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Management of Deep Median Sternotomy Wound Infection after Open Heart Surgery

Nour El-Din Noaman Gwely, Sameh Mostafa Amer, Ahmad Abdel Aleem ElDerie*, Mohamed Mohamed Zaki Zahran

Department of Cardiothoracic Surgery, Faculty of Medicine, Mansoura University, Egypt

***Corresponding author:** Ahmad AbdelAleem ElDerie, **Mobile:** (+20) 01093668612, **E-Mail:** doctorzahran@gmail.com

ABSTRACT

Background: Deep sternal wound infection (DSWI) is a rare but potentially devastating complication of median sternotomy performed in cardiac surgery. The incidence of DSWI is reported to be between 0.2% and 3%. Identifying high-risk patients and strategies to optimize risk factors plays an important role in reducing the incidence of DSWI.

Objective: This retrospective prospective study was designed to evaluate the management of deep median sternotomy wound infection after open heart surgery as regard the risk factors, rate and the outcome of its surgical treatment in Cardiothoracic Surgery Department, Mansoura University Hospital.

Patients and methods: This retrospective prospective observational study was conducted in Cardiothoracic Surgery Department at Mansoura University Hospitals from January 2016 to December 2019. The data were obtained from 24 retrospective patient and 7 prospective patients. 31 patients had DSWI and treated surgically, the incidence was 2.9%.

Results: We found that 16 (51.6%) patients were males and 15 (48.4 %) were females. The mean age was 58.23±7.898 (year), minimal age was 40 year and the maximal was 71 years. The mean BMI was 32.18 ±5.364. 14 (45.16%) of patients had diabetes mellitus (D.M). 18 (58.06%) patients were hypertensive. 10 (32.3%) patients were smokers. 51.6% of patients had coronary artery bypass graft (CABG). The most common causative organism was MRSA in 35% of patients.

Conclusion: Using of vacuum and pectoral flap in DSWI management is more effective with better healing, higher success rate and less mortality.

Keywords: Deep sternal wound infection, Open Heart Surgery.

INTRODUCTION

Median sternotomy is currently the standard incision for surgery of the heart and great vessels. However, patients still suffer from its complications [(1)]. Deep median sternotomy wound infection is a severe complication despite the progress in its prevention and management [(2)].

Deep median sternotomy wound infection diagnosis needs one of the following to be present: (1) positive cultures taken from mediastinal tissue or fluid. (2) Presence of mediastinitis (during surgery or on histopathological examination) (3) one of the following clinical findings: Fever more than 38°C, sternal instability, or chest pain with one of the following findings: Purulent discharge from mediastinum, positive culture from blood, or mediastinal widening in radiology [(3)].

Risk factors for deep median sternotomy wound infection include patient comorbidities, intraoperative and postoperative factors [(3)]**.** Patient comorbidities such as obesity, smoking, chronic obstructive pulmonary disease (COPD), diabetes, steroid use**.** Intraoperative factors such as poor sternal wire fixation or paramedian sternotomy, bilateral internal mammary artery harvesting for coronary artery bypass graft (CABG) and bone wax use. Postoperative factors including re-exploration and prolonged positive pressure ventilation, tracheostomy [(4)]**.**

The most common causative microorganisms blamed for deep sternal wound infection are considered to be Staphylococcus aureus and Coagulase-negative staphylococci [(5)]. Studies show that there is a relation between etiology and causative organism [(6)]**.** Deep sternal wound infection (DSWI), management is complex and may need an interdisciplinary team including microbiologists, infectious disease specialists, cardiothoracic and plastic surgeons**.** There is a progress in deep sternal wound infection management in the last 50 years. Deep median sternotomy wound infection treatment must be individualized based on the depth of the infection, the organisms that are cultured, and the patient's clinical status [(7)].

If DSWI is suspected, cultures should be taken as early as possible followed by administration of empirical intravenous broad-spectrum antibiotics against the most likely causative organism, debridement of all devitalized and necrotic tissue, drainage of all infected spaces, after sternal debridement, primary or delayed wound closure can be done [(8)]**.** Reconstruction using pectoralis major, omentum, rectus abdominis, or latissimus dorsi muscle flaps can be used. Negative pressure wound therapy can also be used and it is recommended [(9)]**.**

This retrospective prospective study was designed to evaluate the management of deep median sternotomy wound infection after open heart surgery as regard the risk factors, rate and the outcome of its surgical treatment in Cardiothoracic Surgery Department, Mansoura University Hospital.

PATIENTS AND METHODS

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January 2016 to December 2019. The data were obtained from 24 retrospective patient and 7 prospective patients who fulfilled criteria that will be mentioned later. In the period of the study, we found that of 1053 patients underwent open heart surgery in Mansoura University Hospitals, Cardiothoracic Department. 31 patients had DSWI and the incidence was 2.9%.

Inclusion criteria: Adult patients > 18 years of age, both genders, and patients with deep median sternotomy wound infection who were treated surgically.

Exclusion criteria: Minimally invasive incisions, and patients with deep median sternotomy wound infection who were treated only with medical treatment.

Ethical consent:

Ethical approval was obtained from Institutional Research Board (IRB) of Mansoura Faculty of Medicine code number MS.19.04.587. An approval of the study was obtained from Mansoura University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of the operation. This work was carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Preoperative data of the patient:

Clinical data and medical history were obtained from the patients. The patients were submitted to the following:

- Full history taking including: Age, gender, New York Heart Association (NYHA) class, surgical history, smoking history, comorbid diseases including diabetes mellitus, hypertension, COPD (chronic obstructive pulmonary disease), PVDs (peripheral vascular diseases), previous myocardial infarction (MI), steroid use.
- Vital signs.
- Body mass index (BMI).
- Routine preoperative laboratory investigations (complete blood count (CBC), liver function tests, kidney function tests, international normalized ratio (INR), blood group, random blood sugar and glycated hemoglobin A1C (HbA_1C) in diabetic patients).
- Preoperative left ventricular ejection fraction by echocardiography.
- Coronary angiography in patients with: Ischemic heart disease, male patients with valvular heart disease older than 40 years, and postmenopausal women with valvular heart disease.

Intraoperative data:

All patients were given broad spectrum antibiotic during induction of general anesthesia; all patients were observed and the following data regarding the surgery were recorded:

- Type of surgery (elective, urgent, emergent).
- Main open-heart surgery which includes CABG (coronary artery bypass graft) alone, or combined CABG and valve replacement, valve replacement and repair, adult congenital, aortic surgeries.
- Operation time (skin to skin).
- Total bypass time.
- Total cross clamp time.
- In coronary artery bypass graft (CABG) patients: number of grafts, type of used grafts.
- Method of sternotomy closure (simple, figure of eight and robicsek and modified robicsek technique).
- Number of drains.

Postoperative management:

The following data of all patients were recorded:

- Length of mechanical ventilation in hours.
- Need for re-exploration for bleeding.
- Glycemic control in diabetic patients which were divided into: Good glycemic control, which means that random blood sugar 180 mg/dl, and poor glycemic control, which means that random blood sugar is more than 180 mg/dl
- Time to removal of drains in days.
- Lengths of hospital stay in days.
- The criteria of deep median sternotomy wound infection which can appear early postoperatively or during serial follow up in outpatient clinic and include the following (diagnosis):

To diagnose DSWI one of the following findings must be present: (1) Positive cultures from mediastinal tissue. (2) Mediastinitis (during surgery or on histopathological examination). (3) One of the following clinical findings: Fever more than 38°C, sternal instability, or chest pain with purulent discharge from mediastinum or mediastinal widening in radiology.

Pneumomediastinum, air-fluid levels, and mediastinal widening may be found on chest radiograph. CT chest can be used to show the location of the infected areas and their depth.

For all patients who developed median sternotomy wound infection:

- Patients were classified according to **Pairolero and Arnold** [(10)] classification. Classifications and time between 1ry main surgery and diagnosis of DSWI was calculated in days.
- once we suspect DSWI wound swab, culture and sensitivity tests were done to know the type of the causative organism and the appropriate antibiotics,
- Empirical antibiotics were started till the results of the cultures.
- primary debridement was done to all patients to remove all necrotic and devitalized tissue as much as we can
- Open dressing three times daily with betadine and topical antibiotics.

- In some cases, vacuum was used either as an interval till definitive wound closure or as a definitive treatment. Sub-atmospheric negative pressure was applied to good-sealed foam suited over the wound.
- Operative closure of the wound done after the wound become clean. Closure of the wound can be soon after primary debridement if the wound was clean and no signs of infection, or delayed after a time using daily dressing or vacuum till become clean.
- Indications of operative management include failure of conservative management. At the time of closure another debridement was done to eradicate all sources of infection, even sternectomy was done in some cases.
- Closure of sternum was done if there was enough sternal remnant to achieve reasonable approximation either by using simple, figure of eight, or Robicsek technique.
- Soft tissue flap reconstruction using either unilateral myocutaneous pectoral flap or bilateral pectoral flap and myocutaneous rectus abdominis muscle flap was required in patient who had large sternal defect that can't be closed or after sternal closure to achieve further strength.
- Outcome of management over a period of 90 days was estimated and the result was: Complete recovery and healing and these patients were divided into two categories: Healing completely after first time management without need to 2ry management. Healing complication requiring 2ry management. Failure of healing and death.

Technique of vacuum (negative pressure wound therapy; NPWT)

Its system consists of polyurethane foam cut to match the required area size and connected to a drain tube connected to a container to collect the wound discharge. Then we covered the wound with a sterile OPSITE dressing. Suction was adapted on about -100 mmHg for most patients. If the cardiac surface was exposed directly to the device, negative pressure was adapted on -50 mmHg because we fear of cardiac function impairment and hemorrhage. Changing of foam dressing was done every 3 days and it was cultured to adjust the treatment.

Technique of pectoralis major advancement flap:

Dissection and release of costal and sternal origins of pectoralis major was done. Then the inferior and lateral borders were dissected upwards towards its humoral insertion, and then the free pectoral muscle was rotated toward the midline along the axis of its insertion to preserve its normal function. Careful dissection of pectoral neurovascular bundles is necessary to maintain its nervous and blood supply. Dissection must allow the muscle to cross the midline so it can be attached to the pectoral fascia of the opposite side if unilateral flap is used or to crisscross with the other pectoralis major muscle to cover the defect by both muscles. Determination of the type of flap is based on the size of the sternal defect.

Statistical analysis

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for Social Sciences) version 22 for Windows® (IBM SPSS Inc, Chicago, IL, USA). Data were tested for normal distribution using the Shapiro Walk test. Qualitative data were represented as frequencies and relative percentages. Chi square test ($\chi 2$) to calculate difference between two or more groups of qualitative variables. Quantitative data were expressed as mean ± SD (Standard deviation). Independent samples t-test was used to compare between two independent groups of normally distributed variables (parametric data). P value < 0.05 was considered significant.

RESULTS

As regard demographic and preoperative data, minimal age was 40 year and the maximal was 71 years. The rest of data are as in table (1).

Table (1): Demographic and preoperative data of the studied patients

Variant		Frequency	percentage	Mean	Standard deviation
Age (years)				58.23	7.898
gender	male	16	51.6%		
	female	15	48.4%		
BMI (Kg/m^2)				32.18	5.364
Hypertension		18	58.06%		
Diabetes mellitus		14	45.16%		
Smoking		10	32.3%		
COPD		5	16.1%		
CKD		2	6.5%		
PVD		2	6.5%		
Steroid use		2	6.5%		
HBA1C					

Perioperative data of the patients are shown in table 2. 27 (87.1%) patients had elective surgery and 4 (12.9%) patients had urgent surgery.

Table (2): Perioperative data of the studied patients

Variant		Frequency	Percentage	Mean	Standard deviation
NYHA class	Class 2	12	38.7%		
	Class3	19	61.3%		
Coronary angiography	NORMAL	8	25.8%		
	LM	2	6.5%		
	Multivessel disease.	20	64.5%		
	NOT DONE	1	3.2%		
Main surgery	CABG	16	51.6%		
	CABG and valve replacement	6	19.4%		
	DVR	4	12.9%		
	MVR	2	6.5%		
	AVR	2	6.5%		
	Bentall	1	3.2%		
Preoperative Ejection fraction (%)				50.5806	7.95309
Previous MI		8	25.8%		

NYHA: New York Heart Association, CABG: Coronary artery bypass graft, DVR: Double valve replacement, MVR: Mitral valve replacement, AVR: Aortic valve replacement.

According to the operative data and ICU data: The mean cross clamp time was 141.45±44.370 min the minimum was 80 min and maximum was 230 min. The rest of data are as in table (3).

Table (3): Operative data and ICU data of the studied patients

Variant		Frequency	Percentage	Mean	Standard deviation
Operation time (min)				440.97	67.644
Total bypass time (min)				178.55	49.248
Total cross clamp time (min)				141.45	44.370
No of grafts				2.61	1.801
No of drains				3.129	0.7634
Method of sternotomy closure	Simple	24	77.4%		
	Figure of eight	7	22.6%		
Re exploration	Yes	7	22.6%		
	No	24	77.4%		
Glycemic control	Good	26	83.9%		
	Poor	5	16.1%		
IABP use		4	12.9 %		
length of mechanical (hours)				13.113	12.2302
Time to removal of drains(days)				3.06	.772

Types of DSWI according to **Pairolero and Arnold**[10] classification and according to causative organism (wound swap, culture) are shown in Table 4.

Table (4): Types of deep sternal wound infection (DSWI) and causative organism in the studied patients

Variant		Frequency	Percentage	Mortality	
				Frequency	Percent
Type	1	3	9.7%	0	0%
	2	25	80.6%	5	20%
	3	3	9.7%	2	66.67%
Causative organism	No growth	6	19.4%	0	0%
	S. aureus(MRSA)	11	35%	5	45%
	S. aureus	6	19.4%	0	0%
	Pseudomonas aeruginosa	2	6.5%	1	50%
	Candida	2	6.5%	1	50%
	E-Coli	1	3.2%	0	0%
	Multiple organisms	3	9.7%	0	0%

Regarding method of treatment, mortality and mean hospital stay are shown in table 5 as well as the time between surgery and diagnosis of DSWI. Primary wound debridement was done to all patients then definitive wound closure was done with mean time of 13.19±9.669 day.

Table (5): Treatment of deep sternal wound infection (DSWI) and mortality among the studied patients

Variant	Mean	Standard Deviation	NO	Percent	Mortality	
					No	Percent
Open dressing			20	64.51%	7	35%
Hospital stay	42.6	15.8				
Vacuum use			17	54.8%	2	11.7%
Hospital stay	30.7	13.774				
Time between main open heart surgery and diagnosis of DSWI (day)	16.77	12.049				

Outcomes of patients according to method of wound closure are shown in table 6. Wound complications included partial sloughing of newly inserted wires, recurrent sternal defect, and recurrence of infection. For all surgical methods of closure treatment 6 patients had wound complications that were completely cured and healed by using vacuum in 4 patients and 2 patients were managed with conservative treatment (Table 6).

Table (6): Outcomes according to undertaken procedure in the studied patients

Technique		Total	Cured	Complicated	died
Successful sternal rewiring	Only	10 (32.25%)	5 (50%)	2 (20%)	3 (30%)
	Pectoral flap	12 (38.7%)	9 (75%)	2 (16.7%)	1 (8.3%)
Impossible rewiring	Bilateral Pectoral flap	7 (22.6%)	4 (57%)	2 (28.5%)	1 (14.3%)
	Pectoral+ rectus flap	1 (3.2%)	1 (100%)	0%	0

Results of 90-day survival and prognosis are shown in table 7. Mortality rate included pre-procedural mortality rate, i.e., mortality occurring during wound preparation (one patient) and post-procedural mortality rate, i.e., mortality occurring after completion of the procedure (6 patients). Mortality was due to septicemia and septic shock in 4 patients, respiratory failure in 2 patients, one patient died due to cardiogenic shock.

Table (7): Prognosis of the studied patients

	Frequency	Percent
Complete recovery	24	77.4%
Died	7	22.6%

DISCUSSION

In the period of the study, we found that 1053 patients underwent open heart surgery in Mansoura University Hospitals, Cardiothoracic Department among them 31 patients had DSWI; the incidence was 2.9%. This goes with **Gwely *et al.*** [1] as the incidence of deep sternotomy wound infection was 4.6%, **Nešpor *et al.*** [11] the incidence was 2.28%, and in **Kasb and Amr** [12] it was 1.54%.

In our study we found 16 (51.6%) patients were males and 15 (48.4 %) were females. While in **Chan *et al.*** [13] 66% were male as he had lesser number of patients with valve replacement. In our study the mean age was 58.23±7.898 years. This goes with **Kasb and Amr** [12] in which the mean age was 61.5± 8.2 years**,** while, **Chan *et al.*** [13] age was higher (68.2 ±12.0 years) as he had lesser number of patients with valve replacement. The mean BMI was 32.18 ±5. 364. This goes with **Chan *et al.*** [13] in which the mean BMI was (28.8 ±4.3) and with **Kasb and Amr** [12] in which the mean BMI was 30.3 ± 4.1.

In our study 14 (45.16%) patients had diabetes mellitus (D.M) while **Chan *et al.*** [13] 31% of patients had diabetes as we had larger number of female patients. In our study 18 (58.06%) patients were hypertensive, while, **Chan *et al.*** [13] 78% of patients were hypertensive, as he had more males and higher ages. In our study 10 (32.3%) patients were smokers and this goes with the study of **Chan *et al.*** [13] in which 38% of patients were smokers. In our study we found 12 (38.7 %) patients were NYHA class 2 and 19 (61.3%) patients were NYHA classes 3 and this goes with **Chan *et al.*** [13] in which 67% of patient was class 3.

In our study we found that 16 (51.6%) patients had CABG (coronary artery bypass graft) operation, 6

(19.4%) had CABG combined with valve replacement, 8 (25.8%) had valve replacement, 1 (3.2%) had aortic procedure (Bentall operation) while **Chan *et al.* [13]**, had lesser valve replacement 16% and had more aortic procedure 11% and in the study of **Filsoufi *et al.* [14]** 13% of patients had valve replacement and 19% had aortic procedure; as rheumatic fever is endemic in our community

27 (87.1%) patients had elective surgery and 4 (12.9%) patients had urgent surgery. In the study of **Chan *et al.* [13]** 25% was urgent as they had different environment and culture with better diagnostic tools.

In our study we found that the mean cross clamp time was 141.45±44.370, while in the study of **Pan *et al.* [7]** the mean cross clamp time was 174 ±16. This difference is because they had lesser number of valve replacement, a greater number of aortic and urgent procedure.

According to causative organism (wound swap, culture) of deep sternal wound infection in the studied group , we found that 6 (19.4%) patient had no growth with no mortality, 11 (35%) patient had MRSA with 5 (45%) patient mortality, 6 (19.4%) patients had S. aureus with no mortality, 2 (6.5%) patients had Candida with 1(50%) patient mortality, 2 (6.5%) patients had Pseudomonas aeruginosa with 1 (50%) patient mortality, 1 (3.2%) patient had E-Coli with no mortality, 3 (9.7%) and patients had multiple organisms without mortality. **Filsoufi *et al.* [14]** found that wound cultures were positive in (98%), in (35%) of patients, more than 1 strain was identified. The most prevalent organism was methicillin-resistant Staphylococcus aureus (MRSA) (35%), followed by Staphylococcus epidermidis (30%), methicillin-sensitive Staphylococcus aureus (22%), and Pseudomonas (17%). The difference in organisms between the studies is due to the different culture and community but the two studies showed that MRSA is the most common causative organism with a close percentage.

According to the initial method of treatment we found that 20 (64.5%) patients had open wound dressing with 7 (22.58%) mortality while 17 (54.8%) had vacuum with 2 (11.7%) mortality. The mean hospital stay with traditional method was 42.6±15.8 day while in vacuum use it was lower as the mean was 30.7±13.7 day, so vacuum use showed better wound healing, less hospital stays and less mortality. Our results are close to **Tocco *et al.* [15]** and **Petzina *et al.* [16]** studies. They reported the effectiveness of vacuum for treatment of DSWI in decreasing mortality rate and better healing. **Tocco *et al.* [15]** had no mortality as vacuum was used in all patients from the start, while in **Petzina *et al.* [16]** study, the in-hospital mortality rate after treatment of post-sternotomy mediastinitis was significantly lower in the NPWT group than in the conventional group (NPWT group 5.8% and conventional therapy group 24.5%), the length of hospital stay was 42 days ± 15.4 day in the vacuum group and 51 days ± 26.7 in the conventional group. They had lesser mortality than us in the vacuum group as they used the vacuum from the start and for longer periods.

According to the method of wound closure: (I) 10 (32.25%) patients had rewiring only with no use of flaps: 5 (50%) patients cured, 2 (20%) patients had wound complications, 3 (30%) patients died. (II) 12 (38.7%) patients had rewiring and pectoral flap used was done: 9(75%) patients cured, 2 (16.7%) patients had wound complications, 1 (8.3%) patient died. (III) 7 (22.6%) patients had bilateral pectoral flap without rewiring of the sternum: 4 (57%) patients cured, 2 (28.5%) patients had wound complications, 1 (14.3%) patient of them died. (IV) 1 (3.2%) patient had pectoral and rectus flap with no mortality or morbidity.

So, our results show that using pectoral flaps gives better success and less morbidity and mortality rates even in the most complicated patients. **Filsoufi *et al.* [14]** found that direct closure with rewiring was performed in lesser number (19% of patients), and flaps used more as musculocutaneous pectoral flap alone was used in 44% of patients, with an additional rectus flap in 26% of patients. 4% of patients had omental flap. This difference is due to better health care and more available supplies.

In our study we found that mortality rate in the patients had DSWI was 22.6%. It is close to the study of **Gwely *et al.* [1]** in which the mortality was 25%, but in **Filsoufi *et al.* [14]**, study it was 14% due to the advancement in flap use including omental flaps.

CONCLUSION

Deep sternal wound infection is still one of the serious complications of median sternotomy, which is still the main incision in open heart surgery. Despite the progress in its prevention and management it still has high incidence and high mortality rates with a heavy burden on our patients and health system.

At the end of this study, we conclude that using of vacuum and pectoral flap in DSWI management is more effective with better healing, higher success rate and less mortality. More studies should be done in this field on larger numbers, new techniques as omental flap should be considered.

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