Management of sternal wound dehiscence

Sternal wound complications may result from median sternotomy procedures following cardiothoracic surgery and can represent a significant management problem, for example, infections and dehiscence can increase hospital stay, morbidity and mortality. Morbidity from sternal wound dehiscence was close to 50% until recently, but with recent advances, including sternal fixation techniques and various reconstructive surgical options, this has improved. This article outlines the problems of wound dehiscence and delayed healing following median sternotomy and provides an overview of the pertinent management options.

**KEY WORDS**
Sternal wound dehiscence
Mediastinitis reconstruction
Sternotomy
Sternal instability

However, postoperative wound infection of the sternum is common and if severe, chronic or untreated, can lead to sternal wound dehiscence. The incidence of sternal wound infections following median sternotomy procedures is in the region of 0.5–8.4% as negative pressure wound therapy (NPWT) has reduced the morbidity rate to approximately 10% (Miller and Nahai, 1989; Jones et al, 1997; Sjögren et al, 2006).

Sternal wound infections and dehiscence also prolong recovery time as well as increasing hospital stay, reoperative rates, morbidity and mortality (Losanoff et al, 2002b).

This article aims to highlight the problems of sternal wound dehiscence and delayed healing following median sternotomy, as well as providing an overview of the management options.

**Median sternotomy**

Median sternotomy was introduced in the 1950s (Julian et al, 1957) and has revolutionised the world of cardiothoracic surgery. The midline incision is made through the bony sternum and provides excellent access to the thoracic organs as well as permitting a range of procedures to be performed on the thoracic structures (Grevious, 2009). This can be further complicated by development of osteomyelitis of the sternum which has a reported incidence of 0.8–2.5%.

Sternal wound dehiscence can lead to mediastinitis, which is where the superficial wound infection travels deeper and affects the mediastinal structures. It has an incidence of 1–5% of median sternotomies (Grevious, 2009) and results in a chronic inflammatory state and infection, both on the surface (sternal wound) and the mediastinal structures.

Morbidity from sternal wound dehiscence and its associated complications ran at nearly 50% until recently, but advances in management options and medical devices such as negative pressure wound therapy (NPWT) has reduced the morbidity rate to approximately 10% (Miller and Nahai, 1989; Jones et al, 1997; Sjögren et al, 2006).

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An accurate clinical evaluation is essential to recognise the early signs and symptoms of sternal wound dehiscence (Figure 1). Clinicians should be alert for signs of local wound changes such as erythema or increased exudate, pain, systemic signs such as pyrexia, and respiratory symptoms (e.g. pleural effusions). Clinicians should be extra-alert to the possibility of complications in high-risk patients, such as increased risk of infection, delayed wound healing and wound dehiscence (Losanoff et al, 2002a).

If infection is suspected, appropriate swabs, samples and cultures should be taken (Grevious, 2009). Empirical broad-spectrum antibiotics may be started if the infection is overwhelming with surrounding progressive cellulitis, systemic infection or sepsis. However, if the infection is localised and minimal, it is reasonable to withhold antibiotics (provisional or definitive) are available, or at least after obtaining tissue samples (either in ward or theatre) for microbiological analysis.

The key aim once infection is identified is to perform swift and thorough surgical debridement, following which further management can be decided upon. The aim of surgical debridement is to remove all non-viable tissue back to bleeding tissue and produce a clean wound that allows definitive management to be performed.
immediately or at a later time (Grevious, 2009). If there is evidence of mediastinitis and extensive disruption of the sternum, more radical surgery and reconstruction should be considered. Before surgery, baseline preoperative investigations (for example, full blood count, electrolytes, inflammatory markers such as C-reactive protein [CRP] and serum albumin levels) are needed to ensure the patient’s fitness for general anaesthesia.

Plain radiography of the sternum may also demonstrate mediastinal air or separation of the sternal half (when performing a median sternotomy, the sternal bone is longitudinally [vertically] sawn in half and the ‘sternal half’ refers to these two halves of bone) (Gualdi et al, 2005). Ultrasound may be used to identify any collections of fluid. Computerised tomography (CT) scans are useful for detecting sternal disruption, the location of fluid, and any underlying lung or mediastinal pathology.

If it is suspected that the infection has extended into the bones, this can be established by a magnetic resonance imaging (MRI) scan. However, the effectiveness of any MRI may be limited by the presence of sternal metalwork (Gualdi et al, 2005). Intraoperatively, both superficial wound swabs and deep tissue biopsy may be obtained for microbiological analysis (O’Brien Norris, 1995).

Management
A number of factors need to be considered when evaluating and managing non-healing sternal wounds, including:
- Presence and depth of infection
- Any evidence of underlying osteomyelitis (Figure 2)
- Anatomy of any tissue defects
- Sternal stability
- General health of the patient and any associated comorbidities.

In the 1950s, dehisced and non-healing sternal wounds were mostly left to heal by secondary intention, which included debridement, packing and open drainage. However, with these techniques alone, morbidity was close to 50%. In 1963, the concept of catheter antibiotic irrigation of sternal wounds was introduced, leading to a reduction in morbidity from 50% to approximately 20% (Shumacker and Mandelbaum, 1963). Although this reduction was considered to be a significant step forward, it was associated with a major complication — the erosion of major vessels by the catheter, leading in some cases to fatal haemorrhage (Grevious, 2009). This resulted in the drive for better and alternative management options.

Current treatment options include:
- Promoting healing by secondary intention through the use of NPWT
- Split-skin grafting if appropriate
- Sternal stabilisation procedures
- Reconstructive procedures.

The above management techniques have meant that the incidence of morbidity and subsequent mortality from sternal wounds has fallen to around 10% (Miller and Nahai, 1989; Jones et al, 1997; Sjögren et al, 2006). A suggested treatment algorithm for the management of sternal wounds is shown in Figure 3.

Negative pressure wound therapy (NPWT)
The introduction of negative pressure wound therapy (NPWT) in 1997 greatly improved the outcomes of sternal wound dehiscence (Song et al, 2003; Agarwal et al, 2005). This therapy involves the application of a negative pressure pump to the wound via a special occlusive dressing (Sjögren et al, 2006). It can be applied to sternal wounds after initial debridement (Sjögren et al, 2006) and can either be used to encourage secondary healing in selected patients (Song et al, 2003; Malmjö et al, 2007), or as an interim measure between debridement and attempts at definitive closure (Song et al, 2003). Negative pressure wound therapy has been shown to:
- Reduce the number of dressing changes
- Expedite time to definitive treatment
- Lower costs
- Reduce the length of in-patient stay (Agarwal et al, 2005).

Negative pressure wound therapy has a number of local effects on wound healing. It is known to decrease wound area, stimulate blood flow, remove excess fluid, and stimulate granulation and local inflammatory response (Malmjö et al, 2007). It also helps to stabilise the sternum, thus decreasing the ventilatory requirements of intensive care patients who are receiving respiratory support.

Reconstruction with flaps
The concept of debridement and reconstruction involves the use of flaps...
to reduce the dead space in the sternal defect as well as to provide bulk (muscle mass or omentum) to encourage healing (José, 1999). Previous irradiation of the chest wall or abdominal surgery may preclude the use of certain types of flaps. Therefore, full assessment of the patient is essential before embarking on a specific type of reconstruction (O’Brien Norris, 1995; Grevious, 2009). Lee et al introduced the omental flap in 1976 (Lee et al, 1976; Jurkiewicz and Arnold, 1977), and later more complex myocutaneous flaps were developed following the work of Jurkiewicz (Jurkiewicz and Arnold, 1977). These include the pectoralis major; rectus abdominis and latissimus dorsi flaps (Jurkiewicz et al, 1980; Tizian et al, 1985).

Defects of the upper third are most easily and successfully covered using the pectoralis flap (Jones et al, 1997). Defects of the mid and lower third and larger defects can be covered using the rectus abdominis flap (Greig et al, 2007). The two techniques can be combined for larger defects, resulting in better outcome.

A major study by Castelló et al (1999) that examined sternal wounds demonstrated that pectoralis flaps were the most commonly used flap in sternal reconstruction, with the second choice being pectoralis combined with rectus abdominus flaps, and then the rectus abdominus muscle alone. Latissimus dorsi or omental flaps were only used in a small number of cases. The study showed that there was an overall reduction in mortality using these techniques (José et al, 1999).

Pectoralis muscle flaps (Figure 4)

Sternal wounds, particularly in the upper third, can be covered using the pectoralis muscle flap (Greig et al, 2007). It is often the first choice due to its proximity to the defect requiring coverage. The muscle is harvested through a midline incision. The flap is based either on the thoracoacromial pedicle or on the internal mammary perforators (a flap involves taking a piece of tissue — usually fascia or muscle with or without the overlying skin — to cover a defect or wound. In order for the ‘tissue’ to survive and healing to take place, the flap needs a blood supply. This comes from the blood vessels supplying the original tissue, i.e. fascia or muscle, and the term ‘based’ is used to denote the blood vessel that supplies the flap. These ‘flaps’ can remain attached by their blood supply to their original location [pedicled flaps], or be divided and re-attached by microsurgery to a new location (free flap) (Tobin, 1989; Grevious, 2009). This flap can be used for ‘simpler’ wounds by dissecting only the medial portion of the muscle from the ribs and moving this medially over the defect. One disadvantage of the pectoralis muscle flap is the resulting compromise in the functionality of the shoulder girdle.
Rectus muscle flap (Figures 5a–5e)
The rectus abdominis muscle forms part of the anterior abdominal wall. It provides abdominal flexion and offers support to the abdominal contents. The muscle originates from the pubic symphysis and crest and inserts into the costal cartilages. The rectus flap is based on this muscle and it can be harvested along with a skin paddle using a vertical or transverse incision. Alternatively, the muscle can be used on its own and a split-skin graft placed over it. The rectus muscle flap is based on the superior and the inferior epigastric arteries (Coleman and Bostwick, 1989; Grevious, 2009), and the innervation is from the intercostal nerves.

If the internal mammary artery is used for coronary bypass grafting, the contralateral rectus abdominis muscle should be used. There is, however, a secondary blood supply from the eighth anterior intercostal perforator; but, in the authors’ experience, this is somewhat unreliable. If there are concerns over the blood supply or if both internal mammary arteries have been harvested, another flap option or a free flap needs to be considered (Coleman and Bostwick, 1989; Grevious, 2009).

Latissimus dorsi muscle flap
The latissimus dorsi is a large muscle in the back that normally helps with activities that involve the shoulder girdle such as climbing and swimming. This muscle flap is based on the thoracodorsal artery and is supplied by the thoracodorsal nerve that arises from the posterior cord of the brachial plexus. The flap can be developed to give a pedicle of up to 10–15cm. However, the latissimus dorsi flap is not as commonly used as the pectoralis or the rectus muscle flaps since pectoralis and rectus abdominus muscles are in closer vicinity to the sternum, and dissection and movement of these muscles leads to less functional deficit as compared to the latissimus dorsi muscle.

The omental flap (Figure 6)
The greater omentum is a connective tissue structure found in the abdomen that has a role in combating infection and adhesions within the abdomen. The omental flap is vascularised via omental branches of the gastroepiploic artery and the flap is based on the right omental artery. The versatility of the omentum enables coverage of irregular defects and it has inherent resistance to infection. However, since this flap is harvested via a laparotomy (abdominal surgery), it has its own set of complications such as injury to abdominal viscera, wound healing problems, incisional hernias and spread of infection from the chest wall to the abdomen.

To circumvent this, laparoscopic harvest techniques are being developed, although these are not widely used. In addition, as there is no option for a cutaneous island as part of the flap (i.e. no skin covering), skin grafting over...
Key points

- Sternal wound infection and dehiscence are important consequences of median sternotomy in cardiothoracic surgical procedures.
- Sternal wound infections and dehiscence prolong recovery time, and increase hospital stay, re-operation rate, morbidity and mortality.
- One should be alert to early warning signs such as local wound erythema, increased exudate, pain, pyrexia and respiratory symptoms.
- NPWT is a useful adjunct in the management of non-healing sternal wounds and has reduced overall morbidity.
- Most superficial dehiscences heal with good wound care and regular dressings supplemented with NPWT, but major or complicated sternal wound dehiscence requires multidisciplinary input and reconstructive surgery.

**Bony union**

To achieve complete healing of a complicated sternal wound, adequate fixation of the sternum must be achieved to ensure the optimum environment for healing and to prevent long-term complications. The constant motion and stress placed on the sternum makes it a difficult area for bony healing. This can lead to respiratory insufficiency, chronic pain and instability if sound bony union is not achieved. The aim of sternal fixation is to achieve close opposition of the sternal edges with minimal movement to allow the best environment for primary bone healing to occur (Voss et al, 2008; Grevious, 2009).

The traditional approach to achieving fixation of the sternum is sternal wiring. However, since wires can break, cut out, loosen or cause skin problems, more recently, sternal fixation using rigid plates and screws has been introduced. With this technique, a lower rate of sternal wound infections and a lower incidence of non-union has been demonstrated (Cicilioni et al, 2005; Voss et al, 2008). They allow primary closure or flap reconstruction to be performed on a stable base with reduced wound tension (Cicilioni et al, 2005).

Literature suggests that rigid fixation of the sternum using plating techniques is superior to traditional wiring techniques (Voss et al, 2008). Plates, consisting of rigid titanium with locking screws, can be applied transversely or longitudinally (Cicilioni et al, 2005; Voss et al, 2008). They allow primary closure or flap reconstruction to be performed on a stable base with reduced wound tension (Cicilioni et al, 2005).

When sternal non-union occurs alone or as part of a dehiscence, removal of any existing fixation devices followed by debridement of devitalised and scar tissue and re-fixation is the treatment of choice. This can involve re-wiring or plate fixation. One established method is the Robicsek wiring technique that involves passing wires parasternally and weaving them between the ribs, and reinforcing this further with ‘figure-of-eight’ wires passed across the sternal halves (Robicsek et al, 1977). Modification and variation of the Robicsek wiring technique as well as other novel techniques for closure have been subsequently described (Losanoff et al, 2001a).

When there is extensive osteomyelitis of the sternum, fixation may not be possible, or, in cases where metal work has become infected, resection of a portion of the sternum may be required. If the manubrium can be preserved and stabilised, patients often have no major functional deficit (Douville et al, 2004; Grevious, 2009).
Conclusion
Sternal wound complications exist on a spectrum of severity but, fortunately, a large proportion heal with appropriate conservative management. Most superficial dehiscence heals with regular dressings and good wound care, but major or complicated sternal wound dehiscence requires multidisciplinary input and surgery.

All risk factors should be addressed before median sternotomy surgery, especially in patients in the high-risk group. Careful patient selection and meticulous surgical technique is essential to prevent complications. Postoperatively, diligent observations for any early signs of wound breakdown or infection are vital.

References

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