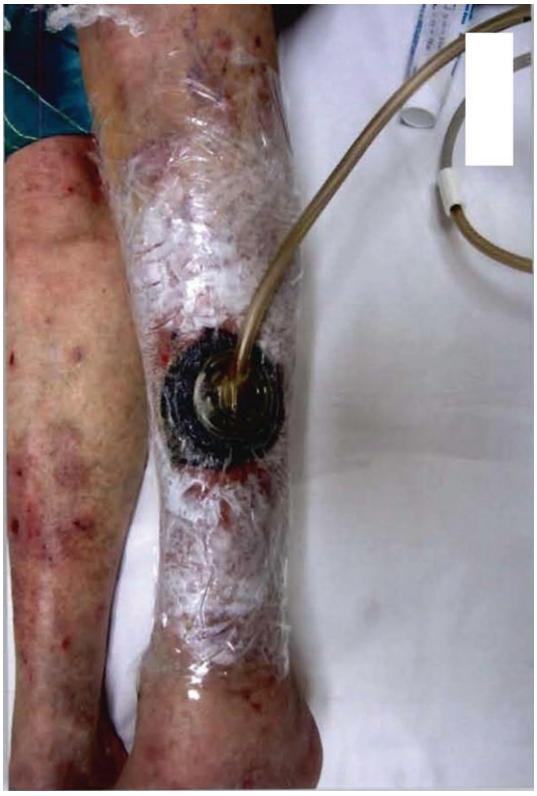

Figure 2 Bagautdinov dressing.

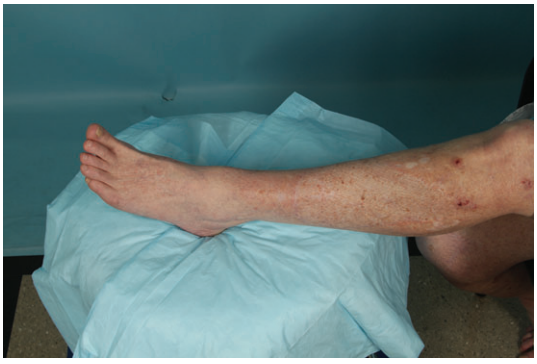

Figure 3 Completely healed wound and free flap on 2-year follow-up.

from the left anterior thigh to cover the muscle. A healed wound resulted with full incorporation of the free flap (Figure 3).

Discussion

NPWT has proven successful in the management of both acute and chronic wounds (2,3,6). Although clinical guidelines (18) and U.S. Food and Drug Administration (FDA) indications for NPWT include full- and partial-thickness burns and ulcers, skin grafts and flaps, radiation ulcers are not explicitly described as indicated for treatment by either commercial manufacturers or the FDA (18,19). Despite the concern that responses to NPWT are limited by the poor vascularisation and severe fibrosis of many radiation ulcers (20,21), recent studies have demonstrated NPWT to be effective in stimulating the healing of some ulcers resulting from XRT (21,22). Our unpublished experience in two other radiation ulcer cases was that healing could be achieved by combining NPWT with a dermal substitute. As a consequence, although NPWT has not been proven by clinical trials to be effective in the management of radiation ulcers, there is reason to have confidence that NPWT has utility in the management of these often difficult cases.

There are three basic forms of cutaneous hypersensitivity: irritant contact dermatitis, allergic contact dermatitis and contact urticaria. Fifteen million Americans are estimated to have or have had contact dermatitis. The majority of cases are caused by skin irritation by a non-immune-mediated direct toxic response of the skin. In a minority of cases, true allergy of the skin is present. Over 50 000 irritants (including acrylates) are known to generate skin reactions, ranging from weakly or marginally sensitising to strongly corrosive acids and bases (23).

The drapes supplied by most vendors of NPWT systems have an acrylate adhesive on one side (8,9). The monomeric acrylic acid subunits used to form acrylate polymers (e.g. hydroxyethyl acrylate) are both strong irritants and notorious allergens. Acrylate reactions can be because of irritation, allergy or both (24). Irritation alone is thought to be the primary mechanism when significant amounts of unreacted monomers are in contact with

skin as they are highly reactive. This appears to be the predominant mechanism of acrylate contact sensitivity in dentists and dental technicians who use ultraviolet light to initiate monomer polymerisation. True allergic contact dermatitis, although less common than direct irritation of the skin by reactive acrylate monomers, has been demonstrated in patients with reactions to ECG leads and grounding pads. Of note, based on patch testing, acrylate allergy is present in approximately 1% of patients with apparent acute contact dermatitis (25), but as commercially available patch test systems do not reliably identify all the acrylates implicated in allergic dermatitis (25,26), this may be an underestimate.

Multiple providers of NPWT systems were contacted regarding the incidence of allergic reactions to adhesive drapes; however, information was not provided. This suggests that contact dermatitis to the acrylate adhesives used is probably very rare. Of note, acrylate adhesives in medical tapes and devices have been used for over 50 years and are regarded as less prone to induce contact dermatitis than the natural rubber latex adhesives they have largely replaced. Although acrylate contact dermatitis appears to be quite uncommon, medical adhesive-related skin injury (MARSI) is very common and is estimated to occur in as many as 15% of paediatric inpatients or elderly patients in skilled nursing facilities. The use of medical adhesives has been implicated as the primary cause of skin breakdown in neonatal intensive care units (1,27,28).

Although contact sensitivity is a common manifestation of MARSI, skin damage may result from purely mechanical effects. When the adhesion of tape or drape is stronger than skin cell attachment, removal of the adhesive device leads to the separation of the epidermal layers or even the epidermis from the dermis; this injury, especially if repetitive, can result in skin tears or compromised skin barrier function with inflammation and infection (27). The risk for mechanical injury is the greatest in neonates and infants, whose skin is as much as 60% thinner than in adults (29). Similarly, changes in the skin with advanced age lead to an increased risk for MARSI because of the loss of cohesion between dermis and epidermal layers, epidermal thinning and reduced tensile strength (28,29).

The implication is that the adhesive drapes normally used for NPWT may have more risk for significant skin irritation or damage than just the risk for acrylate sensitivity. We have encountered other patients with less severe erythema and dermatitis under NPWT drapes than in the case reported here. These changes are often attributed to candidiasis despite little effect when topical antifungal agents (e.g. powder, ointments) are used to treat the problem. Whatever the cause of irritation is, however, when significant skin reactions occur that compromise NPWT with standard adhesive drapes, the Bagautdinov method should be considered a practical alternative.

Of note, maintaining NPWT for days at a time without dressing changes requires secure attachment of the dressing. The forces securing a NPWT dressing include a downward force pushing the drape against the porous foam. When 100 mm Hg subatmospheric pressure is exerted by a vacuum pump, the 100 mm Hg difference between the pressure inside and outside the wound chamber results in 1·47 pounds per square inch (approximately 6·5 N) of force fixing the drape to the foam. The second factor preventing dislodgement is the attachment of the drape to the surrounding skin. The presence of oil or grease between the skin and drape itself creates a partial or complete hermetic seal between skin and polyethylene film such that the same pressure mechanism that fixes the drape to the foam also, to a lesser degree (depending on how completely gas is eliminated between the drape and skin), fixes the non-sticky drape to the skin. The strength of the attachment of drape to skin is moderately less with the Bagautdinov method than that achieved with acrylate adhesive (authors' unpublished observations) as both pressure gradient and adhesive effects appear to combine to create a stronger attachment. As a consequence, although not necessary in this case, when the Baguatdinov method is used, additional measures may be required to prevent dressing dislodgment, such as using reinforcement with a non-acrylate tape containing a silicone or rubber latex adhesive (27) or a circumferential elastic wrapping.

Conclusion

Despite severe contact dermatitis to the drapes used in commercial systems, patients can still be treated with NPWT using the Bagautdinov method, which does not use adhesive drapes to create the necessary hermetic seal. The Bagautdinov method is a practical alternative method for the delivery of NPWT.

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