almost similar to the yield obtained with the Autovac needle.¹⁰

Compared with the thrust technique, the drill technique allows a more precise adjustment of the depth of the biopsy needle and makes it easier to observe on the fluoroscope when the lesion has been penetrated by the needle. The Vacu-Cut 1.2 mm is so rigid that it can be introduced without a guide needle. The cost of the high diagnostic yield was a relatively high incidence of pneumothorax. There was no relation between the number of biopsy passes and the incidence of pneumothorax; however, the incidence was lower than in the series of Köhler *et al*,² being 37%, possibly because a guide needle was used.

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Single lung transplantation for end stage emphysema

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Abstract

Background - The first successful single lung transplantation was carried out in 1983 for pulmonary fibrosis. Because of the inherent advantages of single lung transplantation, a transplantation programme has been started for patients with end stage lung disease due to emphysema. **Methods** - Between October 1990 and August 1993 25 patients with severe emphysema (15 men, mean age 51 years) received a single lung transplant at our institution. All patients were severely disabled with a mean (SD) 12 minute walking distance of 281 (165) metres. There were five deaths in the series, four in the first 20 days and one on day 503. Two patients suffered graft compression by air trapping in the native lung. Bronchial narrowing requiring insertion of endobronchial stenting occurred in four patients.

Results - Mean (SD) FEV₁ improved from a preoperative value of 17.8(13)% predicted to a six month value of 53.6(13)%, and FEV₁/FVC from 23.8(12)% to 68.6(15)%. After the transplant 12 patients are in New York Heart Association (NYHA) class I and the rest of the survivors are in NYHA II. Actuarial survival was 82% at one year and 74% at three years. **Conclusions** - Single lung transplantation is an effective treatment for end stage lung

disease due to emphysema and carries an acceptable mortality and morbidity.

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Keywords: single lung transplantation, emphysema.

Since 1983 single lung transplantation has been an acceptable form of treatment in patients with end stage lung disease due to pulmonary fibrosis.¹ Because of its inherent advantages over other forms of lung transplantation, namely the ability to treat twice the number of patients and the avoidance of cardiopulmonary bypass in most patients, we have embarked on a programme of single lung transplantation in patients with emphysema.

Methods

SELECTION CRITERIA

Patients selected for transplantation had reached the end stage of their disease and were beyond the scope of any further medical treatment with a short life expectancy. Exclusion criteria included chronic infection assessed by repeated sputum culture, and bronchiectasis identified by high resolution computed tomographic scans. Patients had to have adequate cardiac function as determined by echocardiography without any significant coronary disease (men over 40 and women over 45 underwent coronary arteriography.)

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PATIENTS

Between October 1990 and August 1993 48 patients with emphysema and/or α_1 -antitrypsin deficiency were accepted for lung transplantation, 25 of whom received a single lung transplant during this time. There were 15 men and 10 women with a mean age of 51 (range 42–61) years. The mean (SD) waiting time between being accepted for transplantation and being transplanted was 175 (174) days (range 8–560). All the patients were severely disabled (NYHA IV) with a mean (SD) 12 minute walking distance of 281(165) metres. The mean (SD) FEV₁ was 17.7(8)% of predicted with a mean FEV₁/FVC percentage ratio of 23(8)%.

As in heart transplantation, patients received lungs from donors who were ABO compatible. Size matching was achieved by taking lungs from donors whose estimated total lung capacity (TLC) lay between the recipient's predicted and actual TLC. Recipients who were cytomegalovirus (CMV) negative at assessment received organs from donors who were also CMV negative.

In all cases attempts were made to replace the lung with the largest bullae to minimise postoperative air trapping. Otherwise, the right lung was replaced. Cardiopulmonary bypass was used in seven patients because of severe hypoxia on single lung ventilation or right ventricular decompensation and hypotension on pulmonary artery clamping.

IMMUNOSUPPRESSION AND PROPHYLAXIS

Immunosuppression consisted of a standard triple therapy regime of corticosteroids and azathioprine started in the preoperative period, and cyclosporin started when the patient could tolerate oral fluids. By day 4 whole blood trough cyclosporin levels of 400 ng/ml had been achieved. In addition, all the patients received four daily doses of rabbit antithymocyte globulin to achieve a T lymphocyte count of 20% or 100 cells/ml.

All the patients received cefotaxime and flucloxacillin for 48 hours, topical chlorhexidine

nasal cream and amphotericin lozenges whilst in hospital, and prophylactic co-trimoxazole whilst on steroids. Acyclovir in a dose of 400 mg four times daily was given as prophylaxis against herpes simplex virus and was continued for 12 months. Patients who were CMV positive were given ganciclovir 5 mg/kg/day in divided doses for four weeks.

POSTOPERATIVE MANAGEMENT

Patients with severe bullous emphysema do not tolerate mechanical ventilation very well and were therefore extubated early.

Patients underwent a fibreoptic bronchoscopy for inspection of the anastomosis at 14 days and again at one month when a surveillance transbronchial biopsy was performed.

At home, patients measured FEV₁ and FVC using a small electronic spirometer. If the FEV₁ fell by 15% or more they were admitted to hospital for laboratory lung function tests to confirm the deterioration. If confirmed, fibre-optic bronchoscopy and transbronchial biopsy were performed. Rejection episodes (ISHLT grade >1a in the biopsy sample)² were treated with augmented corticosteroid immunosuppression.

Results

DEATHS AND COMPLICATIONS

There were four deaths in the first 30 days, two as a result of bacterial infection of the lungs (*Escherichia coli* in one and organism unknown in the other), one of invasive aspergillosis (*A fumigatus*) and bronchial necrosis, and one of severe pancreatitis. There was one late death on day 503 due to bacterial infection (*Staphylococcus aureus*) in the native lung.

Two patients required single lung ventilation because of severe graft compression and mediastinal shift. Bronchial narrowing occurred in four patients and was treated with endobronchial stenting using Gianturco wire stents. One patient suffers from bronchiolitis obliterans syndrome stage two 48 months after transplantation.³

Pseudo-obstruction of the large bowel occurred in three patients and one patient developed ischaemic colitis. Two patients developed pancreatitis.

In the first three months there were 5.41 lung rejection events per 100 patient days. By the end of the first month actuarial freedom from rejection was only 24%.

In the first three months there were 3.17 episodes of infection per 100 patient days. Of the 15 patients who were CMV positive before transplantation only one patient developed CMV disease (pneumonitis) which resulted in loss of lung function despite otherwise successful treatment with ganciclovir.

SURVIVAL

Mean (SD) hospital stay was 26(13) days. Actuarial survival (Cutler Ederer) at one year was 82% and at three years was 74% (fig 1).

Figure 1 Actuarial survival (Cutler Ederer) after single lung transplantation.

Figure 2 Spirometric values before and after single lung transplantation.

LUNG FUNCTION

The mean (SD) FEV₁ increased from 17.8 (13)% predicted before the transplant to 53.6 (13)% at six months and 50(16)% at 12 months ($p < 0.001$, unpaired t test). Mean FEV₁/FVC increased from 23.8(12)% in the preoperative period to 68.6 (13)% at six months and 63.1(15)% at 12 months ($p < 0.001$, fig 2). Twelve patients are in NYHA class I and the rest of the survivors are in NYHA II.

Discussion

In patients with chronic obstructive pulmonary disease age and baseline postbronchodilator FEV₁ have been identified as the best prognostic factors in multicentre trials.⁴ Uncorrected hypoxaemia worsens the prognosis and in the Nocturnal Oxygen Therapy Trial⁵ patients treated with nocturnal oxygen had a two year survival of 60%. Of the 48 patients with emphysema who were accepted for transplantation at this institution 13 have died while waiting.

Guidelines for referring patients with emphysema for transplantation include a post-bronchodilator FEV₁ of <30%, resting hypoxia, hypercapnia, and a deteriorating clinical course.

The choice of procedure for patients with emphysema lies between heart-lung trans-

plantation, double lung, or single lung transplantation. This report, with reports from other lung transplantation centres,^{6,7} has shown that single lung transplantation can be carried out in this group of patients with acceptable morbidity and mortality. Although lung function is not as good as when both lungs are replaced,⁸ the functional class of the patients undergoing single lung transplantation is just as good.⁸ In addition, survival after single lung transplantation is comparable, or even superior to, other forms of lung transplantation.⁹

Patients with α_1 -antitrypsin deficiency constitute 16% of those undergoing single lung transplantation worldwide.⁹ The deficiency is still present after the transplantation, but as it takes several years for lung damage to develop there is no need for such patients to receive replacement therapy.

We have shown that single lung transplantation is an effective treatment for young patients with end stage lung disease due to emphysema. Although lung function is not returned to normal, there is a significant improvement in the functional ability and survival of treated patients.

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