Al-Azhar International Medical Journal

Volume 5 | Issue 5 Article 34

5-31-2024

Section: Thoracic and cardiovascular surgery

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How to Cite This Article

Reda, Ahmed; Shimy, Gamal Galal; and Mohamed, Alaa Elsayed Gadelkarem (2024) "Simple Trans Sternal Closure of the sternum Versus Figure of Eight Closure of The Sternum in Open Heart Surgery," *Al-Azhar International Medical Journal*: Vol. 5: Iss. 5, Article 34.
DOI: https://doi.org/10.58675/2682-339X.2436

ORIGINAL ARTICLE

Simple Trans Sternal Closure of the sternum Versus Figure of Eight Closure of The Sternum in Open Heart Surgery

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Abstract

Background: ***Julian's colleagues were early proponents of median sternotomy for cardiac surgery in 1957. Subsequently, it has become the conventional methodology for numerous open-heart procedures.***

Aim and objectives: ***To study the significance of simple trans sternal closure versus the figure of eight closures.***

Patients and methods: ***This was a prospective randomized research study carried out on sixty individuals presented to Aswan Heart Centre scheduled open heart surgery. The participants were randomly categorized into two groups: Group I, Which Included 30 individuals who underwent figure-of-8 closure of the sternum, and Group II, which Included 30 individuals who underwent simple interrupted closure of the sternum. The study started in January 2023.***

Results: ***There was no statistical significance among both groups concerning age, gender, height, BSA, risk factors, the number of smokers, the period of mechanical ventilation (P = 0.815), the number of hospital stays of patients (P = 0.141), and the number of patients who had inotropic support (P = 0.766). The mean maximum pain of patients in the figure-of-8 closure group was 36.60±6.34, while in the simple interrupted closure group, it was 41.67±5.24, which was statistically significant.***

Conclusion: ***The figure of eight sternal closures is equally effective and comparable to simple interrupted wiring in preventing complications such as sternal dehiscence and sternal wound infection following open heart surgery. Sternal closure's stability promotes the prevention of complications.***

Keywords: Simple Trans Sternal Closure; Figure of Eight Closure of The Sternum; Open Heart Surgery

1. Introduction

Julian and colleagues first proposed median sternotomy in cardiac surgery in 1957.[1] Subsequently, it has become the conventional methodology for numerous open-heart procedures.

While sternotomy closure may appear uncomplicated, it is full of complexities. It has been documented that sternal wound infection and dehiscence transpire in an estimated 0.5 to 5 percent of instances .[2,3] Instability of the bone fragments hinders healing and can result in complete sternal collapse, sternal wound infection, and mediastinitis, the latter of which is associated with a 14–47% mortality risk if not detected early .[4,5]

Off-midline sternotomy, osteoporosis, protracted cardiopulmonary bypass, transverse fractures of the sternum, and bilateral internal mammary artery harvesting are intraoperative risk factors. Additional risk factors for sternal dehiscence encompass protracted postoperative respiratory support, concurrent infection, chronic obstructive pulmonary disease (COPD), repeated operations, renal failure, diabetes mellitus, chronic steroid use, and obesity .[5,6]

A significant correlation exists between obesity (24 < BMI < 30) and sternal lesion infections. Patients with a body mass index greater than 30 experience an extended ventilation time in the operating room and intensive care unit (ICU). An elevated incidence of deep wound infection has been observed in individuals with high blood glucose levels. Insulin-treated diabetes is associated with an increased incidence of reoperations for mediastinitis and a lower midterm survival rate. Utilizing a pedicle internal mammary artery (IMA) represents an additional autonomous risk factor. The use of IMA increases the risk of sternal incision infection by a factor of 4 to 20 .[6]

Our research aimed to study the significance of simple transsternal closure versus figure-of-eight closure.

Accepted 21 May 2024.
Available online 31 May 2024

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https://doi.org/10.58675/2682-339X.2436

2. Patients and methods

This prospective randomized research carried out on sixty cases presented to Aswan Heart Centre scheduled open heart surgery randomly categorized into two groups: Group I included 30 cases who underwent figure-of-8 sternum closure, and Group II Involved thirty cases who underwent simple interrupted sternum closure. It started in January 2023. Cases were categorized into two groups: Group I involved thirty cases that underwent figure-of-8 sternum closure, and Group II involved thirty cases that underwent simple interrupted sternum closure.

2.1.Inclusion criteria

This includes both sexes, adult patients (40-70 years), and cases scheduled for elective open-heart surgery.

2.2.Exclusion criteria

Emergent or urgent coronary artery grafting, Redo-patient, Osteoporosis of the sternum and sternal fractures, and Combined cardiac diseases (valvular diseases, Ascending Aorta, and congenital heart defects).

2.3.Ethical consideration

All participants signed a written informed consent form explaining the study's aim before the study's initiation and after approval by the ethical committee at Aswan Heart Centre.

2.4.Methods

All patients were subjected to the following:

Preoperative assessment

History taking, Clinical examination, physical examinations, Laboratory investigations, Radiological examination, and Cardiac studies (ECG, Echocardiography, Coronary angiography).

2.5.Postoperative procedure

Pre-anesthesia

All patients received sedating medication and shaved their body hair the night of the operation. In the operating theatre, ECG electrodes and a pulse oximeter were placed for monitoring.

2.6.Anesthesia

All patients were operated under general anesthesia. Induction of anesthesia was obtained and maintained with Fentanyl IV and Propofol IV along with muscle relaxation as Atracurium Besylate 0.5 mg/kg IV. The initial dose of prophylactic antibiotics (Cefazoline, vancomycin, and Amikacin) was given with induction of anesthesia, and the second dose was given during cardiopulmonary bypass (CPB).

2.7.Surgical Procedure

In all cases, Median sternotomy was performed and cardiopulmonary bypass was instituted; the pericardium was opened and hanged. Heparin was given IV (300 units/kg, with ACT > 400). Aortic, two-stage single right atrial, and cardioplegic cannulae were inserted as usual. Two mediastinal drains were inserted. After that, the sternotomy wound was closed by the two studied techniques: Within group A, the sternum was sealed utilizing the figure of eight techniques. This involved the utilization of four complete stainless-steel wires, each of which was wound around the sternum in a manner that formed the number eight and culminated in the knotting of its two ends. Typically, the initial two wires were advanced transdermally via the manubrium, whereas the subsequent wires were advanced either parasternal or transdermally. Group B underwent sternal closure using a straightforward wiring technique. The sternum was encircled with eight parasternal sutures made of stainless steel wires; two wires were inserted through the manubrium. To ensure proper securing, the wire ends were entwined together. The contorted extremities were subsequently encased in sternal tissue.

2.8.Postoperative

Early postoperative

After finishing surgery, all cases were transferred to ICU. All cases received sedation on mechanical ventilation and monitored for vitals. Weaning from mechanical ventilation was done gradually after the following: Satisfactory respiratory functions, consciousness level, and hemodynamic data of all patients and Daily ICU routine laboratory investigations; plain chest x-ray was done daily, and ECG was done regularly. Analgesic drugs are given to all patients according to the following protocol on the first day in ICU: Morphine 20 mg IV, Paracetamol 1gm every 8 hours IV, and Diclofenac Sodium 50 mg IM every 12 hours. In the following days, patients received Paracetamol 1 gm every 8 hours IV and Diclofenac Sodium 50 mg IM every 12 hours for two days. Then, all patients received 1gm Paracetamol orally every 8 hours for two weeks: the Pain chart or visual analog scale (VAS). A chest belt was used for every patient (for two months). Each individual was subsequently transferred to the ward, where they were monitored daily for clinical and radiological evaluations of sternal dehiscence, site of laceration, cardiac and respiratory conditions, and general condition. In cases of sternal dehiscence, cases will be evaluated for superficial or deep sternal wound infection. After satisfactory case conditions were achieved, patients were discharged to home.

2.9.Late postoperative

Following discharge from the hospital, all cases of cardiothoracic surgery in the outpatient clinic were observed weekly for the initial month and monthly for the subsequent six months. Throughout this follow-up, the cases were examined routinely. Also, the sternum and the site of the wound were examined to assess any complications. Further investigations, such as chest x-ray P-A view and lateral view, were done if any complications were detected with admission to

the hospital if needed. After three months, and then after six months, all patients were followed up according to the following: Sternal stability and wound condition, Full clinical evaluation to evaluate improvement of NYHA functional class, ECG, and Echocardiography.

3. Results

There was no statistical significance among the both groups concerning age, gender,

height, BSA, risk factors and number of smokers. Table 1

The mean CPB time of patients in figure-of-8 closure group was 167.87±6.71while in simple interrupted closure group was 168.27±8.82 and this was statistically insignificant. The mean cross clamp time of patients in figure-of-8 closure group was 105.93±7.57 while in simple interrupted closure group was 107.93±9.79 and this was statistically insignificant. Table 2

There was no statistically significant variance among the both studied groups concerning duration of mechanical ventilation (P = 0.815), ICU stays of patients (P = 0.509), hospital stays of patients (P = 0.141) and number of patients who had inotropic support (P = 0.766). Table 3

Age, HBA1C, Weight, Height, BMI, EF, CPB time, Cross clamping time and number of vessels affected were assessed. HBA1C is considered the only risk factor for developing Sternal Dehiscence with significant P- value (.017). Quantitative risk factors affecting Sternal Dehiscence using one-way Anova test. Table 4

Age, HBA1C, Weight, Height, BMI, EF, CPB time, Cross clamping time and number of vessels affected were assessed. HBA1C is considered the only risk factor for developing Sternal Dehiscence with significant P- value (.017). Quantitative risk factors affecting Sternal Dehiscence using one-way Anova test. Table 5

DM, and critical lesions are considered significant risk factors for developing Sternal Dehiscence with significant P-value (.03; .0001). Table 6

The mean post sternotomy pain minimum of patients in figure-of-8 closure group was 22.43±3.40 while in simple interrupted closure group was 24.60±3.61 and this was statistically significant. The mean maximum pain of patients in figure-of-8 closure group was 36.60±6.34 while in simple interrupted closure group was 41.67±5.24 and this was statistically significant. Table 7

Table 1. Demographic data of the examined groups

VARIABLE	GROUP FIGURE-OF-8 CLOSURE (N=30)		GROUP SIMPLE INTERRUPTED CLOSURE (N=30)		T	P VALUE	95% CI	
							Lower	UPPER
AGE(YEARS) MEAN± SD	62.17±6.64		61.30±4.27		0.601	0.550	-2.02	3.75
WEIGHT(KG) MEAN± SD	89.13±4.35		88.33±6.34		0.570	0.571	-2.01	3.61
HEIGHT(CM) MEAN± SD	175.87±4.20		174.93±4.91		0.791	0.432	-1.43	3.30
BSA(M2) MEAN± SD	2.18±0.15		2.15±0.18		0.855	0.396	-0.022	0.055
	No.	%	No.	%	X2			
GENDER								
MALE	11	36.67	13	43.33	0.278	0.598	---	---
FEMALE	19	63.33	17	56.67				
SMOKING					0.617	0.432	---	---
NO	19	63.33	16	53.33				
YES	11	36.67	14	46.67				

BSA: Body Surface Area

Table 2. Intra-operative bypass time, cross clamp time and number of disease vessels among the studied patient.

VARIABLE	GROUP FIGURE-OF-8 CLOSURE (N=30)	GROUP SIMPLE INTERRUPTED CLOSURE (N=30)	T	P VALUE	95% CI	
					lower	UPPER
CPB TIME (MINUTES) MEAN± SD	167.87±6.71	168.27±8.82	0.198	0.844	-4.45	3.65
CROSS CLAMP TIME(MINUTES) MEAN± SD	105.93±7.57	107.93±9.79	0.886	0.380	-6.52	2.52

CPB: Cardiopulmonary bypass

Table 3. Post-operative care among the studied patients.

VARIABLE	GROUP FIGURE-OF-8 CLOSURE (N=30)		GROUP SIMPLE INTERRUPTED CLOSURE (N=30)		T	P VALUE	95% CI lower	UPPER
DURATION OF MECHANICAL VENTILATION(HOURS) MEAN± SD	7.51±0.14		7.52±0.06		0235	0.815	-0.06	0.05
ICU STAYS(DAYS) MEAN± SD	3.04±0.71		3.17±0.80		0.665	0.509	-0.52	0.26
HOSPITAL STAYS (DAYS) MEAN± SD	8.10±1.88		9.00±2.72		1.492	0.141	-2.11	0.31
INOTROPIC SUPPORT								
NO					X2=	0.766	--	--
YES	8	26.67	7	23.33	0.089			
	22	73.33	23	76.67				

ICU: Intensive Care Units

Table 4. Post-operative follow-up among the studied patients.

VARIABLE	GROUP FIGURE-OF-8 CLOSURE (N=30)		GROUP SIMPLE INTERRUPTED CLOSURE (N=30)		TEST	P VALUE
STERNAL DEHISCENCE						
NO					FET=	0.389
YES	28	93.33	26	86.67	0.741	
	2	6.67	4	13.33		
SSWI					FET=	
NO YES	27	90.00	26	86.67	0.162	0.688
	3	10.00	4	13.33		
DSWI					FET=	
NO YES	29	96.67	28	93.33	0.351	0.554
	1	3.33	2	6.67		
WIRE REMOVAL						
NO	29	96.67	29	96.67	0.000	1.000
YES	1	3.33	1	3.33		
REWIRING						
NO YES	30	100.00	29	96.67	1.017	0.313
	0	0.00	1	3.33		

SSWI: Secondary Sternal Wound Infection, DSWI: Deep sternal wound infection FET: Fisher's exact test.

Table 5. Comparison between Dehiscence group and Non-Dehiscence group regarding Quantitative risk factors for Sternal Dehiscence

VARIABLE	DEHISCENCE GROUP (N= 6)	NON-DEHISCENCE (N=54)	ANOVA TEST	P-VALUE
AGE(YEARS)	63.2± 4.3	60.9± 5.2	3.9	.06
HBA1C	7.3± 2.00	6.8± 2	6	.017*
WEIGHT (KG)	91± 4.5	88.4± 5.6	1.1	.283
HEIGHT(CM)	176.5± 5.9	175.2± 4.4	.38	.538
BMI	25.7± .8	25.2± 1.5	.78	.348
EF	55.16± 3.7	52± 7.2	1.08	.3
CPB TIME(MIN)	162.6± 10.7	168.6± 7.2	3.3	.07
CROSS CLAMPING TIME(MIN)	106.6± 8.7	106.9± 8.8	.006	.938
NUMBER OF VESSELS	3.3± .5	3.2± .47	.001	.99

Table 6. Comparison between Dehiscence group and Non-Dehiscence group regarding qualitative risk factors for Sternal Dehiscence

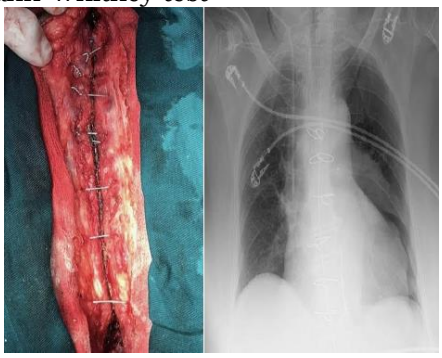
VARIABLE	DEHISCENCE GROUP (N= 6)	NON-DEHISCENCE (N=54)	X TEST	P-VALUE
GENDER (MALE)	4 (66.6%)	32 (64.1%)	.12	.54
DM	6 (100%)	30 (55.5%)	4.4	.039*
HTN	6 (100%)	44 (81.4%)	1.3	.317
COPD	6 (100%)	36 (66.6%)	2.8	.105

SMOKING	3 (50%)	22 (40.7%)	.19	.492
CRITICAL LESIONS	4 (66.6%)	0 (0%)	38.5	.0001*
INOTROPIC SUPPORT	6 (100%)	39 (72.2%)	2.2	.163

Table 7. Post-operative pain among the studied groups.

VARIABLE	GROUP FIGURE-OF-8 CLOSURE (N=30)	GROUP SIMPLE INTERRUPTED CLOSURE (N=30)	U	P VALUE	95% CI lower	95% CI UPPER
POST STERNOTOMY PAIN MINIMUM MEAN± SD	22.43±3.40	24.60±3.61	2.394	0.020*	0.36	3.98
MAXIMUM PAIN MEAN± SD	36.60±6.34	41.67±5.24	3.374	0.001*	2.06	8.07

U: Mann-Whitney test



A

B

Figure 1. A) Simple interrupted closure of sternum versus B) eight closure of sternum, postoperative.

4. Discussion

In our study, the two groups were comparable in age, height, BSA, and risk factors, as we had no statistical significance between the two groups, giving us two matched groups for the study.

Similar studies like Ramzisham et al.,[4] which was a prospective randomized clinical study, occurred between January 2007 and June 2008 and enrolled 195 patients randomized into two groups (figure-of-8 suturing group & interrupted suturing group), the average age in years was(62.5±7.5) in group A and (60.6±6.3) in group B (P 0.062) in contrast to (62.17±6.64) & (61.30±4.27) in our examined groups I & II, respectively (P 0.550). Women cases were 33% in both groups compared to 60% in our studied groups.

Our study showed that the mean cross-clamp time and Period of mechanical ventilation postoperative of patients in the figure-of-8 closure group were 105.93±7.57(in minutes) and 7.51±0.14(in hours), while in the simple interrupted closure group, they were 107.93±9.79 (in minutes) and 7.52±0.06(in hours), respectively, and this was statistically insignificant.

This correlates with the outcomes of Mourad et al.[6] in their prospective study conducted from January 2018 to the end of January 2019, which enrolled 100 cases scheduled for cardiac surgeries and compared the same two methods of sternal closure. They discovered that the mean cross-clamp time (in minutes) for group (I) was 67.22 with a standard deviation of 13.071, whereas for group (II), it was 65.22 with a standard deviation of 13.068. This variance was statistically insignificant (p-value 0.32).

Our study found that 6.76% of cases of group A (figure eight) developed sternal dehiscence. In comparison, 13.33% of cases of group B (simple interrupted) suffered the same, with no significant differences among both groups.

Our results agree with the study by Ramzisham et al.[4], which reported no significant variance in rates of sternal dehiscence among both groups.

Our study found that the frequency of SSWI and DSWI in the two groups was almost similar. 10.00% of Group A experienced SSWI, compared to 13.33% of Group B. Also, only one case from group A developed DSWI, compared to 2 cases from group B.

Abbas et al.[7] conducted a prospective study on 200 patients and found a lower incidence rate of sternal wound dehiscence with a figure of eight closures than the traditional simple method. However, asymptomatic patients with sternal dehiscence were not followed up. Therefore, it is possible that not all individuals with sternal dehiscence from either group were stated.

Concerning operation ICU stays and

hospitalization duration, we found a slight difference between the two studied groups, longer in group B but without any statistical difference. The length of postoperative hospitalization is important in dealing with sternum instability cases. This constitutes a burden to the hospital's resources concerning the cost of management and the need for second reconstructive surgery if needed.

McGrego et al.[8] investigated the mechanical impact of physiological forces on a sternum secured with seven simple interrupted steel wires. They utilized four mature human cadavers in their research. They discovered that adequate fixation is not always achieved when the sternum is closed using that technique when subjected to physiologic mechanical stress.

In our study, one case in each group required wire removal within six months after the procedure, while only one case in group B required rewiring within six months post-surgery, with no cases needed the same in group A.

Tekumit et al.[9] reported an incidence rate comparison of sternal dehiscence between the two sternal closure techniques in a retrospective cohort investigation involving 6211 patients: Closed closure is 1.43 percent. At the same time, the figure of eight is 1.46 percent. Additionally, postoperative complications and mortality rates (including chest re-exploration, inotropic agent use, delay to sternal re-fixation, and prolonged intensive care unit [ICU] stay) did not exhibit any significant variants.

Also, Abo El Nasr and Taha[10], in their retrospective study conducted on 48 patients, noted that The researchers failed to specify the technique employed to close the sternum of the patients even though sternal wire removal was an effective treatment for chronic post-sternotomy pain.

We also studied the impact of patients' risk factors on sternal stability. DM and critical lesions are considered significant risk factors for developing sternal dehiscence. A high level of HBA1C is considered the main independent contributor to disturbed sternal stability.

Our research's outcomes agree with those of Ramzisham, Aykut, and Tekumit et al. [4,9,11]

4. Conclusion

Figure-eight sternal closure is similar to and effective as simple interrupted wiring in preventing sternal wound complications such as sternal dehiscence and sternal wound infection after open heart surgery. In fact, the stability of sternal closure is a promoting factor in preventing complications.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

Funding

No Funds : Yes

Conflicts of interest

There are no conflicts of interest.

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