SHORT REPORTS

Thoracoscopic carbon dioxide laser treatment of bullous emphysema

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A new technique of thoracoscopic laser ablation of pulmonary bullae suitable for patients with multiple bullae and diffuse emphysema was developed and assessed in 22 patients. 20 of 22 patients survived. Pre-operative and postoperative functional evaluation is available for the 11 patients followed up for more than a month; at 1 to 3 months postoperatively there were increases in FVC (mean 2·0 litres pre-operatively to 2·7 litres postoperatively, $p<0·001$), in FEV_1 (0·74 to 1·06 litres, $p=0·01$), and in maximum exercise treadmill times (5·4 min to 8·0 min, $p<0·01$). Postoperative air leaks lasted a mean of 13 days and usually resolved spontaneously. Other complications were bleeding (1 patient) and unilateral acute lung injury (1 patient). These early results suggest that selected patients with diffuse emphysema and pulmonary bullae may benefit from thoracoscopic carbon dioxide laser ablation.

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Bullous lung disease develops to a variable extent in patients with chronic obstructive lung disease and other acquired or congenital disorders.[1] In general, patients with isolated giant unilateral or bilateral bullae and crowding of adjacent vasculature, but not the larger group of patients with diffuse bullous emphysema, have shown improvement in lung function after surgical resection.[2-4] During investigation of CO_2 laser for treatment of spontaneous pneumothorax,[5] we observed shrinkage of subpleural bullae exposed to the laser. We thus developed a thoracoscopic method to ablate pulmonary bullae with a low-energy CO_2 laser and describe here the first 22 patients treated with it.

Criteria for inclusion were: (1) respiratory symptoms sufficient to cause major impairment of activity and lifestyle, and (2) radiographic or computed tomographic (CT) evidence of bullous lung disease, preferably with crowding of adjacent lung tissue.

Pre-operative functional evaluation consisted of routine physical examination and laboratory investigations and, for all but 4 patients, pre-bronchodilator and post-bronchodilator pulmonary function testing and maximum exercise treadmill testing according to a modified low-level protocol specifically designed for pulmonary impaired patients.

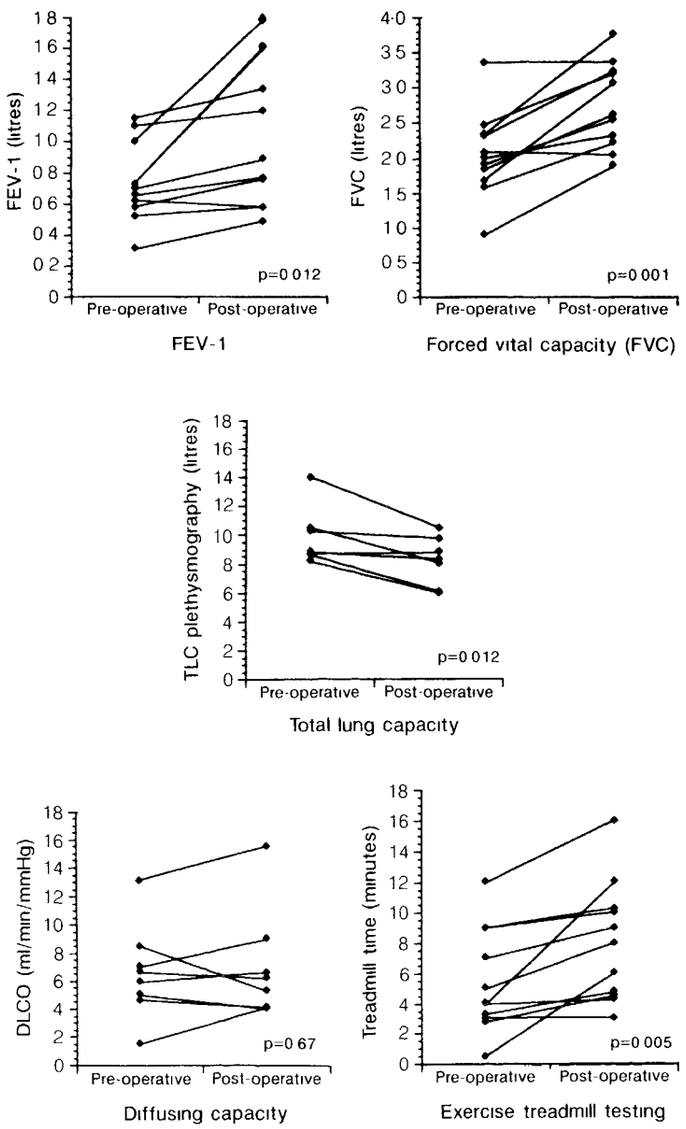

Fig 1—Pulmonary and treadmill test results in patients with bullous emphysema before and 1–3 months after thoracoscopic laser bullous ablation.

Difference between mean pre-operative and mean postoperative values for:

FEV_1	0·32 (SEM 0·11, 95% CI 0·07 to 0·57)
FVC	0·70 (SEM 0·15, 95% CI 0·36 to 1·04)
TLC	−1·66 (SEM 0·52, 95% CI −2·8 to −0·5)
DLCO	0·3 (SEM 0·7, 95% CI −1·2 to 1·8)
Treadmill time	2·60 (SEM 0·73, 95% CI 0·98 to 4·22)

Thoracoscopic procedures were done under general anaesthesia with patients intubated with a double-lumen endotracheal tube and placed in a lateral position. 11 mm trocars were inserted through two small incisions, one in the anterior and one in the posterior axillary line at the fifth intercostal space for the passage of the rigid thoracoscopes and operating instruments. The lung was collapsed. Defocused CO_2 laser beams were applied to the external surface of the bullae. Thick intraparenchymal bullae were opened and the laser beams were applied to the internal surface of the bullae. After complete contraction of all visible bullae, the lung was re-expanded and a chest tube was placed in the anterior chest. At the end of the procedure, the wounds were closed in routine fashion.

Postoperatively patients were maintained on a mechanical ventilator until adequate oxygenation and ventilation could be achieved with spontaneous breathing. The chest tubes were left in place until there were no more air leaks. Pulmonary function testing, chest radiographs, and treadmill testing were repeated at 1 to 3, 6, and 12 months.

The procedure was done twenty-four times in 22 patients (20 men, 2 women) over an 18-month period. 2 patients

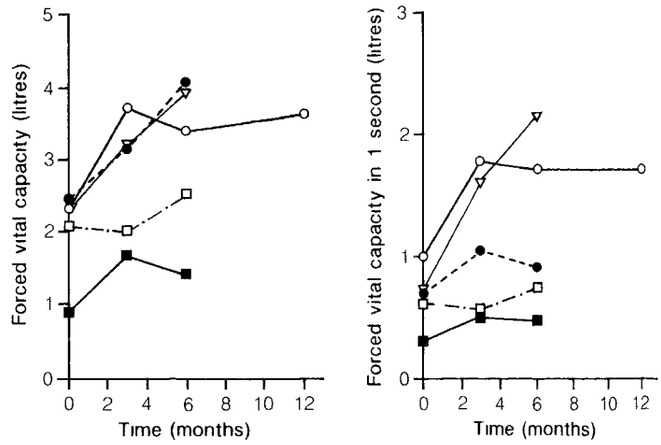

Fig 2—Follow-up of patients for 6 months or more postoperatively.

underwent bilateral procedures 3 and 4 months apart. 1 patient died 14 days after surgery of myocardial infarction, and 1 patient on the 10th postoperative day of contralateral pneumonia. Thus, the surgical mortality rate was approximately 10%. Both patients had been extremely debilitated by severe emphysema before surgery.

Persistent air leak occurred to some degree in all patients. It lasted 1 day to 5 weeks (mean 13 days). 1 patient required repeat laser thoracoscopy to seal air leaks 48 h postoperatively, after which air stopped leaking within 24 h. 3 patients required thoracotomies—1 to control air leaks, 1 to remove a flaccid bullous wall that had wrapped around the chest tubes, and 1 to control bleeding. These 3 patients subsequently did very well.

In the immediate postoperative period all patients showed worsening of interstitial and alveolar infiltrates on chest X-ray films and increased requirements for supplementary oxygen, but the lung injury responded to conventional supportive treatment, although radiographic abnormalities persisted for several weeks in some patients.

Patients enrolled in this study had very advanced emphysema with severe pulmonary dysfunction. Mean pre-operative forced expiratory volume in 1 second (FEV_1) was 0·84 litres (SEM 0·02) (26% predicted values, n = 22 [as calculated by Morris criteria]). All patients reported improvement in symptoms such as shortness of breath on exertion. Postoperative pulmonary function tests were done in 11 patients. FEV_1 and FVC increased significantly, TLC decreased, DLCO was unchanged (fig 1). Maximum exercise treadmill capacity increased significantly (fig 1). Continued pulmonary function improvement is being seen more than 3 months postoperatively in some patients (fig 2). Chest radiographs showed complete disappearance of bullae in 20 chests and reappearance in 2.

Surgical bullectomy, used for over 30 years for treatment of bullous lung disease,[1-4,6] carries a high complication rate and is generally limited to the rare group of patients with single or a few giant bullae occupying at least half the hemithorax and compressing normal adjacent lung tissue.[1] When there is severe underlying emphysema[1,7] surgical mortality rates (up to 20%) are high and long-term results are poor.[3,6,7] In patients with severe bullous lung disease, surgical mortality rates for intracavitary drainage and pleurodesis procedures[8-10] are similar to those of surgical bullectomy. The advantages of thoracoscopic laser ablation include the safety of the procedure for adjacent lung parenchyma and its suitability for patients with severe underlying lung disease. Since most of our patients (19/21) had severe diffuse bullous emphysema and did not satisfy

standard criteria[6] for conventional surgical bullectomy, the overall operative mortality rate of 10% seems acceptable.

It is uncertain whether the acute lung injury found in all patients immediately after the laser operation represents reperfusion injury, re-expansion interstitial pulmonary oedema, or laser thermal injury. Physiologically, increased shunting and hypoxaemia seem to peak at approximately 24–72 h and to subside gradually in most patients, but in some they persisted to variable degrees for over 4 weeks.

Significant objective improvement occurred in all 11 in whom follow-up measurements were made. Patients with large multiple bullae showed more striking improvement than those with small-to-medium bullae. All but 1 patient showed significant improvement in treadmill performance after the laser treatment. In contrast to most reports on surgical resection,[7] patients with less than half of their hemithoraces replaced by bullae also improved after laser ablation of the lesion.

In patients followed up 6 months or more the improvement has persisted. Whether it is only temporary, as reported after surgical resection[3,6,7] remains to be determined by long-term follow-up studies.

ADDENDUM

Laser ablation has been done in 4 more patients. There have been no further perioperative deaths, but 2 patients have died during follow-up—1 at 15 months from a stroke unrelated to respiratory disease and 1 at 4 months from a contralateral pneumonia.

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