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.

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

PATIENTS
Between October 1990 and August 1993 48 patients with emphysema and/or α1-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 fiberoptic 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, fiberoptic bronchoscopy and transbronchial biopsy were performed. Rejection episodes (ISHLT grade >1a in the biopsy sample) 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.

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).
LUNG FUNCTION
The mean (SD) FEV$_1$ 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 FEV$_1$/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 FEV$_1$ have been identified as the best prognostic factors in multicentre trials. Uncorrected hypoxaemia worsens the prognosis and in the Nocturnal Oxygen Therapy Trial 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 postbronchodilator FEV$_1$ of <30%, resting hypoxia, hypercapnia, and a deteriorating clinical course.

The choice of procedure for patients with emphysema lies between heart–lungs, double lung, or single lung transplantation. This report, with reports from other lung transplantation centres, 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, the functional class of the patients undergoing single lung transplantation is just as good. In addition, survival after single lung transplantation is comparable, or even superior to, other forms of lung transplantation.

Patients with α$_1$-antitrypsin deficiency constitute 16% of those undergoing single lung transplantation worldwide. 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.