Site of Pleural Drain Insertion and Early Postoperative Pulmonary Function Following Coronary Artery Bypass Grafting With Internal Mammary Artery*

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Study objectives: Coronary artery bypass graft (CABG) surgery using the left internal mammary artery (LIMA) impairs postoperative pulmonary function. We studied the changes in pulmonary function and subjective pain relative to the site of chest tube insertion.

Design: Thirty patients undergoing CABG surgery using the LIMA were randomized into two groups. Group A (n = 15) received a left chest tube inserted from the midline (subxyphoid). Group B (n = 15) had a tube placed in the sixth intercostal space at the anterior axillary line. All of the patients underwent bedside pulmonary function testing preoperatively and on postoperative days (PODs) 1, 3, and 5. Pain sensation was quantified by a standardized score (1 to 10).

Results: A significant impairment of pulmonary function parameters was observed in both groups until POD 5. For group A, the decline in percent predicted (± SD) in the vital capacity (VC) from before surgery to POD 5 was, respectively, 92.3 ± 30.6% to 56.9 ± 12.6% (p < 0.001). For group B, the decline in the VC was from 88.0 ± 18.2% to 55.5 ± 14.8% (p < 0.001). The FEV₁ declined concomitantly in group A from 86.2 ± 18.2% to 50.8 ± 12.1%, and in group B from 83.5 ± 16.4% to 53.9 ± 12.5% (p < 0.001). On POD 1, a significantly lower decrease in the VC was measured in group A than in group B, respectively: 45.3 ± 15.5% vs 28.6 ± 8.7% (p < 0.001). A significantly lower decrease in the FEV₁ was also seen in group A than in group B, respectively: 36.9 ± 12.9% vs 28.0 ± 10.6% (p < 0.05). Pain experienced during deep inspiration was also significantly less in group A than in group B, respectively: 1.2 ± 1.1 vs 2.5 ± 0.9 (p < 0.01).

Conclusions: Subxyphoid insertion of the pleural drain leads to a significantly lower impairment of pulmonary function and less subjective pain than insertion at the intercostal position. The drainage of the left pleural space is equally effective with both techniques.

Key words: CABG; chest tube; lung function; pain score; pulmonary mechanics

Abbreviations: CABG = coronary artery bypass graft; LIMA = left internal mammary artery; POD = postoperative day; VC = vital capacity

Impairment of gas exchange after coronary artery bypass graft (CABG) surgery utilizing the left internal mammary artery (LIMA) can complicate the early postoperative period.²

In our department as in others, the LIMA is used as the primary conduit in > 95% of CABG procedures because of its better patency rate.³ However, several studies have demonstrated that use of the LIMA leads to changes in pulmonary mechanical behavior and a greater decrease in pulmonary function because of the pain associated with the opening of the pleural space.²

We hypothesized that pain and decreased pulmonary mechanics resulting in reduced pulmonary function may depend on the insertion site of the pleural drain. We therefore compared lung function parameters in patients with the left chest drain placed from the midline (subxyphoid) to patients with standard intercostal drain placement. Pain sensation at rest and during functional pulmonary testing was assessed using a modified standard pain score.⁴

Materials and Methods

The study group consisted of 30 men (mean [± SD] age of 65.7 ± 11.1 years) without lung disease who were undergoing
elective CABG surgery using the LIMA. All of the patients had normal cardiac function (a left ventricular ejection fraction of > 55%) and no pulmonary or chest wall disease. Preoperatively, the lung function parameters of vital capacity (VC) and FEV\textsubscript{1} were evaluated using a transportable spirometer unit (LAP2; Allied Healthcare; St. Louis, MO). Each test was repeated at least three times, and the best results were selected. Arterial blood gas analyses (P\textsubscript{O}\textsubscript{2} and P\textsubscript{CO}\textsubscript{2}) were determined preoperatively with the patient breathing room air, and postoperatively with the patient breathing oxygen via a mask. The requirement of oxygen postoperatively was dictated by each patient’s need to reduce dyspnea.

The CABG surgery was carried out through a median sternotomy. After a wide pleurotomy, the LIMA was dissected in a standard fashion for at least 10 cm. After the operation and before the chest was closed, bent tubes (28F) were inserted at the subxyphoid position (group A; n = 15) or at the sixth intercostal space (group B; n = 15). In all of the patients, a substernal drain was also placed via a subxyphoid approach (Fig. 1). Care was taken that the drain tip was placed into the phrenicocostal sinus. Fluid drainage was monitored hourly. Daily chest radiographs and ultrasound examinations were performed for the evaluation of diaphragmatic motion, intrapleural fluid retention, or atelectasis.\textsuperscript{5} In the patients reported, the mediastinal drain was removed on postoperative day (POD) 1, and the pleural tube was removed on POD 2.

Postoperatively, pulmonary function testing was carried out on days 1, 3, and 5 by respiratory therapists blinded to the surgical procedure. Individual pain sensations were assessed with the patient at rest and during spirometry, and they were quantified with a modified standard score (0 = no pain to 10 = unbearable pain).\textsuperscript{4} A standard pain medication, diclofenac (1.5 mg/kg), was administered 1 to 2 h before spirometry in all patients on PODs 1, 3 and 5.

Data are expressed as means (± SD). Patient variables were analyzed by Student’s t test for unpaired data when appropriate. The results of pain scores, blood gas analyses, and pulmonary function parameters were analyzed with repeated measures analysis of variance. Multiple pairwise comparisons with the Bonferroni test were used to isolate statistically significant differences between the groups, and p values of < 0.05 were considered significant.

**RESULTS**

For both groups, there were no significant differences in the demographic data, the intraoperative variables, or the duration of mechanical ventilation or postoperative ICU stay (Table 1). The preoperative VC and FEV\textsubscript{1} findings were also comparable between the groups. Postoperatively, in both groups there was significant impairment in lung function until POD 5 (p < 0.001; Table 2).

In group A, the decrease in the VC and FEV\textsubscript{1} was significantly less on POD 1. Group A also had significantly less pain sensation during forced inspiration on POD 1 (p < 0.001; Fig 2). Following the removal of the chest drains, the pain scores on PODs 3 and 5 were comparable between the groups at rest, as well as during forced inspiration (Table 3). Arterial blood gas analyses showed no significant differences in the entire postoperative period.

**Table 1—Pre-, Intra-, and Perioperative Patient Characteristics for Experimental Groups* **

<table>
<thead>
<tr>
<th></th>
<th>Group A (n = 15)</th>
<th>Group B (n = 15)</th>
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</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>57.8 ± 11.2</td>
<td>60.7 ± 9.4</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>81.2 ± 12.1</td>
<td>79.9 ± 16.2</td>
</tr>
<tr>
<td>Time of operation, min</td>
<td>201 ± 20</td>
<td>189 ± 20</td>
</tr>
<tr>
<td>Time of extracorporeal circulation, min</td>
<td>64 ± 18</td>
<td>69 ± 13</td>
</tr>
<tr>
<td>Time of aortic cross-clamp, min</td>
<td>41 ± 3</td>
<td>42 ± 4</td>
</tr>
<tr>
<td>Time of intubation, h</td>
<td>12.5 ± 4.6</td>
<td>14.0 ± 5.7</td>
</tr>
<tr>
<td>No. of venous bypass grafts</td>
<td>2.9 ± 0.7</td>
<td>2.7 ± 0.7</td>
</tr>
</tbody>
</table>

*Values are mean ± SD.
period, but the need for supplemental oxygen was less in group A (n = 3) than in group B (n = 6; Table 4).

None of the patients had inappropriate drainage with fluid retention in the pleural space, or diaphragmatic immobility resulting from phrenic nerve injury.

**DISCUSSION**

Like previous studies, the present study demonstrates that there is an evident impairment of pulmonary function in the early postoperative course after CABG surgery using the LIMA. Whether the use of the LIMA itself can cause this decrease in pulmonary function remains speculative. The significant reduction of the VC and FEV₁ following CABG surgery is probably a result of the sternotomy, the impaired pulmonary mechanics, the pleurotomy, and the pain in the early postoperative period. The division of the sternum can impair chest stability and decrease chest compliance. In addition, pleural fluid retention

<table>
<thead>
<tr>
<th>Group</th>
<th>Preoperative</th>
<th>POD 1</th>
<th>POD 3</th>
<th>POD 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VC (L/min)</td>
<td>FEV₁</td>
<td>VC (L/min)</td>
<td>FEV₁</td>
</tr>
<tr>
<td>A (n = 15)</td>
<td>3.7 ± 0.7</td>
<td>2.5 ± 0.7</td>
<td>1.9 ± 1.0†</td>
<td>1.2 ± 0.4</td>
</tr>
<tr>
<td>B (n = 15)</td>
<td>3.6 ± 0.9</td>
<td>3.3 ± 1.0</td>
<td>1.2 ± 0.4</td>
<td>1.0 ± 1.0</td>
</tr>
</tbody>
</table>

*Values are mean ± SD.
†p < 0.05 between groups.
‡p < 0.001 between groups.

![Figure 2. Subjective postoperative pain score on POD 1 based on location of the intrapleural drains.](http://journal.publications.chestnet.org/pdfts/115/3/520-009/115035759.CHEST-115-03-04662.3.05-009.0.001-009.0.001-009.0.001.jpg)
and lung atelectasis\textsuperscript{10} may reduce lung volume. Phrenic nerve paralysis or dysfunction caused by injury during internal mammary artery harvesting or by local hypothermia is rare, but it may reduce pulmonary function by impairing diaphragmatic motion.\textsuperscript{11} The influence of pain leading to inadequate and shallow breathing seems to be higher than expected. The pleura is very sensitive, and the breathing-dependent friction on drains causes suffering for the patient. Furthermore, intercostal nerve irritation resulting from large bore drain placement between the ribs will increase pain and cause the patient to favor the area during breathing. Consequently, inadequate compliance with respiratory therapy may delay the functional recovery of the lung. A small amount atelectasis and mucus retention may foster pneumonia as a major complication during the postoperative course.\textsuperscript{12}

From previous studies, it is obvious that a number of factors may inhibit pulmonary function after CABG surgery using the LIMA. Technical questions concerning the chest tube placement site and its influence on postoperative patient discomfort, however, have not been addressed to date.

Our study showed that when compared to intercostal placement, subxyphoid chest drain insertion results in reduced pain and, therefore, significantly better pulmonary function in the early postoperative period.

There were no differences in the blood oxygen content between the two groups, probably because of the individualized oxygen application for each patient. Nevertheless, the need for supplemental oxygen to reduce dyspnea was seen less often in patients with subxyphoid chest drain placement. This represents only a trend, but it may also indicate that pulmonary recovery occurs earlier in these patients.

It is often argued that intrapleural fluid drainage is more efficient when an intercostal placement site is used. In this study, all of the chest drains had 20 mm of H\textsubscript{2}O suction. For adequate drainage, only the position of the sealed draining system is important. The problem of tube occlusion because of clotting is comparable in both groups, but the surgeon should exclude sharp bends at the insertion site, and make sure that the distal part reaches the phrenicocostal sinus. In our study, there was no fluid retention demonstrated by ultrasonography, indicating sufficient drainage regardless of the insertion site. From the surgical point of view, the substernal position is safer than the intercostal approach because of the bleeding that can result from injury of the intercostal artery.

In conclusion, this study demonstrates a marked decrease in early lung function following CABG surgery using the LIMA. A clear improvement in lung function parameters as well as a decrease in postoperative pain can be seen when avoiding chest tube placement in the left intercostal space. Subxyphoid drain insertion is equally effective and less painful, thus leading to better patient compliance with respiratory therapy and to earlier functional recovery of the lung. Whether subxyphoid drain insertion will lead to a reduction in postoperative pulmonary infections and, consequently, to a shortened hospital stay needs to be proven in a larger patient series. These findings may be of special interest when the left and the right internal mammary arteries are used for coronary revascularization in one patient, requiring the opening and drainage of both pleural cavities.

\begin{table}[h]
\centering
\caption{Comparison of Blood PO\textsubscript{2} and PCO\textsubscript{2} After Subxyphoid and Intercostal Placements of Intrapleural Drains\textsuperscript{*}}
\begin{tabular}{|c|c|c|c|c|}
\hline
\textbf{Group} & \multicolumn{2}{c|}{POD 1} & \multicolumn{2}{c|}{POD 3} \\
& Preoperative & & Preoperative & \\
& PO\textsubscript{2} & PCO\textsubscript{2} & PO\textsubscript{2} & PCO\textsubscript{2} \\
\hline
A, mm Hg & 86.4 ± 8.8 & 39.3 ± 7.4 & 85.2 ± 15.2 & 42.2 ± 6.5 & 89.4 ± 10.5 & 39.0 ± 2.4 & 79.7 ± 9.1 & 41.6 ± 5.4 \\
(n = 15) & & & & & & & & \\
B, mm Hg & 81.9 ± 9.1 & 42.3 ± 11.2 & 79.3 ± 9.9 & 39.0 ± 6.5 & 88.1 ± 7.8 & 41.1 ± 5.6 & 84.1 ± 7.4 & 38.3 ± 6.0 \\
(n = 15) & & & & & & & & \\
\hline
\end{tabular}
\textsuperscript{*}All patients received between 2 and 4 L of oxygen during the early postoperative period until the second day. Values are mean ± SD.
\end{table}
REFERENCES


