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Original Research Article

Prakash versus figure of eight technique in sternal closure in CABG patients

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ABSTRACT

Background: Median sternotomy was recommended in 1957 by Julian for complete exposure of the heart. Despite the high importance of correct sternotomy, proper sternal closure is vital to ensure fewer post-operative complications. The sternum can be closed by wires and other methods. Sternal closure using the most suitable technique can dramatically reduce the risk of development of such complications.
Methods: It is a prospective randomized comparative study of two patient groups, each included 30 patients, diagnosed of ischemic heart disease and underwent CABG. Group A with the patients' sterna closed by figure of eight method and group B with multi-twist (Prakash) technique. Both groups were compared regarding postoperative pain and complications as superficial and deep sternal wound infections (SSWI, DSWI), wire removal and rewiring within six months of follow up.
Results: The mean of minimum post sternotomy pain in group A patients was 24.50±11.7, whereas in patients of group B, it was 27±10.1. Only two patients (group A) suffered sternal dehiscence within six months follow up. The incidence of SSWI and DSWI among both groups was almost similar with only two patient of group A needed wire removal and one of them required rewiring.
Conclusions: The multi-twist sternal closure provides better sternal stability after CABG especially in patients who are vulnerable to sternal dehiscence.

Keywords: Closure, Figure of eight, Multi-twist, Prakash, Sternum

INTRODUCTION

Approaches to expose the heart have been described for over 100 years. Initially, exposure was made through a conventional anterolateral or a posterolateral thoracotomy. As cardiac procedures evolved, these incisions were commonly extended across the sternum. Midline axial sternotomy, first described by Milton in 1887, was recommended in 1957 by Julian for a more complete exposure of the heart.[1]

Although the median sternotomy is mainly associated with cardiac surgery, it is used in a number of other operations. The incision allows access to both pleural spaces and mediastinum.[2]

Sternotomy should be performed properly to avoid post-operative complications. The surgical technique is well established and some principles are considered crucial to minimize complications such as vigilant osteotomy to decrease the risk of injury to underlying important structures.[3]

Despite the high importance of correct sternotomy, proper sternal closure is a vital procedure to ensure low risk of post-operative complications. There are different

methods of sternal closure invented for minimizing post-operative complications. These techniques include: wire techniques, staples, clips, zipfix and sternal talon.[4]

The use of stainless-steel wire to close the sternum has been used as the standard method of closing the sternum. Sternal wiring is performed through several techniques including simple wiring, repair of straight, figure of eight, and multi-twist method. Simple wiring and figure of eight are performed by using four to eight stainless steel wires that can be passed directly through the sternum (transsternal technique) or through the intercostal spaces (peristernal or pericostal technique).[5,6]

Multi-twist and Prakash techniques are performed through using multiple stainless-steel wires which are passed pericostally except in the manubrium where they are passed transsternally.[6,7]

In Prakash technique; At least 6 wires have to be passed. The wires should run around the sternum in the intercostal spaces except in the manubrium where they have be passed through the bone. Adjacent wires on the surgeon's side are wrapped around each other. The wires on the surgeon's side are then pulled towards the assistant's side by the assistant so that the sternum is re-approximated. Alternatively, the surgeon can also pull the wires at the assistant's side towards himself or herself approximating the sternum. Adjacent wires on the assistant's side are then wrapped around each other. The wrapped wires on both sides are then wrapped around each other. The wrapped wires are then twisted around with a twister, closing the sternum tightly and the ends of the wires are buried.[7]

There are several complications that can result from improper closure of sternum such as sternal instability, mediastinitis, osteomyelitis, and sternal wound infection (either superficial or deep). The incidence of DSWI is increased with advanced patient age, diabetes, obesity, smoking, steroid therapy, and COPD.[8]

The objective of the study is to compare two methods of sternal closure; Multi-twist (Prakash) and figure of eight methods in patients underwent coronary artery bypass graft surgery (CABG).

METHODS

This study was designed to be a prospective randomized comparative study that enrolled 60 patients diagnosed with ischemic heart disease and underwent CABG. Those patients were selected and divided randomly using the coin toss into two randomized groups; group A which enrolled 30 patients whose sternum was closed at the end of CABG with figure of eight technique, and group B which enrolled 30 patients whose sternum was closed at the end of CABG with Prakash (multi-twist) technique.

This study was conducted in Menoufia University Hospital and Al-Ahrar Teaching Hospital over six months from February 2018 till August 2018 after obtaining the approval of the local ethical committee and a fully-informed written consent from each patient. Both locations used the same protocols regarding the preoperative assessment, operation and postoperative management.

Inclusion criteria

- Adults
- Both genders
- Ischemic heart disease
- Single or multivessel disease for CABG.

Exclusion criteria

- Children and neonates
- Valvular heart diseases, aortic wall surgeries
- Redo CABG
- Below normal cardiac contractility (EF <55%).

All patients were subjected to the following; preoperative assessment which included full history, general and local clinical examination, routine preoperative investigations, ECG, chest x-ray, echo and catheter coronary angiography.

Operative procedure: all patients were operated under general anaesthesia, and in all cases, the used surgical approach to reach the heart was median sternotomy. At the end of the operation, the sternum was closed by using two different techniques; one technique for each group of study. In group A, the sternum was closed with figure of eight technique, in which four complete stainless-steel wires were used to close the sternum in figure of eight fashion, where the wire was passed around the sternum to form a figure (shape) of 8 before twisting its two ends around each other to form a knot. The first two wires were usually passed transsternally through the manubrium, while the remaining wires were passed either transsternally or peristernally. In group B, eight wires were used in simple fashion.

All eight wires were passed around the sternum with the first two were passed through the manubrium, and the remaining six wires were passed around the sternum (peristernally). Then, every two adjacent (consecutive) wires on the surgeon's side were wrapped around each other. After that, all wires on the assistant's side were pulled towards the surgeon's side by the surgeon to re-approximate the two halves of the sternum. Also, the same was done to the wires on the assistant's side. Then, the wrapped wires on both sides were twisted around each other forming knots.

After sternal closure, muscles were closed using two Vicryl suture, and the skin was closed using Vicryl suture size 3/0.

Post-operative management: after finishing surgery, all patients were transferred to ICU. All patients were transferred sedated and on mechanical ventilation. Weaning from mechanical ventilation was done gradually after satisfactory neurological, cardiac, and respiratory functions were gained.

Daily ICU routine laboratory and radiological investigation were performed to ensure the stability of cardiac and respiratory functions. All patients received the same protocol of analgesia. The Pain chart was obtained for all patients to compare the degree of pain in both groups of study regarding the musclo-skeletal pain after excluding other causes of chest pain.

Chest belt was used for every patient to ensure sternal stabilization with instructions to patients not to sleep on their sides or lean on upper limbs. All patients were then transferred to ward and followed up with daily assessment of patients' general, cardiac and chest conditions, site of wound, sternal instability, post-operative pain and complications such as sternal dehiscence, superficial wound infection and deep wound infection till home discharge.

In the out-patient clinic of cardiothoracic surgery, all patients were followed up weekly in the first month and monthly for six months after discharge from the hospital. During this follow up, the patients' general and cardiac conditions were examined in addition to assessment of sternotomy wound. After three months, then after six months all patients were followed up regarding sternal instability and wound condition.

Statistical analysis

All data were collected, tabulated and statistically analysed using Statistical Package of Social Science (SPSS) version 20.0 for windows (SPSS Inc., Chicago, IL, USA). P value at 0.05 was used to determine significance where P-value >0.05 to be statistically insignificant, and P-value ≤0.05 to be statistically significant.

RESULTS

This was a prospective clinical trial to compare the outcome of sternal closure by two different techniques in 60 patients diagnosed with ischemic heart disease and underwent CABG.

Table 1: Comparison between studied groups regarding demographic characteristics, personal data and risk factors of cases.

Data		Group A (No.=30)		Group B (No.=30)		Test of sig.	P value
		No	%	No	%		
Gender	Male	23	76.7	17	56.7	χ^2 2.70	0.08
	Female	7	23.3	13	43.3		
DM	Yes	11	36.7	8	26.7	χ^2 0.69	0.29
	No	19	63.3	22	73.3		
HTN	Yes	5	16.7	5	16.7	χ^2 0.00	1.00
	No	25	83.3	25	83.3		
Age (years)	Mean±SD	55.3±8.1		57.7±6.6		t 1.25	0.21
	Range	38-70		39-70			
	Median	54		59			
Weight (Kg)	Mean ± SD	81.8±11.8		78±11.2		t 1.28	0.20
	Range	65-110		60-125			
	Median	80		77.5			
Height (cm)	Mean±SD	169.4±5.7		169.4±5.6		t 1.55	0.12
	Range	158-180		155-177			
	Median	168.5		168			
Body surface area	Mean ± SD	1.92±0.14		1.86±0.13		t 1.60	0.11
	Range	1.67-2.26		1.60-2.33			
	Median	1.89		1.87			

Group A=figure of eight technique; Group B=Prakash technique; DM=diabetes mellitus; HTN= hypertension; χ^2 test = Chi square test ' t=student's t test; SD = standard deviation

Table 1 shows that the number of males to females in group A was 23:7, while it was 17:13 in group B. Both groups were homogenous regarding the demographic data as age, weight and height, and also risk factors for ischemic heart disease like diabetes and hypertension.

Table 2 reveals that; the mean of ICU stay (days) for patients of group A was 2.57±0.77 and it was 2.23±0.43 for patients of group B, and this was statistically significant.

Table 2: Comparison between studied groups regarding post-operative care.

Data	Group A No.=30	Group B No.=30	Test of sig.	P value
Inotropic support				
Mean±SD	1.47±0.68	1.70±0.59	U 0.49	0.62
Range	1-3	1-3		
Median	1	2		
ICU stay (days)				
Mean±SD	2.57±0.77	2.23±0.43	t 2.1	0.04
Range	2-5	2-3		
Median	2	2		
Hospital stay (days)				
Mean±SD	7.83±1.53	7.43±0.50	t 1.3	0.18
Range	7-15	7-8		
Median	7.5	7		

Group A=figure of eight technique; Group B=Prakash technique; t=student's t test; U=Mann-Whitney test; SD = standard deviation

Use of inotropic drug support in both groups was statistically insignificant with mean 1.47±0.68 for group A and 1.70±0.59 for group B.

The hospital stays ranged from seven to 15 days in group A with mean 7.83±1.53 and 7 to 8 days with mean 7.43±0.50 in group B, and this was considered statistically insignificant.

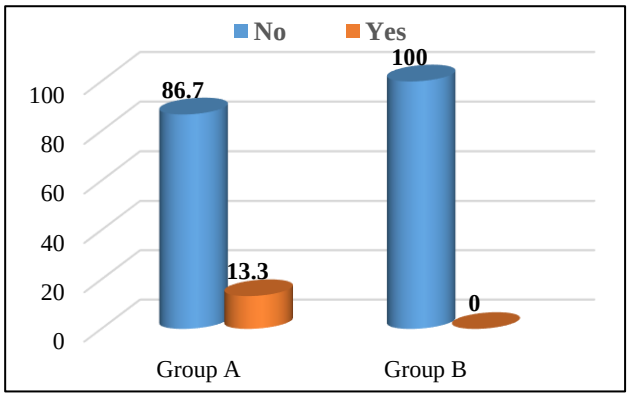

Figure 1: Comparison between studied groups regarding reoperation for bleeding.

Table 3 shows that four patients in group A were re-explored surgically due to bleeding in comparison to no patients had the same in group B (Figure 1), and this was significant statistically. While 11 patients in group A suffered chest infection, nine patients in group B had the same, and this was statistically insignificant.

Regarding wound hospital acquired infection, four and five patients in group A and B respectively experienced this without significance in statistics (Figure 2).

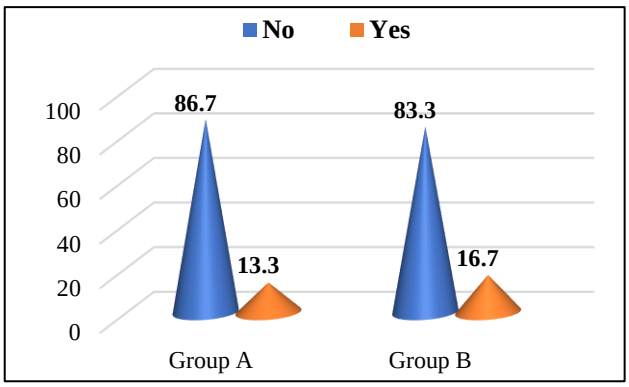

Figure 2: Comparison between studied groups regarding hospital wound infection.

The mean of minimum degree of post sternotomy pain on Visual Analogue Scale (VAS) (graded from 0 to 100) among patients of group A was 24.50±11.7 whereas in patients of group B, it was 27±10.1 hence it was statistically insignificant (Figure 3).

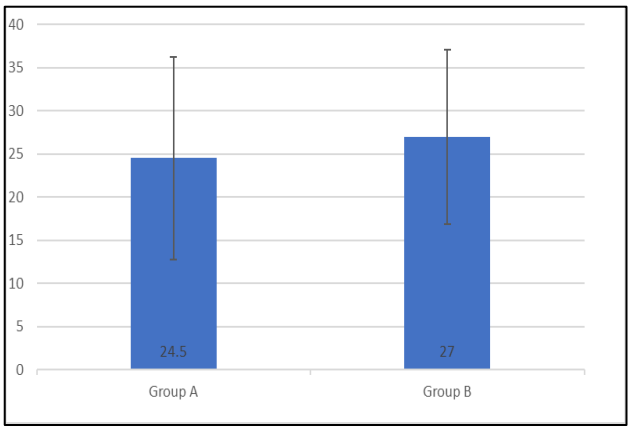

Figure 3: Comparison between studied groups regarding the minimum post sternotomy pain.

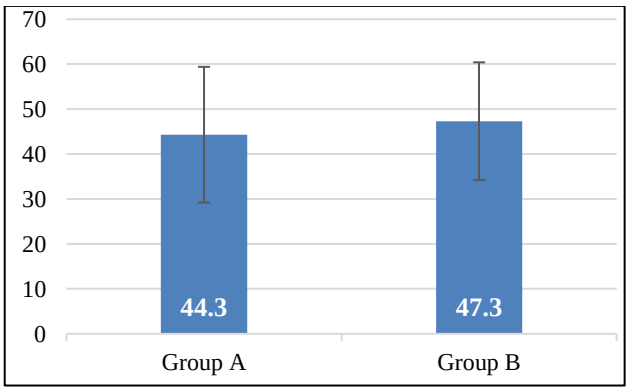

Figure 4: Comparison between studied groups regarding the maximum post sternotomy pain.

The range of maximum degree of post sternotomy pain was almost the same among the patients of groups A and B, and this was statistically insignificant (Figure 4).

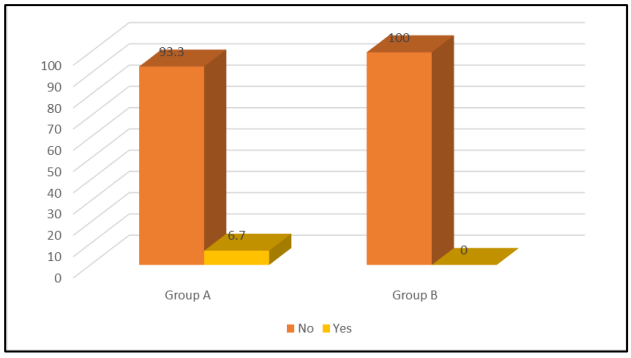

Figure 5: Comparison between studied groups regarding sternal dehiscence within 6 months.

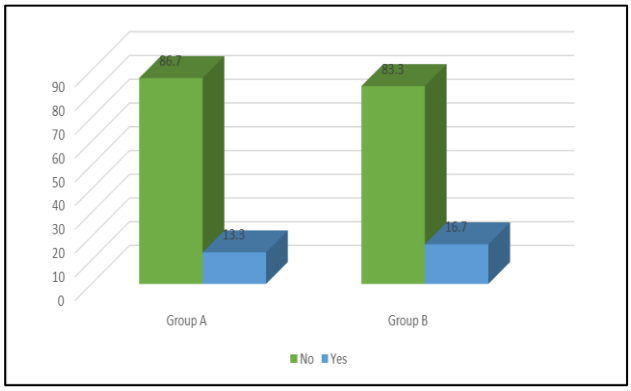

Figure 6: Comparison between studied groups regarding SSWI within 6 months.

All patients in both groups received the same fixed protocol for pain management.

Table 4 shows the follow up of all patients of the study within six months after surgery. Out of 30 patients of group A, only two suffered sternal dehiscence compared to no patients of group B had the same, and this was statistically insignificant (Figure 5).

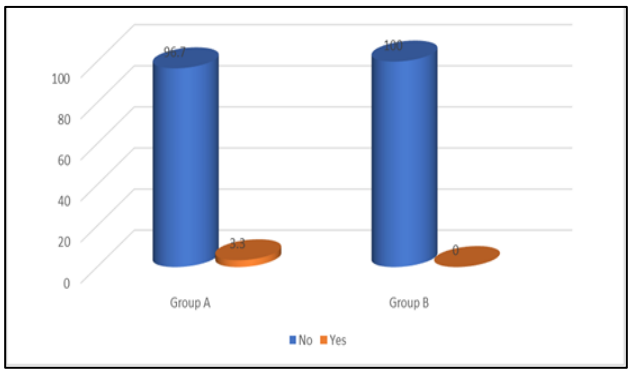

Figure 7: Comparison between studied groups regarding DSWI within 6 months.

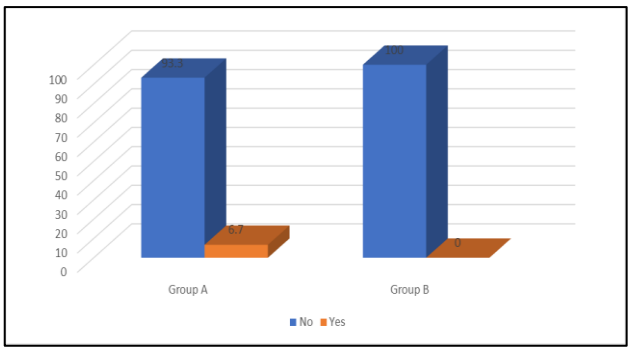

Figure 8: Comparison between studied groups regarding wire removal within 6 months.

The percentage 13.3% of patients of group A who developed superficial wound infection within six months after surgery was comparable to that 16.7% of patients of group B, and this was insignificant statistically (Figure 6).

Regarding deep wound infections, only one patient in both groups of study developed this within six months after surgery (Figure 7).

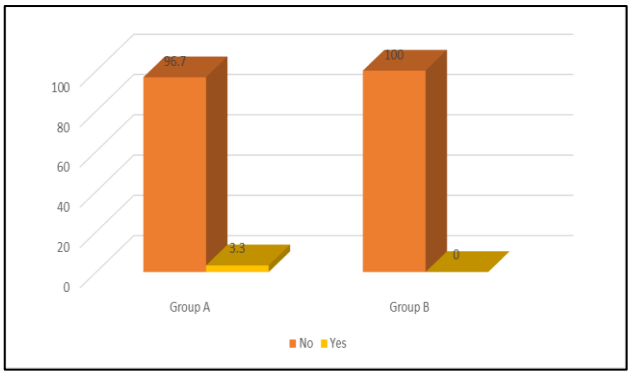

Figure 9: Comparison between studied groups regarding rewiring within 6 months.

While there was not any patient in group B who needed wire removal or rewiring within the first six months after surgery, two patients in group A needed to remove wire (Figure 8) and one patient needed rewiring (Figure 9), and both were statistically insignificant.

DISCUSSION

The median sternotomy incision was first described for use in cardiac surgery in 1957. Although sternal separation or dehiscence is a rare complication of median sternotomy (0.5-2.5%), it carries a mortality rate between 10% and 40%. Sternal instability, wound infection, osteomyelitis and dehiscence are related. The most important factor in preventing sternal dehiscence and mediastinitis is a stable sternal approximation.[9,10]

The current standard for sternotomy closure remains the method of wire cerclage. Wiring of sternum has several

different techniques that include, simple (straight), figure of eight, Robicsek and multi-twist techniques.[9,11] The purpose of this study was to analyse the efficacy of sternal closure by figure of eight technique versus multi-twist technique to prevent post sternotomy wound complications.

Table 3: Comparison between studied groups regarding post-operative pain and complications of cases.

Data		Group A (No.=30)		Group B (No.=30)		Test of sig.	P value
		No	%	No	%		
Reoperation for bleeding	No	26	86.7	30	100	Fisher's exact test 4.2	0.05
	Yes	4	13.3	0	0		
Chest infection	No	19	63.3	21	70	χ^2 0.30	0.39
	Yes	11	36.7	9	30		
Hospital wound infection	No	26	86.7	25	83.3	Fisher's exact test 0.13	0.71
	Yes	4	13.3	5	16.7		
Post sternotomy pain VAS (minimum)	Mean±SD	24.50±11.7		27±10.1		U 0.85	0.39
	Range	5-52		6-52			
	Median	24		27			
Post sternotomy pain VAS (maximum)	Mean±SD	44.3±15.1		47.30±13.1		U 1.11	0.26
	Range	20-84		21-81			
	Median	41		47			

Group A=figure of eight technique; Group B=Prakash technique; χ^2 test = Chi square test; VAS= visual analogue scale; U=Mann-Whitney test ; SD = standard deviation

Table 4: Comparison between studied groups regarding post-operative follow-up of cases.

Data		Group A (No.=30)		Group B (No.=30)		Fisher's exact test	P value
		No	%	No	%		
Sternal Dehiscence within 6 months	No	28	93.3	30	100	2.06	0.15
	Yes	2	6.7	0	0		
Superficial wound infections within 6 months	No	26	86.7	25	83.3	0.13	0.71
	Yes	4	13.3	5	16.7		
Deep wound infections within 6 months	No	29	96.7	30	100	1.01	0.5
	Yes	1	3.3	0	0		
Wire removal within 6 months	No	28	93.3	30	100	2.06	0.15
	Yes	2	6.7	0	0		
Rewiring within 6 months	No	29	96.7	30	100	1.01	0.50
	Yes	1	3.3	0	0		

Group A=figure of eight technique; Group B=Prakash technique

This study encompassed 60 CAD patients who underwent CABG. Patients were divided into two equal groups; group A with its patients' sterna were closed by figure of eight technique, and group B with sternal closure was performed by multi-twist (Prakash) technique.

Both groups were homogenous regarding the demographic data and also risk factors for ischemic heart disease like diabetes and hypertension.

Present study found that 6.7% of patients of group A (figure of eight) developed sternal dehiscence within six months while no patients of group B (multi-twist) suffered the same. Although this was statistically insignificant, but it correlated with the results of Casha et al.[12] In 1999, Casha et al, described the method of sternal closure with interlocking multi-twist technique. They used this method in more than 2000 patients over ten years. The dehiscence rate was only 0.5%.[12]

Schimmer et al, found that Robicsek technique of sternal closure was superior to conventional sternal closure in preventing dehiscence and DSWI in a study that included 84 patients with different types of surgeries requiring sternotomy.[11]

On contrast, shortly after the previous study, the same author with other colleagues explained that there was no difference between simple wiring and Robicsek sternal closure in preventing sternal dehiscence, SSWI and DSWI in a prospective randomized study.[13]

By comparing figure of eight to interrupted stainless steel wire sternal closure in a prospective randomized clinical trial, Ramzisham et al, proved that figure of eight sternal closure was equally effective as simple interrupted suturing in preventing sternal dehiscence after CABG.[14]

Losanoff et al, compared biomechanically five different sternal closure techniques using 53 fresh adult human cadaveric sterna. They concluded that the mechanical stability of peristernal and alternating peristernal and transsternal wires was significantly greater than that of the other tested methods.[15]

By using a mechanical testing system, Dasika et al, found that lower sternum is the site of greatest instability and that reinforcement of this area with an additional wire effectively stabilizes the closure. They also explained that Figure-of-eight wires were not superior to simple wires.[16]

In a study conducted by McGregor et al, they mechanically examined the effect of physiological forces on sternum closed by seven simple interrupted steel wires. Their study involved four adult human cadavers. They found that closure of sternum with that technique does not always provide adequate fixation when the closure is subjected to physiologic mechanical stress.[17]

In present cohort, authors found that 13.3% of group A experienced SSWI, compared to 16.7% of group B. Also, only one case (group A) developed DSWI in both groups. While our study included only patients underwent CABG, the study performed in The John Hopkins Hospital included all kinds of operations required sternotomy.

In a retrospective study performed at The John Hopkins Hospital from March 1994 to February 2004, a total of 12,380 median sternotomies were performed. All sternotomies performed between 1994 to 2002 were closed by six or seven single stainless-steel wires tightened by multi-twist technique. After 2002, double wires closure done through multi-twist method. Only 0.39% of the study group experienced a non-infectious sternal dehiscence while 2.4% developed an infectious sternal dehiscence.[18]

In present study, two cases in group A (figure of eight) required wire removal within six months after CABG with no patients needed the same in group B. one of those two patients needed rewiring within the first six months after surgery.

Casha et al, tested the rigidity of interlocking multi-twist wire closure biomechanically in a metal sternal model along with five different fixation techniques. They concluded that the multi-twist sternal closure was the most rigid among all methods tested.[9]

The study carried out by Casha et al, differed from current study in patient selection. They did multi-twist sternal closure particularly in patients at a higher risk of sternal dehiscence, while our cohort's patients were homogenous regarding risk factors without statistical significance.

Although many studies proved the efficacy of Robicsek sternal closure in preventing sternal dehiscence and SSWI or DSWI like Molina et al and Schimmer et al, current study along with the study carried out by Casha et al. found that multi-twist sternal closure was highly effective in preventing sternal dehiscence and DSWI. The SSWI rate in present study in multi-twist sternal closure was comparable to that of figure of eight sternal closure.[11,12,19]

In present study, authors didn't find any difference in degree of pain related to the method used for sternal closure in both groups. This was evident by the scores patients of both groups made on visual analogue scale which were almost the same.

While Abo El Nasr et al, in their retrospective study, found that removal of sternal wires was effective in management of chronic post-sternotomy pain, their study didn't mention the technique used for sternal closure done to their patients.[20]

In conclusion, it is well established that there are several risk factors that lead to post-sternotomy complications. Most authors agree that the most important one is sternal stability after closure.[9,13,14,21]

While many studies were performed to compare sternal closure methods, till now there is no ultimate method that gained the full support from all surgeons. In present study, authors compared two techniques and concluded that, regarding sternal stability, the multi-twist sternal closure showed better results than figure of eight technique despite the difference between both methods was not statistically significant mainly due to small number of patients involved in the study. Concerning post sternotomy pain, sternal wound infection, and wire removal, none of both techniques was superior over the other.

Recommendations

On the basis of these findings, authors recommend using multi-twist technique for sternal closure especially for patients in high risk of post-operative sternal instability.

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