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Deep Sternal Wound Infections after Coronary Artery Bypass Grafting: Analysis of 29 Cases from Iraq

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Abstract

Background: Deep sternal wound infection (DSWI), or mediastinitis, is a devastating complicationof coronary artery bypass grafting (CABG). This prospective study aimed to assess our management of DSWI in view of the published literature.

Methodology: Over 2-years (ending at January 2016), 29 patients (20 males) developed DSWI amongst 520 patients who underwent standard CABG surgeries (5.6%). Pre-, intra-, and postoperative variables were documented. Whenever possible, the infections were culture-verified. Besides antibiotics, patients received oneor more of the following therapies: drainage, debridement, closed irrigation, sternal re-wiring, vacuum-assisted closure (VAC) and bone resection.

Result: Male to female ratio was 2.2: 1. Meanage was 58.1 ± 7.3 years. The mean body mass index (BMI) was 27.9 ± 3.4 kg/m^2. There were 18, 16 and 11 patients with diabetes mellitus (DM), hypertension and chronic obstructive pulmonary disease (COPD) respectively. Cardiopulmonary bypass (CPB) was utilized in 26 (89.7%) patientswith a mean time of 117.5 ± 3.3 minute. Most surgeries (n=21, 72.4%) lasted 5-6 hrs. Accordingto Pairolero classification, there were 3 (10.3%) Type I, 22 (75.9%) Type II and 4 (13.8%) Type III infections. Four (13.8%) cases were culture-verified. Twenty-three (79.3%) DSWIs were surgically managed. Sternal re-wiring was performed in 14 (48.3%) cases while VAC was added to other therapies in 2 (6.9%) patients. DSWIs completely resolved in 18 (62.0%) patients within 3-24 weeks while two (6.9%) patients died within 30-days.

Conclusion: We have identified six independent risk factors for DSWI (male gender, obesity, DM, hypertension, COPD and CPB), five of them are modifiable.

Keywords: Deep sternal wound infection • Mediastinitis • Coronary artery bypass grafting • Median sternotomy • Vacuum-assisted closure • Wound debridement

Introduction

Deep sternal wound infection (DSWI), also called mediastinitis, is a serious complication after median sternotomy with an incidence of 1 to 5%. While superficial sternal wound infections (SSWI) involves the skin, subcutaneous tissue, and pectoralis fascia only and has much less mortality (0.5 to 9%), DSWI involves retrosternal space, prolongs the hospital stay by an average of 20 days and is associated with a mortality of 10 to 47% which is double the mortality of those without mediastinitis [1,2].

The incidence of DSWI is particularly high in the presence of Diabetes Mellitus (DM), smoking history, chronic obstructive pulmonary disease (COPD), osteoporosis and obesity [1-4]. Prolonged stay in the Intensive Care Unit (ICU), use of assist devices and reoperation boost the incidence as well. Coronary Artery Bypass Grafting (CABG) is associated with a higher rate of sternal wound infections compared with other surgeries performed through the same surgical approach. Moreover, the technique used in harvesting the internal mammary artery (IMA) for CABG was found to influence the rate of sternal wound infections [5]. When the artery is dissected along the accompanying veins, fascia, adipose tissue and lymphatics (pedicled harvest), the sternal blood flow is decreased by up to 90%, thus increasing the rate of sternal wound infection. In contrast, dissecting the artery free from the surrounding tissues (skeletonized technique) has been shown to preserve the blood supply of the sternum and thereby reducing the rate of sternal wound infections [1]. DSWI is a complication greatly influenced by the surgical technique and can be reduced by a shorter operation and perfusion time, and lesser use of electrocautery. On the other hand, shaving with razors, the use of bone wax, reoperation for bleeding and sternal rewiring are some surgical risk factors which increase the likelihood of this complication [1].

The diagnosis of DSWI could be based on the presence of a group of clinical features such as erythema, fever, drainage and unstable sternum; although a low grade fever may be the only presentation. According to Pairolero, median sternotomy wound infection could occur within the first week (Type I), or the 2nd to 4th week (Type II) or months to years after surgery (Type III). Most instances of DSWI are of Type II [1].

Unlike SSWI which completely resolve with intravenous (IV) antibiotics and local wound care, DSWI is more difficult to cure and requires a much more aggressive treatment regimen. The previous treatment options of DSWI have included closed suction and continuous irrigation while currently, surgical debridement, vacuum-assisted closure (VAC) therapy, flap coverage, and sternal plating are added options [1,6].

Surgical treatment for angina pectoris was first proposed in 1899. Decades of experimental surgery for coronary artery disease (CAD) finally led to the introduction of CABG in 1964 [7]. Median sternotomy, first proposed by Milton in 1897 [8], was utilized in open heart operation in Iraq for the first time in 1964 by Prof. Yousif D Al-Namaan (1923-1968) and his mate Prof. Muayyad M Al-Omeri (1927), cardiothoracic pioneers. Trials of CABG were performed few years later by Prof. Al-Omeri at the former Republic Hospital (later called Baghdad Medical City) while a modern-time CABG was started by Dr. Najih

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Al-Asadi (FRCS, a Cardiothoracic & Vascular Surgeon) in 1989 at Al-Rasheed Military Hospital, Baghdad [9]. Despite the seriousness of DSWI after CABG, no study addressed this problem in our country so far. The current study was conducted in a major tertiary Iraqi cardiac surgical center in order to assess the incidence, clinical and microbial characteristics, perioperative factors, and the outcome of surgical and conservative treatment of this devastating complication in view of the published literature.

Patient and Methods

From January 2014 to January 2016, 520 patients underwent CABG in the Iraqi Center for Heart Diseases (ICHD). DSWI was diagnosed in 29 patients (20 males, 69% and 9 females, 31%). Patients with DSWI following CABG combined with another procedure and those operated upon elsewhere were excluded from this prospective study. The Ethical Committee of our center approved the study protocol and written informed consents of the patients to participate in the study were obtained.

The patients were thoroughly evaluated. The studied preoperative variables included age, gender, risk factors such as high body mass index (BMI), DM, COPD and renal impairment, cardiac variables such as LVEF%, number of diseased vessels, type of angina (stable *vs.* unstable), congestive heart failure, myocardial infarction, previous coronary intervention and pre-operative use of aspirin and Low Molecular Weight Heparin (LMWH). Moreover, operative variables such as type of surgery (elective *vs.* urgent, on-pump *vs.* off-pump), durations of surgery, cardiopulmonary bypass (CPB) and aortic cross clamp (ACC), number of the grafts and bilateral IMA harvesting were noted. Furthermore, postoperative events such as the length of staying in the ICU and ward, re-exploration for bleeding/tamponade, stroke, coma for >24 hrs and renal impairment were documented. The type of treatment offered to patients with DSWI and death occurring within 30 days of diagnosis of sternal wound infections were reported.

All procedures were performed by the same surgical and anesthetic teams. Median sternotomy incision and closure was done according to the standard technique. The number of grafts was dictated by the angiographic and intra-operative findings. Conduits were either the internal mammary artery (IMA) or great saphenous vein. Most CABG procedures were performed under CPB with topical and central cooling, cross - clamping of the aorta and cardioplegic arrest of the heart while the off-pump technique was occasionally used. At the end of surgery, the wounds were cleaned with Povidone-Iodine and covered with a 30 cm adhesive gauze plaster, which was kept for 2 days post-operatively.

Parenteral antibiotics (3rd generation cephalosporin and/or penicillin + aminoglycosides) were routinely given for 3-5 days post-operatively and then switched to oral antibiotics for 5 days if the patients had uneventful recovery. Patients with a smooth postoperative course usually stayed for 48 hours in the ICU while those with adverse events stayed longer. The total duration of patients' stay in the hospital was affected by the presence of the sternal wound infection and other comorbidities such as arrhythmias, myocardial ischemia, renal impairment, cerebro vascular accident, and bleeding. Upon discharge from the hospital, patients prone to sternal wound infection and sternal instability (BMI >30 kg/m^2, COPD, DM, age >75 years) received a thoracic vest for 4- 6 weeks.

DSWI was defined according to the guidelines from the US Centers for Disease Control and Prevention (CDC) for post-sternotomy mediastinitis [10] which includes involvement of the deep tissues beyond the skin and subcutaneous tissues including the fascial, muscle layers, sternum and retrosternal space with or without sternal instability**.** DSWIs require the presence of one of the following criteria: [1] an organism isolated from culture of mediastinal tissue or fluid; (2) evidence of mediastinitis seen during operation; or [3] presence of either chest pain, sternal instability, or fever (> 38°C), and either purulent drainage from the mediastinum, isolation of an organism present in a blood culture, or culture of the mediastinal area [1]. Whenever possible, culture verification of the sternal wound infection was attempted by taking wound swabs or wound drainage for culture and sensitivity tests.

Patients in this study received one of the following treatments:

1. Drainage, debridement and wound closure
2. Drainage, debridement and sternal re-wiring
3. Drainage, debridement, sternal re-wiring and closed irrigation
4. Drainage, debridement and resection of the bone
5. Debridement, VAC and steel wire (s) removal.

Each patient was followed up for 6 months from the onset of diagnosis of DSWI.

Statistical analysis was done using the Excel Sheet of Microsoft office 10. The data were expressed as mean ± SD, ranges, numbers and ratios. P-value was calculated using the chi-square test, Odd's ratio, and the 2-way contingency table analysis formulas. P value <0.05 was considered statistically significant.

Results

Over 2 years, 520 patients (425 males, 81.7%) underwent CABG procedures for different indications in our cardiac center. The incidence of DSWI in the current study was 5.6% (29 of 520 patients). Males were significantly more frequently involved than females (p=0.0001) with a male to female ratio of 20/9 (2.2:1). Male gender was an independent risk factor for DSWI. The age distribution of the patients is shown in Table 1 and Table 2.

The age of the studied patients ranged between 38 and 75 years with a mean of 58.1 ± 7.3. Most (n=25, 86.2%) patients were in the 6th and 7th decades of their lives.

The BMI ranged between 22 and 37.3 with a mean of 27.9 ± 3.4 kg/m^2 and it was an independent risk factor for DSWI (P-value=0.0001). It is worthy to note that only minority of patients (n=5, 17.2%) had a normal body weight while the majority (n=24, 82.8%) were either overweight or obese (Table 3).

Most patients (n=23, 79.3%) had a good LVEF% (50-75%). Three to four vessel CAD constituted the majority (n=25, 86.2%) of cases in this series. Patient had unstable angina more than stable angina (16 *vs.* 13). Nine (31%) patients didn't stop their daily 100 mg aspirin and 4 (13.8%) patients continued to use LMWH preoperatively. A few patients had MI and CHF.

Three quarters of patients had elective CABG. The majority of procedures (n=26, 89.7%) were done using CPB and this was an independent risk factor for DSWI (p=0.0089). Most patients (n=24, 82.8%) received 3 to 4 grafts. The mean CPB time was 117.5 ± 23.3 minute and the mean ACC time was 60.5 ± 12.8 minute while the mean duration of surgery was 5 ± 1.6 hrs. Most surgeries

Table 1. Age distribution of the studied patients.

Age (years)	Number	%	P value
30-40	1	3.5	
41-50	1	3.4	
51-60	12	41.4	
61-70	13	44.8	
71-80	2	6.9	-
Total	29	100	
Mean ±SD	58.1 ± 7.3		

Table 2. Shows the distribution of patients according to their BMI.

BMI kg/m^2	Number	%	P value
18.5-24.9	5	17.2	
25-29.9	18	62.1	
30-34.9	4	13.8	
35-39.9	2	6.9	0.0001
Total	29	100	
Mean ±SD	27.9 ±3.4		

(n=21, 72.4%) lasted 5-6 hrs. No patient in the study group had bilateral IMA harvesting. Worthy to mention that of 520 patients, 19 had bilateral IMA harvesting (3.7%) but none developed DSWI (Tables 4-6).

Renal (n=8, 27.6%) and neurological complications (n=5, 17.2%) were on the top. Characteristics of DSWI in the studied patients are shown in Table 7.

Almost three quarters of patients had Pairolero Type II DSWI with a mean time of presentation after surgery of 19.1 ± 12.2 days. Only few cases (n=4, 13.8%) were verified by culture which revealed *Staphylococcus aureus* (n=1), *Pseudomonas aeruginosa* (n=1) and a mixed growth (n=2). Clinical presentation of the DSWI patients in our study were mostly wound dehiscence with continuous purulent discharge, chest pain, fever, high WBCs count and sternal instability. CXR usually revealed mediastinal widening, slipped or displaced steel wires, and separated sternal edges.

Twenty-three (79.3%) patients were surgically managed and sternal re-wiring was performed in 14 (48.3%) cases while VAC system was used adjuvant to other therapies in 2 (6.9%) patients. DSWIs outcome was uneventful in 18 (62.0%) patients in whom the infected sternotomy wounds healed after an average of 3-24 weeks. Two (6.9%) patients died because of coma, septicemia and multiple organ failure within one month of surgery (Table 8).

Discussion

Median sternotomy is one of the most commonly used incisions in open heart surgery. DSWI is a rare complication, and its improper treatment may result in serious sequelae and even death. Prevention and early recognition of sternal infections are important factors for optimal treatment and management [6].

We performed a retrospective review of 520 consecutive CABG patients operated upon in our center from 2014 to 2016 and found an incidence of DSWI of 5.6%. Other studies reported lower incidences (1.5 to 1.8%) [2,11,12]. The relatively high incidence in this study could be attributed to higher rates of hypertension, DM, COPD, and obesity among our patients.

Like other studies, male gender, obesity, DM, hypertension, and COPD

Table 3. Risk factors for DSWI in the study group.

Risk Factor	Number	%	P value
Diabetes Mellitus (DM)	18	62.1	0.0001
Hypertension (HTN)	16	55.2	0.0001
*Chronic lung disease (COPD)	11	37.9	0.0015
**Renal impairment	2	6.9	

*COPD: FEV1<70%, symptomatic and/or on bronchodilators for at least 6 months.
** Preoperative renal impairment without dialysis, Creatinine >1.3 mg/dL
Diabetes mellitus, hypertension and COPD were all found to be independent risk factors (P-value < 0.05).

Table 4. Shows the specific cardiac risk factors related to DSWI.

Risk Factor	Number	%
LVEF%		
50-75%	23	79.3
36-49%	3	10.3
≤ 35%	3	10.4
LMS (left main stem)	6	20.7
Number of diseased vessels		
3	17	58.6
4	8	27.6
1	2	6.9
2	2	6.9
Stable Angina	13	44.8
Unstable Angina	16	55.2
CHF	2	6.9
MI	4	13.8
Previous coronary intervention	10	34.5
Preoperative use of LMWH	9	31
Aspirin not stopped preoperatively	4	13.8

Table 5. Shows the operative variables

Number of Diseased Vessels		
3	17	58.6
4	8	27.6
1	2	6.9
2	2	6.9
Stable Angina	13	44.8
Unstable Angina	16	55.2
CHF	2	6.9
MI	4	13.8
Previous coronary intervention	10	34.5
Preoperative use of LMWH	9	31
Aspirin not stopped preoperatively	4	13.8

Table 6. Reveals the postoperative events

Event	Number	%
Acute renal impairment within 30 days of surgery.	8	27.6
Re-operation for bleeding/tamponade during day 0	3	10.3
Stroke	3	10.3
Persistent coma for >24hrs	2	6.9

Table 7. DSWI characteristics.

Characteristic	Number	%
Pairolero Type I	3	10.3
Pairolero Type II	22	75.9
Pairolero Type III	4	13.8
Mean (days) ± SD	19.1 ± 12.2	
Culture Verified Cases	4	13.8
Staphylococcus aureus	1	3.4
Pseudomonas aeruginosa	1	3.4
Mixed Growth	2	6.9

Table 8. Types of management of DSWI.

Type	Number	%
Number of patients who received surgery	23	79.3
Total Re-wiring	14	48.3
Drainage, Debridement, Sternal Re-Wiring and daily wound care	9	31.0
Drainage, Debridement, Wound closure, and daily wound care	8	27.6
Debridement, sternal re-wiring, VAC, secondary intension and daily wound care	2	6.9
Drainage, debridement, Resection of the bone partially, removal of steel wires, pectoralis major musculocutaneous and muscular flap, wound closure and daily wound care	1	3.4
Conservative treatment with frequent daily dressings, topical antibiotics, I.V antibiotics, simple wound approximation after 10 to 14 days.	6	20.7

were recognized as independent risk factors for DSWIs [6]. Furthermore, Ridderstolpe concluded that another important risk factor for DSWI is the causative microorganism particularly *Staphylococcus aureus* [6]. Unfortunately, only a few cases of DSWI in the present study were culture-verified as most patients have already received empirical antibiotics at the time of clinical diagnosis. Worthy to note, that one of our four cases which had culture and sensitivity test proved to have a growth of *Staphylococcus aureus*.

The mean age of our patients was 58.1 ± 7.3 years and 25 (86.2%) patients were in the 6th and 7th decades of their lives. Other studies had similar findings [2,11,13,14]. Old age was identified as a predictor of DSWI by some authors [15,16] and has been associated with many complications after surgery. Hung Ku reported that with a 1-year increase in patient's age, the risks of sternal wound infection would be increased 14%. Cruse and Foord have demonstrated that in patients over the age of 66 years, the chances of developing wound infection are twice as great as in patients between 21-50 years of age [16]. Female gender is considered one of the risk factors for DSWI in many scoring systems [13,17,18]. However, males predominated in our study as well as in some other studies [19,20].

In the current series, the mean BMI was 27.9 ± 3.4 kg/m^2 and the majority of patients (n=24, 82.8%) were either overweight or obese. The preoperative risk stratification of DSWI after coronary surgery considered BMI ≥ 30 kg/m^2 as one of the predictors of this complication [17,18]. Kuduvalli and Birkmeyer found that the risks of DSWI were significantly increased in the obese. Moulton et al., analyzed 2299 patients after cardiac operations and found that obese patients were 2.3 times more prone to develop SSWI. Ridderstolpe, et al., in a recent analysis of >3000 patients, showed that obese patients were 2.1 times more susceptible to sternal wound infections. Likewise, Lu JC et al. found that sternal wound infections were doubled in the obese [3]. According to Molina JE, et al. [4] obesity has been identified as the single most important risk factor for postoperative sternal infection in coronary bypass surgery patients. Moreover, obesity is a major risk factor for sternal dehiscence after any type of cardiac operation with or without infection [4]. The possible reasons for obesity being a risk factor include the ineffective dose of prophylactic antibiotic, difficulty of proper skin preparation, adipose tissue providing a good substrate for infection and difficulties in vascular graft harvesting [16].

Eighteen (62.1%) patients with DSWI in this series had non-insulin dependent DM. An equivalent rate was reported by Omran AS, et al. [13]. DM was identified as a predictor of DSWI by many authors [1,12,14,15,21]. Hypertension was observed in 16 (55.2%) patients in this series and was comparable to Omran AS, et al. [13] and Kasb I and Amr M [2]. Preoperative hypertension is a significant risk factor for sternal wound infections, rarely reported in the past [13]. In this series, 11 (37.9%) patients had COPD. Similar rates were reported by other authors [2,13,14,19] while Colombier S, et al. [11] reported a much lower rate (13.5%). Patients with COPD are prone to chest infection and may experience exacerbation of cough and expectoration in the postoperative period interfering with sternal stability. They may be prescribed steroids beside bronchodilators. The former reduces the immunity and increase the chance of wound infection.

In the study of Hoseini MJ, et al. [16] patients with Grade III and IV NYHA score showed a statistically significant relation with SWI. Critical pre-operative status of the patients undergoing CABG is a predictor of DSWI [18]. Unstable angina (n=16, 55.2%) among our patients, which was equally reported by other researchers [13,14], could have contributed to DSWI as well as patients with low LVEF% (n=6, 20.7%).

In the present series, 31% of patients didn't stop their daily 100 mg aspirin and 18.8% of patients continued to use LMWH preoperatively. These medications might have contributed to re-operation for bleeding and thus increased the likelihood of DSWI. Worthy to mention, re-operations for bleeding/tamponade were performed three times (10.3%) in this study which

was comparable to other studies [13,19]. Medalion B, et al. [22], on the other hand, believe that these medications are not associated with increased postoperative bleeding while Huang et al found that the risk of re- operation for bleeding was elevated among preoperative aspirin users in patients undergoing valve operations only [23]. Kubota H, et al. [12] found that when re-exploration for bleeding was performed, mortality was significantly higher than when it was not performed.

Cardiopulmonary Bypass was used in 26 (89.7%) patients in this series and was an independent risk factor for DSWI. Hence, the off-pump technique could have been protective. This opinion is shared by Nakano J et al. [21] who found that when off-pump CABG was used for patients with high risk of DSWI, it showed a significant decrease in the incidence of DSWI. Use of CPB may induce suppression of the immune system and thus predispose to infections [16]. However, our study and some other studies [11,13,19] showed that the time of CPB was not a significant risk factor for DSWI.

The duration of operation is a major risk factor for DSWI [19]. Operations lasting for > two hours are associated with increased infection rates. The longer the duration of surgery, the more environmental exposure, hence a higher infection rate is expected [16]. In our series, the mean operative time was 5 ± 1.6 hours and most operations (n=21, 72.4%) lasted 5-6 hours. This could be explained by the severity of CAD in this series [3-4 vessels in 25 (86.2%) patients] which required 3 to 4 grafts in 24 (82.8%) patients. Increasing number of grafts was identified by Lu et al. as an independent predictor of DSWI [3]. The use of bilateral internal mammary artery grafts increases the risk of DSWI in patients undergoing CABG surgery [15]. In our series, we didn't have any patient with bilateral IMA harvesting. But during the study period, 19 of 520 CABG patients had bilateral IMA harvesting without any instance of DSWI. Urgent surgical priority is one of the risk factors for DSWI [17]. In this series, 7 (24.1%) patients had urgent surgeries.

The conventional treatment of DSWI usually involves surgical revision followed by open wound dressings with or without wound irrigation. Vacuum-assisted closure has been shown to have several advantages over conventional treatment, including lower in-hospital mortality, improved wound healing and shorter length of stay. Steingrimsson S, et al. [10] recommend VAC as a first line therapy for most DSWIs following open heart surgery as was adopted in Iceland since 2005. VAC technique is adopted in wound management to assist in the drainage of necrotic tissue and effusion. This technique is known to increase the capillary diameter and blood flow velocity, as well as to stimulate angiogenesis and endothelial cell proliferation, thereby promoting tissue proliferation and wound closure. These benefits are especially important for seriously infected patients who are unfit for an operation. The VAC technique can be used preoperatively after open wound debridement followed by a secondary reconstruction and flap closure [6]. In the current study, VAC was used twice as adjuvant to other therapies and the number of treated patients was too small to draw conclusions.

Early debridement was advised by Wu L, et al. [24] study in which primary aggressive management helped in reducing the hospital stay, costs, and potentially improved the outcome of the patients with DSWI by preventing it from spreading to more tissues. This aggressive treatment policy is similarly recommended by Shi YD, et al. [6]. Similar to other studies [2,11], most DSWIs in the present series (n=22, 75.9%) were of Type II Pairolero, presenting 2-4 weeks after surgery, and were surgically treated.

Apart from re-operation for bleeding which was performed 3 times (10.3%), the top postoperative complication among our patients was acute renal impairment observed in 8 (27.6%) patients. This is an indicator of seriousness of DSWI as sepsis may affect multiple organs including the kidneys. Unfortunately, we lost two (6.9%) patients because of coma, septicemia and multiple organ failure within one month of surgery. However, this death rate is well below the reported 10 to 47% mortality rate of DSWI [1,2]. This low mortality could be attributed to early diagnosis of DSWI by the operating surgeon and prompt admission to the hospital once a diagnosis of sternal wound infection is suspected and the initiation of tailored therapy to each patient.

Conclusion

This study does have some limitations. It involved a small number of patients as it was a single center study; if more cardiac centers were involved, the number would be higher and thus the conclusions would be more valid. Unfortunately, only a few patients were culture-verified and the follow up period was short. In conclusion, DSWI is a rare yet serious complication of median sternotomy particularly following CABG. Meticulous technique of median sternotomy and correction of the modifiable perioperative risk factors are crucial to avoid or minimize the incidence of this complication.

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