Sternal wound complications after primary isolated myocardial revascularization: the importance of the post-operative variables

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Abstract

Objective: Select pre-, peri-, and post-operative variables, predictive for sternal wound complications (SWC), in a clinical setting.

Methods: We analyzed pre-, peri-, and post-operative data of 3815 patients who underwent a primary isolated bypass grafting. 100 patients (2.6%) had post-operative SWC. Unifactor and multifactor risk analysis, were used for statistical analysis.

Results: Unifactor analysis identified age (\(P \leq 0.05\)), obesity (\(P \leq 0.001\)), lung disease (\(P \leq 0.001\)), extracorporeal circulation >100 min (\(P = 0.02\)), graft choice (\(P = 0.01\)), post-operative low cardiac output, reoperation, nephrological, pulmonary problems (\(P < 0.001\)) as risk factors. Multifactor analysis, identified obesity (\(P = 0.005\)), reoperation (\(P = 0.01\)), nephrological (\(P = 0.0001\)), pulmonary problems (\(P = 0.001\)) and NoIMA-use (\(P = 0.05\)) as independent predictors. Age \(< 50\) years (\(P = 0.04\)) decreased the risk for SWC. There is, however, an interaction of the graft-use and the pre-operative and post-operative predictors, that can mask the precise effect of the graft-use.

Conclusion: Reoperation, nephrological and pulmonary problems are strong predictors, obesity and age independent preoperative risk factors for sternal wound complications. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Myocardial revascularization; Postoperative morbidity; Sternum; Wound complication

1. Introduction

Median sternotomy is the most common incision in cardiac surgery. Sternal wound complications (SWC) are not so frequent (1–5%). Age, gender, diabetes and graft-choice are variables, mostly related with SWC. In the clinical setting, surgeons take decisions, certainly concerning graft use, based on patient characteristics, to decrease post-operative SWC. However, despite this ‘selection’ SWC persist and also the consequences, mortality, morbidity and increase of hospital stay and costs [1–4].

The objective of this study is to select variables from sets of pre-, peri-, and post-operative variables, which contribute independently to a decreased or an increased risk of SWC.

2. Material and methods

2.1. Patients

With the aid of our database, Coronary Surgery Database, Radboud Hospital (CORRAD), a registry that stores pre-, peri-, and post-operative data on all patients undergoing isolated coronary bypass grafting (CABG), we identified a series of 3834 patients undergoing a primary isolated CABG from January 1987 to December 1995. These 9 years are subdivided into 3 time cohorts of 3 years. January 1987 to December 1989 (1292 patients), January 1990 to December 1992 (1130 patients), and January 1993 to December 1995 (1412 patients). Of these 3834 patients, 100 (2.6%) had post-operative SWC. Post-operative SWC was defined as when there was: a relaxation of the sternum, even without clinical signs of infection, and mediastinitis, defined as every SWC with or without sternal instability but with positive mediastinal wound cultures during the first 30 days post-operative. Isolated superficial wound problems with a stable sternum were not included. Table 1 presents the frequency of SWC in the three time cohorts.

Pre-operatively, diabetes was defined as having a positive glucose tolerance test, oral antidiabetic medication, or insulin dependency. Obesity was defined as being ≥20% overweight. Kidney disease was registered in patients with a documented history of renal dysfunction (creatinine ≥150 \(\mu\)mol/l), pre-operative dialysis, and renal transplantation.

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Lung disease was registered in patients with chronic obstructive pulmonary disease, and/or a history of previous lung disease. Emergency operation is defined as operation for involving myocardial infarction, ischaemia not responding to medical therapy, or cardiogenic shock. Post-operative myocardial infarction as a new post-operative Q wave or T wave accompanied by increased cardiac enzymes (CPK-MB > 10%). Low cardiac output as the need for inotropic support (dopamine need increasing 4 μg/kg/min for at least 12 h) or as cardiac index below 2.2 l/min/m². Reoperation is defined as all resternotomies for bleeding, tamponade or other reasons during hospital stay. Under nephrological problems, post-operative dialysis and renal dysfunction (creatinine ≥150 μmol/l) were noted. Pulmonary infections and other pulmonary morbidity were noted under pulmonary problems. Nephrological and pulmonary problems secondary to SWC were not incorporated in this analysis.

### 2.2. Surgical technique

All patients were operated on using standard cardiopulmonary bypass technique, aortic and right atrial (two stage) cannulation, hypothermia (28–32°C), and myocardial protection using St. Thomas' Hospital cardioplegia. The only surgical change was the increase of the use of arterial grafts [5].

The operative field was scrubbed with Hibitane 4% (ICI Pharma, Holland bv Rotterdam, The Netherlands) and painted with Hibitane 0.5%. All patients received prophylactic antibiotics, cefazolin and ampicillin, starting just before bypass and continuing for 48 h after the operation. Sternal closure was performed using twisted stainless steel wires, in the first time cohort, in several patients the sternum was closed using the controlled tension osteosynthesis system [6].

### 2.3. Statistical analysis

Unifactor and multifactor risk analysis methods were applied. To test which variables can be considered risk factors for SWC the $\chi^2$ test or Fisher’s exact test was used. Associations with continuous variables were tested using Student’s $t$-test or one-way ANOVA. Cochran–Armitage trend test was applied to study the incidence of SWC with age (unifactor risk analysis). Multiple logistic regression analysis was used to identify risk factors from the sets of pre-, peri- and post-operative variables which independently contribute to a decrease or an increase in risk of SWC (multifactor risk analysis).

Odds Ratio’s (OR) are used as approximations of relative risk. Statistical significance was assumed at $P < 0.05$. A $P$-value between 0.05 and 0.10 was considered indicative for statistical significance.

### 3. Results

Table 1 shows the incidence of post-operative SWC in the three time cohorts. The overall incidence of wound complications in period 1987–1995 is 2.6%. The incidence of SWC is not associated with the time cohorts ($\chi^2$ test, $P = 0.24$).

#### 3.1. Unifactor risk analysis

Table 2 lists the variables tested for post-operative SWC, for each variable the $\chi^2$ test statistics ($P$-value) for no association with the incidence of SWC was calculated. Age ($P = 0.05$), obesity ($P = 0.001$), and lung disease ($P = 0.001$) were pre-operative risk factors for SWC. Duration of the extracorporeal circulation longer than 100 min ($P = 0.02$) and graft choice ($P = 0.01$) are peri-operative risk factors. For patients with only vein grafts the incidence of SWC was 4.0%, for patients with one internal mammary artery (one-IMA) graft 2.0% and patients with bilateral use of the internal mammary artery 2.9%.

All post-operative variables are associated with the risk of wound complications; very strongly associated are low cardiac output, reoperation, nephrological and pulmonary problems ($P < 0.001$).

Table 3 shows the association between age and IMA-use and the incidence of SWC in each subgroup. There is a clear association between age and IMA-use ($\chi^2$ test, $P = 0.001$). In the age-group >70 years the percentage of patients with BIMA-use is relatively small (4.7%), but with a relative high risk for SWC (2.35, 5.7%). Patients below the age of 50 years with No-IMA-use or one-IMA-use have very little risk (1/291, 0.3%).

#### 3.2. Multifactor risk analysis

The results of the logistic regression analysis using all variables are presented in Table 4 (Model A: 19 variables). Variables associated with an increased independent risk for SWC are: male sex ($P = 0.05$), obesity ($P = 0.004$), ‘No-IMA-use’ ($P = 0.07$), reoperation ($P = 0.009$), nephrological problems ($P = 0.001$) and pulmonary problems ($P = 0.0001$). The variables age <50 years ($P = 0.06$) and kidney disease ($P = 0.08$) are indicative for a decreased risk for SWC.

The results of the logistic regression analysis using only...
variables associated with an independent contribution to the risk of SWC, are presented in Table 5 (Model B: 10 variables). In Model B, 6 variables contribute significantly to the risk of SWC ($P < 0.05$). Age $<50$ years ($P = 0.04$) decreases the risk of SWC. Obesity ($P = 0.005$), ‘No-IMA-use’ ($P = 0.05$), but in the first place, reoperation ($P = 0.01$), nephrological problems ($P = 0.0001$) and pulmonary problems ($P = 0.0001$) increases the risk of SWC.

To investigate whether detailed information about these risk factors provides additional information about the risk of SWC, the risk factors were divided into subcategories (subgroups) (Table 6). The overall incidence of SWC in case of reoperation is 8.2%. By subcategory the observed risk ranges from 0 to 19%. In case of nephrological problems the overall risk is 19.1%, by subcategory the risk varies from 17 to 25%, and for pulmonary problems the global risk is 13.2%, varying from 9.6 to 16% for subgroups.

Table 7 shows the association of the graft-use with pre- and post-operative predictors. Age (mean age), male gender and obesity are different in the three categories. The graft-use is associated with reoperation ($P = 0.02$), nephrological problems ($P = 0.001$) and pulmonary problems ($P = 0.01$). Nephrological and pulmonary problems occur more frequently in patients with only vein grafts. Reoperations occur more frequently in the BIMA-group. The use of one IMA is associated with a relative low prevalence of reoperations and pulmonary problems (6.5 and 7.2%).

### 4. Discussion

The criticism on this study is of course the bias of the graft use in relation to pre- and preoperative variables. However it is just the intention of the study to identify predictive variables for SWC in the clinical situation. Only double-blind randomized studies can identify the real independent predictors of SWC, but such studies were, for ethical reasons, not acceptable.

SWC are described in 1–4% of sternotomies, in our series the overall incidence of SWC in the period 1987–1995 is 2.6% [1–4]. The incidence of SWC appears not to be associated with the three time cohorts (Table 1). That the use of the controlled tension osteosynthesis system made no difference in SWC comparing with the use of steel wires was already discussed in a previous paper. [6] The risk of SWC in specific subgroups may vary from close to 0 to 20% or more (Table 2). Patients below the age of 50 years have a...
relatively low risk (0.9%); if in the younger age-group not the two IMA’s are used, the risk drops even to 0.3% (Table 3). In contrast if there are post-operative pulmonary problems, the risk of SWC increases to 13.2%, and if nephrological problems are present, the risk amounts to 19.1% and even to 25% if post-operative dialysis is needed (Table 6).

4.1. Pre-operative variables

4.1.1. Age

The risk of SWC increases with age (Table 2), and elderly age has been associated with SWC in other studies [4,8,9]. Below the age of 50 years the risk is 0.9%, between 50±70 years the risk is 2.7% and above 70 years it amounts to 3.1%. In comparison to the overall risk (2.6%) the risk below the age of 50 is relatively low. This is reflected in the Odds Ratio of age, 50 in Table 5 (OR 0.35). Since age, 50 years is a ‘negative’ risk factor, it may be that the risk in certain subgroups of this age group is very low. Although in our analysis an additional risk was not detected for patients above 70 years (Table 5), it may be that a more refined analysis of the elderly patients can detect ‘old age’ as an independent risk factor. Borger identified age, 74 years as predictor for sternal wound infection [4].

4.1.2. Sex

Sex may be an independent risk factor for SWC (Table 5). Also other studies identified male sex as a risk factor for SWC [2,4,10]. The reason is unclear, certainly because female sex is normally associated with a higher mortality and morbidity in myocardial revascularization [11]. Borger suggests that males tend to have increased tension on their sternal incision, which in turn leads to increased risk of sternal instability [4].

4.1.3. Obesity

If the risk factor obesity is present, the risk for SWC seem about twice as large in comparison with no-obese patients (Table 5). The Parisian mediastinitis study group identified obesity as the only independent preoperative risk factor for deep sternal wound infection after myocardial revascularization.
Diabetes is associated with age (does not mean that diabetes is not a risk factor for SWC). This diabetic patients in the study of Borger [2,4]. In our study diabetics the Parisian mediastinitis study group an 19% patients (13.1%) is comparable with other studies, 11% diabetes is not an independent risk factor (Table 4). This can explain the difference in several studies identifying diabetes whether or not, [4,2] or depending on ‘BIMA-use’,[1] as a risk factor for SWC. It may be a point of criticism that preoperative variables such as chest radiation, use of steroids, affecting wound healing [12] are not included as preoperative variables in this analysis. However, the number of patients that could be included in these subgroups is very low (<2%), and these patients have mostly also other pre-operative risk factors. So the power and the sense of these subgroup analysis would be very low and questionable as we have already seen with the variable kidney disease.

4.1.6. Lung disease

For lung disease, there is a clear association with the risk of SWC (Table 2) [1]. However, pulmonary pathology was not identified as an independent risk factor (Table 3). The effect of pulmonary problems on the risk on SWC can probably be considered an indirect risk.

The use of grafts is significantly associated with the risk on SWC (Table 2). The differences in risk in the three categories, ‘No-IMA-use’ (risk 4.0%), one-IMA-use (risk 2.0%) and ‘BIMA-use’ (risk 2.9%) seems in contradiction with other studies identifying IMA and BIMA use as predictors for SWC [1,2,13]. It must be clear, that the use of an IMA graft depends on surgeons’ decision, depending on several (subjective) risk factors. Certainly in the first time cohort (1987–1989) there was some reserve in using IMA grafts in elderly patients, urgent/emergency operations. Patients with ‘No IMA-use’ have a mean age of 64 years; patients with ‘BIMA-use’ are on average 7 years younger. Also the distribution of sex and obesity appears to be different in the three categories (Table 6). But also other factors,
as pre-operative radiotherapy, use of steroids, have influenced the no-use of an IMA-graft [13]. It must be clear that the patients operated without IMA-use are for a certain reason ‘a priori’ susceptible for SWC. And in fact it is logical that these patients have more SWC than the others, because we need a good reason for no-use of an IMA-graft for myocardial revascularization [14]. This selection process leads to selection bias very likely to a bias in the results of the statistical analysis.

We can suppose, however, that in our group of patients <50 years operated without IMA-use (71 patients, no SWC), the no-use of an IMA-graft was especially determined by the coronary artery anatomy, only a vein graft to a distal right coronary artery, or distal circumflex, diagonal coronary artery. Comparing this group without IMA-use, with patients younger than 50 years with ‘IMA-use’ and ‘BIMA-use’, we see an increasing percentage of SWC (Table 3). It is difficult to determine in model B (Table 4) the precise effect of the graft-use on the risk of SWC, because the inclusion of pre- and post-operative predictors can mask it. If the post-operative variables are let out from model B there is an indication that ‘BIMA-use’ is also an independent predictor \((P = 0.09, \text{OR} = 1.6)\). To a certain extent this may be due to the finding that ‘BIMA-use’ is related with a higher percentage of reoperations, an independent predictor of SWC (Table 6).

4.3. Post-operative predictors

That the post-operative variables, reoperation, nephrological problems and pulmonary problems are strong predictors for SWC is confirmed by several studies [1–3]. The importance of these variables for the prediction is illustrated by the subgroup analysis (Table 6). In case of resternotomy for cardial problems the risk increase to nearly 20% in contrast with 0% if there is resternotomy for other reasons, as removal of a fixed drain; also in case of postoperative renal dysfunction and dialysis the risk amounts to 17%, respectively 25%. In case of a pulmonary infection the risks amounts to 16%. In fact in post-operative situations in relation with cardiac performance (low cardiac output), there is a strong relation with the occurrence of SWC.

5. Conclusion

The post-operative problems, reoperation, nephrological and pulmonary problems, are strong predictors of sternal wound complications. Obesity and age (young age decreases the risk) are independent preoperative risk factors. There is an indication that BIMA-use is also an independent predictor; however, the choice of a graft is related to knowledge of pre-operative patient characteristics, which leads to selection bias. Furthermore the graft-choice is associated with the post-operative predictors.

The importance of this study is that in clinical practice, where we are performing CABG’s, taking in account several pre- and per-operative risk factors, to minimize the risk for SWC, a certain percentage of SWC occurs. These SWC were in the first place predicted by postoperative variables.

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References


