The biphasic spirogram: a clue to unilateral narrowing of a mainstem bronchus

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Abstract

Two patients with narrowing of a mainstem bronchus each showed two unusual functional features that are likely to be characteristic of this condition. The maximum inspiratory flow-volume curve showed an end inspiratory "tail" and the forced expiratory spirogram had a biphasic shape with normal initial curvature but a "straight line" appearance in later expiration. In one patient relief of the bronchial stenosis by the insertion of a stent restored normal contours to the spirogram and flow-volume curves.

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Tracheal stenosis produces characteristic abnormalities of maximum flow-volume curves, the exact pattern depending on whether the narrowing affects the intrathoracic or the extrathoracic trachea. The functional effects of narrowing of one or other main bronchus are less well recognised. In a recent study of patients with unilateral mainstem bronchial obstruction by Gelb *et al*[1] the pattern of ventilatory function appeared to be mainly "restrictive," the predominant abnormality being a reduction in vital capacity; after relief of the obstruction the vital capacity increased, accompanied by a "parallel shift" of the maximum expiratory flow-volume curve and little change in the slope of the descending limb.

We have recently seen two patients with unilateral main stem bronchial narrowing who showed two further functional features, neither of which was mentioned in the paper by Gelb and associates[1] or in an accompanying editorial review of unilateral bronchial obstruction.[2]

Case reports

PATIENT 1

A 55 year old ex-smoker presented with a six month history of right sided chest pain. He had no other respiratory symptoms. Examination of the chest showed nothing remarkable. The chest radiograph showed cylindrical opacities consistent with bronchiectasis, apparently limited to the right upper lobe. Bronchoscopy showed a cartilagenous ridge, presumably developmental, causing almost complete obstruction of the right main bronchus; this was confirmed by bronchography, which also showed that the right upper lobe orifice was reduced to pinhole size. His forced expiratory spirogram and maximum expiratory and inspiratory flow-volume (MEFV, MIFV) curves are shown in figure 1.

PATIENT 2

A 56 year old woman with fibrosing alveolitis underwent left single lung transplantation. About a month after operation she became more short of breath and a fixed wheeze was audible over the left upper chest. She was otherwise well and there was no radiographic abnormality in the transplanted lung. Bronchoscopy showed stenosis of the left main bronchus at the site of the anastomosis. She subsequently underwent dilatation and insertion of a stent, with improvement in her symptoms. The spirometric values and flow-volume curves before and after insertion of the stent are shown in figure 2.

Discussion

The patterns of the forced expiratory spirogram and maximum flow-volume curves of the two patients before insertion of the stent were very similar. During forced expiration the initial 50% or so of the vital capacity was expired rapidly, giving a normal initial curvature to the spirogram, while the second half of the vital capacity was expired much more slowly, giving the spirogram a straight line appearance. The latter appearance implies an almost constant expiratory flow and corresponds to the long expiratory "tail" on the MEFV curve. During forced inspiration the MIFV curves showed a pronounced slowing of maximum inspiratory flow towards the end of inspiration. After correction of the bronchial stenosis in patient 2 (fig 2, *c* and *d*) the shape of the spirogram and flow-volume curves became virtually normal. End inspiratory slowing on the MIFV curve has been mentioned previously in brief reports[3,4]; but to our knowledge the rather abrupt change in the

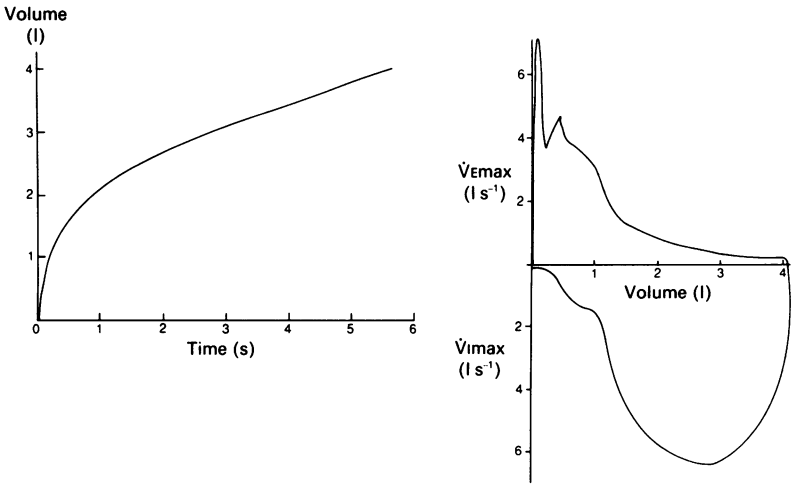

Figure 1 Forced expiratory spirogram (left) and maximum flow-volume curves (right) of patient 1 (see text for description).

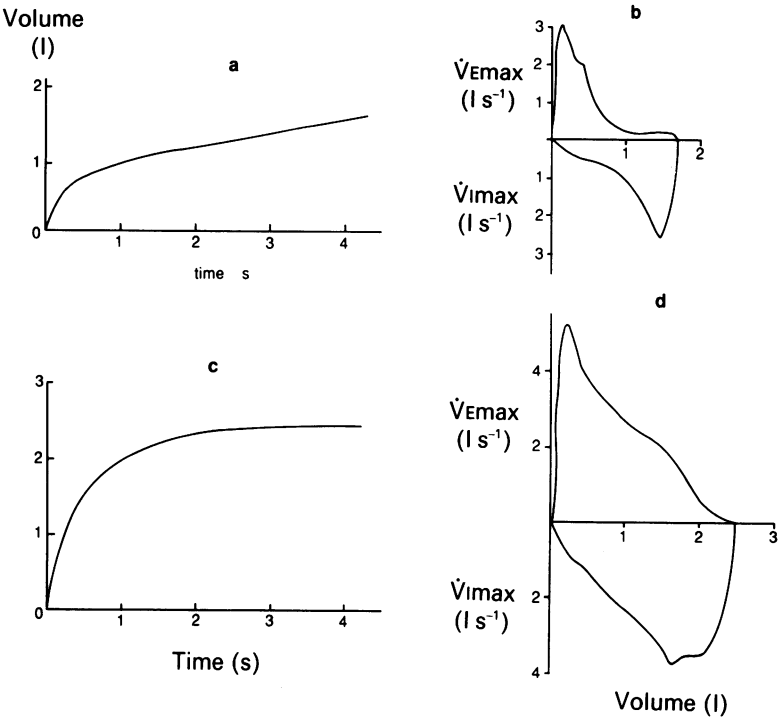

Figure 2 Forced expiratory spirograms (a, c) and maximum flow-volume curves (b, d) of patient 2 before (a, b) and after (c, d) insertion of a stent in the narrowed left main bronchus (see text).

expiratory spirogram, giving a biphasic pattern, has not been reported previously.

The abnormalities are compatible with emptying and filling of the lungs as two distinct compartments, one fast and the other much slower, the slower compartment corresponding to the lung whose main bronchus is severely narrowed. The unaffected lung dominates the early part of forced expiration or inspiration, so that the contribution of the slowly ventilated lung becomes evident only in the second half of the manoeuvre.

The biphasic pattern of the spirogram in these two patients is the reverse of that seen with tracheal stenosis, where a fixed resistance results in virtually constant flow in the first part of expiration and hence the characteristic "straight spirogram"[5]; in later expiration flow declines, causing curvature of the spirogram, because at smaller lung volumes maximum expiratory flow is no longer determined by the tracheal narrowing but results from dynamic compression of intrathoracic airways. In our patients lung emptying via a severely narrowed main bronchus with an effectively fixed resistance becomes apparent as a straight line spirogram in later expiration once emptying of the normal lung is virtually complete. Both patients had clearly demonstrable localised narrowing of the main bronchus, causing the unilateral delayed emptying. Asynchronous emptying of the two lungs would also be expected with diffuse airway disease affecting only one lung, as in hypoplastic conditions (such as Macleod's syndrome) or in the resident lung after unilateral transplantation for emphysema; whether such conditions produce functional features similar to those described here is not known.

The general shape of the MEFV curve in our patients is similar to the appearance seen in patients with the more usual types of generalised intrathoracic airways obstruction, though the convexity towards the volume axis is more striking than usual. For this reason it would be easy to fail to recognise the relevance of the appearance of the MEFV curve. The flow-volume relation does not display information related to time. The advantage of the volume-time curve is that it emphasises the contribution of slowly emptying lung compartments. The appearance of the MIFV curve is likely to be more specific than that of the MEFV curve for recognising mainstem bronchial narrowing, as the end inspiratory tail is not a feature of generalised airways obstruction; forceful inspiratory manoeuvres, however, require more cooperation on the part of the patient and reproducibility is generally less good than for forced expiration. We suggest that a forced expiratory spirogram of the biphasic type illustrated here should raise the possibility of mainstem bronchial narrowing.

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2 Jett JR. The flow-volume loop and main-stem bronchial obstruction [editorial]. *Am Rev Respir Dis* 1988;**138**: 1379–80.
3 Rhodes ML. End inspiratory plateau: flow volume loop in localized bronchial stenosis [abstract]. *Am Rev Respir Dis* 1980;**121** (4, suppl): 182.
4 Gibson GJ. *Clinical tests of respiratory function*. London: Macmillan, 1984:186.
5 Shim C, Corro P, Park SS, Williams MH. Pulmonary function studies in patients with upper airway obstruction. *Am Rev Respir Dis* 1972;**106**:233–8.