Role of Left Internal Mammary Artery Harvesting with closed Pleura vs. open Pleura in Fast track Extubation

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ABSTRACT

Objective: To Compare the Role of Intact Pleura Versus Open Pleura After Left Internal Mammary (LIMA) Harvesting During Coronary Artery Bypass Grafting (CABG) In Fast Track Extubation. Recovery of Postoperative Pulmonary Functions and Respiratory Complications. **Patients and Methods:** Sixty adult patients undergoing elective on-pump CABG were randomly divided into 2 groups: Group I (n=30) with LIMA harvesting without pleurotomy, and Group II (n=30) with LIMA harvesting with pleurotomy. **Results:** Patients with intact pleura (group I) had significantly lower blood loss. The rate of postoperative pleural effusion was significantly lower in group I (intact pleura) than in group II (open pleura). The scores of atelectasis were significantly lower in group I (intact pleura) than in group II (open pleura). PaO2 was significantly higher in group I (intact pleura) than in group II (open pleura) before extubation and after extubation, while PaCO2 was significantly lower after extubation. The intensity of pain was significantly lower in group I than in group II at 12h after surgery and after the removal of chest tubes. **Conclusion:** Post-operative Respiratory Functions were significantly recovered in **patients undergoing CABG Without pleurotomy** (group I) than in **Patients undergoing CABG With pleurotomy** (group II), also keeping the pleura intact associated with an early low rate of atelectasis and pleural effusion after CABG. Clinically, it significantly decreases the postoperative amount of blood loss and intensity of pain. **Keywords:** Coronary artery bypass, pleural integrity, pleural effusion, atelectasis, postoperative pain.

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INTRODUCTION

Left internal mammary artery (LIMA) to the left anterior descending artery (LAD) is still the gold standard conduit for coronary artery bypass grafting (CABG) as it provides increased survival and freedom from myocardial infarction, symptoms, and reinterventions compared to venous graft [1].

Opening of the pleura during LIMA harvesting is preferred by some surgeons to have better LIMA exposure and to reduce pericardial effusion and tamponade, but this method carries a high chance of pleural effusion and postoperative pulmonary complications which may be reduced when the pleura is kept intact [2].

Respiratory problems are one of the major factors affecting morbidity and mortality after CABG [3].

Based on recent evidence in literature, preservation of pleural integrity seems to contribute to decreased respiratory complications and improved clinical outcomes, such as, bleeding, pain, pulmonary functions, and length of hospital stay [4].

However, preservation of pleural integrity is not advocated to be used as a routine for all patients during LIMA harvesting.

The aim of the present study was to examine and compare the effects of preservation of pleural integrity in patients undergoing CABG with Lima harvesting **(with pleurotomy and without pleurotomy)** on post-operative clinical outcomes, post-operative respiratory functions, and post-operative pain.

Patients and Methods

Sixty patients undergoing CABG between February 2022 and September 2022 were included in this prospective study, after obtaining a written informed consent from all of them. Data collected from Cairo university hospitals and Sohag cardiac center.

Patients were randomly assigned into two groups: **Group I: the closed (intact) pleura group (n = 30 patients)**, **Group II: the opened pleura (pleurotomy) group (n = 30 patients).**

The Inclusion criteria: Adult Patients Older Than 40 Years Old, patients Undergoing Elective On-Pump CABG Were Included, diabetic Patients with HbA1c < 8 mg/dl and all Known Smoker Patients had stopped smoking for at least 4 months pre-operative proved by Clinical Auscultation, CXR Or CT-Chest, Pre-Pulmonary Function Test.

The Exclusion criteria: Age more than 65 years, patients in Heart Failure (with moderate to severe LL edema), uncontrolled Diabetic Patients (with HbA1c > 8 mg/dl), poor Contractility: Low ejection fraction < 40%, coronary Artery Bypass Graft associated with Other Valve procedures, redo-Surgery, Emergency CABG, patients with Restrictive or Obstructive Lung Disease (Poor Pulmonary Function tests), preoperative Chest Infections, Atelectasis or Consolidation on Chest X-Ray, skeletal abnormalities that causes Pulmonary Restriction, patients with Chronic Renal Failure and patients with Coagulation Disorders.

All patients were thoroughly evaluated pre-operatively, intra-operatively and post-operatively.

Preoperative pulmonary function tests were done on all patients. We assessed all 60 patients at 5 days postoperatively and on the day of hospital discharge.

Data collection: The preoperative, intraoperative and postoperative data were prospectively collected in both groups and it included: **Preoperative Data:** Age, Gender, Co-morbid risk factors (smoking, DM, hypertension), ECHO Parameters: Ejection Fraction (EF) and pulmonary function tests and ABGs.

Intraoperative Data: Number of grafts per patient, cross Clamp Time, Cardio Pulmonary Bypass Time.

Postoperative Data: Ventilation time, Total ICU stay, Total Hospital stay, Amount of Blood Loss, Re-Opening, Post-operative Pulmonary Function Tests and Arterial Blood Gases, Post-operative Atelectasis, Pleural Effusion and Pneumothorax and Post-operative Intensity of Pain.

Collected Data Included The Following: Patients' Clinical Status, Labs: Complete Blood Count (CBC), Coagulation Profile: PT, aPTT, INR, Renal Function Tests: Urea, Creatinine, Viruses: HBV, HCV and HIV, Arterial Blood Gases, Plain Chest X-ray, and Chest Computed Tomography, Abdominal Ultrasound, Carotid Duplex, Lower Limb Venous Duplex, Pulmonary Function Tests: Forced Vital Capacity percent to normal (FVC%), Forced Expiratory Volume percent to normal (FEV%), FEV1/FVC ratio. Parameters were analysed at the patients on the day before surgery and were repeated on 5^{th} postoperative day using a spirometer, all patients treated were with the same analgesic protocol and were given daily physiotherapy until discharge.

The pain intensity was evaluated by visual analogue scale (VAS).

Operative Technique: LIMA Harvesting Technique without Pleurotomy and LIMA Harvesting Technique with Pleurotomy

LIMA Harvesting Technique without Pleurotomy

Initial steps: After median sternotomy, **The Pericardium is opened** to inspect the target epicardial vessels**. Meticulous hemostasis is important**. Oozing from the subcutaneous fat, the sternum, or the sternal edges can compromise visibility. After achieving adequate hemostasis, **the left internal mammary artery (LIMA) retractor is placed into the chest** to elevate the left hemi sternum. **In CP group, the left pleura were retracted with moisturized sponge and the pleura were kept intact.** When left pleura were incidentally opened, the patient was excluded. **Harvesting of LIMA was performed using Skeletonized technique without endothoracic fascia and the tissue. First, the parietal pleura should be separated from the internal thoracic wall. Grab and pull down the pleura or the edge of the opened pericardium with forceps,** and divide the yellowish “foamy layer” to create an approximately 5-6 cm wide plane between the thoracic wall and the parietal pleura. Opening the pleural space is not necessary.

Incision of the Endothoracic Fascia: After freeing the pleura from the chest wall, **The LIMA and the two accompanying veins** (the medial and lateral internal thoracic veins) **should be visible under the endothoracic fascia**. Look for pulsations. If the LIMA is not visible, palpation can help in identifying the vessel. The next step **is the incision of the endothoracic fascia**, medial to the medial internal thoracic vein. **Grab and pull down the endothoracic fascia with forceps and incise with diathermy**. Incise the endothoracic fascia along the full length of the LIMA to expose the vessel. **Technique of LIMA Harvesting: With the flat of the diathermy blade, carefully dissect the vessel from the chest wall**. The shank of an open forceps might be used to gently pull down the LIMA to help exposure**, but never grab the LIMA itself**. **While freeing side branches, dissect towards the chest wall** rather than towards the LIMA; this minimizes the risk of tears at the origin of the side branches. **After the side branch is completely freed, place a small vascular clip on it** flush with the LIMA and another at the chest wall. **Placing clips too close to the LIMA can narrow the vessel** and should be avoided. Divide side branches with scissors at the level of the chest wall. Alternatively, low energy diathermy might be used at a safe distance. **Starting at the midpoint, first proceed distally, towards the diaphragm**. **The LIMA should be freed completely until the level of its bifurcation** to the musculophrenic and superior epigastric artery is reached. After the distal part is finished, continue proximally using the same technique.

Pedicled LIMA Harvesting Technique with pleurotomy: Set the diathermy to low energy. **Start the LIMA harvest at the uppermost point** (this is usually the midpoint of the incision). Starting here will make the LIMA automatically fall away from the chest wall, helping in the exposure. **Begin the dissection above a rib**, where there are usually no side branches. **Pull down the incised endothoracic fascia and carefully develop a plane between the LIMA and the thoracic wall** with the flat of the diathermy blade using cold dissection.

Technique of LIMA Harvesting: With the flat of the diathermy blade, carefully dissect the vessel from the chest wall. The shank of an open forceps might be used to gently pull down the LIMA to help exposure**, but never grab the LIMA itself**.

While freeing side branches, dissect towards the chest wall rather than towards the LIMA; this minimizes the risk of tears at the origin of the side branches. **After the side branch is completely freed, place a small vascular clip on it** flush with the LIMA and another at the chest wall. **Placing clips too close to the LIMA can narrow the vessel** and should be avoided. Divide side branches with scissors at the level of the chest wall. Alternatively, low energy diathermy might be used at a safe distance. **Starting at the midpoint, first proceed distally, towards the diaphragm**. **The LIMA should be freed completely until the level of its bifurcation** to the musculophrenic and superior epigastric artery is reached. After the distal part is finished, continue proximally using the same technique.

Statistical analysis: Data were coded and entered using the statistical package for the Social Sciences (SPSS) version 28 (IBM Corp., Armonk, NY, USA). Data was summarized using mean and standard deviation for quantitative variables and frequencies (number of cases) and relative frequencies (percentages) for categorical variables. Comparisons between groups were done using unpaired t test (Chan, 2003a) [88]. For comparing categorical data, Chi square ($\chi 2$) test was performed. Exact test was used instead when the expected frequency is less than 5 (Chan, 2003b) [89]. P-values less than 0.05 were considered as statistically significant.

Results

In Our study sixty patients aged 40-65 y admitted in department of cardiac surgery who underwent CABG and fulfilled inclusion and exclusion criteria were selected for study sample and divided into **two groups**

Table (1):

	CABG with closed pleura		CABG with open pleura		
	Mean	Standard Deviation	Mean	Standard Deviation	P value
Age	53.20	8.86	53.20	8.86	1.000

Table (1): shows that there were insignificant differences between both groups in Age and Echo parameters with mean age (53.2 ± 8.8) ($p > 0.05$). There were no significant differences between the two groups of patients regarding mean age. The highest percentage of patients from both group I and group II belonged to 40 – 65 years ($p>0.05$).

Table (2)

	CABG with closed pleura		CABG with open pleura		
	Mean	Standard Deviation	Mean	Standard Deviation	P value
Pre FEV %	88.90	3.37	88.90	3.37	1.000
Pre FVC %	85.47	3.15	85.47	3.15	1.000
Pre FEV /FVC %	86.2	2.3	82.9	2.6	0.042

In **Table** (2): pre pulmonary function test (mean ± Standard Deviation) shows that pre-FEV in group I and group II are (88.90 ± 3.37) ($p > 0.05$), pre-FVC in group I and group II are (85.47 ± 3.15) ($p >0.05$), also FEV/FVC% in group I and group II are (86.2 ± 2.3 and 82.9 ± 2.6 respectively) ($p < 0.05$) with insignificant differences between both groups.

Table (3)

	CABG with closed pleura		CABG with open pleura		
	Mean	Standard Deviation	Mean	Standard Deviation	P value
Cross Clamp	52.90	7.30	54.37	6.53	0.415
CPB	80.43	11.66	100.00	0	0.05

Table (3): shows that cross-clamp time and cardiopulmonary bypass time in both groups are insignificantly different, with cross-clamp in group I and group II are (52.90 ±7.30 and 54.37 ± 6.53 respectively) (p 0.415), while CPB time in the group I and group II are (80.43 ± 11.66 and 98.67 ± 1.33 respectively) (p 0.05).

Table (4)

	CABG with closed pleura		CABG with open pleura		
	Mean	Standard Deviation	Mean	Standard Deviation	P value
Ventilation Time	5.70	1.29	6.87	1.31	0.001
Drainage Total (ml)	501.00	129.70	725.00	325.03	0.001
ICU Stay	1.47	0.57	2.30	0.47	< 0.001
Hospital stay	4.67	0.76	5.77	0.86	< 0.001

Table (4): shows that There were statistically significant differences in Ventilation time between the CP group and OP group (5.70 ±1.29 and 6.87 ± 1.31, respectively) (p: 0.001). Also, there were statistically significant differences in Drainage(total) between the CP group and OP group (501.00 ± 129.70 and 725.00 ± 325.03, respectively) (p: 0.001). There were statistically significant differences in ICU stay between the CP group and OP group (1.47 ± 0.57 and 2.30 ± 0.47, respectively) (p: < 0.001). There were statistically significant differences in hospital stay between the CP group and OP group (4.67 ± 0.76 and 5.77 ± 0.86, respectively) (p: < 0.001).

Table (5)

		CABG with closed pleura		CABG with open pleura		P value
		Count	%	Count	%	
Pneumothorax	**No**	30	100.0%	30	100.0%	------
Pleural effusion	**Mild**	0	0.0%	2	6.7%	0.0492
	No	30	100.0%	28	93.3%	
Lung Atelectasis	**Yes**	4	13.3%	10	33.3%	0.0067
	No	26	86.7%	20	66.7%	
Re-Open	**Yes**	0	0.0%	1	3.3%	1
	No	30	100.0%	29	96.7%	

Table 5 shows that there were statistically significant differences in pleural effusion between groups with CP group and OP group (0% and 6.7% respectively) (P= 0.0492). There were statistically significant differences in lung atelectasis between the CP group and OP group (13.3% and 33.3%, respectively) (P= 0.0067). There were statistically significant differences in Re-opening between the CP group and OP group (0% and 3.3%, respectively) (P= 1).

Table (6)

	CABG with closed pleura		CABG with open pleura		
	Mean	Standard Deviation	Mean	Standard Deviation	P value
Post FEV%	75.00	3.05	55.00	3.05	< 0.001
Post FVC%	74.13	3.26	54.13	3.26	< 0.001
Post FEV /FVC%	99.13	5.53	97.20	4.63	0.041

Table (6): shows post-pulmonary function test with a significant increase in Post FEV, FVC, and a statistical increase in postoperative FEV1/FVC, especially in the CP group.
Post FEV in the CP group and OP group are (75.00 ± 3.05 and 55.00 ± 3.05, respectively) ($p < 0.001$)
Post FVC in the CP group and OP group are (74.13 ± 3.26 and 54.13 ± 3.26, respectively) ($p < 0.001$)

Table (7)

Postoperative pain	CABG with closed pleura		CABG with open pleura		
	Mean	Standard Deviation	Mean	Standard Deviation	P value
1h after surgery	0.73	0.66	1.06	0.78	0.09
12h after surgery	2.53	0.68	2.93	0.8	0.001
After the removal of chest tubes	1.6	0.78	2.66	0.78	0.03

Table (7): there was no statistically significant difference between both groups when measured at 1 hour after surgery (p = 0.07), while it was significantly lower in the CP group than in the OP group at 12 hours after surgery (p = 0.001) and after removal of chest drain (p = 0.03).

Discussion

The LIMA is a commonly used conduit of choice for myocardial revascularization. Maintenance of pleural integrity may affect patients' post-operative course, as demonstrated by our findings.

In this way, closed pleural IMA harvesting may be particularly relevant to decrease the early postoperative respiratory impairment; in the present study Group I (n = 30) patients had intact pleura with skeletonized LIMA, and Group II (n = 30) patients had pleurotomy with pedicled LIMA.

There were insignificant differences between both groups in Age and Echo parameters with mean age (53.2 ± 8.8) (p > 0.05). Echo parameters were in significantly different with EF > 50 %

Similar findings were found by Rezk et al., [5] when doing a study on 100 patients **divided into 2 groups:** Closed Pleura (n=50), Open Pleura (n=50) **showing data insignificantly different with** mean age in CP and OP (61.7±7.4 and 58.6±5.3 respectively) and EF > 40 %.

Similar findings were found by Elwany et al., [6] when doing a study on 60 patients **divided into 2 groups:** Closed Pleura (n=30), Open Pleura (n=30) **showing data insignificantly different with** a mean age in the CP group and OP group (56.5 ± 7 and 59.3 ± 7.6 respectively) and EF in CP group and OP group are (60.36 ± 10.50 and 57.83 ± 9.51 respectively)

In our study, there were insignificant differences between both groups: pre-FEV in the CP group and OP group are (88.90 ± 3.37) (p>0.05), pre-FVC in the CP group and OP group is (85.47 ± 3.15) (p>0.05), also FEV/FVC% in CP group and OP group are (86.2 ± 2.3 and 82.9 ± 2.6 respectively) (p<0.05)

Similar findings were found by Rezk et al., [5] when doing their study **showing statistically insignificant different data (**pre FEV in CP group and OP group are (94.2 ± 4.4 and 91.5 ± 4.7 respectively) (p<0.05), pre FVC in CP group and OP group are (92.7 ± 4.4 and 87.4 ± 4.6) (p<0.05), also FEV/FVC% in CP group and OP group are (86.2 ± 2.3 and 82.9 ± 2.6 respectively) (p<0.05)**.**

In our study, there were insignificant differences between both groups: pre PaO2 in the CP group and OP group are (92.93 ± 7.2) (p>0.05), also pre PaCo2 in the CP group and OP group are (42.43 ± 2.06) (p>0.05)

In our study, there were insignificant differences between both groups, with CABG x 2 in the CP group and OP group (30%), CABG x 3 in the CP group and OP group (63.3% and 66.7%) respectively, and CABG x 4 in CP group and OP group are (6.7% and 3.3%) respectively with P value **(p>0.05).**

Similar findings were found by Atay et al., [7] when doing their study, **showing a statistically insignificant difference between 2 groups, with mean no. of grafts** in the CP group and OP group being (2.91 ± 0.8 and 2.82 ± 0.7) (p: 0.06).

In our study, there were insignificant differences between both groups with cross-clamp in the CP group and OP group (52.90 ±7.30 and 54.37 ± 6.53 respectively) **(p 0.415)**.

Similar findings were found by Elwany et al., [6] when doing their study **showing the statistically insignificant difference between 2 groups with** cross-clamp in the CP group and OP group are (51.53 ± 18.93 and 51.83 ± 15.78 respectively) **(p: 0.94)**.

Similar findings were found by Atay et al., [7] when doing their study **showing the statistically insignificant difference between 2 groups with** cross-clamp in the CP group and OP group are (42.9 ± 15 and 42.7 ± 11.5 respectively) **(p: 0.82)**

In our study, there was an insignificant difference between both groups with CPB time in the CP group and OP group (80.43 ± 11.66 and 98.67 ± 1.33, respectively) **(p>0.05)**.

Similar results were found by Rezk et al. [5] when doing their study **showing statistically insignificant different data.**

In our study, there were significant differences between both groups with ventilation time in the CP group and OP group (5.70 ± 1.29 and 6.87 ± 1.31, respectively) (p < 0.001)

Similar results were found by Elwany et al., [6] when doing their study, **showing a statistically significant difference between 2 groups with ventilation time in** the CP group and OP group (9 ± 3 and 10 ± 3.1 respectively) (p: 0.21)
Similar results were found by Atay et al., [7] when doing their study, **showing a statistically significant difference between 2 groups with ventilation time in** the CP group and OP group (12.4 ± 3.9 and 14.03 ± 10.7 respectively) (p: 0.0001)
In our study, there was a significant difference between both groups with total drainage in the CP group and OP group (501.00 ± 129.70 and 725.00 ± 325.03, respectively) (p: 0.001).
Similar results were found by Iqbal et al., [8] when doing their study, **showing a statistically significant difference between the CP group and OP group in blood loss** (500 ± 300 and 520 ± 350 respectively) ($p < 0.77$).
In our study, there were insignificant differences between both groups with ICU stay in the CP group and OP group (5.70 ± 1.29 and 6.87 ± 1.31 respectively) ($p < 0.001$)
Similar results were found by Elwany et al., [6] when doing their study **showing statistically insignificant difference** in ICU stay between the CP group and OP group (2.06 ± 0.9 and 2.56 ± 1.38 respectively) (p: 0.1).
In our study, there were significant differences between both groups, with reopening in the CP group and OP group (0% and 3.3%, respectively) **($p < 0.05$)**.
Similar results were found by Elwany et al., [6] when doing his study **showing statistically significant difference with Re-opening (no** patient in CP group and 1 (3.3%) patient in OP group**) (P: 0.31)**
In our study, there was a significant difference between both groups with post-FEV in the CP group and OP group (75.00 ± 3.05 and 55.00 ± 3.05 respectively) ($p < 0.001$), also post-FVC in the CP group and OP group (74.13 ± 3.26 and 54.13 ± 3.26 respectively) ($p < 0.001$) with a statistical increase in postoperative FEV1/FVC % (99.13 ± 5.53 and 97.20 ± 4.63 respectively in CP group and OP group) (p: 0.041)
Similar results were found by Rezk et al. [5] when doing his study **showing statistically significant different data (**post FEV in CP group and OP group are (70.6 ± 4.8 and 53.04 ± 4.6 respectively) (p: 0.001), also post FVC in CP group and OP group are (70.1 ± 4.7 and 54.6 ± 4.1 respectively) (p: 0.001) with a statistical increase in postoperative FEV1/FVC % (99.1 ± 5.6 and 97.1 ± 4.4 respectively in CP group and OP group especially in CP group) (p: 0.001)
The larger decrease of the FVC, FEV1, oxygenation, and gas exchange observed in this study likely reflects the patients that were subjected to a greater degree of chest wall trauma.
In our study, there were insignificant differences between both groups, with Pain at 1h after extubation in the CP group and OP group (0.73 ± 0.66 and 1.06 ± 0.78 respectively) (p: 0.09), **while Pain was significantly different at 12h after extubation** in CP group and OP group are (2.53 ± 0.68 and 2.93 ± 0.8 respectively) (p: 0.001) **and after removal of chest tubes** in CP group and OP group (1.6 ± 0.78 and 2.66 ± 0.78 respectively) (p: 0.03)

Conclusion
Our study showed that preservation of pleural integrity may decrease the incidence of atelectasis, pleural effusion, and pain, also, pulmonary functions during the postoperative period recovered better when compared to patients undergoing CABG with pleurotomy. This may be an important factor for patients with an increased risk

of postoperative respiratory problems. In patients with chronic pulmonary disease or a concomitant disease that may adversely affect postoperative respiratory functions, preserved pleural integrity may decrease the possibility of respiratory complications such as atelectasis and pleural effusion, and improve respiratory functions.

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