Rigid Plate Fixation of the Sternum

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Sternotomy is the most common osteotomy performed worldwide and has traditionally been closed by wire circlage. Recent studies have demonstrated the superiority of internal plate fixation both in promoting bony stability and osteosynthesis and in decreasing the incidence of postoperative mediastinitis. Despite its advantages, this method of sternal closure has not yet gained widespread use. We describe a simple technique of sternal closure using plates secured with screws.

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FEATURE ARTICLES

Sternal instability has been linked to increased rates of postoperative mediastinitis [1], which poses an especially significant threat to high-risk patients [2, 3]. Clinical [1, 4, 5] and biomechanical studies [6] have shown the superiority of rigid plate fixation over wire circlage in healing of sternotomies [7] and reducing postoperative complications. However, cardiac surgeons have traditionally being trained to close sterna by wire circlage and have been reluctant to change to newer, more effective techniques of bony fixation. We adapted rigid internal fixation techniques, commonly used by orthopedic surgeons, maxillofacial surgeons, and neurosurgeons for osteotomy closure, using specially designed plates to ensure expedient and strong sternal closure. This technique is described in this article.

Technique

Rigid internal fixation by using plates has been shown to be a safer and more effective method of sternotomy closure. This technique is applicable to all patients undergoing median sternotomy and is especially appropriate for high-risk patients who are subject to various preoperative or intraoperative risk factors, including chronic obstructive pulmonary disease, reoperative surgery, renal failure, diabetes, chronic steroid use, morbid obesity (body mass index > 30), concurrent infection, and acquired or iatrogenic immunosuppression, off midline sternotomy, osteoporosis, long cardiopulmonary bypass runs (greater than 2 hours), and transverse sternal fractures [8]. Since the year 2000 we have used the technique of rigid plate internal fixation to close sternotomies in more than 500 high-risk patients. High risk is defined as three or more risk factors as outlined in Table 1.

In addition to being safer and more effective, we have found that the current iteration of this procedure, presented herein, is quicker than wire circlage. This is performed by the primary cardiac surgeon responsible for the procedure.

To lay the groundwork for an effective closure, it is important to take care while performing the sternotomy. Prior to opening the sternum, the pectoral muscle is locally reflected off of the sternal edges, especially at the level of the second intercostal space. It is also important to open the sternum right down the middle to ensure that there is a sufficient amount of bony substrate in which to solidly anchor the fixation plates. For similar reasons it is important to avoid transverse sternal factures, especially while retracting the sternal edges. To avoid transverse sternal fractures we used the following method of retracting the sternal edges (ie, a single-bladed retractor is used for retraction, which is positioned in such a way that the blades are as far away from the manubrium as possible and the retractor is opened slowly). Sternal retraction is performed in a similar manner during internal mammary artery harvest by using the same retractor placement and exercising caution while opening the retractor.

When sternal closure is desired, hemostasis is secured along the sternal halves and the pectoral muscles are reflected off the body of the sternum using cautery, enabling direct plate to bone contact. The thickness of the sternum is estimated prior to closure to guide the depth of drilling and to aide in the selection of appropriate sized screws. The screws should not be longer than the thickness of the sternum, yet they should penetrate deep enough to provide a strong purchase in the sternum, ideally of both cortices. In addition, it is necessary to account for the thickness of the plate when selecting screw size.

However plate selection and orientation should be tailored to the width and shape of the sternum. A figure 8 of wire is placed around the manubrium and once more around the xiphisternal junction to assist with alignment and reduction of the sternum. Bone reducing forceps are placed in the second and fifth intercostal spaces. The sternal halves are first grossly reduced by tightening the wires and then the final reduction is made by use of the bone approximating forceps. Note that it is important

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Table 1. Criteria for Sternal Plate Fixation (3 or More of the Risk Factors)

Chronic obstructive pulmonary disease
Renal failure
Morbid obesity (body mass index > 30)
Immunosuppression
Acquired or concurrent infection
Diabetes mellitus
Chronic steroid use
Off midline sternotomy
Transverse sternal fractures
Long runs of cardiopulmonary bypass (>120 minutes)
Reoperative or redo surgery

to obtain near perfect anatomical alignment when reducing the sternum. Once the sternal halves have been brought back together in good alignment, both wires are tightened and the appropriate fixation plates are chosen, which are usually two X-shaped plates or one X-shaped and one box-shaped plate that are used for fixation. Plates should not be used in the xiphoid process because of the small size and relative fragility of the xiphisternum. Rather a figure 8 of wire should be used to secure this region of the osteotomy. Prior to positioning the plates, the sternum should be inspected for transverse fractures. If any exist, the plates should be positioned in such a way that they cover the transverse fracture, thus stabilizing it and the longitudinal fracture of the sternotomy. After inspecting for transverse sternal fractures, the plates are positioned on the surface of the sternum, allowing enough clearance on both sternal halves to ensure good purchase for the screws on the bone. If they do not sit flush with the surface of the sternum, the plates can be bent to conform to the contours of the sternal surface. The reflection of the pectoral muscle is performed over a small area in a very localized fashion to allow the plates to sit flush with the sternum. The periosteum is preserved and there is no risk of devitalizing the sternum.

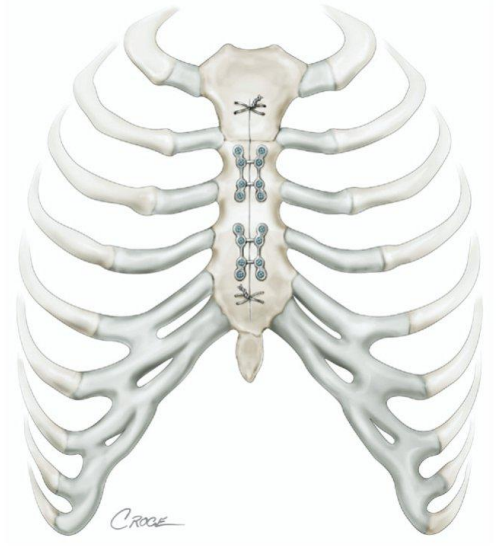

Fig 1. Artist's drawing of sternum fixed with wires and plates.

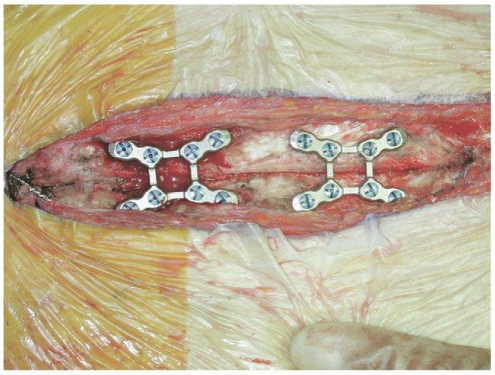

Fig 2. Operative photograph of a plated sternum.

The plates are then secured to the body of the sternum with appropriately sized self-tapping screws, precluding the need for drilling. Once the plates are secured the subcutaneous tissue is closed over the plates and the wires in a routine fashion. If the patient is obese and there is a significant potential space, a Blake drain is placed in the subcutaneous space. Figure 1 is an artist's drawing of the sternum fixed with plates for the body and figure 8 of wires for the manubrium and lower sternum. Figure 2 is an operative photograph of a sternal body that has been fixed with plates.

It is important to note that this closure is performed by cardiothoracic surgeons. The original technique was developed by a plastic surgeon (DHS), but we have modified it significantly since then and adapted the technique to everyday closure. We have worked with the engineers at Walter Lorenz Inc (Jacksonville, FL), in developing the tools required to effect this kind of closure. We have not had to use pectoral flap closure of any of our complicated sternotomies, because we have used the internal fixation technique.

Comment

We first used this technique in 2000 and have since modified the plates and screws to make it simpler and user friendly. The procedure as previously described is the present iteration, which takes less time than conventional sternal wire circlage. We have experience with internal fixation using plates in more than 400 high-risk patients. Initially we used this technique in less than 10% of sternotomies. However, as our percentage of high-risk

procedures has grown, our use of internal fixation of the sternum has expanded. Currently we perform between 550 and 600 sternotomies per year. Currently we have approximately 28% to 30% of our sternotomies that end up being internally fixed with plates; this has helped reduce our deep sternal wound infection rate to less than 1% in high-risk patients. Based on evidence from biomechanical studies and our clinical experiences, we believe that the method of internal fixation by using plates is superior to wire circlage in the closure of high-risk sternotomies. This method of internal fixation of the sternum will help reduce morbidity related to sternal dehiscence in a high-risk population.

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