



## Comparison Between Different Techniques of Sternotomy Closure Regarding Early Results

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### Abstract:

**Background:** Proper sternal closure greatly reduces the incidence of sternal dehiscence and sternal wound infection. The purpose of our study is to address the effects of the different techniques of sternal closure in order to determine the standard technique.

**Methods:** The study was conducted on 150 patients and divided into three groups, A, B, and C, each including 50 cases. Regarding group A, the closure of the sternum was with a simple interrupted technique; in group B, the closure was with the figure of eight technique; and in group C, the closure was with a multi-twisted (Prakash) wire technique. Patients of the study underwent cardiac surgeries at cardiothoracic surgery departments at Cairo University and Beni Suef University hospitals during the period between September 2022 and April 2023.

**Results:** The incidence of sternal dehiscence in our study was 4%, 6%, and 8% in groups A, B, and C, respectively, with no significant differences between the three groups. There were no significant differences between the three groups regarding early postoperative complications like postoperative bleeding, wound infection, postoperative pain, and return to normal activity.

**Conclusion:** Different techniques of sternal closure as simple interrupted, figure-of-eight, and Prakash (multi-twisted wire) techniques, might have similar results regarding the development of sternal dehiscence as well as early postoperative complications like postoperative bleeding and infections.

**Keywords:** Figure of eight - Prakash – Full median Sternotomy – Wound Infection – Bleeding- Simple interrupted technique

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**Introduction:**

Full median sternotomy is the classic standard approach for the different cardiac surgeries<sup>(1)</sup>. However, there are risk factors that might have a negative impact on such an approach. The predisposing factors for sternal wound infection or sternal dehiscence include chronic obstructive pulmonary disease (COPD), patients with high body mass index (BMI), diabetes mellitus (DM), chronic kidney disease (CKD), osteoporosis, old age, smoking and factors related to surgical techniques used for closure.<sup>(2,3)</sup>

Studies of the biomechanics of sternum closure techniques have indicated that the physical forces of the body occurring through coughing and vigorous movements can lead to instability and thus increase the risk of wound infection and, therefore the risk of mortality.<sup>(4,5)</sup>

Our study compares the different techniques of sternotomy closure: simple interrupted, figure of eight & multi-twisted (Prakash) wires regarding early postoperative results in cardiac surgery patients.

**Patients and Methods:****Study design:**

This study was conducted on 150 patients who received open-heart surgery at cardiothoracic surgery departments at Cairo University and Beni Suef University hospitals through full median sternotomy during the period between September 2022 and April 2023. Patients were divided into 3 matched groups, A, B, and C, each including 50 cases. Regarding group A, the closure of the sternum was with a simple interrupted technique; in group B, the closure was with the figure of eight technique; in group C, the closure was with a multi-twisted (Prakash) wire technique. Patients under the age of 16 years were excluded. Informed written consent were obtained from all of the patients of the study. The ethical committee approval of the study was obtained.

**Preoperative assessment:**

Preoperative assessment of the patients of the study included: full history and clinical examination and full investigations in the form of ECG, chest x-ray, echo and catheter coronary angiography (if indicated) as well as full lab tests: CBC, urea, creatinine, ALT, AST, albumin, bilirubin, coagulation profile, HbA1c, and hepatitis markers

**Operative Data:**

Patients were operated upon under general anesthesia. The surgical approach used in all cases was full median sternotomy. At the end of the operation, the sternum was closed using three techniques; one for each group.

In group A, simple interrupted closure was used. Three wires were used for the manubrium, while the other five wires were for the remaining sternum. The wires were passed through the

sternum about 1.5 cm from the free edge of the sternal body (trans-sternal) or passed around the sternum (parasternal) according to the sternal width. The end of each wire was then closed in the opposite side using horizontal traction in order to bring the sternal ends close to each other. Initial twisting of all ends was done, then vertical traction of each loop before the final twisting was done. Care was taken during wire twisting to avoid excessive traction and mechanical breakdown.

In group B, closure of the sternum was with the figure of eight technique, in which four pairs of wires were used to close the sternum in figure of eight fashion. The first wire was passed through the manubrium trans-sternal while the second one was passed around manubrio-sternal junction. The remaining wires were passed either trans-sternal or parasternal according to the sternal width.

In group C, eight wires were used in simple fashion. Then, every two adjacent (consecutive) wires on the surgeon's side were wrapped around each other. Then all wires on the assistant's side were pulled towards the surgeon's side for approximation of the two halves of the sternum. Also, the same was done to the wires on the other side. Finally, the wrapped wires on both sides were twisted around each other forming knots.

Patients were transferred to cardiac ICU while ventilated. Gradual weaning from mechanical ventilation and extubation was done after maintaining the hemodynamic stability.

### Research Outcome Measures:

A- Primary (main):

Assessment of complete healing of the sternum by:

- 1-Clinical examination every 2 weeks in first 2 months postoperatively.
- 2-Radiological assessment through CT chest 2 months postoperatively.

B- Secondary:

- 1- Evaluation of wound infection in first 4 weeks postoperatively.
- 2-Evaluation of the pain symptom of patients postoperatively by using a scale for rating the pain.

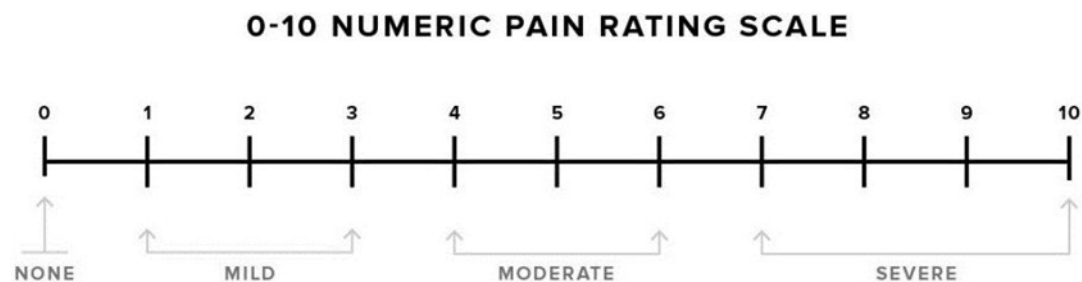


Figure (1): Numeric pain rating scale <sup>(6)</sup>

The patients rate their pain on a scale of 0 to 10. Zero means that there is no pain while 10 means that the pain is the worst ever. <sup>(6,7)</sup>

3 -Evaluation of normal activity after 2 months.

### Definitions:

Superficial wound infection was defined by involvement of the skin and subcutaneous tissues. Deep wound infection was defined by involvement of deep tissues (muscles) down to the outer table of the sternum but without sternal instability (Rocking). Mediastinitis was defined by sternal dehiscence with the presence of clinical evidence of toxemia and fever together with positive results of bacterial culture. <sup>(8)</sup>

### Statistical Analysis:

All data were revised for completeness, and logical consistency and items were then transferred to the Statistical Package of Social Science Software program, version 26 (SPSS) for statistical analysis.

Qualitative variables were described by frequency and percentage while quantitative variables were described in the form of mean and standard deviation (mean  $\pm$  SD).

A propensity matching scoring system was used to create 3 matched groups according to preoperative criteria included in the study.

The means of continuous data were compared by the student's t- test while the rates and proportions were compared by the chi- square tests. A p value  $< 0.05$  was considered significant.

### Results:

#### Preoperative data:

150 patients were divided into three groups: A (simple interrupted), B (figure of eight) and C (Prakash), each including 50 cases. The group C had the highest mean age  $49.60 \pm 8.85$  years. There were no statistically significant differences between the groups of the study regarding the preoperative data of the patients as shown in table (1).

**Table (1):** Preoperative data of the groups

Item	Group (A) (Simple interrupted) (No= 50)	Group (B) (Figure of eight) (No= 50)	Group (C) (Prakash) (No= 50)	P-value

<b>Age (years)</b>	45.32±10.52	43.64 ±13.29	49.60 ±8.85	0.062
<b>Sex:</b>				
<b>Male</b>	26 (52.0%)	28(56.0%)	30 (60.0%)	0.723
<b>female</b>	24(48.0%)	22(44.0%)	20(40.0%)	
<b>BMI (kg/m<sup>2</sup>)</b>	30.15 ± 4.4	28.89± 5.60	29.58 ± 6.63	0.367
<b>Comorbidities:</b>				
<b>-DM</b>	12 (24%)	15 (30.0%)	14 (28.0%)	0.791
<b>-Systemic HTN</b>	21 (42%)	18 (36%)	20 (40%)	0.822
<b>-COPD</b>	15(30%)	14 (28%)	17(34%)	0.803
<b>-CKD</b>	2 (4%)	2 (4%)	1 (2%)	0.813
<b>Smoker</b>	15 (30.0%)	16 (32.0%)	18 (36.0%)	0.809

### Operative data:

Coronary artery bypass grafting (CABG) surgery was the most frequently done operation. It represented 32% of operations of group (A), 26% of the operations of group (B) and 36% of the operations of group (C). Table (2) shows the distribution of different operations in the study.

**Table (2):** Distribution of different operations

<b>The Operation</b>	<b>Group (A) (Simple interrupted) (No= 50)</b>	<b>Group (B) (Figure of eight) (No= 50)</b>	<b>Group (C) (Prakash) (No= 50)</b>
<b>CABG</b>	16(32%)	13 (26%)	18 (36%)
<b>MVR</b>	13 (26%)	12 (24%)	10 (20%)
<b>AVR</b>	8 (16%)	10 (20%)	7 (14%)
<b>Double valve replacement</b>	4 (8%)	7 (14%)	5 (10%)
<b>SAM excision</b>	0 (0%)	2 (4%)	0 (0%)
<b>Supra-coronary conduit</b>	3 (6%)	0 (0%)	1 (2%)
<b>ASD closure</b>	2 (4%)	1 (2%)	0 (0%)
<b>Redo :</b>			
<b>-AVR</b>	2 (4%)	3 (6%)	5 (10%)
<b>-MVR</b>	2 (4%)	2 (4%)	4 (8%)

There were no statistically significant differences between the groups regarding the duration needed for closure of the sternum as shown in table (3). Sternal closure time begins with the

first wire that passes through the sternum till the burial of the last wire knot's tip in the muscle.

**Table (3):** Time needed for sternotomy closure

	<b>Group (A) (Simple interrupted) (No= 50)</b>	<b>(Group (B) Figure of ) (eight (No= 50)</b>	<b>Group (C) (Prakash) (No= 50)</b>	<b>P-value</b>
<b>Sternal closure time (min)</b>	13.9 ± 5.0	10.3 ± 3.3	15.3 ± 4.1	0.147

#### Postoperative Data:

All patients were transferred to ICU on mechanical ventilation. Weaning from the mechanical ventilation was done gradually after evaluation of neurological, cardiac and respiratory functions as well as making sure that all functions are satisfactory gained. In patients who needed re-exploration for bleeding control, rewiring was done with the same technique used in the primary closure with no significant differences between the groups as shown in table (4).

**Table (4):** Re-exploration for bleeding control

	<b>Group (A) (Simple interrupted) (No= 50)</b>	<b>Group (B) (Figure of eight) (No= 50)</b>	<b>Group (C) (Prakash) (No= 50)</b>	<b>P-value</b>
<b>Re-exploration</b>	5 (10%)	4 (8%)	3 (6%)	0.762

#### Follow up Data:

Patients were followed up every 2 weeks in the first two months after discharge from the hospital for assessment of the healing of the sternum as well as the sternotomy wound while assessment of normal activity of the patients and evaluation of the musculoskeletal pain related to the wound after excluding other causes of chest pain had been done after the end of the two months duration. Wound infections were managed by frequent dressings and proper antibiotics according to culture and sensitivity and in cases of sternal dehiscence surgical debridement, rewiring and augmentation with pectoral or omental flap were done. During the follow up period, there were no statistically significant differences between the study groups as shown in table (5).

**Table (5):** Follow up data between the different study groups

Item	Group (A) (Simple interrupted) (No= 50)	Group (B) (Figure of eight) (No= 50)	Group (C) (Prakash) (No= 50)	P-value
<b>Healing of sternum:</b>				
-Complete	48 (96%)	47 (94%)	46 (92%)	0.701
-Dehiscence or Rocking	2 (4%)	3 (6%)	4 (8%)	
<b>Wound infection:</b>				
-Superficial	6 (12%)	5 (10%)	7 (14%)	0.827
-Deep	2 (4%)	1 (2%)	3 (6%)	0.594
<b>Mediastinitis</b>	1 (2%)	1 (2%)	2 (4%)	0.773
<b>Normal activity (after 2 months)</b>	40 (80%)	42 (84%)	39 (78%)	0.741
<b>Pain score (after 2 months)</b>	1.25 ± 0.85	1.01 ± 0.65	1.12 ± 0.70	0.590

**Discussion:**

Full median sternotomy is the golden traditional approach for exposure of the heart and great vessels. Sternal dehiscence represents failure of healing and is considered to be a serious complication associated with a high degree of postoperative morbidity and mortality.<sup>(9)</sup> Bony union depends on adequate sternal approximation, fixation, and immobilization and on factors related to the patients in the form of following the instructions as avoidance of sleeping on either sides or lean on upper limbs.<sup>(10)</sup>

Our patient population had a lower mean age when compared with other studies.<sup>(9)</sup> This may be attributed to the inclusion of cardiac valve surgeries in our study where the rheumatic pathology is the main cause and occurring at a young age.

According to our study, the most frequently done operation was CABG; however the incidence of sternal dehiscence didn't show any relation to the type of operation in different groups.

Results of our study showed that there were no statistically significant differences in incidence of sternal dehiscence between the three groups. However, our study had a lower incidence of sternal dehiscence when compared with other studies<sup>(11)</sup>, which may be attributed to the recent time of our study with improved techniques of sternotomy closure. Some studies used a modified sternal closure technique for obese cases that significantly reduced the incidence of dehiscence compared with the standard closure technique.<sup>(12)</sup> Other

studies proved that the figure of eight technique was equally effective as the simple interrupted one in preventing sternal dehiscence. <sup>(13)</sup> The interlocking multi-twist technique was used for sternal closure in about 2000 patients with a dehiscence rate was 0.5%. <sup>(14)</sup> The lower part of the sternum had been found to be the most vulnerable site for instability, and thus reinforcement with an additional wire stabilizes the closure effectively. <sup>(15)</sup>

Regarding postoperative wound infection in our study, there were no significant differences between the different groups. The incidence of superficial wound infection was 12%, 10%, and 14% in groups A, B, and C, respectively, while the incidence of deep wound infection was 4%, 2% and 6% in group A, group B and group C, respectively after 4 weeks. Our results were nearly similar to other studies regarding postoperative sternal wound infection. <sup>(10)</sup> Similar to the results of our study, there were no differences in the degree of pain related to the methods used for sternal closure. <sup>(16)</sup>

### **Limitations:**

Our study had some limitations due to the relatively small sample size of the patients, also surgical procedures were performed by different surgical teams, however surgical techniques have not been substantially changed. So, we recommend doing future studies which should be conducted on large scale in different groups of patients to establish and suggest the most efficient technique for closure of the sternum.

### **Conclusion:**

As statistically proved from our study, the most commonly used sternal closure techniques as simple interrupted, figure-of-eight and Prakash (multi-twisted wires) techniques might have similar results in terms of postoperative sternal dehiscence, wound infection as well as postoperative pain and returning to normal activity.

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