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Original Article

Effect of Intact Pleura on Early Outcome after Off-Pump Coronary Artery Bypass Grafting

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Key Words :
IHD, CABG, Pleural Effusion.

Abstract

Background: *Among the various options of treatment of ischemic heart disease coronary artery bypass grafting (CABG) remains one of the standard modes of revascularization. Coronary artery bypass grafting can be done with or without using cardiopulmonary bypass (CPB). This study was to compare postoperative early (up to 1 month) outcome of intact versus open pleura after off pump coronary artery bypass grafting (OPCAB).*

Methods: *In this study, sixty patients aged 18-70 years admitted in Department of Cardiac Surgery, NICVD who underwent OPCAB were selected for the study sample and divided into two groups. Groups I (n=30) consist of the patients who underwent OPCAB with pleurotomy and Group II (n=30) consists of patients who underwent OPCAB with intact pleura. Outcome of patients including Forced expiratory volume in first second (FEV1) & Forced vital capacity were evaluated.*

Results: *Patients having OPCAB with intact pleura showed lower incidence of atelectasis and pleural Effusion in 2^{nd} postoperative & 5^{th} postoperative day ($p<0.05$). Lower amount of chest tube drainage and transfusion requirement were observed in group II patients than Group I (530.00 ± 28.97 vs. 485.96 ± 38.62; $p<0.05$ and 611.23 ± 99.22 vs. 577.93 ± 135.38, $p>0.05$, respectively). Moreover, higher duration of ventilation were noted in group I (7.50 ± 2.22 vs. 6.30 ± 2.32, $p<0.05$). Beside these, total duration of ICU stay & hospital stay were significantly higher in patients OPCAB with open pleura ($p<0.05$).*

Conclusion: *Keeping the pleura intact during OPCAB is significantly associated with low rate of atelectasis and pleural effusion. Clinically, it decreases postoperative amount of blood loss and significantly lowers ICU stay, mechanical ventilation time and hospital stay. Therefore, it can be concluded that intact pleura during OPCAB improves postoperative pulmonary outcomes.*

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Introduction

Ischemic heart disease is the most common form of heart disease. The incidence of ischemic heart disease is increasing rapidly. Among the various options of treatment of ischemic heart disease coronary artery bypass grafting (CABG) remains one of the standard modes of revascularization.[1,2] Coronary artery bypass grafting can be done with or without using cardiopulmonary bypass (CPB). In recent years OPCAB is done to avoid CPB related complications like pulmonary dysfunction, increased bleeding tendency & renal failure.[1,2] From the beginning of cardiac surgery the contribution of postoperative pulmonary complications to morbidity & mortality was recognized. Pulmonary functions deteriorate significantly for at least three and half months after cardiac surgery.[3] Nearly 20% of otherwise healthy patients who underwent elective CABG suffered postoperative pulmonary complications.[4] The most common pulmonary complication after coronary revascularization is pleural effusion, haemothorax, atelectasis, pulmonary edema, diaphragmatic dysfunction, pneumothorax, pulmonary infection, pulmonary embolism, respiratory failure & post-pericardiotomy syndrome.[5] There are different factors which may cause pulmonary complications after OPCAB such as anesthesia, preoperative pulmonary function & operative techniques like type of conduits used for grafting & pleural integrity.[6]

Two most commonly used conduits for coronary revascularization are the left internal mammary

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artery (LIMA) and great saphenous vein graft (SVG).[7,8] Although it is possible to harvest the LIMA without opening the left pleura, this is often difficult in some cases due to the intimate anatomical relationship of the LIMA with chest wall and pleura.[9] Pleura may also open during sternotomy, pericardiotomy, during grafting for better exposure. After grafting of LIMA pleurotomy may need to be done to reduce tension on LIMA due to inadequate length.[10,11] The preservation of pleural integrity is controversial. Some surgeons believe that with preserved pleural integrity, there can be tension & torsion on LIMA & the inflated lung can dislocate LIMA which may cause injury. On the other hand, preserved pleural integrity can prevent lung injury & the exposure of the thorax to blood thus reducing the incidence of pleural effusion, atelectasis, pain & prolonged bleeding in postoperative period.[11] Moreover, pleural opening during OPCAB causes reduction in static lung compliance and increase in total respiratory system resistance, furthermore contributing to impair pulmonary function in early postoperative period.[12] Opening of the pleura is also associated with more pain which causes change in pulmonary mechanical characteristics causing shallow breathing and ineffective cough which ultimately lead to many pulmonary complications.[11] The diagnosis of postoperative pulmonary complication requires symptomatic pulmonary dysfunction & associated clinical findings that meet the specific criteria of the particular diagnosis. The clinical manifestations of postoperative pulmonary dysfunction range from arterial hypoxemia in 100% patients to acute respiratory distress syndrome, which occurs in 0.4% to 2% of patients.[13] This study was designed to evaluate the effect of pleurotomy on early (up to 1month) postoperative pulmonary complications.

Study Methods:

This was a prospective observational study conducted in Department of cardiac surgery, National Institute of Cardiovascular Diseases (NICVD) from 1st August, 2017 to 31st July, 2019. Patients admitted to Department of Cardiac Surgery, NICVD and underwent OPCAB during the specified period of time and fulfilling inclusion and exclusion criteria were included in the study. Grouping of the patients: Group I: 30 Patients having OPCAB with pleurotomy and Group II: 30 Patients having OPCAB without pleurotomy

Adult patients (18-70 years) who underwent OPCAB in NICVD during the study period with Forced expiratory volume in first second (FEV1) & Forced vital capacity (FVC) e"70% of the predicted value and Left ventricular ejection fraction (LVEF) e" 35% were included in the study. Patients with associated cerebro-vascular disease, valvular heart diseases or any congenital cardiac anomalies, emergency OPCAB surgery, redo coronary artery bypass grafting surgery, patients having thoracic skeletal abnormalities, patients having chronic obstructive pulmonary disease were excluded from the study.

Patient's preparation and surgical Procedure: For the patients who received clopidogrel, clopidogrel was discontinued 72 hours before surgery. Aspirin was continued up to the surgical operation. Patient in supine position under general anesthesia with endotracheal tube in situ standard median sternotomy was performed. If pleural breach occurred during sternotomy or pericardiotomy then pleura was opened deliberately and these patients was included in group I. Those with intact pleura belonged to group II. LIMA was harvested in skeletonized technique. In group I patients the pleura was opened deliberately with the aid of electro-cautery. LIMA was dissected from the first part of the subclavian artery up to its bifurcation. LIMA and other vascular conduits (great saphenous vein) were prepared. Patients were heparinized by administering 150 IU/kg heparin. Distal anastomosis was performed first. Intra-operative blood transfusion was performed when haematocrit values reached 30%. In case of tension on the LIMA after grafting to LAD due to inadequate length pleurotomy was done for avoiding tension & those patients were included in group I. For group II patients, fatty tissue between pleura and mediastinum was separated meticulously or fasciotomy to the LIMA pedicle was done to optimize the length of LIMA and then LIMA was placed in the groove formed by thymus and fatty tissue. Proximal aortic anastomosis was performed using side clamps. Mediastinal and pleural drains were placed as necessary. At the end of surgery, an appropriate dose of protamine sulfate (1mg for every 100IU heparin administered) was administered to keep the activated coagulation time (ACT) level at 140-150s. After the operation, the patients were transferred to the postoperative cardiac surgical unit. The lungs were initially ventilated in controlled mode ventilation at 12 to 14 breaths/minute, an inspiratory / expiratory ratio of 1:2, PEEP of 5 cm H2O, tidal volume of 8 ml/kg of body weight, pressure support to maintain this volume and FiO2 for keeping arterial oxygen saturation above 95%. Extubation was performed when the patient was haemodynamically stable and alert to maintain self-ventilation and good blood gas values. Blood transfusion was done postoperatively when haematocrit value was below 30%.

Statistical analysis: All data were recorded systematically in preformed data collection form (questionnaire). Statistical analyses were performed by using windows based computer software devised with Statistical Packages for Social Sciences (SPSS-25) (SPSS Inc, Chicago, IL, USA). Quantitative data was expressed as mean and standard deviation and qualitative data as frequency distribution and percentage. 95% confidence limit was taken. Continuous variables were compared by using the unpaired student's t test. Categorical variables were compared by using the Chi-Square test. The summarized data were interpreted accordingly and then presented in the form of tables. p value was considered significant when the value was less than 0.05.

Results

In this study, sixty patients aged 18-70 years admitted in Department of Cardiac Surgery, NICVD who underwent OPCAB and fulfilled inclusion and exclusion criteria were selected for the study sample and divided into two groups, Group I (n=30) having OPCAB with pleurotomy and Group II (n=30) having OPCAB without pleurotomy.

Table-I

Distribution of age between two groups (N=60).

Age (in years)	Group I (n=30) No. (%)	Group II (n=30) No. (%)	p-value
20 – 30	1 (3.3%)	0	
31 – 40	3 (10.0%)	4 (13.3%)	
41 – 50	4 (13.3%)	5 (16.7%)	
51 – 60	14 (46.7%)	13 (43.3%)	
> 60	8 (26.7%)	8 (26.7%)	
Mean ± SD	56.1±10.53	57.90±11.41	0.528^{NS}
Range	(23-67) yrs.	(35-70) yrs.	

Data were expressed as frequency and percentage and mean ± SD. Unpaired student's t-test was performed to compare between two groups. NS= Non-significant

Table I indicates that, there were no significant differences between the two groups of patients regarding mean age. Highest percentage of patients from both group I and group II belonged to 51 – 60 years (46.7% and 43.3% respectively).

Table-II

Distribution of sex among two groups (N=60).

Sex	Group I (n=30) No. (%)	Group II (n=30) No. (%)	p-value
Male	28(93.3%)	27(90.0%)	
Female	2(6.7%)	3(10.0%)	0.640^{NS}
Total	30(100.0%)	30(100.0%)	

Figures in the parentheses indicate corresponding percentage; Chi squared Test (?^{2}) was done to analyze the data. NS= Non-significant

No statistical difference was found in gender between two groups. Male patients were predominant in both groups (93.3% in group I and 90% in group II) [Table II].

Table-III

Distribution of BMI between two groups (n=60)

BMI (kg/m^2) (in years)	Group I (n=30) No. (%)	Group II (n=30) No. (%)	p-value
Underweight (<18.5)	1(3.3%)	0(0.0%)	
Normal (18.5-24.9)	12(40.0%)	13(43.3%)	
Overweight (25.0-29.9)	16(53.3%)	14(46.7%)	
Obese (>30.0)	1(3.3%)	3(10.0%)	
Mean- + SD	25.31±3.09	24.98±3.88	0.721^{NS}

Figures in the parentheses indicate corresponding percentage; Unpaired student's t-test was performed to compare between two groups. NS= Non-significant

Figures in the parentheses indicate corresponding percentage; Unpaired student's t-test was performed to compare between two groups. NS= Non-significant

No statistical difference was found in body mass index (BMI) between two groups [Table III].

Table-IV

Distribution of the patients by preoperative risk factors between two groups (N=60).

Variables	Group I (n=30) No. (%)	Group II (n=30) No. (%)	p-value
HTN	19(63.3%)	23(76.7%)	0.260^{NS}
DM	6(20.0%)	12(40.0%)	0.091NS
Smoking	5(16.7%)	6(20.0%)	0.739^{NS}

Figures in the parentheses indicate corresponding percentage; Chi-squared Test (?^{2}) was done to analyze the data. NS= Non-significant

Among group I patients, 63.3% were hypertensive, 20% were diabetic and 16.7% were smoker. Among group II patients, 76.7% were hypertensive, 40% were diabetic and 20% were smoker. The distribution was statistically similar ($p>0.05$) [Table IV].

Table-V

Distribution of the patients by preoperative investigations between two groups (N=60).

Preoperative variables	Group I (n=30) Mean ± SD	Group II (n=30) Mean ± SD	p-value
Haematocrit (%)	37.4±3.70	38.67±3.50	0.182^{NS}
FEV_1 (L)	2.72±0.32	2.74±0.43	0.843^{NS}
FVC (L)	3.62±0.65	3.56±0.56	0.731^{NS}
Ejection fraction (%)	58.56±1.07	58.06±1.61	0.164^{NS}
PaO2 (mmHg)	91.20±2.92	92.20±2.91	0.190^{NS}
$PaCO_2$ (mmHg)	41.93±3.70	40.90±3.27	0.257^{NS}

Data were expressed as mean ± SD. Unpaired student's t-test was performed to compare between two groups. NS= Non-significant

Regarding preoperative variables, comparison of mean of haematocrit (%), platelet, FEV_1(L), FVC (L), ejection fraction, PaO2 (mmHg) and $PaCO_2$ between Group I and Group II showed that there was no statistically significant difference between two groups ($p>0.05$) [Table V].

Table-VI

Per-operative variables between two groups (N=60).

Per-operative variables	Group I (n=30) Mean ± SD	Group II (n=30) Mean ± SD	p-value
Duration of surgery (minute)	314.60±21.04	310.43±21.89	0.455^{NS}
Grafts per patient	2.36±1.06	2.63±0.76	0.270^{NS}

Data were expressed as mean ± SD. Unpaired student's t-test was performed to compare between two groups. NS= Non-significant

The duration of surgery (minute) and grafts per patient were not statistically significantly different between two groups ($p>0.05$) [Table VI].

Table VII shows that, percentages of patients suffering from atelectasis and pleural effusion after operation was significantly lower among group II patients in comparison to group I patients on 2nd & 5th post-operative day but there was no significant difference between two groups during follow-up on the 30th post-operative day.

Table-VII

Effect of Pleural Integrity on Postoperative Atelectasis and Pleural Effusion between two groups (N=60).

Postoperative	Day Group	Atelectasis Present	Atelectasis Absent	Pleural Effusion Present	Pleural Effusion Absent
2nd POD	Group I	10 (33.3)	20 (66.7)	9 (30.0)	21 (70.0)
	Group II	3 (10.0)	27 (90.0)	2 (6.7)	28 (93.3)
	p Value	0.028^{S}		0.019^{S}	
5th POD	Group I	8 (26.7)	22 (73.3)	8 (26.7)	22 (73.3)
	Group II	2 (6.7)	28 (93.3)	1 (3.3)	29 (96.7)
	p Value	0.037^{S}		0.011^{S}	
30th POD	Group I	5 (17.2)	24 (82.8)	4(13.8)	25 (86.2)
	Group II	1 (3.4)	28 (96.6)	1 (3.4)	28 (96.6)
	p Value		0.068^{NS}		0.126^{NS}

Result is presented as frequency (%). Figures in the parentheses indicate corresponding percentage within groups; Chi-squared Test ($?^2$) was done to analyze the data. NS= Non-significant ,S=Significant

Table-VIII

Distribution of the patients by postoperative arterial blood gas analysis (N=60).

Variables	Group I (n=30) Mean ± SD	Group II (n=30) Mean ± SD	p-value
PaO2 (mmHg)			
1 hour after extubation	85.63±3.73	93.56±3.01	<0.001[S]
2nd POD	87.53±3.67	94.76±2.68	<0.001[S]
5th POD	95.67±2.39	96.60±2.01	0.108[NS]
$PaCO_2$ (mmHg)			
1 hour after extubation	43.93±3.70	42.90±3.27	0.257[NS]
2nd POD	41.13±3.50	40.26±3.11	0.315[NS]
5th POD	40.30±2.08	39.03±3.11	0.069[NS]

Data were expressed as mean ± SD. Unpaired student's t-test was performed to compare between two groups. NS= Non-significant, S=Significant

Table VIII shows the postoperative clinical data. There were significant differences between groups in regard to mean PaO2 at 1st hour after extubation (p<0.05), and on 2nd postoperative day (p<0.05). However, on 5th POD, PaO2 was not significantly different between two groups (p>0.05). The difference in mean $PaCO_2$ between two groups at 1st hour after extubation, on 2nd POD and on 5th POD were statistically insignificant (p>0.05).

Table-IX

Distribution of the patients in according to the postoperative outcomes (n=60)

Variables	Group I (n=30) Mean ± SD	Group II (n=30) Mean ± SD	p-value
Chest tube drainage (ml)	530.00 ± 28.97	485.96±38.62	<0.001[S]
Ventilation time (hr.)	7.50 ± 2.22	6.30±2.32	0.045[S]
Transfusion requirement(ml)		577.93±135.38	0.282[NS]
ICU stay (days)	3.83±0.91	2.30±0.83	<0.001[S]
Hospital stay after surgery (days)	9.50±1.16	8.00±0.94	<0.001[S]
Mortality	1(3.3%)	1(3.3%)	1.0[NS]

Data were expressed as mean ± SD. Unpaired student's t-test was performed to compare between two groups. NS= Non-significant, S=Significant

Among the different post-operative findings, postoperative mediastinal bleeding, ventilation time (hours), the mean length of ICU stay and Hospital stay after surgery (days) were significantly higher in group I than group II (p<0.05 in all cases) except transfusion requirement (p>0.05). Though, transfusion requirement was higher in group I. Mortality did not vary significantly between two groups [Table IX].

Discussion:

The LIMA is a commonly used conduit of choice for myocardial revascularization. The LIMA has more advantages than saphenous vein, and that is why the former is widely utilized in CABG procedures.[18] In the present study, LIMA harvesting was performed via skeletonized technique. Group I patients had pleurotomy and group II patients had intact pleura. The mean age of patients in both groups was within mid-sixties. Male patients were predominant in both groups. A study by Kibria and Ahmed, also noted majority of their cases between 41 and 60 years of age and male gender as predominant.[10] Similar findings were found by Oz, et al.[11], and Ghavidel, et al.[19] In present study BMI, diabetes mellitus, hypertension and smoking was found in statistically similar proportion of patients in both groups. In this study, comparison of mean of pre-operative haematocrit (%), FEV_1 (L), FVC (L), PaO_2 (mmHg), $PaCO_2$ (mmHg) and ejection fraction (%) between Group I and Group II did not show statistically significant difference. The duration of surgery (minute) was statistically similar in both groups in this study. This is concordant with the finding of Guizilini and his colleagues who reported a mean duration of operative time of 309.4±19.3 minutes in opened pleura group and 295.6±22.6 minutes in closed pleura group.[20] Mean number grafts needed per patient were statistically similar in two groups.

In present study atelectasis was seen in 13 & 10 patients on 2nd & 5th postoperative day respectively. Patients with pleurotomy had significantly higher proportion of atelectasis during 2nd & 5th POD. Pleural effusion was seen in respectively 11 & 9 patients during 2nd & 5th postoperative day. Again incidence of pleural effusion was significantly higher in pleurotomy group during 2nd & 5th POD. This is similar to other studies where it was reported that pleural effusion on the 2nd, 5th, and 7th postoperative day and atelectasis on the 5th and 7th day were significantly greater in the opened pleura than closed pleura group.[6] In their study of 122 patients, Peng and his associates showed that 41% of patients with opened pleura had pleural effusion on the 6th postoperative day.[21] According to Oz and his coworkers, the incidence of pleural effusion was higher in the pleurotomy group on 5th and the 30th postoperative day.[11] In present study, there was no significant difference in incidence of atelectasis & pleural effusion during follow up at 30th POD. The conventional pleural opening and placement of the chest tube certainly involves trauma. The drain causes damage to the parietal pleura and intercostal muscles, both are very sensitive structures. The friction of the drain between ribs during breathing increases pain due to the ongoing irritation of the intercostal nerves and costal periosteum. As a consequence, the patient usually reacts with superficial breathing, and deep breathing may be restricted until the drain is removed. The capacity to cough decreases, and this could induce mucus retention, atelectasis, and aggravate hypoxemia. Major incidences of respiratory complications during the postoperative course may occur and delay recovery of pulmonary function.[20]

In our study, Post-operative PaO_2 was significantly lower in patients undergoing pleurotomy than those without pleurotomy on 1 hour after extubation & on 2nd POD. PaO_2 returned back to normal level on fifth post-operative day. A very similar finding was noted by Ahmed, et al.[10] They noted a significant drop of PaO_2 six hours after extubation and on 2nd POD. Guizilini, et al.[20] showed that there was a significant drop in PaO_2 on POD 1 for both groups but the intact pleura group maintained higher values than the opened pleura group. In our study post-operative PaO_2 values was not significantly different among two groups at 5th POD. This result is also similar with the result found by Ahmed, et al.[10] Regarding $Paco_2$, there was an insignificant rise in early post-operative period which came down to baseline afterwards in both groups. The reason remains unclear but inadequate postoperative pain management in some patients might have contributed. Moreover, in group I patients, increased incidence of postoperative atelectasis and pleural effusion might have caused alveolar hypoventilation reflected as increased $Paco_2$. Similar findings were also noted by Ahmed, et al.[10] & Guizilini, et al.[20]

Previously, several authors concluded that intact pleural technique is superior in terms of postoperative amount of chest tube drainage.[22-24] In present study the same finding was noted. The mean value of postoperative chest tube drainage was significantly higher in group I in this study. There could be several reasons for the increased chest tube drainage in the pleurotomy group. In case of pleurotomy there is more extensive distortion of surrounding tissue. Reduced trauma of the surrounding musculofascial tissue and tamponade effects of the intact pleura may be the reasons of reduced blood loss. Opening the pleura induces the mediastinal blood loss to shift in the pleural cavity, increasing the chest tube drainage quantity.[25] Chest tube drainage can also increase as lymphatic drainage from the pleural space can decrease postoperatively due to the damage of the associated lymphatic if pleurotomy occurs.[8] Totaro and his colleagues found that blood loss was decreased in patients with preserved pleural integrity than open pleural group.[24] But they found no difference in blood transfusion requirements.[24] In present study, the mean value of transfusion requirement (ml of blood) is slightly higher in pleurotomy group than the group without pleurotomy, but the difference was not significant. Similar result was also demonstrated in the study of Ghavidel, et al.[19] However, other studies showed mean value of blood transfusion requirement was significantly higher in the group with open pleura.[8]

In this study, the mean value of postoperative ventilation time (hours) was significantly higher in the group who had pleurotomy than those without pleurotomy. Our observation suggests that immediate drop of PaO_2 after operation; pleural effusion and atelectasis are responsible factors for relatively prolonged ventilation time which were significantly higher in the pleurotomy group. Guizilini, et al.[20], reported advantages in preserving pleural integrity including a shorter intubation time, a decrease in respiratory complications; and consequently, a shorter hospital-stay. In our study, the opening of the pleural space was also associated with a significantly longer length of hospital stay compared with the intact pleura group confirming previous report. A significant reduction in the intubation time and hospital stay in patients with intact pleura would lead to lower costs in this group of patients.[20] However, contradictory to our findings, several authors did not find any difference in the duration of mechanical ventilation between these groups.[24,11] In the present study, mean length of ICU as well as hospital stay was significantly longer in Group I compare to Group II. A concordant finding was noted by Guizilini, et al.[20] & Ahmed, et al.[10] The pleurotomy group required increased time to recovery from early postoperative pulmonary complications. Removal of chest drain tube was delayed due to increased amount of drain. So, increased length of ICU & hospital stay occurred. In conclusion, during OPCAB pleurotomy appears to cause deterioration of lung function. This in turn increases the duration of Mechanical ventilation time, length of ICU & hospital stay leading to increased patient sufferings & cost of surgery.

Conclusion:

Keeping the pleura intact during OPCAB is significantly associated with low rate of atelectasis and pleural effusion. Clinically, it decreases postoperative amount of blood loss and significantly lowers ICU stay, mechanical ventilation time and hospital stay. Therefore, it can be concluded that intact pleura during OPCAB improves postoperative pulmonary outcomes. It also makes OPCAB surgery cost-effective reducing ventilation time, ICU & hospital stays.

Conflict of Interest - None.

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