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A Technique for the Treatment of Sternal Infections Using the Vacuum Assisted Closure™ Device

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Robert E. Hersh, MD,[1] Aditya K. Kaza, MD,[2] Stewart M. Long, MD,[2] Steven M. Fiser, MD,[2] David B. Drake, MD,[1] Curtis G. Tribble, MD[2]

University of Virginia Health System, Charlottesville, Virginia
[1]Department of Plastic Surgery
[2]Division of Thoracic and Cardiovascular Surgery, Department of Surgery

ABSTRACT

Background: Sternal infections after median sternotomy remain a serious cause of postoperative morbidity and mortality. The treatment of sternal infections has evolved over the past few decades, and now aggressive surgical debridement with rotational muscle flap closure has provided an acceptable means of managing this complication. However, there are several disadvantages with this approach, mainly related to the morbidity associated with serial debridements with dressing changes and open packing until the wound is closed. Other disadvantages include potential morbidity and mortality associated with the shearing forces between the beating heart and the debrided sternal edges, and the need to paralyze the patient during the period after debridement.

Methods: Our method of managing sternal infections is based on the triad of prompt surgical debridement, serial quantitative wound cultures, and the use of the Vacuum Assisted Closure™ (VAC) device (KCI International, San Antonio, TX). Following debridement and irrigation, a biopsy of the healthy appearing bone is sent for quantitative culture. If culture results are favorable, the wound is then fitted with the VAC™ device, which consists of a non-collapsible, open-cell, polyurethane sponge with embedded vacuum tubing, a vacuum pump, and transparent adhesive dressing. When systemic signs of infection and quantitative cultures indicate the resolution of the local infection, regional muscle flap or primary wound closure is performed.

Conclusions: The VAC™ serves as a bridge to sternal wound closure and is a safe and effective therapeutic strategy for patients with impaired physiologic reserve and/or highly contaminated wounds. We feel that it is also reasonable to consider the VAC™ as a preventive strategy against right ventricular rupture. Furthermore, because the firmness of the vacuum sponge apparatus acts as an impressive sternal stabilizer, post-debridement extubation is possible, reducing the need for prolonged paralysis and mechanical ventilation. This stabilization also allows early postoperative ambulation with the VAC™ in place. In summary, we believe that the VAC™ device offers an effective means of managing patients with sternal infections.

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Address correspondence and reprint requests to: Dr. Curtis G. Tribble, Professor of Surgery, Division of Thoracic and Cardiovascular Surgery, University of Virginia Health System, P.O. Box 801359, Charlottesville, VA 22908-1359, Email: ctribble@virginia.edu

INTRODUCTION

Sternal infections and mediastinitis remain a major source of postoperative morbidity and mortality after cardiac surgery. The incidence of sternal infections after sternotomy has been reported to range from 0.15% to 5% [Baskett 1999]. It is one of the most devastating complications, resulting in multiple operative procedures and prohibitive hospital costs.

The treatment of sternal infections has evolved over the past few decades. With the advent of superior antibiotics and more refined surgical techniques, the mortality has decreased considerably. In 1963, Schumaker et al. [Schumaker 1963] advocated the use of a closed mediastinal antibiotic irrigation system for the treatment of sternal infections. This treatment decreased patient mortality significantly compared with the earlier techniques. However, this was not felt to be a definitive treatment for this complication. Jurkiewicz et al. [Jurkiewicz 1980] first proposed the muscle flap technique for the treatment of sternal infections, and a variety of muscle flaps have since been used for this technique.

The success of this treatment modality has helped promote the development of standardized treatment for this disease process: aggressive debridement of sternal infections with open packing, antibiotic treatment, and closure of the sternal defect with muscle flaps after the infection has subsided. However, this technique continues to be plagued with high mortality rates ranging from 10% to 20% [Loop 1990, Milano 1995]. Several complications were also noted to occur in the time interval from open packing to muscle flap closure. These complications included pneumonia, respiratory failure and, rarely, ventricular rupture resulting from shear forces generated during open packing [Arbulu 1996].

We describe the use of a new technique for the treatment of such infections in which we abandon the technique of open packing in favor of the Vacuum Assisted Closure™ (VAC) device (KCI International, San Antonio, TX). This device allows for a closed and controlled environment during

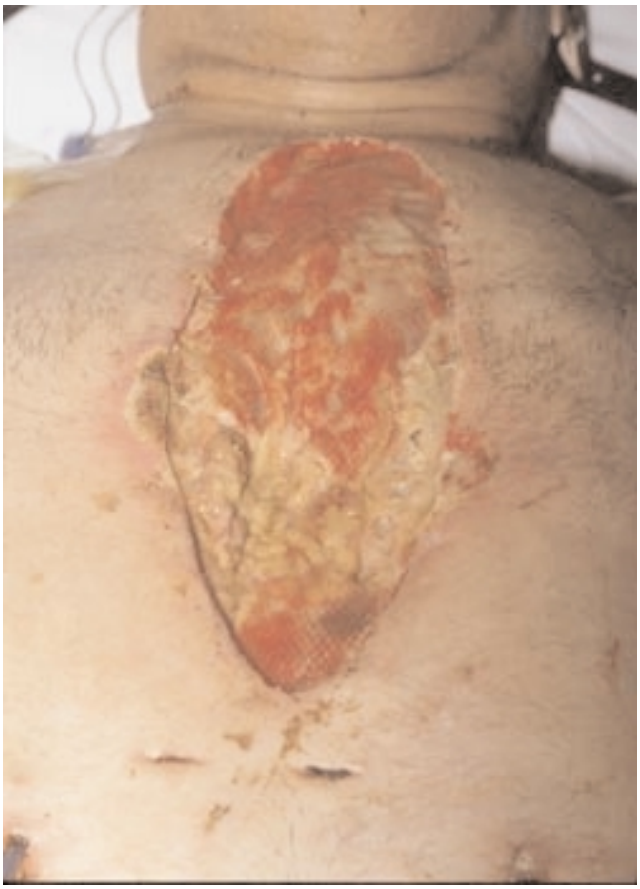

Figure 1. The appearance of a sternal wound infection prior to debridement.

the treatment of sternal infections until the muscle flap procedure can be accomplished. We reported our experience using this closure system for 16 patients in a recent report [Hersh 2001]. Fifteen of these patients recovered successfully, with one mortality related to dysrhythmia during the muscle flap procedure.

TECHNIQUE

Our management of sternal infections is based on the triad of prompt surgical debridement, serial quantitative wound cultures, and the use of the VAC™ device. Debridement was scheduled as soon as practical following the diagnosis of sternal wound infection (Figure 1, ◎). All devitalized soft tissue was excised (Figure 2, ◎) and sternal wires were removed. Bony debridement was performed until healthy bleeding bone was revealed. Pulsed irrigation was initiated following debridement with 3-6 liters of normal saline at 15 psi. At the conclusion of the debridement, a biopsy of the healthy appearing bone was sent for quantitative culture. Culture results < 105 cfu/g tissue were required for wound closure to be considered.

Following the debridement procedure, the wound was fitted with the vacuum assisted closure device. The VAC™ device consists of a non-collapsible, open-cell, polyurethane sponge with embedded vacuum tubing, a vacuum pump, and transparent adhesive dressing. The suction generates a continuous vacuum in the foam beneath the adhesive dressing (Figures 3-5, ◎). This provides a high contact zone in the wound-foam interface. Pressures of -100 to -125mm Hg were utilized depending on the patient's tolerance for discomfort. When systemic signs of infection and quantitative cultures indicated the resolution of the local infection, regional muscle flap or primary wound closure was employed (Figure 6, ◎).

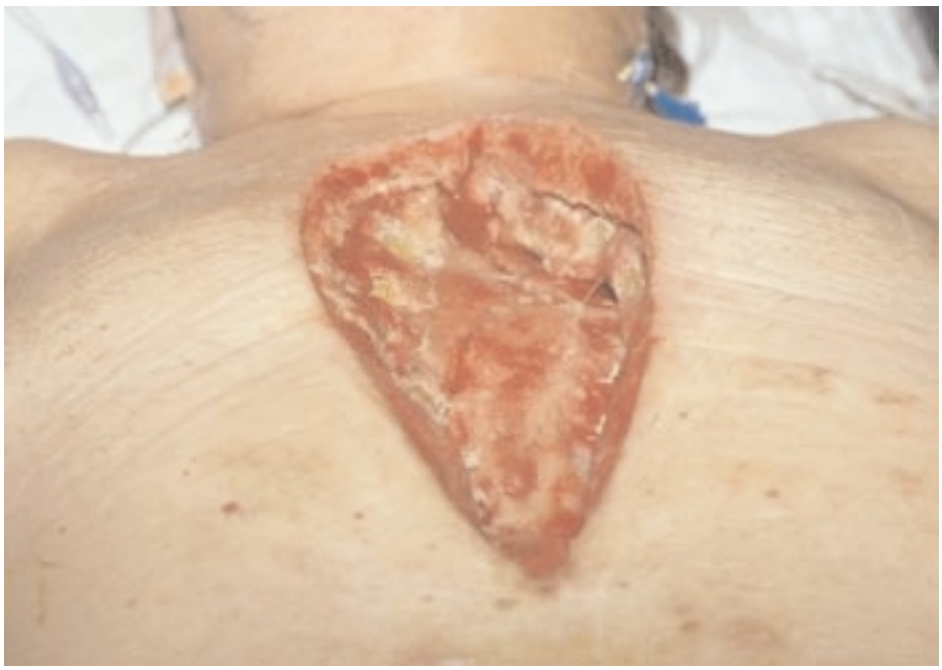

Figure 2. The appearance of the wound after thorough debridement.

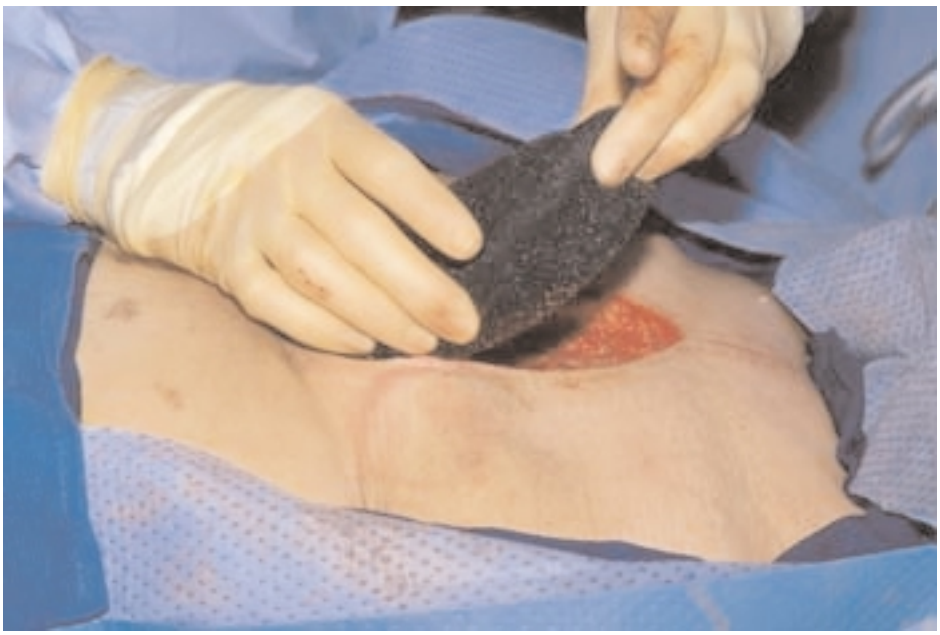

Figure 3. The non-collapsible, open-cell, polyurethane sponge is then placed in the wound.

DISCUSSION

The VAC™ device was first introduced by Argenta and Morykwas for the treatment of pressure ulcers and chronic wounds [Argenta 1993]. Since then the VAC™ device has been shown to have many applications in wound care [Argenta 1997, Mullner 1997]. The VAC™ has been used as a bolster for skin grafts, to enhance reepithelization of a skin graft donor site, and even for temporary closure of the abdomen [Smith 1997, Blackburn 1998, Genecov 1998]. Theoretically, the VAC™ device should have several advantages over open packing for deep sternal wounds. The uniform negative pressure when applied to a wound permits arteriolar dilatation which, in effect, promotes granulation tissue proliferation

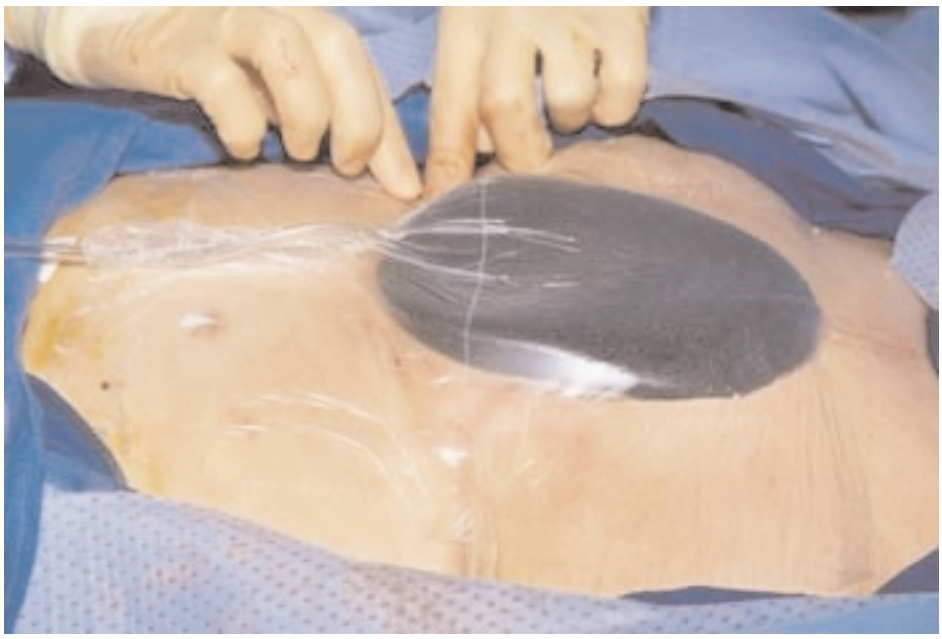

Figure 4. The vacuum tubing and the sponge are then covered with transparent adhesive dressing.

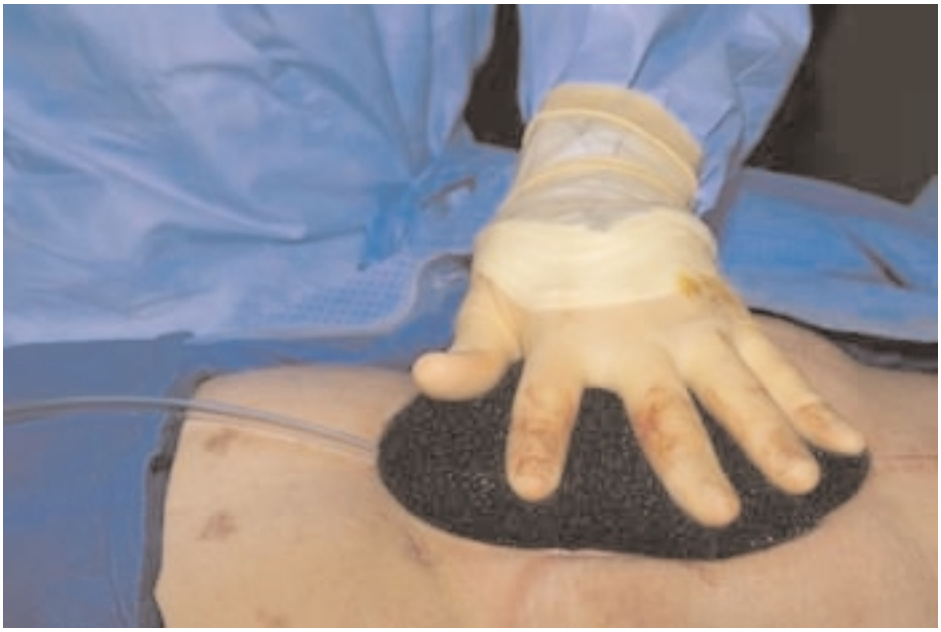

Figure 5. The appearance of the wound after suction is applied using the vacuum pump.

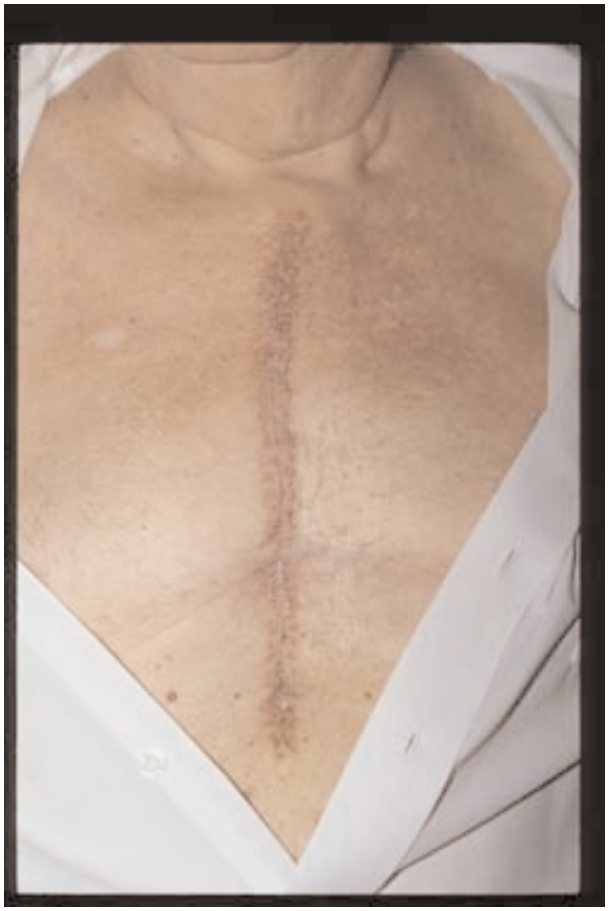

Figure 6. The appearance of the wound after VACTM treatment and muscle flap rotation.

[Argenta 1994]. In addition, research has shown this technique to decrease excess fluids and edema, and to reduce bacterial colonization of the wound [Morykwas 1997]. These positive effects on a wound bed accelerate the healing process which, in turn, should ultimately help a patient achieve wound earlier. A shorter length of time between primary debridement and delayed muscle flap closure would also decrease the chance of complications and reduce the length and cost of hospital stay. The VAC™ technique for sternal wound management could be viewed as a method that combines the benefits of both closed and open treatment types. Vacuum sealing the wound provides an optimal physiologic environment for tissue repair.

Jones [Jones 1997] has shown that a strategy of single-stage debridement and muscle flap closure can be safely employed, resulting in low morbidity and reduced length of stay in selected patients. However, we believe there is a subset of patients, mainly those with impaired physiologic reserve and/or highly contaminated wounds, for whom single-stage debridement and closure is not prudent. Use of the VAC™ as a bridge to sternal wound closure is a safe and effective therapeutic strategy for these patients.

Prior to the institution of the VAC™ therapy, it was our policy to maintain patients with open sternums on mechanical ventilation and paralysis and perform bedside dressing changes and serial operative debridement until the sternum was closed with muscle flaps. This policy evolved after a patient had a right ventricular rupture in the days following sternal debridement for mediastinitis. It was felt that in this case right ventricular rupture occurred as a result of a shearing force between the debrided sternum and the heart. The sealed vacuum of the VAC™ prevents desiccation of the myocardium, and placement of the sponge between the right

ventricle and the overlying sternal elements prevents the sternal edges from injuring the anterior right ventricle. Furthermore, the vacuum device stabilizes the chest to avoid distraction injury of the right ventricle [Arbulu 1996]. For those reasons, it is reasonable to consider the VAC™ as a preventive strategy against right ventricular rupture. Also, since the firmness of the vacuum sponge apparatus acts as an impressive sternal stabilizer, post-debridement extubation is possible, reducing the need for prolonged paralysis and mechanical ventilation. Because of this stability, the patient's chest and mediastinum are stable even when the patient is coughing. Stabilization also allows early postoperative ambulation with the VAC™ in place.

CONCLUSION

The VAC™ serves as a bridge to sternal wound closure and is a safe and effective therapeutic strategy for patients with impaired physiologic reserve and/or highly contaminated wounds. It is also reasonable to consider the VAC™ as a preventive strategy against right ventricular rupture, and its stabilizing characteristics allow for post-debridement extubation, reducing the need for prolonged paralysis and mechanical ventilation. In summary, we believe that the VAC™ device offers an effective means of managing patients with sternal infections.

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