UPPER AIRWAY OBSTRUCTION

Y C Chee
Y T Wang
S C Poh

SYNOPSIS

Upper airway obstruction (UAO) is usually silent till the airway obstruction is quite advanced. It can be variable or fixed obstruction, intra- or extra-thoracic in site. This paper introduces flow volume curves, a reproducible noninvasive test, useful in evaluating airway obstruction, both upper and lower but concentrates on UAO by illustrating six cases. Their causes were laryngeal carcinoma, bilateral vocal cord palsy, multinodular goitre, post-tracheostomy stricture, tuberculous tracheal stenosis and lung carcinoma infiltrating the carina and main bronchus.

INTRODUCTION

Dyspnoea is the sensation of breathlessness. The patient is conscious of his increased craving for air relative to his ability to breathe comfortably. Dyspnoea is a symptom common to both cardiac and pulmonary disease. Often the cause may be obvious after clinical evaluation. At other times spirometry and the response to bronchodilators help elucidate the aetiology. However upper airway obstruction is frequently unrecognised and the tracheal shadow on the plain chest radiograph often ignored. Patients with upper airway obstruction may be treated for years as suffering from asthma, chronic bronchitis, emphysema or recurrent pulmonary infections. Correct diagnosis often leads to curative surgery.

Flow volume curves can help elucidate the cause of dyspnoea due to various types of airway abnormalities(1). From October 1980 to December 1982, six cases with abnormal flow volume curves due to upper airway abnormality were detected in the Respiratory Function Laboratory, Tan Tock Seng Hospital. Their cases are analysed.

FLOW VOLUME CURVES

The flow volume curve is useful for differentiating the various types of airway abnormalities which may not be recognised using conventional spirometry. It is a simple reproducible and non-invasive test although when comparing flow volume curves even in the same patient, variation in lung volume may make the two curves incomparable. They represent flow at various lung volumes and are very useful in the diagnosis of upper airway obstruction.

Department of Medicine III
Tan Tock Seng Hospital
Moulmein Road
Singapore 1130

Y C Chee, MBBS, M Med(Int Med), MRCP(UK), AM, Senior Registrar

Y T Wang, MBBS, M Med(Int Med), MRCP(UK), Senior Registrar

S C Poh, MBBS, FRCPE, AM,
Clinical Assoc Professor of Medicine and Head.

The patient exhales to total lung capacity (TLC), then does a forced expiratory vital capacity manoevre. He then inhales as quickly as possible back to TLC. A normal curve is shown (Fig 1).

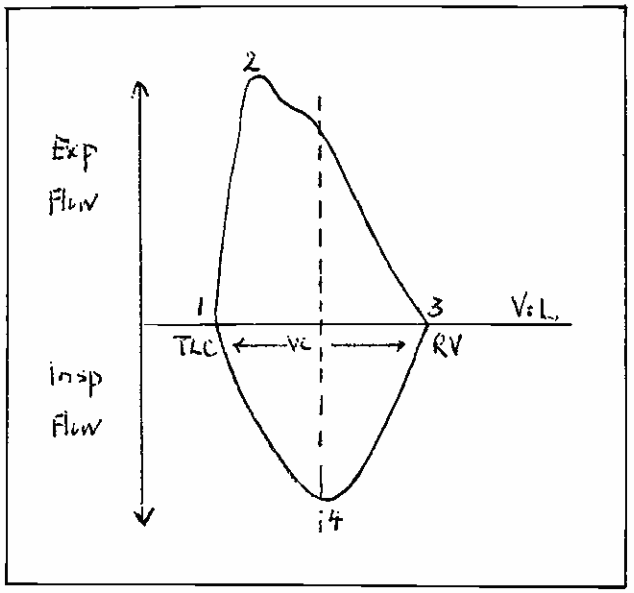

Figure 1.
A normal flow volume curve. RV — residual volume TLC — total lung capacity VC — vital capacity Tracing 123 in expiration and from 341 in inspiration 2 — peak flow rate Stippled line represents 50% of vital capacity

The portion of the expiratory curve in the upper third of the vital capacity (VC) is effort dependent and that in the lower two thirds of VC is effort independent with flow being limited by dynamic compression of airways. At fifty percent of VC, the ratio of expired to inspired flow (the mid-VC ratio of MEF 50 to MIF 50) in normal subjects is about 0.9(2). This ratio is useful in diagnosis. In addition to data derived from the curve, it is important to assess the contour of the curve since many abnormalities produce characteristic changes in the shape of the curve (3,4).

CASE REPORTS

Case 1. A 64 year old woman had thyroid adenomata in the right lobe since the age of 19 years which increased in size recently. She was euthyroid and the nodules were "cold" on radioiodine scanning. A right hemithyroidectomy was performed in November 1980. Histology showed multiple foci of papillary cacinoma so a left hemithyroidectomy was done in February 1981. In October 1981 she had stridor with dyspnoea of three weeks' duration. Her chest X ray showed collapse of the right lower lobe with patchy bronchopneumonia. Stridor was worse at night and she had expiratory and inspiratory rhonichi.

Her flow volume curve (Fig 2) showed flattening of the curve in both inspiratory and expiratory flow. The Ear, Nose and Throat surgeon found bilateral vocal cord palsy with only a small glottic chink of 1 to 1.5 mm and a trickle of abduction of the cords. Her serum calcium and phosphate levels were normal. The severely narrowed airway was only sufficient for the patient at rest and without laryngeal infection. Lateralisation of the vocal cords was the definitive treatment.

Case 2. This was a 56 year old woman with a week's cough whose chest X ray showed a right apical opacity. Tomograms showed tracheal compression and deviation to the left. The thyroid scan showed symmetrical uptake in both lobes with no retrosternal activity. Her flow volume

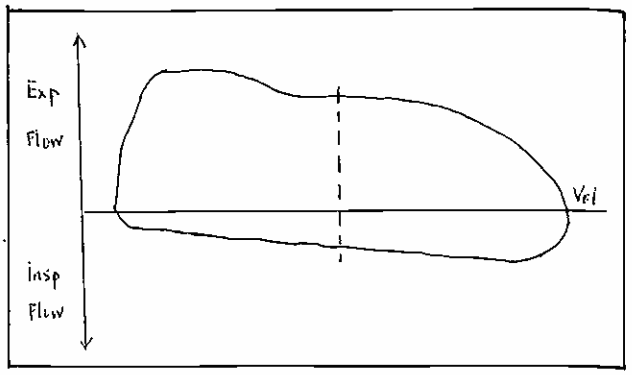

Figure 2.
Flow volume curve of patient with bilateral vocal cord palsy. Mid VC ratio 0.88/0.28 = 3.2

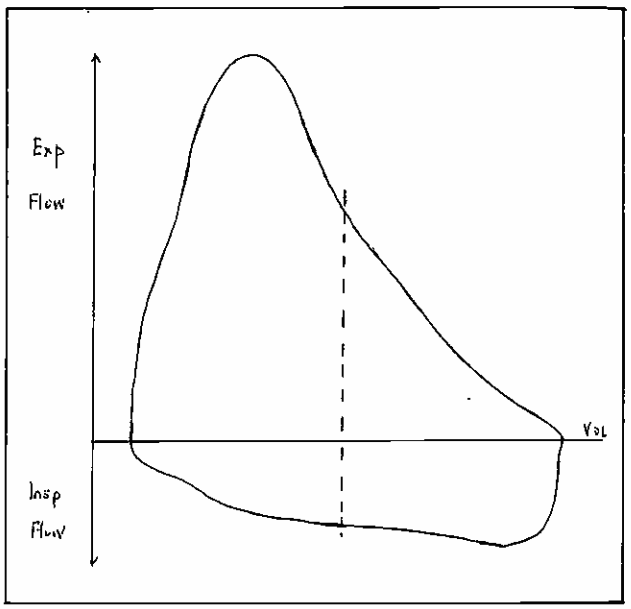

Figure 3.
Flow volume curve of patient with extrathoracic compression by a multinodular goitre.
Mid VC ratio 1.84/0.72 = 2.56

loop (Fig 3) showed a plateau of the inspiratory curve. At operation a multinodular goitre whose lower pole extended into the mediastinum and compressed the trachea was found. A partial thyroidectomy was carried out.

Case 3. This was a 59 year old woman who in 1978 had acute laryngeal obstruction caused by a vocal cord polyp which was removed after an emergency tracheostomy. She now presented with a post-tracheostomy stricture which despite tracheal dilatation still obstructed her upper airway. There was no recurrence of the polyp. Her flow volume curve (Fig 4) showed a plateau of the inspiratory flow curve and the calculated mid VC ratio was 4.17.

Case one, two, and three all had mid VC ratios greater than two. Case 4. A 70 year old woman had difficult and harsh breathing for three weeks. For the previous few months there was effort dyspnoea and haemoptysis. Rhonchi were audible in both lung fields. Her chest X ray (Fig 5a) showed a right paratracheal opacity which on tomography (Fg 5b) was shown to be a large 6 cm by 8cm mass in the right superior mediastinum compressing the trachea at the thoracic inlet. Her flow volume curve (Fig 5c) revealed greater expiratory than inspiratory obstruction. This lesion turned out to be a lung carcinoma.

Case 5. A 23 year old female was seen in June 1982 for cer-

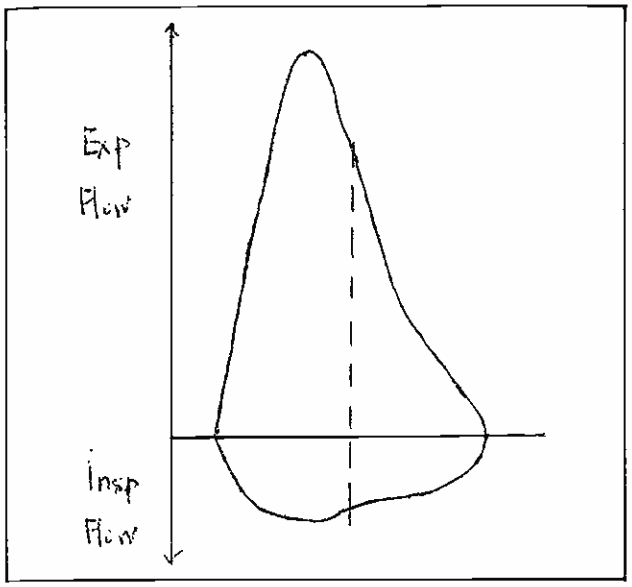

Figure 4.
Flow volume curve of patient with post-tracheostomy structure. Mid VC ratio of 4.17

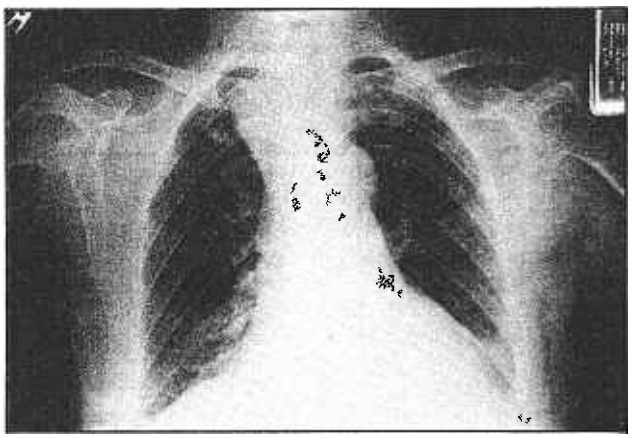

Figure 5a.
Plain chest radiograph showing right paratracheal opacity.

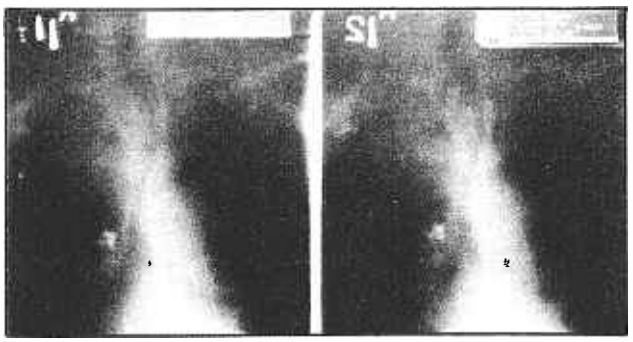

Figure 5b.
Tomogram of chest X ray opacity.

vical lymphadenopathy. Postnasal space biopsy showed nasopharyngeal tuberculosis. Chest x ray showed minimal right upper zone tuberculosis but the laryngeal cultures were positive for Mycobacterium tuberculosis. She was started on standard chemotherapy of streptomychin, ethambutol and isoniazid. In September 1982 she complained of severe dyspnoea and tomogram revealed narrowing of the lower third of the trachea and right main bronchus due to tuberculous infiltration. Her flow volume curve (Fig 6) showed plateaus of both the inspiratory and expiratory curves with a mide VC ratio of 0.6.

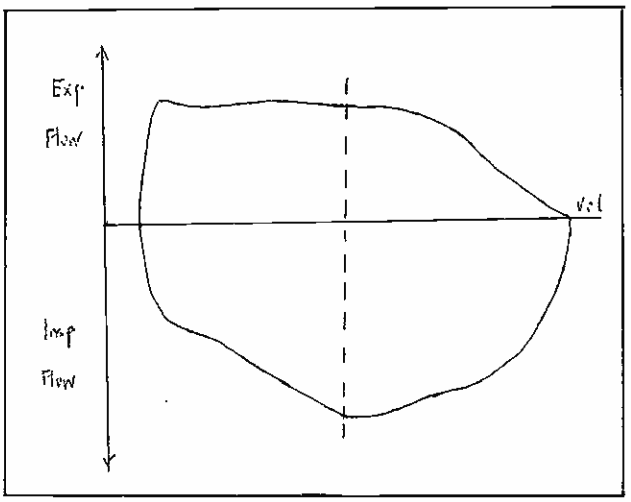

Figure 5C.
Flow volume curve of patient showing intrathoracic obstruction by lung carcinoma.
Mid VC ratio 0.88/1.44 = 0.61

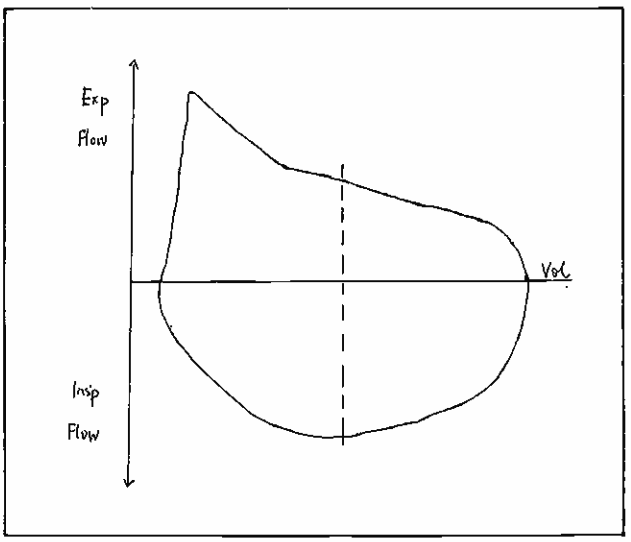

Figure 6.
Flow volume curve of patient with tracheal tuberculosis.
Mid VC ratio 2.25/3.60 = 0.6

Case 6 was a 67 year old Indian man who had laryngeal carcinoma in 1973 for which he received a course of deep X ray therapy. In 1981 he was seen for hoarseness of voice. His flow volume curve (Fig 7) showed almost equal compressions of the inspiratory and expiratory flow curves with a mid VC ratio of 1.06. He had a recurrence of the cancer and underwent laryngectomy followed by deep X ray therapy.

DISCUSSION

For the purpose of pulmonary function tests, the upper airway is taken as that proximal to the carina. This contrasts with the anatomical division of upper and lower respiratory tracts taken arbitrarily at the level of the lower border of the cricoid cartilage(5). Flow volume curves can reflect both upper and lower airway dysfunction when the contours are examined. The six cases here reported only reflect upper airway abnormalities.

Using flow volume loops, upper airway obstruction can be subdivided into three functional groups: (1) fixed obstruction, (2) variable extrathoracic obstruction, and (3) variable intrathoracic obstruction which give curves as

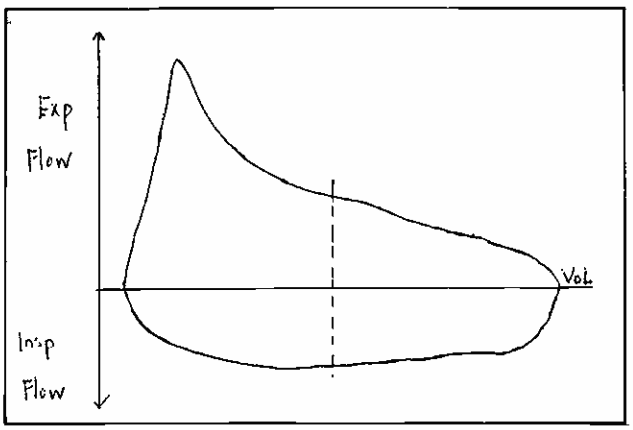

Figure 7.
Flow volume curve of patient with laryngeal carcinoma. Mid VC ration 1.06

shown in Figure 8.

In fixed obstruction, the airway diameter at the site of the lesion does not change in inspiration or expiration. Constant flow represented by a plateau is seen on the expiratory curve in the effort dependent portion near TLC with very little change in the effort independent portion near RV. The inspiratory part of the curve also shows a plateau. In this series, this is represented by case six, a patient with laryngeal carcinoma.

In variable obstruction, the obstruction caused by a lesion changes with the respiratory cycle and can be intra- or extra-thoracic. Three patients gave the pattern of extrathoracic variable obstruction (Fig 8B); case one with vocal cord paralysis, case two with a goitre, and case three with a post-tracheostomy stricture. Other causes of this pattern are scars, cancers, enlarged lymph nodes and fat deposits in and around the trachea (2, 6, 7). During forced inspiration, the pressure within the airway is markedly negative compared to the atmospheric pressure around

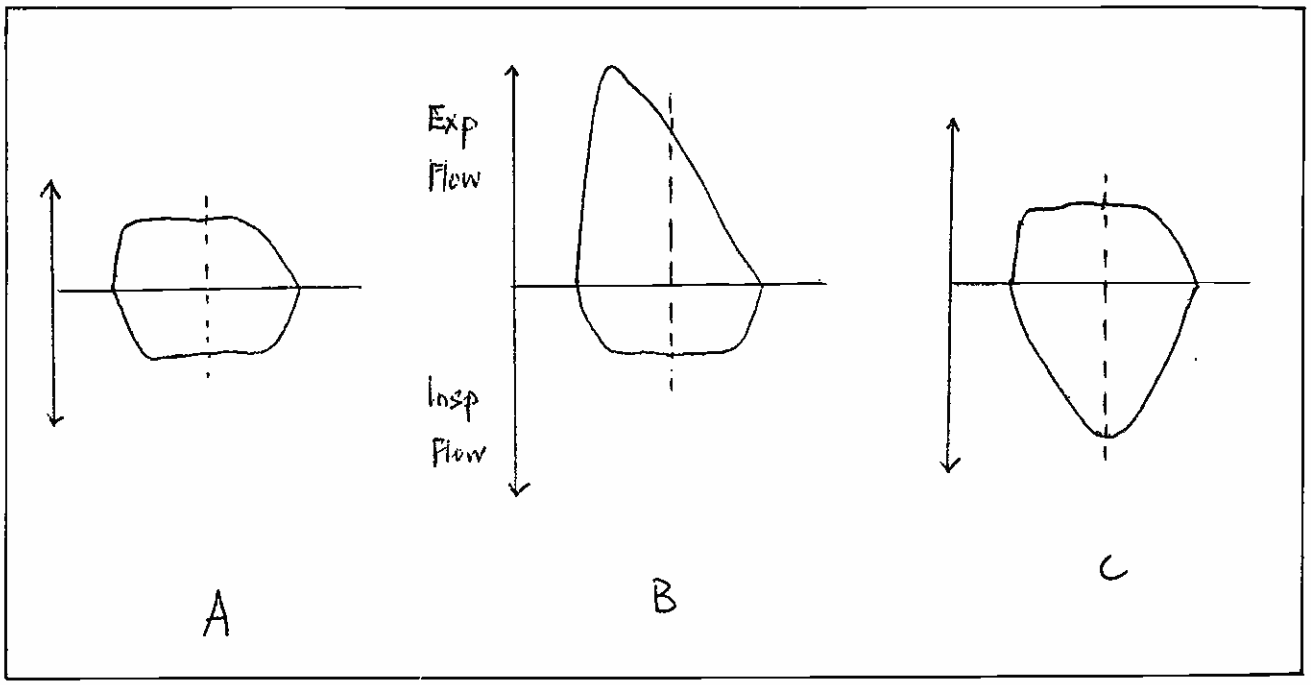

Figure 8.
Maximal flow volume curves in
(A) fixed obstruction (intra- or extra-thoracic)
(B) extrathoracic variable obstruction
(C) intrathoracic variable obstruction

Table I. Summary of the six cases with upper airway obstruction

Case number	Sex	Age (years)	Diagnosis	Mid VC ratio
A. Fixed obstruction				
6	male	67	Laryngeal carcinoma	1.06
B. Extrathoraic variable obstruction				
1	female	64	Bilateral vocal cord palsy	3.20
2	female	56	Multinodular goitre	2.56
3	female	5[illegible]	Post-tracheostomy stricture	4.17
C. Intrathoracic variable obstruction				
4	female	23	Tuberculous tracheal stenosis	0.60
5	female	70	Poorly differentiated carcinoma of lung infiltrating right main bronchus and carina	0.61

the airway. The resultant transmural pressure will tend to decrease the diameter of the airway so that forced inspiration increases the obstruction and a plateau shows on the inspiratory curve. In addition, the Bernoulli effect might cause further dynamic collapse on the alveolar side of the obstruction (8). During forced expiration, marked positive intra-airway pressure will tend to decrease the obstruction so that the expiratory curve tends to be normal. Thus the mid-VC ratio will be greater than two.

Variable intrathoracic obstructions (Fig 8C) are caused mainly by tumours. During forced expiration, pleural pressure is greater than intratracheal pressure thus decreasing the airway diameter and increasing the obstruction; a plateau will be seen on the expiratory flow volume loop. During forced inspiration, the pressure acting around the obstruction is negative so that obstruction is decreased and the inspiratory flow curve may be normal. This decrease in expiratory relative to inspiratory flow causes the mid-VC ratio to be very low. Cases four and five are representative of this pattern.

Once symptoms like inspiratory stridor in extrathoracic obstruction, wheezing and dyspnoea during exercise, posture-dependent dyspnoea, musical-sounding cough or hoarse voice occur, they usually mean the obstruction is quite advanced. Early upper airway obstruction produces few symptoms and is difficult to diagnose.

For definitive treatment, the Ear Nose Throat surgeon had to lateralise the vocal cords in case one to prevent asphyxiation should oedema from any cause e.g. viral infection, totally occlude the airway. Case four who already was on antituberculous therapy and steroids required tracheal dilatation at intervals. Reconstructive tracheal surgery was not possible because of the length of involvement. The elderly lady with poorly differentiated carcinoma infiltrating the carina and right main bronchus had deep X ray therapy. The passage of fibreoptic bronchoscopes through severely narrowed airways is hazardous as they may occlude the airway completely. Biopsy of intractracheal lesions may lead to bleeding which can also asphyxiate the patient. Sometimes the airway is so narrow that endotracheal intubation prior to anaesthesia is very difficult.

When confronted with a patient complaining of dyspnoea and wheezing, asthma is almost too easy a misdiagnosis to make(9). Spirometry values for FEV1/FVC if very low with no reversibility after bronchodilator therapy should alert the phsyician to investigate further especially if the patient were not young. Spirometry tracings of the FEV1 and FVC should be seen and flow volume curves done. Even if a patient had asthma, upper airway obstruction could still be present. Two cases of laryngeal stridor during acute asthma due to apposition of the vocal cords in inspiration with complete closure of the glottic chink have been reported (10, 11).

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