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Treatment of Soft Tissue Defects in Pediatric Patients Using the V.A.C.™ System

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Twenty-seven consecutive pediatric patients presenting to the orthopaedic surgery or plastic surgery services were reviewed after completion of wound care with the Vacuum Assisted Closure (V.A.C.™) system. Each patient presented with complex soft tissue wounds requiring coverage procedures. Patients with acute wounds and wounds present after nonsuccessful attempts at surgical closure (dehisced incisions and failed flaps) were treated. All soft tissue defects healed without extensive coverage procedures using the V.A.C.™ system. In the majority of patients, use of the V.A.C.™ system produced a profuse bed of granulation tissue over all exposed bone, tendon, joint, and/or hardware, which could be covered with split thickness skin graft. Other patients were treated successfully with delayed primary closure, local flap advancement (one patient underwent a pedicled cross-leg flap), or by secondary intention. Use of the V.A.C.™ device is valuable in increasing the rate of granulation tissue formation and healing of extensive soft tissue injuries in pediatric patients. This vacuum system aids in the debridement of necrotic tissue and local soluble inflammatory mediators that may inhibit the proliferation of granulation tissue. These improvements in the local wound environment seem to accelerate wound healing compared with traditional methods. Before the development of the V.A.C.™ system, a minimum of nine patients within this group would have required free tissue transfer to obtain adequate coverage. The V.A.C.™ device seems to permit earlier coverage with local tissue or split-thickness skin grafting techniques, thereby decreasing the need for extensive microvascular tissue transfers in pediatric patients.

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Treatment of soft tissue defects, traumatic defects, and those defects resulting from surgical complications, often is problematic. Multiple techniques have been developed and advocated in attempts to facilitate wound closure. The V.A.C.™ wound closure system (KCI, Inc, San Antonio, TX) was developed originally for use in difficult soft tissue situations effecting adults, primarily decubitus ulcers and those associated with vascular insufficiency.[1,5] The authors have extended its use to acute and chronic complex soft tissue defects in pediatric

patients including those with exposed bone, orthopaedic hardware, or both. The results of the use of the V.A.C.™ system are reported in 27 pediatric patients.

METHODS

All pediatric patients (≤18 years of age) with complex wounds who were treated with the V.A.C.™ system were assessed retrospectively. Hospital and clinic charts were reviewed. Patients were treated either by members of the Departments of Orthopaedic Surgery or Plastic and Reconstructive Surgery.

Specific data points were obtained on each patient. Wound type (acute or traumatic versus chronic) and location (appendicular versus axial) were noted. The number and frequency of V.A.C.™ system applications were recorded. When the system was placed as a bolster over the final split thickness skin graft, this was counted as an application. Final coverage techniques, including split thickness skin graft, delayed primary closure, secondary intention, pedicled local flap, cross extremity flap, and vascularized free flap, were documented. In addition any previous methods of closure before V.A.C.™ placement were detailed. Finally, any complications attributable to the system were noted.

TECHNIQUE

All patients underwent a thorough, intraoperative debridement of all nonviable tissue and cleansing of all macroscopic contamination. Tissue cultures were not routinely obtained before V.A.C.™ initiation, but the system was not used until the wound could be considered a clean, contaminated defect.

The V.A.C.™ sponge and outflow tube were cut to appropriate size so as to fit the wound. The wound then was sealed using either the adhesive drape provided or a commercially available, iodine impregnated drape (Ioban). Negative pressure was applied to assess the seal, and the drape was reinforced until an adequate, nonleaking, seal was obtained. In most patients, 125 mm Hg continuous negative pressure was used via the portable suction generator supplied with the system. Suction was maintained for as close to 24° per day as possible when performed in an inpatient or outpatient setting.

Patients underwent V.A.C.™ changes approximately every 3 days at the discretion of the attending physician. All dressing changes in pediatric patients were done intraoperatively or with the patient under conscious sedation. When a thick, continuous bed of granulation tissue was present, definitive wound coverage was performed. The manner of coverage was not standardized, and also was at the discretion of the attending surgeon. In wounds covered with split thickness skin graft, the V.A.C.™ system was placed over the donated graft as the bolster dressing, because the authors' experience has shown that this has markedly improved graft adherence and survival.[5]

Representative Case 1

In 1994, a 17-year-old boy presented to the authors' institution after proximal tibial osteotomy for adolescent tibia vara complicated by compartment syndrome, tibial osteomyelitis, and resultant massive soft tissue and bony defect. He underwent multiple debridements, tibial saucerization, and treatment with polymethylmethacrylate antibiotic impregnated beads. His tibia was stabilized with an external fixator. A free vascularized rectus abdominus free flap was placed and failed, leaving the defect shown in Figure 1. Resection and bone transport was not thought to be a viable option at that time, and the patient and family refused amputation.

The V.A.C.™ system was applied after operative irrigation and debridement in December 1994. Intraoperative V.A.C.™ changes were performed twice during the next 10 days, and home V.A.C.™ system changes were undertaken approximately every 3 days for approximately 6 weeks by home nursing services. Appropriate intravenous and oral antibiotics for polymicrobial osteomyelitis were managed by the Infectious Disease Service. The wound

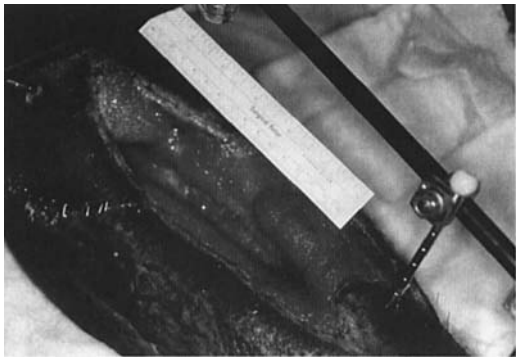

Fig 1. An anterior tibial wound with exposed bone before to initiation of V.A.C.™ treatment is shown.

granulated over exposed bone, contracted extensively, and split thickness skin grafting was performed in February 1995 (Fig 2). The wound has remained stable for approximately 2 years, although a small area required additional split thickness grafting. The grafted area subsequently was excised and closed after placement of tissue expanders in 1997.

Representative Case 2

A 4-year-old girl presented to the author's institution after being struck by an automobile. She sustained an extensive avulsion injury with complete skin and soft tissue loss involving the dorsal and lateral aspects of her left foot and ankle. At the time of initial debridement, she had segmental loss of multiple toe extensor tendons, open tarsometatarsal joints, an open calcaneocuboid joint, avulsion of her distal fibula, and an open, unstable ankle. Transfixing pins were placed to stabilize the forefoot, midfoot, and hindfoot. The V.A.C.™ system was placed after the initial debridement. The V.A.C.™ was changed with the patient under a light general anesthesia approximately every 3 days. At the time of the fourth V.A.C.™ change, abundant granulation tissue was observed covering all exposed joints with only a small cartilaginous portion of the cuboid still visible (Fig 3). A split thickness skin graft was placed, and the V.A.C.™ system was replaced over the split thickness skin graft as a bolster dressing and was removed 5 days later. At this time there was complete graft adherence (Fig 4). At most recent followup (Fig 5) 4 months after injury, the patient was fully ambulatory with excellent active plantar and dorsiflexion. The patient did not return for additional followup.

RESULTS

From 1993 to 1997, 27 pediatric patients were treated with the V.A.C.™ system at the au-

Fig 2. An anterior tibial wound now contracted and granulated after 6 weeks of V.A.C.™ treatment is shown.

Fig 3. Photograph of an anterolateral foot wound taken after four V.A.C.™ changes, at the time of split thickness skin graft.

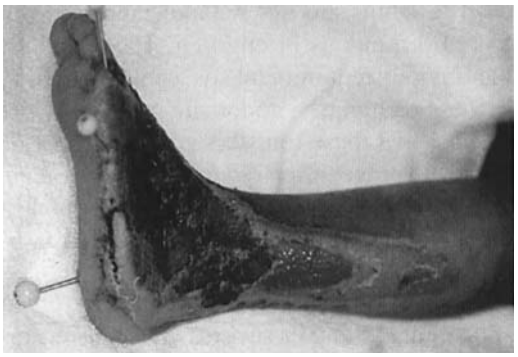

Fig 4. Photograph of an anterolateral foot wound taken 5 days after split thickness skin graft at time of V.A.C.™ removal.

thors' institution. The patients ranged in age from 3 days to 18 years at the time of initial application. Fourteen patients were male and 13 were female.

Eleven patients were treated for acute extremity wounds secondary to trauma, including those wounds associated with open fractures that were considered too extensive for acute or delayed closure at the time of second look irrigation and debridement. Nine patients underwent V.A.C.™ placement for chronic extremity wounds. These included patients with failed flap coverage, failed primary closure, and two patients with extensive soft tissue and bony defects after debridements for osteomyelitis. Finally, seven patients were treated for chronic axial wounds, including abdominal or sternal dehiscence, and one patient with myelodysplasia who had compromised skin and soft tissue was treated for a deep spinal wound infection after posterior fusion.

Wound closure and coverage was obtained with split thickness skin grafting after V.A.C.™ assisted granulation in 15 of 27 patients. Five wounds were closed by delayed primary technique and four were allowed to granulate and close by secondary intention. Two pedicled flaps were used in cases of sternal dehiscence, and one foot and leg wound was treated with a cross extremity flap after granulation. Despite the size and complexity of the wounds in the current series, no patient required vascularized free tissue transfer for final coverage.

Those patients who were treated on an inpatient basis underwent an average of 4.8

Fig 5A–B. Photographs taken 4 months after injury showing (A) active plantar and (B) active dorsiflexion.

V.A.C.™ system changes (range, one–eight changes). However, there were significant variations in the times between system changes because of attending surgeon preference and patient age, because the system was replaced more frequently in very young patients. This seems necessary because the rate of granulation tissue formation in the very young patient seems to be considerably greater, and there is greater potential for ingrowth of granulation tissue into the pores of the sponge. In general, the system was changed approximately every 3 days, and each change required the patient to receive conscious sedation or brief general anesthesia. One patient, however, did undergo home V.A.C.™ changes with the assistance of home health personnel, although the number of system changes was not well documented.

All patients tolerated V.A.C.™ treatment. Complications have been seen infrequently in adult patients including overgrowth of granulation tissue into the sponge with bleeding at dressing change, recurrent infection, and maceration of adjacent skin. There were no complications observed in this pediatric group beyond minimal bleeding attributable to disrupted granulation tissue at the time of system changes. In no patients were V.A.C.™ treatments discontinued because of pain or infection. There were no skin injuries caused by the suction system or the use of the adherent drape.

DISCUSSION

Wound treatment is an issue as old as medicine. Modern methods range from simple dressing changes with eventual closure by secondary intention to complex soft tissue rearrangement and muscle transfers requiring extensive microsurgical techniques. Wound care, particularly that of large defects, is extremely problematic in the pediatric patient. Daily dressing changes require sedation or anesthesia in most children, thereby exposing them frequently to this risk. In addition, the microvascular transfers that commonly are used in adults are not without increased potential difficulties in children. These include the obvious requirement for technical facility in these techniques, donor site morbidity, and the fact that these transfers generally provide bulky coverage, often requiring later revision.

In an attempt to facilitate the treatment of patients with complex wounds, the V.A.C.™ system was developed by two of the authors (LA and MM). It has been used extensively in adult patients, and its success in increasing patient comfort, decreasing morbidity, and decreasing cost of wound care is well documented.[1,4,5] No data exist detailing the use of the V.A.C.™ system in an exclusively pediatric group.

The V.A.C.™ system consists of an open cell polyurethane ether foam sponge with a pore size ranging from 400 to 600μm in diameter. The sponge is cut to size, and used to fill the depth and breadth of the wound. A suction or evacuation tube is placed within the sponge and exits the wound. The wound and sponge are sealed with an adhesive drape and suction is delivered at 125 mm Hg via a combined suction pump and collection device.

The primary goals of the system are to stimulate the rapid formation of granulation tissue. The direct action of the sponge under suction is to remove interstitial fluid from the wound. This fluid has high levels of cytokines, collagenases, and elastases that are known to inhibit development and proliferation of fibroblasts and endothelial cells that are prominent in wound healing.[2,3,6,7] In addition, this third space fluid has been shown to cause mechanical occlusion of local capillary blood flow, thereby decreasing tissue perfusion.[2,3] Finally, the continuous suction pressure within the wound acts to slowly draw the wound together, analogous to the action of an Ilizarov type device on bone and adjacent soft tissue.

An in vivo study of the V.A.C.™ effect on wound healing has been done in a porcine model.[4] In this study, laser Doppler evaluation revealed a four times increase in local blood flow when the sponge dressing was placed

within an experimental wound, and exposed to suction pressures as generated in the clinical use of the V.A.C.™ system. The same in vivo study showed significantly increased granulation tissue formation, decreased tissue bacterial counts, and increased random pattern flap survival versus controls using saline and gauze dressings.[4] All of these improvements seem to be a result of increased removal of large amounts of interstitial fluid, or wound edema using subatmospheric pressure exposure.

A previous clinical evaluation of the V.A.C.™ system has focused exclusively on its use in adult patients.[1] The use of the V.A.C.™ system has shown greater efficacy in the treatment of wounds ranging from large traumatic soft tissue defects to decubitus ulcers in elderly patients when compared with traditional wound treatment techniques.[1,5] The current report shows the use and efficacy of the V.A.C.™ system in pediatric patients. All patients tolerated the system, and in each case the wounds were covered successfully. It seems that use of the V.A.C.™ system provides notable advantages over traditional wound care in the younger population. Patients require fewer potentially painful dressing changes than in standard daily wound treatment, and may require less extensive coverage procedures. The V.A.C.™ wound closure system seems to be a valuable adjuvant in the treatment of complex wounds in adult and pediatric patients, and as such continues to be used widely at the authors' institution.

The V.A.C.™ system was used successfully in this group of pediatric patients. In general, it was well tolerated and minimized the need for the routine and frequent dressing changes required with traditional wound care techniques. The system aided in closure and/or coverage using relatively simple methods without the need for complex microsurgical interventions. Finally, there were no significant complications in this patient population. Overall, the V.A.C.™ system seems to be a viable alternative to standard, daily wound care techniques, and provides multiple advantages over traditional methodologies.

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