Indian Journal of Thoracic and Cardiovascular Surgery (December 2018) 34 (Suppl 3):S349–S354
https://doi.org/10.1007/s12055-018-0686-3

REVIEW ARTICLE

A review of the AATS guidelines for the prevention and management of sternal wound infections

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Received: 9 March 2018 / Revised: 30 April 2018 / Accepted: 14 June 2018 / Published online: 17 July 2018

Abstract

Purpose To summarize the AATS guidelines for the prevention and treatment of sternal wound infections.

Methods The current AATS guidelines for the prevention of sternal wound infections during the preoperative, intraoperative, and postoperative periods, and the most effective methods and techniques to treat sternal wound infections were reviewed.

Results The guidelines identified multiple interventions that can be instituted during the preoperative, intraoperative, and postoperative periods to reduce sternal wound infections during cardiac surgery. These include the use of perioperative antibiotics, glycemic control to maintain serum glucose < 180 mg/dl, avoidance of bone wax and the use of vancomycin paste to the sternal edges, and figure of eight suture techniques to re-approximate the sternum. Wound Vac therapy should be instituted whenever possible to treat and enhance recovery from mediastinitis.

Conclusions The prevention of sternal wound infections and mediastinitis can be achieved by adherence to the AATS guidelines. The institution of these interventions requires a multi-disciplinary team effort among surgeons, anesthesiologists, referring physicians, nurses, and OR and ICU personnel.

Keywords Mediastinitis · Sternal wound infections · Wound Vac therapy

Introduction

Sternal wound infections following cardiac surgery increase morbidity and mortality, prolong hospital length of stay, and increase medical costs [1, 2]. They are publically reported in the USA, and hospitals will no longer receive reimbursement for costs related to deep sternal wound infections following coronary artery bypass graft (CABG) surgery [3].

In 2016, the American Association for Thoracic Surgery (AATS) published guidelines for the prevention of wound infections during the preoperative, intraoperative, and postoperative periods as well as techniques and methods to treat sternal wound infections should they occur [4]. By adopting these guidelines, the incidence of deep sternal wound infections has decreased to 0.3% in CABG patients in the most recent update on outcomes from the Society of Thoracic Surgeons Adult Cardiac Surgery Database [5]. This review will summarize the AATS guidelines, which when implemented, have resulted in a dramatic decrease in the incidence of this life-threatening complication.

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Preoperative prevention

Decreasing bacterial colonization

***All cardiac surgery patients should have nasal swabs and polymerase chain reaction (PCR) testing, if available, prior to surgery (Class I Recommendation; Level of Evidence = A).

***Routine mupirocin administration is recommended for all cardiac surgery procedures in the absence of PCR testing or nasal cultures positive for staphylococcal colonization (Class I Recommendation; Level of Evidence = A).

***Presurgical bathing with chlorhexidine may be helpful in reducing skin bacterial counts (Class II b; Recommendation; Level of Evidence = B).

The majority of cardiac surgical wound infections are caused by staph species which arise from the patients' own skin and nasal flora [6]. Therefore, all patients undergoing cardiac surgery should have nasal swab testing prior to

surgery. In those patients undergoing urgent or emergent surgery in whom culture results are not available, PCR (polymerase chain reaction) assays can identify staph carriers in less than 12 h, but may not be available in all hospitals. The best method to eradicate staph colonization is to use intranasal mupirocin ointment. However, it has no effect on patients who are not nasal staph carriers and in those patients with a negative PCR assay. Furthermore, it only decolonizes 45 to 50% of methicillin-resistant *Staphylococcus aureus* (MRSA) carriers. Therefore, it should only be given to those patients with positive nasal cultures for staph species and in those with a positive PCR assay, or in patients in whom culture results are not available at the time of surgery. It should be administered within 24 h of surgery and continued for 5 days.

Preoperative bathing with chlorhexidine has been shown to decrease bacterial skin counts to a greater extent than other agents [7]. However, it alone cannot reduce the incidence of clinical wound infections.

Reducing risk factors responsible for sternal wound infections

Nutritional status

***Preoperative hypoalbunemia is associated with an increased risk for sternal wound infections and should be corrected prior to surgery if possible (Class I Recommendation; Level of Evidence = B).

Patients with poor nutritional status have a higher incidence of sternal wound infections, especially elderly patients with a serum albumen < 2.5 g/ml, and those with greater than a 10% total body weight loss within 6 months of surgery [8–10]. Preoperative nutritional support via an enteral route should be instituted in those patients in whom surgery can be safely delayed for 7–10 days.

Remote, extrathoracic infections

***All distant, extrathoracic infections should be treated prior to cardiac surgical procedures (Class I Recommendation; Level of Evidence = C).

Infections involving the urinary tract, lungs, abdominal organs, and soft tissues significantly increase the incidence of wound infections [11]. Whenever possible, in non-emergent cases, the responsible organisms should be identified and appropriate antibiotics instituted until the infection has totally resolved.

Optimizing glycemic control

***Optimizing glycemic control is preferable in patients with elevated HbAIc levels > 7.5 and serum glucose levels > 200 mg/dl prior to any cardiac surgery procedure (Class I Recommendation; Level of Evidence = B).

Maintaining serum glucose < 200 mg/dl has been shown to significantly decrease the incidence of sternal wound infections [12, 13]. Every effort should be made to optimize glycemic control prior to cardiac surgical procedures. In those patients who require urgent or emergent surgery and in whom serum glucose levels are > 180 mg/dl, IV insulin infusions are the most effective method to rapidly achieve glycemic control. If necessary, IV insulin infusions should be continued during the intraoperative and postoperative periods.

Smoking cessation and aggressive pulmonary toilet

***Smoking cessation and aggressive pulmonary toilet should be performed in patients who are active smokers and those with chronic obstructive pulmonary disease COPD (Class I Recommendation; Level of Evidence = B).

Whenever possible, patients should stop smoking for at least 30 days prior to surgery. Active smoking at the time of cardiac surgery is an independent risk factor for sternal infections, especially in older patients [14]. In all active smokers, aggressive preoperative pulmonary physiotherapy should be performed to loosen secretions and minimize mucus plugging to prevent increased coughing which contributes to sternal instability and ultimately sternal dehiscence and mediastinitis.

Preoperative antibiotics

***A cephalosporin, either cefazolin or cefuroxime, should be given within 60 min prior to the skin incision and be continued for no longer than 48 h (Class I Recommendation; Level of Evidence = A).

***Vancomycin is reserved for patients with a history of type I allergic reactions to a beta-lactam agent or in cases where MRSA is a special concern (Class IIa Recommendation; Level of Evidence = B).

***Vancomycin is not recommended as the sole prophylactic antibiotic for cardiac surgery procedures (Class III Recommendation; Level of Evidence = B).

***An aminoglycoside should be added for one preoperative and at most one additional dose for gram negative coverage when vancomycin is the primary prophylactic antibiotic (Class IIb Recommendation; Level of Evidence = C).

The AATS guidelines had adopted the Society of Thoracic Surgeons (STS) Evidence Based Guidelines for the duration and choice of antibiotics in cardiac surgery [15, 16]. The dosing of antibiotics should be weight based and antibiotics should be re-dosed for procedures lasting more than 4 h. Vancomycin should be given not only for patients who are allergic to beta-lactam agents but also for patients hospitalized for > 3 days, patients transferred from another in-patient facility, or institutions where there is a high prevalence of MRSA,

and for those procedures involving a prosthetic valve or a vascular graft.

Intraoperative prevention

Antibiotics

***A cephalosporin should be administered within 60 min of a cardiac surgical procedure and re-dosed for procedures lasting > 4 h (Class I Recommendation; Level of Evidence = A).

***Vancomycin should be administered between 60 and 120 min prior to the incision and at most for only one additional dose when it is used with a cephalosporin (Class I Recommendation; Level of Evidence = A).

Timing is important when re-dosing antibiotics during cardiac surgical procedures. Intraoperative re-dosing of cefazolin has been shown to significantly reduce infections when cardiac surgical procedures last longer than 4 h, and cardiopulmonary bypass times exceed 120 min [17, 18].

Glycemic control

***A continuous infusion of insulin should be instituted to maintain serum glucose < 180 mg/dl (Class I Recommendation; Level of Evidence = A).

Glucose levels > 200 mg/dl during the intraoperative period are an independent risk factor for sternal wound infections [19]. Continuous intravenous insulin infusions should be instituted to maintain serum glucose levels < 180 mg/dl.

Topical antibiotics

***Topical antibiotics should be applied to the cut edges of the sternum upon opening and prior to closing the sternum in all cardiac surgical procedures involving a sternotomy (Class I Recommendation; Level of Evidence = B).

Topical antibiotics applied to the cut edges of the sternum, achieve much higher wound concentrations than are possible with systemic antibiotics [20]. VanderSalm et al. found that topical vancomycin reduced the incidence of sternal wound infections from 3.6 to 0.5%; $p = 0.02$ [21]. Lazar et al., in a study involving over 3000 patients, found that topical vancomycin applied as a slurry to both edges of the sternum, in conjunction with perioperative antibiotics and tight glycemic control (< 180 mg/dl), resulted in total elimination of both superficial (0 vs 1.6%; $p < 0.001$) and deep (0 vs 0.7%; $p = 0.005$) or any type of wound infection in both non-diabetic (0 vs 2.2%; $p < 0.001$) and diabetic (0 vs 3.3%; $p = 0.0004$) patients [22]. In a retrospective study involving over 1000 patients, Arruda et al. found that vancomycin paste applied to the sternal edges reduced the incidence of sternal wound infections to 0.5% [23]. Lazar et al. also found that topical vancomycin did not result in any increased incidence of drug resistant infections or postoperative renal toxicity [24]. In a recent meta-analysis, Kowalewski et al. showed that the use of vancomycin paste was associated with a 76% significant risk reduction of any sternal wound infection and a 76% significant reduction in the incidence of deep sternal wound infections [25]. In another meta-analysis, Kowalewski et al. showed that gentamicin-collagen sponges also significantly reduced both superficial and deep sternal wound infections by 40% [26]. My own choice for a topical antibiotic is vancomycin. It is inexpensive, easy to prepare and handle, and has no local or systemic side-effects. It provides both bacteriocidal and bacteriostatic protection against gram-positive bacteria and clostridia organisms.

Avoid bone wax

***Bone wax should not be applied to the cut edges of the sternum at any time (Class III Recommendation; Level of Evidence = B).

Bone wax acts as foreign body, prevents bone union, and is an independent risk factor for sternal dehiscence and infections [27, 28]. It should not be applied to the sternum during cardiac surgery.

Intraoperative techniques to maintain sternal stability

***Closing the sternum with a figure of eight technique is preferable to prevent sternal dehiscence and wound infections (Class IIb Recommendation; Level of Evidence = B).

***Closing a sternum with multiple fractures using the Robicsek weave technique prevents dehiscence and wound infections (Class IIa Recommendation; Level of Evidence = B).

***Rigid sternal fixation with bands or plates may reduce sternal dehiscence and wound infections (Class IIb Recommendation; Level of Evidence = B).

A figure of eight sternal closure decreases sternal mobility and prevents sternal dehiscence and ultimately infections [29]. An inadvertent paramedian sternotomy is often accompanied by sternal fractures which can also lead to instability, dehiscence, and infections. When this occurs, a "Robicsek Weave," placing the wires through the intercostal spaces parasternally, in conjunction with standard transverse wires, can decrease the incidence of sternal dehiscence and ultimately infections [30]. Rigid sternal fixation with bands and plates has been used in obese, diabetic, and COPD patients to decrease dehiscence, but the results are inconclusive. They should not

be used in patients with osteoporosis and in the presence of active infections.

Postoperative prevention

Chest wall stabilization

***External chest support vests may limit the incidence of sternal dehiscence and infections (Class IIb Recommendation; Level of Evidence = B).

External chest support devices have been used to maintain sternal stability, especially in obese patients and patients with persistent coughing. These vests are cumbersome to wear, and patient compliance is variable.

Antibiotics

***Appropriate antibiotics should be continued postoperatively for no longer than 48 h (Class I Recommendation; Level of Evidence = A).

STS guidelines recommend that prophylactic antibiotics be given for no longer than 48 h following surgery. Vancomycin, when used in combination with other antibiotics, should only be given for one additional postoperative dose.

Glycemic control

***Continuous insulin infusions should be instituted in the ICU for at least 24 h following surgery to maintain serum glucose < 180 mg/ml. (Class I Recommendation; Level of Evidence = A).

Serum glucose should be < 180 mg/dl for the first 24 h following surgery while the patient is in the ICU, using IV insulin infusions [31]. Insulin infusions should be continued in those patients in whom extended periods of ICU care are necessary due to the need for inotropic support, mechanical ventilator support, mechanical circulatory support, or antiarrhythmic and renal replacement therapy.

Drainage and indwelling catheters

All chest drainage catheters should be removed as soon as drainage decreases. Indwelling urinary and central venous catheters serve as a potential nidus for infection and should be removed when vital signs stabilize and frequent hemodynamic monitoring is no longer necessary. Re-exploration for bleeding should be done expeditiously to control bleeding sites and minimize blood transfusions and evacuate hematomas which serve as a culture medium for infection and increases the risk for mediastinitis.

Guidelines for management of sternal infections

***Use of dilute povidine-iodine irrigation for treatment of deep sternal wound infections with mediastinitis should be avoided (Class III Recommendation; Level of Evidence = B).

***Negative pressure wound therapy (NPWT) should be initiated whenever possible in patients in whom delayed sternal closure is anticipated following deep sternal wound infections (Class IIa Recommendation; Level of Evidence = B).

***When using negative pressure wound therapy, it is necessary to place a barrier dressing between the sponge and the heart and great vessels to prevent tissue erosion resulting in fatal hemorrhage (Class IIa Recommendation; Level of Evidence = B).

The treatment of all sternal wound infections involves debridement of all devitalized and necrotic tissue, drainage of all infected spaces, antibiotics, and closure of the sternal space. In superficial infections, incision and drainage followed by packing and dressing changes may be all that is needed. For deeper infections associated with sternal necrosis and chest wall instability, other techniques are necessary.

In previous years, the standard of care for these deep infections involved continuous mediastinal drainage with a povidone-iodine solution. However, this results in a high rate of absorption of iodine which has been associated with renal failure, electrolyte disturbances, altered thyroid function, mental changes, and seizures [32, 33]. In view of these complications, if an irrigation system is to be used, the iodine should be replaced with a dilute antibiotic solution.

In patients in whom a primary sternal wound closure cannot be performed, sternal wound flap closure with muscle or omentum is now the procedure of choice. However, before proceeding with flap closure, the wound must be free of active infection and all necrotic tissue must be debrided. In order to "bridge" these patients to a permanent flap closure, negative pressure wound therapy should be instituted. NPWT stabilizes the chest wall and allows for earlier extubation, removes excess fluid and decreases wound edema, accelerates wound healing, and has resulted in earlier wound closure, shorter hospital stays, and decreased mortality [34–36]. In order to avoid fatal exsanguination from exposed myocardium, great vessels, and bypass conduits, a barrier dressing should be placed when using NPWT to minimize the delivery of excessive negative pressure to the underlying myocardium [37].

Conclusions

The implementation of the AATS guidelines has resulted in a dramatic decrease in the incidence of sternal wound infections in cardiac surgical patients. However, sternal wound infections may still occur. In a recent CTSNET study, the incidence

of mediastinitis was 0.79% [38]. Hospital readmissions and mortality rates were five times higher in these patients. Multivariate analyses revealed that postoperative hyperglycemia, especially in non-diabetic patients, was associated with an increased risk of sternal wound infections. The use of bilateral internal mammary artery grafts and red blood cell transfusions did not result in an increased rate of infection. Protocols for glycemic control varied among the institutions and in some instances, serum blood glucose levels were recorded only every 6 h for the first 24 h after surgery. The failure to institute adequate glycemic control was clearly responsible for these infections. This study highlights the importance of adherence to the AATS guidelines in preventing sternal wound infections. While it is unrealistic to believe that sternal wound infections will never occur following cardiac surgery, institution of the AATS guidelines will decrease the incidence of sternal wound infections in all types of cardiac surgical procedures to less than 0.5%. The guidelines are easy to institute and should become the standard of care in all hospitals in which cardiac surgery is performed.

Compliance with ethical standards

Conflict of interest

The author declares that he has no conflict of interest.

Ethical approval, Statement of Human and Animal Rights, Informed consent–Being a Review article, these are not required.

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