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Sternal Wound Complications in Bilateral Internal Thoracic Artery Grafting: A Comparison of the Off-Pump Technique and Conventional Cardiopulmonary Bypass

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ABSTRACT

Background. Sternal wound complication is a major concern in bilateral internal thoracic artery grafting. The purpose of this study was to assess whether avoiding cardiopulmonary bypass has beneficial effects with fewer wound complications in patients receiving bilateral internal thoracic artery grafting.

Methods. Retrospective review was performed using prospectively gathered data of 69 patients who had undergone elective coronary artery bypass grafting and received conventional pedicled bilateral internal thoracic artery grafting from December 2002 through April 2004 by the same surgical team. The patients were divided into 2 groups: those who underwent coronary artery bypass grafting without cardiopulmonary bypass (off-pump group, n = 41), and those who underwent coronary artery bypass grafting with cardiopulmonary bypass (CPB group, n = 28). Chart review and 3-month follow-up were obtained for all patients. These 2 groups were compared for sternal wound complications and preoperative, intraoperative, and postoperative variables.

Results. Deep sternal wound infection (SWI) was seen in 1 patient (2.4%), superficial SWI in 2 patients (4.8%), and sternal dehiscence in 1 patient (2.4%) in the off-pump group. Deep SWI was seen in no patients, superficial SWI in 2 patients (7.1%) and sternal dehiscence in 2 patients (7.1%) in the CPB group. No statistically significant difference in the frequency of occurrence of sternal complications was detected between the 2 study groups.

Conclusions. The results suggest that the avoidance of CPB has no beneficial effect on the number of sternal wound complications in patients receiving bilateral internal thoracic artery grafting. However, further prospective, randomized studies on large patient groups are required to assess this finding.

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INTRODUCTION

Despite accumulating evidence of prolonged survival and decreased cardiac events [Lytle 1999; Taggart 2001; Rizolli 2002], many surgeons avoid bilateral internal thoracic artery (ITA) grafting because of the increased risk of sternal wound complications [Grossi 1991; Borger 1998].

With the advent of interventional catheterization laboratory techniques and better management of patients, patients with more comorbidities are being referred for operation. These patients make up a group that is at higher risk for the development of infections in the postoperative period. On the other hand, these patients usually have severe and diffuse coronary artery disease, and bilateral ITA (BITA) grafting strategy may be of particular benefit.

Cardiopulmonary bypass (CPB) produces widespread alterations in immune, endocrine, humoral, and metabolic functions [Butterworth 2000; Hornick 2000] that may directly or indirectly affect postoperative mortality and morbidity related to infection and poor wound healing. The off-pump technique is a potentially more physiologic method to maintain the functional integrity of major organ systems with the possibility of reducing mortality and morbidity [Ascione 2003]. In the past few years, a large body of evidence has been presented in the literature that off-pump operations reduce postoperative morbidity and organ dysfunction compared to conventional coronary artery bypass grafting (CABG) and cardioplegic arrest [Ascione 2003]. To our knowledge, there is no literature available about the comparison of sternal wound complications in patients undergoing BITA grafting with and without CPB.

The objectives of this study were to assess whether avoiding CPB has beneficial effects with fewer wound complications in patients receiving bilateral internal thoracic artery grafting and to improve our understanding of the potential benefits of off-pump procedures.

PATIENTS AND METHODS

Patients

We reviewed prospectively gathered computerized data and surgeons' follow-up forms of patients who had undergone elective CABG and received BITA grafting from December 2002 through April 2004. The study was approved

by the institutional review board. Then a manual chart review was performed on each of these patients. Exclusion criteria were as follow: (1) redo operations; (2) prior history of malignancy or disorders involving the immune system, connective tissue, and endocrine system (except diabetes mellitus); (3) preoperative abnormal levels of white blood cells, C reactive protein levels, albumin, or sedimentation rate; (4) preoperative signs and symptoms of any infection; (4) use of corticosteroids preoperatively, perioperatively, or during the 3-month follow-up period postoperatively; and (5) concomitant cardiac or extracardiac procedures. A total of 69 patients were enrolled in this study. The patients were divided into 2 groups: those who underwent CABG without CPB (off-pump group, n = 41) and those who underwent CABG with CPB (CPB group, n = 28). All patients were operated on by the same surgical team. The decision regarding whether conventional CPB or the "off-pump" technique was to be used was made on an individual basis by the attending surgeon, in consultation with the patient. Patients with comorbidities (eg, diabetes, obesity) and patients with diseases involving the posterior descending or circumflex coronary arteries were considered candidates for either procedure.

Perioperative Management

The night before the operation, the hair overlying potential surgical sites on all patients was removed with hair clippers, followed by an antiseptic wash with a 10% povidone-iodine–containing scrub brushes (Real-scrub brush; Fulya Medikal, Istanbul, Turkey). All patients received a similar balanced anesthetic regimen, including fentanyl, propofol, and sevorein. Curarization was achieved with pancuronium bromide. Antimicrobial prophylaxis consisted of cefazolin, which was given intravenously at a dose of 1 g at the induction of anesthesia and followed by 1 g every 6 hours for 24 hours. In cases of reexploration for bleeding, antimicrobial prophylaxis consisted of 2 doses of intravenous 1 g vancomycine; 1 dose before the skin incision and followed by the second dose after 12 hours, in addition to routine cefazolin prophylaxis.

The operative field was painted with 10% povidone-iodine solution (Batticon; Adeka, Samsun, Turkey) and the skin was covered with SETA drapes (Ste-Med By-Pass Ortu Seti; Stemed, Ankara, Turkey). The skin was incised with a scalpel and electrocautery was used to open the parasternal layers and pericardium. A complete median sternotomy was performed in all cases. Bone wax was used sparingly, only if sternal bleeding was profuse. ITAs were harvested as conventional pedicled in situ grafts with the standard technique; that is, pedicled ITAs were dissected from the thoracic wall, along with the accompanying internal thoracic veins, muscle, and fascia, using electrocautery. Both right and left ITAs were dissected from the first rib to a point close to the bifurcation of the ITA into superior epigastric and musculophrenic arteries. Arterial side branches were controlled with small hemoclips. Saphenous vein segments and radial arteries were used as additional bypass conduits as required.

Bilateral pleural spaces were widely opened in all patients. Chest tubes were placed in the mediastinum and into pleural spaces. The sternum was closed with stainless steel wires. The parasternal space was closed with 2 layers of absorbable suture, and the skin was closed with a subcuticular absorbable suture. The materials used in the closure of sternum, parasternal layers, and skin were the same for all patients. All incisions were draped with a special wound covering (Oper Por 9 × 35 cm IHT; Iberhospitex SA, Barcelona, Spain). Postoperatively, both groups of patients were admitted to an intensive care unit (ICU). The patients were extubated as soon as clinically indicated. Chest tubes were removed the morning after the operation as soon as the macroscopic appearance of the drainage fluid turned to serosanguineous.

Off-Pump Technique

After median sternotomy, all patients were heparinized (100 U/kg) to achieve an activated clotting time (ACT) of >250 seconds. The distal anastomoses were completed with the use of mechanical stabilizers (Octopus Tissue Stabilizers; Medtronic, Minneapolis, MN, USA or OPVAC Synergy II; Estech–Least Invasive Cardiac Surgery, Danville, CA, USA) for immobilization of the myocardial surface at the site of the target coronary artery. The heart was positioned with heart positioners (Starfish; Medtronic or Estech Pyramid Positioner; Estech–Least Invasive Cardiac Surgery) for accessing hard-to-reach lateral and posterior vessels. To obtain a bloodless field, 2 4-0 polypropylene sutures were used to temporarily occlude the coronary artery on either side of the anastomosis site. Revascularization of the left anterior descending artery was performed first, which was followed by the revascularization of the circumflex and right coronary artery distributions. The proximal anastomoses were performed before the distal anastomoses with the assistance of a partial occlusion aortic clamp.

Cardiopulmonary Bypass Technique

After median sternotomy, all patients were given 300-400 U/kg heparin, and following standard cannulation patients were placed on CPB. Roller pump (Sarns 9000 perfusion system; 3M, Ann Arbor, MI, USA) and membrane oxygenators (Sechrist 3500/3500 HL Series; Sechrist, Anaheim, CA, USA) were used in all operations. The pump priming consisted of Ringer' s lactate (1500 mL), mannitol 20% (150 mL), and sodium bicarbonate 8.4% (60 mL). The pump flow was set at 2.2-2.4 L/m^2/min. Patients were cooled to 28°C. For myocardial protection, potassium-based cold blood cardioplegia was intermittently administered and cold Ringer's solution (4°C) was topically applied to the heart.

Follow-up

Postoperative 3-month follow-up was obtained for 100% of patients. Follow-up was completed first by review of the surgeon's patient follow-up forms, then patients' hospital records and computerized data.

Sternal Wound Complications

In this study we have assessed the following sternal wound complications: superficial SWI, deep SWI, mediastinitis, and sternal dehiscence. SWIs were defined according to the surgical site infection (SSI) criteria of the Centers for Disease Control and Prevention's National Nasocomial Infections Surveillance System [Horan 1992].

Table 1. Comparison of Preoperative Variables*

	Off-Pump Group, n = 41	CPB Group, n = 28	*P*
Age, y	62.4 ± 12.9	56.1 ± 11.3	.0419
Age ≥ 65 years	21 (51.2%)	8 (28.6%)	.08
Female, n	2 (4.9%)	6 (21.4%)	.05
Overweight (BMI 25-29.9 kg/m^2)	17 (41.5%)	13 (46.4%)	.80
Obesity (BMI >30 kg/m^2)	3 (7.3%)	5 (17.9%)	.26
Active smoking	20 (48.8%)	17 (60.7%)	1.00
Hypertension	25 (60.9%)	16 (57.1%)	.81
Diabetes mellitus	4 (9.8%)	5 (17.9%)	.47
Taking insulin	1 (2.4%)	1 (3.6%)	1.00
Taking OHGs	2 (4.9%)	4 (14.3%)	.21
COPD	5 (12.2%)	2 (7.1%)	.69
CRF	1 (2.4%)	0	1.00
Extracardiac arteriopathy	2 (4.9%)	0	.51
LVEF	50.98 ± 9.2	48.75 ± 8.3	.31
LVEF ≤ 35%	6 (14.6%)	3 (10.7%)	.73
MI <90 days preoperatively	8 (19.5%)	6 (21.4%)	1.00
CCS Class I or II	10 (2.4%)	8 (28.6%)	.78
CCS Class III or IV	31 (75.6%)	20 (71.4%)	.78
History of stroke	0	0	–
Length of preoperative hospital, d	1.07 ± 0.26	1.14 ± 0.59	.98

*CPB indicates cardiopulmonary bypass; BMI, body mass index; OHGs, oral hypoglycemic agents; COPD, chronic obstructive pulmonary disease; CRF, chronic renal failure; LVEF, left ventricular ejection fraction; MI, myocardial infarction; CCS, Canadian Cardiovascular Society.

Superficial incisional SSI is defined as infection that occurs within 30 days after the operation and involves only skin or subcutaneous tissue of incision and at least 1 of the following: (1) purulent drainage, with or without laboratory confirmation, from the superficial incision; (2) organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision; (3) at least 1 of the sign or symptom of infection (pain, tenderness, localized swelling, redness, or heat) and superficial incision deliberately opened by surgeon, unless incision is culture-negative; (4) diagnosis of superficial incisional SSI by the surgeon or attending physician [Horan 1992].

Deep incisional SSI is defined as infection that occurs within 30 days after the operation if no implant is left in place or within 1 year if implant is in place and the infection appears to be related to the operation and involves deep soft tissues (eg, fascial and muscle layers) of the skin and at least 1 of the following: (1) purulent drainage from the deep incision but not from the organ/space component of surgical site; (2) a deep incision spontaneously dehisces or is deliberately opened by a surgeon when the patient has at least 1 of the following signs or symptoms: fever (>38°C), localized pain, or tenderness, unless site is culture-negative; (3) an abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiologic examination; (4) diagnosis of deep SSI by the surgeon or attending physician [Horan 1992].

Organ/space SSI is defined as infection that occurs within 30 days after the operation if no implant is left in place or within 1 year if implant is in place and the infection appears to be related to the operation and involves any part of the anatomy (eg, organ or spaces), other than the incision, which was opened or manipulated during an operation and at least 1 of the following: (1) purulent drainage from a drain that is placed through a stab wound into the organ space; (2) organisms isolated from an aseptically obtained culture of fluid or tissue in organ/space; (3) an abscess or other evidence of infection involving the organ/space that is found on direct examination, during reoperation, or by histopathologic or radiologic examination; (4) diagnosis of an organ/space SSI by the surgeon or attending physician [Horan 1992].

Study Variables

Multiple variables were recorded prospectively and analyzed retrospectively. Some of the study variables which need to be defined were (1) body mass index (weight in kg divided by square of height in m^2); (2) hypertension (patients on hypertensive medication preoperatively); (3) diabetes mellitus (fasting blood glucose >140 mg/dL in at least 2 assays or use of antidiabetic medication); (4) chronic obstructive pulmonary disease (long-term use of inhalational or oral bronchodilators or steroids); (5) chronic renal failure (serum creatinine >1.8 mg/dL); (6) extracardiac arteriopathy (defined as any 1 or more of the following: claudication, carotid occlusion or >50% stenosis, or previous or planned intervention on the abdominal aorta, limb arteries, or carotids); (7) perioperative myocardial infarction (development of new Q waves with rise in creatinine kinase-MB); (8) postoperative low output syndrome (use of inotropic agents [excluding dopamine <3μg/kg^{-1}/m^{-2}] or use of intraaortic balloon pump).

Statistical Analysis

Data are expressed as the mean ± the standard deviation. The significance of difference between groups was assessed by the Student *t* test, Mann-Whitney *U* test, chi-square test, or the Fischer exact test, as appropriate. Probability values ≤ .05 were considered to indicate statistical significance.

RESULTS

Comparison of preoperative variables is shown in Table 1. No great variation was observed among patients' demographic data. The grafts used for different coronary arteries distributions are shown in Table 2. All ITA grafts were used as in situ grafts. Patients' intraoperative and postoperative variables are shown in Tables 3 and 4, respectively. No patients in either study group had perioperative myocardial infarction or required use of intraaortic balloon pump. All reopening procedures of the sternum for excessive bleeding in the early postoperative stage were performed under sterile conditions in the operating room. None of the reexplored patients developed sternal wound complications. During the follow-up period there was no mortality. The frequency of occurrence of overall sternal wound complications was 9.8% in the off-pump group and 14.3% in the CPB group, which was statistically not significant. Comparisons of the sternal wound complications are shown in Table 5. No case of mediastinitis occurred in either study group. All sternal complications were identified within 3 weeks after discharge. From the

Table 2. Coronary Arteries Revascularized with Internal Thoracic Artery, Saphenous Vein, and Radial Artery Grafts, Including All Patients of the 2 Study Groups*

	Revascularized coronary arteries			
	LAD	D	LCX	RCA
Left ITA	19	5	45	0
Right ITA	50	0	5	14
SV	0	3	5	2
Radial artery	0	0	5	8

*LAD indicates left anterior descending artery; D, diagonal branch; LCX, left circumflex artery; RCA, right coronary artery; ITA, internal thoracic artery; SV, saphenous vein.

sternal wounds of sternal dehiscence cases, no microorganisms have been cultured despite repeated cultures. All these patients underwent reexploration of the wound and refixation of sternum and recovered uneventfully.

Staphylococcus aureus was cultured from the wounds of all patients with superficial SWI, which was sensitive to trimethoprim sulfamethoxazole. The patients were given oral trimethoprim sulfamethoxazole. Outpatient follow-up with wound debridement, wound dressing twice daily, and delayed closure was sufficient for recovery in all cases. From the wound of the patient with deep SWI, staphylococcus aureus was again cultured. The patient was given vancomycine intravenously for 10 days, which was followed by oral trimethoprim sulfamethoxazole for 7 days. After discharge, the patient was advised to use a sternal corset and follow with frequent outpatient visits for wound dressing. The results of the follow-up cultures were negative, and the sternal stability was achieved spontaneously after 3 weeks. While on daily outpatient follow-up, the patient used wound debridement, wound dressing at least twice daily, and delayed closure; the patient recovered in 3 weeks.

DISCUSSION

There is increasing evidence that patients who receive BITA grafts have better long-term outcomes than those receiving single ITA grafts [Lytle 1999; Taggart 2001; Rizolli 2002]. However, surgeons have resisted the idea of routine BITA grafting for multiple reasons. The most persistent objection to BITA grafting has been an increased risk of sternal wound complications [Grossi 1991; Borger 1998; Lytle 2001]. Many clinical conditions have been considered unsuitable for the use of BITA grafts, including diabetes mellitus, instability, acute myocardial infarction, obesity, female sex, advanced age, and poor ventricular function [He 1994; Lytle 2001]. In diabetic patients particularly, the majority of surgeons have avoided using BITAs for fear of sternal wound complication [Lytle 2001]. However, BITA use may be of particular benefit to diabetic patients with diffuse coronary artery disease [Lytle 2001].

The increased risk of wound complications is most likely caused by sternal ischemia [Cohen 1999; Lytle 2001; Lorberboym 2002]. Recently, skletonization of ITA grafts has been suggested as a technique that results in less devascularization of the sternum [Cohen 1999; Lorberboym 2002; Peterson 2003].

Are there other avenues for decreasing the risk of sternal wound complications associated with BITA grafting other than skletonizing ITA grafts, patient selection [Lytle 2001], or implementation of recommendations for the prevention of surgical site infections? Could avoiding CPB decrease the risk of sternal wound complications for patients undergoing bilateral ITA grafting? This study sought to answer the latter question.

There is increasing evidence that CPB may be responsible for the morbidity associated with cardiac surgery. However, there is conflicting evidence to date from published series comparing clinical outcomes in terms of sternal wound complications of CABG performed with and without CPB. Some series have found no significant difference in sternal wound complications [Puskas 2002; Berson 2004] between off-pump CABG and conventional CPB, whereas other reports showed a significant reduction in the rates of sternal wound infection [Puskas 2001; Sabik 2002].

Table 3. Comparison of Intraoperative Variables*

	Off-Pump Group, n = 41	CPB Group, n = 28	*P*
Length of stay in the OR, h	4.68 ± 0.54	5.55 ± 0.58	<.0001
Number of bypass grafts	2.2 ± 0.4	2.6 ± 0.6	.0358
Crossclamp time, min	–	52 ± 12.5	–
CPB time, min	–	93.6 ± 17.8	–

*CPB indicates cardiopulmonary bypass; OR, operating room.

Table 4. Comparison of Postoperative Variables*

	Off-Pump Group, n = 41	CPB Group, n = 28	*P*
Low output syndrome	1 (2.4%)	1 (3.6%)	1.00
Ventilation time, h	8.8 ± 2 .4	8.8 ± 3.7	.41
Total chest drainage, mL	1077.1 ± 549.4	1180.4 ± 731.3	.75
Transfusion of blood and blood products, Units	4.7 ± 1.9	5.5 ± 1.4	.014
Reopening of sternum for bleeding	3 (7.3%)	1 (3.6%)	.64
Length of stay in the ICU, h	23.2 ± 4.7	23.2 ± 5.6	.98
Renal failure	1 (2.4%)	0	1.00
Stroke	0	0	–
Length of hospital stay, d	8.2 ± 7.9	6.7 ± 1.7	.49
Hospital stay >7 days	16 (39%)	5 (17.9%)	.07

*CPB indicates cardiopulmonary bypass; ICU, intensive care unit.

Table 5. Comparison of Sternal Wound Complications*

	Off-Pump Group, n = 41	CPB Group, n = 28	*P*
Superficial SWI	2 (4.8%)	2 (7.1%)	1.00
Deep SWI	1 (2.4%)	0	1.00
Sternal dehiscence	1 (2.4%)	2 (7.1%)	.56

*SWI indicates sternal wound infection.

During the past decade, off-pump coronary surgery has been audited against conventional techniques by many observational, case-matched, and prospective, randomized studies. Considering the commonly quoted risk factors for the development of sternal wound complications in cardiac surgery, which include length of hospital stay before operation, obesity, female sex, diabetes, chronic obstructive pulmonary disease, operating room (OR) time, blood transfusion, prolonged mechanical ventilation, low cardiac output, and reexploration for bleeding [Ottino 1987; Blanchard 1995; Borger 1998], we reviewed the literature for the comparisons of the modifiable risk factors for sternal wound infections between off-pump technique and conventional CABG with the use of CPB. Among various reported benefits of off-pump surgery relative to CABG with CPB, reduction in transfusion requirements, shorter mechanical ventilation times, and fewer reexplorations for bleeding have been remarkably consistent across multiple studies [Lancey 2000; Ascione 2001; Ascione 2003; Deuse 2003; Meharval 2003; Puskas 2003; Edgerton 2004]. The OR times were not compared in most of the studies. However, we believe that with the growing experience of the surgical team in performing off-pump procedures, the OR times should be significantly shorter when compared to on-pump procedures. In our study, the OR times and transfusion requirements were significantly lower in the off-pump group. However, we have found no significant difference in reexploration for bleeding between the 2 study groups. Nevertheless, it seems that avoiding CPB might have many beneficial effects on modifiable risk factors commonly quoted for sternal wound complications.

On the other hand, the capacity to counteract microbial infection by the innate immune system is reduced postoperatively in patients undergoing CPB due to a waste of complement factors and a decrease in the cellular elements of the innate immune response, for example, neutrophils, T and B lymphocytes, and natural killer cells [Hornick 2000]. In patients undergoing CPB, serum levels of immunoglobulin and complements are markedly reduced [Hornick 2000]. As a consequence, the contribution of these proteins to host defense is quantitatively affected, resulting, for example, in reduced opsonization of bacteria in vitro [Hornick 2000]. Leukocyte counts fall with the onset of CPB. The sequestration of leukocytes in tissues is increased after their activation by anaphylatoxins C3a and C5a [Hornick 2000]. After CPB, the chemotactic ability of granulocytes is impaired [Hornick 2000], which may also contribute to a higher susceptibility to bacterial infections. Other studies show that not only the phagocytic function but also the metabolic function of leukocytes is impaired after CPB [Hornick 2000]. The bactericidal activity of serum is also depressed after CPB [Hornick 2000]. It is clear that the inflammatory and immunologic sequelas of CPB are not responsible for large morbidity or mortality rates, per se. However, they assume more importance in longer, more complex surgery performed on patients who are at the extremes of age or who have significant comorbid conditions, which is usually the case in patients undergoing BITA grafting.

CPB produces also widespread alterations in endocrine, humoral, and metabolic functions [Butterworth 2000]. A variety of pituitary-related hormonal activities and adrenal responses are affected by CPB [Butterworth 2000]. Potential effects of these hormonal changes and influences of acute anemia and hemodilution following CPB on wound healing are not clear.

There is evidence that improved glucose control in patients with diabetes may improve immune system function [Alexiewicz 1997]. Carbohydrate metabolism is regulated by insulin, glucagon, cortisol, growth hormone, and epinephrine, the concentrations of which are generally perturbed during and after CPB [Butterworth 2000]. Type II diabetics exhibit marked insulin resistance during CPB [Butterworth 2000]. One of the potential beneficial effects of avoiding CPB might be easier and better perioperative control of blood glucose levels in diabetic patients; this factor needs to be evaluated.

Directly measured subcutaneous tissue oxygenation (P_t0_2) reflects the adequacy of regional tissue oxygenation and influences wound infection healing [Hopf 1997; Cody 2004]. Cody and associates recently reported a study in which they have measured the P_t0_2 in patients undergoing CABG with and without CPB and observed significantly higher P_t0_2 in the subcutaneous tissue of the leg in the saphenous vein harvest wound during the 20-hour duration of the study in patients who have undergone off-pump CABG [Cody 2004]. Their findings also support the hypothesis that off-pump surgery has beneficial effects on wound healing.

In summary, avoiding CPB might contribute to improved recovery of surgical wounds and reduce wound infections in CABG patients, theoretically. But practically our results did not support this hypothesis. We have found no significant difference between the frequencies of occurrence of sternal wound complications and CPB. However, this study was limited by its small size and the lack of randomization and has small statistical power.

In conclusion, the results of this study suggest that the avoidance of CPB has no beneficial effects in the number of sternal wound complications in patients receiving BITA grafting. However, further prospective, randomized studies on large patient groups are required to assess this conclusion.

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REVIEW AND COMMENTARY

Reviewer MB134:The definitions are unnecessarily complex. Deep infections involve the bone. Mediastinitis involves the tissues below the bone, and superficial infections are everything else, with no bone or mediastinal involvement.

Author's Response by Dr. Naz Aydin: Centers for Disease Control and Prevention (CDC) states that the identification of surgical site infections (SSI) involves interpretation of clinical and laboratory findings, and that it is crucial that a surveillance program use definitions that are consistent and standardized. While of course every surgeon knows what SSIs are, in our manuscript we preferred to use CDC's National Nasocomial Infections Surveillance standardized criteria for defining SSI's.

Reviewer MB134: It is my experience that studies relating to sternal wound complications need to have many more patients in order to reach statistical significance because the incidence of such complications are so low to begin with that only a large study can detect a difference not due to chance. I am thus suspect that the statistics are not valid. A statistician may be needed to tell if there was sufficient power in the study to make the conclusions stated by the author. This fact may also explain why the author found no differences in his 2 groups. The study may just be too small for answering this question.

Author's Response by Dr. Naz Aydin: We definitely agree with the reviewer. The statistics were done in consultation with a statistician and we have already discussed this in the abstract conclusion and discussion section. Despite small statistical power, we have written our results so far to attract attention to this topic, which might have a potential clinical importance. We hope and expect that further prospective, randomized studies on large patient groups will follow up our study.