NEW TECHNOLOGY

Elastic Device Facilitating Delayed Primary Closure of Sternal Wound Infection

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Purpose. **Management of the sternal wound after extensive debridement continues to be a resource-intensive problem in cardiac surgery. There are a number of techniques available to achieve definitive closure of these wounds, all of which have limited effectiveness or are associated with serious complications. This article describes the use of a novel elastic system that approximates these wounds gradually, achieving dynamic wound closure. The purpose of this study is to evaluate the efficacy of this system.**

Description. **We report our initial series of 3 patients who underwent dynamic wound closure using a novel elastomer system after debridement for sternal wound infection.**

Evaluation. **All patients achieved satisfactory healing with a mean duration of 29 days of treatment without additional procedures.**

Conclusions. **Dynamic wound closure is an effective and feasible method of dealing with the open sternotomy wound after debridement.**

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Sternal wound infection after cardiac surgery often necessitates aggressive surgical debridement that may result in large defects, presenting a challenge for subsequent wound closure. Tissue transfers, such as pectoral flaps, are often required to accomplish definitive closure. These techniques, although effective, carry inherent morbidity and complications with them. An ideal technique for control of these difficult sternal wounds would be to allow ongoing debridement and facilitate delayed primary closure without the need for additional procedures.

Technology

The Dynamic Wound Closure System (Canica Design Inc, Almonte, Canada) is an adhesive elastic device that spans the wound edges. The elastics can be gradually tightened, placing constant tension on the tissues, and the wound slowly closes over time achieving dynamic wound closure. This prevents tissue edema, fibrosis, and retraction of wound edges, thus facilitating delayed primary closure. The following is a description of the initial 3 patients who underwent this closure technique.

Technique

The charts of the 3 patients were retrospectively reviewed. Approval for this case review was granted by the Ottawa Hospital Research Ethics Board.

The Dynamic Wound Closure System (Canica Design, Inc) consists of adhesive anchors and elastic silicone cords called elastomers (Fig 1). The skin surrounding the wound is cleaned and the anchors are adhered to the skin (1 cm back from the wound margin). The anchors have a wire cleat with an eye and a long-tapered slot. The elastomer can be secured at any point and released for wound management or for tension adjustment. The anchors are placed on opposing sides of the wound and an elastomer is laced across. The elastomers are tightened appropriately every 3 to 4 days, and the device is left on the skin until skin apposition and sufficient adhesion of the edges has been achieved.

Clinical Experience

Patient 1

An obese, 49-year-old, type 2 diabetic woman on oral hypoglycemic medication underwent uncomplicated coronary artery bypass grafting using bilateral mammary arteries. The patient returned to the hospital on postoperative day 14 with fever and purulent drainage from her sternal incision. Wound and blood cultures were positive

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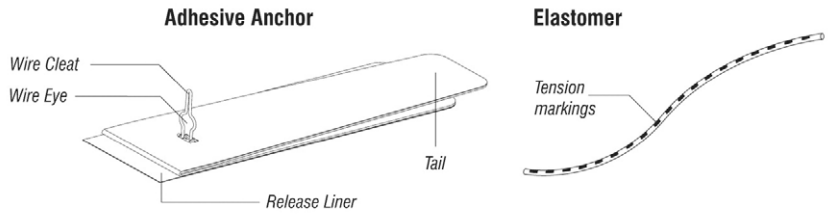

Fig 1. Adhesive anchor wound closure system (Canica Design, Inc, Almonte, Canada).

for *Staphylococcus aureus*. An incision and drainage of the superficial subcutaneous tissue of the lower aspect of the wound was performed on postoperative day 15. The patient was initially treated with intravenous cloxacillin. After the procedure, the wound edges were found to be separating. Nineteen days after the original surgery (ie, 4 days after debridement), the adhesive closure device was placed and the patient was discharged home with the device and oral ciprofloxacin for 6 weeks in duration. The anchors were removed at follow-up 33 days after debridement (postoperative day 52), when the wound edges had approximated (Fig 2). Total duration of treatment with the anchors was 33 days.

Patient 2

An obese, 73-year-old, type 2 diabetic man underwent coronary artery bypass grafting complicated by postoperative bleeding necessitating reopening. The patient's recovery was further complicated by the development of a superficial sternal wound infection that was treated with oral antibiotics. On postoperative day 62 he presented to hospital with sternal pain, fevers, night sweats, and purulent drainage from the incision. Cultures were positive for *S. aureus.* A computed tomographic (CT) scan demonstrated sternal osteomyelitis. The patient returned to the operating room where necrotic tissue was debrided to healthy, bleeding tissue. The anterior table of the sternum was curetted back to healthy bone and the wires were left in situ. The incision was initially left open and transiently treated with vacuum-assisted closure. Ninety days after the original surgery (ie, 13 days after debridement) the dynamic closure device was applied. The patient was discharged home with the device and intravenous cefazolin for 4 weeks duration. The anchors were removed 39 days after debridement (ie, postoperative day 116) by the nurse in the patient's home. At the follow-up visit (2.5 months after discharge) the wound was found to be completely healed. The total duration of treatment was 26 days.

Patient 3

An obese, 54-year-old, type 1 diabetic woman underwent coronary artery bypass grafting using bilateral mammary arteries. She re-presented 4 months postoperatively with purulent drainage from her chest incision and anterior right thoracic pain. Bone scan and CT scan demonstrated extensive sternal osteomyelitis. Blood and wound cultures were positive for *S. aureus* and *Pseudomonas aeruginosa.* The patient was treated with intravenous ceftazidime and ciprofloxacin and returned to the operating room for extensive debridement of the necrotic subcutaneous tissue to healthy, bleeding tissue. The anterior table of the sternum was curetted back to healthy bone and the wires were left in situ. The wound was packed

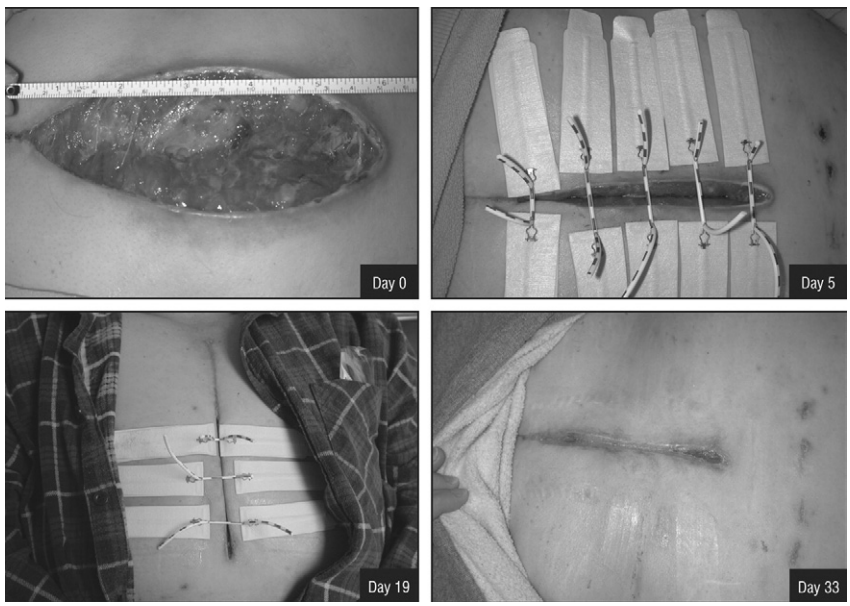

Fig 2. Patient 1: the wound before, during, and after placement of the adhesive closure device. Top left: day 0 post debridement; top right: day 5 post debridement; bottom left: day 19 post debridement; bottom right: day 33 post debridement.

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and left open. On the second day after the debridement (ie, postoperative day 189), the dynamic closure system was applied. She was discharged home 4 weeks after debridement with the dynamic closure device in place. The anchors were removed 30 days after debridement (ie, postoperative day 217) by the nurse in the patient's home. At the follow-up visit (6 weeks after discharge) the wound was completely healed. The total duration of treatment was 28 days.

Comment

Sternal wound infection will become an increasingly important resource demand for cardiac surgery for the foreseeable future due to the continued shift of the demographic profile of patients presenting for surgery. Patient factors such as diabetes, obesity, and previous heart surgery coupled with more complex procedures with longer bypass and ventilation times [1–3], and the expanding use of bilateral mammary arteries [4], will inevitably impact wound infection rates and mandate a consistent and reliable approach to this problem.

Aggressive debridement as a primary approach is essential to curative therapy [1, 2], but the management of the subsequent open wound remains controversial. Two general approaches for the immediate management of the sternal wound after aggressive debridement have been described. The wound can be closed primarily over drainage catheters that facilitate antibiotic irrigation of the wound, initially reported by Shumaker and Mandelbaum [5]. Potential drawbacks of this approach include systemic toxicity of the irrigation as well as the fear of hemorrhage related to drainage catheters left in the mediastinal space. A further major concern is the persistence of closed spaces in which infection can remain.

Alternatively, the infected sternal wound can be left open to facilitate repeated packing [1, 6]. This allows ongoing debridement and dressing changes, and obviates the potential for persistent infection in closed spaces. However this approach can result in large tissue defects. Fibrosis and edema of wound edges occurs and delayed primary closure becomes an increasing challenge.

In recent years there has been growing popularity of the use of the vacuum-assisted closure system to augment the healing of open sternal wounds. This technique is extremely successful in facilitating sterilization and granulation of these wounds. However, closing the wound after sterilization with vacuum-assisted closure has been a challenge. In one series in which the vacuum-assisted closure system was used to augment healing, the rate of successful delayed primary closure was only 45.5% [7].

Sterile wounds that have been treated with open packing or vacuum-assisted closure share the common problem of tissue fibrosis, retraction, and difficulty in eventual closure. Tissue flaps may be used to close dead space after major wound debridement. Options for this strategy include use of the pectoral muscle flap [8] and the omentum [2]. These techniques, although effective, carry with them inherent morbidity. Mobilization of the pectoral muscle can be associated with significant pain and alteration of chest wall mechanics, and can be cosmetically unappealing. Harvesting of the omentum requires violation of the peritoneal space and can be associated with omental ischemia. In addition these procedures require further surgery in patients who are already sick.

A safe and reliable method of delayed primary wound closure is currently needed. Dynamic wound closure has been described for other indications. The effectiveness of this technique for closing fasciotomy incisions for compartment syndrome and avoidance of skin grafts has been reported [9]. The use of this technique in the setting of the debrided sternal wound would be ideal, as it allows ongoing debridement and facilitates delayed primary closure to occur.

In this series, delayed primary closure has been achieved in patients using the Canica adhesive anchor system. All patients had the wound sterilized by surgical debridement prior to application of the dynamic closure system. The first 3 patients achieved excellent healing with a mean of 29 days of treatment without undergoing secondary surgery.

We advocate the use of dynamic closure for patients who have had superficial or deep sternal infection develop, but only after complete surgical debridement and a sterile wound have been achieved. Vacuum-assisted closure therapy may be used to augment healing post-debridement if indicated. Its use does not preclude the subsequent use of dynamic closure. However, we advocate the application of the device as early as possible after debridement to attenuate early fibrosis and tissue retraction. We have demonstrated acceptable and cosmetically excellent results using delayed primary closure for these indications.

The dynamic closure device is a convenient method of treating these patients. As soon as all other medical issues are stable, the patient may be discharged with the device in place, as in our experience the open wound is a minor inconvenience for patients. The elastomers can be tightened at 3 to 4 day intervals by trained nurses who will visit the patient's home. The device may be discontinued when adequate adhesion of tissue edges has been achieved. This is in contrast to a patient who would be kept in the hospital for a number of days with an open wound and then undergo a second procedure with its associated morbidity to achieve closure with a tissue flap. Subsequently, recovery in the hospital for a period of time is required prior to discharge with a cosmetically inferior result.

This case series was a retrospective review of a single institution's experience with a dynamic method of delayed primary wound closure for sterile median sternotomy wounds after debridement for infection. Dynamic wound closure is a feasible and effective method of dealing with the open sternotomy wound after debridement. It yields good results and avoids the morbidity and poor cosmesis of reconstructive surgery.

Disclosures and Freedom of Investigation

Co-author, Michael Bell, MD, discloses a financial relationship with Canica Design, Inc, Almonte, Canada, as co-inventor of the Dynamic Wound Closure System. All devices used in the study were hospital stock and were not paid for by the authors or Canica Design. The authors had full control of the study and production of the article.

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