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Prevention of Sternal Dehiscence Following Use of Bilateral Internal Mammary Arteries in OPCAB

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Abstract

Purpose: We harvested bilateral Internal Mammary Arteries and made LIMA-RIMA Y in all the patients undergoing OPCAB at our center irrespective of the presence or absence of various risk factors for sternal dehiscence. The purpose of this study was to find an effective way of sternal closure in patients undergoing OPCAB with both the Internal Mammary Arteries harvested for grafting. **Method:** The patients who did not have any risk factors were placed in group I and all of them had a standard six wire closure of sternotomy. The patients having any risk factors were placed in group II. The patients in group II were randomized by including every alternate patient from group II to subgroup II A and every other alternate patient from group II to subgroup II B. Patients in subgroup II A again had a standard closure of sternotomy while in patients of subgroup II B bilateral Robiscek repair and four-five interlocking figure of eight wires were used for closure of sternotomy. **Results:** The patients who had risk factors for sternal dehiscence had higher risk for sternal dehiscence as compared to patients without any risk factors if bilateral Internal Mammary Arteries were harvested for OPCAB. But if we used bilateral Robiscek repair with four to five interlocking figure of eight wires for sternal closure then the rate of sternal complications in the patients with risk factors for sternal dehiscence was not more than the patients without risk factors. **Conclusion:** We can harvest bilateral Internal Mammary Arteries for OPCAB without fear of sternal complications even in patients with high risk for sternal dehiscence if we use bilateral Robiscek repair with four to five interlocking figure of eight wires for sternal closure.

Keywords

Robiscek Repair, Interlocking Figure of Eight Wires, Sternal Dehiscence, Bilateral Internal Mammary Arteries

1. Introduction

Sternal dehiscence after median sternotomy is a serious complication and may lead to prolonged hospitalization, increased cost of care and significant mortality [1] [2] [3] [4]. Use of bilateral internal mammary arteries for revascularization of heart is one of the risk factors for sternal dehiscence in patients undergoing coronary artery bypass grafting [5]. Standard closure after median sternotomy re-approximates the sternum using steel wires with a simple suture technique or figure of eight configuration. However, this closure technique has been associated with several serious complications that have prompted surgeons to look for new methods of sternal closure. It has been said that rate of these complications is higher if bilateral Internal Mammary Arteries (IMAs) have been harvested in a case of coronary artery bypass grafting. This risk is even higher if the IMAs have been harvested with pedicle because it compromises the blood supply to sternum, whereas if the skeletonized IMAs have been used it preserves the blood supply to sternum and risk of sternal complications is less. These complications include sternal instability, dehiscence and mediastinitis as a result of bone non-consolidation or bone disruption caused by steel wires. These conditions are major cause of morbidity and mortality after cardiac surgery [6].

Infection rates after median sternotomy vary from 0.2% to 10% and in case of infection, morbidity and mortality rates vary from 5% to 25% [7]. The incidence of post-operative complications is more frequent with the following risk factors: thoracic radiation, diabetes, chronic lung disease, immunosuppression, obesity, advanced age, renal failure, hypertension and chronic use of corticosteroids [8] [9] [10] [11].

To minimize the incidence of complications, newer techniques have been used for the closure of median sternotomy. However, an optimal technique has yet to be established [12] [13]. Several alternative methods have been developed. Some are based on anchoring of the steel wires to prevent rupture of sternal bone. The first method was described by Robiscek in 1977 [14]. It consists of passing para sternal continuous wire sutures alternatively in front of and behind the costal cartilages and leaving them within the usual parasternal sutures. This repair is known as Robiscek repair.

Another technique uses staples: the metal staples are placed longitudinally in the sternum, serving as an anchor to prevent the transverse steel wires from cutting the sternum [15]. Other techniques using different devices to avoid dehiscence of the sternum have been used: titanium plate, titanium double-foot hook system, nitinol thermos reactive clips, Kirschner wires, biocompatible adhesives, and others. All of these alternative closure methods have the disadvantage of being more labor-intensive than the standard method. They also increase the surgical time and cost of intervention.

We used Robiscek repair on both halves of sternum with four to five interlocking figure of eight wires vs standard closure with six steel wires in our study. We harvested bilateral internal mammary arteries in the all the cases for coronary revascularization. All the patients were operated off pump.

2. Patients and Methods

Between July 2014 and September 2020 we did 668 OPCABs using bilateral IMAs (Table 1). We harvested both the IMAs with pedicle in all the cases. Right IMA was harvested up to bifurcation and was divided both proximally and distally. Proximal end of free right IMA was anastomosed end to side on the proximal part of LIMA to make a LIMA-RIMA Y. Adequate flow from both the limbs of Y was confirmed before doing coronary artery bypass grafting. These patients were divided into group I and group II depending on the absence or presence of the following risk factors [3] for sternal wound complications:

1) Age above 65 years;
2) Diabetes mellitus;
3) Eccentric sternotomy;
4) Obesity, body weight more than 20% higher than expected;
5) COPD.

The patients who did not have any of these risk factors were placed in group I and all of them had a standard six wire closure of sternotomy. The patients having any of these risk factors were placed in group II. The patients in group II were randomized by including every alternate patient from group II to subgroup II A and every other alternate patient from group II to subgroup II B. Patients in subgroup II A again had a standard closure of sternotomy while in patients of subgroup II B bilateral Robiscek repair and four-five interlocking figure of eight wires were used for closure of sternotomy.

Table 1. Clinical profile of patients who had OPCAB using bilateral IMAs during the study.

Total Patients	668
Male	590 (88.32%)
Female	78 (11.68%)
Group I	280 (41.92%)
Group II	388 (58.08%)
Subgroup II A	194 (29.04%)
Subgroup II B	194 (29.04%)
Age Range:	
<60 years	185 (27.7%)
60 - 65 years	320 (47.9%)
65 - 70 years	94 (14.07%)
>70 years	69 (10.33%)
Mean Age	64.55 years
Procedure performed	OPCAB using bilateral IMAs

In this technique, two additional wires were used parasternally in a longitudinal manner craniocaudally, followed by four-five interlocking figure of eight wires depending on the length of sternum. Care was taken that all the figure of eight wires were interlocked with each other and were placed outside the longitudinal wires on both halves of sternum and both at inner and outer table of sternum.

Three patients in subgroup II A who developed sternal dehiscence subsequently had a bilateral Robiscek repair with interlocking figure of eight wires similar to the patients in subgroup II B.

For statistical analysis incidence of various risk factors present in subgroup II A and II B were compared using χ^2 test (Table 2). Fischer'exact test was used to compare the incidence of sternal wound complications between these two subgroups. The incidence of sternal wound complications in low risk group I was also compared with high risk subgroups II A and II B separately using χ^2 test.

Operative Technique

The technique of sternotomy closure adopted in group I and subgroup II A comprised of passage of six No.5 stainless steel wires transversely through manubrium and the body of sternum. Two wires were passed through the body of the manubrium and four wires were passed through the intercostal spaces starting just below the manubrium and progressively going down. We were not worried about the injury to IMAs as both the IMAs had been harvested. Care was taken to pass the wires grazing the lateral edge of the sternum and the upper edge of the lower rib in each intercostal space. After elevating the operating table and retraction of the sternal edges, hemostasis was ensured and the wires were tightened.

In subgroup II B, belonging to the high risk category for sternal complications, the Robiscek repair was done on both sides. Two lengths of No.5 stainless steel wires were used parasternally in a longitudinal fashion starting from the upper end of each side and going down to the 7th intercostal space. The wires were drawn anterior and posterior to alternate ribs in such a manner that both ends of the wire were drawn out near the rostral ends of the sternum. Both ends of each wire were then twisted and tightened.

Then four-five interlocking figure of eight wires were passed lateral to these

Table 2. The incidence of various risk factors for sternal dehiscence in patients included in subgroup II A and II B.

	Subgroup II A (N = 194)	Subgroup II B (N = 194)	p
Age > 65 years	98 (14.67%)	100 (14.97%)	0.71729
Diabetic	76 (11.38%)	75 (11.23%)	0.85847
Obesity	96 (14.37%)	98 (14.67%)	0.66635
COPD	112 (16.77%)	109 (16.32%)	0.78745
Eccentric Sternotomy	27 (4.04%)	30 (4.49%)	0.50534
Female Gender	27 (4.04%)	30 (4.49%)	0.50534

parasternal wires. The longitudinal wires acted as struts to the figure of eight wires. After adequate hemostasis the figure of eight wires were twisted and tightened. The tightened wires were cut short and the remaining stubs were carefully buried under the soft tissue. The soft tissues were then closed in two layers using vicryl sutures (**Figure 1**).

3. Results

Among 280 patients belonging to group I who did not have any risk factor for sternal wound complications only one patient (0.36%) had sternal instability after conventional sternal wire closure and none of them developed sternal dehiscence. In subgroup II A (N = 194), the patients who had one or more risk factors but had conventional closure, the incidence of sternal wound complications was significantly higher compared to group I (p = 0.0002) and subgroup II B (p = 0.00065). In this group 16 patients (8.25%) developed sternal instability and 3 (1.55%) of them later developed sternal dehiscence. One patient developed sternal dehiscence on 5th postoperative day. He developed superficial wound infection before dehiscence. Second and Third patients were obese females who developed sternal dehiscence on 7th and 8th postoperative day. None of them developed frank mediastinitis. All of these patients were diabetics and after debridement all of them subsequently had a bilateral Robiscek repair with four-five interlocking figure of eight wires closure of sternum as in subgroup II B.

In subgroup II B (N = 194) the bilateral Robiscek repair with interlocking figure of eight wires technique was used for sternal closure in all patients. Though

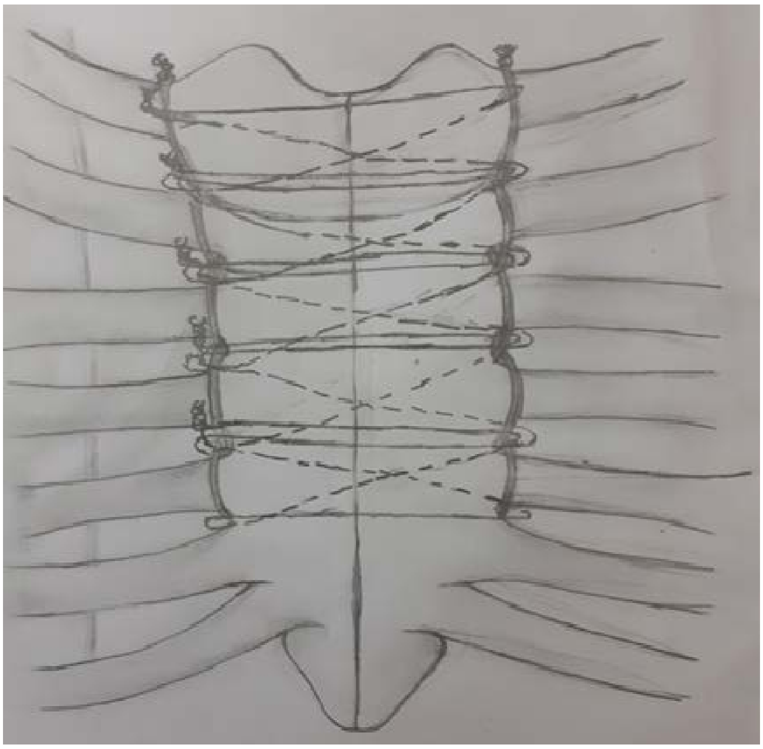

Figure 1. Bilateral Robiscek repair with interlocking figure of eight wires.

the patients were having one or more risk factors for sternal dehiscence, the incidence of sternal wound complications was extremely low (0.51%) and comparable to that seen among normal risk patients of group I ($p = 0.64771$). Only one (0.51%) of the patients in this group developed sternal dehiscence (**Table 3**). This was an elderly diabetic lady who had discharge from wound and low grade fever after going home. She came back after one and half month with necrosis of sternum and mediastinitis. We involved the Plastic Surgery team to manage this complication. They did rectal muscle advancement flap for reclosure after adequate debridement. This patient had infection and sternal dehiscence because of uncontrolled diabetes.

One patient in each subgroups II A and II B, had infected sternal wires in follow-up. Both were treated successfully with appropriate antibiotics and wire removal. All the patients who had sternal dehiscence were successfully treated with bilateral Robiscek repair and are now symptom free in a follow-up ranging from 48 to 72 months. Mean follow-up was 59.62 months. There was no increase in the incidence of post-operative bleeding, pain, discomfort or wound infection in the bilateral Robiscek repair group. There was no risk of accidental injury to IMAs in this study as the bilateral IMAs had already been harvested. The incidence of infected wires was also comparable in both subgroups II A and II B (one in each subgroup). The mean hospital stay was prolonged by 12 ± 3 days in patients with sternal dehiscence and 5 ± 2 days in the sternal instability group. There was no mortality related to sternal wound dehiscence in either of the groups.

4. Discussion

Median sternotomy is the standard approach to heart and great vessels during most of the cardiac procedures. It is also used for pulmonary resections for bilateral lesions. First of all Milton [16] used steel wires for sternal closure. The complications of median sternotomy range from superficial wound infections to chronic osteomyelitis, costochondritis, and sternal dehiscence to frank mediastinitis posing risk of vein graft occlusion or prosthetic valve endocarditis [17]. These complications are associated with 19% to 39% mortality in spite of adequate treatment and without treatment the mortality may be 100% due to generalized

Table 3. Incidence of sternal complications in both groups.

	Group I	Group II	
		Subgroup II A	Subgroup II B
Sternal instability	1/280 (0.36%)	16/194 (8.28%)	Nil
Sternal dehiscence	Nil	3/194 (1.55%)	1/194 (0.51%)
Mediastinitis	Nil	Nil	1/194 (0.51%)
Mortality due to sternal complications	Nil	Nil	Nil
Infected sternal wire	Nil	1/194 (0.51%)	1/194 (0.51%)

sepsis, endocarditis, fatal hemorrhage and multiorgan failure [18].

The most important factor in preventing sternal wound complications is a stable sternal approximation, as bony union depends on adequate reduction and immobilization of the sternocostal junctions. Various techniques have been described to achieve maximum sternal stability and each technique has its own merits and demerits. The Robiscek repair has been used to close the fragile and fractured sternum [14]. Modified Robiscek closure with two vertical weaves on each side of the sternum with bilateral Pectoralis Major Flaps has also been described to successfully treat mediastinitis after aggressive sternal debridement [18].

Surgeons have also used "figure of eight" pericostal wire sutures [17], nylon bands [19] and custom made titanium H plates [20] to achieve stable sternal fixation. Sternal plates have also been used for sternal nonunion [21]. None of these techniques offers an objective advantage over steel wire encirclage. Besides, the use of bands and custom made plates may have an additional disadvantage of restricted availability, consequent increase in the cost of surgery and leaving an avoidable foreign material within the body. The delay to unscrew and remove plates could be potentially catastrophic when emergent entry into the chest is warranted in ICU settings. Moreover, the drilling of holes in the sternum may actually cause small fractures, especially in thin and osteoporotic sternum and the fractured segments act as foci for infection.

Sternal halves fixed with wire fixation techniques have proven to be more stable biomechanically then other methods of sternal closure [22]. Despite this, there are incidences of sternal wire closure failure because of composite play of forces which ultimately result in wires cutting through the bones transversely. This results in sternal separation because of increased movements between two halves of the sternum. It also leads to increased pain at the sternotomy site, inadequate respiratory excursions for expectoration, various respiratory complications and consequently further interplay of forces that deteriorate sternal healing. The advantage of "figure of eight" technique is that it allows oblique and horizontal angle of shearing forces instead of direct perpendicular forces. Thus these wires are less likely to loosen for fracture [17].

The advantage of Robiscek repair is that it reinforces the bilateral sternal table to allow tight closure which decreases the likelihood of the wires cutting through. These parasternal wires act by providing a metal strut for the transverse wires so that the disrupting forces are distributed over a wider surface of sternum [14].

In addition, the longitudinal wires provide an equal resistance to the cutting forces of transverse wires, thereby preventing direct burrowing of wires into the sternum. Interlocked figure of eight wires also provide additional safety against cutting through of the sternum by wires itself.

The bilateral Robiscek repair along with four to five interlocking figure of eight wires was successfully used by us for prevention of sternal wound dehiscence. Thus, among the high risk patients who had conventional closure of sternum with bilateral IMAs harvested, the incidence of sternal wound complications was significantly higher (8/194 = 4.12%) compared to negligible incidence (1/194 = 0.51%) observed in patients in whom the bilateral Robiscek repair with four-five interlocking figure of eight wires was used. Our overall experience in the high risk group II is that the patients who have insulin dependent diabetes mellitus, obesity and COPD have a very high risk of post-operative sternal dehiscence if bilateral IMAs are harvested. All four patients (1.03%) in group II who had sternal dehiscence including 3 (0.77%) in subgroup II A and one (0.26%) in IIB were dependent on insulin, three were obese and three were having COPD with persistent cough. In all three patients who had sternal dehiscence after conventional closure in subgroup II A, the transverse wires had cut through the sternum causing multiple fractures in sternum. This did not happen in any of the patients who had closure with bilateral Robiscek repair and four-five interlocking figure of eight wires. Moreover, in three of the patients who had sternal dehiscence after conventional sternal wire closure in subgroup II A, successful sternal reclosure was achieved after appropriate debridement with bilateral Robiscek repair and four-five interlocking figure of eight wires.

This study shows the clinical efficacy of adopting bilateral Robiscek repair along with four-five interlocking figure of eight sternal wires is an easily reproducible and safe method for prevention of sternal dehiscence in patients in whom bilateral IMAs are harvested. We, therefore, strongly recommend that there should be no fear of sternal dehiscence even in high risk patients in harvesting bilateral IMAs if we use this technique.

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Ethical Approval

Ethical Clearance was obtained from Ethical Clearance Committee.

Informed Consent

Informed consent was obtained from all the patients in the study.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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