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Original Article

The outcomes of Skeletonized and Pedicled Internal Thoracic Artery in Patients undergoing coronary artery bypass grafting: a randomized clinical study

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Abstract

Background: Internal thoracic artery became the cornerstone graft in coronary artery bypass grafting. This study aimed to investigate sternal healing and wound infection in patients undergoing coronary artery bypass graft (CABG) surgery using skeletonized versus pedicled internal thoracic artery.

Methods: 100 patients who underwent isolated CABG were divided into two groups; skeletonized internal thoracic artery (ITA) (50 patients) and pedicled internal thoracic artery (50 patients). The postoperative assessment was performed three months after surgery. Physical and radiological examinations were performed after surgery to assess sternal healing.

Results: There was no significant difference in patients' demographics between groups. Skeletonized group had more diabetic patients (65% vs 44%; p= 0.016). There was no significant difference between the two groups regarding the number of grafts (2.72 ± 0.89 vs. 2.68 ± 0.90; skeletonized vs pedicled group; p= 0.84). Harvesting time was longer in the skeletonized group (55.69 ± 8.80 vs. 44.28 ± 6.95 minutes; p=0.09). Superficial wound infection occurred more frequently in the pedicled group (24% vs. 8%; p=0.03).

Conclusion: Skeletonization of the internal thoracic artery conduits lowers the risk of superficial and deep sternal wound infection in patients undergoing CABG compared to the pedicled technique. However, skeletonization of internal thoracic artery conduits prolongs the operation time and requires more surgical skills.

KEYWORDS
Coronary bypass graft; Internal thoracic artery, Sternal healing

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Introduction

The Internal thoracic artery (ITA) plays a vital role in coronary artery bypass grafting (CABG). The left ITA is the gold standard conduit in grafting the left anterior descending coronary artery (LAD) [1]. During coronary artery bypass grafting (CABG), the internal thoracic artery may be harvested either as a pedicle together with the accompanying veins, lymphatics, sympathetic plexus, and internal thoracic fascia or skeletonized free of all surrounding tissues [2, 3].

There is insufficient evidence to prompt the surgeon to harvest the ITA in a skeletonized fashion. Randomized studies comparing the

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skeletonized to the pedicled ITA are few, and most of the current knowledge on this subject comes from observational studies that offer insufficient evidence with or against skeletonization of the ITA [4].

Poor healing of the sternum is one of the potential complications encountered after CABG, and it was reported more frequently with the pedicled technique of ITA harvest [5]. Slow healing prolongs the hospital stay, increases healthcare costs considerably, and delays the return to work or social activities. Poor healing of the sternum often leads to deep sternal wound infection, which is a serious complication of CABG [6].

This study aimed to compare the effect of pedicled and skeletonized LITA harvest on sternal healing, wound infection, operative, and postoperative complications.

Patients and Methods:

Design:

This randomized clinical study included 100 patients (62 males and 38 females) diagnosed with ischemic heart diseases (IHD) and needed surgical myocardial revascularization (CABG) in the Cardiothoracic Surgery Department at Benha Faculty of Medicine and El-Zyton Specialized Hospital in the period between December 2017 and May 2019. We included patients who had isolated elective CABG, and their age ranged from 30 to 70 years, and body mass index was less than 30 Kg/m2. Patients who underwent combined valve surgery, left ventricular restoration, or aortic surgery were excluded.

Ethical approval:

The Research Ethics Committee at the Faculty of Medicine, Benha University, has approved the study, and all patients provided written consent before participation with adherence to the guidelines of the Declaration of Helsinki [7].

Patients:

Patients were randomly assigned to either: group A (n= 50 patients) who had pedicled ITA and group B (n= 50) and included patients who had skeletonized ITA. Group A had 30 male patients, and their age was 60.20± 1.21 years. Group B included 32 male patients, and their age was 59.92± 1.29 years.

Preoperative preparation was standardized in all patients; which started with careful and thorough history taking and clinical examination taking into consideration the patient's following items: age, sex, weight, body surface area "BSA", diabetes mellitus, hypertension, hyperlipidemia, smoking, left main lesion, previous stent, left ventricle ejection fraction, number of vessels and routine laboratory investigations for CABG patients. All diabetic patients had controlled HgA1c preoperatively.

Surgical technique for pedicled ITA:

An incision was made in the parietal pleura and muscle on the medial side of the ITA. A parallel incision lateral to the ITA and the accompanying lateral internal thoracic vein was made. The pedicle was freed from the sixth costal cartilage using the tip of the electrocautery blade. With the pedicle gently retracted downward and with gentle blunt dissection, the intercostal arteries were identified and occluded with small metal clips and divided. After completing its proximal dissection, heparin was administered before division was done at 6-7th space. With the proximal end controlled using a small bulldog clamp and the distal end ligated or clipped [8].

Skeletonization of ITA:

A median sternotomy was performed. After dissecting the reflection of the mediastinal pleura from the endothoracic fascia without opening of pleura, the ITA and both satellite veins were visualized. The space between the medial satellite vein and the ITA was carefully dissected. The contact time of the electrocautery at low power was set at 0.1 to 0.2 seconds, and the scalpel was moved lightly and quickly along several centimeters of the vessel as the main trunk (“quick-touch” method). In this way, the main trunk was skeletonized safely and promptly. In contrast, treatment of the branches was a slower process. ITA branches were exposed and clipped. The ITA was then separated from the fascia, with completion of skeletonization [9].

After pericardiotomy, routine aortic and right atrial cannulation was done using a common single atrial venous cannula. A double outlet cardioplegia cannula was inserted in the aortic root in all cases. Cardiopulmonary bypass was carried out at normothermia in all cases. Intraoperative myocardial protection was achieved using antegrade intermittent warm blood cardioplegia, starting with the initial dose of 300 ml/minute for 3 minutes containing 15 mEq of Potassium Chloride (KCL). All distal anastomoses were constructed during one period of aortic cross-clamping. Additional doses of cardioplegia were given after completion of each anastomotic point (200 ml/minute for 2 minutes containing six mEq of KCL) [10].

Performing the distal anastomoses was usually done in the same sequence for all cases of both groups. Initially, the right coronary artery (RCA) or posterior descending artery (PDA) was started followed by the marginal branches of the circumflex artery and the diagonal branches of the left anterior descending (LAD). The integrity of the grafts was carefully checked for flow, and any possible leakage from the suture line before the LITA (left internal thoracic artery) was anatomized to the LAD vessel as a final step in all patients. The distal anastomoses in all cases were done in an end-to-side fashion. After all distal anastomoses were finished, and before removal of aortic cross-clamping, all patients were given a hot shot of pure warm oxygenated blood at a rate of 300 ml/minute for 3 minutes (without KCl), via the cardioplegia line. Two grams of magnesium sulfate was given via the same line upon removal of the aortic cross-clamp [11].

Sternum closure:

The sternum was closed with stainless steel wire, and the wound was closed in layers. The following variables were collected: skeletonized or pedicled internal thoracic artery, cardiopulmonary bypass time, cross-clamp time, number of grafts.
The sternal wound was examined immediately, one month and three months postoperatively, and in case of presence of sternal click, chest computed tomography (CT) was done to detect sternal dehiscence.

Outcomes:

The study endpoints were; reopening for bleeding, duration of mechanical ventilation, length of ICU stay and hospital stay, superficial sternal wound infection, deep sternal wound infection, sternal dehiscence, rewiring of the sternum.

Table 1: Patients' demographics. (Continuous data are presented as mean± standard deviation and binary data as number and percent)

	Pedicled (n=50)	Skeletonized (n= 50)	P- value
Age (years)	60.20± 1.21	59.92± 1.29	0.96
Height (m)	1.68± .023	1.67 ± 0.022	0.84
Weight (kg)	83.84± 2.30	82.36± 2.28	0.86
BMI (kg/m2)	29.51± .311	29.34± 0.38	0.61
LVEF %	43.83 ± 10.05	40.88 ± 7.75	0.74
Female	20 (40%)	18 (45%)	0.099
Diabetes mellitus	22 (44%)	34 (68%)	0.016
Hypertension	46 (92%)	42 (84%)	0.218
Hyperlipidemia	26 (52%)	32 (64%)	0.224
Smoking	24 (48%)	22 (45%)	0.688

BMI: body mass index, LVFT: left ventricle ejection fraction

Table 2: Operative data. (Continuous data are presented as mean± standard deviation and binary data as number and percent)

Variables	Pedicled (n=50)	Skeletonized (n= 50)	P- value
Time of harvesting (minutes)	44.28 ± 6.95	55.69 ± 8.80	0.09
Number of grafts	2.68 ± 0.90	2.72 ± 0.89	0.84
Bypass time (minutes)	96.52 ± 24.4	95.92 ± 25.629	0.81

Statistical Analysis

Continuous data were expressed as mean ± standard deviation (SD) and were compared with the Student t-test. The distribution of qualitative variables across groups was analyzed by Chi-square test or Fischer's exact test as appropriate. All comparisons were bilateral and a P-value <0.05 was the limit of statistical significance. The analysis was performed by SPSS statistical software version 23 for Windows (IBM Corp, Chicago, IL, USA) [12].

Results

There was no significant difference in patients' demographics between groups (Table 1). Skeletonized group had more diabetic patients (p= 0.016). There was no significant difference between the two groups regarding the number of grafts (2.72 ± 0.89 versus 2.68 ± 0.90; skeletonized vs. pedicled group; respectively) (P =0.84). There was no significant difference in total bypass time between the two groups (P =0.81) (Table 2).

There was no significant difference between the two groups regarding the postoperative drainage (P =0.7), duration of ventilation (P =0.83) and ICU stay (P =0.6); while mean hospital stay was significantly lower in the skeletonized group (11.6 ± 3.5 versus 7.88 ± 1.90 days) (P= 0.04) (Table 3). The skeletonized group showed fewer complications than the pedicled group regarding reopening for bleeding (2 versus 6 patients; p=0.14), superficial sternal wound infection (4 versus 12 patients; p=0.03), deep sternal wound infection (2 versus 4 patients; p=0.4) and sternal rewiring (0 vs. 2 patients; p= 0.56). There were non-significant differences between the two groups regarding postoperative complications except superficial sternal wound infection which was significantly lower in the skeletonized group (Table 3).

Discussion

Compared to saphenous vein graft, patients who receive an ITA to the left anterior descending artery survive longer and experience less hospitalization for cardiac events, lower rates of cardiac reoperation, and less recurrent myocardial infarction [13]. The ITA may be harvested as a pedicle or as a skeletonized graft, with evidence suggesting that pedicled ITA may affect sternal healing to a greater extent. Therefore, understanding the impact of ITA harvesting techniques on sternal healing is vital for cardiac surgeons to tailor the optimal conduit harvesting strategy to each patient undergoing CABG [14].

Table 3: Postoperative data. (Continuous data are presented as mean± standard deviation and binary data as number and percent)

Variables	Pedicled (n= 50)	Skeletonized (n= 50)	P- value
Postoperative drainage (ml / 24 hours)	610 ± 132.28	442.36 ± 166.06	0.7
Duration of ventilation (hours)	13 ± 3.01	9.36 ± 3.174	0.83
ICU stay (days)	2.88 ± 0.781	2.28 ± 0.678	0.6
Hospital stay (days)	11.6 ± 3.5	7.88 ± 1.90	0.04
Re-exploration for bleeding	6 (12%)	2 (4%)	0.14
Superficial wound infection	12 (24%)	4 (8%)	0.03
Deep sternal infection	4 (8%)	2 (4%)	0.4
Sternal rewiring	2 (4%)	0	0.56

ICU: intensive care unit

Several factors could contribute to delayed sternal healing. Carmelo and colleagues reported that obesity and old age were major factors that affected sternal healing [15]. Nagachinta and coworkers identified obesity as the strongest predictor, with 14% of the obese patients developed mediastinitis [16]. Loop and associates identified obesity as the second most important independent predictor of mediastinitis, defining obesity as only a 20% increase in height-adjusted weight [17]. In our study, the patients selected in the two groups were approximately the same regard age, weight, height, and BMI.

Diabetes mellitus is one of the factors that could affect sternal healing. Our study shows that 16% of all patients developed a superficial wound infection. 12 out of 16 (75%) were diabetic, and 4 out of 12 (34%) of that diabetic patient who developed superficial wound infection were in the skeletonized group. These results point to diabetes mellitus as an independent predictor for superficial wound infection. Moreover, these results show that the incidence of superficial wound infection was more in pedicled group compared to the skeletonized group. In a study by Lenz and colleagues on 590 patients who underwent CABG, they found that sternal wound infection occurred more in diabetic patients [18].

Most studies assessing sternal healing have compared the effect of surgical technique on harvesting ITA either skeletonized or pedicled were limited by comparing bilateral skeletonized ITA versus bilateral pedicled ITA, or bilateral skeletonized ITA versus single skeletonized ITA. In the present study, the graft arrangement was strictly controlled with only the LITA to LAD and saphenous vein graft to other coronary arteries to minimize other factors affecting the healing of the sternum; therefore, the simple role of skeletonized technique in single ITA was well evaluated.

In our study, bypass time was similar in the two groups; however, harvesting time was shorter in the pedicled group. Carmelo and his colleagues found that prolonged cardiopulmonary bypass and operative time were significant independent predictors of decreasing the sternum healing and increasing the incidence of mediastinitis [15].

Sergio and colleagues reported that prolonged intensive care unit stay increased the risk of wound infection [19]. In our study, there was no significant difference between the two groups regarding ICU stay. However, there was a significant difference in hospital stay in favor of the skeletonized group.

Re-exploration for bleeding was an independent predictor of superficial and deep sternal wound infection [20]. In our study, the difference between the pedicled group and the skeletonized group was insignificant regarding the amount of bleeding in the first 24 hours postoperatively. However, the number of cases who required re-exploration was more in pedicled group. This can be explained by the large surgical raw area during LITA harvesting as pedicled compared to a small surgical raw area during LITA harvesting as skeletonized. This indicates that skeletonization of LITA may decrease the risk of early re-exploration for bleeding and hence reducing the risk of superficial and deep sternal wound infection.

In a study by Ozulku and Aygun on 160 subjects underwent CABG, they found that the amount of drainage was higher in the pedicled group [21]. In our study, there were 16 patients who developed wound infection; two patients underwent sternal rewiring. These patients were males 57 and 59 years old, smokers, hypertensive and diabetic with BMI 30 and 31, respectively. The patients went for CABG and ITA was pedicled. The operation time was long (110 min, 117 min), and the patients were ventilated for 21, 23 hours. The patients were re-explored for bleeding after drainage of 800cc and 850cc in the first 6 hours. ICU stay was 4, 5 days, and hospital stay were 19, 20 days. The patients developed superficial wound infection then deep wound infection, and lately developed sternal dehiscence and required sternal rewiring.
The main risk factor was the pedicled technique of harvesting LITA as it caused large surgical raw areas, and the patient's blood drainage was the large amount, which was the main cause for re-

sternotomy. This course could be avoided if The LITA was harvested as a skeletonized with its small surgical raw area which causes less bleeding indeed. The surgical re-sternotomy caused more surgical damage to the tissue besides the need to close the sternum with a new wire and the tissues with new sutures; this extensive manipulation caused more tissue damage, which decreased the healing process and increased the risk for wound infection.

In a study by Lazar, he studied the different effects of pedicled and skeletonized ITA on sternal wound infection in CABG, and he concluded that skeletonization of ITA grafts reduced deep sternal wound infection [22]. On the other hand, Kaul illustrated that risk factors for deep sternal wound complications included long operations, postoperative bleeding, poor wound closure, obesity (BMI > 30), older age, diabetes, and prolonged mechanical ventilation [23]. While Momin and colleagues in a retrospective analysis on 7581 patients who underwent CABG through a pedicled single or bilateral internal thoracic artery found that the dehiscence rate for diabetics and nondiabetics was not significantly different [24].

Study limitations

The major limitation of the study is the small patients' number; however, the study is randomized, and there was a difference between groups as regards the prespecified endpoints.

Conclusion

Skeletonization of the internal thoracic artery conduits lowers the risk of superficial and deep sternal wound infection in patients undergoing CABG compared to the pedicled technique. However, skeletonization of internal thoracic artery conduits prolongs the operation time and requires more surgical skills. The skeletonization technique is recommended in patients with risk factors that may affect sternal healing.

Conflict of interest: Authors declare no conflict of interest.

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