Lobar volume reduction surgery: a method of increasing the lung cancer resection rate in patients with emphysema

J G Edwards, D J R Duthie, D A Waller

Abstract

Background—Guidelines on patient selection for lung cancer resection identify a predicted postoperative forced expiratory volume in 1 second (ppoFEV1) of <40% as a predictor of high risk. Experience with lung volume reduction surgery suggests that ppoFEV1 may be underestimated in those with concomitant emphysema.

Methods—Anatomical lobectomy was performed in 29 patients with a resectable lung cancer within a poorly perfused, hyperinflated emphysematous lobe identified by radionuclide perfusion scintigraphy and computed tomographic scanning. Perioperative changes in spirometric parameters at 3 months were compared in 14 patients (group A) of mean age 69 years (range 48–78) with ppoFEV1 <40% (mean (SD) 31.4 (7)%), and 15 patients (group B) with ppoFEV1 >40% (mean (SD) 47 (5)%). The correlation between predicted and actual postoperative FEV1 was also assessed.

Results—In group B there was a significant perioperative reduction in FEV1 (p=0.01) but in group A FEV1 did not change significantly after lobectomy (p=0.87); mean difference in perioperative change between groups A and B 331 ml (95% CI 150 to 510). Despite the difference in ppoFEV1 between the groups, there was no difference in actual FEV1 at 3 months. In-hospital mortality was 14% in group A and zero in group B, but at a median follow up of 12 (range 6–40) months there was no difference in survival between the groups.

Conclusions—Selection for lung cancer resection in patients with emphysema using standard calculations of ppoFEV1 may be misleading. The effect of lobar volume reduction allows for an extension of the selection criteria.

(Thorax 2001;56:791–795)

Keywords: lobar volume reduction surgery; lung cancer; patient selection

Increasing the resection rate is fundamental to improving outcome in non-small cell lung cancer (NSCLC). The suboptimal resection rate in the UK, currently around 10%,1 may be partly attributed to the assessment of inoperability in the large number of patients who have both lung cancer and concomitant emphysema.2 Prediction of postoperative respiratory function has been found to be a predictor of pulmonary complications,4 with a predicted postoperative forced expiratory volume in 1 second (ppoFEV1) measurement of less than 40% predicted associated with an unacceptable risk of postoperative morbidity.3 These values have previously guided our patient selection. However, increased understanding of lung volume reduction surgery (LVRS) has shown that resection of relatively functionless emphysematous lung may actually improve lung function.6,7 We have therefore applied the principles of selection for LVRS to those patients presenting with resectable NSCLC and moderate to severe emphysema. We report our initial experience with this cohort of patients undergoing lobectomy for NSCLC who, as a result, effectively have undergone LVRS. Our objectives were to assess whether lung function changes uniformly with lobectomy in all patients, whether the currently used predictive methods are accurate in all cases, and whether the cut off point of 40% ppoFEV1 is clinically binding.

Methods

All patients were referred primarily for resection of a newly diagnosed NSCLC rather than for treatment of emphysema. Resectability was confirmed by computed tomographic (CT) scanning and, where indicated, cervical mediastinoscopy. Simple spirometric measurements of FEV1, and forced vital capacity (FVC) were made as part of an assessment of operability. Patients did not undergo routine plethysmography.

The preoperative COPD index8 was derived for each patient using the following formula:

\[
\text{COPD index} = \text{FEV1} \times (\% \text{ predicted}) + (\text{FEV1/}\text{FVC (lit)})
\]

Predicted postoperative FEV1 (ppoFEV1) was also derived for each patient using the following formula estimating the number of pulmonary segments to be resected:

\[
\text{ppoFEV1} = \text{preoperative FEV1} \times (1 - (b - n)/42 - n)\text{ where } b = \text{ number of segments to be resected and } n = \text{ number of obstructed segments of that lobe.}
\]

In patients whose ppoFEV1 was less than 60% predicted, quantitative radionuclide scintigraphy was performed to estimate the function of emphysematous areas of the lung. These were correlated with anatomical findings on the CT scan.

Lung resection was only attempted in patients with a ppoFEV1 of less than 40% predicted if the tumour was resectable by lobectomy, the target lobe was emphysematous and contributed less than 10% of overall

www.thoraxjnl.com
Table 1  Patient characteristics and perioperative results

<table>
<thead>
<tr>
<th></th>
<th>Group A (n=14)</th>
<th>Group B (n=15)</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>68.9 (48–78)</td>
<td>71.4 (55–79)</td>
<td>2.47</td>
<td>-3.8 to 8.7</td>
<td>0.42</td>
</tr>
<tr>
<td>Male/female</td>
<td>9:5</td>
<td>12:3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postoperative stay (days)</td>
<td>12.7 (6–36)</td>
<td>13.2 (6–39)</td>
<td>0.5</td>
<td>-7 to 8.1</td>
<td>0.89</td>
</tr>
<tr>
<td>30 day mortality</td>
<td>2</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survival (days)</td>
<td>403 (7–1150)</td>
<td>427 (61–1059)</td>
<td>23.7</td>
<td>-245 to 293</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Values are mean (range).

Table 2  Perioperative changes in pulmonary function

<table>
<thead>
<tr>
<th></th>
<th>Group A (n=14)</th>
<th>Group B (n=15)</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative FVC (%) pred</td>
<td>71.8 (63–93)</td>
<td>79.3 (66–97)</td>
<td>7.5</td>
<td>-0.5 to 15.4</td>
<td>0.06</td>
</tr>
<tr>
<td>Postoperative FVC (%) pred</td>
<td>64.4 (40–84)</td>
<td>65 (46–88)</td>
<td>0.6</td>
<td>-12 to 13.1</td>
<td>0.93</td>
</tr>
<tr>
<td>Preoperative FEV1 (l)</td>
<td>1.0 (0.68–1.5)</td>
<td>1.63 (0.9–2.65)</td>
<td>0.62</td>
<td>0.33 to 0.92</td>
<td>0.0001</td>
</tr>
<tr>
<td>Postoperative FEV1 (l)</td>
<td>1.02 (0.65–1.25)</td>
<td>1.31 (0.75–2.33)</td>
<td>0.29</td>
<td>-0.001 to 0.59</td>
<td>0.06</td>
</tr>
<tr>
<td>Perioperative change in FEV1 (l)</td>
<td>0.06 (0.37–0.34)</td>
<td>-0.27 (0.54–0.0)</td>
<td>0.33</td>
<td>0.15 to 0.51</td>
<td>0.001</td>
</tr>
<tr>
<td>FEV1/FVC (%)</td>
<td>44 (27–76)</td>
<td>57 (49–87)</td>
<td>0.13</td>
<td>0.02 to 0.24</td>
<td>0.03</td>
</tr>
<tr>
<td>Predicted postoperative FEV1 (%) pred</td>
<td>31.4 (16–39)</td>
<td>47.3 (40–56)</td>
<td>19.9</td>
<td>11.2 to 20.6</td>
<td>0.0001</td>
</tr>
<tr>
<td>Actual postoperative FEV1 (%) pred</td>
<td>41.5 (18–57)</td>
<td>46.6 (30–61)</td>
<td>5.0</td>
<td>-4.0 to 14.0</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Values are mean (range).
FVC = forced vital capacity; FEV1 = forced expiratory volume in 1 second.

Perioperative changes in respiratory function

Overall, there was a significant perioperative decrease in FEV1 (mean difference 116 ml, 95% CI 2 to 231, p=0.04; fig 1, table 2). In group B there was a significant perioperative increase in FEV1 of 16 ml (95% CI 2 to 231, p=0.04; fig 1, table 2).
decrease in FEV$_1$ (mean difference 270 ml, 95% CI 170 to 380, p=0.001) and FVC (mean difference 440 ml, 95% CI 80 to 800, p=0.02), but not in group A where lobectomy resulted in no significant change in either FEV$_1$ (mean difference 60 ml, 95% CI –20 to 110) or FVC (mean difference 280 ml, 95% CI –140 to 700). There was a significant difference between groups A and B in the mean perioperative change in FEV$_1$ (mean difference 331 ml, 95% CI 150 to 510). Although there was a significantly lower mean FEV$_1$ in group A than in group B before surgery, at 3 months after lobectomy there was no significant difference in FEV$_1$ between the groups. There was a significant correlation between the perioperative change in FEV$_1$ and the preoperative COPD index ($r$=–0.53, p=0.01, fig 2).

PREDICTION OF POSTOPERATIVE RESPIRATORY FUNCTION

Predicted postoperative FEV$_1$ was significantly lower than the actual FEV$_1$ in group A (mean difference 10.3%, 95% CI 4.9 to 15.6, p=0.002), but there was no significant change in group B (mean difference –0.4%, 95% CI –3.7 to 4.5, fig 3). A Bland-Altman plot (fig 4) shows that the mean discrepancy between actual and predicted FEV$_1$ was greater in group A. In only one patient in group A was the actual postoperative FEV$_1$ less than the ppoFEV$_1$.

Discussion

We have found that lobectomy for NSCLC in patients with poor lung function secondary to emphysema is feasible. Although perioperative risk is increased, subsequent survival is not compromised. We would therefore contend that surgery is preferable to radical radiotherapy in this group of patients. Furthermore, in these patients anatomical lobectomy has been shown to have a therapeutic effect on postoperative respiratory function.

Previous studies have also seen an improvement in pulmonary function in selected patients with severe emphysema undergoing lobectomy for lung cancer. However, unlike our experience, there were few patients in these series with ppoFEV$_1$ less than 40% predicted. In a study of 13 patients a mean perioperative improvement of 3.7% was noted in predicted FEV$_1$ and a similar improvement in mean FEV$_1$ of 4% was found in another small series of 10 patients, but again in patients with better preoperative respiratory function than ours. We have also demonstrated the use of a COPD index to predict perioperative change in FEV$_1$.

While we are confident in attributing our demonstrated improvement to the effects of surgery, we concede that a small proportion of the effect is due to the optimising of medical treatment for COPD during hospitalisation. There may also be a psychological component to the effect, secondary to increased motivation after successful removal of a lung cancer. To avoid the immediate detrimental effects of surgery, assessment of spirometric parameters was not made before three postoperative months had elapsed.
The estimation of perioperative risk in patients with respiratory dysfunction has focused on the calculation of ppoFEV₁. A value for ppoFEV₁ below 40% predicted has been proposed as the lower limit of acceptable risk and this is the reason for our arbitrary selection of this value to divide the patients into two groups. A hazard ratio of 1.46 for every 200 ml decrease in ppoFEV₁ below this value has been calculated. The simplest method of ppoFEV₁ calculation is based on a reduction factor proportional to the number of bronchopulmonary segments to be resected. However, this assumption of function of resected segments to be equivalent to the rest of the lung. It has been recognised that there is a possible source of underestimation if the tumour to be resected is obstructing the airway. A correction for this factor has been proposed. In our series there were no obstructing tumours, although our calculations of predicted function did not take into account the effect of deflation of the overexpanded thoracic cage, hence our underestimation of postoperative function in those patients with more severe emphysema. Quantitative radionuclide perfusion scintigraphy may give useful information regarding prediction of function after pneumonectomy, but the information is not in sufficient anatomical detail to predict function after lobectomy.

Extrapolation of selection criteria for LVRS for emphysematous patients with concomitant lung cancer has suggested that both conditions can be treated simultaneously. In two series where malignant pulmonary nodules have been discovered during preoperative investigation for LVRS, subsequent simultaneous LVRS and contralateral lobectomy have been successful. Furthermore, anatomical lobectomy has been used successfully for LVRS alone in patients without lung cancer. The beneficial effects on lung elastic recoil and chest wall mechanics of resecting a hyperinflated tumour-containing lobe thus outweigh any loss of function, particularly if the lobe is poorly perfused. It is reasonable to assume that lobar LVRS would have a bilateral effect on chest wall mechanics (and therefore a significant respiratory improvement) since some authors have found little difference in the comparative overall benefit of unilateral versus bilateral LVRS. It is important to emphasise that in this study all patients underwent anatomical lobectomy and no patients underwent any form of sublobar “lung shaving” as is performed in LVRS.

The clinical implication of extending the selection criteria for lung cancer surgery is obviously an increase in the resection rate. In our unit we have operated on 14 patients with ppoFEV₁ less than 40% who would otherwise have been denied surgery. This equates to around 7% of all resections performed over this same time period. In the UK annually about 3000 resections are performed for NSCLC; thus, if our experience was applied nationally, over 200 more patients would undergo resection each year. While perioperative mortality would probably increase as a result of operating on more high risk patients, further work is required to analyse whether longer term overall survival from lung cancer would be improved. We have not found that 1 year survival from surgery in this series is worse in those with poorer preoperative lung function.

In conclusion, consideration of fitness for surgery in lung cancer should acknowledge the effect of lobar LVRS. Current methods of calculation may underestimate prediction of postoperative respiratory function and the cut off point of 40% for ppoFEV₁ should not be clinically binding. Current guidelines should include an acknowledgement of the effects of surgery in heterogenous emphysema. Lung function does not change uniformly after lobectomy and these patients may even derive early benefit. Further study of durability and related health status changes is required.


www.thoraxjnl.com
Lobar volume reduction surgery

Lobar volume reduction surgery: a method of increasing the lung cancer resection rate in patients with emphysema
J G Edwards, D J R Duthie and D A Waller

Thorax 2001 56: 791-795
doi: 10.1136/thorax.56.10.791

Updated information and services can be found at:
http://thorax.bmj.com/content/56/10/791

These include:

References
This article cites 20 articles, 6 of which you can access for free at:
http://thorax.bmj.com/content/56/10/791#BIBL

Email alerting service
Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Topic Collections
Articles on similar topics can be found in the following collections
- Lung cancer (oncology) (670)
- Lung cancer (respiratory medicine) (670)
- Lung neoplasms (608)
- Screening (oncology) (407)
- Airway biology (1100)
- Cardiothoracic surgery (676)
- Epidemiologic studies (1829)
- Lung function (773)
- Radiology (diagnostics) (812)

Notes

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/