

Risk Factors for Mediastinitis and Sternal Dehiscence After Cardiac Surgery

Guillermo Careaga Reyna,^a Georgina G. Aguirre Baca,^a Luz E. Medina Concebida,^b Gabriela Borrayo Sánchez,^c Guillermo Prado Villegas,^a and Rubén Argüero Sánchez^a

^aDepartamento de Cirugía Cardiorácica, Hospital de Cardiología Centro Médico Nacional Siglo XXI, Instituto Mexicano del Seguro Social, Mexico DF, Mexico.

^bDepartamento de Terapia Posquirúrgica, Hospital de Cardiología Centro Médico Nacional Siglo XXI, Instituto Mexicano del Seguro Social, Mexico DF, Mexico.

^cUnidad de Cuidados Intensivos Cardiovasculares, Hospital de Cardiología Centro Médico Nacional Siglo XXI, Instituto Mexicano del Seguro Social, Mexico DF, Mexico.

Introduction and objectives. The aim of our study was to identify risk factors for the development of post-sternotomy mediastinitis and sternal dehiscence without infection.

Patients and method. The records of all patients who presented with sternal abnormalities between January 1, 1997 and December 31, 2003 were reviewed retrospectively, and potential risk factors were examined. Patients were divided into three groups: group A had mediastinitis; group B had sternal dehiscence; and group C served as a control group. Multivariate analysis was carried out and the three groups were compared using the Kruskal-Wallis test.

Results. The incidence of mediastinitis was 0.34% and that of sternal dehiscence without mediastinitis was 0.55%. The main risk factors for mediastinitis were postoperative pneumonia ($P=.006$), urinary tract infection ($P=.02$), and use of intra-aortic balloon counterpulsation ($P=.027$). Risk factors for sternal dehiscence without infection were age >60 years ($P=.01$), postoperative pneumonia ($P=.003$), antiplatelet agent use ($P=.006$), and beta-blocker use ($P=.0001$).

Conclusions. The incidences and risk factors for mediastinitis and sternal dehiscence were different in this series. Postoperative pneumonia was the only risk factor common to the two conditions.

Key words: Mediastinitis. Sternum. Cardiac surgery. Sternal dehiscence.

Factores de riesgo para mediastinitis y dehiscencia esternal después de cirugía cardíaca

Introducción y objetivos. El objetivo de nuestro estudio fue identificar los factores de riesgo para presentar mediastinitis postesternotomía o dehiscencia esternal sin infección.

Pacientes y método. Se revisaron, en forma de cohorte retrospectiva, los expedientes de los pacientes que presentaron alteraciones esternales entre el 1 de enero de 1997 y el 31 de diciembre de 2003; se analizaron los factores considerados de riesgo y se dividió a los pacientes en 3 grupos: A, con mediastinitis; B, con dehiscencia esternal, y C, grupo control. Se realizaron un análisis multivariable y pruebas de Kruskal-Wallis para comparar los 3 grupos.

Resultados. Se encontró una incidencia de mediastinitis del 0,34% y de dehiscencia de esternón sin mediastinitis del 0,55%. Los principales factores de riesgo para mediastinitis fueron: neumonía postoperatoria ($p = 0,006$), infección de vías urinarias ($p = 0,02$) y uso de balón intra-aórtico de contrapulsación ($p = 0,027$). Los factores de riesgo para dehiscencia esternal sin infección fueron: edad > 60 años ($p = 0,01$), neumonía postoperatoria ($p = 0,003$), tratamiento con antiagregantes plaquetarios ($p = 0,006$) y tratamiento con bloqueadores beta ($p = 0,0001$).

Conclusiones. La incidencia de mediastinitis difiere de la de dehiscencia esternal y se asocia con factores de riesgo distintos, con excepción de la neumonía postoperatoria, que favorece la aparición de ambas complicaciones.

Palabras clave: Mediastinitis. Esternón. Cirugía cardíaca. Dehiscencia esternal.

Correspondence: Dr. G. Careaga Reyna.
División de Cirugía Cardiorácica. Hospital de Cardiología. CMN Siglo XXI, IMSS.
Avda. Cuauhtémoc, 330. Col. Doctores. 0672. México DF. México.
E-mail: gcareaga3@aol.com

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INTRODUCTION

Median sternotomy provides an excellent approach for the performance of cardiopulmonary bypass in

cardiac surgery. However, several studies have indicated that poststernotomy mediastinitis occurs in 1%-5% of cases, with a morbidity rate of up to 50% provoking prolonged hospital stays,¹⁻⁵ and a mortality rate of 14%-47%.^{1-4,6-15} Treating mediastinitis considerably increases the costs of care² and several surgical procedures may be required after diagnosis. Reida¹ classified poststernotomy mediastinitis into 5 types:

- Type I: infection occurs within 2 weeks after surgery, in the absence of risk factors.
- Type II: infection occurs within 2 to 6 weeks after surgery, in the absence of risk factors.
- Type III: infection presents in the first 2 weeks, with 1 or 2 risk factors.
- Type IV: infection presents after it has been previously treated.
- Type V: infection occurs for the first time more than 6 weeks after the initial surgery.

Other authors classify poststernotomy mediastinitis as sternal dehiscence without infection and with infection, with the latter being subdivided into several subtypes, including restriction of infection to soft tissue, sternal osteomyelitis, and retrosternal infection.^{1,2}

Reported risk factors^{1-4,6,8,9,11} include use of the mammary artery for revascularization, prolonged time in surgery, excessive use of electrocoagulation or bone wax, reoperation because of bleeding, hospital-acquired pneumonia, peripheral infections, prolonged mechanical ventilation, diabetes mellitus, age, obesity, and chronic obstructive pulmonary disease (COPD).

The most frequent signs and symptoms of mediastinitis are drainage from the wound site, fever, leucocytosis, positive culture, and local changes in the surgical wound.^{1-4,6,8,9,11}

An early diagnosis is very important and depends primarily on the clinical examination. Tomography may be useful when retrosternal fluid collection is present, but it may give false positives because of poststernotomy changes in the sternum deriving from the normal scarring process.¹⁶

Immediate surgical intervention is crucial if secondary deterioration to a septic process is to be avoided. Such a process may become generalized and can even lead to the patient's death.¹⁶

The most frequently isolated micro-organisms include *Staphylococcus aureus*, which is present in over 60% of cases, and other gram-negative micro-organisms, such as *Serratia marcescens*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*. Some studies have reported that *Candida albicans* is the cause of 14% of cases of poststernotomy mediastinitis.^{1,2,6,9-12,17-22}

The aim of the present study was to determine the frequency of mediastinitis and sternal dehiscence without infection and to analyze associated risk factors, in patients receiving a sternotomy for cardiac surgery.

PATIENTS AND METHODS

The clinical records of patients with an infection of a surgical wound infection requiring re-suturing of the sternum were reviewed retrospectively for the period from January 1, 1997 to December 31, 2003. Records were retrieved from among patients receiving cardiac surgery in the study center during the study period, thereby generating a retrospective cohort which allowed us to determine the incidence of mediastinitis and sternal dehiscence and to identify risk factors associated with both. Two case-control studies were performed within the retrospective cohort.

The study was performed in a tertiary level hospital specializing in cardiology and cardiothoracic surgery.

Prophylaxis in the study center is based on the use of a first generation cephalosporin (cephalotin), with 2 g given at induction of anesthesia, followed by 1 g intravenously every 8 h. Vancomycin (500 mg given intravenously every 12 h) is used in patients who are allergic to penicillin or cephalosporins.

Diagnosis of mediastinitis was based on clinical and laboratory criteria and surgical findings. Clinical signs included fever, pain at the site of the surgical wound, sternal instability, and erythema. Laboratory criteria included positive culture, and leucocytosis >11 000/ μ l with a predominance of polymorphonuclear cells. Surgical findings included the retrosternal collection of serous fluid or fibrinopurulent material, putrid smell, and loss of sternal bone tissue. Patients were divided into 3 groups. Group A consisted of patients meeting the diagnostic criteria for mediastinitis. Group B consisted of patients classified as having sternal dehiscence without infection, i.e. patients with inadequate sternal union, but absence of infection. Group C was a control group which included patients with the same demographic and illness characteristics as patients in groups A and B, and who underwent cardiac surgery in the same period, but who did not develop mediastinitis or sternal dehiscence. Variables measured included age, sex, type of surgery, presence of diabetes mellitus (DM), smoking, obesity, COPD, systemic arterial hypertension (SAH), prior sternotomy, preoperative chronic renal insufficiency, use of mammary artery (one or both), number of grafts, number of transfusions of blood-derived products, the duration of the cardiopulmonary bypass (CPB), hemodynamic instability requiring the use of intra-aortic balloon counterpulsation (IABC), condition of the sternum at first surgery, reoperation because of bleeding, hospital-acquired pneumonia, postoperative infection of the urinary tract, other associated infections, and the treatment provided. Time between first surgery and the appearance of symptoms, the treatment employed, the results of the cultures taken, and the number of procedures employed after diagnosis of mediastinitis or sternal dehiscence were also recorded.

TABLE 1. Frequency of Mediastinitis and Sternal Dehiscence by Procedure*

Procedure	Number of Cases	Mediastinitis Group A	Sternal Dehiscence Group B
Valve surgery	2594 (32.9%)	6 (0.23%)	10 (0.38%)
Revascularization with CPB	2909 (37%)	19 (0.65%)	27 (0.92%)
Revascularization without CPB	315 (4%)	2 (0.63%)	2 (0.63%)
Congenital	1887 (24%)	0 (0%)	1 (0.05%)
Revascularization + valve	157 (1.9%)	0 (0%)	4 (2.5%)
Total number of sternotomies	7862	27 (0.34%)	44 (0.55%)

*CPB indicates cardiopulmonary bypass.

TABLE 2. Clinical Characteristics of Patients*

Characteristic	Group A (n=27)	Group B (n=44)	Group C (n=142)	P
Current smoker	15 (55%)	18 (40%)	53 (37.3%)	.3
COPD	7 (25.9%)	13 (29.5%)	16 (11.2%)	.03
Diabetes mellitus	13 (48%)	14 (31.8%)	63 (44.3%)	.07
Systemic arterial hypertension	19 (70.3%)	28 (63.3%)	72 (50.2%)	.05
Previous sternotomy	1 (3.7%)	3 (6.8%)	11 (7.7%)	.2
Obesity	15 (55.5%)	15 (34%)	82 (57.7%)	.04
Renal insufficiency	4 (14.8%)	2 (4.5%)	7 (4.9%)	.04
Hospital-acquired pneumonia	13 (40%)	7 (16%)	30 (21%)	.002
Age, mean±SD years	58.9±10.8	58.6±10.4	58.1±10.9	NS
Urinary tract infection	7 (25.9%)	2 (4.5%)	6 (4.4%)	
Use of IABC	5 (18.5%)	1 (2.2%)	15 (10.5%)	.48
Use of antiplatelet agents	23 (85.1%)	30 (68%)	76 (53.5%)	.003
Use of beta-blockers	24 (88.8%)	31 (70%)	67 (47%)	≤.0001

*IABC indicates intra-aortic balloon counterpulsation; SD, standard deviation; COPD, chronic obstructive pulmonary disease; NS, not significant.

Descriptive statistics were used to characterize the 3 study groups. The χ^2 test was used for the comparison of proportions. Two logistic regression models were developed, in which the dependent variables were the presence or absence of mediastinitis and sternal dehiscence, and the independent variables were patient antecedents; variables with a *P* value of <.05 were retained in the models.

RESULTS

From January 1, 1997 to December 31, 2003, 11 538 cardiac operations were performed at the study center. Sternotomy was used in 7862 cases. Standard surgical techniques and general anesthesia, were employed, together with CPB when indicated. In most cases, myocardial protection was provided using a modified St Thomas solution and, occasionally, HTK solution. In all cases, the sternum was closed initially with steel wire, and soft tissues were closed in 3 planes using non-absorbable material.

Table 1 shows the distribution of the 7862 sternotomies by procedure, as well as the frequency of occurrence of mediastinitis and sternal dehiscence for each procedure.

Of the total number of patients, 27 (0.34%) developed mediastinitis (group A) and 44 (0.55%) had sternal dehiscence without infection (group B). One hundred

and forty two randomly selected patients were included in group C (the control group).

Mean age in groups A and B was 58.9±10.8 years (range, 21-79 years), and 58.1±10.9 years (range, 24-81 years) in group C.

There was a greater proportion of men than women in all study groups (19 in group A, 34 in group B, and 87 in group C).

Table 2 shows patients' clinical characteristics, and the surgical procedures employed are presented in table 3. Table 3 also shows the frequency of each variable for the three groups and the *P* values for between group comparisons. Surgery was elective in 20 (74%) patients in group A, in 42 (95%) patients in group B, and in 105 (74%) patients in group C. There were 7 emergency interventions (26%) in group A, 2 (5%) in group B, and 37 (26%) in group C. Ischemia and CPB times, the total duration of the procedure, the need for reoperation because of bleeding, and the *P* values for between groups comparison are shown in Table 4.

The left internal thoracic artery was used systematically only in myocardial revascularization, whilst other aortocoronary grafts were performed using the saphenous vein or the radial artery.

IABC was employed in 5 patients in group A, 1 patient in group B, and 15 patients in the control group.

TABLE 3. Type of Surgery Performed*

Surgery	Group A	Group B	Group C	P
Valve implant	6 (22.2%)	10 (12.2%)	53 (37.3%)	.08
Revascularization with CPB	19 (70.3%)	27 (61.3%)	94 (66.1%)	.03
Revascularization without CPB	2 (7.4%)	2 (4.5%)	9 (6.3%)	.2
Congenital	0	1 (2.2%)	1 (0.7%)	.6
Revascularization + valve	0	4 (9.09%)	5 (3.5%)	.2

*CPB indicates cardiopulmonary bypass.

TABLE 4. Surgery Times

Time, min	Group A	Group B	Group C	P
Cardiopulmonary bypass	100 (59-210)	110 (62-199)	112 (68-219)	.04
Aortic clamp	61 (42-107)	65 (44-118)	69 (49-135)	.03
Total time of surgery	340 (230-440)	364 (254-470)	358 (248-462)	.04

The sternum was reported to be in good condition in 20 (74%) patients in group A, in 36 (81.8%) in group B, and in 123 (86.6%) in group C.

A clinical profile suggesting mediastinitis or sternal dehiscence appeared in <14 days in 17 patients in group A (63%) and in 29 patients in group B (66%), and in >2 weeks in 10 patients in group A (37%) and in 15 in group B (34%).

Predominant symptoms in patients with mediastinitis (group A) were sternal dehiscence and fever in 26 patients (96.2%), leucocytosis >11 000/ μ l in 92%, pain at the surgical wound in 85%, wound discharge in 94%, and changes in color at wound edges in 85%. Surgical findings revealed retrosternal collection in 92.5% of cases, putrid smell in 74%, bone tissue with ischemic aspect in 89%, bone loss in 85%, fibrinopurulent material in 100%, and positive culture in 92%.

In group B, the predominant symptoms were sternal instability (92% of patients) and pain (74%). Surgical findings showed sternal dehiscence in all cases, scarcity of fibrous material in 85%, viable bone tissue in 92%, absence of retrosternal collection in all cases, and partial sternal bone loss in 35%.

Treatment provided in group A included surgical debridement in all patients, fixation of wire "tracks" in 95%, complete sutures with non-absorbable material in 80%, interposition of pectoral muscle in 9 patients (33.3%), continuous irrigation with povidone in 80% of patients, and with cephalosporin in 20%. In group B, "tracks" were fixed in 40 patients (91%) and continuous irrigation with cephalosporin in 6 patients. The first intervention was sufficient to control the mediastinitis in 67% of patients in group A; 33% of patients in this group required 2-5 additional interventions to control the infection and reconstruct the thorax. In total, 35 patients in group B (79.5%) required only 1 procedure after diagnosis of sternal dehiscence, and 20.5% needed 2-3 procedures to reconstruct the thorax.

Although statistically significant differences were found in ischemia (aortic clamp), cardiopulmonary bypass and surgery times, there was no association between these variables and the presence of mediastinitis or sternal dehiscence (table 3).

Intensive postoperative treatment lasted a mean of 38 days in group A (range, 21-156 days), 11.7 days in group B (range, 8-17 days), and 4.5 days (range, 3-7 days) in group C ($P<.05$).

Total duration of hospital stay was 57.5 days (range, 37-171 days) in group A, 21.3 days (range, 15-35 days) in group B, and 10.2 days (range, 9-12 days) in group C. Differences between the groups were statistically significant ($P<.05$).

In group A, the most frequently isolated microorganisms were *S aureus* (15 patients, 55%), *K pneumoniae* (6 patients, 22.2%), *P aeruginosa* (4 patients, 14.8%), and *Enterococcus* (2 patients, 7.4%). There was no bacterial development in patients in group B.

The following were found to be risk factors for mediastinitis: use of intra-aortic balloon counterpulsation (odds ratio [OR] =2.4; 95% confidence interval [CI], 1.5-4.0; $P=.027$), postoperative pneumonia (OR=2.3; 95% CI, 1.3-4.1; $P=.006$), and infection of the urinary tract (OR=2.4; 95% CI, 1.4-3.9; $P=.022$). In all cases, microorganisms isolated in cultures from the sternotomy wound were the same as those isolated in cultures taken from the respiratory or urinary tracts. Reoperation for bleeding had a relative risk (RR) of 2.4 ($P=.03$).

Risk factors for sternal dehiscence without infection were: age >60 years (RR=2.5; $P=.01$); treatment with antiplatelet agents (OR=3.7; 95% CI, 1.3-10.4; $P=.006$) and beta-blockers (OR=5.9; 95% CI, 1.8-19.2; $P=.0001$); and having postoperative infections such as pneumonia (OR=3.02; 95% CI, 1.5-6.0; $P=.003$).

There were a total of 8 deaths in group A, 6 in group B, and none in group C.

COPD, obesity, and renal insufficiency were also included in the logistic regression model, but were not statistically significant.

There were no missing values in the patient records for any of the variables analyzed.

DISCUSSION

Poststernotomy mediastinitis increases treatment costs and morbidity and, according to some authors, may have mortality rates up to 47%, with diminished survival in the first year after surgery and poorer quality of life.^{5,9,10,19,20}

Treatment includes surgical debridement and cleansing in 100% of patients, fixation of the sternum with bilateral wires which do not produce bone ischemia and, in some cases, closure using the Robicsek technique to redistribute tensile force over the sternum. Continuous irrigation with vancomycin solution, or with antibiotics selected according to the results of the culture, is used, though general irrigation with povidone solution provides a further alternative, depending on the culture results. The latter treatment may also be used as a specific, independent treatment of the bacterium causing the mediastinitis. Irrigation is suspended when the quantity of waste or purulent material from the thoracic drains is reduced to less than 40 ml in 24 h using high- or low-pressure suction. Open thorax management is necessary when it is not possible to close it in the first instance, as in the case of mediastinitis with substantial bone loss. In these cases, transposition of the omentum provides another option for controlling the infection, and may be combined with closed irrigation and reconstruction of the thorax using flaps from the pectoralis major and rectus abdominus muscle groups, when bone loss in the sternum is >60%.^{1-4,6,8,9,11,15,16,18,20,21}

Some risk factors could not be assessed in the present study, including the use of bone wax and electrocoagulation. Various studies have suggested that these interventions may favor development of mediastinitis. The measurement of these factors is subjective, however, as the quantity of bone wax and electrocoagulation time per centimeter of tissue likely to produce infection have not been defined.¹⁻³

Risk factors inherent to surgery, such as wound management during the operation and use of inert material for hemostasis, can be modified, but patient characteristics such as concomitant illness, can only be controlled by taking them into account prior to the operation, and trying to reduce occurrence of mediastinitis. The use of broad spectrum antibiotics may lead to replacement of the more common microorganisms by more resistant bacteria, thereby complicating the prescription of antibiotics.

The fact that the use of "tracks" in osteosynthesis appears as a risk factor for mediastinitis is likely to be related to the condition of the bone which initially led to a need for this type of reinforcement. Bone porosity and

vascularity would almost certainly be risk factors for mediastinitis.

On the other hand, we could find no biological explanation for the negative impact of the use of beta-blockers, particularly when the majority of patients in the 3 groups used this medication.

In the present study, microorganisms isolated in cultures taken from the respiratory and urinary tracts were usually the same as those found in cultures from the retrosternal collections, thereby providing support for the idea that hospital-acquired infections spread hematogenically or through contiguity.

Risk factors in patients with sternal dehiscence without infection were not the same as those for mediastinitis; in the present study, only postoperative pneumonia was common to both conditions. Other factors in which non-significant differences were found (age >60 years did show differences), such as the use of the mammary artery for myocardial revascularization, are related to the scarring process. This process becomes slower the older the patient, and the use of the mammary artery for revascularization reduces local circulation at the sternum and also delays scarring. We could find no explanation for differences between the present study and earlier studies in regard to these factors, though they could be due to racial aspects or the types of hospital flora present, among others. The objectives and design of the present study did not, however, allow us to confirm these possibilities.

It should be pointed out that, despite using a definition of mediastinitis which was similar to that used in the Paris multicenter study,²² the incidence was lower in the present study, even though subclassifications of sternal infections, such as osteomyelitis and mediastinitis itself, were used.

The development of mediastinitis in cardiac surgery patients can have devastating results as well as leading to increases in mortality for reasons which are unrelated to the actual heart disease; the quality of life of patients surviving mediastinitis is also negatively affected. Efforts should therefore be made to identify each patient's risk factors, so as to prevent the appearance of mediastinitis or sternal dehiscence; although they occur only infrequently, the associated morbimortality is considerable and several procedures are required to control the infection and reconstruct the thorax.

Clearly, mortality was higher in patients who developed mediastinitis than in those who only had sternal dehiscence, or in patients with neither condition. Adequate and energetic treatment is therefore indicated, as noted by other authors.¹⁶

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