

Topical Application of Bacitracin Ointment Is Associated with Decreased Risk of Mediastinitis after Median Sternotomy

Robroy H. MacIver, MD, Robert Stewart, MD, James W. Frederiksen, MD,
David A. Fullerton, MD, Keith A. Horvath, MD

Northwestern Memorial Hospital, Chicago, Illinois, USA

ABSTRACT

Background. The diagnosis of mediastinitis after open-heart surgery is infrequent but dreaded as it carries a high morbidity and mortality. The purpose of this study was to investigate the impact that topical antibacterials would have on the postoperative mediastinitis rate.

Methods. Data were collected from 2455 consecutive patients who underwent sternotomy and cardiopulmonary bypass for both valvar and ischemic heart disease. Prior to 1999, patients ($n = 1036$) underwent surgery with standard perioperative intravenous antibiotics but no application of bacitracin. After 1999, patients ($n = 1419$) underwent surgery with intravenous antibiotics and application of bacitracin ointment to the sternotomy incision after closure.

Results. Cases of mediastinitis occurred in 12 patients (1.2%) not treated with bacitracin, which required re-exploration, sternectomy, and soft tissue closure of the mediastinum. Alternatively, 3 patients (0.2%) in the group treated with bacitracin developed mediastinitis ($P < .01$). Therefore, the use of topical antibacterials was associated with a 6-fold reduction in the risk of mediastinitis after cardiac surgery. This significant difference in the infection rate was observed even though the percentage of patients with risk factors for mediastinitis was equal to greater than the group not treated with bacitracin. Non-bacitracin versus bacitracin: diabetics, 298 versus 484; emergency operations, 24 versus 50; bilateral internal thoracic grafts, 28 versus 29; and obesity (body mass index >30), 294 versus 396.

Conclusions. The use of topical antibacterials is associated with a decrease in the risk of mediastinitis after cardiac surgery.

INTRODUCTION

Mediastinitis following sternotomy is associated with significant morbidity and mortality [Cheung 1985; Loop 1990; Ivert 1991; Farinas 1995; Ridderstolpe 2001]. The incidence of mediastinitis following cardiac surgery has been reported between 0.5% and 1.6% [Cheung 1985; Loop 1990; Ivert 1991; Farinas 1995; Milano 1995; Zacharias 1996; Ridderstolpe 2001]. The etiology is most commonly a bacterial infection, and management usually requires surgical debridement [Ivert 1991; Oakley 1996; El Gamel 1998]. Even when successfully treated, the infection is associated with physical impairment and chronic medical problems [Oakley 1996; Ridderstolpe 2001]. Numerous studies have attempted to identify the risk factors for mediastinitis as well as strategies to avoid this complication. Risk factors consistently cited include obesity, diabetes, use of bilateral internal thoracic arteries (ITAs), emergent operations, and peri-operative transfusions [Breyer 1984; Wouters 1994; Milano 1995; Zacharias 1996; Bitkover 1998]. With the aim of decreasing the rate of mediastinitis at our institution, we adjusted our antisepsis protocol to include the application of bacitracin ointment directly to the closed wound. To assess the efficacy of this intervention, we compared our incidence of mediastinitis under the new protocol to a historical cohort operated on at our institution.

MATERIALS AND METHODS

Data were collected from 2455 consecutive patients who underwent sternotomy and cardiopulmonary bypass for both valvar and ischemic heart disease at Northwestern Memorial Hospital between 1996 and 2002. All patients in the study were treated using a consistent standard pathway with the exception of the topical antibiotic. Prior to the use of bacitracin in 1999, 1036 patients underwent surgery with this protocol and served as the control group. Beginning in 1999, a thick coat of bacitracin ointment was liberally applied to the closed wound prior to covering it with sterile gauze dressing. The ointment was not reapplied postoperatively. The gauze dressing was removed on postoperative day 2. The remainder of the patients' treatment remained similar.

Patients showered with an antibacterial soap the night before the procedure. Patients requiring dental work were

Received December 30, 2005; received in revised form April 11, 2006; accepted April 29, 2006.

Address correspondence and reprint requests to: Robroy MacIver, Department of Surgery, Northwestern University Medical School, 251 East Huron St., Galter 3-150, Chicago, IL 60611-2950, USA; 312-926-8060 (e-mail: r-maciver@northwestern.edu).

treated prior to any valve insertion. Diabetic patients were instructed to take half of their normal dose of hypoglycemics the morning prior to the procedure. All patients were given antacid therapy prior to anesthetic induction.

Perioperative prophylactic intravenous antibiotics were administered to all patients within 1 hour prior to the incision. The standard antibiotic regime was consistent throughout the study period and consisted of 1.5 grams of cefuroxime or, if penicillin allergic, 15 mg/kg of vancomycin. The high-risk antibiotic regime was given to patients who were undergoing a prosthetic valve replacement or vascular graft implantation, who were hospitalized greater than 72 hours preoperatively, or who had received broad spectrum antibiotics within the previous 14 days. These high-risk patients received 15 mg/kg of vancomycin plus 1.5 grams of cefuroxime or, for penicillin allergic patients, vancomycin plus 2 grams of aztreonam. Postoperatively, all patients received the same antibiotic selected preoperatively on a standard schedule for 48 hours adjusted for creatinine clearance.

Each patient's chests, groins, and legs were shaved with electric clippers immediately prior to being cleansed with 70% isopropyl alcohol followed by Dura-Prep (0.7% available iodine, isopropyl alcohol 74% w/w; Baxter, Deerfield, IL, USA). The chest and legs were covered with Ioban Antimicrobial Incise barriers (3M, St. Paul, MN, USA). Disposable paper drapes were used on all patients. At the end of the procedure, the sternum was secured with stainless steel wires or Mersilene #5 sutures (Ethicon, Somerville, NJ, USA). The fascial, subcutaneous, and subcuticular layers were closed in progression with separate running vicryl sutures. No steri-strips were applied to the wound.

All patients were admitted to a dedicated cardiovascular intensive care setting following their operation. Invasive monitoring was obtained by an arterial and pulmonary arterial line. Patients were weaned off mechanical ventilation and extubated by a standard "fast track" protocol. Blood sugar levels were controlled with an insulin drip as needed to keep serum glucose <200 mg/dL. Chest tubes were kept at 20 cm pleurovac suction and removed once drainage had diminished to <20 mL over 8 hours and no air leaks were present. Foley catheters were removed once patients became ambulatory. Patients were transferred to a separate step-down cardiac telemetry unit on postoperative day 1 if they were hemodynamically stable and off inotropic support. All patients had pacing wires that were removed on postoperative day 3 if not required for active pacing. Patients were allowed to shower on postoperative day 4. Bacitracin ointment was not used routinely on any postoperative surgical site.

Mediastinitis is defined throughout this study as wound infections that required operative debridement of the sternum and had a positive intraoperative wound culture. All patients' dressings were removed on postoperative day 2 and were not reapplied. The wound was examined at least once per day by both residents and attendings. Mediastinitis was not stratified by severity. Superficial site infections were not included in this study as data were not available prior to 1999. This group included those that may have had bedside opening of the superficial wound, but did not require further debridement. Antibiotic treatment was guided by sensitivity studies from

Prevalence of Known Risk Factors for Mediastinitis in the Bacitracin and Non-Bacitracin Groups Reported as n (%)

Mediastinitis Risk Factors	Bacitracin Group (n = 1036)	Non-Bacitracin Group (n = 1419)	P
Diabetes mellitus	298 (28.8%)	484 (34.1%)	.07
Emergency operation	24 (2.3%)	50 (3.5%)	.26
Bilateral internal thoracic artery	28 (2.7%)	29 (2.0%)	.77
Obesity (Body Mass Index >30)	294 (28.4%)	396 (27.9%)	.87

cultures of debrided sternum. Statistical analysis was performed using chi-square or Fisher exact tests as appropriate.

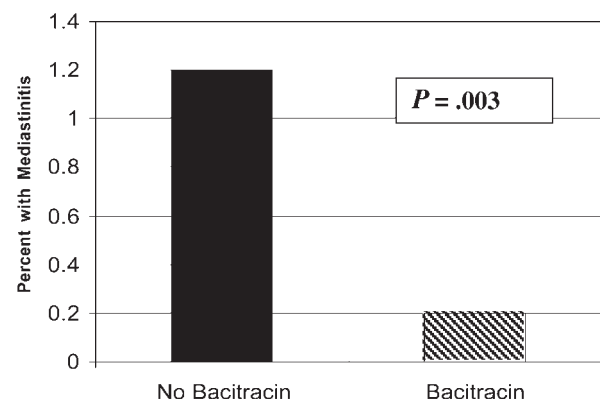
RESULTS

Comparison of the 2 groups' variables is listed in the Table. A greater percentage of diabetics existed in the bacitracin population. There were cases of culture-positive mediastinitis in 12 (1.2%) of the 1036 patients operated on prior to the use of bacitracin, compared to cases of mediastinitis in only 3 (0.2%) among the 1419 patients treated with bacitracin ($P = .003$) (Figure 1).

The organisms isolated from the wounds in the control group included 6 gram positive, 3 gram negative, and 2 mixed gram negative and gram positive bacteria. Data for one of the positive cultures in the control group were not available. In the bacitracin group, there was 1 gram negative, 1 gram positive, and 1 mixed gram negative and gram positive culture. There were no fungal infections in either group.

DISCUSSION

Mediastinitis remains a serious complication of cardiac surgery. The inherent risks for this complication include devascularization of the sternum, hypothermia, and introduction of foreign bodies. In our study, we found that bacitracin ointment decreased the mediastinitis rate compared to historical controls. The efficacy of topical antibiotics is likely sec-



Comparison of percentage of patients with mediastinitis treated with and without bacitracin.

ondary to inadequacies of systemic antibiotics penetration of tissue, iatrogenic immunosuppression of the host, and perioperative contamination of the wound. It is believed that this modification in the antisepsis regime is effective because it improves multiple aspects of the intraoperative and postoperative management of the patient.

Overall, cardiac patients have more comorbidities than in the past, which often are risk factors for mediastinitis [Van Domburg 2002]. These older and sicker patients frequently are hospitalized longer preoperatively and subsequently have an increased risk of colonization with potentially resistant bacteria [Asensio 1996; Suntharam 2002; Borg 2003; Gnanalingham 2003]. Many of the preoperative risks associated with mediastinitis such as obesity and diabetes are unable to be altered prior to surgery. Accordingly, mediastinitis prevention efforts have focused on decreasing bacterial colonization of the host prior to surgery with the hope that this will decrease infection rates. Although an illness score, such as an APACHE, was not calculated on the patients, there was an equivalent or higher percentage of known risk factors in the bacitracin group as shown in the Table.

One theory of the mechanism of mediastinitis involves a decrease in blood flow to the sternum. Iwakura et al demonstrated in a rat model a significant decrease in blood flow after the use of bilateral ITA grafts [Iwakura 2000]. The judicious use of ITA grafts has been clinically shown to decrease infection rates [Grossi 1991; Antunes 1997; Risnes 2001]. This is an area of debate as some studies have shown no increase in infection rates using bilateral ITAs [Loop 1990; Sethi 1991; Wouters 1994; Sofer 1999]. Although the use of bilateral ITA grafts in diabetic patients was limited during the Northwestern Memorial Hospital study, diabetes was not an absolute contraindication of their use in the study. Furthermore, overall use of bilateral ITA grafts was low in both groups.

Transient decreases in blood flow can also impair proper healing of the sternum. Kurz et al demonstrated during general surgical procedures that hypothermia, a component of most cardiac operations, increased the rate of wound infections [Kurz 1996]. The authors theorized that this was caused by reduced levels of oxygen in the tissue impairing oxidative killing by neutrophils and localized vasoconstriction around the wound. Local destruction of tissue also temporarily decreases blood flow to the healing wound. Many surgeons have reduced this destruction by limiting the use of cauterization that was demonstrated by Nishida et al to decrease infection rates [Nishida 1990]. All surgeons at Northwestern Memorial Hospital adhere to the policy of minimizing the use of cautery. Additionally, the use of bone wax was avoided to prevent foreign material in the wound. We feel the majority of organisms causing mediastinitis have their origin as skin flora secondary to our culture results. As such, there is likely also contamination occurring during the operation, but this contamination is likely more effectively treated by the systemic antibiotics.

Topical antibiotics have been used in the past as a means to obtain higher concentrations of antibiotics at the wound site. In cardiac and other surgical populations, topical antibacterials have been shown to decrease colonization of bacteria and lower infection rates [Mack 1967; Pitt 1982; Lau 1986; Bencini 1991; Gruessner 2001]. For example, Kaiser et al

demonstrated that cleansing the skin with antibacterials can decrease cutaneous bacterial flora [Kaiser 1988]. Langford et al in the emergency medicine population showed that topical antibiotics decrease the healing time needed for traumatic lacerations and abrasions [Langford 1997]. Troy et al have used topical antibiotics for hernia repairs with implanted foreign material and showed reduced infection rates [Troy 1996]. Walker et al has attempted to prevent mediastinitis by injecting antibiotics directly into the sternum [Walker 1986]. This study was able to show a decrease in colonization of bacteria, but failed to demonstrate a decrease in the rates of infection.

Bacitracin is not dependent on blood flow, temperature, or viable tissue to decrease colonization of bacteria. In addition, resistance to bacitracin is less than that of systemic antibiotics and does not limit the choices of antibiotics for any postoperative infections [Ming 2002; Spann 2003]. Bacitracin is bactericidal against both gram positive and gram negative organisms by blocking bacterial cell wall synthesis [Ming 2002; Spann 2003]. We feel that the bacitracin ointment served as a physical barrier against invasion in addition to its chemical bactericidal properties. Additionally, the intracutaneous suture was covered with one application of bacitracin. We initially attempted reapplication of the bacitracin ointment after the initial 24 hours for continued coverage, but met resistance and noncompliance from the intensive care unit nursing staff as well as the patients. The barrier properties of the ointment in the first 24 hours are likely the most important function of the ointment, while the patient is in the intensive care unit setting and epithelialization is taking place.

As with any intervention, the application of a topical antibiotic has risks associated with it. Although the study did not specifically look at mild allergic reactions with the use of topical antibiotics, no major allergic complications to the antibiotics were encountered. Smacker et al compared an anergic compound, petroleum ointment, to bacitracin with efficacy found in both groups [Smack 1996]. In post-procedure dermatology wounds in this study, the incidence rate of infection was reduced to 2.0% with the use of petrolatum dressing versus 0.9% with the use of bacitracin dressing. This reduction in both groups supports the theory that a large effect of the bacitracin ointment is as a barrier dressing.

There are multiple antibiotics that are formulated for topical use. Our choice for the use of bacitracin alone rather than a formulation combining multiple antibiotics was due to the proven efficacy of bacitracin and was secondary to the low cost of the ointment at our institution. Within the study, it was a common belief that the main function of the bacitracin was as a barrier dressing. Therefore, any modifications with the formulation would likely result in minimal improvement to the mediastinitis rate. The choice and need of antibiotics in the topical ointment could be investigated further. Although other studies investigating topicals have progressed to compare topicals alone to systemic antibiotics, there are no plans to attempt this in our cardiac surgery patients.

CONCLUSION

The application of topical bacitracin to the sternotomy incision postoperatively has decreased mediastinitis at our

institution with little added cost or risk to the patient. This has led to the adoption of bacitracin into our surgical routine for cardiac surgery. We do not feel that the use of such topical antibiotics has created more resistant strains of bacteria.

REFERENCES

- Antunes P, Bernardo JE, Eugenio L, et al. 1997. Mediastinitis after aorto-coronary bypass surgery. *Eur J Cardiothorac Surg* 12:443-9.
- Asensio A, Guerrero A, Quereda C, et al. 1996. Colonization and infection with methicillin resistant *Staphylococcus aureus*: associated factors and eradication. *Infect Control Hosp Epidemiol* 17:20-8.
- Bencini PL, Galimberti M, Signorini M, et al. 1991. Antibiotic prophylaxis of wound infections in skin surgery. *Arch Dermatol* 127:1357-60.
- Bitkover C, Bardlund B. 1998. Mediastinitis after cardiovascular operations: a case-control study of risk factors. *Ann Thorac Surg* 65:36-40.
- Borg MA. 2003. Bed occupancy and overcrowding as determinant factors in the incidence of MRSA infections within general ward settings. *J Hosp Infect* 54:316-8.
- Breyer RH, Mills SA, Hudspeth AS, et al. 1984. A prospective study of sternal wound complications. *Ann Thorac Surg* 37:412-6.
- Cheung EH, Craver JM, Jones EL, et al. 1985. Mediastinitis after cardiac valve operations. Impact upon survival. *J Thorac Cardiovasc Surg* 90:517-22.
- El Gamel A, Yonan NA, Hassan R, et al. 1998. Treatment of mediastinitis: early modified robicsek closure and pectoralis major advancement flaps. *Ann Thorac Surg* 65:41-7.
- Farinas MC, Peralta FG, Bernal JM, et al. 1995. Suppurative mediastinitis after open-heart surgery: a case-control study covering a seven-year period in Santander, Spain. *Clin Infect Dis* 20:272-9.
- Gnanalingham KK, Elsaghier A, Kibbler C, et al. 2003. The impact of methicillin-resistant *Staphylococcus aureus* in a neurosurgical unit: a growing problem. *J Neurosurg* 98:8-13.
- Grossi E, Esposito R, Harris LJ, et al. 1991. Sternal wound infections and use of internal mammary artery grafts. *J Cardiovasc Surg* 102:342-7.
- Gruessner U, Clemens M, Pahlplatz PV, et al. 2001. Improvement of perineal wound healing by local administration of Gentamicin-impregnated collagen fleeces after abdominoperineal excision of rectal cancer. *Amer J Surg* 182:502-9.
- Ivert T, Lindblom D, Sahni J, et al. 1991. Management of deep sternal wound infection after cardiac surgery—Hanuman syndrome. *Scand J Thorac Cardiovasc Surg* 25:111-7.
- Iwakura A, Tabata Y, Miyao M, et al. 2000. Novel method to enhance sternal healing after harvesting bilateral internal thoracic arteries with use of basic fibroblast growth factor. *Circulation* 102:III307-11.
- Kaiser AB, Kernodle DS, Barg NL, et al. 1988. Influence of preoperative showers on *Staphylococcal* skin colonization: a comparative trial of antiseptic skin cleansers. *Ann Thorac Surg* 45:35-8.
- Kurz A, Sessler DI, Lenhardt R. 1996. Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. *N Eng J Med* 334:1209-15.
- Langford JH, Artemi P, Benrimoj S. 1997. Topical antimicrobial prophylaxis in minor wounds. *Ann Pharmacother* 31:559-63.
- Lau WY, Fan ST, Chu KW, et al. 1986. Combined topical povidone-iodine and systemic antibiotics in post-appendicetomy wound sepsis. *Brit J Surg* 73:958-60.
- Loop F, Lytle BW, Cosgrove DM, et al. 1990. Sternal wound complications after isolated coronary artery bypass grafting: early and late mortality, morbidity, and cost of care. *Ann Thorac Surg* 49:179-87.
- Mack RM, Cantrell JR. 1967. Quantitative studies of the bacterial flora of open skin wounds: the effect of topical antibiotics. *Ann Surg* 166:886-95.
- Milano CA, Kesler K, Archibald N, et al. 1995. Mediastinitis after coronary artery bypass graft surgery. Risk factors and long-term survival. *Circulation* 92:2245-51.
- Ming LJ, Epperson JD. 2002. Metal binding and structure-activity relationship of the metalloantibiotic peptide bacitracin. *J Inorganic Biochem* 91:46-58.
- Nishida H, Grooters RK, Merkley DF, et al. 1990. Postoperative mediastinitis: a comparison of two electrocautery techniques on presternal soft tissues. *J Thorac Cardiovasc Surg* 99:969-76.
- Oakley RM, Wright JE. 1996. Post-operative mediastinitis: classification and management. *Ann Thorac Surg* 61:1030-6.
- Pitt HA, Postier RG, Gadacz TR, et al. 1982. The role of topical antibiotics in "high-risk" biliary surgery. *Surgery* 91:518-24.
- Ridderstolpe L, Gill H, Granfeldt H, et al. 2001. Superficial and deep sternal wound complications: incidence, risk factors and mortality. *Eur J Cardiothorac Surg* 20:1168-75.
- Risnes I, Abdelnoor M, Baksaas ST, et al. 2001. Sternal wound infections in patients undergoing open heart surgery: randomized study comparing intracutaneous and transcutaneous suture techniques. *Ann Thorac Surg* 72:1587-91.
- Sethi GK, Copeland JG, Moritz T, et al. 1991. Comparison of postoperative complications between saphenous vein and IMA grafts to left anterior descending coronary artery. *Ann Thorac Surg* 51:733-8.
- Smack DP, Harrington AC, Dunn C, et al. 1996. Infection and allergy incidence in ambulatory surgery patients using white petrolatum vs. bacitracin ointment. A randomized controlled trial. *JAMA* 276:972-7.
- Sofer D, Gurevitch J, Shapira I, et al. 1999. Sternal wound infections in patients after coronary artery bypass grafting using bilateral skeletonized internal mammary arteries. *Ann Surg* 229:585-90.
- Spann CT, Tutrone WD, Weinberg JM, et al. 2003. Topical antibacterial agents for wound care: a primer. *Dermatol Surg* 29:620.
- Suntharam N, Lankford MG, Trick WE, et al. 2002. Risk factors for acquisition of vancomycin-resistant enterococci among hematology-oncology patients. *Diag Microbiol Infect Dis* 43:183-8.
- Troy M, Dong Q, Dobrin P, et al. 1996. Do topical antibiotics provide improved prophylaxis against bacterial growth in the presence of polypropylene mesh? *Amer J Surg* 171:391-3.
- Van Domburg RT, Takkenberg JJ, Meeter K, et al. 2002. Coronary bypass surgery in 1971-80 and 1995-96: increased age and comorbidity, unchanged survival rates and fewer early re-operations 1 and 5 years postoperatively. *Ned Tijdschr Geneesk* 146:2192-6.
- Walker WS, Raychaudhury T, Faichney A, et al. 1986. Wound colonization following cardiac surgery. Reduction by adjuvant use of preincisional, presteral antibiotic infiltration: a double blind prospective randomized study. *J Cardiovasc Surg* 27:662-6.
- Wouters R, Wellens F, Vanermen H, et al. 1994. Sternalitis and mediastinitis after coronary artery bypass grafting. Analysis of risk factors. *Tex Heart Inst J* 21:183-8.
- Zacharias A, Habib RH. 1996. Factors predisposing to median sternotomy complications. Deep vs. superficial infection. *Chest* 110:1173-8.