Respiratory dysfunction after coronary artery bypass grafting employing bilateral internal mammary arteries: the influence of intact pleura

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Abstract

Objective: To evaluate the role of intact pleurae regarding the postoperative respiratory functional status in patients undergoing coronary revascularization employing both internal mammary arteries (IMAs), according to the pedunculated or skeletonized technique (SKT) with opened or intact pleurae. Materials and methods: Using both IMAs, 299 patients underwent elective coronary revascularization. They were randomized and divided into group I (n = 82, undergoing IMA harvesting according to the SKT without opening the pleurae); group II (n = 186, undergoing IMA harvesting according the pedunculated technique with open pleurae); and group III (n = 31, undergoing IMA harvesting according the SKT with incidentally opened pleurae). There were no differences regarding the preoperative patient characteristics and the anaesthetic and surgical management. Results: There were two deaths in group I versus seven in group II and one in group III (P = ns). The number of total arterial myocardial revascularization and arterial composite grafts was significantly higher in groups I and III than in group II, (P < 0.001 and P < 0.005, respectively). The incidence of postoperative complications was similar between groups. Blood loss of >1000 ml was significantly higher in group II than group I (P < 0.028), but the incidence of re-thoracotomy and blood transfusion was similar between groups. The mechanical ventilation time was significantly higher in groups II and III versus group I (P < 0.018 and P < 0.02, respectively). The incidence of prolonged ventilation (>24 h), pleural effusion, thoracocentesis and atelectasis, resulted in being significantly higher in group II than group I. The incidence of thoracocentesis was significantly higher in group III than group I. The pain score and analgesic requirements at 1–12 h after awakening were significantly higher in groups II and III versus group I, becoming similar after the chest tubes were removed. PaO\textsubscript{2} was significantly higher, and PaCO\textsubscript{2} and FiO\textsubscript{2} were significantly lower in group I than in group II, (P = 0.02, respectively). The incidence of postoperative complications was similar between groups. Blood loss of >1000 ml was significantly higher in group II than group I (P < 0.028), but the incidence of re-thoracotomy and blood transfusion was similar between groups. The mechanical ventilation time was significantly higher in groups II and III versus group I (P < 0.018 and P < 0.02, respectively). The incidence of prolonged ventilation (>24 h), pleural effusion, thoracocentesis and atelectasis, resulted in being significantly higher in group II than group I. The incidence of thoracocentesis was significantly higher in group III than group I. The pain score and analgesic requirements at 1–12 h after awakening were significantly higher in groups II and III versus group I, becoming similar after the chest tubes were removed. PaO\textsubscript{2} was significantly higher, and PaCO\textsubscript{2} and FiO\textsubscript{2} were significantly lower in group I than in groups II and III at 1 and 4 h before extubation and at 1 and 4 h after extubation. PaO\textsubscript{2} and PaCO\textsubscript{2} became similar between groups at the 5th postoperative day. Conclusions: According to our results, we may conclude that pleural integrity has beneficial effects on the respiratory functional status after coronary revascularization using both IMAs. A meticulous and more careful IMA harvesting approach significantly reduces the postoperative morbidity regarding the pulmonary functional status, and as a consequence, reduces the hospital costs. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Bilateral internal mammary artery; Coronary revascularization; Respiratory dysfunction

1. Introduction

Saphenous vein graft atherosclerosis continues to be the major cause of coronary artery bypass grafting (CABG) late failure [1]. The internal mammary artery (IMA) is the conduit of choice [2,3] in CABG because of superior graft patency, reduced cardiac events, and enhanced short- and long-term survival [4,5]. Other studies have documented the long-term patency rate of the grafted IMAs [4,6]. The employment of both IMAs for myocardial revascularization has been demonstrated to be more advantageous over the use of only one IMA in combination with vein grafts with respect to survival and quality of life, i.e. freedom from angina and re-intervention [4,7,8]. Employing in situ IMA [9] as an arterial conduit is particularly indicated for expected long postoperative outcomes. It appears that maximal long-term benefits of using bilateral IMAs are achieved by grafting these arterial conduits to the coronary arteries that supply more left ventricular myocardial muscle [10], which is better performed by employing both skeletonized IMAs [11].

Respiratory complications are one of the most frequently found complications during CABG surgical procedures [12]. The causes of postoperative respiratory complications are different and depend on anaesthesia, cardiopulmonary
bypass and the surgical techniques [13]. Furthermore, it is noted that the employment of the IMAs versus only vein grafts increased the pulmonary complication incidence and postoperative pain after CABG surgery, inducing a worse postoperative outcome [14,15].

Different techniques have been employed for IMA harvesting, such as the pedunculated, skeletonized and semi-skeletonized techniques. Some surgeons prefer to open the pleural cavity during the IMA harvesting for better exposure of this arterial conduit.

The aim of this study was to evaluate the influence of open pleurae and the type of IMA harvesting technique used on the postoperative respiratory functional status and thoracic pain in patients undergoing CABG employing both IMAs.

2. Materials and methods

Between January 1998 and September 2000, we studied 299 patients, randomized for age, sex, left ventricular function, and respiratory functional data, undergoing elective CABG procedures employing both IMAs. We excluded from the study patients undergoing emergency surgery, patients with left ventricular ejection fractions of <30%, pleural adhesions and reoperation. Patients were divided into three groups: group I (n = 82 patients undergoing IMA harvesting according to the skeletonized technique (SKT) without opening the pleural cavity); group II (n = 186 patients undergoing IMA harvesting according to the pedunculated technique (PKT) with open pleural cavity); and group III (n = 31 patients undergoing IMA harvesting according to the SKT with open pleurae). Routinely, we open the pleurae during IMA harvesting by the PKT. Instead, we try to not open the pleurae during IMA harvesting by the SKT; in cases when small pleural holes were identified intraoperatively, the air in the pleural cavity was aspirated and the hole was closed by suture. All patients (n = 12) with repaired pleurae were included in group I. All patients undergoing IMA harvesting according to the SKT, presenting incidental multiple pleural lacerations or when the air aspiration of the pleural cavity was not satisfactory, necessitating chest drainage, were included in group III. The decision to undergo IMA harvesting according to the PKT or SKT was taken by the surgeon, primarily reflecting the preference or inexperience with the SKT.

2.1. Patient characteristics

These are given in Table 1. There were no differences according to the preoperative cardiac status and associated pathologies, spymometric and blood gas analysis data between groups.

2.2. Anaesthesia

All patients received the same anaesthetic regimen. The premedication was achieved with diazepam (0.1 mg/kg), scopolamine (0.2–0.4 mg), and morphine (0.1 mg/kg). During the operation, electrocardiogram (ECG), radial pressure, central venous pressure, pharyngeal and rectal temperature, and urinary output were monitored. The induction of anaesthesia consisted of fentanyl (25–30 μg/kg), diazepam (0.2 mg/kg), and pancuronium bromide (0.1 mg/kg), and was maintained with supplemented dosages of remifentanil hydrochloride (1–3 μg/kg per min), propofol (4–8 mg/kg per h), and low-concentration dosages of isoflurane if necessary.

2.3. Surgical techniques

IMAs were harvested according to the SKT as previously described [11]. After a median longitudinal sternotomy incision, the mediastinal pleurae were dissected gently from the endo thoracic fascia, meticulously avoiding their damage. Then, the endothoracic fascia was incised medially and the IMA and both satellite veins were visualized. The IMA was separated from the chest wall and isolated from
the fascia, the veins satellite and adipose tissue. Sternal, pericardial and anterior intercostal branches were ligated with small-sized haemostatic clips frequently, only by the IMA side. The left (LIMA) and right (RIMA) internal mammary arteries were harvested in a skeletonized fashion until the origin at the subclavian artery, just the terminal branches, without opening the pleural cavities. The IMA’s stem is left intact to allow blood flow through until it is ready for use and covered with gauze impregnated with warm (37–40°C) papaverine solution (4 mg/ml), which allows a pharmacological dilatation. In both sides of the superior mediastinum, the pleura-pericardial tissues were dissected and the IMA ‘beds’ were created.

The IMAs were mobilized through these ‘beds’ and penetrate into the pericardial cavity anterior to the phrenic nerve. The IMA’s ‘bed’ allows it to lie median and posterior to the lung and the ventilation does not produce any stretch or distortion of the arteries, and these are protected should resternotomy be required. Routing of the RIMA behind the superior vena cava and further into the transverse sinus allows additional length, thereby facilitating the grafting of the marginal obtuse coronary arteries via a less circuitous and more protected route. The internal blood pressure will force the graft to always have the right orientation to avoid graft distortion. In cases where the pleural cavity was opened incidentally, the pleural cavities were drained separately.

When IMAs were harvested according to the PKT, the pleurae were opened, and the internal thoracic fascia, muscle and fat tissue containing IMA and concomitant veins was incised with the electrocautery along both sides of the IMA, 0.5–1 cm away: next, the pedicle was dissected working from its distal to proximal end and the major IMA branches were clipped by haemoclips. The pedicle is wrapped in gauze soaked with warm papaverine solution. After heparin was administered, the IMA was cut, the distal end was closed by transfixing ligation and clamped proximally with a bulldog, and, until initiation of the grafting procedure, recovered with the gauze impregnated with papaverine solution. At the end of intervention, a large drain tube is located in the pleural cavities (30±32 F), draining separately under aspiration (~20/–30 cm H2O).

The pericardium was opened, the aorta and right atrium were cannulated in the usual fashion, and cardiopulmonary bypass was started. Normothermia or moderate hypothermia were cannulated in the usual fashion, and cardiopulmonary bypass was continued immediately after the aorta was unclamped, according to the haemodynamic situation, and was continued during the postoperative course in the intensive care unit and eventually combined with diltiazem. Oral vasodilator therapy was continued for 4 postoperative weeks.

The intraoperative data are given in Table 2.

2.4. Cardiopulmonary bypass

A roller pump was used, producing a flow rate of 2.4 l/m² per min and the mean arterial pressure was between 60–80 mmHg, eventually with pharmacological corrections. A membrane oxygenator and Alpha-stat control of the acid–base control were used. Distal anastomoses were constructed during aortic clamping and cardioplegic arrest.

The ventilation technique was identical in all groups. During cardiopulmonary bypass, the lungs remained collapsed.

2.5. Postoperative ventilation

In the intensive care unit, the patient management protocol included:

- supplementary intermittent mandatory ventilation (SIMV) at 12–14 breaths/min.
- a tidal volume of 10 ml/kg of body weight.
- a pressure support of 10–20 cm H2O.
- a positive end expiratory pressure (PEEP) of 3–5 cm H2O.
- an inspiratory/expiratory ratio of 1:2.

Arterial blood gas analysis data at 1 and 4 h, and before extubation in patients under mechanical ventilation extubation were taken (Table 3). Extubation was performed when the patient was warmed, haemodynamically stable, non-bleeding, alert, with good gas analysis data and capable of

Table 2 Intraoperative data

<table>
<thead>
<tr>
<th>Variablesb</th>
<th>Group I</th>
<th>Group II</th>
<th>Group III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number</td>
<td>82</td>
<td>186</td>
<td>31</td>
</tr>
<tr>
<td>Mean distal anastomoses/patient</td>
<td>3.2 ± 0.7</td>
<td>3.1 ± 0.4</td>
<td>3.2 ± 0.3</td>
</tr>
<tr>
<td>Radial artery employed</td>
<td>12 (15)</td>
<td>30 (15)</td>
<td>6 (19)</td>
</tr>
<tr>
<td>Cardiopulmonary bypass time (min)</td>
<td>92 ± 11</td>
<td>94 ± 9</td>
<td>93 ± 13</td>
</tr>
<tr>
<td>Aortic cross-clamping time (min)</td>
<td>67 ± 5.2</td>
<td>68 ± 3</td>
<td>67.3 ± 6</td>
</tr>
<tr>
<td>Operation time (h)</td>
<td>4.2 ± 1</td>
<td>3.98 ± 0.9</td>
<td>4.2 ± 1.4</td>
</tr>
<tr>
<td>Number of normothermia CBP</td>
<td>54 (66)</td>
<td>118 (63.5)</td>
<td>19 (61.3)</td>
</tr>
<tr>
<td>Total arterial revascularization</td>
<td>53 (65)</td>
<td>62 (33)</td>
<td>19 (61.3)d</td>
</tr>
<tr>
<td>Composite grafts</td>
<td>39 (47.6)c</td>
<td>29 (15.6)</td>
<td>11 (35)c</td>
</tr>
<tr>
<td>Combined surgical procedures</td>
<td>TEA</td>
<td>3 (6.65)</td>
<td>11 (5.9)</td>
</tr>
<tr>
<td>Hospital mortality</td>
<td>2 (2.4)</td>
<td>7 (3.7)</td>
<td>1 (3.2)</td>
</tr>
</tbody>
</table>

* Figures in parentheses represent percentage values.

b CPB, cardiopulmonary bypass; TEA, carotid thromboendarterectomy.

c P < 0.001, group I versus group II.

d P < 0.005, group III versus group II.

e P < 0.02, group III versus group II.
maintaining self-ventilation. The arterial blood gas analyses were studied at 1 and 4 h after extubation (Table 3).

Chest X-ray examination was performed daily during the stay in the intensive care unit and on the day of discharge. The pain score was evaluated routinely by self-reporting, using a scale of 1–5: 1, no pain; 2, mild pain; 3, moderate pain; 4, severe pain; 5, extremely severe pain. The measurements were taken by nurses who did not know to which group the patients belonged. Patients whose chest pain score reached 3 or more (≥moderate pain) were treated with morphine and ketorolac–tromentamina (FANS).

Chest tubes were left in situ until 1–2 postoperative days. On the second postoperative day, central and arterial lines and the urinary catheter were removed, and the patients were mobilized.

The criteria for hospital discharge were: normal pulse and arterial pressure, no pyrexia and leucocytosis, haemoglobin >8 mg/dl, creatinine, transaminases and electrolytes in range, normal ECG and chest X-ray.

In this study, postoperative spirometry evaluation was not performed.

2.6. Definitions

Hospital mortality was defined as death for any reason occurring within 30 days after operation. Perioperative
myocardial infarction was defined as the appearance of new Q-waves or a significant loss of R-wave forces peak creatine phosphokinase MB fractions of greater than 10% of the total CK. Low cardiac output syndrome was defined as a cardiac index of <2.0 l/min per m², requiring pharmacological support and/or contropulsation. Postoperative renal dysfunction was defined as an increment in the creatinine level of ≥1 mg/dl compared with the preoperative value. Gastrointestinal complications included a confirmed diagnosis of upper and lower gastrointestinal haemorrhage, intestinal ischaemia, acute cholecystitis and pancreatitis.

2.7. Statistical analysis

Group statistics are expressed as means ± 1 SD. The Mann–Whitney test was used for continuous variables. Fisher’s Exact test was used for non-parametric variables. Multivariate analysis was performed by the long-rank test. Significance between data was considered achieved when P < 0.05.

3. Results

The operation, cardiopulmonary bypass and aortic cross-clamping times, number of employed grafts, and the number of distal anastomoses were similar between groups (Table 2). Total arterial revascularization was performed in 53 (65%) patients in group I versus 62 (33%) patients in group II (P < 0.001). The number of arterial composite grafts was significantly higher in group I than group II: 39 (47.6%) and 29 (15.6%) patients, respectively (P < 0.001). Total arterial revascularization and the number of composite grafts were significantly higher in group III versus II, P < 0.005 and P < 0.02, respectively (Table 2). There were two, seven and one hospital deaths in groups I, II and III, respectively (P = ns). Five patients (two of group I) died of progressive cardiac failure unresponsive to inotropic and/or IABP support, one patient died of multi-organ failure, two of sepsis, and there was one death from neurological complications.

Postoperatively, we found a similar incidence of cardiac, neurological, gastrointestinal and renal complications between groups. Six (7.5%) patients in group I versus 34 (19%) in group II bled more than 1000 ml during the first operative day (P < 0.028), but the incidence of re-thoracotomy for bleeding was the same between groups (Table 4). The mean blood transfusion/patient was similar between groups, due to the re-employment of the lost drained blood re-transfusion using appropriate closed systems. The intensive care unit stay was significantly higher in groups II (P < 0.005) and III (P < 0.002) versus group I.

The chest pain score evaluation was significantly higher in groups II and III at 1–12 h after awakening, becoming non-significant after the chest tubes were removed (Table 4). Also, there were significant differences in the analgesia requirements: the mean morphine quantity given during the postoperative course was greater in groups II and III versus group I (P < 0.001). There were no differences regarding

### Table 4

Postoperative pain and complications

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group I (n = 80)</th>
<th>Group II (n = 179)</th>
<th>p&lt;sup&gt;Ⅰ-Ⅱ&lt;/sup&gt;</th>
<th>Group III (n = 30)</th>
<th>p&lt;sup&gt;Ⅰ-Ⅲ&lt;/sup&gt;</th>
<th>p&lt;sup&gt;Ⅱ-Ⅲ&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest pain score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At awakening</td>
<td>2.4 ± 0.8</td>
<td>2.6 ± 1</td>
<td>&gt;0.1</td>
<td>2.4 ± 1</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>60 min later</td>
<td>2.7 ± 0.6</td>
<td>3 ± 0.8</td>
<td>0.003</td>
<td>2.9 ± 0.8</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>120 min later</td>
<td>2.9 ± 1</td>
<td>3.4 ± 0.5</td>
<td>0.001</td>
<td>3.4 ± 0.3</td>
<td>0.008</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>12 h later</td>
<td>2.4 ± 0.6</td>
<td>3.2 ± 0.7</td>
<td>0.001</td>
<td>3 ± 0.5</td>
<td>0.001</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Drains removed</td>
<td>2.3 ± 1</td>
<td>2.6 ± 1.2</td>
<td>&gt;0.05</td>
<td>2.5 ± 0.8</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Morphine (mg)</td>
<td>9 ± 3</td>
<td>17 ± 5</td>
<td>0.001</td>
<td>15 ± 6</td>
<td>0.001</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Perioperative myocardial infarction</td>
<td>3 (3.75)</td>
<td>7 (3.9)</td>
<td>&gt;0.1</td>
<td>1 (3.2)</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Low cardiac output</td>
<td>4 (5)</td>
<td>11 (6.2)</td>
<td>&gt;0.1</td>
<td>1 (3.2)</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Intra-aortic balloon pump</td>
<td>3 (3.75)</td>
<td>6 (3.4)</td>
<td>&gt;0.1</td>
<td>0</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>7 (8.75)</td>
<td>18 (10)</td>
<td>&gt;0.1</td>
<td>2 (6.4)</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Other arrhythmias</td>
<td>4 (5)</td>
<td>9 (5)</td>
<td>&gt;0.1</td>
<td>1 (3.2)</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Blood loss &gt;1000 ml</td>
<td>6 (7.5)</td>
<td>34 (19)</td>
<td>0.028</td>
<td>2 (6.4)</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Blood transfusion (ml)</td>
<td>65 ± 28</td>
<td>72 ± 35</td>
<td>&gt;0.1</td>
<td>59 ± 20</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Re-exploration for bleeding</td>
<td>4 (5)</td>
<td>16 (9)</td>
<td>&gt;0.1</td>
<td>1 (3.2)</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Neurological complications</td>
<td>2 (2.5)</td>
<td>5 (2.8)</td>
<td>&gt;0.1</td>
<td>0</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Gastrointestinal complications</td>
<td>0</td>
<td>3 (1.7)</td>
<td>&gt;0.1</td>
<td>0</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Renal dysfunction</td>
<td>5 (6.25)</td>
<td>16 (9)</td>
<td>&gt;0.1</td>
<td>2 (6.4)</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Postoperative ultrafiltration/dialysis</td>
<td>4 (5)</td>
<td>11 (6.2)</td>
<td>&gt;0.1</td>
<td>0</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Multi-organ failure</td>
<td>0</td>
<td>1 (0.6)</td>
<td>&gt;0.1</td>
<td>0</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Deep sternal wound infections</td>
<td>2 (2.5)</td>
<td>10 (5.6)</td>
<td>&gt;0.1</td>
<td>0</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Sepsis</td>
<td>1 (1.25)</td>
<td>3 (1.6)</td>
<td>&gt;0.1</td>
<td>0</td>
<td>&gt;0.1</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Intensive care stay (days)</td>
<td>1.03 ± 0.5</td>
<td>1.4 ± 0.7</td>
<td>0.005</td>
<td>1.35 ± 0.4</td>
<td>0.002</td>
<td>&gt;0.1</td>
</tr>
</tbody>
</table>

<sup>a</sup> Figures in parentheses represent percentage values.

<sup>b</sup> p<sup>Ⅰ-Ⅱ</sup>, group I versus II; p<sup>Ⅰ-Ⅲ</sup>, group I versus III; p<sup>Ⅱ-Ⅲ</sup>, group II versus III.
the chest pain score and analgesia requirements between groups II and III (\( P = \text{ns} \) in all measurements).

Pulmonary complications and the respiratory functional status were analyzed in all patients.

The mechanical ventilation time was significantly higher in groups II and III versus group I: 6.2 ± 2.9 and 6 ± 1.1 h, respectively versus 5.4 ± 1.2 h (\( P < 0.018 \) and \( P < 0.02 \)).

The incidence of prolonged ventilation for >24 h (\( P = 0.03 \)), pre-extubation necessity of assist pressure of \( \geq 20 \text{ cm H}_2\text{O} (\ P = 0.001 \)), unilateral pleural effusion (\( P = 0.011 \)), postoperative thoracocentesis (\( P = 0.027 \)), atelectasis during the intensive care unit period (\( P < 0.013 \)) were significantly higher in group II versus group I. Instead, only the incidence of postoperative thoracocentesis (\( P < 0.027 \)) was significantly higher in group III versus group I. There were no differences between groups II and III regarding postoperative pulmonary complications. The incidence of haematis versus serous pleural effusion was significantly higher in groups II and III versus group I (\( P < 0.003 \) and \( P < 0.01 \), respectively; Table 3).

Arterial gas analysis, according to our protocol, demonstrated a significantly depressed respiratory function during mechanical ventilation in groups II and III (Table 3). In all measurements during mechanical ventilation and within 4 h after extubation, the patients of groups II and III necessitated a significantly greater FiO\textsubscript{2} to attain acceptable PaO\textsubscript{2} and PaCO\textsubscript{2} arterial levels. Even though the arterial blood gas analyses were within normal levels postoperatively in all groups, the outcome in terms of higher PaO\textsubscript{2} and lower PaCO\textsubscript{2} under a lower FiO\textsubscript{2} was significantly better in group I compared with groups II and III. From all of the blood gas variables, it seems that PaCO\textsubscript{2} is the most discerning variable. There were no differences regarding the arterial blood gas analyses between groups II and III (\( P = \text{ns} \)). The arterial blood gas data analysis results were similar in both groups (\( P = \text{ns} \)) at 5 days after the surgical procedure (Table 3).

**4. Discussion**

Altered pulmonary function is a frequently found complication after CABG surgery. Patients with previous pulmonary disease, chronic obstructive pulmonary disease and a history of smoking are at a higher risk for developing pulmonary complications and altered gas exchange compared with other patients. The respiratory status of all patients undergoing CABG should be identified preoperatively.

We have previously employed the SKT for IMA harvesting [11,16]. Even in this series, the number of patients undergoing total arterial myocardial revascularization and the number of the arterial composite grafts were significantly higher in patients undergoing IMA harvesting according the skeletonized approach with closed or opened pleurae. This technique provides more conduit length, and as a consequence, the possibility of composite graft construction, than the PKT.

Other reports have demonstrated that IMA harvesting during CABG surgery is an adjunctive factor for further impairment of postoperative pulmonary function [12,13,17]. Taggar et al. [18] hypothesized that one possible explanation of the post CABG surgery ‘respiratory dysfunction’ is the general inflammatory response induced by cardiopulmonary bypass and pulmonary interstitial alterations. Perhaps this hypothesis alone is insufficient for explaining all the post CABG surgery pulmonary alterations. The optimal management of the lungs during CABG surgery remains to be defined. The authors’ opinions regarding the effect of bilateral IMA grafts on respiratory function are controversial. Some authors found an increased incidence of postoperative pulmonary complications and others did not find any difference in the arterial blood gas and respiratory complications in this pool of patients [14,18–20]. Other authors noted a positive effect on postoperative pulmonary function when the pleura remained intact during IMA harvesting for CABG surgery [21–23]. Nevertheless, there is no proper study regarding the role of the integrity of the pleurae in postoperative respiratory dysfunction in patients undergoing harvesting of both IMAs for CABG surgery.

In our series of 299 patients, we found significantly higher bleeding in patients undergoing IMA harvesting according to the PKT, probably due to the more extensive dissection of surrounding tissue during the surgical procedure of IMA harvesting. Another factor that may explain such a result could be the incomplete visualization of the IMAs and unclipped mammary vein collaterals in patients undergoing IMA harvesting according to the SKT. Also, the unilateral pleural effusion and thoracocentesis incidence was higher in patients undergoing IMA harvesting by the PKT with open pleurae. In most of the cases in this group of patients, the pleural effusion was haematis, in contrast to the most frequently found serous effusion in patients undergoing IMA harvesting by the SKT with intact pleurae. We hypothesized that these differences depend, in part, on the surgical technique for IMAs preparation. Opening the pleurae induces the mediastinal blood loss to shift in the pleural cavity, increasing the pleural effusion quantity. In our study, IMA harvesting with intact pleurae demonstrated a significant pain reduction within the first hours after the surgical procedure. The reduction in the subjective estimation pain score was significant after 1–12 h after awakening, becoming non-significant after the thoracic drains were removed. The lack of a significant difference in the pain score within 60 min after awakening reflects primarily the effect of the intraoperative anaesthetic–analgesic treatment. In the postoperative period, the combination of pain reduction and the limited use of morphine and FANS in patients with intact pleurae may induce less pulmonary function impairment. These findings demonstrate clearly that the chest tubes, inserted in the pleural cavity due to the intraoperatively opened pleurae, is a supplementary factor inducing a painful inspiration and greater respiratory dysfunction.

The opened pleurae negatively influenced blood arterial...
gas concentrations, resulting in a lower PaO₂ and higher PaCO₂ and FiO₂ during the mechanical ventilation and in the first hours after extubation, returning to similar levels only during the fifth postoperative day. Even though the arterial blood gas analysis results were within the acceptable postoperative values in all patients, independently of the opened or intact pleurae, the FiO₂ level was significantly higher in patients with opened pleurae. The analysis of the arterial blood gases revealed less significance between patients undergoing IMA harvesting by the SKT with intact or opened pleurae than between patients undergoing IMA harvesting by the SKT with intact pleurae and IMA harvesting by the PKT with opened pleurae, but we do believe that this was due to the small number of patients undergoing skeletonized IMAs with incidentally opened pleurae that were included in this study. The incidence of thoracoacentesis and atelectasis was significantly higher in patients undergoing CABG with open pleurae, revealing a higher morbidity in this pool of patients compared with those undergoing CABG surgery with intact pleurae.

In conclusion, based on such results, we may say that the pleural integrity has beneficial effects on the respiratory functional status after CABG using bilateral IMAs. A meticulous and more delicate IMA harvesting approach significantly reduces the postoperative morbidity regarding the pulmonary functional status, and as a consequence, reduces the hospital costs. We did not find any differences in the respiratory function related to the type of IMA harvesting technique employed.

Study limits included: (1) a small number of patients undergoing IMA harvesting according the SKT with opened pleurae; (2) we did not perform mechanical respiratory tests postoperatively, but we do believe that longer mechanical ventilation and assisted pressure times in patients with opened pleurae demonstrate indirectly that the pleural integrity improves the respiratory mechanics during the postoperative course; (3) even though we do not have exact figures regarding the hospital costs between patients with opened and intact pleurae, we may say that a significant reduction of the mechanical ventilation, intensive care unit stay, lower postoperative morbidity in terms of the thoracoacentesis and atelectasis incidence in patients with intact pleurae are significant indicators demonstrating lower hospital costs in this pool of patients.

References