A prospective analysis of the inter-relationship between lung volume reduction surgery and body mass index

Paul Vaughan, Inger F. Oey, Michael C. Steiner, Mike D.L. Morgan, David A. Waller

Abstract

Objectives: LVRS is thought to result in significant improvements in BMI. Patients with a higher BMI at the time of diagnosis of COPD are known to have better survival, and those with a low BMI prior to LVRS have significantly worse perioperative morbidity. We aimed to assess the influence of BMI on the outcome of LVRS in our own experience. Methods: Complete preoperative BMI data was available in 114 of 131 consecutive patients who have undergone LVRS since 1995. These patients were arbitrarily classified into three categories: underweight (BMI < 19 kg/m²), normal (BMI 20–25 kg/m²) and overweight (BMI > 26 kg/m²). The in-hospital course and perioperative change in BMI at 3, 6, 12, 24 and 36 months were prospectively recorded for each category and compared. Results: There were no significant differences in preoperative variables except BMI. There were significantly more postoperative ITU admissions among the lowest two BMI groups (12/29, 18/58 and 3/27 patients, respectively, p = 0.02), and significantly shorter hospital stay in overweight patients [16 days (5–79) vs 18 days (6–111) vs 13 days (6–25), respectively, p = 0.005, expressed as median (range)]. However, there was no difference in survival between the three groups (p = 0.21). Postoperative physiological improvements in the first year were related to preoperative BMI for both FEV₁ (r = 0.29, p = 0.02) and DLCO (r = 0.33, p = 0.02). Postoperative BMI significantly increased in the underweight yet significantly decreased in the overweight at all time points. Conclusions: The perioperative course of LVRS and its physiological benefits are influenced by preoperative BMI. Whilst the treatment of the underweight is more complicated, LVRS may be the only way of increasing their BMI. Future work is needed to explore the roles of changing energy requirements and body composition following LVRS. © 2007 European Association for Cardio-Thoracic Surgery. Published by Elsevier B.V. All rights reserved.

Keywords: Lung volume reduction surgery; Body mass index; Chronic obstructive pulmonary disease; Thoracic surgery

1. Introduction

Chronic obstructive pulmonary disease (COPD) is characterised by dyspnoea, impaired exercise tolerance, and frequent weight loss and nutritional depletion [1–3]. Patients with a higher body mass index (BMI) at the time of diagnosis of their COPD have been shown to have significantly longer survival than both underweight and normal weight patients [4]. It is hypothesised that this is due to a combination of muscle weakness or wasting and elevated metabolic requirements. This reduction in respiratory muscle strength, in combination with altered pulmonary mechanics may have an impact upon recovery in the postoperative period [5]. Certainly following lung volume reduction surgery (LVRS), patients with a low preoperative BMI had significantly longer hospital stays, and more requirements for ventilatory support [6].

LVRS has been shown to give significant improvements in spirometry, hyperinflation, exercise capacity and quality of life in selected patients with severe COPD [7–9]. These results have also been shown to be durable in further highly selected patient groups [10]. The changes in BMI following LVRS and the impact of the surgery upon BMI and outcome are less well investigated. Significant improvements in BMI have been documented up to 2 years following LVRS [11], correlating with the improvements seen in health status. The postoperative BODE index, a cumulative scoring system comprising BMI, FEV₁, dyspnoea and exercise capacity, has also been correlated with survival following LVRS [12]. The purpose of this study was two-fold. Firstly to further investigate the impact of preoperative BMI upon morbidity and mortality following LVRS, and secondly to assess the impact of preoperative BMI upon postoperative changes in BMI, spirometry, hyperinflation and gas transfer.

2. Patients and methods

A retrospective review of all the prospectively collected data on consecutive patients undergoing LVRS at our
institution from 1995 to 2007 was performed. All patients with complete preoperative height and weight data were included in the study.

2.1. Calculation of BMI

Body mass index was calculated upon all patients in the standard method (weight in kilograms divided by height in metres$^2$). Patients were then allocated to one of three groups depending upon their BMI as defined by the National Institute for Clinical Excellence [13].

Underweight was defined as BMI $< 19 \text{ kg/m}^2$, normal as BMI $20—25 \text{ kg/m}^2$ and overweight as BMI $> 26 \text{ kg/m}^2$. The distribution of BMI within the study population is shown in Fig. 1.

2.2. Patients

All patients were initially assessed by a multi-disciplinary team and underwent basic spirometry, body box plethysmography, arterial blood gas analysis, chest radiography, computed tomography and radionuclide scintigraphy. All patients were subjected to previously published inclusion and exclusion criteria [14].

2.3. Surgical approach

Initially all patients undergoing LVRS at our institution underwent median sternotomy and bilateral LVRS. Subsequently video-assisted thoracoscopic (VAT) unilateral LVRS was adopted following publication of a comparison between the two approaches showing similar spirometric outcomes [15]. Patients from both groups were included in this study.

LVRS was performed upon the previously identified target areas using staples buttressed with bovine pericardium.

2.4. Postoperative management

Similar management and discharge protocols were applied to all patients. Chest drains remained in situ until there was no evidence of air leak. To encourage mobilisation, one-way flutter valves and portable bags (Portex Ltd, Hythe, UK) were utilised as early as possible in the postoperative period. All patients were reviewed in a surgical clinic at 3 months, 6 months, 12 months and annually thereafter. Measurement of BMI, spirometry, gas transfer and body box plethysmography was also performed at these intervals.

2.5. Statistical analysis

All data are presented as median (range) unless stated otherwise. All statistical analysis was performed using SPSS v11 (SPSS Inc. Chicago IL). One-way ANOVA was used to compare pre- and perioperative values between the groups. The $\chi^2$ test was used to compare qualitative data. Survival was calculated according to the method described by Kaplan—Meier. The paired Student’s $t$-test was used to compare changes in variables postoperatively, and correlations were performed using Pearson’s test. A $p$-value of $< 0.05$ was considered significant throughout.

3. Results

Complete preoperative height and weight data were available in 114 of the 132 consecutive patients who have undergone LVRS. These patients therefore comprised the study group. The underweight group comprised 29 patients, the normal weight group 58 patients and the overweight group 27 patients. Fig. 1 demonstrates the normal bell-shaped distribution of these patients.

There were no significant differences found between any of the preoperative variables except BMI as shown in Table 1, although shuttle walk distance did approach statistical significance.

The comparison of perioperative variables is shown in Table 2. No significant differences were found between the three groups’ proportions of patients undergoing bilateral or

*Table 1*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low BMI</th>
<th>Normal</th>
<th>High BMI</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>63 (41—69)</td>
<td>60 (46—73)</td>
<td>58 (46—70)</td>
<td>0.46</td>
</tr>
<tr>
<td>Gender (% male)</td>
<td>74</td>
<td>62</td>
<td>70</td>
<td>0.57</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>18.08 (13.9—19.8)</td>
<td>23.08 (20.05—25.83)</td>
<td>28.63 (26.3—33.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>FEV$1$ (% pred)</td>
<td>27 (16—51)</td>
<td>25 (12—60)</td>
<td>28 (18—44)</td>
<td>0.64</td>
</tr>
<tr>
<td>RV/TLC ratio</td>
<td>60 (44—76)</td>
<td>65 (43—85)</td>
<td>65.5 (54—75)</td>
<td>0.34</td>
</tr>
<tr>
<td>DLCO (% pred)</td>
<td>43 (21—75)</td>
<td>45 (17—75)</td>
<td>46 (21—67)</td>
<td>0.89</td>
</tr>
<tr>
<td>Modified MRC score</td>
<td>4 (2—5)</td>
<td>4 (2—5)</td>
<td>4 (3—5)</td>
<td>0.7</td>
</tr>
<tr>
<td>Shuttle walk distance (m)</td>
<td>220 (80—360)</td>
<td>250 (90—480)</td>
<td>180 (90—370)</td>
<td>0.07</td>
</tr>
</tbody>
</table>
unilateral procedures. There was also no difference in operating times and air leak duration. Significant differences were found between the three groups’ intensive care unit (ITU) requirements ($p = 0.02$) and overall length of hospital stay ($p = 0.005$).

Using the Kaplan–Meier method, no difference was found in postoperative survival between the three groups ($p = 0.21$) (see Fig. 2). When survival was compared between the underweight and the overweight groups only, the difference was found to approach statistical significance [66 months (32–100) vs 80 months (67–93), $p = 0.07$]. We also investigated if there were any differences in 30- and 90-day mortality between the two groups. The results are summarised in Table 3.

Postoperative changes in BMI revealed the most interesting results. At all time points up to 3 years postoperatively, the underweight group had a significant increase in their BMI, while the overweight group had a significant reduction in their BMI. Patients with a normal BMI preoperatively did not significantly alter their BMI postoperatively, although a trend towards increased BMI is evident (see Fig. 3).

Weak but statistically significant correlations were found between preoperative BMI and percentage change in FEV$_1$ ($r = 0.29$, $p = 0.02$) and DLCO ($r = 0.33$, $p = 0.02$) for up to 1 year postoperatively.

No correlation was found between BMI and reduction in hyperinflation. Also no difference was found between the three groups’ reductions in hyperinflation.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low BMI</th>
<th>Normal</th>
<th>High BMI</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VATS/sternotomy</td>
<td>23/6</td>
<td>51/7</td>
<td>26/11</td>
<td>0.23</td>
</tr>
<tr>
<td>Operating time (min)</td>
<td>103 (40–255)</td>
<td>80 (40–240)</td>
<td>83 (35–150)</td>
<td>0.17</td>
</tr>
<tr>
<td>ITU usage (no. of patients)</td>
<td>12/29 (41%)</td>
<td>18/58 (31%)</td>
<td>3/27 (11%)</td>
<td>0.02</td>
</tr>
<tr>
<td>Air leak duration (days)</td>
<td>10 (3–55)</td>
<td>14 (2–53)</td>
<td>9 (3–32)</td>
<td>0.13</td>
</tr>
<tr>
<td>Length of hospital stay (days)</td>
<td>16 (5–79)</td>
<td>18 (6–111)</td>
<td>13 (6–25)</td>
<td>0.005</td>
</tr>
</tbody>
</table>

4. Discussion

The relationship between nutritional indices such as BMI, fat free mass and fat mass has been extensively studied in COPD. The main correlations are between BMI, % of normal BMI, albumin, weight loss and severity of airflow obstruction. Unfortunately the impact of L VRS upon nutritional indices is less well studied. Previous studies from our unit [8,11] have demonstrated an overall increase in BMI following L VRS, which has been correlated to health status improvements. Other studies have reported improvements in fat free mass and body weight [16].

Little is also known about the effects of the preoperative nutritional status on the outcome following L VRS. Our study has demonstrated that preoperative BMI affects both length of hospital stay and ITU usage, but has no significant impact upon mortality or air leak duration. These findings are corroborated by Mazolewski et al. [6], who demonstrated a correlation between BMI and perioperative morbidity. Interestingly when the survival of the underweight patients was compared with the overweight patients, the results approached statistical significance. This needs to be interpreted cautiously however given the small numbers of patients involved. When we investigated 30- and 90-day mortality again no significant differences were found, despite an apparent higher mortality in the underweight group, although again this may be due to the small number of postoperative deaths to analyse.

Our study has also demonstrated a weak but significant correlation up to 1 year between preoperative BMI and improvements in gas transfer and FEV$_1$. To our knowledge this is the first time such a correlation has been documented.
Based upon this study, future work is to be directed towards the impact of preoperative BMI and its affect upon health status changes postoperatively.

The interesting findings from this study are the changes to BMI postoperatively depending upon preoperative BMI. We have demonstrated that underweight and nutritionally depleted patients gain weight following LVRS. It has been suggested that this is due to a reduction in work of breathing and resting energy expenditure following this procedure [17], as well as an increased calorific intake [16]. It is more difficult to explain why the overweight group lost weight at all time points. One could hypothesise that these patients have lost weight because of the catabolic effects of major surgery, or because of an increased exercise capacity; however, all patient groups were exposed to the same procedure and met the same strict inclusion and exclusion criteria [14]. It has recently been shown that fat free mass correlates better with severity of COPD than BMI [18]. BMI may be a poor marker of nutritional status, and perhaps we should be studying fat free mass in these patients.

This study raises further questions regarding the measurement of nutritional indices in patients prior to undergoing LVRS, namely what is the role of fat-free mass/lean muscle mass in these patients? Our study also raises the possibility that if patients with a higher BMI have a shorter hospital stay, mass in these patients? Our study also raises the possibility that if patients with a higher BMI have a shorter hospital stay, mass in these patients. L VRS, namely what is the role of fat-free mass/lean muscle mass in these patients.

The surgical treatment of the underweight is more complicated and yet, paradoxically, these patients have most nutritionally beneficial effects. L VRS should not, therefore, be denied on the basis of weight.

The outcome of LVRS is evidently influenced by preoperative BMI and yet BMI is affected by the results of LVRS. The surgical treatment of the underweight is more complicated and yet, paradoxically, these patients have most potential nutritional benefit from LVRS. LVRS should not, therefore, be denied on the basis of weight.

References