Comparison of Simple Wire and Figure-of-Eight Technique in Terms of Development and Outcome of Sternal Dehiscence in Patients Undergoing Coronary Artery Bypass Graft Surgery

ABSTRACT

Objective: To see effects of simple wiring and figure of eight techniques on the development and outcome of sternal dehiscence in patients undergoing Coronary Artery Bypass Grafting Surgery (CABG).

Study Design: Retrospective study.

Place and Duration: From 15/09/2010 to 30/11/2014. The data was retrieved from the cardiac surgery departments of three hospitals i.e. Pakistan Institute of Medical Sciences, Islamabad, Bilal Hospital, Rawalpindi and King Faisal Specialist Hospital and Research Center, Saudi Arabia.

Materials and Methods: A total of 250 patients were retrospectively analyzed. Out of these 160 underwent simple wire technique, 60 had figure of eight technique and 30 cases underwent Robicsek technique. All patients underwent similar preoperative preparations for different cardiac procedures mainly Coronary Artery Bypass Grafting Surgery (CABG) and some other cardiac surgeries. The outcome was determined in terms of development of sternal dehiscence and its outcome between the two groups i.e. simple wire technique and figure of eight technique.

Results: Average age of patients was found slightly variable in the simple wire (50.0 ± 19.0) and figure of eight (45.0 ± 18.0) study groups. Male gender was dominant in this study (72.0%) and most of the patients were Diabetic, Chronic respiratory problem with or without history of smoking Chronic renal Disease and also overweight or obese. Overall (8.0%) patients developed deep sternal wound infection (DSWI) and 4.4% had superficial wound infection (SWI). When compared between simple wire and figure of eight techniques both SWI (4.4% vs 3.2%) and DSWI (7.5% vs 8.3%) were equally distributed statistically.

Conclusion: The outcome of sternal dehiscence is significantly different among simple wire and figure of eight techniques. Inotropic usage, chest re-exploration, sternal rewiring, superficial wound infections and deep sternal wound infections were all found high in both study groups compared to Robicsek technique.

Keywords: Coronary Artery Bypass Grafting, Sternal dehiscence, simple wiring, figure of eight technique, Superficial wound infection, Deep sternal wound infection.

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Introduction

Postoperative sternal dehiscence is a serious and potentially devastating complication continuing to be amongst the great challenges of cardiac surgery with incidence rates ranging between 1 to 3%.\(^1,2\) Sternal wound complications result in increased morbidity and mortality, reaching 10% to 40%.\(^3\) Vigorous coughing can exacerbate this process. Tight fixation of sternal wires and sufficient blood circulation are the essential factors for a successful healing. There is a direct relation between sternal dehiscence and development of sternal wound infection.\(^3\) Surgical techniques are a key component for the prevention of sternal dehiscence, we hypothesized that in patients with an increased risk for sternal dehiscence and sternal wound infection, a reinforced closure—like the technique described by Robicsek—could reduce the rate of sternal wound complications.\(^4,5\)

One factor for the development of sternal wound infection (SWI) is bony instability after sternotomy. This study compares different sternal closure techniques with respect to the occurrence of Sternal Dehiscence, Superficial and Deep sternal wound infection in patients with higher risk factors. As it is well known that mediastinitis is a multifactorial disease with an incidence between 0.5 and 5%. The main independent risk factors are obesity, diabetes, smoking, COPD, use of pedicle internal thoracic artery and prolonged on-pump time.\(^6,7\)

In our experience surgeries are done in a totally different patient population where Chronic kidney disease obesity, diabetes mellitus, Chronic obstructive pulmonary disease, smoking and old age were commonly found risk factors.

Sternal wound infections are significantly related to levels of obesity (24_<BML<30). The length of stay in operation room and intensive care unit (ICU) (ventilation time) is increased in patients with high of Body Mass Index (> 30)]. High blood glucose levels are associated with a higher incidence of deep wound infection. Insulin-treated diabetes has a poorer midterm survival and higher incidence of reoperations for mediastinitis. Another independent risk factor is the use of a pedicle internal thoracic artery (ITA). Using ITA is associated with 4-20-fold increase risk of sternal wound infection.\(^8\)

Sternal motion and instability may occur during the first days or weeks after median sternotomy owing to the technical issues related to the bone, wire or surgical technique. Optimal sternal closure with durable stability will preclude sternal dehiscence in most cases. The most important factor in the prevention of sternal dehiscence is a stable sternal approximation. Mostly, good results are obtained if the closure method provides good rigidity [stiffness, which means less motion when the sternum is stressed] and strength. The most commonly used two sternal closure techniques in cardiac surgery are interrupted simple wire and figure-of-eight wire techniques. The primary aim of this study was to determine the effects of different wiring techniques and post operative chest binder advanced sternal external fixation on prevention of sternal instability and mediastinitis. In addition to see effects of these techniques on the development and outcome of non-microbial sternal dehiscence in patients undergoing isolated on-pump Coronary Artery Bypass Grafting Surgeries.

Materials and Methods

All patients between ages 18 to 80 years who underwent CABG (coronary artery bypass grafting) and valvular heart surgery or combined operation through median sternotomy at Pakistan Institute of Medical sciences Islamabad, Bilal Hospital and King Faisal Specialist Hospital and Research Center Saudi Arabia were reviewed. A total of 250 patients underwent this procedure between 15/09/2010 to 30/11/2014. All the surgeries were performed by a single operating surgeon or as first assisting surgeon. Similarly, sternal closures during these operations were done by the investigator or other colleague.

All patients underwent similar preoperative preparations for different cardiac procedures (78% Coronary Artery Bypass grafting with pedicle Internal Mammary Artery harvesting and 22% other cardiac procedures), using standard median sternotomy. In case of diagnosed wound infection, appropriate antibiotics were administered based on culture and sensitivity results. In some cases (n=12/250) surgical rewiring was needed. When mediastinitis became evident (n=20/250), surgical debridement (necrotic tissue and steel wires) followed by temporary vacuum assisted Closure (VAC) was performed. The definite sternal wound closure followed after sterile microbiological cultures were confirmed.

In the first postoperative week patients were evaluated for pain relief and discomfort during coughing, functional disability and restrictions in daily life and quality of life. After discharge, all patients were supposed to come after one week for routine follow-up. So patient with
superficial wound infection (SWI) (n=13/250), sternal dehiscence and mediastenitis were diagnosed on follow up in outdoor clinic or presented through emergency and admitted as indoor case for further management. All sternotomy cases (n=160/250) were closed by simple wiring 7 to 8 steel wire peristernal 3 wires through manubrium and (n=60/250) were closed by using figure-of-eight technique. Some of the patients who were obese, diabetic, old age, with chronic kidney disease and respiratory problem were managed using robicsek technique (n=30/250) as first choice placing continuous, heavyatraumatic wire parasternally on both sides.

Study definitions: The diagnosis of Deep Sternal Wound Infection (DSWI) was based on clinical assessment chest pain, sternal instability, temperature more than 38°C if present and there was either purulent discharge from the mediastinum or positive blood culture and sensitivity by isolating organism by culture of sternal fluid/tissue and operative evidence of mediastinitis was measured during re-exploration. None of the patients with Deep Sternal Wound Infection (DSWI) were managed conservatively. Therefore, additionally a requirement of surgical intervention via the re-opening of the sternum was added to the definition of DSWI. Superficial sternal wound infection (SSWI) was defined as a wound infection limited to the skin and subcutaneous tissue, requiring local surgical intervention with regular wound care, accompanied by antibiotic therapy and/or vacuum-assisted closure and/or wire removal. The entire patients who underwent rewiring for unstable sternum, Robicsek technique was used as the 2nd and definitive choice. Robicsek technique was used for Re-enforcement of the sternum for some of the high risk patient as primary choice.

Statistical considerations: All the study data was entered and analyzed in SPSS software version 11.0. Descriptive statistics was applied to measure frequency and percentages from categorical variables and mean and standard deviation from continuous numerical variables. The baseline and clinical features during pre and peri operative period were compared using student’s t-test in case of continuous variables and chi-square test for categorical variables. As per objective the outcome of sternal dehiscence was compared among the two interventions using chi-square test. A p-value of <0.05 was considered significant.

Results

Pre, peri and postoperative characteristics of patients are presented in Table I. The overall mean age of the patients was 55.0 ± 11.0 and slight variability was found between simple wire and figure of eight technique (50.0 versus 55.0). Male gender was dominant with 180 (72.0%) proportion. No statistical difference was found in gender and Body Mass Index levels among the two study groups. Most of the pre-operative features were equally distributed among simple wire and figure of eight technique study groups, however, diabetes (18.0% vs 38.3%), renal dysfunction (1.8% vs 15.0%) and chronic cough (1.2% vs 35.0%) respectively were significantly different between the two groups. The peri-operative features like duration of Cardiopulmonary Bypass (CPB) was significantly associated with simple wire technique as well as Left Internal Thoracic Artery usage (p-value= <0.001).

As per study objective the outcome of sternal dehiscence was compared between the two groups i.e. simple wire and figure of eight technique. During hospitalization, patients were evaluated for signs and symptoms of delayed wound healing or wound infections. Sternal instability was characterized by excessive sternal motion due to sternal non-union or fracture with the resultant pain and discomfort typically creating restrictions in the performance of activities of daily living. Postoperative data is summarized in patients developed sternal wound infections. Overall (8.0%) patients developed superficial deep surgical wound. There was no mediastinitis related mortality. Eleven patients developed superficial wound infection while 13 patients were diagnosed with sternal click, unstable sternum and later on underwent Rewiring by using Robicsek technique. All those patients with sternal closure by using Robicsek as first choice had no incidence of Deep Sternal Wound Infection and sternal dehiscence. Only 2 patients develop superficial wound infection. Out of 160 cases with simple sternal closure, 7 (4.4%) developed superficial wound infection and 12 (7.5%) developed Deep Sternal Wound Infection managed by wound toilet and Vacuum Assisted Closure (VAC) dressing whereas in figure of eight technique 2 (3.2%) and 5 (8.3%) developed Superficial Wound Infection and Deep Sternal Wound Infection respectively. Sternal re-wiring was done in 10 (6.2%) cases in simple wire technique and 2 (3.2%) cases in figure of eight technique. Mortality was found in 2 (1.2%)
cases in whom simple wire technique was applied. The other outcome parameters in terms of Intra Aortic Balloon Pump (IABP) usage, postoperative CerebroVascular Accidents, SWI and unstable (non-infective) sternum were found equal among the two study groups. Compared to simple wire and figure of eight techniques, the Robicsek technique was found associated with no or very few deranged outcome of sternal dehiscence. Further details can be seen in Table II.

Table II: Outcome of sternal dehiscence according to sternal wiring technique

<table>
<thead>
<tr>
<th>Variables</th>
<th>All patients (n=250)</th>
<th>Simple wire technique (n=160)</th>
<th>Figure-of-eight technique (n=60)</th>
<th>Robicsek Technique (n=30)</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prolonged ICU stay</td>
<td>9 (3.6%)</td>
<td>4 (2.4%)</td>
<td>3 (5.0%)</td>
<td>2 (6.6%)</td>
<td>0.39</td>
</tr>
<tr>
<td>Inotropic use</td>
<td>21 (8.4%)</td>
<td>7 (4.4%)</td>
<td>9 (15.0%)</td>
<td>5 (16.5%)</td>
<td>0.01</td>
</tr>
<tr>
<td>IABP use</td>
<td>6 (2.4%)</td>
<td>3 (1.8%)</td>
<td>1 (1.6%)</td>
<td>2 (6.6%)</td>
<td>1.0</td>
</tr>
<tr>
<td>Chest re-exploration</td>
<td>14 (5.6%)</td>
<td>10 (6.2%)</td>
<td>4 (6.7%)</td>
<td>0 (0.0%)</td>
<td>0.91</td>
</tr>
<tr>
<td>Postoperative CVA</td>
<td>1 (0.4%)</td>
<td>1 (0.6%)</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
<td>1.0</td>
</tr>
<tr>
<td>Sternal Rewiring</td>
<td>13 (5.2%)</td>
<td>10 (6.2%)</td>
<td>3 (5.0%)</td>
<td>0 (0.0%)</td>
<td>0.52</td>
</tr>
<tr>
<td>SWI</td>
<td>11 (4.4%)</td>
<td>7 (4.4%)</td>
<td>2 (3.2%)</td>
<td>2 (6.6%)</td>
<td>1.0</td>
</tr>
<tr>
<td>DSWI</td>
<td>20 (8.0%)</td>
<td>12 (7.5%)</td>
<td>5 (8.3%)</td>
<td>3 (10.0%)</td>
<td>0.68</td>
</tr>
<tr>
<td>Unstable (non infective)</td>
<td>3 (1.2%)</td>
<td>3 (1.8%)</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
<td>0.56</td>
</tr>
<tr>
<td>Mortality</td>
<td>2 (0.8%)</td>
<td>2 (1.2%)</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Discussion

Sternal wound complications after CABG are infrequent but can be potentially devastating leading to severe morbidity and mortality. Studies have reported 10 to 40% morbidity and mortality rates associated with sternal wound complications. The outcome of sternal dehiscence depends on different surgical procedures done through median sternotomy. We planned to
determine the outcome of simple wire and figure of eight technique in terms of sternal wound infection, rewiring, chest re-exploration and mortality. In this study we retrospectively measured the common causes for sternal dehiscence depending on age, body mass index, diabetes, smoking, Chronic Obstructive Pulmonary Disease, Internal Mammary Artery harvesting, prolonged operation time, peripheral arterial disease, chronic kidney disease and ventilation time. The pre-operative preparation and postoperative wound management were also similar depending upon the type of wound and stability of the sternum. The average age of patients was slightly variable in the simple wire and figure of eight technique while male gender was found dominant in both groups. Overweight and obese patients underwent Coronary Artery Bypass Grafting more frequently than normal Body Mass Index in this study. The pre-operative most frequent risk factors were diabetes mellitus, hypertension, renal dysfunction, smoking, chronic cough and Ejection Fraction <30% in this study. Previous literature also supports these findings as many investigators have reported that obesity, female sex, diabetic disease, bilateral internal mammary artery harvesting, postoperative renal failure, and prolonged ventilation are known factors that increase the risk of sternal complications. A study by Crabtree and colleagues found out obesity, diabetes, more than 2 transfusion units as independent risk factors of sternal wound infection. Another study by Sachithanandan and colleagues found of DSWI associated with diabetes, smoking, age and prolonged ventilation. These studies are also comparable to our findings of pre operative risk factors of patients undergoing CABG. Similarly, in this study duration of CPB was found significantly associated with simple wire technique and the duration of x-clamp was also longer in this group, however, not statistically proven different from figure of eight technique. Five patients had underwent rewiring by using Robicsek technique as a 2nd choice. There was 1 (0.3%) mortality post Coronary Artery Bypass Grafting due mediastinites and unstable sternum whereas 1 (0.3%) patient died following surgical revision and debridement one two months after the procedure due to the injury to the right ventricle. Two (1.0%) underwent major surgical reconstruction of the anterior chest wall. In the current study sternal wound infection and deep sternal wound infection were quite high (4.4% and 8.0%) respectively. In a previous study by Crabtree et al, DSWI was found in 2.2% cases. In another study by Sachithanandan and colleagues found out (1.7%) cases of DSWI. Compared to our study the rate of sternal wound infection is low in these reports. The probable factors showing a poor outcome in this study could be inotropic usage (8.4%), chest re-exploration (5.6%) and sternal rewiring (5.2%). Comparatively re-exploration for bleeding has been analyzed as an independent risk factor for Deep Sternal Wound Infection in many studies. In case of sternal wire migration there is a need to observe patients conservatively, however, it should be assessed radiologically with CT scan to rule out potential mediastinal injury. Radiological findings can easily reveal sternal dehiscence and displaced sternal wires in proximity to lung parenchyma. The wires, on a background of persistent dry cough, could have account for direct lung injury with subsequent traumatic pneumothorax which could be lethal as well. Though not our main objective, 30 cases were managed by Robicsek technique just to have a comparative view with the two study interventions. Though not statistically measured there was a clear significance of Robicsek technique which showed very few cases of Superficial Wound Infection, Deep Sternal wound Infection and need of sternal rewiring. There are many advantages of this study. Firstly, very few studies are available on the outcome of sternal dehiscence according to different wiring techniques. A reasonable number of patients were observed (n=250). A detailed outcome of patients was analyzed which is one of the first attempts. Whereas the limitations of the study are related to its observational (retrospective) research design and also the data on the long term outcome is not available.

**Conclusion**

The outcome of sternal dehiscence is significantly different among simple wire and figure of eight techniques. Chest re-exploration, sternal rewiring, superficial wound infections and deep superficial wound infections were all found high in both study groups. Compared to the two aimed wiring techniques, Robicsek technique has been seen less associated with poor outcome of sternal dehiscence. Before generalization of current study findings, there is a need to conduct more studies on these techniques in large scale research projects with rigorous and adequate methodological designs. Generally, speaking
the intraoperative and postoperative management should be individualized to minimize the risk of sternal complications.

References