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Relevance of Drainages, Diabetes Mellitus and Nyha Score on Surgical Site Infections after Coronary Artery Bypass Grafting during 2000 – 2010

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Abstract

Background: Surgical site infections can be a severe complication associated with an increase in mortality following coronary artery bypass graft surgery. We performed a study to determine risk factors for the development of SSI and to set up prevention strategies in the management of these patients.

Methods: Case-control study at a 302-bed, teaching hospital. Case-patients with surgical-site infection occurring up to 1 month following coronary artery bypass grafting performed between January 2000 and December 2010 were identified prospectively by hospital epidemiologist using National Nosocomial Infections Surveillance (NNIS) System methods. Two control-patients were selected for each case-patient, matched by date of surgery.

Results: Eighty-seven patients with infections (65 superficial and 22 deep) were identified. Logistic regression analysis identified tree variables independently associated with the development of infection: diabetes mellitus (OR, 1.9; 95% confidence interval [95% CI], 1.0 to 3.8.; $P = 0.05$), a NYHA class IV score (OR, 3.4; 95% CI, 1.8 to 8.4; $P = 0.0001$) and the use of surgical drains (OR, 1.2; 95% CI, 1.1 to 1.4; $P = 0.0001$). Factors not statistically associated with the development of infection included age, NNIS System risk index score, presence of various co morbidities, surgeon, duration and type of procedure, or other invasive procedures.

Conclusion: The use of closed suction drainage, diabetes mellitus and a high NYHA score were associated with the development of surgical-site infection following coronary artery bypass grafting. Avoiding the use of surgical drains and careful monitoring of blood glucose in patients undergoing coronary artery bypass grafting should reduce the risk of infection.

Introduction

More than 12,200 coronary artery bypass grafting (CABG) procedures were studied in the last HELICS report, a European collaborative project with the goal to reduce the level of health care associated infections in surgery and intensive care units. Surgical site infection (SSI) can be a serious complication, occurring in a mean of 2.8% to 9.04% of CABG procedures in Europe [1]. SSI is associated with significant morbidity, prolonged hospitalization, and increased treatment costs [2].

Risk factors that have been identified for the development of SSI following CABG have included the presence of various underlying diseases and co morbidities (e.g., obesity, diabetes mellitus, chronic renal failure) [3-9], use of bilateral mammary arteries [3,7,9] and prolonged ventilator support [3,9].

However, little has been published on the experiences of hospitals in Spain with regards to the risk factors associated with SSI after CABG. In our hospital, we have been monitoring SSI incidence, given feed-back information and recommendations. However, SSI rates were completely unacceptable.

The aim of this study was to describe the characteristics of the patients and procedures, and identify possible risk factors for infection of SSIs after CABG.

Methods

Study design

A case-control design was performed to ascertain risk factors for SSI in patients undergoing CABG at a single hospital.

Setting

The Hospital Universitari de La Ribera is a university-affiliated teaching hospital with 302 beds. There are two cardiac surgeons who perform a median of 96 (range 74 to 138) CABG procedures each year. One operating room without laminar airflow is used. All patients to undergo CABG are admitted to the hospital the night before surgery. Patients were shaven with a razor and took an antimicrobial shower the same morning.

There are standing orders for preoperative antimicrobial prophylaxis with cefazolin (or vancomycin if the patient has a penicillin allergy). All the prophylactic antibiotics are administered during the 60 minutes before surgery and are given for the usual 24 hours post-operation.

Case–control definitions and ascertainment

Surveillance for SSI in patients undergoing CABG from January 1, 2000, to December 31, 2010, was conducted prospectively by a hospital epidemiologist. Post-discharge surveillance was continued for 1 month from the date of surgery and was done through the surgeons' outpatient clinic, the microbiology department and the emergency room service.

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Any complication related to the CABG was routinely referred back to the cardiac surgeon. The classification of the depth of SSI was based on published criteria from the Centers for Disease Control and Prevention [10]. Stitch abscesses were excluded. Case-patients were defined as any patients with an SSI within 1 month of CABG. Those were, patients exposed to CABG who developed clinical evidence of infected presternal tissue (chest pain, purulent discharge from the surgical wound, redness), sternal osteomyelitis (chest pain, redness, purulent discharge from the mediastinum or purulent drainage, sternal instability, fever higher than 38°C), or mediastinal sepsis (redness, secretion, purulent drainage, fever higher than 38°C and leukocytosis) with or without positive mediastinal or blood culture. Superficial wound infection was defined as any wound infection confined to the subcutaneous tissue; and deep wound infection (mediastinitis) as a wound infection associated with sternal osteomyelitis with or without infected retrosternal space.

Control-patients were defined as patients exposed to CABG in the same centre who did not have SSI after 1 month of surgery.

For each case-patient, two control-patients matched by date of surgery who did not have a SSI were selected. If more than two controls were available per case, the patients with the times or dates of surgery closest to that of the case-patient were chosen as controls.

The medical records of case-patients and control-patients were reviewed to extract the following preoperative, intraoperative, and postoperative information: age, gender, smoking habit, calculated body mass index, underlying diseases and co morbidities, immunosuppressive therapy, functional class according to the New York Heart American Society (NYHA), left ventricular ejection fraction, surgeon, duration of surgery, use of cardiopulmonary bypass (CBP), aortic cross-clamp time, number of grafts, use of double mammary, prosthesis implanted, NNIS and ASA scores [11], postoperative blood transfusions, use of surgical drains, other invasive procedures and length of hospital stay. The postoperative data were comprised of interval time between surgery and SSI occurrence, wound dehiscence, re-exploration and causes, type of microorganism in wound or blood culture, characteristics of the infections and mortality within a 1-year period after operation.

Statistical analysis

The McNemar's test was used to compare categorical variables between cases and controls, and the Wilcoxon signed rank test was employed for comparison of continuous variables. Matched Odds Ratios (OR) was calculated to estimate the magnitude of associations between each exposure and outcome using conditional logistic regression analyses. Test of departure from linear trend were used to decide whether a linear or categorical effect were more appropriate. All *P* values were two-tailed, and a *P* value of 0.05 or less was considered to be statistically significant.

Power analysis showed that was about 87% chance of detecting a significance difference using a two-sided test with significance level = 0.05. Data were analyzed using STATA software (version 9.0; Stata, College Station, TX).

Results

During the study period, there were 87 patients who developed SSI following a total of 1090 CABG procedures. Six infections were documented in 2000 (infection rate, 5.1%), 1 infection in 2001 (0.8%), 9 infections in 2002 (10%), 8 infections in 2003 (10%) and 8 infections in 2004 (8.9%). Since 2008 to 2007, the infection rate slightly decreased and over the last three years the infection rate increased reaching 14.8% in 2009.

Sixty-five of the infections were superficial and 22 were organ–space. All of these infections were identified within 30 days of the surgical procedure. The infections occurred in 68 males and 19 females, with a median age of 68 years. Seven of these patients were being treated for cancer, 57 patients were diabetic, 14 had chronic pulmonary disease, 32 had a history of ischemic heart disease, 14 had chronic renal insufficiency and 28 were active smokers.

The results of univariate analysis indicating those variables statistically associated with the development of SSI are listed in Table 1.

The median time of prophylaxis administration was 25 minutes before incision but this was only written in 8 case-patients. The most frequent microorganisms causing SSI in these patients were coagulase negative *Staphylococcus* (37 patients), *Staphylococcus epidermidis* (18 patients), polymicrobian (8 patients) and *Staphylococcus aureus* (6 patients). The whole distribution of microorganisms and infection characteristics are shown in Table 2. Cultures were either negative or not performed in 7 patients with SSI.

Sixty percent of cases and 55% of controls had a NNIS risk index score of 1; 32% of cases and 17% of controls had a score of 2 (P=0.0001). Patients with a NNIS risk score > or =2 were 2.6 times more likely to develop an SSI than those with a NNIS score < 2 (odds ratio, 2.6; 95% confidence interval, 1.3-5.1, P= 0.005).

The median length of ICU stay for the cases was 4 (range 2 to 82) days, whereas the median for the controls was 2 (range 0 to 41) days, (P = 0.0001). Overall mortality was high, 16.1% of cases died versus 2.3% of controls. Ten of the 87 cases died because of the SSI, representing a case-fatality ratio of 11.5%.

Conditional logistic regression analysis indicated that the best predictors of SSI following CABG were diabetes mellitus (OR, 1.9; 95% confidence interval [95% CI], 1.0 to 3.8.; *P* = 0.05), a NYHA class IV score (OR, 3.4; 95% CI, 1.8 to 8.4; *P* = 0.0001) and a protracted use of surgical drains (OR, 1.2 for each day; 95% CI, 1.1 to 1.4; *P* = 0.0001) (Table 3).

Discussion

In the current study we found a SSI total incidence of 7.9%. This incidence goes nearly into the highest limit described in the Helics report from 2006 [1], where the range is from 2.8% to 9.0% in the different countries. Other studies report sternal infection incidence of 1.4 to 9.7% [3,6,9]. However, as Berg et al. [12] pointed out, comparison should be done cautiously as the methodology and definitions of infections differ. These latest authors reported in a national surveillance system for SSIs following CABG, incidences for sternal and harvest site infections of 5.1% and 8.9%, respectively. Reaching as a whole incidence of 13.9%.

In our report, twenty-two (25%) SSIs were deep or organ–space infections, corresponding to a 2% overall incidence. Nevertheless, these cases required prolonged antimicrobial therapy, additional surgical procedures and leaded to more complications and higher case-fatality ratio.

Several co morbidities and medical conditions have been associated with the development of SSI following CABG. Other investigations have also identified severity of illness as measured by the NYHA [9].

In this study, we identified three independent risk factors for SSI following CABG on multivariable analysis. These risk factors are

	N (%)			
Characteristics	**Cases N = 87**	**Controls N = 174**	**Unadjusted mOR (CI 95 %)**	**P**
Preoperative factors				
Age (years), Mean (SD)[1]	68 (9.1)	66 (8.7)	1.0 (0.9-1.04)	0.5
Male gender	68 (78.2)	138 (79.3)	0.9 (0.5-1.7)	0.8
Diabetes Mellitus	57 (65.5)	70 (40.2)	2.8 (1.6-4.8)	0.0001
Underlying Chronic lung disease	14 (16.1)	18 (10.3)	1.6 (0.8-3.4)	0.2
Acute myocardial infarction	32 (36.8)	46 (27.4)	1.7 (0.9-3.0)	0.07
Neoplasm	7 (8.0)	9 (5.2)	1.7 (0.6-4.9)	0.3
BMI ≥ 30 kg/m ^{2}	52 (60.0)	90 (51.7)	1.4 (0.8-2.4)	0.2
Albumin < 3 g/dl	51 (59.3)	111 (64.0)	0.8 (0.4-1.4)	0.5
Peripheral vascular disease	9 (10.3)	20 (11.5)	0.8 (0.3-2.1)	0.7
Ejection fraction < 30	2 (2.3)	5 (2.9)	0.8 (0.1-4.1)	0.8
Chronic Renal Insufficiency	14 (16.1)	17 (9.8)	1.7 (0.8-3.7)	0.1
Smoking	28 (32.2)	37 (21.2)	1.8 (1.0-3.4)	0.04
NYHA class IV	36 (42.3)	29 (16.7)	4.2 (2.1-8.3)	0.0001
Intraoperative factors				
Double IMA	8 (9.2)	6 (3.4)	2.7 (0.9-7.6)	0.07
Other procedure [1]	8 (9.2)	15 (8.6)	1.1 (04-2.7)	0.8
Mean duration of surgery (SD, min)	187.4 (65.2)	161.7 (49.7)	1.01 (1.0-1.01)	0.001
Mean perfusion time (SD, min)	73.2 (36.5)	65.4 (28.7)	1.01 (1.0-1.01)	0.04
Surgeon experience	43 (49.4)	78 (44.8)	1.2 (0.7-1.8)	0.5
NNIS risk index ≥2	28 (32.2)	30 (17.2)	2.6 (1.3-5.1)	0.005
Post-operative factors				
Length of stay, Mean (SD, d)[2]	29.7 (21.0)	13.4 (9.6)	1.1 (1.05-1.1)	0.0001
Central venous catheter, Mean (SD, d)[2]	9.9 (13.1)	4.3 (7.0)	1.08 (1.03-1.1)	0.01
Urinary catheter, Mean (SD, d)[2]	16.4 (22.3)	6.0 (8.0)	1.06 (1.03-1.1)	0.0001
Surgical drainage, Mean (SD, d)[2]	9.5 (9.3)	4.6 (3.2)	1.3 (1.1-1.4)	0.0001
Mechanical ventilation, Mean (SD, d)[2]	6 (10.8)	1.8 (3.1)	1.1 (1.04-1.2)	0.002
Other infection	27 (31.4)	19 (33.3)	1.2 (0.5-2.9)	0.6
Reexploration	15 (17.2)	6 (3.4)	6.8 (2.2-20.6)	0.001
AVC	7 (8.0)	2 (1.1)	12.5 (1.5-103.1)	0.02
Transfusion	46 (53.0)	68 (39.1)	1.8 (1.05-3.1)	0.03
Dehiscence	33 (37.9)	1 (0.6)	66 (9.0- 482.5)	0.0001

CABG: Coronary artery bypass grafting; SD: standard deviation, mOR: matched Odds Ratio, CI: Confidence Interval, ICU: Intensive Care Unit. NNIS: National Nosocomial Infection Surveillance. BMI: body mass index.
1Common Odds Ratio assuming a linear trend.
2Other procedures include repair of atrioseptal defect and ventriculoseptal defect, removal of atrial myxoma, and graft repair of the ascending aorta.

Table 1: Risk factors for surgical site infection after CABG among 261 patients.

	Superficial	Deep-Mediastinitis	P
	N = 65	N = 22	
Days until infection, mean (SD, d)	11.5 (7.4)	13.5 (7.9)	0.3
Fever (%)	22 (33.8)	14 (63,6)	0.01
Leucocytosis, mean (SD)	11.102 (4230)	12.946 (4712)	0.09
Isolated microorganism (%)			
Staphylococcus aureus	3 (4.6)	3 (13.6)	
Staphylococcus aureus MR Staphylococcus	1 (1.5)	-	
Coagulase-negative Staphylococcus	33 (50.7)	4 (18.2)	
epidermidis	9 (13.8)	9 (40.9)	
Enterococcus faecalis	2 (3.1)	2 (9.1)	
Streptococcus viridans	1 (1.5)	-	
Pseudomonas aeruginosa	1 (1.5)	-	
Other gram negative [1]	1 (1.5)	2 (9.1)	
Polimicrobian	8 (12.3)	-	
Bacteremia (%)	6 (9.4)	6 (27.3)	0.03
Case-fatality ratio (%)	5 (7.6)	5 (22.7)	0.05

[1]Includes: *Proteus mirabilis* (1), *Proteus vulgaris* (1), *Serratia marcensces* (1).
Abbreviations: SD: standard deviation, MR: methicillin-resistant

Table 2: Surgical site infection characteristics and systemic effect.

Risk factor	mOR[1]	CI 95 %	P
Diabetes Mellitus	1.9	1.0-3.8	0.05
NYHA class IV	3.9	1.8-8.4	0.0001
Surgical drainage [2]	1.2	1.1-1.4	0.0001

[1]mOR: matched Odds Ratio adjusted by the variables shown in the table, CI: Confidence Interval,
[2]Common Odds Ratio assuming a linear trend. Abbreviations: NYHA: New York Heart American Society.

Table 3: Risk factors for surgical site infection after coronary artery bypass graft. Multivariate analysis.

biologically plausible as contributing to postoperative wound infection and two of them are potentially modifiable. We were unable to identify the presence of peripheral vascular disease associated with the development of SSI, but we think that this co morbidity could be under diagnosed. Similarly, inadequate or poorly timed antibiotic prophylaxis were not found to be risk factors for infection, as appropriate antibiotics were almost always given within 60 minutes of onset of the procedure and stopped 48 hours after. We applied the NNIS risk index to stratify the patients but, although the risk of SSI increased as the NNIS risk index score increased, as occurred to Roy et al. [13] it was not finally an independent risk factor for SSI. Probably, due to that 80% of the patients fell into the same risk category. Berg et al. [12] found a similar result.

Drains may increase the risk of infection by causing local tissue inflammation, by providing a route of entry for microorganisms from the skin surface or by increasing the length of stay [14,15]. Therefore, drains that are left in place for more than 24 hours following surgery could be associated with increased SSI rates. Factors that could have influenced that the median time of drainage in our patients was approximately 4 days were that the most experienced surgeon left the hospital, the manifestation of other nosocomial infections among the patients involved and the incorporation of new staff into the Intensive Care Unit who were afraid of prompt drainages removing. This matched case-control analysis showed that the risk of SSI increased with every additional day of exposure to the surgical drains (OR, 1.2; $P = 0.0001$). The drains were typically in place for approximately 5 days; less than 25% of the drains were in place for 48 hours or lesser. Although the use of drains varied among the cardiac surgeons so that surgical technique might be considered a confounding factor, we attempted to control for this by including individual physicians in the analysis but there was no association between surgeon experience and SSI.

Although microbiologic findings were diverse, gram-positive organisms were most frequently implicated in the infections. In most of the cases, a single pathogen was implicated in infection. Bacteremias accounted for 13.8% (12/87) of SSIs, 83.3% of them occurred with *Staphylococcus* and were statistically more common with deep SSIs.

Strengths of this study include the use of strict definitions of case-patients and control-patients and standardized prospective surveillance methods performed by the same epidemiologist over 10 years. There are, however, several potential limitations to this study. It is possible that post-discharge surveillance was incomplete and may have missed a few infections. We believe this is unlikely to have occurred as all CABG patients with postoperative complications are routinely referred back to the cardiac surgeon for assessment. Although individual surgeons were included as variables in the analysis, it is possible that our study missed important details related to the technique or operating room personnel.

The results of this study suggest that the delayed use of surgical drains, diabetes mellitus and NYHA of 4 are associated with the development of SSI following CABG. Accordingly with this outcome, we have revised the tendencies of these factors over the last years in our records and coherently we observed an increase in the proportion of patients with diabetes mellitus, NYHA of 4 and misuse of surgical drains. These factors along with those that we underlined as limitations of our study could be associated to the increase of SSI incidence detected.

In summary, on the basis of these results, we would recommend avoiding the protracted use of surgical drains in CABG procedures and careful treatment and monitoring of diabetes mellitus. The implementation of these measures along with proper hair removal and preoperative cleansing of the patient's skin with chlorhexidine–alcohol in patients undergoing CABG at our hospital is currently being evaluated.

Author Disclosure Statement

All authors declare that there are no potential conflicts of interest and no funding.

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