

The effects of internal thoracic artery preparation with intact pleura on respiratory function and patients' early outcomes

Plörotomi yapılmaksızın internal torasik arter grefti hazırlanmasının solunum fonksiyonları ve erken dönem iyileşme periyodu üzerine etkileri

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ABSTRACT

Objective: Postoperative respiratory functions, arterial blood gases, blood loss and clinical outcome following coronary artery bypass surgery (CABG) were assessed in a prospective randomized single-blind (patient- blind) clinical study comparing two different techniques of internal thoracic artery (ITA) harvesting.

Methods: Fifty-four patients admitted for CABG were allocated into two groups according to 'random numbers' technique. In a Group 1 (n=26) ITA was prepared keeping the pleura intact and in a Group 2 (n=28) pleura was opened. Both groups were compared in terms of postoperative respiratory functions, arterial blood gases, bleeding and clinical outcomes using ANOVA for repeated measurements analysis.

Results: Analysis of spirometric and partial oxygen pressure data showed that postoperative reductions in forced expiratory volume (0.17±0.18 lt vs. 0.28±0.14 lt, p=0.016), forced vital capacity (0.18±0.19 lt vs. 0.28±0.13 lt, p=0.037) and arterial oxygen measurements (-0.03±0.22 mmHg vs. 0.15±0.4 mmHg, p=0.023) were less pronounced in patients of Group 1 as compared with patients of Group 2. The increase in intrapulmonary shunts (Qs/Qt ratio) after the operation was more pronounced in Group 2 patients than in Group 1 patients (p<0.01) and the mean values of Qs/Qt ratio 24 hours after the operation were higher in group 2 as compared to Group 1 patients (0.100±0.063 vs. 0.054±0.048, p=0.001).

Radiological evaluation revealed that costophrenic angle obliteration after operation more often occurred in Group 2 (14/28 patients) than in Group 1 (0/26 patients) (p<0.0001). Cardiothoracic index increased significantly after operation only in group 2 patients (p=0.001). Postoperative blood loss within 24 hours was significantly lower in Group 1 compared to Group 2 (656±179 ml vs. 907±257 ml, p=0.001). There was no significant difference between groups in the ICU stay duration (p=0.186), whereas the hospital stay was significantly longer in group 2 patients than in Group 1 patients (8.8±2.0 days vs. 7.6±2.0 days, p=0.039).

Conclusion: According to our results, preserving pleural integrity has positive effects on the respiratory functions and patients' clinical outcomes following CABG operations. (*Anadolu Kardiyol Derg 2008; 8: 368-73*)

Key words: Pleurotomy, coronary artery bypass surgery, internal thoracic artery harvesting, intact pleura

ÖZET

Amaç: Koroner arter baypas greftleme uygulanan hastalarda internal torasik arterin (ITA) iki ayrı teknikle hazırlandığı iki hasta grubunda post-operatif solunum fonksiyonları, arteryel kan gazları, kanama miktarı ve klinik seyir prospektif randomize tek kör (hasta kör) çalışmada karşılaştırıldı.

Yöntemler: Kurumumuza KABG için başvuran ve çalışma koşullarını karşılayan 54 hasta randomize numaralama yöntemiyle iki gruba ayrıldı. Grup 1'de (n=26) ITA; plevra açılmadan, grup 2'de (n=28) plevra açılarak hazırlandı. İki grup postoperatif solunum fonksiyonları, arteryel kan gazları, kanama miktarı ve klinik seyir açısından grup içi ve gruplar arasında preoperatif ve postoperatif olarak farklar açısından "ANOVA for repeated measurements" analizi ile istatistiksel olarak kıyaslandı.

Bulgular: Spirometrik ölçümler ve parsiyel oksijen basıncı verileri zorlu ekspiratuvar volüm (0.17±0.18 lt; 0.28±0.14 lt, p=0.016), zorlu vital kapasite (0.18±0.19 lt; . 0.28±0.13 lt, p=0.037), ve arteryel oksijen basınçları (-0.03±0.22 mmHg; 0.15±0.4 mmHg, p=0.023) değerlerinde postoperatif değerlerde preoperatif ölçümlere göre düşüşün Grup 1 hastalarında Grup 2'ye göre daha az belirgin olduğunu gösterdi. Postoperatif 24. saat ortalama QS/Qt değerleri Grup 2'de Grup 1'e göre daha yüksekti (0.100±0.063; 0.054±0.048, p=0.001). Radyolojik değerlendirme kostofrenik sinüs kapanmasının Grup 2 hastalarında (14/28 hasta) Grup 1'e göre (0/26) daha sık görüldüğünü ortaya koydu (p<0.0001). Postoperatif kardiyotorasik indeks artışı yalnızca Grup 2'de istatistiksel olarak anlamlıydı (p=0.001). Ameliyat sonrası ilk 24 saatte kanama miktarı Grup 1'de 2'ye oranla belir-

gin olarak azdı (656±179 ml; 907±257 ml, p=0.001). Intrapulmoner şant (Qs/Qt) ölçümlerinde ameliyat sonrası artış Grup 2 hastalarında Grup 1'e göre daha belirgin idi (p<0.01). Her iki grup arasında yoğun bakım kalış süreleri açısından bir fark yokken (p=0.186), Grup 2'de hastanede kalış süreleri daha fazla olarak saptandı (p=0.039).

Sonuç: Internal torasik arterin hazırlanırken, plevranın korunmasının, solunum fonksiyonlarını olumlu yönde etkileyeceğine inanmaktayız. (Anadolu Kardiyol Derg 2008; 8: 368-73)

Anahtar kelimeler: Plevrotomi, koroner arter baypas cerrahisi, internal torasik arterin çıkarma tekniği, intakt plevra

Introduction

Within the last 20 years, prevalence of ischemic heart disease has increased (1). As a consequence, the coronary artery bypass grafting (CABG) operations became routine, involving more sophisticated surgical procedures. Particularly, in the last decade (2, 3) common use of arterial grafts resulted in increase of patients' ischemia free period. Therefore, in the current era full arterial revascularization has been performed progressively in several cardiac centers (4, 5). Left internal thoracic artery (LITA) is the most widely used arterial graft with angiographically proven longer patency and survival rates. Technical solutions and potential risks concerning the preparation of the grafts were also widely discussed (6-8). Various techniques for LITA harvesting were described by several surgeons and extrapleural internal thoracic artery (ITA) harvesting is one of these methods. Besides, the graft patency protection of extracardiac thoracic anatomy and nature may be an important issue, especially in patients with obstructive lung disease and particularly in the early postoperative temporary respiratory impairment period. Protection of pleura may prevent blood or air leakage to the thoracic cavity so that additional chest tube insertion becomes unnecessary. Pain due to this chest tube usually influences patient's respiratory capacity and accordance to the postoperative respiratory exercises thus favoring atelectasis. Accordingly keeping pleura intact may decrease postoperative pain and analgesia requirement.

The aim of this study was to evaluate the influence of open pleura and the type of ITA harvesting technique used on the postoperative respiratory functional status as well as the early outcome in patients undergoing CABG procedure.

Methods

In a prospective single-blind (patient-blind) randomized clinical trial, we studied 54 consecutive patients undergoing coronary artery bypass grafting with LITA graft. The study has gained ethical approval from Istanbul University Ethics Committee and 'Written informed consents' were obtained from each patient. The sample size (25 patients per each group) was calculated with power analysis of comparison of changes of the 1st second forced expiratory volume (FEV₁) of the groups with the alpha error of 5%, and power of the study of 80%. Patients with abnormal pulmonary functions, previous cardiac operations, coagulation disorders, poor cardiac functions (ejection fraction <30%), diabetes mellitus, and skeletal disorders were not included into the study.

Patients, being demographically similar, were allocated into two groups according to 'random numbers' technique. Two different techniques of ITA harvesting were performed: in Group 1 (n=26 pts), the pleural space was left intact (extrapleural

takedown group) and in group 2 (n=28 pts), complete incision of the pleura was performed routinely.

Spirometric analyses with assessment of vital capacity (VC), FEV₁ and forced vital capacity (FCV) were made a day before for the initial assessment and a week after the operation supposing patients became fully mobilized, and their hemodynamic parameters stabilized and pain resolved.

Pulmonary artery catheterization with Swan-Ganz catheter was performed for blood gases work-up. Blood gases were recorded immediately before, 1 hour after and on the 24th hour after the operation. The first arterial blood samples were taken in the operating theatre before the intubation as the initial measurement. The other two samples were taken at the first postoperative hour for the assessment of the intubated-ventilator dependent period and at the 24th postoperative hour for the assessment of the extubated period. The intrapulmonary shunt ((Qs/Qt: (CcO₂-CaO₂) / (CcO₂-CvO₂)) was calculated 3 times; at the beginning of the operation and 1 and 24 hours after the operation.

Chest tube drainage was recorded for 24 hours postoperatively. For the evaluation of the pleural effusion and cardiothoracic index (CTI), a chest roentgenogram was performed routinely a day before the operation and on the 5th day postoperatively. Pleural effusion and left costophrenic sinus were evaluated on the 5th postoperative day by the same radiologist. The intubation time, intensive care unit (ICU) stay and the hospital stay were also recorded.

Surgical Technique

Following midline sternotomy before heparinization, ITA dissection was performed. Electrocautery was used for dissection and hemoclips were used for side branch occlusions.

The left ITA was removed as a pedicle with adjacent veins, fascia, and pleura attached. After the sternum was opened, the left side is elevated with a mammary retractor. The endothoracic fascia was divided to expose the pleura and extrapleural fat. Anteriorly, the correct plane was entered by reflecting the transversus thoracic muscle from the sternum and the anterior ends of the 3rd or 4th intercostal spaces. The pleura and transverse thoracic muscle were retracted posteriorly to display the venae comitantes and the ITA. Perforating and anterior intercostal branches were clipped near ITA and divided with electrocautery close to the chest wall at a distance from the artery, thus avoiding damage to the ITA. The 1st perforating branch is often large and may be mistaken for the main artery. If large, the 1st and 2nd perforating vessels were divided between clips. Superiorly, the ITA was mobilized to the level of the inferior border of the subclavian vein so that the pedicle was free to lie medial to the lung near hilum. This avoids tension on the graft from the medial edge of the lung during vigorous ventilation. Dissection was continued inferiorly to the level of the 6th intercostal space to expose the superior epigastric and musculophrenic vessels. The transversus thoracic muscle,

endothoracic fascia, and pleura were divided lateral to the pedicle and parallel to the line of the sternotomy. This leaves a pedicle about 1.5 cm wide. The terminal branches of the ITA were clipped and divided beyond the bifurcation. The artery is sprayed with papaverine hydrochloride solution (2 mmol/liter). After division of the pedicle, a mixture of papaverine (1 mmol/liter) and blood is injected to the distal end of the ITA.

In the intact pleura group, mediastinal pleura was dissected smoothly from the endothoracic fascia and extreme attention had to be taken to prevent pleural injury. ITA was mobilized through its bed anterior to the phrenic nerve into the pericardial cavity. So, it lies median and posterior to the lung and the ventilation does not cause any pressure on the artery. In the pleurotomy group, a tunnel was created into the pericardium above the phrenic nerve and ITA was crossed through this tunnel into the pericardial space.

The CABG was performed by the same surgical team in the usual fashion, under cardiopulmonary bypass with antegrade K⁺ enriched blood cardioplegia. Following cardiopulmonary bypass weaning, a chest tube was inserted to the mediastinal space in all patients. For the patients in the pleurotomy group an additional tube was placed into the left hemithorax through the mid-axillary line and a window was created in the posterior pericardium to prevent possible posterior pericardial hematoma.

Statistical Analysis

Statistical analyses were performed with SPSS 11.0 for Windows™ software (SPSS Inc., Chicago IL, USA). Data are expressed as means ± SD. Normally distributed continuous variables were compared between the groups using the unpaired Student’s t test, and abnormally distributed variables were compared using Mann-Whitney U test. Chi-square test and Fischer exact test were used for comparison of ordinal and nominal data. The intragroup changes in cardiothoracic ratio before and after operation were compared using paired Student’s t test. Two-way repeated measurements ANOVA test was performed to compare magnitude of changes in continuous variables before and after operation between groups. Bonferroni test was performed as posthoc test for pairwise comparison of group differences. Statistical significance was described as p<0.05.

Results

Preoperative characteristics of the patients are given in Table1. There were no significant differences in age, sex, nicotine use, cardiac status, spirometric and arterial blood gas analysis data between two groups before CABG operation (p>0.05 for all).

Pulmonary Function

All patients were extubated within the first 24 hours. However, the time period of intubation was significantly longer in pleurotomy group than in intact pleura group (11.7+3.7 h vs 9.2+3.6 h, p=0.017).

Vital capacity, FEV₁ and FVC were compared pre and postoperatively in both groups (Table 2). Factorial repeated measurements ANOVA analysis demonstrated that changes in VC in both groups after operation did not differ significantly (p=0.78). However, magnitude of postoperative reductions in

Table1. Demographic and preoperative clinical characteristics of patients

Parameters	Group 1 (intact pleura)	Group 2 (pleurotomy)	p*
Sex, males/females ratio	24/2	23/5	0.08
Mean age, years	56.2±7.2 56.0 (44-68)	60.3±9.4 61 (37-79)	0.09
Preoperative myocardial infarction, n (%)	14 (53)	18 (64)	0.075
Mean LVEF, %	38.0±7.8 35 (25-58)	41.0±10.4 37 (22-60)	0.1
Peripheral vascular disease, n	3	5	0.08
Smoker, n	17	20	0.15
Preoperative spirometric data			
FEV ₁ , lt	2.66±0.80 2.7(1.2- 4.6)	2.65±0.78 2.6 (1.05-4.6)	0.9
FVC , lt	3.5±0.7 3.15 (1.25-5.5)	3.6±0.5 2.2 (1.25-5.8)	0.2
PaO ₂ , mmHg	76.1±10.8 80.5(68-144)	85.8±16.4 78 (49-104)	0.13
Number of grafts**	3.8±0.8 4 (2-6)	3.9±0.8 4 (2-6)	0.713
Aortic clamping time, min	46.7±10.8 45 (28-70)	46.4±10.4 48 (12-65)	0.9
Cardiopulmonary bypass time, min	78.0±14.0 78 (54-116)	78.3±10.9 79 (50-98)	0.92

Data are represented as percentage/number, Mean±SD and Median (Min-Max) values
 * -Fisher’s exact and Chi- square tests for comparison of nominal and categorical variables, Students unpaired t test for comparison of continuous variables
 ** -Mann Whitney U test
 FEV₁ -forced expiratory volume (1sec), FVC - forced vital capacity, LVEF - left ventricular ejection fraction, PaO₂ - partial arterial oxygen pressure

Table 2. Comparison of preoperative and postoperative changes of pulmonary function parameters and partial oxygen pressure in both groups

Variables	Group 1		Mean difference	Group 2		Mean difference	F*	p*
	preoperative	postoperative		preoperative	Postoperative			
FEV ₁ , lt	2.6±0.8	2.13±0.5	0.17±0.18	2.6±0.7	1.8±0.5	0.28±0.14	6.247	0.016
VC, lt	3.2±0.9	2.5±0.5	0.18±0.19	3.28±0.9	2.3±0.6	0.26±0.14	3.239	0.078
FVC, lt	3.5±0.7	2.9±0.6	0.18±0.19	3.6±0.5	3.2±0.7	0.28±0.13	4.591	0.037
PaO ₂ , mmHg	76±10	87±22	(-) 0.03±0.22	85±16	84±23	0.15±0.4	5.496	0.023

Data are represented as Mean±SD
 *- 2x2 factorial design ANOVA for repeated measures analysis
 FEV₁ - forced expiratory volume (1 sec), FVC - forced vital capacity, PaO₂ - partial arterial oxygen pressure, VC - vital capacity

FEV₁ (0.17±0.18 lt vs. 0.28±0.14 lt, p=0.016) and FVC (0.18±0.19 lt vs. 0.28±0.13 lt, p=0.037) were less pronounced in patients of Group 1 as compared with patients of Group 2. Similarly, changes in arterial oxygen pressure after operation were significantly different in intact pleura and pleurotomy groups (-0.03±0.22 mmHg and 0.15±0.4 mmHg, p=0.023) with trend to increase after operation in Group 1 and decrease in Group 2.

Intrapulmonary Shunt

The Qs/Qt values before (p=0.187) and 1 hour after the operation (p=0.169) did not differ between the two groups, however QS/Qt ratio at 24th hour after operation was higher in pleurotomy group as compared with intact pleura group (p=0.001) (Table 3).

The intragroup analysis of Qs/Qt ratio dynamics showed significant differences (p=0.007) between pre-operative and postoperative 24th hour values in Group 1, while Group 2 Qs/Qt values significantly increased at 1st hour and with further raise at 24th hour after operation as compared with pre-operative values (p=0.007 for both).

Radiological Assessment

Although the occurrence of pleural effusion was higher in Group 2 versus Group 1, this was not statistically significant on the 5th postoperative day (p=0.112). Radiological evaluation of the left costophrenic sinus showed significant difference between the two groups in favor of greater occurrence of sinus obliteration in pleurotomy group (p<0.0001) (Table 4). The postoperative CTI was high in Group 2 as compared with Group 1 (p=0.006). Intragroup differences in CTI between two measurements (pre- and postoperative) were found to be significant in Group 2 (p=0.001) (Table 4).

Postoperative Blood Loss

Chest tubes were left in situ until the 2nd postoperative day. Postoperative blood loss within the 24 hours was significantly lower (p=0.001) in Group 1 than in Group 2 (Table 4). Reexploration of the chest due to bleeding was unnecessary in either group.

The ICU and Hospital Stay

There were no major differences between ICU stay of the patients (p=0.186). The hospital stay, however, was considerably longer in Group 2 than in Group 1 (p=0.039) (Table 4).

Discussion

Our study demonstrated that extrapleural ITA harvesting provides better postoperative pulmonary function (preserved FEV₁ and FVC),, less blood loss, and also decreased hospital stay.

The respiratory problems in CABG patients are the critical issues influencing patient's early outcome (9). It is well known that most of the ischemic heart disease patients are also current or ex-smokers. Additional negative effects of the extracorporeal circulation (ECC) on the respiratory protection system (ciliar motility, mucus excretion etc.) also led to excessive postoperative mucus secretion and atelectasis. However, there is still no consensus on the ITA harvest technique, which is well known to be one of the major actors in the issue. There are some studies demonstrating the respiratory effects of the ITA preparation technique on the postoperative outcomes but we still miss the evidence (10-12).

In the current surgical era, routine ITA use (with even its bilateral or extensive use) have emerged new harvesting techniques of this invaluable arterial graft (5-8). With the skeletonization of this vessel, it is possible to obtain longer grafts. However, spasm of the artery is the major problem of this technique. The technique in which the pleura is kept intact the graft is nearly skeletonized or semi-skeletonized as described by Horii and colleagues (6). The opposite judgment about pleural integrity is the possible stress on the graft following sternal closure. Another question is the increased risk of injury of the graft, due to its midline course, in patients requiring reoperation. However, these two risks can be prevented by the use of the peripleural supporting tissues. On the other hand, we did not observe any early ischemic symptoms, which led us to conclude there is no need to worry about any possible pressure on these grafts. Furthermore, in graft stretching cases such as distal LAD bypass or short ITA graft, one can perform fasciotomy and/or peripleural incisions to minimize stretching and to omit damage to the pleura.

Table 3. Intrapulmonary shunts measurements (Qs/Qt)

Qs/Qt	Group 1	Group 2	p
Preoperative	0.019±0.01	0.027±0.02	0.187
Postoperative 1 st hour	0.035±0.036	0.055±0.066	0.169
Postoperative 24 th hour	0.054±0.048	0.1±0.063	0.001
Intragroup difference	a ^x	ab ^x	

* - Two-way repeated measures ANOVA test
a= difference between postoperative 24th hour and preoperative data.
b= difference between postoperative 24th hour and postoperative 1st hour data
X= p=0.007

Table 4. Postoperative clinical variables

Variables	Group 1	Group 2	p*
Pleural effusion, n	0/26	4/28	0.112
Costophrenic sinus obliteration, n	0/26	14/28	<0.0001
CTR			
Preoperative	0.47±0.03 0.47 (0.42-0.57)	0.47±0.04 0.48 (0.37-0.57)	1.00
Postoperative	0.47±0.02 0.47 (0.43-0.51)	0.50±0.05** 0.50 (0.30-0.62)	0.006
Drainage, ml	656±179 635 (300-1550)	907±257 850(400-1550)	0.001
Intubation time, hours	9.2±3.6 8(5-18)	11.7±3.7 11.5 (6-20)	0.017
Stay in ICU, days	2.0±0.4 (2-4)	2.25±0.8 (2-5)	0.186
Hospital stay, days	7.6±2.0 7 (6-15)	8.8±2 8 (6-14)	0.039

Data are represented as numbers, Mean±SD and Median (Min-Max) values
* - Fischer exact test and Chi- square test for comparison of categorical variables and Students unpaired t test for comparison of continuous variables
** - p=0.001 differences are significant as compared with preoperative value - paired Students t test
CTR - Cardiothoracic ratio, ICU – intensive care unit

According to the studies comparing ITA and saphenous grafts, ITA is considered to increase the postoperative drainage and also to have negative effects on the postoperative respiratory functions (9). However, former studies proved that bleeding is decreased when ITA is harvested with pleural integrity. Our study supports this finding since there is a considerable decrease in the amount of tube drainages (bleeding) in the intact pleura group as compared with pleurotomy group. When pleura is opened, more extensive dissection of surrounding tissues will be performed during the ITA harvest and thus leading to increased blood loss. Moreover, blood oozing from the thorax wall will be collected in the pleural space and as a consequence, there will be pressure on the lungs which will facilitate atelectasis. A significant reduction of bleeding in the patient with intact pleura might be considered due to the hematoma in the mediastinum. However, significantly high values of postoperative cardio-thoracic ratio in pleurotomy group (despite creation of a posterior pericardio-pleural window) do not support this possibility. Additionally, we did not observe any symptom of cardiac tamponade neither in the pleurotomy group nor, which is more striking, in the intact pleura group.

An increase in atelectasis rate can be considered natural due to the pressure of the hematoma in the pleural space, which can support anatomic factors influencing atelectasis following CABG operations. Measurement of the intrapulmonary shunt (Q_s/Q_t) is an objective method to analyze atelectasis quantitatively (13). Observing a similarity between the early period measurements in both groups and detecting a significant difference only after twenty-four hours support the hematoma effect hypothesis. As a result, of the increase in the total blood volume collected in the pleural space and of the hematoma which is thought to be more and more organized, dead space will enlarge. Also, since positive ventilation is not used atelectasis will not regress. In patients without pleurotomy, as the hematoma volume is less, increase of the atelectatic lung segments will be limited. In fact, such an increase following mechanical ventilation is already expected. Significant decrease in the intrapulmonary shunt displays the positive effect of the intact pleura on the respiratory functions.

In our study, we also evaluated the respiratory function tests, which reflects the clinical results. The statistical analysis of these tests revealed lesser reduction of FEV₁ and FVC after operation in the intact pleura group as compared with pleurotomy group. These findings confirmed the direct reflection of atelectasis on the clinical status of the patients. Although Lim et al. (13) also confirmed the decrease of the intrapulmonary shunt in patients without pleurotomy, they could not find any clinical consequence of it. When we consider the fact that most of the CABG patients are current or ex-smokers, even a little progress in the respiratory function tests will contribute to their recovery period. Furthermore, the arterial blood gas analysis just before their discharge verifies this rapid recovery. The considerably shorter intubation time in patients with intact pleura can be considered as the clinical manifestation of a lower atelectasis incidence. As a result of all these findings, considerably different periods of hospital stay of these patients were found.

On the other hand, pleurotomy may also be considered protective to cardiac tamponade and graft stretching. Left pleural chest tube insertion may prevent any possible pressure caused by possible excessive bleeding from the LITA harvest. Although we did not observe any tamponade or pneumothorax case in either study group, one can postulate that open pleura can help to avoid pneumothorax occurrence, since there is always a risk of pleural injury while harvesting LITA and thus compromising patient's safety.

Although some authors reported important studies declaring advantages of pleurotomy, some previous studies demonstrated the lesser postoperative bleeding and low incidence of pulmonary complications in extrapleural access and preparation of ITA graft without pleurotomy (14-15). Our results being in an agreement with those studies, confirmed that pleural integrity decreases postoperative bleeding and carries advantageous effects on the postoperative respiratory functions of the patients and provides notable decrease in duration of hospital stay.

Study limitations

There are some limitations of our present study. We could not perform long-term respiratory tests of the patients due to the institutional causes of postoperative outpatient controls, which are followed by the cardiology department. Although, our sample size is relatively limited compared to some previous studies, we are still enrolling new patients and planning to enlarge our research.

Conclusion

In conclusion, we emphasize that extrapleural ITA harvest being a safe technique with acceptable risks of pneumothorax and hemothorax, has beneficial effects on postoperative pulmonary functions, blood loss, and hospital stay.

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