Pak Heart J

FIGURE-OF-8 STERNAL CLOSURE VS SIMPLE INTERRUPTED STERNAL CLOSURE IN REDUCING STERNAL DEHISCENCE IN PATIENTS WITH CORONARY ARTERY BYPASS GRAFTING (CABG)

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Date Received: April 05,2016
Date Revised: September 17,2016
Date Accepted: January 19,2017

Contribution

SG, SA conceived the idea, planned the study and drafted the manuscript. MI, AA helped in acquisition of data& did statical analysis. TK, JSK drafted and critically revised manuscript. All authors contributed significantly to the submitted manuscript.

All authors declare no conflict of interest.

This article may be cited as: Abbas S, Gul S, Abbas A, Iqbal M, Khan T, Khan JS. Figure-of-8 sternal closure vs simple interrupted Sternal closure in reducing sternal dehiscence in Patients with CABG. Pak Heart J 2017; 50 (02): 94-9.

ABSTRACT

Objective: To compare the frequency of sternal wound dehiscence in patients undergoing CABG with figure-of-8 vs simple interrupted sternal closure.

Methodology: This randomized controlled trial consisted of patients of either gender aged 40-70 years, undergoing elective CABG at Cardiothoracic Surgery Unit, Punjab Institute of Cardiology, Lahore, Pakistan, from 17th July 2012 to 27th August 2012 . These consented patients were randomly grouped for figure-of-8 (Group A) and simple interrupted sternal wire closure (Group B). Demographical data, diabetes mellitus and smoking, cardiopulmonary bypass and cross-clamping time and postoperative sternal dehiscence were recorded. Patients were observed at 2 weeks follow up.

Results: About 200 patients with 100 in each group, were included with mean age of 52.92±7.9 years, male to female ratio of 3.4:1, mean weight of 72.155±9.6 and average height of 166.72 cms, while BSA was 1.81±0.14 kg/m^2. Diabetes Mellitus was found in 95 patients while 70 patients were smokers. Mean CPB time was 101.035±35.7 (range 50-235 min) and cross clamp time 54.955±21.4 min. There were 10 sternal dehiscence cases: 2 in Group A and 8 in Group B. Five patients were asymptomatic and without infection. Dehiscence was found in elderly, diabetic, overweight patients with increased CPB and Cross clamp times. Group A had less frequency of dehiscence.

Conclusion: Applying figure of 8 sternal steel wires significantly reduced incidence of sternal wound dehiscence in CABG patients significantly.

Key Words: Sternum; Wound; Dehiscence; Coronary artery bypass grafting

INTRODUCTION

Since its very beginning in 1957 midline sternotomy is established as the gold standard for variety of open heart operations, however, not without adverse effects.[1] Sternal dehiscence after the operation is recognized devastating complication, having incidence rates from 1%-25%.[2,3] When not recognized during early postoperative period, it may result into complete sternal breakdown, infection, and thus into full blown mediastinitis, the later is linked with mortality ranging from 14% to 47%.[3,4]

More than a three dozen varieties of sternal closure techniques have been known, all been claimed for superior postoperative stability of sternum.[5] The established closure technique uses steel wires in either figure 8 or simple interrupted suturing methods. In this typical technique, the steel wires are pushed across the each half of sternum, however peristernal and pericostal placement appears to reduce sternal damage and weakening of sternal wire.[4-6] Movement of sternum and its stability may be compromised within first few weeks postoperatively secondary to some unavoidabe technical problems in bone, wire or surgical technique itself.[2, 7,8] Moreover,better results can be achieved when sternotomy closure results into marvelous rigidity with strength.[4,9]

Some researchers are strongly in favour of figure of 8 sternal wire closure technique, however is not adopted by many others, thus not falling into category of Gold standard approach [7,8].Additionally, AykutKet al found dehiscence in 9.33% sternal closures through figure of 8 wire closure [7]. Moreover, Song DH et al, discovered that among 207 cases just 1.35% patients got wound dehiscence and in these patients simple interrupted closure technique was performed [8]. Thus due to lesser available supporting evidence, lack of randomization and conflicting data regarding Figure of 8 Closure technique Kiessling AH et al found 12% incidence of sternal wound dehiscence, whereas Ramzisham et al described no difference for figure of 8 closure when compared to simple interrupted sternal wire closure. Surprisingly, Snyder et al found wound dehiscence in as much as 12% of patients who were treated with simple interrupted wire closure, a finding in contrast to previous researchers.[3,4,6,9] Additionally, researchers are struggling to devise latest, costly and difficult approaches to reduce wound dehiscence, when this fairly simple figure of 8 wire closure is available.

Thus, secondary to such disputed researches, where there is lack of randomization, but with regular application of both methods without any comparative studies made, and when there appears no such study known in our population (with particular classes of risk factors quite different from other populations studied thus far), this study aims to compare the effects of figure 8 technique and simple wire technique for closing sternum, as an etiologic factor for development of sternal dehiscence in those patients who get operated for Coronary Artery Bypass Grafting.

METHODOLOGY

Conducted at Department of Cardiovascular Surgery, Punjab Institute of Cardiology Lahore, this randomized control trial was done from 1st July 2012 till 31st August 2013. Cases were collected in sample with 5% level of significance, 80% power of test and placing %ages of wound disruption in both subsets i.e. in Figure 8 technique 9.33% versus 1.35% in simple interrupted technique in patients for CABG. Non-Probability sampling method was used. Patients, whether male or female, aged 40-70 years, those opted for elective CABG were placed in this research. However, cases of non-elective Coronary artery grafting, Reoperative CABG Surgery, and osteoporosis of sternum, associated cardiac diseases (pre-op echocardiographically or angiographically detected damage to valves, aneurysm of Ascending Aorta and congenital birth disease,), COPD, chronic cough, high BMI (body mass index, $\geqslant 30\ kg/m^2$) were not included in this study.

Some operating team of the institute performed all cases in this study. Preopeartive assessment was performed as per Institute protocol. Cardiopulmonary bypass with body cooling 28-34°C, Cardiac diastolic arrest via hyperkalemic blood cardioplegia was used as per policy. In all cases, stainless-steel no.5 wire were applied for closing together sternal halves, primarily using any one distinct techniques: figure 8 or simple interrupted method. In figure 8 method exact three steel wires were pierced parasternally (two at the sternal body whereas one at the manubrium) (Figure1), in contrast to simple technique where we placed 2-3 interrupted steel sutures into manubrium and 4 steel wires at lateral sternal border. After sternal closure standard skin and facial closure was performed.

Once informed written consent was obtained, cases were randomly grouped either for figure 8 sternal wire closure or for simple steel wire closure. This was based on computer generated randomization. We collected data in individual patient especially associated risk factors for the occurance of sternal disruption e.g. demographic record, risk factors found before operation (smoking & Diabetes Mellitus), intraoperative risk factors (cardiopulmonary bypass and X-clamp times) and postop sternal wound dehiscence. After operation the we managed the patients during ICU stay and then at least 2 weeks follow up, to detect signs of sternal wound dehiscence (end point variable) (Figure 2). Available patient data was also analyzed for certain risk factors (diabetes & smoking) so that effect modifiers may be addressed.

SPSS v.21 (Statistical Package for Social Sciences) was utilized for analyzing available record. Frequency tables,

Figure 1: Figure of 8 Sternal Closure Technique

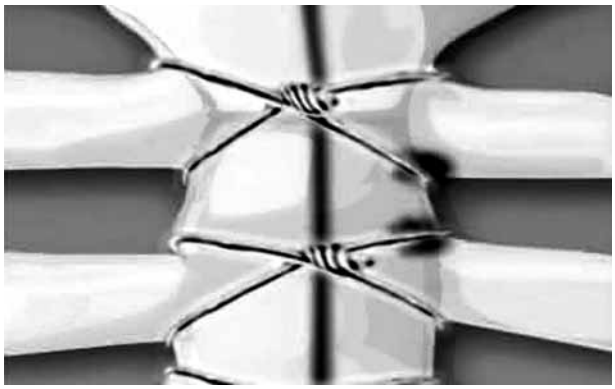
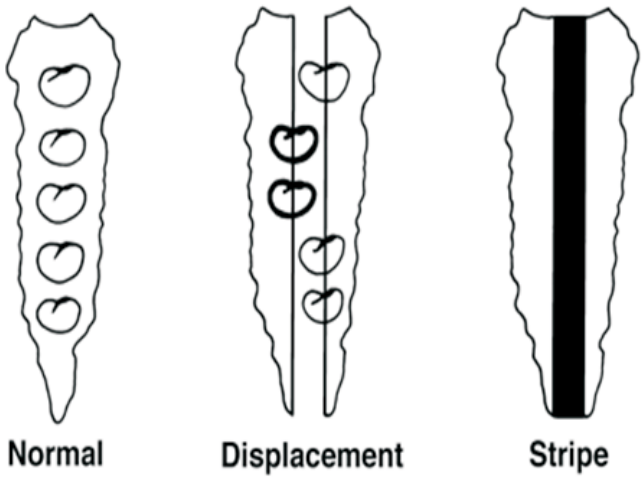


Figure 2: Radiographic Signs of Sternal Dehisecence



percentages and graphs and charts were used for all qualitative variables, e.g. gender and sternal wound dehiscence. All quantitative variables were illustrated as mean±standard deviation and bar charts. For both Groups A & B frequency of sternal wound dehiscence was compared with the help of chi-square test. A significant value was considered if $p \leqslant 0.05$.

RESULTS

In this study 200 cases were enrolled, 100 cases each in Group A and B. The age of patients ranged from 40-70 years, with mean of 52.92±7.9 years. The 4/5th of patients were aged ⩽ 60 years. Female: Male ratio observed as1:3.4. The weight of patients varied between 58-100 kg whereas mean weight was 72.155±9.629kg. Surprisingly, in 76.5% of patients, the weight was <80kg. The mean height being 166.72 cm, whereas body surface area calculated as 1.81±0.149 kg/m^2.In 59% of patientsthe height was ⩽ 169cm, and BSA in 70% patients was ⩽ 1.91 kg/m^2. In 95 (47.5%) patients diabetes mellitus was diagnosed whereas in 70 (35%) patients, history of smoking was present. The average CPB time calculated as 101.035(±35.708) (ranged 50-235 minutes), while time on cross clamp was noted as 54.9(±21.4244) (ranged 23-129 minutes).

The total sternal wound dehiscence rate accounted for 5 %. A total of ten sternal dehiscence cases were documented: 2 patients belonged to Group A whereas 8 belonged to Group B (Table 1). Five out of ten patients remained without any symptoms and infection. The diagnosis was accomplished with history and examination findings, augmented with radiologic evidence. Infected sternal dehiscence was detected in only single patient among group A. About 6 cases were ⩽ 60 years in age, 9 male patients, and 7 diabetic patients whereas no one was smoker. Weight of more than 81kg was found in 5 patients, in 3 patients the height was greater than 171cm and BSA in five patients was over 1.92 kg/m^2. In 9 patients overall operative time accounted > 305min, CPB time is six patients was calculated as > 130 min while time on cross clamp as>63 min. A total of 7 (70%) patients got dehiscence on 12th or 13th day. Significant statistic difference was detected among both sternal closure techniques and sternal dehiscence($p=0.026$), as shown in Table 2.

Table 1: Demographic Variables and their Relation to Sternal Dehiscence in Study Population (n=200)

Variables	Group A (M±SD)		Group B (M±SD)	
	Dehiscence	No Dehiscence	Dehiscence	No Dehiscence
Age (years)	51.00±12.72	52.30±8.25	54.88±8.58	53.46±7.62
Gender (M/F)	2/0	76/22	7/1	70/22
Weight (kg)	79.50±21.92	72.17±9.60	76.00±13.04	71.64±9.13
Height (cms)	174.00±8.49	166.09±7.88	170.25±9.94	166.91±9.21
BSA	1.94±0.29	1.81±0.15	1.88±0.20	1.81±0.15
Diabetes Mellitus	2	44	5	44
Smoking	0	35	0	35
Mean CPB time (min)	70.0±14.14	97.78±33.69	149.62±53.85	100.95±33.36
Mean Cross Clamp time (min)	35.00±11.31	56.02±21.82	75.25±30.85	52.48±19.21

Table 2: Sternal Dehiscence in differnet Sternal Closure Techniques in Study Population (n=200)

Sternal Dehiscence		Sternal Closure Technique		P-Value
		Figure of Eight (Group A)	Simple Interrupted (Group B)	
	Yes	2	8	0.026
	No	98	92	
Total		100	100	

DISCUSSION

Thoracic Surgery was revolutionized by Julian in 1957 with invention of midline sternotomy to access intrathoracic viscera.[1]Even now this same recognized technique exists for exposure of heart, although it is linked with many sternal wound adverse effects e.g., infection and dehiscence. These undesired effects result into longer hospitalization time, heavy management costs, worse morbidity, and even mortality. Since its introduction sternotomy is related to wound infection and dehiscence in approximately 0.5-8.4%.[10-12]Additionally, incidence of sternal dehiscence has been established in 4.5% of CABG.[11-12]

Careaga Reyna and colleagues detected variety of risk factors associated with sternal dehiscence, but without infection; these include ⩾46 years of age, use of antiplatelet and beta blocker medications, postoperative infections like pneumonia. [13] Our study noticed that patients were>50 years age in 2/3rd patients with wound dehiscence. Diabetes Mellitus, Obesity, COPD, prolonged surgical bypass time, grafting with internal mammary artery, redo surgery for mediastinal hemorrhage, and longer ICU ventilatory support have also been proposed as predisposing factors.[14] In our study we have analyzed smoking and Diabetes Mellitus as the risk factors and have detected diabetes mellitus in significant relation with sternal wound dehiscence (p=0.000), though no such relation was found with smoking. In our study, we excluded patients with obesity, however included patients who were overweight. Nevertheless, higher weight was linked with wound dehiscence in this study (p=0.006).

Sternal dehiscence may be clinically insignificant in few cases, but is a physical finding. Early diagnosis is necessity for successful management of patients[15]. Thus, determining whether radiography could be of any help in sorting out this complication is matter of debate.[16] Two important signs on radiography were proposed: the median sternal stripe sign and the other one as sternal steel wire displacement. We have however, detected that presence of median sternal stripe sign is not related to diagnosis of sternal wound

dehiscence. In contrast, sternal wire displacement is a very valuable sign on radiograph which plays significant part in reaching diagnosis of such adverse event.

More than few dozens of techniques were formulated to get highest sternal stability, however each technique has its pros and cons.[16] Nevertheless, two most frequently closure techniques for sternotomy used in thoracic surgical procedures are simple interrupted wiring procedure and figure 8 wiring.[16] Though such two techniques ass assessed by biomechanical stress evaluation is of significance, but these tests are no parallel to the clinical trials. This is because the experimental model comprised of gradually inclining tension which might not relate with real time physiologic stress in humans. The researches of Casha, Krejca, Shih Glennie and Dasika were outstanding, however unable to mark superiority of one technique over another [17-21]. These all studies failed to propose significant change between simple wires and figure 8 wires as regards sternal stability and at the same time they all proposed enhancement of the lower 1/3rd sternum with more wires. In contrast, we put 2 figure 8, or 3 simple interrupted stenal wires in lower 1/3rd of sternum to provide superior lower sternum stability.

Losanoffet al and Casha et al worked on animalsand adult human cadavers,detected no important difference between bothsternal closure techniques, as regards strength of the wire[22,23]. No biomechanical study was performed in our study however.

Ramzishamet al placed 6–8 interrupted wires or 4 figure 8 wires; both techniques appear to provide higher strength and prevention of sternal dehiscence, however without any superiority over each other [24]. Asymptomatic patients made the majority number, and the diagnosis was confirmed on a median sternal strip sign on chest X Ray.

Casha et al reported wound dehiscence rate of 0.5% in 2000 patients, additionally Goodman et aldescribed relatively same incidence of sternal dehiscence with figure-of-eight wire sternal closure[24,25]. In contrast advantage of figure 8 technique was proposed by Sharma et al describing sternal dehiscence incidence of 1/386 [26]. In our study compared with above authors, detected that figure of 8 technique allows oblique and horizontal angulations of shearing against direct perpendicular forces, predominantly in high risk patients, thus proposing that this closure technique is less likely to disrupt or loose.

Murray et al, demonstrated that figureof 8 distributes any shear stress over more area and reduces not only lateral but also longitudinal movement. [27] Murray et al applied such method as routine for all midline sternotomy incisions closed in 86 patients, and for an additional 34 high risk cases. None of their patients developed wound dehiscence therefore recommended such modified technique predominantly for high risk surgeries. DiMarcoet al described the figure of 8 closure in a clinical trial of 978 continuous surgeries, however, not a single case had mediastinitis or wound dehiscence[28]. Ramzishamet al found same wound dehiscence rate with both techniques (1.46% for figureof 8 technique whereas 1.44% for simple wire closure) [4]. Incidence of non infected wound dehiscence was 6.5%, and with infection of 1.5%, is comparable to findings of many experiments showing sternal wound dehiscence with mediastinitis in 1%–5% of patients.[28]

In our study, 5% (n=10) of patients were found to have wound dehiscence over 2 weeks postoperatively. Such number relates to internationally available data. About 80% of patients with sternal wound dehiscence belonged to Group B. In a clinical study on obese patients, Kiesslinget al placed 3 figure of 8 steel wires [10]. They found lower sternal instability (2%) in contrast to standard closure (12%). In another study by Olbrecht et al wound dehiscence incidence of 0.39% was reported along with sternal motion and instability found usually within the first couple of weeks postoperatively, before clinical significant healing [2].

Ramzishamet al detected mortality of 11.1% once there appeared wound dehiscence, however, not influenced by type of sternal wire technique used for closure [4]. In our study, none died or was reopened, this may be secondary to meticulous approach performed to negate involvement of any risk factor for sternal dehiscence in patients.

We analyzed impact of both cardiopulmonary bypass and cross clamp on the incidence of sternal wound dehiscence, and found that these two factors are directly associated with dehiscence (p=0.006 & p=0.031 respectively). Results of our study are in line with studies of Ramzisham, Aykut, and Tekumit et al [4,5,7].

LIMITATIONS

Limitations of our study were unavailability of complete record from the huge number of patients who progressed to sternal closure post-sternotomy but were not able to develop wound dehiscence. Secondly, cases of two groups operated at two different frames of time, by various surgeons. Such data may provide insights for upcoming researches that would test the effects of these two sternal wire closure techniques.

CONCLUSION

We propose that application of figure of 8 sternal steel wires decreases the incidence of sternal wound dehiscence remarkably, in comparison with simple interrupted sternal steel wire closure method post-CABG. Thus this technique may be used primarily to decrease the development of a morbid complication of sternal dehiscence in open heart surgery.

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