Preoperative Assessment of Patients Undergoing Pulmonary Resection*

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A careful preoperative assessment of patients with lung cancer is essential for identifying those at high risk for morbidity and mortality related to the surgical procedure. The clinician must assess the risk associated with such treatment, decide whether the risk is prohibitive, and institute therapy to reduce such risk. Testing modalities used in the preoperative evaluation include spirometry, full pulmonary function tests, measurement of arterial blood gases, radionuclide lung scanning, exercise testing, invasive measurement of pulmonary artery pressure, and a variety of studies involving lobar occlusion or lateral position testing. Studies evaluating the utility of these procedures are reviewed. Additionally, the impact of advanced age on postsurgical outcome is evaluated, as are the possibility of operating on high-risk patients and the use of preoperative interventions. (Chest 1993; 103:3425-45)

Because of the current lung cancer epidemic among both men and women in the United States, clinicians specializing in thoracic disease are frequently asked to evaluate candidates for pulmonary resection preoperatively. The lack of reliably effective alternative treatments, the association between lung cancer and chronic obstructive lung disease,† and the fact that cigarette smoking is a major risk factor for lung disease, lung cancer, and atherosclerotic disease, all contribute to the common scenario in which patients with significant comorbid disease require major surgical procedures, often entailing resection of a significant amount of pulmonary parenchyma. It is the job of the clinician to provide an assessment of the risk associated with such treatment, decide whether the risk is prohibitive, and institute therapy to reduce such risk. This article reviews data concerning preoperative risk assessment in this patient population.

Many studies in the literature have determined the utility of a variety of testing modalities in the preoperative evaluation of patients with presumed lung cancer. These modalities include spirometry, full pulmonary function tests, measurement of arterial blood gases, radionuclide lung scanning, exercise testing, invasive measurement of pulmonary artery pressures, and a variety of studies involving lobar occlusion or lateral position testing. In addition, other studies have examined demographic factors that are independent predictors of risk.

Spirometry

A number of studies have used preoperative spirometry to screen patients who would be at high risk for complications or mortality following thoracotomy. These studies were recently reviewed by Zbirak and colleagues.‡ Their analysis demonstrated that spirometry alone did not identify patients at high risk for mortality or postoperative complications. However, almost all of these studies excluded patients with prohibitively poor pulmonary function, which is usually defined as a predicted postoperative forced expiratory volume in 1 s (FEV₁) <0.8 to 1.0 L. These numbers are based on data reported by Gaensler and colleagues§ on patients with tuberculosis in the early 1950s.

Since then, there have been no prospective studies establishing a "safe" lower limit of pulmonary function. In the most widely cited series, Olsen et al.¶ prospectively evaluated 56 patients with impaired pulmonary function and outlined a set of criteria of inoperability that uses a predicted postoperative FEV₁ of <800 ml as a cutoff. The authors stated, however, that this figure was not derived from clinical studies but rather from physiologic principles and observations that patients with this degree of airway obstruction usually have hypercapnia. Most studies since that time and recent reviews have used this figure as a cutoff for operability.‖ A critical review of the literature over the past 30 years could not find a study in which such patients underwent thoracotomy, thus the mortality from this procedure is unknown. This fact is noted implicitly in the position paper of the American College of Physicians on preoperative pulmonary function testing.¶

Although prethoracotomy spirometry has not been clearly established as a definitive test for determining who should or should not undergo surgery, most authorities agree that severe abnormalities detected by this procedure should prompt further preoperative evaluation and a critical assessment of the patient's overall condition. The rate of postoperative complications and morbidity is probably higher in patients with pulmonary dysfunction than in other patients,‖ but no current series has addressed whether the rate is prohibitively high.

Prediction of Postoperative Pulmonary Function

The early literature addressed many techniques to predict postoperative pulmonary function, including a simple mathematical calculation based on a loss of 5.26% for each segment resected,‖ bronchoprovocation with measurement of oxygen uptake in each lung, lateral position testing, and most recently, use of radiolabeled, macroaggregated albumin lung scanning. The data suggest that for patients with normal or mildly impaired function in whom there is no atelectasis, hilar movement, or suspicion of endobronchial disease, simple calculation is sufficient for determining lung function postresection.

For patients with more severe pulmonary obstruction or in whom history, examination, radiographic imaging, or

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Preoperative Assessment for Pulmonary Resection (Reilly, Mentzer, Sugarbaker)
Table 1—Use of Radionuclide Scanning to Predict Postoperative Pulmonary Function

<table>
<thead>
<tr>
<th>Author</th>
<th>No. Patients</th>
<th>Conclusions</th>
</tr>
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<tr>
<td>Kristersson et al&lt;sup&gt;10&lt;/sup&gt;</td>
<td>19</td>
<td>Scanning and PFTs accurate predictors of postoperative VC (r = 0.73)</td>
</tr>
<tr>
<td>DeMeester et al&lt;sup&gt;11&lt;/sup&gt;</td>
<td>20</td>
<td>Scanning and PFTs as good as bronchospirometry (r = 0.95), better than lateral position test (r = 0.86)</td>
</tr>
<tr>
<td>Olsen et al&lt;sup&gt;18&lt;/sup&gt;</td>
<td>13</td>
<td>Good prediction: (VC, r = 0.70; FEV&lt;sub&gt;1&lt;/sub&gt;, r = 0.72)</td>
</tr>
<tr>
<td>Ali et al&lt;sup&gt;19&lt;/sup&gt;</td>
<td>27</td>
<td>Good correlation</td>
</tr>
<tr>
<td>Corris et al&lt;sup&gt;19&lt;/sup&gt;</td>
<td>28</td>
<td>Good correlation with spirometry (V&lt;sub&gt;Emax&lt;/sub&gt;, Vo&lt;sub&gt;2&lt;/sub&gt;)</td>
</tr>
<tr>
<td>Kristersson et al&lt;sup&gt;19&lt;/sup&gt;</td>
<td>27</td>
<td>Good correlation (VC, r = 0.87; FEV&lt;sub&gt;1&lt;/sub&gt;, r = 0.90)</td>
</tr>
<tr>
<td>Tonnesen et al&lt;sup&gt;19&lt;/sup&gt;</td>
<td>36</td>
<td>Good correlation (r = 0.89)</td>
</tr>
<tr>
<td>Schoonover et al&lt;sup&gt;22&lt;/sup&gt;</td>
<td>24</td>
<td>All patients had severe COPD. Scanning superior to lateral position test</td>
</tr>
</tbody>
</table>

*PFT = pulmonary function test; VC = ventilatory capacity; FEV<sub>1</sub> = forced expiratory volume in 1 s; V<sub>Emax</sub> = maximum flow per unit of time; Vo<sub>2</sub> = oxygen consumption.

bronchoscopy suggests significant airway obstruction, perfusion scanning accurately predicts postoperative pulmonary function. When inaccurate, the test tends to underestimate postoperative lung function. Some representative studies establishing the accuracy of lung scanning as a predictive test are cited in Table 1. With the availability of lung scanning, there is little indication for bronchospirometry or lateral position testing.

**Hemodynamic and Exercise Testing**

Several groups have attempted to refine the identification of patients at high risk for perioperative morbidity and mortality by incorporating either hemodynamic measurements or exercise testing in the preoperative evaluation. Their studies are summarized in Table 2. Two studies demonstrated that patients with low maximum oxygen consumption (MVo<sub>2</sub> max) are at increased risk for postoperative morbidity and mortality. The data on pulmonary hypertension and pulmonary vascular resistance are contradictory and inconclusive (Table 2).

**Arterial Blood Gases**

Anecdotal reports in the literature have indicated that patients with hypoxemia and/or hypercarbia (respectively defined as partial pressure of oxygen in arterial blood [PaO<sub>2</sub>] <50 mm Hg and arterial carbon dioxide pressure [PaCO<sub>2</sub>] >45 mm Hg) are at increased risk for morbidity or mortality after thoracotomy. As noted earlier, the maxim that an FEV<sub>1</sub> <800 ml poses prohibitive risk stems from the association of hypercapnia with severe airflow obstruction. Several articles cite these figures as risk factors, although there are no retrospective studies with significant numbers of patients and no prospective studies examining this question. Most authorities feel that a PaCO<sub>2</sub> >45 mm Hg identifies patients at higher risk. As with spirometry, it is unclear whether such risk is prohibitive.

**Age**

The demographics of lung cancer are such that clinicians are often confronted with the evaluation of an elderly patient with proven or suspected bronchogenic carcinoma. The literature examining age as a risk factor for perioperative morbidity and mortality is somewhat contradictory and is summarized in Table 3. It appears that age alone is not a contraindication to thoracotomy. Age, however, may be an
additive risk factor in patients with other risk factors such as severe airflow obstruction or coronary artery disease.

**Surgery in the High-Risk Patient**

Several studies have addressed the possibility of surgery in patients with impaired pulmonary function. Peters et al. operated on patients with markedly impaired pulmonary function but with relatively preserved vital capacity. Overall mortality was less than 8%, and no postoperative deaths occurred from respiratory insufficiency. Miller and Hatcher reported their experience operating on selected patients with severe airflow obstruction, defined as an FEV₁, between 0.6 and 1 L. These patients underwent limited resection, either segmentectomy or wide wedge excision, with 84% and 78% 2-year survivals, respectively.

It appears that patients formerly considered to be at prohibitive risk can safely tolerate thoracotomy. The advent of limited resection, nonanatomic resection, and thoracoscopic surgical techniques allows surgery to be considered for patients who otherwise would have been at prohibitively high risk. Use of postoperative local analgesia, eg, with the epidural catheter, combined with early mobilization, aggressive pulmonary toilet, and inhaled bronchodilators probably also contributes to the success of operative therapy in these patients. Anecdotal experience here and elsewhere suggests that such an approach has redefined the traditional concepts of who is an operative candidate.

**Preoperative Interventions**

Common clinical wisdom is that preoperative interventions such as smoking cessation, intensive pulmonary toilet, antibiotics (for existing infection), bronchodilator therapy, and pulmonary rehabilitation serve to decrease the risk of perioperative morbidity or mortality. Although use of these interventions makes sense physiologically, there are few supportive data available, and some experienced clinicians disagree on their utility. One study in the literature has addressed this question. Stein and Cassara identified patients at high risk by virtue of pulmonary function and randomized them to 2 groups: 1 received intensive preoperative and postoperative pulmonary therapy and the other received standard therapy. Four complications of relatively mild severity were reported in 17 patients undergoing thoracotomy in the intensive therapy group. In contrast, 13 of 17 patients in the standard care group had complications, 9 of which were moderate or severe. These data support the contention that an aggressive interventional program reduces perioperative risk.

**Conclusions**

Preoperative spirometry and arterial blood gas determinations help identify patients at high risk for complications and mortality after thoracotomy. In patients with suspected endobronchial disease, hilar masses, or other data that suggest nonfunction of all or part of the lung to be resected, radionuclide scanning can help accurately predict postoperative FEV₁. Patients with a predicted postoperative FEV₁ of <1 L should be carefully evaluated for the presence of comorbid disease and any reversible factors that may potentially benefit from aggressive preoperative intervention. In this patient population exercise testing may help identify those patients at very high risk for morbidity or mortality postthoracotomy.

With the advent of less morbid surgical techniques, more nonanatomic and segmental resections, and better perioperative care, it is possible to safely offer resection to patients with severe airflow obstruction, even those with a predicted postoperative FEV₁ of ≤500 ml. Given the fact that surgery remains the most effective therapy for lung cancer and that radiation therapy delivered with curative intent can cause comparable physiologic derangement of the lung, an aggressive pretreatment evaluation of such patients is warranted. These patients should be evaluated and treated as centers that offer the approaches outlined above.

**Table 3—Age as a Risk Factor**

<table>
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<tr>
<th>Authors</th>
<th>No. Patients</th>
<th>&gt;60 years</th>
<th>&gt;70 years</th>
<th>Exclusions</th>
<th>Conclusions</th>
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</thead>
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<tr>
<td>Jezek et al</td>
<td>77</td>
<td>23 (&gt;65)</td>
<td>53</td>
<td>Excluded 85% based on cachexia, inoperability</td>
<td>Age not a risk factor</td>
</tr>
<tr>
<td>Ebner et al</td>
<td>53</td>
<td></td>
<td>53</td>
<td></td>
<td>7.5% mortality. Safe in selected elderly patients</td>
</tr>
<tr>
<td>Keagy et al</td>
<td>369</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td>Age &gt;60 yr, male sex, low FEV₁, all increase risk</td>
</tr>
<tr>
<td>Berggren et al</td>
<td>82</td>
<td>82</td>
<td></td>
<td>PFTs &gt;2 SD below mean, &lt;50 W for 6 min</td>
<td>15.9% mortality. Safe in selected elderly patients</td>
</tr>
<tr>
<td>Peters et al</td>
<td>49</td>
<td>23</td>
<td>6</td>
<td>NS—10 patients with impaired lung function</td>
<td>Age alone not a risk factor</td>
</tr>
</tbody>
</table>

*NS = not specified; FEV₁ = forced expiratory volume in 1 s; PFT = pulmonary function test; SD = standard deviation.
20 Brundler H, Chen S, Perrucoud AP. Right heart catheterization in the preoperative evaluation of patients with lung cancer. Respiration 1985; 48:261-68
32 Stein M, Cassara EL. Preoperative pulmonary evaluation and therapy for surgical patients. JAMA 1970; 211:787-90