Bronchography in the assessment of patients with lung collapse for endoscopic laser therapy

P J M George, M C Pearson, D Edwards, R M Rudd, M R Hetzel

Abstract
In an attempt to improve selection of patients and the efficacy of endoscopic laser treatment, a bronchographic technique has been developed for patients with tumours causing complete endobronchial obstruction. This technique has shown patent distal airways in 16 out of 17 patients with a collapsed lung or lobe. These airways were abnormally dilated in each case, suggesting bronchiectasis. In one patient the appearances of bronchiectasis were sufficiently severe to decide against attempting treatment. Treatment was not attempted in another patient as a large cavity was seen within the collapsed lung and this was thought to carry a risk of postoperative infection and haemorrhage. Treatment with a neodymium YAG laser under general anaesthesia successfully reanalysed the airway in 12 of the 15 remaining patients and was associated with a substantial reduction in breathlessness. The procedure was abandoned prematurely in one patient because of life threatening haemorrhage. In the remaining two patients in whom treatment was unsuccessful bronchography had suggested very extensive endobronchial obstruction. Spirometry and radionuclide lung scans were performed before and after treatment in eight patients treated successfully and showed significant improvements. Four patients were investigated within two weeks of lung re-expansion by repeat bronchography (three patients) or computed tomography (one patient); in each case the calibre of the airways had returned almost to normal. Thus the radiological demonstration of bronchial dilatation in a collapsed lung does not necessarily imply a diagnosis of irreversible bronchiectasis and should not be regarded as a contraindication to treatment. It is concluded that preoperative bronchography provides reliable data on the extent of tumour, the patency of the distal airways, and presence of extensive cavitation. This information should facilitate successful laser treatment.

Patients and methods
PATIENTS
We studied 17 patients (10 males and seven females) with inoperable bronchial malignancy. The average age was 66 with a range of 43–78 years. All patients were severely limited by breathlessness and their airways were obstructed predominantly by intraluminal tumour. Obstruction was within a main bronchus in each case; 16 patients had collapse of a lung and one collapse of a lower lobe. Serial chest radiographs indicated that collapse had been present for at least one month. The histological types of the tumours were: squamous cell carcinoma (10 patients), large cell carcinoma (5), small cell carcinoma (1), and undifferentiated carcinoma (1). Seven patients had not received any previous treat...
BRONCHOGRAPHY

After premedication with intramuscular injections of papavaretum and atropine, fiberoptic bronchoscopy was performed under local anaesthesia with topical lignocaine. If necessary, additional sedation was produced with up to 10 mg intravenous diazepam. A multipurpose angiographic catheter (Cordis, FG 7), containing a J guide wire, was passed through the biopsy channel of the bronchoscope and directed through the tumour under radiographic screening. The J guide wire was advanced beyond the tip of the catheter to allow the catheter to pass into the distal airways with minimal trauma.

When the catheter had been advanced 3–4 cm beyond the proximal border of the tumour, the guide wire was removed and water-soluble radio-opaque contrast (Omnipaque) was injected through the catheter under screen control. The air within the catheter, which was expelled, outlined the distal airways, which were then opacified with contrast. If distal airways were not seen, the guide wire was replaced and the catheter advanced. The procedure was repeated until bronchi were identified. The catheter was then slowly withdrawn while continuing to inject contrast in order to demonstrate the proximal and distal margins of the tumour in addition to the bronchial tree beyond (fig 1).

LASER TREATMENT

Treatments were given with neodymium YAG lasers operating at a wavelength of either 1.064 μm (Fiberlase 100, Pilkington Medical Systems; University College Hospital) or 1.32 μm (MBB-Medizintechnic; London Chest Hospital). Treatment with the two lasers was essentially the same; both used a combination of rigid and flexible bronchoscopes, with general anaesthesia produced by intravenous agents. For treatment with the 1.064 μm laser, however, we used power settings of 40–70 watts in pulses of up to two seconds, but with the 1.32 μm laser powers of 10–20 watts in pulses of up to one second.

PREOPERATIVE AND POSTOPERATIVE ASSESSMENTS

Lung re-expansion was assessed in all patients with chest radiographs. Breathlessness was graded on the basis of the Medical Research Council (MRC) questionnaire. Measurements of peak expiratory flow (PEF), forced expiratory volume in one second (FEV1), and forced vital capacity (FVC) were obtained whenever possible.

We also attempted to evaluate changes in ventilation and perfusion within the treated lung by comparing preoperative and postoperative radionuclide lung scans. Perfusion was assessed by using technetium-99m labelled human albumin macroaggregates, and ventilation with either krypton-81m gas (University College Hospital) or 133Xe labelled DTPA aerosols (London Chest Hospital). Anterior and posterior views were obtained and the number of counts was averaged by taking the geometric mean counts from the
two views. Ventilation and perfusion were
calculated by using the mean number of
counts in the treated lung as a percentage
of the total counts in both lungs to produce
a fractional score. Full details of this
method have been described. Patients whose
airways had not been recanalised were not
asked to repeat these tests after the procedure.

ANALYSIS
Mean values for breathlessness score (MRC
grade) were compared before and after treat-
ment by Wilcoxon’s matched pairs signed
rank test. Student’s paired t test was used to
assess lung function (FEV₁, FVC, PEF) and
fractional scores of ventilation and perfusion
before and after treatment.

**Results**

**BRONCHOGRAPHY IN 17 PATIENTS WITH A
COLLAPSED LUNG OR LOBE**

Bronchography was well tolerated by all
patients and there were no complications.
Patent distal airways were seen in 16 of the 17
patients with a collapsed lung or lobe. The
bronchi in these 16 cases were abnormally
dilated, suggesting radiographic bronchiec-
tasis. In one patient the appearances of severe
bronchiectasis led to a decision not to attempt
laser treatment (fig 2a).

In two patients cavities were seen within the
collapsed lung. Treatment was not attempted in
one of these patients (fig 2b) because the
cavity was thought to carry a serious risk of
postoperative infection and haemorrhage. In
the other patient treatment was directed at the
unaffected lobe, no attempt being made to
recanalise the bronchus supplying the cavitated
lobe.

**Laser Treatment In 15 Patients**

Endoscopic laser treatment was attempted in
15 patients and achieved successful recanalisa-
tion in 12. Treatment was successful initially in
only nine patients but it was repeated in four
whose bronchograms had shown patent distal
airways. Repeat treatments resulted in success-
ful recanalisation in three of these patients.

Preoperative bronchography suggested very
extensive tumour in two of the three patients
whose treatment was unsuccessful. In one case
distal patent airways could not be seen, and in
the other case tumour was shown to extend
from the orifice of the left main bronchus to the
segmental divisions of the lower lobe. In the
third patient, although bronchography showed
limited endobronchial obstruction, treatment
had to be abandoned prematurely as a result of
life threatening haemorrhage.

**Assessments In Patients With Recanalised
Airways**

In patients with a collapsed lung postoperative
chest radiographs showed complete re-expansion
in six and partial re-expansion in five. Re-
expansion was also obtained in the patient with
a collapsed lobe. In each case breathlessness
was reduced to such an extent that the MRC
grade in the 12 patients improved from a mean
value of 4-4 to 2-8 (p = 0.002).

Respiratory function was assessed before and
after treatment in eight patients (table). There
was a significant increase in mean values of
FEV₁ and FVC (p = 0.05 and 0.005) but no
change in PEF. The most striking improvements
were observed in patients with

<table>
<thead>
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<th>Before</th>
<th>After</th>
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<tbody>
<tr>
<td>PEF (l/min)</td>
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</tr>
<tr>
<td>FEV₁ (l)</td>
<td>1.26 (0.42)</td>
</tr>
<tr>
<td>FVC (l)</td>
<td>1.91 (0.79)</td>
</tr>
</tbody>
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*p = 0.05; **p = 0.005 (paired Student’s t test).
Discussion

In an attempt to evaluate patients with a collapsed lung, we initially performed computed tomography but found that the scans could not define bronchial anatomy within the area of the collapse. Our experience with preoperative bronchography has been more encouraging, however, as it has provided reliable information on the extent of tumour and patency of the distal airways. It has also enabled us to avoid the potential hazards of infection and haemorrhage, which we have previously encountered after recanalising cavitated lung. The technique has been easy to perform and well tolerated, and appears to be safe.

In addition to its value as a preoperative screening procedure, bronchography may improve the chances of achieving successful re-expansion. Without the knowledge that patent distal airways existed beyond the tumour, treatment might have been abandoned prematurely and would not have been repeated in three patients in this series whose lungs subsequently re-expanded. The patients with complete endobronchial obstruction who were selected for bronchography had longstanding collapse and thus represented the most challenging group of patients to be treated. Successful recanalisation in 12 of the 15 patients compares favourably with previously published figures of 5 of 17, 4 of 25, 11 of 23, and 7 of 11.

Although radiological re-expansion provides a convenient end point, it represents a poor index of functional improvement. In the present study spirometry and radionuclide lung scanning revealed a wide range of improvement, which could not have been predicted from the plain chest radiograph. Differences in postoperative airway calibre and the inconsistent effects on the lung of extrabronchial tumour and previous radiotherapy may have contributed to this variability. Nevertheless, successful recanalisation resulted in a significant functional improvement and a valuable reduction in breathlessness.

Laser recanalisation in patients with a collapsed lung may be further helped by the technique of intraoperative bronchography, developed by Joyner et al. Their technique uses a transbronchial biopsy needle to perforate the obstructing tumour and then inject radiopaque contrast distally. The angle of the needle is adjusted until contrast flows freely into the distal airway, thereby providing information that guides the operator’s plane of dissection through the tumour. The best possible results therefore may be obtained when intraoperative bronchography is used to guide treatment in patients selected by preoperative bronchography.

In the present study preoperative bronchography consistently showed abnormal bronchial dilatation within the collapsed lung and suggested the presence of radiographic bronchiectasis. These findings were of concern as it was feared that re-expansion of a lung or lobe with the laser might add to the patient’s distress by causing chronic productive cough.
Figure 4 Example of reversible bronchial dilatation. Collapsed right lung (a), caused by a tumour occluding the right main bronchus. Preoperative bronchography (b) showed tumour extending from the orifice of the right main bronchus to the intermediate bronchus. The middle and lower lobe bronchi were patent but dilated. The upper lobe bronchus could not be identified. Endoscopic laser resection successfully recanalised an airway to the intermediate bronchus but not to the upper lobe, and resulted in re-expansion of the middle and lower lobes (c). Bronchography two weeks later showed that the calibre of the right middle and lower lobe bronchi had improved substantially (d and e).

Furthermore, our previous experience has shown that patients whose lungs or lobes are successfully expanded are particularly at risk of developing pneumonia after the procedure, occasionally with fatal outcome.

Joyner et al do not say whether any of their patients had bronchial dilatation. Nevertheless, the finding of bronchial dilatation is well known in atelectatic lungs obstructed by endobronchial tumours and inhaled foreign bodies. In the present study the finding of normal bronchial calibre in two patients whose lungs had re-expanded after a period of collapse and of reversible bronchial dilatation (fig 4) in four patients suggests that the dilatation is not necessarily permanent and may be
reversed when the lung or lobe re-expands. The decision not to treat the patient with severe bronchial dilatation (fig 2a) was taken before we had observed this reversibility and would not have been made in the light of our more recent experience.

Reversible bronchial dilatation has been observed in patients with atelectasis associated with viscid secretions and severe infection. In these cases repeat bronchography showed that the airways had returned to a normal calibre when the infection and secretions had been treated satisfactorily and the lung had re-expanded. Whether these cases and those presented in this paper should be regarded as genuine cases of bronchiectasis is debatable. The bronchiectasis literally means dilatation of the bronchii; it has been argued, however, that the dilatation should be permanent before such a term is used. It has been suggested that bronchial dilatation occurs in patients with atelectatic lungs as a result of distension caused by an accumulation of viscid secretions and that collapse may lead to foreshortening of the airways and so further enhance the appearances of bronchiectasis. Prompt relief of the obstruction with drainage of secretions and re-expansion of the lung should therefore restore a normal airway. If infection supervenes, however, it is suggested that the bronchial wall is weakened and the adjacent lung becomes fibrosed. The combination of mural weakening and traction by the surrounding fibrosis is thought to produce the characteristic changes of irreversible bronchiectasis.

If these suggestions are correct, it is clearly important to use the laser to attempt lung re-expansion as promptly as possible before infection and fibrosis have become established. The duration of complete endobronchial obstruction and of collapse could not be documented precisely in our patients but were probably in the region of one to two months. In Linton’s series of 16 patients irreversible bronchiectasis was observed in four patients seven months to six years after inhalation of a foreign body.

The finding of bronchial dilatation in patients with a collapsed lung does not therefore necessarily imply a diagnosis of irreversible bronchiectasis and should not be regarded as a contraindication to attempting laser treatment. We believe that bronchography is a valuable preoperative screening procedure as it identifies patients with patent distal airways in whom treatment is likely to lead to a worthwhile symptomatic and functional improvement. It also enables the unnecessary risks of treatment under general anaesthesia to be avoided in patients with non-viable lungs. The technique may also have a wider value in assessing patients before other palliative treatments, such as radiotherapy, are attempted.

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