MEDICAL PRACTICE

Occasional Review

Fibreoptic bronchoscopy: ten years on

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Summary and conclusions

Fibreoptic bronchoscopy was introduced more than 10 years ago and is now in many centres a routine diagnostic procedure, having superseded rigid bronchoscopy. Its major role is in the diagnosis of bronchial carcinoma, where the results are as good as, if not better than, results with the rigid instrument. Other major applications have been found in investigating haemoptysis, transbronchial lung biopsy in interstitial lung disease, and in the critically ill patient in the intensive care unit. More recently, the instrument has been used to perform bronchoalveolar lavage in investigating interstitial lung diseases and to enable lobar and segmental lung function studies to be performed.

Fibreoptic bronchoscopy is a major advance in the diagnosis of pulmonary diseases, but there will always be times when rigid bronchoscopy is preferable.

Introduction

The fibreoptic bronchoscope has come to play an increasingly important part in diagnosing a wide variety of lung diseases since its introduction by Ikeda.[1] Inspection of the tracheobronchial tree is now practicable as an outpatient procedure with minimal discomfort and risk for the patient. It is rarely necessary to use general anaesthesia except in children, and this has proved invaluable in a health service where anaesthetists and theatre time are at a premium. In many hospitals fibreoptic bronchoscopy performed by physicians has largely superseded rigid bronchoscopy.

Details of the technique used for anaesthesia and insertion of the fibrescope have been well documented elsewhere.[2 3] Most operators[4] insert the instrument through the nose when facing the semi-recumbent patient rather than from behind as with the rigid bronchoscope. This helps the operator to communicate verbal and visual reassurance to the patient more easily.

Other technical advantages with the fibrescope are the greater visual range[5] compared with the rigid instrument and ease of inspection and biopsy of the upper lobes. Although the biopsy specimens with the fibrescope are small, special fixation techniques have been developed that give a high rate of accurate histological diagnosis.[6]

We have reviewed our experience at Brompton Hospital in the context of available published reports on fibreoptic bronchoscopy. In our series of 1223 cases 71% were male, the youngest patient was 6 years old and the eldest 85. In 41% of our patients the final diagnosis was bronchial carcinoma. A diagnosis was established in groups of patients with sarcoidosis, pneumonia, fibrosing alveolitis, secondary carcinoma, lymphoma, and benign tumours. Fibreoptic bronchoscopy was used to investigate haemoptysis, and a few patients with bronchiectasis, pulmonary tuberculosis, bronchopulmonary aspergillosis, and chronic cough also had fibreoptic bronchoscopy for various indications. Most (81%) needed no other diagnostic procedure; the remainder went on to have thoracotomy, mediastinotomy, needle biopsy, or rigid bronchoscopy.

Malignant disease

Despite the increasingly wide applications of the fibrescope most bronchoscopies are still undertaken for suspected malignant disease. Although the rate of positive biopsy specimens for visible tumours is similar to that obtained by the rigid instrument overall, a higher percentage of positive biopsy specimens is achieved because with the

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fibrescope many more tumours are visible, especially in the upper lobes.[7] In addition, by using fluoroscopy with bronchoscopy it is possible to biopsy more peripheral tumours beyond the range of direct vision. In our own series bronchial carcinoma was eventually diagnosed in 499 patients. Several series[8-11] have shown that when tumour is visible at bronchoscopy, an accurate histological diagnosis can be made in 77-94%. In our series 48% had visible tumour, and of these, 91% had a positive biopsy specimen, whereas Martini and McCormick[10] found only 37% to have visible tumour with 93% positive biopsy specimen. On the other hand, Kvale *et al*[11] found 75% to have visible tumour with 71% positive biopsy specimen. Not surprisingly, when no tumour is directly visible, the positive biopsy rate is lower, and in our series it was 43%. Of our 499 patients with carcinoma, fibreoptic bronchoscopy provided positive histology in 69% overall (48% squamous carcinoma, 19% adenocarcinoma, 18% small-cell and 15% large-cell carcinoma). In 17% other biopsy procedures were required, including thoracotomy. In the remainder no further diagnostic attempts were made as either the patients were too old or ill or they declined further investigation. We included them in this series as they all followed the expected clinical course for the disease, and no alternative diagnoses emerged. In some, confirmatory histology was obtained at necropsy.

Some authors[10 11] emphasise the importance of combining forceps biopsy with brush cytology to increase the diagnostic yield. In our series a direct comparison could not be made, as brush cytology has only recently been included routinely.

Transbronchial lung biopsy with the fibrescope is useful in diagnosing peripheral carcinomas that are out of visual range bronchoscopically. In our series of 75 patients with carcinoma who had transbronchial lung biopsy performed 48 (64%) had positive histology obtained by the procedure. This is clearly of value as it avoids more invasive procedures, which carry higher morbidity and mortality.

Early diagnosis of carcinoma

It has been suggested[12 13] that where sputum cytology is positive repeated fibreoptic bronchoscopy may be used to locate malignant tumours not visible on a chest radiograph. At present it seems unlikely that fibreoptic bronchoscopy can be applied as a screening procedure except in such small groups of highly selected patients. In our series 12 patients with a normal chest radiograph had carcinoma, representing considerably less than 1% of all the patients with carcinoma. Five had positive mucosal histology, five positive sputum cytology but negative mucosal biopsy specimens, and one had positive cytology in a trapped specimen of secretions obtained at fibreoptic bronchoscopy. In a further patient the diagnosis was made after excision biopsy of a metastasis. Seven had squamous-cell carcinoma, two had small-cell carcinoma, and the remainder were unclassified.

Assessment of operability

It is sometimes claimed that operability of lung tumours cannot be assessed by fibreoptic bronchoscopy because mobility of the carina cannot be tested with the fibrescope. In conscious patients at fibreoptic bronchoscopy, however, mobility of the carina is readily appreciated with the movement of breathing and coughing, and neoplastic invasion of the carina may be seen. So far there has been no satisfactory comparison of the mobility of the carina, as judged by either method, with the extent of infiltration of mediastinal nodes found at thoracotomy.

Treatment of carcinoma of the bronchus is under critical review, and pretreatment assessment will probably eventually include computed axial tomography, mediastinoscopy, and other invasive methods, so that bronchoscopic findings alone may become less important.

Transbronchial lung biopsy

Owing to the low morbidity and mortality transbronchial lung biopsy is a useful alternative to open lung biopsy[14] in diagnosing both diffuse lung disease and discrete peripheral lesions beyond the range of direct vision at bronchoscopy. The results of transbronchial lung biopsy compare favourably with those obtained by percutaneous needle biopsy and trephine biopsy,[15] with the advantage of a much lower rate of pneumothorax. Transbronchial lung biopsy performed using a fibrescope rather than the rigid instrument has the advantage that upper lobe lesions can be biopsied with precision.

For diffuse disease or circumscribed opacities, the biopsy forceps are advanced under direct vision through the fibrescope into a lobar or segmental bronchus leading to the site of the shadowing on the radiograph and then advanced on, under fluoroscopic control, towards the periphery of the lung, or into the opacity.[2 16] In our series, as in others,[14 16-18] a wide variety of histological diagnoses were obtained in nearly half of the patients having transbronchial lung biopsy, and in diffuse lung disease, tissue providing representative samples for diagnostic histology may be obtained in 60-80%. In our series of 93 patients with diffuse chest radiograph abnormality, 73% were diagnosed by transbronchial lung biopsy. The diagnoses included sarcoidosis, fibrosing alveolitis, carcinoma, pneumonia, lymphoma, and pulmonary haemosiderosis. Transbronchial lung biopsy was particularly successful with sarcoidosis, where the diagnostic yield in our series of 61 patients was 82%, but in fibrosing alveolitis and other diseases, where the distribution of the histological change varies widely between different parts of the lung, it has been less useful. In these cases it is unlikely that the limited detail of the histology from the small samples of lung obtained can supplant open lung biopsy.

Transbronchial lung biopsy for solitary or multiple opacities is also less successful because it is often impossible to advance the biopsy forceps into the tumour mass even with the use of fluoroscopy and a rotating table to aid accurate positioning of the forceps tip. This is presumably because the blunt-nosed flexible biopsy forceps will follow the line of least resistance and so tend to pass around the surface of solid masses. In addition, pulmonary metastases and pulmonary lymphomas that originate in lymphatics and vascular structures may not be accessible from the airways. Generally, the likelihood of obtaining a positive transbronchial biopsy specimen is related to the size of the tumour. For malignant growths of 4 cm diameter or more, the diagnosis can be confirmed in over 80% but in those of less than 4 cm in diameter the diagnostic rate falls to 58% or lower.

Haemoptysis

Fibreoptic bronchoscopy is particularly useful when investigating patients with haemoptysis. In the series reported[19 20] the commonest causes of haemoptysis were chronic obstructive airways disease, bronchiectasis, bronchial carcinoma, and tuberculosis, and in many cases no cause was found. The greater visual range of the fibrescope allows more accurate locating of peripheral causes of haemoptysis.[5] At a thorough examination the nose and upper airways may be inspected for the occasional carcinoma giving rise to spurious haemoptysis. If bronchoscopy is performed during or shortly after haemoptysis it is common to find that blood has spread throughout the tracheobronchial tree and the site of origin is not obvious. If each segment is then washed in turn with saline the reappearance of blood in that lobe or segment indicates the source of haemorrhage.

With these methods the source of haemoptysis has been localised to a segmental or subsegmental level in more than 90% of cases.[20] This locating the site of bleeding is particularly important in massive haemoptysis, when emergency surgical resection may be necessary. In addition success has been reported in the control of massive haemoptysis by balloon tamponade with a catheter introduced through the fibrescope.[9] In our own series 137 patients presented with haemoptysis as the only symptom; 87 had a normal chest radiograph. In 77 patients no cause was found, 14 had bronchitis, 12 bronchiectasis, seven bronchial carcinoma, and six pneumonia. In the remainder other diagnoses were established including lung abscess, pulmonary embolus, broncholith, and Munchausen's syndrome. Histological evidence was obtained at bronchoscopy in four of the seven patients with carcinoma, the other three needing needle biopsy or thoracotomy. Of the seven patients with carcinoma, four had a normal chest radiograph.

Persistent chronic cough

Forty-six patients aged between 23 and 83 underwent bronchoscopy because of persistent cough. Two-thirds were women, and two-thirds had a normal chest radiograph. At bronchoscopy, 10 had mucosal inflammatory changes. There were no cases of carcinoma or adenoma in this group.

Bronchoscopy in critically ill patients

The fibrescope is the ideal instrument for assessing the position and patency of endotracheal tubes, the nature and extent of mucosal damage, and the integrity of bronchial suture lines after surgery. While tenacious secretions and foreign material may be removed by lavage[21] this is still often best undertaken with the rigid instrument, which gives a wider channel for suction. The fibrescope is useful for investigating stridor after removal of endotracheal tubes and for assessing laryngeal and tracheal oedema caused by inhalation of smoke.[22] For the removal of foreign bodies the rigid instrument is still the most satisfactory method, although success has been reported with the fibrescope.[23]

Opportunist lung infections

Considerable success has been reported with transbronchial lung biopsy through the fibrescope for immunosuppressed patients with new shadows on the chest radiograph. The problem posed is to obtain good lung specimens for histology and microbiology from often critically ill patients, and fibreoptic bronchoscopy is ideally suited for this. The diagnostic yield from transbronchial lung biopsy in one series[24] was 74%, comparing favourably with trephine biopsy (82%) and with the advantage that the incidence of pneumothorax was less (19%) than with trephine biopsy (60%).

A wide range of viral, bacterial, and parasitic infections were diagnosed in addition to infiltration by lymphoma and drug-induced pulmonary fibrosis. In another series[25] a specific diagnosis was obtained in 78% of patients with diffuse shadows and 64% of patients with focal shadows who had lymphoma or leukaemia. In thrombocytopenic patients it is advisable to give a platelet transfusion before the procedure. Transbronchial lung biopsy has been especially valuable in diagnosing *Pneumocystis carinii* pneumonitis with a low incidence of false-negative biopsy specimens.[26 27]

Complications of fibreoptic bronchoscopy

The complication rate with the fibrescope should be very low, partly because general anaesthesia is not necessary. In a large multicentre series[4] the incidence of minor complications was 0·2% and of major complications 0·08%, with a mortality of 0·01%. Adverse reactions to local anaesthesia have been reported, and lignocaine seems to be safest in this regard. A fall in arterial oxygen tension of 1·3 kPa (9·8 mm Hg) or more[28] often occurs, and this can be readily counterbalanced if oxygen is given through a nasal cannula during the examination. Other reported complications include laryngospasm after unskilful insertion of the bronchoscope, bronchospasm in asthmatics, and fever.[29] The major complications of transbronchial lung biopsy are haemorrhage (9%) and pneumothorax (5%).[30] In our series of 1223 bronchoscopies there were no fatalities, mild haemorrhage occurred in five patients (four after transbronchial lung biopsy), fever in two, haemorrhage of 50-500 ml in two (one after transbronchial lung biopsy), and respiratory arrest in two. There were no adverse reactions to local anaesthetic and two cases of pneumothorax, both after transbronchial lung biopsy.

Research applications of fibreoptic bronchoscopy

TRACHEAL MUCUS VELOCITY

Small Teflon discs can be deposited through the fibrescope on to the tracheal surface and their subsequent upward movement recorded by time-lapse cinematography. Tracheal mucus velocity and cilial function may thus be assessed. Santa Cruz *et al*[31] have shown significant decreases in mucus velocity in patients with chronic obstructive airways disease compared with non-smokers. The technique can be used to study the effect of bronchodilators, inspired oxygen concentration, and anaesthetic agents on mucus velocity.

BRONCHOALVEOLAR LAVAGE

Bronchoalveolar fluid and free-cell content may be sampled with ease through the fibrescope. The tip of the instrument is impacted in a subsegmental bronchus, and 60-120 ml of buffered saline is introduced. This is then aspirated through the suction channel. This process may be repeated several times and the aspirated fluid collected for analysis. The technique is safe, although occasional patients develop pyrexia after the procedure. Most cells obtained are pulmonary alveolar macrophages, and many aspects of their function have been investigated.[32] In smokers the yield of these cells is increased, their proteolytic activity is enhanced, and they contain inclusion bodies which are thought to consist of kaolinite.[33]

In the context of interstitial lung diseases bronchopulmonary lavage has aroused considerable interest and may be a helpful adjunct to diagnosis and management. Weinberger *et al*[34] found that in patients with sarcoidosis the differential lymphocyte count was increased to 35% and in hypersensitivity pneumonitis (allergic alveolitis) to 65%, whereas in normal controls the lymphocyte count rarely exceeded 10% of the total cell count. In contrast, patients with fibrosing alveolitis, eosinophilic granuloma, and collagen vascular disease with pulmonary involvement had no raised lymphocyte count, providing a useful point of distinction. These latter groups of patients, however, had raised IgG concentrations and neutrophil counts, the greatest increase being found in fibrosing alveolitis (21·2%) compared with only 2·1% in controls. In patients with fibrosing alveolitis who were treated with corticosteroids there was a subsequent fall in neutrophil count. In the patients with sarcoidosis lymphocyte count correlated with disease activity but not with radiological stage. In addition, Haslam *et al*[35] have suggested that lymphocyte content in lavage fluid from patients with fibrosing alveolitis is related to steroid responsiveness.

Clearly the use of the fibrescope to obtain cell populations and bronchoalveolar fluid from the human lung will find increasing applications for the study of cellular defenses to infection and cellular behaviour in interstitial lung diseases.[36]

Lobar and segmental function of the lung

The rigid bronchoscope was first used to detect regional abnormalities of lung function by Hugh-Jones and West.[37] Small flexible probes were passed down the bronchoscope to take gas samples for analysis using a mass spectrometer. Characteristic patterns of change in oxygen, carbon dioxide, and argon concentrations were observed in various pathological conditions including partial bronchial obstruction and pulmonary artery occlusion in different lobes and segments. The fibrescope allows similar observations to be made in conscious patients with minimal discomfort. Fine flexible probes may be accurately positioned, and regional differences in ventilation and blood flow may be examined by mass spectrometry or by using radio nuclides with a gamma camera. Williams *et al*[38] have developed techniques to examine accessible gas volume, alveolar ventilation, and "effective" pulmonary blood flow in lobes or segments of the lung. Effective pulmonary blood flow is the flow of blood that participates in gas exchange with inspired air.[39]

Measurement of alveolar carbon dioxide concentration within a lobe or segment gives an index of its ventilation relative to perfusion, and several different patterns of expired carbon dioxide trace have been described.[40] Effective pulmonary blood flow can be estimated when the patient inspires air containing small amounts of argon, which is insoluble, and fluorocarbon (Freon 22), which is soluble.[38] Fluorocarbon is carried away by blood in the alveolar capillaries so that its concentration falls continuously during expiration. The insoluble argon remains in the alveoli, and the shape of its concentration curve in expiration provides a measure of the accessible volume of ventilated lung and the evenness of ventilation. The difference in concentration with time between fluorocarbon and argon provides an index of perfusion of that segment or lobe. These techniques are of particular value in estimating the anatomical extent of various lung diseases and in predicting the effects of surgical resection.

Conclusion

Fibreoptic bronchoscopy is a major advance in diagnosing pulmonary diseases, and the results obtained compare favourably with the rigid bronchoscope.[41] In addition new roles for the instrument are appearing owing to its greater versatility. There will, however, always be occasions when rigid bronchoscopy is preferable and where there is no substitute for percutaneous needle, air drill trephine, or open lung biopsy.

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A child aged 2½ has an angioma of the face extending from the upper lip towards her nose—probably of the mixed cavernous capillary type. It has shown no signs of regression. When is the optimum age for treatment, and what are the techniques used? Can tattooing be used as a preliminary measure to mask the lesion?

Four clinical types of haemangioma need to be considered in a child of 2½ years. The histological diagnosis of cavernous or capillary types is not helpful in considering diagnosis and treatment. A strawberry naevus is not present at birth, except possibly as a pale stain. It appears to grow rapidly during the first two weeks and may continue to grow until about the age of 3 months. From then on it usually slowly regresses until about the age of 7 years, after which no further change occurs. Episodes of trauma, ulceration, or infection tend to accelerate the regression. Provided the eyesight is not obscured by the haemangioma, and dangerous haemorrhage does not occur, a conservative approach may be adopted. Port-wine stains are present at birth and change little during life. The texture of the skin is commonly normal. It may occasionally be associated with some degree of gigantism of the part affected. Venous haemangiomas may be present at birth or may develop in later life. They change little once established. Commonly the skin is affected only to a limited extent. Arteriovenous haemangiomas may be distinguished from birth or develop later, and have the characteristic arterial element.

Treatment may be by using cosmetics to camouflage the defect. In children such measures are rarely successful since the cosmetic takes some time to apply and may be washed off. Tattooing is unsatisfactory since the colour match of the pigments with normal skin is poor, and the colour fades. The procedure cannot be repeated. For strawberry naevi, intralesional injection of steroids may sometimes cause regression. For strawberry naevi and venous haemangiomas, intralesional elemental magnesium may also cause regression. Injection with hypertonic saline or intralesional diathermy may also be used in selected cases. Arteriovenous haemangiomas require surgical treatment.

A mid-stream specimen of urine is collected from a child who has nocturnal enuresis. What significance does a mucus deposit and much amorphous debris have? Do such deposits indicate a further need for investigation to exclude urinary tract disease or systemic disease? The transport bottle contains borate.

The presence of mucus, amorphous debris, or amorphous crystals in a specimen of urine has no pathological significance and calls for no further investigations. Amorphous crystals are by far the commonest cause of a urine being cloudy macroscopically. Amorphous phosphates tend to appear in neutral or alkaline urines: amorphous urates may appear as a specimen of urine cools. Provided the transport bottle contained the correct amount of borate, a genuine bacterial infection would not have been missed. The question acts as a reminder that infection of the urinary tract must be ruled out in every child with nocturnal enuresis.