minimally invasive techniques

A Case of Unilateral Diaphragmatic Evagination Treated by Plication With Thoracoscopic Surgery*

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A 56-year-old woman underwent plication with U-stitches by thoracoscopic surgery for left diaphragmatic evagination. Marked improvement in left lung expansion, normalization of the position of the left diaphragm on chest radiograph, and improvement of pulmonary function and dyspnea on exertion have been maintained for 2 years. Plication for diaphragmatic evagination should be performed with minimally invasive surgery. (CHEST 1997; 112:530-32)

Key words: diaphragmatic evagination; plication; pulmonary function; thoracoscopic surgery; thoracoscopy; video-assisted thoracoscopic surgery

Abbreviations: MEFR=maximal expiratory flow rate; MVV=maximal voluntary volume; TLC=total lung capacity; VC=vital capacity

Unilateral diaphragmatic evagination and paralysis have the same appearance on radiograph and cause the same symptoms. It is now generally accepted that surgical treatment is indicated only in cases of distinct complaints involving abdominal and/or thoracic organs that can be related to this pathologic condition. The accepted routine surgical procedure for treatment of evagination is plication of the diaphragm with thoracotomy. Herein we describe a patient with evagination of the left diaphragm who we treated using thoracoscopic surgery and in whom we investigated the change in pulmonary function.

Materials and Methods

A 56-year-old woman (weight, 62 kg; height, 156 cm) with evagination of the left diaphragm was referred to our clinic for surgical treatment because of dyspnea on exertion for several years. The evagination was not radiologically evident in 1988, but a chest radiograph at the end of 1994 (Fig 1) showed a high position of the left diaphragm. A pulmonary function study showed a reduction in vital capacity (VC) (2.14 L, 85.3%), FVC (2.06 L), FEV1 (1.65 L), total lung capacity (TLC) (2.65 L), functional residual capacity (1.69 L), and maximal voluntary ventilation (MVV) (71.0 L/min) (Table 1), although the values were within normal limits. Bronchoscopic examination, thoracic

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Figure 1. Chest radiograph before surgery. Left diaphragm is elevated and the left lung is compressed.
CT, and abdominal echography revealed no associated abnormalities. The BP was slightly high (142/92 mm Hg), but there were no abnormal signs in the ECG, and blood test values were within the normal ranges.

Plication of the diaphragm was performed using thoracoscopic surgery to minimize the functional and aesthetic consequences and pain of standard thoracotomy. The patient underwent intubation with a double-lumen endotracheal tube to allow selective right lung ventilation, and was placed in the right lateral decubitus position. The stomach was drained with a nasogastric tube, and the operating table was positioned head-up to decrease the abdominal pressure on the diaphragm. A 12-mm port was placed in the seventh intercostal space on the midaxillary line. A 10-mm second port was placed on the mammary line in the eighth intercostal space. Finally, a 12-mm third port was made in the eighth intercostal space on the posterior axillary line and was used to introduce the optical unit. A zero-degree rigid thoracoscope (Olympus Inc; Tokyo, Japan) was then inserted into the pleural space and the entire thoracic cavity was inspected. The phrenic nerve was found in the normal position and was also of normal appearance. The left diaphragm appeared loose and reduced in thickness, and was easily extended upon gripping with forceps. A 10×5-cm longitudinal plication was accomplished with a series of nine 2-0 nylon monofilament U-stitches between the median and lateral parts of the diaphragm, taking care not to damage the phrenic nerve. At the end of this procedure, the diaphragm was tense to palpation. One chest tube (2SF) was inserted in the posterior aspect of the pleural cavity through the first port, and the lung was then reexpanded. The patient was extubated in the operating room, and the postoperative course was uneventful. The chest tube was removed on the third postoperative day, and the patient was discharged from hospital on the fourth postoperative day.

**RESULTS**

After the operation, dyspnea on exertion had disappeared, and a chest radiograph (Fig 2) showed marked improvement in left lung expansion and normalization of the position of the left diaphragm. Postoperative spirometry carried out 3 months and 2 years after the operation showed that VC, FVC, FEV₁, FEV₁/FVC, MVV, and maximal expiratory flow rate (MEFR) were slightly improved, and that TLC was greatly increased (Table 1).

**DISCUSSION**

Unilateral diaphragmatic eventration is a permanent raising of all or a large proportion of the hemidiaphragm, which is reduced in thickness without enlarged or abnormal orifices and with normal attachments. Unilateral eventration and paralysis have the same effect on ventilation: diaphragmatic weakness causes a decrease in ventilation and oxygenation because of paradoxical motion of the affected diaphragm during inspiration and expiration, like that in flail chest. Eventration of the diaphragm does not require treatment if asymptomatic. However, eventration and lasting paralysis can be treated by plication if there are symptoms of dyspnea, recurrent pneumonia, chronic bronchitis, chest pain, poor exercise tolerance, cardiac arrhythmias, and functional disorders of the stomach. The plication of the diaphragm enlarges the thoracic cavity while reducing abdominal compression, and stiffens the diaphragm, reducing paradoxical motion. Among the changes in pulmonary function, it has been reported that VC, FVC, and FEV₁ are greatly increased. In the present patient, the improvement of VC, FVC, FEV₁, FEV₁/FVC, MVV, and MEFR was not so remarkable, but TLC was greatly increased. Therefore, these improvements in pulmonary function and stiffening of the dilated diaphragm, which caused the paradoxical motion, were thought to have reduced the dyspnea on exertion.

Thoracoscopic surgery is a recent adjunct to the management of intrathoracic disorders, and its full potential has not yet been fully assessed. This tech-

### Table 1—Change in Pulmonary Function After Plication of Diaphragmatic Eventration

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<thead>
<tr>
<th></th>
<th>Preoperative</th>
<th>3 mo</th>
<th>2 yr</th>
</tr>
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<tbody>
<tr>
<td>VC, L</td>
<td>2.14</td>
<td>2.14</td>
<td>2.21</td>
</tr>
<tr>
<td>% VC</td>
<td>85.3</td>
<td>85.6</td>
<td>89.5</td>
</tr>
<tr>
<td>FVC, L</td>
<td>2.06</td>
<td>2.13</td>
<td>2.13</td>
</tr>
<tr>
<td>FEV₁, L</td>
<td>1.65</td>
<td>1.75</td>
<td>1.76</td>
</tr>
<tr>
<td>FEV₁/FVC, %</td>
<td>80.1</td>
<td>82.2</td>
<td>82.6</td>
</tr>
<tr>
<td>MVV, L/min</td>
<td>71.0</td>
<td>75.3</td>
<td>75.7</td>
</tr>
<tr>
<td>MEFR, L/s</td>
<td>4.86</td>
<td>5.27</td>
<td>4.94</td>
</tr>
<tr>
<td>TLC, L</td>
<td>2.05</td>
<td>3.02</td>
<td>3.39</td>
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**FIGURE 2** Chest radiograph 3 months after plication by thoracoscopic surgery, showing marked improvement of left lung expansion and normalization of the position of the hemidiaphragm.
nique is emerging as a viable approach for increasing complex intrathoracic therapeutic procedures such as bullectomy, wedge resection of peripheral lung nodules and closed lung biopsy, thoracic sympathectomy and truncus vagotomy, pericardial fenestration, esophagomyotomy, mediastinal mass resection, major pulmonary resection, and the repair of diaphragmatic tears due to chest trauma. This minimally invasive approach is expected to involve less morbidity than formal thoracotomy, which causes major postoperative pain and ventilatory compromise, even when limited and muscle-sparing procedures are used. Although plication is usually performed with a large thoracotomy incision, the treatment involves repair of functional abnormalities and should be performed with minimally invasive surgery. Recently, the treatment of diaphragmatic eventration with video-assisted thoracoscopic surgery was reported. In this procedure, two superimposed series of transverse back-and-forth continuous sutures are used to invaginate the diaphragm. Our procedure used U-stitches, and the subsequent improvement of pulmonary function and dyspnea on exertion has been maintained for 2 years.

In summary, we have performed plication with U-stitches by thoracoscopic surgery for a case of left diaphragmatic eventration. The treatment involves repair of functional abnormalities and should therefore be performed with minimally invasive surgery. In our patient, the improvement of pulmonary function and dyspnea on exertion has persisted for 2 years.

REFERENCES