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Case report

The use of topical negative pressure in a paediatric patient with extensive burns

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1. Introduction

Over the last 50 years, the evolution of burn treatment has led to a major decrease in mortality. Recently, survival in children has improved to such an extent that the survival rate in children with burns involving 100% total body surface area (TBSA) is 50% [1]. Major advances have been made in early resuscitation, respiratory care, the treatment of inhalation injury, control of infection, modulation of the hypermetabolic response and nutritional support. The biggest impact on survival, however, has been the change in the approach to burn wound treatment. Years ago, burn wounds were allowed to separate by means of human and bacterial collagenases. Today, early tangential or fascial excision and grafting by various techniques makes it possible to remove all dead tissue. Before coverage of the burn, the patient remains immunosuppressed, hypermetabolic, susceptible to infection and in pain. Although the management of the burn wound is extremely challenging, a quick creation of a mechanical and biological barrier between the internal media and the environment is a well-accepted therapeutic concept.

The survival of the patient with major burns goes hand in hand with the survival of the skin grafts. The application of topical negative pressure (TNP) therapy or vacuum-assisted closure (VAC) device has demonstrated improved graft take [2].

The TNP therapy is a modified dressing, consisting of open-cell foam and suction tubing that is secured to the wound with an occlusive dressing. VAC wound closure exposes the wound bed to negative pressure by way of a closed system. Edema fluid is removed from extravascular space, thus eliminating an extrinsic cause of microcirculatory impairment and improving the blood supply during the phase of inflammation. The mechanical tension from the vacuum may also directly stimulate cellular proliferation of reparative granulation tissue. The indications for VAC are manifold and include pressure sores, leg ulcers, wounds with skin defects, burns, complications of surgical wounds and delayed healing. There are no established absolute contra-indications; however, VAC should not be applied to sloughing or necrotic tissue, over open joints, tumours, in patients with coagulopathy, over open peritoneal or pleural spaces and in those with allergic reactions to any of the components that contact the skin [3,4].The TNP-therapy complications reported in the literature include periwound erythema, maceration, partial skin loss, localized bleeding from the granulation tissue, ingrowing of granulation tissue into the foam, periwound cellulites, deep space infection and, a more serious complication, haemorrhaging of the anterior tibial artery [5,6].

2. Case report

While alone in the kitchen a six-year-old boy came too close to a burning candle. His jumper caught fire. Initially he tried to extinguish the flames himself; then he started crying for help. His mother attempted to undress him before she cooled the wounds in the shower. The previously healthy boy sustained 40% TBSA full-thickness flame burns to his right arm, trunk and neck, without inhalation injury.

After initial resuscitation and analgesia on the scene by the paramedics, the victim was flown to the regional hospital. In that hospital his wounds were cleansed, a silver sulfadiazine dressing was applied and intravenous antibiotic therapy was started. Analgesia and fluid replacement went on. Fourteen hours after the admission his respiratory situation worsened due to the constrictive thorax burn

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eschar. The patient was intubated and mechanical ventilation initiated. After another 12 h he was transferred to our burns unit. On admission the patient was immediately brought to the operating room for further wound evaluation and treatment. His body temperature was 36.6 °C; he was on a Ringer–Lactate drip, ventilated and in adequate sedo-analgesia. The initial assessment of the wounds was that of full-thickness circulatory burns to 7% of his right arm, 30% of his thorax and 3% of his neck. Due to impaired circulation of the right arm and hampered ventilation, the patient underwent extensive escharatomies. A central venous catheter was inserted into the right femoral vein as well. After that the Acticoat™-wound-dressing (Smith & Nephew Inc.) was moistened with sterile water and applied to the complete burn area, followed by wet and dry sterile gauze dressing and secured in place with elastic bandages. The patient's body temperature was well maintained. With additional intravenous fluid therapy his vital parameters were stable, diuresis adequate and ventilatory support trouble-free. Enteral tube feeding began; blood samples were taken, where the laboratory parameters showed no major abnormalities.

Thirty-eight hours after the injury Acticoat™ was removed, and a fascial-level excision to 37% of the TBSA and grafting with split thickness 1:2 mesh grafts were performed (Fig. 1). The excision to fascia in this case was chosen due to the questionable viability of subcutaneous fat. The grafts were harvested from the legs, scalp and from a small area of the back. Due to the lack of further suitable donor sites the patient's neck region (3% TBSA) remained unexcised. On the skin donor sites Biobrane™ (temporary wound dressing, Bertec Pharmaceuticals Inc., Morgantown, USA) was used. Over the complete burn area an occlusive VAC dressing (KCI Kinetic Concepts Inc., San Antonio, TX) with continuous −125 mmHg suction was installed. The skin grafts were put down, stapled and covered with Mepithel™ (soft silikocone wound contact layer, Mölnlycke Health Care AB, Göteborg, Sweden). The sponge was cut to the appropriate shape and size, placed over the grafts and stapled in place to avoid shearing effects. Having held it all in position the plastic, adhesive covering was slid over the sponge and the suction device put in. The patient was on the wound VAC for five days. During this time period the VAC was kept on suction to minimize the episodes of shear injury

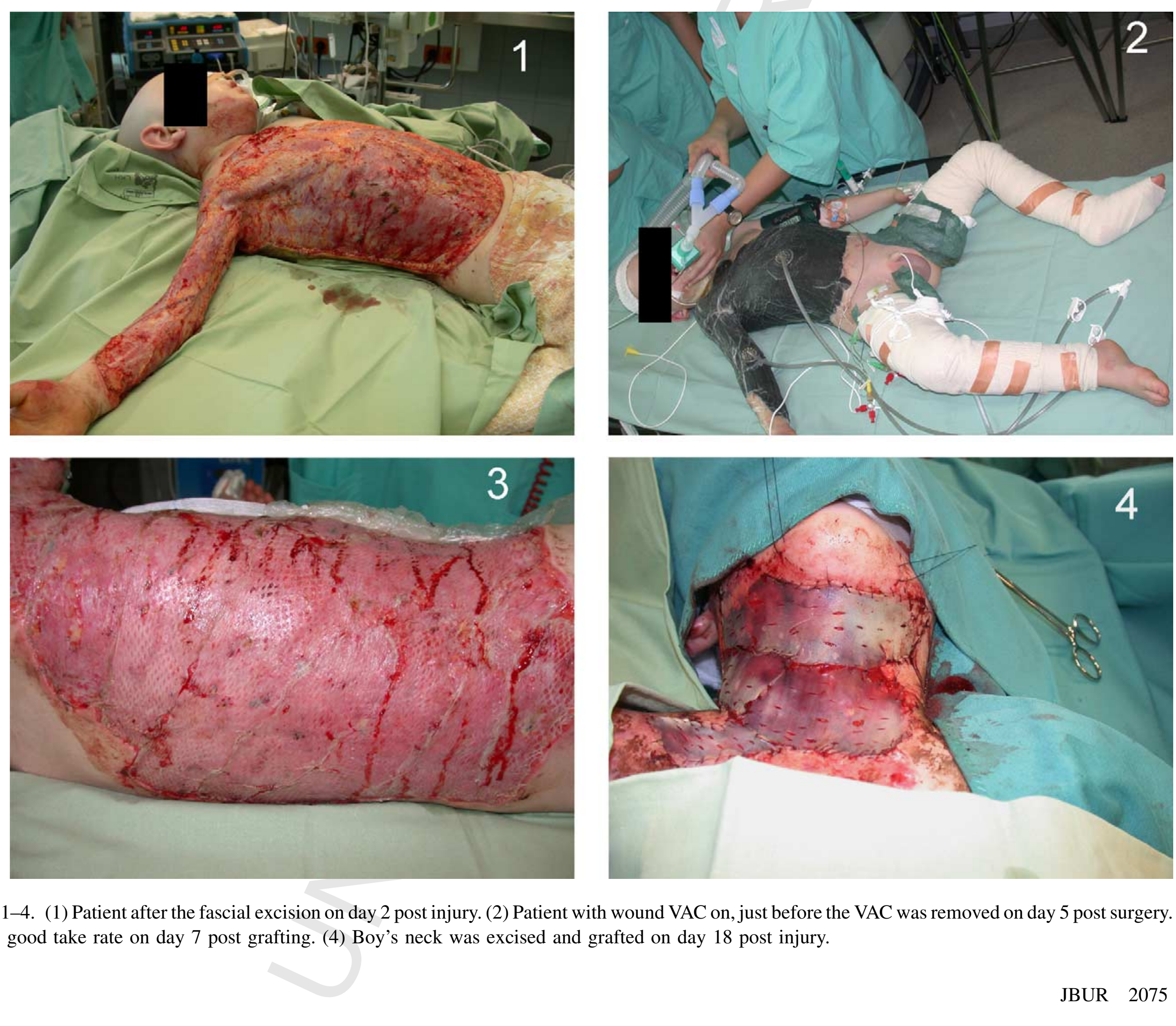

Fig. 1–4. (1) Patient after the fascial excision on day 2 post injury. (2) Patient with wound VAC on, just before the VAC was removed on day 5 post surgery. (3) A very good take rate on day 7 post grafting. (4) Boy's neck was excised and grafted on day 18 post injury.

Table 1
Laboratory checks (reference range in brackets) and fluid out of suction tub (in ml)

	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	21.5	4.6
WBC (5–13 × 10^3/μl)		20.4	12.6	8.7	11.3	13.6	11.9	11.7	14.8	9.4
Protein (5.8–8.0 g/dl)		3.6	4.1	4	4.4	5.1	5		5.5	6.1
Albumin (3.5–5.5 g/dl)		1.5	2.8	2.1	2.4	2.6	2.6	2.6	2.6	
CHE (4500–12,000 U/l)		6592	3558	3431	3307	4165	4104		4966	6160
CK (−160 U/l)		630		858		321		104		
CRP (−8 mg/l)		10	55	57	34	14	7		8	5
ASAT (GOT) (−43 U/l)		31	46	49	33	35	26		27	18
ALAT (GPT) (−45 U/l)		24	31	37	36	34	32		58	15
	Accident	Admission escharatomy	Excison VAC	VAC	VAC	VAC	VAC	VAC		
Fluid (ml)			350	700	220	140	100	50		

and the patient immobilized. The amount of the fluid which came out of the suction tubing was 350 ml during the first 12 h post surgery and 700 ml next day (Fig. 2). During following days the fluid portions lessened. A leak in the VAC-system appeared twice but it was successfully sealed each time. Bacteriologic cultures from the VAC fluid grew some *Klebsiella pneumoniae*, sensitive to all well-established antibiotics; no systemic infection was observed.

The most surprising observations after the surgery and VAC installation were an excellent overall graft survival and the child's outstanding general condition. The boy was alert and, despite wound VAC in place, the extubation proceeded uneventfully on day 3 post injury. The antibiotics, started at the regional hospital immediately on admission, were discontinued on day 6, body temperature was easily kept between 37.5 and 38.5 °C and enteral tube feeding was well tolerated. The patient was in a good mood most of the time and was co-operative during his daily physio- and occupational therapy (Fig. 3).

As can be seen in Table 1, the lab parameters very quickly returned to their normal range.

On day 18 the patient's neck was successfully excised and grafted with sheet grafts, harvested from the back (Fig. 4). The take rate was almost 100%. Matriderm™ was placed under the graft. Matriderm™ (Dr. Suwalec, Skin & Health Care AG, Germany) is a three-dimensional matrix composed of native structurally intact collagen fibrils linked with elastin and obtained from the bovine ligamentum nuchae. The aim of Matriderm™ is to develop a dermal substitute in order to avoid excessive scaring and wound contracture.

Finally, the patient made a good recovery and was discharged home five weeks post injury. The only problem we faced with was a delayed healing of the donor sites due to infection; wound culture swabs showed a substantial growth of *Staphylococcus aureus*.

3. Discussion

Argenta and Morykwas [7] and Morykwas and Argenta [8] presented a new subatmospheric pressure technique—vacuum-assisted closure—for wound treatment. It is a method of increasing the rate of wound healing by secondary intention and of preparing a wound bed to allow successful closure by skin graft. The technique removes chronic edema, leading to increased localized blood flow, and the applied forces result in the enhanced formation of granulation tissue. The VAC technique entails placing open-cell foam dressing into the wound cavity and applying a controlled subatmospheric pressure (125 mmHg below ambient pressure). The authors found that vacuum-assisted closure is an efficacious modality for treating chronic and difficult wounds. The technique of subatmospheric pressure is based on the theory that the application of mechanical stress results in angiogenesis and tissue growth. It has also been suggested that the application of subatmospheric pressure to oedematous chronic wounds results in decreased local tissue turgor due to fluid removal. This removal of excess interstitial fluid from the region of the wound theoretically decompresses small blood vessels and increases localised blood flow. In their animal studies, the authors also demonstrated a significant reduction in wound bioburden: experimental wounds in pigs were inoculated with human isolate of *S. aureus* (RP 12) and a swine isolate of *Staphylococcus epidermidis* (SR 5) and treated with either TPN or moist saline dressings. In full-thickness punch biopsies taken daily for 2 weeks, a reduction from 10^8 to 10^5 organisms per gram of tissue between days 4 and 5 in TPN-treated wounds was found, compared to a mean of 11 days in control wounds. However, Weed et al. [9] presented in their retrospective clinical study that during VAC therapy there generally was no decrease in bacterial bioburden.

The VAC therapy has also been successfully applied for securing skin grafts to the wound bed and achieving a better take rate by having a splintage effect on skin grafts [10,11]. Immobilisation of skin grafts on uneven or mobile surfaces such as nuchal area, axilla, web spaces, and perineal area can also be successfully achieved by using negative pressure dressings for immobilisation [12]. Scherer et al. [13] reported that VAC is an excellent alternative for securing skin grafts to the skin bed and achieving better graft outcome. The grafts were placed for the following indications: burns, soft tissue loss and fasciotomy-site coverage. In their study, the patients exhibited only small wound areas grafted (2–8% body surface area). Moisidis et al. [2] showed in their study that use of TNP therapy on split thickness skin grafts significantly improved the quality of the skin graft's appearance postoperatively. In this study, adult patients with mean wound size of 128 cm^2 (range 35–450 cm^2 or 1.2–2.4% body surface area) were included. Skin grafts receiving TNP displayed epithelialization rates equal to or better than those in control grafts in 75% of cases, and skin grafts receiving TNP were qualitatively equal to or better than control grafts in 85% of cases.

To our knowledge this is the first report where the TNP therapy was applied for securing skin grafts of almost 40% body surface area in a paediatric patient. The VAC device did not interfere with mechanical ventilation and the child was successfully extubated on post burn day 3, still with wound VAC on. The patient's care with wound VAC on was totally uncomplicated and the management of tissue fluid loss easier and measurable. There was no sign of either a local skin graft infection or systemic infection. The take rate was almost 100%.

The other, very surprising observation we made was that the boy never presented symptoms of the systemic inflammatory response syndrome (SIRS). However, systemic consequences of the VAC treatment to the host are unknown yet. We speculate that the removal of interstitial fluid, 1270 ml during the first 48 h, from the 40% body surface area-wound and closely adjacent tissue region, may have contributed to the boy's well being. It is very likely that the massive formation of burn edema fluid and subeschar tissue fluid (STF) in burn victims exerts multiple damaging effects after reabsorption into the systemic circulation [14–16].

To prove our observation that VAC may influence SIRS development, further experimental and clinical studies are planned.

We hypothesize that in our case, a six-year-old boy with 40% full-thickness flame burns made an excellent recovery due to the early wound excision [17] and TNP therapy as an additional treatment. In our opinion the usage of the TNP therapy is a promising approach for the complex treatment of large burns following debridement in children.

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