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A New Technique for the Treatment of Delayed Sternotomy Healing: The Vacuum Therapy

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ABSTRACT

Background: The treatment of nonhealing and infected sternotomies after cardiac surgery is a challenging task, with its increased rates of mortality, morbidity, and costs. Local vacuum therapy (V.A.C. system) allows treatment of local infections, thanks to continuous aspiration and the sealed dressing that stimulates granulation tissue formation. The purpose of this clinical investigation was to evaluate vacuum therapy in cardiac surgery for achieving healing of delayed sternotomy closure after cardiac surgery.

Materials and Methods: From January 1998 to December 2002, 7 patients who underwent coronary artery bypass surgery under cardiopulmonary bypass by median sternotomy approaches presented a nonhealing infected sternal surgical wound that was treated with local vacuum therapy. Aspiration maintained between –125 mm Hg and –200 mm Hg was carried out on the entire surface of the wound with a sponge connected hermetically to an aspiration system. The treatment was associated with antibiotic therapy adapted to the results of bacteriological studies of the aspirates.

Results: All patients with delayed sternotomy closure healed in approximately 8 weeks (2-12 weeks) with the exception of one patient who died of multiorgan failure after a satisfactory muscular pectoral flap. Treatment was possible with vacuum therapy alone (n = 2), with vacuum therapy in association by second intention with a skin graft (n = 1), or both with a muscular pectoral flap (n = 4). Sternal stability appears to be an important factor for achieving satisfactory and complete healing.

Conclusions: This new therapy offers an alternative to the classic treatment of infected sternotomies in cardiac surgery, especially in preparing rewiring and muscular flaps for complicated cases with sternal instability or alone. The treatment must be instituted early to be more effective.

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INTRODUCTION

Median sternotomy is the classical cardiac surgical approach, especially for coronary revascularization. Complications of median sternotomy approaches, such as delayed sternotomy closure and mediastinitis, also include severe regional morbidity and life-threatening events such as septic shock and endocarditis. Risk factors for these unfavorable outcomes include immunodepression such as with corticotherapy, diabetes mellitus, redo surgery, advanced age, obesity, harvesting of both internal thoracic arteries, duration of the procedure, and emergent surgery [Lizan-Garcia 1997, Lauwers 1998]. Management of these complications requires prolongation of hospital stay, additional surgical procedures, and increased costs.

After the first studies of the technique in 1997 by Argenta, Morykwas, and coworkers [Argenta 1997, Morykwas 1997], the Vacuum Assisted Closure system (V.A.C.; Kinetic Concepts Incorporated, San Antonio, TX, USA) has produced outstanding results in plastic and reconstructive surgery [Greer 1999]. The V.A.C. uses negative pressure to enhance wound healing and has been used in our department of cardiovascular surgery since 1998 [Demaria 2000]. We have obtained excellent clinical results with the V.A.C. in the treatment of open, infected groin wounds after elective femoral vessel surgery (venous grafting or endarterectomy with polyester patch implantation) in patients with obesity, diabetes mellitus, or renal failure [Demaria 2001, Giovannini 2001a].

The aim of this retrospective clinical study was to evaluate the efficacy and safety of V.A.C. therapy in a group of 7 patients who underwent coronary surgery under cardiopulmonary bypass via a median sternotomy approach. These patients had risk factors for poor wound healing and experienced severe local complications (tissue defect, diffuse hematoma, abscess, sternal instability, and mediastinitis) that made the achievement of wound healing a challenging task.

MATERIALS AND METHODS

Patients

From January 1998 to December 2002, 52 patients in our cardiovascular surgical department experienced delayed healing of a sternotomy approach performed for cardiac surgery. Seven of these 52 patients received negative pressure therapy for severe local complications, septic shock, or poor general

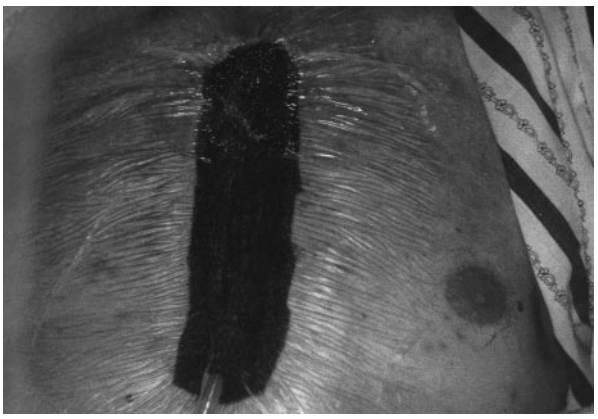

Figure 1. The polyurethane foam dressing of the V.A.C. device is trimmed extemporaneously and used to fill the cavity. Adhesive plastic film is placed over the foam dressing and surrounding skin to maintain negative pressure within the wound. Reprinted with permission from [Demaria 2000].

health after failing to respond to conventional therapies after 7 to 10 days of treatment. There were 6 men and 1 woman with a mean age of 74 years (range, 71-80 years). All patients had vascular risk factors. All underwent operations for coronary artery bypass grafting with harvesting of the left internal thoracic artery. In one patient, both left and right internal thoracic arteries were harvested. All patients underwent operations with cardiopulmonary bypass, and 4 patients had diabetes mellitus. Several days after surgery, wound dehiscence with local inflammation followed by a cloudy discharge was noted in all patients. Low-grade fever was present in some patients. No improvements were seen with polyvidone-iodine bandages changed daily and oral antimicrobial therapy targeted initially to staphylococci followed by surgical debridement and reopening of the wound. Microbiological studies of wound specimens recovered coagulase-negative *Staphylococcus* in 4 cases, *Proteus mirabilis* in 1 case, and no microorganisms in 2 cases. When possible, appropriate antimicrobial agents were given, either orally or intravenously.

The time from initiation of the conventional treatment described above to the initiation of V.A.C. therapy was usually approximately 10 days. V.A.C. therapy was started because of worsening local manifestations (purulent discharge) with systemic evidence of infection (fever and leukocytosis). For all patients, the sternum was closed, and the V.A.C. was applied above the sternum, which was stable or unstable (disjunction) depending on the case. The V.A.C. was never applied directly on the anterior mediastinum. Informed consent was obtained from each patient.

Technique of V.A.C. Therapy

The technique of V.A.C. therapy necessitates a surgical wound cleansing under general anesthesia, followed by the insertion into the wound of sterile polyurethane foam trimmed to the size of the cavity (Figure 1) and connected via a tube to a control panel (Kinetic Concepts Incorporated) equipped with a canister for the aspirated debris (Figure 2). The negative pressure can be regulated directly by the control panel. Aspiration maintained for the thoracic position between –125 mm Hg and –200 mm Hg, depending on the patient's tolerance, was done uniformly on the entire surface of the wound with sterile carbonate foam changed every 2 days and connected hermetically to the aspiration system. Aspiration can be continuous or intermittent. Maintaining the negative pressure requires the wound to be sealed via application of adhesive film over a large area of the surrounding skin. If the seal is not airtight, air leaks occur, producing an increase in pressure that sets off an alarm. When the polyurethane foam is subjected to negative pressure, it immediately collapses and adheres firmly to the edges of the cavity, and this action pulls them together.

The dressing was usually changed every 48 hours, depending on the amount of exudates present in the canister, which was evaluated daily [Giovannini 2001b]. At each dressing change, polyvidone-iodine was applied to the wound, which was then rinsed with an isotonic solution and finally dried. Inflammation of the adjacent skin should be avoided by trimming the foam exactly to the size of the tissue defect and, if needed, by protecting the edges of the wound with a hydrocolloid dressing. Samples from the sterile changeable canister were taken at regular intervals for microbiological studies, and the results of these studies were used to select systemic antimicrobial agents to be given to the patient. Changes in clinical status and microbiological study results were used to evaluate the efficacy of systemic antimicrobial therapy. The treatment was associated with an antibiotic therapy adapted to the bacteriological results (*Staphylococcus*, 4 cases; *Proteus mirabilis*, 1 case; no microoganism, 2 cases). It is possible in some cases to disconnect the V.A.C. system for 15-minute periods to allow the patient some freedom of movement (Figure 3).

RESULTS

All 7 patients with delayed sternotomy closure (septic disjunction) healed in approximately 8 weeks (2-12 weeks) with

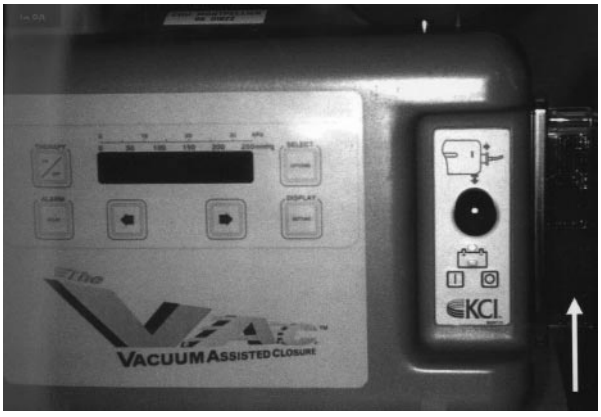

Figure 2. Control panel of the V.A.C. device equipped with a canister for the aspirated debris (arrow). Reprinted with permission from [Demaria 2000].

Figure 3. Patient and the V.A.C. device, allowing mobility of the patient during treatment. Reprinted with permission from [Demaria 2000].

the exception of one patient who died of multiorgan failure after a satisfactory muscular pectoral flap procedure. The mean duration of V.A.C. therapy was 56 days (range, 14-84 days). Satisfactory local improvements were seen in all patients. The evidence of systemic infection was resolved within 2 days, and evidence of local infection was resolved within approximately a week of aspiratory treatment. After a mean of a few weeks, the defects were entirely covered and filled with granulation tissue in patients with a stable sternum (Figure 4).

In patients with an unstable sternum and bone mobility occurring with respiratory motions, the healing could not be completed with the V.A.C. alone. Muscular flaps were then necessary to fill the defect after sternal rewiring and local debridement.

During treatment, none of the patients reported major chest pain or discomfort related to excessive negative pressure. With standard oral analgesic drugs, the pain associated with dressing changes was acceptable to the patients. Inflammation of the wound edges occurred occasionally but responded to application of hydrocolloid film during dressing changes. For one patient, however, the duration of the therapy induced a secondary mood depression.

Healing was possible with vacuum therapy alone (n = 2), vacuum therapy associated in second intention with a skin pinch graft carried out under local anesthesia (n = 1), or both with a skin pinch graft and a muscular pectoral flap (n = 4). One patient experienced a relapse, which required the removal of sternal wires. These procedures were done on the day of V.A.C. device removal. When a muscular flap reconstruction was necessary, the V.A.C. therapy offered a satisfactory improvement of the underlying conditions to favor the implantation of the flap. The patients were discharged several days after reoperation.

DISCUSSION

Local negative pressure therapy is a new method for treating wounds that resist healing, and the V.A.C. system has been proposed in different fields of surgery for the repair of tissue loss [Argenta 1997, Greer 1999, Evans 2001]. Promising results have been obtained, particularly in the treatment of soft tissue wounds [Kalailieff 1998, Alvarez 2001]. This technique combines the principle of negative pressure treatment and an occlusive sterile dressing. It has demonstrated a good, statistically significant improvement in reducing local infection after a few days and is associated with the rapid appearance of granulation tissue [Argenta 1997, Morykwas 1997].

The V.A.C. system consists of porous polyurethane structure that is cut with sterile scissors to the size of the tissue loss area and linked by a silicone tube to a remote container, which collects the wound exudates sucked from the wound. Continuous strong drainage provided by the negative pressure decontaminates the wound by constantly aspirating and eliminating pathogenic organisms. Successful wound healing correlates with an organism count lower than 10^5 per gram of tissue [Kucan 1981], and the organism count after V.A.C. therapy is usually lower than 10^3/g [Argenta 1997]. Through its suction effect, the V.A.C. system applies a pulling force to the interface between the sterile foam dressing and the wound [Mullner 1997]. The sponge distributes the force evenly, thus pulling the edges of the wound together and reducing the size of the cavity. This mechanical force transmitted by the foam also acts directly on the connective tissue fibroblasts to promote tissue budding and collagen production. Furthermore, the continuous drainage of the entire wound surface provided by the V.A.C. system prevents the deposition of autologous fibrin and exudates in the wound, which inhibit fibroblast division and collagen production

Figure 4. After a few weeks, the defects were entirely covered and filled with granulation tissue in patients with a stable sternum. Definitive healing was then possible with vacuum therapy alone or with vacuum therapy associated secondarily with a skin pinch graft carried out under local anesthesia. Reprinted with permission from [Demaria 2000].

[Bucalo 1993]. In addition, the abundant autologous cellular debris formed in the wound is cleared continuously. These effects decrease local inflammation and stimulate angiogenesis mediated by vascular growth factors while improving tissue oxygenation and promoting tissue reconstruction in a propitious, humid environment [Hartnett 1998].

Vacuum-assisted closure has been used in the treatment of mediastinitis after sternotomy for heart surgery since 1999 [Obdeijn 1999, Tang 2000, Doss 2002]. As in our study, these investigators concluded that V.A.C. treatment could be an excellent alternative to the conventional management of these wounds. A comparison of conventional wound care and treatment with the V.A.C. system was not possible because this study was not a prospective randomized study and because all cases treated by V.A.C. had failed to respond to prior conventional therapies; however, the time course to closure seems to have improved significantly in each case with V.A.C. therapy compared with conventional dressing care. If the sternum is partly debrided, the duration of V.A.C. therapy depends on granulation tissue development on the sternum and the local aspect of the wound before direct closure, a skin graft, or a muscular flap is considered (mean duration of V.A.C. therapy, 56 days). Indeed, V.A.C. may be used as a preparation for secondary closure (muscular flap), as preparation for a cleaner bed for the flap, or until complete closure is achieved, especially if the sternum remains stable. Complete debridement of the wound is mandatory before starting any aspiratory treatment. All sternal fragments and foreign material must be removed as well. Indeed, sternum instability is a major risk factor for wound healing failure with V.A.C. therapy. Even when complete healing was not achieved, less aggressive surgical procedures were required, and the preoperative global status of the patient was significantly improved. Acceptance by the patients is also usually excellent. No complications were recorded during the treatment. However, V.A.C. therapy should be started as early as possible, at the onset of the first unfavorable signs, such as an extensive tissue defect, local and systemic evidence of infection, and patient-related risk factors. Selection of the complementary closure technique rests on the local appearance of the wound and the psychological status of the patient. In our unit, negative pressure is now a well-established alternative to the standard management of severely infected wounds in cardiac surgery patients.

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