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Coronary Artery Bypass Grafting Using Bilateral Internal Thoracic Artery Grafting in Elderly; Early Morbidity and Mortality

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ABSTRACT

Background: Myocardial revascularization is effectively achieved through coronary artery bypass grafting (CABG), which typically involves surgical anastomosis of the left internal thoracic artery (ITA) to the left anterior descending (LAD) artery. Additionally, a reversed saphenous vein graft is often used to revascularize other diseased coronary vessels.

For improved long-term survival and preservation of cardiac function, bilateral ITA (BITA) grafting has demonstrated superiority over single ITA (SITA) grafting. However, the routine use of BITA is generally limited to younger patients, due to its association with prolonged operative time, greater technical complexity, and an increased risk of sternal wound complications, particularly in older or comorbid individuals.

Objective: This study aimed to estimate the early morbidity and mortality, in addition to sternal complications incidence in elderly cases undergoing BITA grafting.

Patients and Methods: This retrospective observational comparative cohort study included 126 elderly patients at Cairo University Hospitals. Cases were divided into 2 groups: Group A: underwent SITA grafting with saphenous vein graft (SVG) and group B: underwent BITA ± SVG grafting.

Results: Group B had significantly increased sinus rhythm spontaneous recovery (P<0.001), and significantly decreased inotropic support, intra-aortic balloon pump (IABP), exploration, early and late pericardial effusion and posterior tamponade than group A (P<0.05). Group B had significantly shorter ICU stay, and hospital stay than group A (P<0.05). Early mortality and incidence of sternal wound complications was statistically insignificant between both groups.

Conclusions: In elderly patients, BITA grafting is safe. Early morbidity and mortality are similar to conventional CABG. BITA grafting was linked to faster recovery, shorter hospital stay, and fewer complications. Using the skeletonization technique in harvesting BITAs lowered the probability of sternal wound infections.

Keywords: Coronary Artery Bypass; Early; Morbidity, Mortality, Bilateral Internal Thoracic Artery Grafting.

INTRODUCTION

It was indicated that the most effective method of coronary artery bypass grafting (CABG) is the implantation of a left internal thoracic artery (ITA) graft into the left anterior descending artery during the procedure, with other vessels being grafted by a reverse saphenous vein graft (SVG). The evolution of CABG intervention has resulted in numerous modifications in recent years. Modifications include the selection of the most suitable conduit for an extended patency rate, the development of additional anastomosing techniques, such as sequential anastomosis, and the selection of the coronary artery to be grafted [1].

After 10 years follow up, ITA has a higher angiographic patency rate (90%-95%) than vein transplants (50%-75%). Compared to single ITA (SITA) grafting, bilateral ITA (BITA) transplantation in CABG results in enhanced long-term survival as evidenced by a contemporary observational data [2]. Concerning the long-term survival and cardiac function preservation following surgery, a diverse array of studies had proved that BITA grafting is superior and preferable than SITA grafting [3].

In the elderly, the most commonly performed and conventional interventional procedures for myocardial revascularization are one or more vein grafts and also one pedicled ITA [4]. There have been attempts to develop surgical techniques for comprehensive arterial myocardial revascularization without veins, as vein graft failure is a significant disadvantage of conventional CABG. Bilateral and sequential ITA grafting are prevalent methods for accomplishing this goal [5].

Mixed and conflicting results have been observed in the context of BITA grafting for elderly populations. Various age limits, such as 60, 70, 72, or 74 years, are advocated by certain series. Even at advanced ages, others report survival benefits [6].

Based on the long-term follow-up in elderly patients, a better long-term survival rate is achieved by BITA grafting when implemented on a large scale in comparison to SITA grafting. In patients with multivessel coronary artery disease (CAD), the Society of Thoracic Surgeons has established a substantial body of clinical evidence that reinforces the recommendation of BITA grafting over SITA grafting [7]. Due to the extended period necessary for the survival benefit to be apparent, surgeons seldom consider BITA grafting suitable for elderly patients, as evidenced by the conflicting results of previous research.

This study aimed to assess early morbidity and mortality, with a specific focus on the incidence of sternal complications in elderly patients undergoing BITA grafting.

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PATIENTS AND METHODS

This retrospective observational comparative cohort study included a total of 126 elderly cases who underwent CABG on pump, attending at Department of Cardiothoracic Surgery, Cairo University Hospitals. The study involved patients undergoing surgery between September 2023 to Sept 2024.

Exclusion criteria included patients requiring emergency CABG, those with a history of prior cardiac surgery, and patients with missing or incomplete data on key variables.

Patients age was ranged from 60 to 75 years. They were assigned into two groups; 63 patients each. **Group A** were subjected to CABG using SITA grafting with SVG and **Group B**: patients who underwent CABG and received a BITA grafting +- SVG

Demographics (age, gender, body mass index (BMI)) and comorbidities (e.g., diabetes, chronic kidney disease, hypertension) were collected from all the studied patients.

Preoperative risk factors: included previous myocardial infarction, left ventricular ejection fraction (EF), number of diseased vessels and presence of left main coronary artery disease.

Intraoperative data:

Details of the surgical procedure, duration of surgery, use of cardiopulmonary bypass, and intraoperative complications.

Postoperative data:

Early morbidity (e.g., wound infections, respiratory complications, renal failure, stroke, etc) and early mortality (within 30 days) [8].

Surgical techniques

The standard cardiopulmonary bypass was employed to perform the operations. Intermittent, antegrade, warm blood cardioplegia (30°C-32°C) was the method of myocardial preservation during cardiopulmonary bypass. In group A, pedicled LITA was mobilized from the chest wall, while in group B, LITA and RITA were mobilized as skeletonized vessels **(Figure 1)**.

In Group A, left ITA used to graft LAD while SVG was used to anastomose circumflex and right territories.

In Group B, the left coronary system (which is the myocardial territory supplied by the circumflex and LAD), was revascularized using BITAs and involved the proximal end-to-side anastomosis of a free ITA (typically the right ITA [RITA]) to the in-situ ITA (primarily the left ITA) in a T-graft configuration (composite T-graft). SVG was employed to graft the RCA. Hong Kong solution (verapamil, nitroglycerin, heparin, and sodium bicarbonate) was employed to soak BITA conduits to reduce the risk of arterial graft spasm.

Four figures of eight stainless steel wires were utilized for sternal closure **(Figure 2)**. An intravenous infusion of nitroglycerin (TRIDIL) was administered during the initial 48 hours postoperatively.

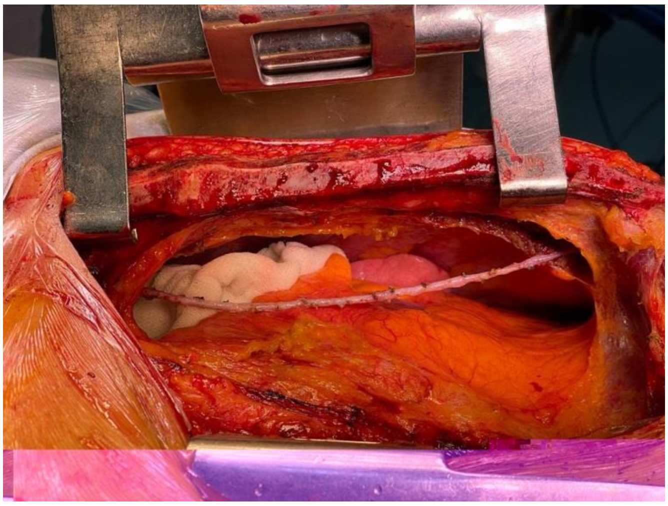

Figure (1): Showing the skeletonized LITA.

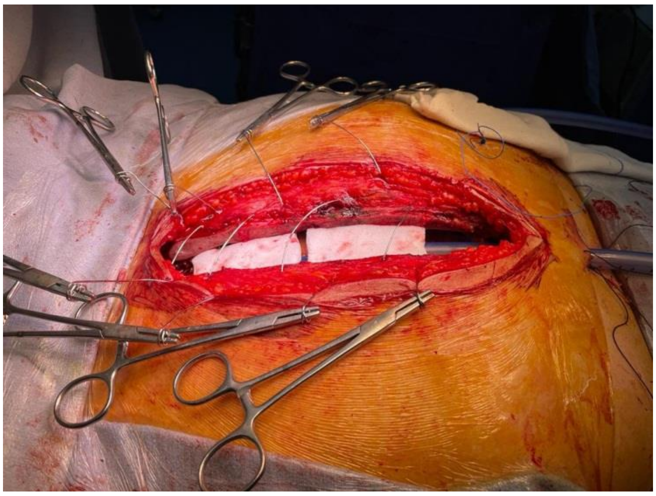

Figure (2): Showing closure of the sternum using 4 stainless steel wires in figure of 8 configuration.

Outcome parameter:

Primary outcome: Early postoperative mortality. We investigated in-hospital mortality, which refers to any fatalities that occurred during the hospitalization period following CABG.

Secondary outcomes: Early postoperative morbidity, including myocardial infarction, wound infections, length of hospital stay, respiratory complications, renal failure, reoperation for bleeding and stroke., etc.

Sample size:

Based on the estimated early morbidity rate of 20% and a margin of error of 10%, a minimum sample size of 126 elderly patients was determined for inclusion in the study, divided into two groups. This calculation was based on achieving 80% power with a significance level of 5%.

***Ethical Consideration*:**

This study was ethically approved by Cairo University Hospitals' Research Ethics Committee (IRB #310-2024). Written informed consent of all the participants was obtained. The study protocol conformed to the Helsinki Declaration, the ethical norm of the World Medical Association for human testing.

Statistical analysis

SPSS v28 (IBM© in Armonk, NY, USA) was utilized for data analysis. The data was checked for normality by histograms and the Shapiro-Wilks test. The chi-square or Fisher's exact tests (when appropriate) were used for the analysis of qualitative variables that were presented as percentages (%). The unpaired student t-test was utilized for assessment of the numerical parametric data, which was given as mean (±SD). Mann-Whitney U-test was utilized for assessment of the numerical non-parametric data which is expressed as median (interquartile range). A probability value (p-value) of 0.05 or less was regarded as statistically significant.

The clinical data standards of the American College of Cardiology/American Heart Association were employed to analyze the patient data [9]. The chronic renal failure incidence is evidenced when the creatinine level > 1.8 mg/dL. The perioperative myocardial infarction, which is characterized by raised creatine phosphokinase-MB fraction levels > 50 mU/m, is evidenced on the electrocardiogram (ECG) by new Q waves. If the postoperative creatinine level was > 2.3 mg/dL, acute renal failure was diagnosed. The definition of a cerebrovascular accident is the presence of a new permanent neurological deficit and cerebral infarction with computed tomographic evidence. The combination of late dehiscence and deep infection that necessitated reconstruction is the characteristic definition of "Deep sternal infection".

Preoperative:

Table 1 shows that both groups had no significant difference regarding the baseline characteristics (age, sex, and BMI) and risk factors (DM, HTN, COPD, hyperlipidemia, AF and previous MI, renal disease and dialysis).

RESULTS

Table (1): Baseline charcteretsics of the studied groups

		Group A (n=63)	Group B (n=63)	P value
	Age (years)	65.13± 3.81	66.4± 4.69	0.098
Sex	**Male**	54 (85.71%)	59 (93.65%)	0.143
	Female	9 (14.29%)	4 (6.35%)	
	BMI (Kg/m^2)	26.46± 0.59	26.44± 0.59	0.849
Risk factors	**DM**	34 (53.97%)	36 (57.14%)	0.720
	HTN	42 (66.67%)	32 (50.79%)	0.070
	COPD	4 (6.35%)	0 (0%)	0.119
	Hyperlipidemia	4 (6.35%)	5 (7.94%)	0.729
	AF	5 (7.94%)	1 (1.59%)	0.207
	Previous MI	14 (22.22%)	17 (26.98%)	0.539
	Renal disease	4 (6.35%)	7 (11.11%)	0.530
	Dialysis	1 (1.59%)	2 (3.17%)	0.559

Data presented as mean ± SD or frequency (%), BMI: body mass index, DM: diabetes mellitus, HTN: hypertension, COPD: chronic obstructive pulmonary disease, AF: atrial fibrillation, MI: myocardial infarction.

Table 2 shows that Hb, preoperative EF, number of diseased vessels and left main disease were insignificantly different between both groups.

Table (2): Preoperative clinical data of the studied groups

	Group A (n=63)	Group B (n=63)	P value
Hb (g/dL)	13.31± 0.73	13.39± 0.76	0.528
Preoperative EF (%)	58.63± 10.18	58.69± 10.41	0.982
No of diseased vessels	2.89± 0.76	3± 0.73	0.409
Left main disease	7 (11.11%)	10 (15.87%)	0.434

Data presented as mean ± SD or frequency (%), Hb: hemoglobin, EF: ejection fraction, *: statistically significant as p value <0.05.

Operative:

Table 3 shows that group B had significantly longer total bypass time and aortic cross clamp time than group A (P=0.003, <0.001) and group B had significantly lower prevalence of DC shock than group A (P<0.001).

Table (3): Operative data of the studied groups

	Group A (n=63)	Group B (n=63)	P value
Aortic cross clamp time (min)	80.41± 21.05	109.44± 13.42	**<0.001***
Total bypass time (min)	114.13± 21.32	128.21± 30.24	**0.003***
DC shock	44 (69.84%)	9 (14.29%)	**<0.001***

Data presented as mean ± SD or frequency (%), DC: direct-current, *: statistically significant as p value <.0.05.

Postoperative:

According to the outcome, group B had significantly increased spontaneous recovery of sinus rhythm than group A (P<0.001). Group B had significantly lower inotropic support, IABP, number of RBCs transfused units, exploration, early and late pericardial effusion, and posterior tamponade than group A (P<0.05). Moreover, group B had significantly shorter duration of both ICU and hospital stay than group A (P<0.001, <0.001).

The incidence of myocardial infarction, new onset AF, mortality, ventilation duration, total drainage, stroke, pleural effusion, sternal wound infection (mediastinitis), pulmonary complications, subxiphoid drainage, and renal failure, were insignificantly different between both groups (**Table 4).**

Table (4): Outcome of the studied groups

		Group A (n=63)	Group B (n=63)	P value
Spontaneous recovery of sinus rhythm		19 (30.16%)	54 (85.71%)	**<0.001***
Inotropic support		48 (76.19%)	4 (22.22%)	**<0.001***
IABP		11 (17.46%)	3 (4.76%)	**0.023***
New onset AF		14 (22.22%)	6 (9.52%)	0.051
ICU stay (days)		4.32± 2.57	2.27± 0.7	**<0.001***
Hospital stay (days)		15.21± 7.66	8.88± 2.59	**<0.001***
Ventilation duration (hrs.)		8.71± 11.64	5.81± 2.59	0.284
		5 (4 - 9.5)	5 (4-6)	
Exploration		10 (15.87%)	3 (4.76%)	**0.040***
Total drainage (ml)		889.52± 466.3	834.29± 371.74	0.464
Pleural effusion		5 (7.94%)	6 (9.52%)	0.752
Pericardial effusion	**Early**	13 (20.63%)	1 (1.59%)	**0.001***
	Late	6 (9.52%)	0 (0%)	**0.028***
Post tamponade		7 (11.11%)	0 (0%)	**<0.001***
Sternal wound infection (mediastinitis)		1 (1.59%)	5 (7.94%)	0.207
Pulmonary complications		7 (11.11%)	7 (11.11%)	1.00
Myocardial infarction		5 (7.94%)	1 (1.59%)	0.207
Subxiphoid drainage		3 (4.76%)	0 (0%)	0.244
Renal failure		6 (9.52%)	2 (3.17%)	0.273
Stroke		2 (3.17%)	1 (1.59%)	1.00
Transfused RBC units		1.39± 0.5	1.06± 0.25	**0.018***
Mortality		2 (3.17%)	1 (1.59%)	1.00

Data presented as mean ± SD, median (IQR), or frequency (%), IABP: intra-aortic balloon pump, AF: atrial fibrillation, ICU: intensive care unit, RBC: red blood cells, *: statistically significant as p value <.0.05.

DISCUSSION

CABG remains the gold standard for the management of CAD, particularly in elderly patients who are at a higher risk of adverse cardiovascular events [10]. Because of the potential for superior long-term outcomes, as reduced graft occlusion and fatality rates, BITA grafting has acquired significant attention as a more competitive alternative to traditional SITA grafting methods [11]. However, BITA grafting is restricted to younger patients rather than seniors due to the more frequent occurrence of sternal wound complications, the extended surgical time, and the complex technical requirements.

In the present study, there was an insignificant difference between both groups regarding the baseline characteristics and risk.

Our results were consistent with **Kim *et al.*** [12], who reported that age, sex, DM, hypertension, COPD, hyperlipidemia and renal disease were comparable between BITA and SITA grafting.

The current study demonstrated that both groups had no significant difference regarding the baseline characteristics and risk factors, hemoglobin, preoperative EF and left main disease, whilst a greater number of diseased vessels was noticed in group B but without statistical significance.

Our results were aligned with **Loberman *et al.*** [13], who found that in the BITA cohort, three-vessel disease was more prevalent. Compared to SITA grafting group, the BITA grafting group frequently showed a more complex CAD that included a greater number of diseased vessels. BITA patients generally had more extensive CAD, which justified the grafting of both arteries.

However, **Elmistekawy *et al.*** [14] reported that preoperative EF was comparable between both groups. Meanwhile, BITA group had significantly higher number of patients with left main disease ($p < 0.05$).

Group B had significantly longer aortic cross clamp time and total bypass time and significantly decreased incidence of DC shock than group A (P=0.003, <0.001, <0.001), due to longer time in distal anastomosis and T configuration of RITA to LITA in our study.

Our findings agreed with **Elmistekawy *et al.*** [14], who reported that BITA group had significantly greater aortic cross-clamp times than the SITA group ($p < 0.0001$).

Regarding the outcome, group B had significantly higher spontaneous recovery of sinus rhythm than group A (P<0.001). In group B Inotropic support, IABP, Exploration, early and late pericardial effusion, no of blood transfused units and post tamponade were significantly less than group A (P<0.05). Group B exhibited significantly shorter duration of ICU stay and hospitalization than group A (P<0.001, <0.001). In both groups, the incidence of mortality, myocardial infarction, renal failure, ventilation duration, new onset AF, mediastinitis, mortality, pleural effusion, total drainage, exploration for bleeding, subxiphoid drainage, pulmonary complications, stroke, and sternal incision infection (mediastinitis) were not significantly different.

Our results were consistent with those of Puskas ***et al.*** [15], who reported that BITA grafting was associated with significantly shorter ICU and hospital stays compared to SITA grafting.

Also, in consistent with the current findings, **Pettinari *et al.*** [16] showed that both SITA and BITA groups had comparable rates of myocardial infarction, mortality, stroke, and sternal wound complications.

However, a significantly higher incidence of deep sternal wound infection ($p < 0.01$) was reported was reported after BITA harvesting by **Deo *et al.*** [17]**,** while peri-operative myocardial infarction, stroke and early mortality were comparable to our results.

Also, **Elmistekawy *et al.*** [14] reported that BITA group showed significantly higher prevalence of sternal site infections (superficial and deep) than SITA group (P<0.05).

In this study, deep sternal wound infections requiring rewiring occurred in 1.59% cases in group A and 7.94% cases in Group B. Nevertheless, the incidence rate of sternal wound complications was comparable between the two groups, despite the fact that group B had a higher prevalence of diabetes. **Benedetto *et al.*** [18] **and Deutsch *et al.*** [19] reported higher incidence rate of severe sternal wound complications (2.3–12.8%) than reported in the current study.

The following is a summary of our experience with the sternal incision complications prevention: As elevated HbA1c has been identified as a high-risk factor for incision complications in cardiac intervention from prior study [20]**.** Therefore, during the perioperative period, diabetic patients should maintain strict control over their blood sugar levels; specifically, preoperative HbA1c should be maintained at or below 8%. The skeletonization technique was selected for IMA harvesting due to its minimal impact on the pectoral wall, and the internal mammary vein and IMA branches were retained. This helped the healing of sternal wounds [21]**.**

Several guidelines demonstrated by **Gatti *et al.*** [22] **and Hashimoto *et al.*** [23] have obviously recommended the skeletonization technique for ITA harvesting in BITA grafting in order to significantly decrease the incidence of sternal incision complications. Precision and strict adherence to the "no touch" principle were necessary for the ITA harvesting during the skeletonization technique, to prevent arterial spasm and endothelial injury. Utilization of the "8-shaped method" was implemented to fix the sternum. Patients with a BMI greater than 40 kg/m^2 during BIMA grafting are at an higher risk of developing complications associated with deep sternal incisions as reported by prior studies [16]. Both groups in the current study neither exceeded 40 kg/m^2.

The limitations of the study included a small sample size, a short follow-up period, and its conduction at a single center.

CONCLUSION

In elderly patients, BITA grafting shows similar morbidity and mortality rates to SITA grafting. BITA grafting is associated with shorter hospital stays, fewer complications, and quicker recovery. Using skeletonization technique in harvesting BITAs reduced the probability of sternal wound infections. These results suggest that BITA grafting can be a good choice (to gain benefits of better long-term patency) for elderly patients undergoing CABG.

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