Deep Sternal Infection Following Bilateral Internal Thoracic Artery Grafting

Andrea Perrotti, Giuseppe Gatti, Fiona Ecarnot, and Sidney Chocron

1 Introduction

Deep sternal wound infection (DSWI) is a serious and potentially devastating complication after cardiac surgery that is associated with longer hospital stays, repeat surgical procedures, and mortality [1, 2]. In the infectious disease literature for all types of surgery, three categories of surgical site infection are defined: type 1, corresponding to superficial incisional; type 2, deep incisional (muscle and fascia); and type 3, deep organ space (bone and/or mediastinum) [3]. The most common definition is that of the US Centers for Disease Control and Prevention (CDC) including at least one of the following criteria:

1. An organism is isolated from mediastinal tissue or fluid obtained during the surgical procedure or needle aspiration.
2. Evidence of mediastinitis seen during surgery or by histopathological examination.
3. At least one of the following: fever (>38°), chest pain, or sternal instability, associated with either purulent discharge from the mediastinal area or organism cultured from blood or mediastinal widening on X-ray [3–6].

A. Perrotti (✉) · G. Gatti · F. Ecarnot · S. Chocron
Department of Thoracic and Cardiovascular Surgery, University Hospital Jean Minjoz, Besancon, France
e-mail: a.perrotti@hotmail.it

Despite many advances in prevention, DSWI remains significant, with an incidence ranging between 0.5 and 6.8% [7, 8]. Numerous studies have identified patient-related and procedure-related factors that may contribute to the occurrence of DSWI. Patient factors include obesity, female sex, age, chronic obstructive pulmonary disease (COPD), diabetes or hyperglycemia during the perioperative period, tobacco smoking, peripheral arterial occlusive disease, kidney dysfunction, recent treatment with antibiotics, skin infection anywhere on the body, and emergency or urgent surgery [5, 9–16]. The high incidence of DSWI in obese patients can be explained by the poor perfusion of subcutaneous adipose layers with low levels of prophylactic antibiotics in this tissue. In fact, Filsoufi showed that obesity was associated with a more than twofold increase in the risk of DSWI [7]. Patients with diabetes mellitus or hyperglycemia are also at increased risk of infection. The reason for the increased risk of DSWI in these patients is that hyperglycemia causes the formation of advanced glycation end products, which can affect host cell function by impairing humoral response, complement activation, chemotaxis, adhesions, and phagocytosis [17, 18]. In a large prospective study, Brown demonstrated that hyperglycemia was an independent risk factor for death, length of hospital stay, and infection rate [19]. Moreover, in a recent study, Gatti [20] reported the importance of HbA1c screening in all patients undergoing cardiac surgery because unrecognized diabetes and

Recent Clinical Techniques, Results, and Research in Wounds (2018)
https://doi.org/10.1007/15695_2018_127, © Springer International Publishing AG
Published Online: 21 August 2018

poor glycemic control may have immediate and long-term prognostic implications in both diabetic and nondiabetic patients. Patient carriage of *Staphylococcus aureus* on the skin and in the nostrils has been identified as an important risk factor for DSWI [21]. The Society of Thoracic Surgeons practice guidelines recommend routine nasal administration of 5-d mupirocin 2% for all patients undergoing cardiac surgery procedures in the absence of documented negative testing for staphylococcal colonization [22]. Surgical risk factors include inadvertent paramedian sternotomy [23], repeat exploration for bleeding [24], use of bone wax, extensive use of electrocauterization [13], prolonged duration of aortic cross clamp or cardiopulmonary bypass [11], postoperative bleeding [25], blood transfusions [7, 12, 26], prolonged mechanical ventilation [4, 7], and finally the use of both internal mammary arteries [4, 13, 27].

2 Why BITA?

In coronary artery bypass graft (CABG) surgery, the conventional strategy has been to utilize the left internal thoracic artery (LITA) for grafting to the left anterior descending artery and the radial artery or saphenous vein to bypass other coronary arteries [28]. The use of LITA grafts has been associated with improved survival at 10 years and reduced incidence of myocardial infarction, cardiac events, and reoperation compared with the use of vein graft alone [29, 30]. Prompted by this evidence, surgeons have attempted to use a bilateral internal thoracic artery (BITA) graft, which should further improve the long-term outcomes of coronary revascularization. Despite the increasing evidence that patients who receive BITA grafts have better long-term outcomes than those receiving single ITA grafts [31, 32], until now, BITA grafting has not been widely adopted. Indeed, BITA grafting is performed in only 4 and 12% of all CABG patients in North America and Europe, respectively [33]. The most salient, persistent, and serious objection to BITA grafting has been an increased risk of sternal wound complications [34, 35].

3 Pathophysiology

In coronary artery bypass grafting, it is clear from experimental and clinical evidence that the increased risk of wound complications appears to be an effect of sternal ischemia caused by the harvest of ITA [36]. Anatomic studies have reported that the harvesting of a single ITA causes significant devascularization of the ipsilateral hemisternum; thus bilateral ITA dissection brings on sternal wound complications [34, 35].

Arnold et al. [37] observed that sternal circulation depends only on a periosteal plexus that arises from segmental sternal branches of the ITA. When one ITA is mobilized, revascularization of that side of the sternum may be possible by crossover collaterals from the unharvested side with intact blood supply. Obviously, a tight sternal closure is necessary to ensure optimal and stable contact between the two sternal sides. According to the same study, complete sternal devascularization occurs with bilateral ITA harvesting. Seyfer [38] demonstrated no evidence for collateral flow to the sternum that could immediately substitute the missing ITA, with a 90% decrease in sternal blood flow after mobilization of one ITA. Moreover, inadequate blood flow impairs local immune response and reduces effectiveness of antibiotics when contamination occurs. These findings could explain the higher rate of sternal wound after BITA grafting.

4 Prevention

In most centers ITA is harvested as a pedicle, together with the vein, muscle, fat, and accompanying endothoracic fascia. The electrocautery that is used for harvesting damages the blood supply to the sternum, and this impairs sternal healing and exposes the sternum to the risk of infection. The anatomic study by Henriquez-Pino et al. [39] showed that some of the 4–6 sternal branches of the ITA and some intercostal branches may arise from the ITA as a common trunk. If that common trunk can be preserved during ITA dissection, then sternal collateralization may be improved. In a study using

technetium-99m methylene diphosphate bone scanning and single-photon emission computed tomography, Cohen et al. showed that a pedicled left internal thoracic artery graft to the left anterior descending artery reduces blood flow to the left side of the sternum during the acute postoperative period. This does not occur when the left internal thoracic artery is skeletonized [36]. This technique for ITA mobilization is associated with a low rate of deep sternal infection, probably associated with less devascularization of the sternum [40]. However, ITA skeletonization is not a universal remedy to avoid sternal complication, but contributes strongly, together with other preventive preoperative and intraoperative measures for avoiding wound problems. First of all, preoperative prevention is of paramount prevention; perioperative intranasal mupirocin is recommended for all cardiac surgery procedures to decrease sternal complications [41, 42], presurgical bathing with chlorhexidine is useful in reducing bacterial count [43], and preoperative identification of untreated diabetes and optimization of glycemic control is strongly recommended [20, 44]. Intraoperatively, meticulous wound opening and closing technique is mandatory. Bone wax should not be used [43], and tight sternal closure with a figure-of-eight technique or using the Robicsek weave technique may prevent sternum instability and infection [45, 46]. Lastly, in order to decrease the risk of wound infections, it is important to avoid bleeding complications that can require repeat surgery [47]. Rapid extubation and early removal of indwelling central venous and urinary catheters may contribute to avoiding complications [48, 49].

Conclusions

To conclude, it is clear that the problem of DSWI is multifactorial, and it is difficult to anticipate exactly which risks factors and triggering events may cause infection. The best results will be achieved through constant engagement and rigorous discipline of all the healthcare professionals in contact with the patient (anesthetist, surgeon, nurse) from the beginning of hospitalization to discharge. Regarding surgical treatment, there are many options for sternal wound closure depending on the degree of the wound and institutional policy. These include closed suction antibiotic catheter irrigation systems, bilateral pectoralis major muscle flap, omental transposition, the latissimus dorsi muscle flap, vacuum-assisted closure, and various combinations of the above [50].

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