Poor pulmonary function may preclude attempted surgical cure for lung cancer. Alternative treatments, such as radiation therapy, have a very low 5-year survival and may also be contraindicated by poor pulmonary function.

Lung volume reduction surgery (LVRS) can significantly improve pulmonary function for selected patients with emphysema. Because smoking is the primary cause of lung cancer and emphysema, some patients with both diseases are identified during the evaluation for LVRS. We hypothesize that LVRS may potentially allow resection of lung cancer in patients who otherwise have physiologically inoperable conditions.

This series, therefore, was reviewed to determine the incidence of both benign and malignant masses in candidates for LVRS and to evaluate the role of LVRS in improving the physiologic candidacy for surgery of patients with lung cancer.

Materials and Methods

From May 1994 through December 1995, 325 patients underwent LVRS for emphysema at Chapman Medical Center and the Hospital of the Good Samaritan. Our patient selection and technique for thoracoscopic LVRS have been described previously. The most important selection criterion was the presence of a strongly heterogeneous pattern of emphysema on CT scan and lung perfusion scan that showed target areas of poorly perfused, anatomically destroyed lung tissue.

The operative technique for thoracoscopic LVRS and thoracoscopic lobectomy have been described previously. Fiberoptic bronchoscopy was performed in all patients at the time of the operation. The goal of the LVRS was resection of 20 to 30% of each lung, which generally meant approximately half of each upper lobe. The tissue targeted for resection was determined by the preoperative CT scan and lung perfusion scan. If a lobectomy was performed, it was a standard, anatomic lobectomy with lymph node dissection for all ipsilateral N1 and N2 lymph nodes. To prevent seeding the incision, lung tissue that included a tumor was placed in a bag for removal. The cancer portion of the operation added no more than 30 min to the time of the procedure and added no morbidity. Chest CT scan, performed as part of the workup for emphysema, identified 49 peripheral lung masses in 47 (15%) of the patients who underwent LVRS.

Specimens from percutaneous needle biopsy, performed in three patients, diagnosed three non-small cell lung cancers. The remaining patients did not undergo needle biopsy because the lung mass was small and the patients were generally considered to be at high risk for pneumothorax. The diagnostic yield for bronchoscopy was considered to be very low for these peripheral masses, so it was performed at the time of the operation. Diagnosis, therefore, was primarily obtained at the time of the emphysema operation.

Five additional patients were referred specifically for the evaluation of a combined operation for emphysema and presumed lung cancer. An operation was not performed on two of these five patients. One patient had a rapidly growing mass in the right middle lobe that crossed the fissure into the lower lobe. The bilobectomy necessary to resect the tumor would have removed the only good lung tissue seen on the chest CT scan and the lung perfusion scan. The chest CT scan in the other patient identified a left hilar...
mass invading the main left pulmonary artery, so a left pneumonec-
tomy would have been required to remove the tumor. Her FEV₁
was 0.35 L, so she was deemed to have a physiologically inopera-
table condition.

All operations were performed with video-assisted thoracic sur-
gery. Our standard operation was unilateral LVRS during the time
that the first three patients with cancer underwent their opera-
tions. Subsequently, eight patients underwent resection of their lung
cancers and simultaneous bilateral staple LVRS (our current stan-
dard procedure). When the frozen section showed a cancer, the
procedure included lymph node dissection and either lobectomy or
wedge resection. Lobectomy was performed if the cancer was lo-
cated in the severely emphysematous lung tissue targeted for lung
volume reduction. A wedge resection was used for patients with
cancers in the healthier areas of lung tissue.

RESULTS

Fifty-three lung masses were resected in 51 (16%) of 325 patients who underwent LVRS. Forty-two pa-
tients (13%) were found to have histologically benign
lung masses that included 20 calcified nodules, 17
granulomas, 4 fibrotic nodules, and 1 hamartoma. Two
patients had both a granuloma and lung cancer. Cul-
tures were positive in only two patients: acid-fast bacilli
(one) and Aspergillus (one).

Eleven clinical stage I non-small cell lung cancers
were resected. Of these 11 cancers, 3 were specifically
referred for combined cancer and emphysema surgery,
7 were found during the evaluation for LVRS, and 1
was an incidental pathologic finding. No additional
cancers were identified at bronchoscopy. Therefore,
the chest CT scan obtained for the evaluation of 325
patients for LVRS identified 7 (2%) previously undi-
agnosed lung cancers.

One patient with multiple areas of pleural scarring
was found pathologically to have a localized cancer in
one area of scarring. Even retrospectively, this could
not be appreciated on the preoperative CT scan.
Intraoperatively, the cancer was not diagnosed because

Table 1—Patients Who Underwent Combined
Operations for Both Lung Cancer and LVRS*

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age, yr/sex</th>
<th>CA</th>
<th>Type</th>
<th>Procedure</th>
<th>LVRS</th>
<th>LOS, d</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>77/M</td>
<td>T1N0</td>
<td>ADENO</td>
<td>Wedge</td>
<td>UNI-ST</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>75/M</td>
<td>T1N0</td>
<td>SQUAM</td>
<td>Wedge</td>
<td>UNI-ST</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>64/M</td>
<td>T2N0</td>
<td>ADENO</td>
<td>Wedge</td>
<td>UNI-ST</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>60/M</td>
<td>T1N0</td>
<td>ADENO</td>
<td>Wedge</td>
<td>BILAT-ST</td>
<td>13</td>
</tr>
<tr>
<td>5</td>
<td>75/F</td>
<td>T1N0</td>
<td>SQUAM</td>
<td>Wedge</td>
<td>RML</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>66/F</td>
<td>T1N0</td>
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<td>RUL</td>
<td>BILAT-ST</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
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<td>T2N0</td>
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<td>RLL</td>
<td>BILAT-ST</td>
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<tr>
<td>8</td>
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<td>RUL</td>
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<tr>
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<tr>
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<tr>
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<td>T1N0</td>
<td>ADENO</td>
<td>Wedge</td>
<td>BILAT-ST</td>
<td>7</td>
</tr>
</tbody>
</table>

*SQUAM=squamous cell carcinoma; ADENO=adenocarcinoma;
RML=right middle lobectomy; RUL=right upper lobectomy; UNI-
ST=unilateral staple LVRS; BILAT-ST=bilateral staple LVRS;
CA=cancer; LOS=length of stay.
improvement for one patient, and no change for the remaining four patients.

Clinical follow-up is complete for all 325 patients who underwent LVRS. During this time, 1 patient who, even retrospectively, had no mass on the chest CT scan died of a pulmonary embolus 10 months after LVRS. To date, no resected cancer has recurred, although follow-up is short (range, 2 to 20 months; mean, 9.7 months).

**DISCUSSION**

The postoperative results of this series suggest that the pulmonary function criteria for pulmonary resection need to be reevaluated for selected patients who are candidates for LVRS. Traditionally, to undergo a pulmonary resection, a patient should have a predicted postoperative FEV$_1$ of 0.8 to 1 L, and patients are considered to be high risk if their preoperative FEV$_1$ is less than 1.2 L.$^6$ In this study, the average preoperative FEV$_1$ was 0.65 L (21.7% predicted), and none of the patients met these traditional pulmonary function criteria to undergo lung surgery.

LVRS can be performed successfully in patients with an FEV$_1$ as low as 230 mL, so thus far, a lower limit of FEV$_1$ that contraindicates LVRS has not been identified.$^3$ This study suggests that the pulmonary function criteria for resection of a lung mass are different for patients who can also undergo simultaneous LVRS.

Although a small, peripheral stage I lung cancer can be cured with either a wedge resection or a lobectomy, a lobectomy is the procedure of choice because it has a much lower incidence of local recurrence and a better 5-year survival.$^7$\textsuperscript{8}

LVRS provides the greatest improvement in pulmonary function for patients with a bilateral upper lobe pattern of severe emphysematous destruction of lung tissue.$^3$ If a lung cancer is located in the area targeted for lung volume reduction, then the preferred operation, a standard anatomic lobectomy with lymph node dissection, may be done. These patients may thus receive the benefit of both the optimal cancer operation and the optimal lung volume reduction operation for improvement in their pulmonary function.

If the cancer is located in the “good” lung tissue that would normally be preserved during a lung volume reduction operation, then a wedge resection can be done for the cancer and lung volume reduction in the target areas. The total amount of lung resected was the same regardless of the location of the lung cancer. Thus, patients with the cancer in the area of the severe emphysematous change targeted for resection would be expected to get greater clinical improvement. For patients with the cancer in the better lung tissue, the loss of pulmonary function expected from the resection of “good” lung tissue for the cancer operation is counterbalanced by the benefit from LVRS, so the cancer can generally be resected without any measurable loss in pulmonary function.

With that surgical philosophy, 11 of 13 patients evaluated for resection of a lung cancer underwent a combined operation for cancer and emphysema, and all 11 patients underwent a complete resection with clear margins. Patients with poor pulmonary function that previously precluded resection can now undergo lung cancer surgery if it is combined with LVRS.

Mediastinal nodal dissection diagnosed N2 disease in 5 to 14% of patients whose conditions were preoperatively staged by CT scan as N0.$^9$\textsuperscript{11}$^{11}$ One patient in this study had unsuspected N2 disease. Ten of 11 patients in this series have pathologic stage I disease, so they have a good prognosis from the point of view of their cancers. No cancers have recurred at the present time, but the follow-up is short. The expected 3-year mortality for patients with an FEV$_1$ less than 30% predicted is 30%.\textsuperscript{10} Long-term follow-up is needed to determine the survival from combined operations for cancer and emphysema.

In summary, 2% of patients who underwent LVRS were found to have previously undiagnosed lung cancers. Surgical treatment for lung cancer is now possible for patients who, prior to LVRS, had inoperable conditions due to poor pulmonary function. During the evaluation for LVRS, the chest CT scan should be studied to look for an unsuspected lung cancer.

**REFERENCES**


![Table 2—Pulmonary Function and Survival in Patients Who Underwent Combined Operations for Both Lung Cancer and LVRS$^*$](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21737/)
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