Post-traumatic sternal wound infection in a resource-constrained tertiary hospital: case report

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Abstract

Sternal wound infections are mostly a result of complications of coronary artery bypass graft, post-trauma sternotomy, penetrating chest trauma and cardiopulmonary resuscitation. In South Africa the majority of rural hospitals are resource-constrained , and tertiary services and academic centres are overloaded with patients. The planning and execution of difficult cases may require a combination of 'simpler' techniques as shown in this case report. The authors' approach for the surgical and reconstructive management of post-traumatic deep sternal wound infection was achieved with a combination of negative-pressure wound therapy (NPWT) and a split thickness skin graft (STSG), a deviation from the usual recommendations for management.

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Introduction

Sternal wound infections are mostly a result of complications of coronary artery bypass graft, post-trauma sternotomy, penetrating chest trauma and cardiopulmonary resuscitation. Less common causes include oesophageal perforation (Boerhaave's syndrome), tracheo-bronchial perforation, descending infection (Ludwig's angina) and tuberculosis.[1]

The management strategy of sternal wound infections was instituted in 1976 when Lee, et al[2] introduced the concept of utilising flaps to reduce the dead space in the anterior mediastinum by using the greater omental flap. In 1980, Jurkiewicz, et al[3] opted to use muscle and myocutaneous flaps, which dramatically improved effectiveness of management of sternal dehiscence and infection.[4] The principle of wide debridement in addition to the use of vascularised regional tissue allows for greater blood flow, obliteration of dead space and faster healing time for quicker infection resolution.[5]

Resource-constrained healthcare facilities provide unique challenges in the management of complicated cases such as patients presenting with sternal wound infections. In this case report, the surgical and reconstructive management of post-traumatic deep sternal wound infections will be discussed in the light of these constraints. Reconstruction and closure of the defect were achieved successfully with a combination of negative-pressure wound therapy (NPWT) and a split thickness skin graft (STSG), a deviation from usual recommendations.

Case report

A 35-year-old previously healthy male was transferred from a regional hospital in one of the Northern Cape districts to Kimberley Hospital Complex (KHC), the sole tertiary hospital situated in the Northern Cape Province (NCP), South Africa, following a stabbed precordium in December 2017. Initial assessment at the base hospital discovered a stab wound located in the left fourth intercostal space midclavicular line with a haemothorax diagnosed with chest radiography. The haemodynamically unstable patient was resuscitated at the referring hospital according to Advanced Trauma Life Support (ATLS) principles,[6] and an intercostal drain inserted, which drained 1 800 mL immediately. The decision was then made to airlift the patient to KHC. The department of general surgery at KHC initially managed the injuries performing an emergency sternotomy based on a sonar diagnosis (Focus Assessment with Sonography for Trauma/ FAST) of haemopericardium, and ongoing haemodynamic instability, requiring blood transfusion. The patient's intraoperative findings on that occasion included a left lung laceration with no injury to the pericardium and a large volume of clots in the pleural cavity. No entry wounds through the heart or major vessels were found.

Following a three-day stay in the intensive care unit (ICU), the patient was discharged to a normal surgical ward. One week after the discharge from ICU, the patient was suspected to have developed sternotomy-related wound sepsis due to drainage of pus from the wound. Investigations following this clinical finding included positive wound and blood cultures of methicillin-resistant *Staphylococcus aureus* (MRSA) and *Pseudomonas aeruginosa*.

A computerised tomography (CT) was performed confirming bilateral homogeneous loculated hydrothorax with a pericardial effusion. Sternal viability could not be commented on (Figure1). Based on the findings, the patient was subsequently referred to the department of cardiothoracic surgery at KHC for specialised care.

The patient underwent a relook sternotomy which revealed copious amounts of pus in the mediastinum. All infected tissue (debris) was removed, without need for debridement of the sternal bone. After thorough washout, the sternal edges were closed with wires and two intercostal and one retrosternal drains were inserted. The wound, measuring 25 cm long and 5 cm wide, was left open to be closed after clearance of the infection (Figure 2). NPWT dressing was commenced using sterile foam over the wound, a nasogastric tube "sandwiched" between foams and transparent film (Tegaderm®) occluding the system; the nasogastric tube drained to a canister which was attached through a gauge to wall suction (Figure 3). After the surgical relook, the wound was managed with acetic acid[7] and NPWT, every three days over a period of 21 days. Subsequently management consisted of weekly washouts in theatre, with chlorexidine dressings (Bactigras®) and NPWT, for 32 days.

Concomitant medical treatment for the infection since diagnosis of MRSA and *P. aeruginosa* included a combination of carbapenem (Meropenem), glycopeptide (Vancomycin) and rifampicin (Rifamycin). The duration of each drug followed the MRSA protocol of 21 days of treatment. The antibiotic therapy was stopped under the guidance of the infectious diseases at Universitas Academic Hospital (UAH) in Bloemfontein, Free Street Province (FSP), following blood culture results showing no growth and improvement in the patient's systemic condition.

During the period of admission, the patient was newly diagnosed as HIV positive and first-line antiretroviral therapy was initiated. The patient was clinically wasted, and nutritional support was necessary initially with supplements prescribed by the dietician and hyper-caloric diet to supply nutritional requirements and improve wound healing.

The nutritional status of the patient during admission, and the protracted course of the infected wound were not ideal for immediate reconstruction with a flap. Following the four-week course of NPWT, clinical improvement of the patient and marked improvement of the wound, a STSG and NPWT were then planned to cover the defect and undertaken by the department of plastic surgery and burns at KHC. A CT scan was performed prior to the procedure to rule out osteomyelitis of the sternum. The procedure was performed 75 days from the initial admission and 57 days after the initial relook (Figures 4 and 5). The patient received in-patient wound care and was discharged from hospital to continue management at the base hospital as an in-patient. The decision for in-hospital wound care followed discussions about the complexity of the case to ensure that proper wound care was achieved (Figure 6). Figure 7 depicts the wound 40 days after the grafting, where some graft loss was observed. Figure 8 shows the more recent picture of the patient with improved graft take and a few granulomas of the wires used to close the sternal edges (to be removed in a near future).

Discussion

There are two types of sternal wound infections: superficial and deep. Superficial sternal wound infections (SSWIs) involve the skin, subcutaneous tissue and the pectoralis fascia only. The incidence of SSWIs is reported as between 0.5% to 9%. The diagnosis may be made clinically by the presence of erythema, drainage, fever, and sternal instability. These clinical features can be occult, with a low-grade fever as the only presentation. SSWIs are often completely

Figure 1. CT scan of the patient depicting bilateral homogeneous loculated hydrothorax with a pericardial effusion.

Figure 2. Poststernotomy picture showing the resulting 25 cm x 5 cm open wound.

Figure 3. NPWT dressing following the relook sternotomy. This dressing was repeated multiple times until the wound was ready for reconstruction.

Figure 4. Day 46 of NPWT dressings, prior to reconstruction.

Figure 5. Day 5 post STSG and NPWT dressing.

Figure 6. Day 19 post STSG.

Figure 7. Picture of the wound day 68 post STSG

Figure 8. Picture of the wound day 90 post STSG.

eradicated with intravenous antibiotics and local wound care if necessary without long-term sequelae.[8,9]

As defined by the Centers for Disease Control and Prevention (DCP), deep sternal wound infections (DSWIs) require the presence of the following: (1) an organism isolated from the culture of mediastinal tissue or fluid; (2) evidence of mediastinitis seen during operation; or (3) presence of either chest pain, sternal instability, or fever (> 38 º Celsius), and either purulent drainage from the mediastinum, isolation of an organism present in blood culture, or culture of the mediastinal area. These patients require a much more aggressive treatment regimen consisting of early surgical debridement with subsequent autologous tissue coverage and long-term intravenous antibiotics.[8,9]

The Pairolero classification of infected median sternotomies divides wounds into three types based on duration and clinical findings. Type I infections occur within the first week after sternotomy, and typically have serosanguinous drainage but no cellulitis, osteomyelitis or costochondritis; they are typically treated with antibiotics and single-stage operation. The majority of cases are Type II infections, which occur between the second and fourth week after sternotomy and usually involve purulent drainage, cellulitis and mediastinal suppuration. Costochondritis is rare, but osteomyelitis is frequent. Treatment begins with exploration and debridement of all necrotic tissue, with removal of all foreign materials and exposed cartilage. Suction drainage and muscle transposition are used to close the wound when the mediastinum is soft and pliable. Type III infections occur months to years post-sternotomy, and typically involve chronic drainage sinus tract and localised cellulitis. Although mediastinitis is rare, osteomyelitis, costochondritis and/or retained foreign bodies are often present. These chronic wounds are left open, packed and treated with frequent dressing changes and repeated debridement. When the wound appears clean, it is closed with methods similar to those used in advanced Type II infection.[8]

Several options for sternal wound closure are available for use following debridement, either for immediate or delayed reconstruction. Flap closure is reserved for patients with significant soft tissue deficits. Flap closure is usually accomplished without the need for bony reapproximation. For most patients, the resulting scar tissue leads to a stable anterior chest wall. Bone grafts are rarely needed, and because of the elasticity of the chest skin, skin grafts are also uncommon.[9] The most common flaps for chest wall closure and coverage are the pectoralis major, latissimus dorsi, and rectus abdominis flaps, which can be combined with an omental flap to fill the defect. The use of a perforator artery flap has also been reported.[10]

The pectoralis major muscle has become the preferred flap for the closure of anterior chest wall defects. A portion of the muscle, based upon the thoracoacromial artery, is detached from the sternum and advanced into the superior mediastinal defect. A larger portion of the muscle can be taken using perforators off the internal thoracic artery as a turnover flap. However, turnover flaps are unreliable in patients who have had the internal thoracic artery harvested as a bypass conduit. Bilateral pectoral flaps are frequently used for larger defects.[3,4]

Omental flaps are rich in blood supply and contour well to irregular defects. The omentum is pulled up through an opening in the central diaphragm and placed into the mediastinal defect.[11] Potential complications to this technique include injury to abdominal organs and gastrointestinal obstruction due to diaphragmatic hernia, abdominal incisional hernia, or postoperative peritoneal adhesions. The omentum can usually be harvested without the need to extend the skin incision or, alternatively, through a laparoscopic approach.

Complications associated with flap closure include: haematoma, flap dehiscence, partial or complete flap necrosis and recurrent wound infection. However, the incidence of recurrent wound infection is lower for flap closure compared with other wound management strategies.[12]

Despite these advances, sternal infection and mediastinitis continue to pose clinical management issues. The procedures described above are all time consuming, demand extensive resources, skilled surgical experience and will require the patient to have a prolonged hospital stay, often also requiring ICU. Reconstructive flap procedures vary in duration, often extending from two to four hours, depending on the skill of the surgeon and the extent of the flap.

The choice to apply a STSG in the patient reported in this study followed the good result obtained after the prolonged application of NPWT dressings; after 53 days, the sternal defect reduced remarkably in width and the sternal cavity had been filled with new granulation tissue, thus eliminating the need for a reconstructive flap which aids in filling the defect. Also, the sternum was kept closed and secure after the relook; the new, filled cavity then provided a suitable wound bed for the placement of a skin graft. The use of STSG was also chosen as it is a less complicated operation offering reduced anaesthetic and operating time, requiring less expertise as compared to a regional flap for sternal closure. Postoperatively, recovery time is shorter and a reduction in possibility of complications, whereas with a regional flap closure the patient usually requires ICU admission postoperatively. Complications can be identified sooner with STSG (even by nursing staff in the ward), and the follow-up of the reconstruction can be done at the local clinic by junior doctors and nursing staff, particularly at the base hospital of this case, as the level of skills available is restricted to junior doctors. Although the uptake of the graft in the follow-up pictures showed some graft failure, we assumed that this resulted from the immune dysregulation from the patient's newly-diagnosed HIV infection.[13]

Currently, the management of sternal wounds involves a multidisciplinary approach. Timeous, nonsurgical management techniques include early debridement, microbiological analysis, and broad-spectrum antibiotics. Soft tissue flaps do not address repair of the bony sternum, which can lead to chronic pain, paradoxical motion, impaired pulmonary function testing, and cosmetic disapproval from the patient. A relevant development to sternal wound issues has been the use of NPWT aiming to serve as a bridge between debridement and reconstruction.[14] NPWT, also called vacuum-assisted wound closure, refers to wound dressing systems that continuously or intermittently apply subatmospheric pressure to the surface of a wound. NPWT has become a popular treatment modality for the management of many acute and chronic wounds.[15]

Subatmospheric pressure has multiple beneficial effects on wound healing in animal models. However, clinical evidence of its superiority over conventional wound dressing techniques for all wound types has not been proven. The available randomised trials have significant heterogeneity regarding the nature of wounds treated and the primary and secondary endpoints, making rigorous comparisons difficult and limiting the ability to generalise their results. There are a few key differences between the makeshift model as applied at Kimberley Hospital and the commercially available devices, including the ability to modify the effector site negative pressure accurately, the lack of dependence on wall suction points connected to the hospital main suction, ability to irrigate wounds whilst under negative pressure and the ability to cycle pressure gradients to allow patient comfort without changing the entire dressing. While the makeshift model may have been lacking in the above features, it managed to mimic the effect of the available products on the market and likely played a critical role in the favourable outcome achieved.[16]

The process of applying these makeshift dressings was often considered laborious and time consuming, yet another shortfall compared to the available products in the market. It usually required multiple doctors to be available for up to an hour or more, especially when dressing changes were outside of the sterile conditions obtained in theatre. While it may be true that the cost of the commercially available NPWT units is not cheap, usually these machines do not need to be purchased, as they are often lent to institutions on a consignment basis; the disposables needed for each dressing, however, do need to be purchased. The benefits of having the gold standard of equipment include: simplicity of applying the dressing, monitoring and adjustment of negative pressure; less frequent dressing changes due to built-in irrigation; portability and ease of use. In resource-constrained facilities such as ours, the makeshift dressings as previously described seem to suggest a viable alternative to commercially available machines in terms of outcome. Other authors have reported the use of these "homemade" apparatus as alternative to the commercially available ones; the pressure obtained is safe (usually from 30 to 70 mmHg), and the results are comparable to the commercial devices.[17-19]

Although flap reconstruction still remains the mainstream for managment of these complex wounds, recent literature has shown that the use of NPWT is associated with a decrease in the indication for complex procedures, which is useful in resource-constrained institutions.[18] Clinical outcomes also have shown excellent survival with the use of NPWT in poststernotomy mediastinitis compared with conventional therapy, demonstrating that NPWT is safe and a reliable option for DSWI.[20,21] Petzina, et al in a review of 118 patients with poststernotomy mediastinitis reported a significantly lower in-hospital mortality in the group treated with NPWT compared with the group with conventional treatment (5.8% x 24.5%; P = 0.005 by Fischer's and 0.008 by chi-square tests).[22]

Although bleeding during NPWT has been reported for the management of postsurgical DSWI, reports of serious bleeding have been exceedingly rare, and usually are not caused by the procedure per se. Other confounding factors have been associated with this complication, and not directly associated with the technique.[23]

Nevertheless, this technique must be used with caution because wall-suction does not have a built-in safety mecahnism which will terminate suction if a certain volume is drained, as is the case with the commercially available devices.

In a province (the least populated of the country) where admissions for stabbed hearts occur roughly once a month with a higher prevalence in December, and where limitations in financial resources, human resources and infrastructure contribute to the suboptimal management of these patients, alternatives such as the one used in this study may contribute to the management of sternal wound infections in resource-constrained facilities similar to ours.

Conclusion

This case report highlights the use of NPWT dressings (using wall suction) followed by reconstruction with STSG, in deep sternal infection with preserved sternum as a viable alternative to more advanced reconstructive methods such as omentoplasty or myocutaneous flaps in a resource-constrained tertiary hospital. Although flap reconstruction still remains the mainstream for management of these complex wounds, recent literature has shown that the use of NPWT is associated with a decrease in the indication for complex procedures, which is useful in resource-constrained institutions.

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