The Impact of Nutritional Status on the Outcome of Lung Volume Reduction Surgery*

A Prospective Study

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Objectives: To study the incidence and clinical significance of nutritional deficiencies in patients with emphysema undergoing lung volume reduction surgery (LVRS).

Design: Prospective observational study.

Setting: University-based teaching hospital.

Patients: Fifty-one consecutive patients with end-stage emphysema undergoing video-assisted thoracoscopic surgery for LVRS.

Interventions: All patients had their body mass index (BMI) and serum nutritional indexes (albumin, transferrin, total protein, cholesterol) measured preoperatively and postoperatively. Various clinical parameters were also compared between two groups.

Results: The BMI was normal in 24 patients (47%), and 27 patients (53%) had a below normal BMI. A preoperative analysis of the serum nutritional indexes revealed no clinically significant differences between the two groups, but postoperative levels were significantly lower in the low BMI group. Anthropometric measurements supported the designation of nutritional status by BMI. Clinically, 26% of the patients in the low BMI group required prolonged ventilatory support (> 24 h), compared to only 4% of the patients with a normal BMI. The hospital length of stay (LOS) also differed, averaging 15.9 days in the low BMI group, compared to an average of 11.8 days in the normal BMI group.

Conclusion: Approximately 50% of patients undergoing LVRS for emphysema have a deficient nutritional status identifiable by BMI, but not by standard nutritional indexes. This impaired nutritional status is associated with increased morbidity following LVRS. We suggest that BMI is an accurate determinant of nutritional status in this patient population, and we speculate that preoperative repletion of nutritional deficiencies may decrease hospital morbidity, hospital LOS, and overall costs in the malnourished population undergoing LVRS.

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Key words: emphysema; lung volume reduction surgery; nutrition; morbidity

Abbreviations: BMI = body mass index; LOS = length of stay; LVRS = lung volume reduction surgery; MAC = mid-arm circumference; MAMC = mid-arm muscle circumference; TSF = triceps skin fold; VATS = video-assisted thoracoscopic surgery; V/Q = ventilation/perfusion

Weight loss and malnutrition in patients with COPD are well recognized.1–4 This nutritional deficit is associated with both impaired muscle strength and a decrease in ventilatory drive.5,6 This diminishment of respiratory muscle function, altered pulmonary mechanics, and any impairment of the immune response may have a detrimental effect in the postoperative period.7

Lung volume reduction surgery (LVRS) was described > 35 years ago by Brantigan and Mueller.8 The procedure, however, was abandoned due to the high morbidity and mortality. The recent revival of this operation with modern surgical techniques has demonstrated superior results and led to the proposal of LVRS as a treatment for incapacitating emphysema without giant bullous disease, and as a possible bridge to lung transplantation.9,10 To our knowledge, no study has yet prospectively evaluated

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the nutritional status of this operative group and the impact it may have on surgical outcome. We, therefore, performed a prospective study evaluating the nutritional status and the possible adverse effects of malnutrition on patients with severe incapacitating emphysema undergoing reduction pneumonoplasty through a VATS approach.

**MATERIALS AND METHODS**

Fifty-one consecutive patients (37 men and 14 women) who underwent bilateral reduction pneumonoplasty utilizing a VATS approach were prospectively evaluated. The preoperative evaluation included a thorough history and physical examination, CBC count, electrolyte panel, nutritional serum indexes (albumin, total protein, transferrin, and cholesterol), ECG, pulmonary function tests, a ventilation/perfusion (V/Q) scan, standard resolution CT of the chest, and a transthoracic echocardiogram. The criteria used to select operative candidates included the following: (1) lifestyle limiting emphysema despite intensive medical management; (2) cessation of smoking at least 3 months prior to operation; (3) FEV$_1$ > 15% and < 35% of predicted; and (4) heterogeneous distribution of disease shown by the chest CT and V/Q scans.

The body mass index (BMI) was calculated from the height and weight.[11] Patients were classified as having a low BMI or a normal BMI according to the guidelines established by The Committee on Diet and Health, Food and Nutrition.[11] With the last 18 patients, preoperative anthropometric measurements (triceps skin fold [TSF], mid-arm circumference [MAC], mid-arm muscle circumference [MAMC]) were also obtained by the same certified dietitian using described techniques.[12] On the third postoperative day, the nutritional indexes were all repeated.

All 51 patients underwent elective bilateral LVRS with a VATS approach, utilizing a combination of resection of maximally diseased areas identified by the V/Q scan and laser thermolication in an ancillary fashion. Resection of an estimated 50% of the upper lobes was the target. Nd:YAG thermolication of the interfissure lung surfaces and the lower lobes was carried out in 36 patients (20 in the normal BMI group and 16 in the low BMI group). No patients required conversion to thoracotomy. The decision on when to extubate the patient was based on his or her respiratory and overall clinical condition.

The Institutional Review Board approved this study. Patient consent was not required because the study was observational, not interventional.

Data are provided as mean values ± SEM. Statistical analysis was performed on continuous and categorical data utilizing the Student’s t test and the χ² analysis, respectively. The p values were considered significant if p < 0.05.

**RESULTS**

**Demographics and Nutritional Status**

The mean age of the 51 patients (37 men and 14 women) was 70 years. All had end-stage diffuse pulmonary emphysema with a mean FEV$_1$, 0.8 L (28 ± 9% of predicted); total lung capacity, 141 ± 28% of predicted; and residual volume (RV), 207 ± 57% of predicted. Determination of BMI indicated that 53% (27/51) of these patients had a low BMI (20.9 ± 2.05), while 47% had a normal BMI (26.10 ± 1.98; p < 0.0001). As shown in Table 1, there were no differences in gender, age, or pulmonary function measurements between BMI groups. More patients in the normal BMI group than in the low BMI group were taking steroids preoperatively.

Preoperative serum nutritional indexes (albumin, total protein, transferrin, cholesterol), hemoglobin, and hematocrit did not differ between the low and normal BMI groups (Table 2); however, there were significant postoperative declines in the low BMI group as compared to the normal BMI group (Table 3). In the patients having anthropometric data, 61% (11/18) were considered malnourished utilizing BMI criteria. These patients demonstrated lower values for TSF, 10.8 vs 13.5 cm (p = 0.09); MAC, 26.7 vs 30.8 cm (p = 0.002); and MAMC, 23.3 vs 26.6 cm (p = 0.01). The mean MAC in the low BMI group was in the tenth percentile for age, and the MAC in the normal BMI group was in the fiftieth percentile for age.[12]

**Clinical**

The low BMI group had more patients (seven patients; 26%) requiring ventilatory support > 24 h than did the normal BMI group (one patient; 4%; p = 0.03). In addition, the low BMI group had a significantly longer hospital length of stay (LOS) than did the normal BMI group: 15.8 vs 11.7 days, respectively (p = 0.045). In other comparisons of the low vs the normal BMI patient groups, the LOS in the ICU (4.8 vs 2.7 days; p = 0.19), total chest tube days (12.2 vs 9.0 days; p = 0.11), and presence of postoperative infection (44% vs 25%, p = 0.15), respectively, did not differ significantly, but showed a trend favoring the normal BMI group. Specifically, four patients in the normal BMI group had urinary tract infections and three patients had pneumonia.

**Table 1—Comparison of the Low and Normal BMI Groups**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Low BMI Group (n = 27)</th>
<th>Normal BMI Group (n = 24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>70.7</td>
<td>69.5</td>
</tr>
<tr>
<td>Gender, No.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>Female</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Pulmonary function, % of predicted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEV$_1$, L</td>
<td>28.0</td>
<td>29.2</td>
</tr>
<tr>
<td>TLC</td>
<td>120.1</td>
<td>115.0</td>
</tr>
<tr>
<td>RV</td>
<td>215.0</td>
<td>200.9</td>
</tr>
<tr>
<td>P$(\text{O}_2)$, mm Hg</td>
<td>66.9</td>
<td>66.3</td>
</tr>
<tr>
<td>Steroid use, No. (%)</td>
<td>4 (14.8)</td>
<td>11 (45.8)</td>
</tr>
</tbody>
</table>

*Data are expressed as mean, unless otherwise indicated; TLC = total lung capacity; RV = residual volume.*
In the low BMI group, 10 patients had urinary tract infections, 7 had pneumonia, and 2 had viral infections.

Perioperative mortality was similar in the two groups: two patients (8.3%) died in the normal BMI group, and two patients (7.4%) died in the low BMI group. No additional patients died in the first 3 months after operations. None of these patients had either an obvious or an occult lung cancer, required reoperation for an air leak, or developed a late pneumothorax after chest tube removal.

**DISCUSSION**

Our experience suggests that approximately half of the patients undergoing LVRS suffer from malnutrition, as determined by their BMI status. This is consistent with the known prevalence of nutritional deficiencies in COPD patients. Preoperative nutritional serum indexes, which can be markers of malnutrition, did not detect the nutritional disparities between patients with a low and a normal BMI, although these indexes did differ between these two groups postoperatively. The reasons for the significant postoperative decline in nutritional indexes in the low BMI group are not entirely clear, but are probably related to a relatively preoperative volume depletion. This is suggested by the fact that postoperative hemoglobin and hematocrit significantly decreased in the low BMI group without any appreciable intraoperative or postoperative blood loss, suggesting that it was due to perioperative fluid administration. It is possible, however, that this postoperative decline may be more indicative of redistribution of plasma proteins between the intravascular and extravascular spaces, but we do not think so for two reasons. First, this significant decline was not observed in the normal BMI group; second, the drop in postoperative indexes was consistent with the patient’s nutritional status, as measured by BMI and anthropometrics.

The important observation is that the nutritional deficiencies in this patient population, as measured by BMI, correlated with a worse postoperative course. The need for prolonged ventilator support, and hospital LOS were greater in the low BMI group. Other types of morbidity, such as infection, prolonged chest tube duration, and prolonged ICU LOS, also tended to be greater in the malnourished group. With a larger number of patients, the differences between these additional clinical parameters would probably also reach statistical significance. The morbidity differences are not explainable by considerations other than the nutritional differences. As shown in Table 1, the two patient groups were similar with regard to identified clinical areas. Steroid use, a possible risk factor, is not responsible, as it was actually more prevalent in the normal BMI group.

Our findings are not surprising. Wilson and co-workers published data on 779 patients with stable COPD. They found that in 25% of patients, the body weight was <90% of ideal body weight. This depleted nutritional state was found to be associated with a higher incidence of infection and with abnormalities in both the humoral and cell-mediated immune response. In addition, patients with severe COPD and poor nutritional indexes have an increased risk of respiratory mortality. High respiratory mortality appears to be related to the lack of fat reserves and muscle mass, which correlate with reductions in overall muscle strength, smaller fiber size of the external intercostal muscles, and a disproportionate decrease in diaphragmatic weight and thickness. These anatomic deficiencies probably result in poor respiratory dynamics that can increase the hospitalized patient’s risk for requiring prolonged ventilatory support and/or acquiring a pulmonary infection. This may account, in part, for the poor clinical course of our patients with a low BMI.

In the 18 patients who were measured anthropometrically, the values for TSF (a measure of fat reserves) and MAMC (a measure of muscle mass) were clearly consistent with a malnourished state, and strongly supported the designation of nutritional status by BMI.

In conclusion, approximately half of the patients undergoing reduction pneumonoplasty are malnourished. Traditional serum indexes do not reliably assess the nutritional status of this patient population.

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**Table 2—Preoperative Values of Serum Nutritional Indices, Hemoglobin, and Hematocrit Indices**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Low BMI</th>
<th>Normal BMI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albumin</td>
<td>4.1 ± 0.7</td>
<td>3.9 ± 0.6</td>
<td>0.09</td>
</tr>
<tr>
<td>Total protein</td>
<td>7.3 ± 1.1</td>
<td>6.9 ± 1.2</td>
<td>0.04</td>
</tr>
<tr>
<td>Transferrin</td>
<td>247 ± 31.2</td>
<td>270 ± 30.9</td>
<td>0.05</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>207 ± 25.5</td>
<td>216 ± 26.2</td>
<td>0.63</td>
</tr>
<tr>
<td>Hemoglobin</td>
<td>14.2 ± 0.9</td>
<td>14.4 ± 1.0</td>
<td>0.65</td>
</tr>
<tr>
<td>Hematocrit</td>
<td>42.9 ± 4.1%</td>
<td>43.8 ± 4.7%</td>
<td>0.48</td>
</tr>
</tbody>
</table>

*Values are expressed as mean ± SEM.

**Table 3—Postoperative Values on Day 3 For Serum Nutritional Indices, Hemoglobin, and Hematocrit**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Low BMI</th>
<th>Normal BMI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albumin</td>
<td>2.8 ± 0.3</td>
<td>3.2 ± 0.4</td>
<td>.006</td>
</tr>
<tr>
<td>Total protein</td>
<td>5.2 ± 0.2</td>
<td>6.0 ± 0.3</td>
<td>.004</td>
</tr>
<tr>
<td>Transferrin</td>
<td>137 ± 15.0</td>
<td>174 ± 14.7</td>
<td>.009</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>129 ± 17.9</td>
<td>172 ± 15.8</td>
<td>.022</td>
</tr>
<tr>
<td>Hemoglobin</td>
<td>11.9 ± 0.8</td>
<td>12.8 ± 0.9</td>
<td>.021</td>
</tr>
<tr>
<td>Hematocrit</td>
<td>36.4 ± 2.7%</td>
<td>40.0 ± 3.8%</td>
<td>.007</td>
</tr>
</tbody>
</table>

*Data are expressed as mean ± SEM.
in the preoperative setting. However, the readily obtainable BMI is an easy and accurate method of preoperative nutritional evaluation. Clinically, a low BMI correlates with an increase in postoperative morbidity. Since patients with a normal BMI have a significantly better postoperative course, repletion of nutritional deficiencies in patients with a low BMI prior to operation may decrease morbidity, hospital LOS, and, ultimately, health care costs. Our group has begun a prospective study to evaluate this potential benefit of nutritional repletion in patients with a low BMI, and we encourage others to do the same.

APPENDIX

1. BMI is a measure of body density that takes into account the patient’s weight relative to their height, and allows for reliable comparisons between people of all ages, weights, and heights.
2. LVRS is the surgical resection of severely diseased areas of emphysematous lung.
3. VATS is surgery of the chest by means of a thoracoscope, which is minimally invasive. Thoracoscopic images are displayed on an adjacent video monitor, allowing the surgeon and the surgical assistants a clear view of the surgical field.
4. LOS is the total duration, in days, that a patient remains in the hospital, eg, LOS in the ICU, or LOS in the hospital.
5. TSF is a measure in millimeters of the fat pad located over the triceps muscle belly. This measurement is made by a caliper and is an indicator of total body fat stores.
6. MAC is a measure in centimeters of the mid-arm circumference. It is used as an indicator of lean body mass.
7. MAMC is a corroborating measure of lean body mass, derived by the following formula: MAMC = (TSF x 0.314).

REFERENCES