

CLINICAL APPLICATION SERIES

FLOW VOLUME CURVES: CLINICAL SIGNIFICANCE

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Flow volume curve is a graphic plot that provides useful information about lung functions and the relationship between lung volume and maximal rate of airflow. This is achieved during inspiration and expiration using maximum effort against relevant lung volumes. The test is simple, reproducible and objective. Over the past decade, there has been considerable effort to improve the precision of pulmonary function tests (PFT), particularly spirometry and this has been achieved by providing clear methodologic guidelines to maximize precision.

Since, the lung responds differently to many different noxious stimuli, injuries and diseases, there is no single test that is diagnostic of a specific disease (1). Even though Flow-Volume (FV) curve is itself explanatory (2), it should be integrated with the clinical context in order to have any true significance.

With the advent of computer-based electronic pulmonary function test apparatus, FV Curves are readily available in the physicians' office. All of the indications for spirometry apply equally to the FV curves (3). In India, due to lack of information, data and guidelines for interpretation, FV curves are not used by many physicians. Hence physiology, clinical implications and limitations of FV curves are discussed in this review.

Physiology

Flow volume curves involve the following four phases of breathing into a spirometer (4,5).

- i) tidal breathing for several breaths
- ii) maximal inspiratory effort to total lung capacity (TLC)
- iii) maximal expiration to residual volume done as forcefully and as quickly as possible, and
- iv) maximal inspiratory effort to TLC.

The volume is displayed on the horizontal axis and the rate of airflow on the vertical axis (Fig. 1).

The highest flow rates are obtained during the first part of expiration and these are effort dependent, i.e. after approximately 1/3 (25-33%) of vital capacity(1). The linear part of the curve after 1/3 of expiration is called the

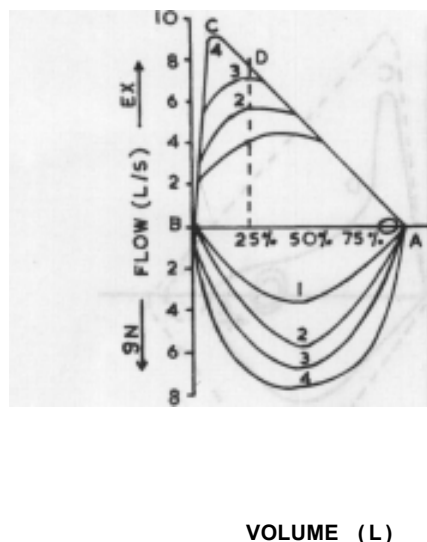


Fig. 1 : Normal flow-volume curve with various inspiratory and expiratory efforts

A : Residual volume, B : Total lung capacity,
AB : Inspiration, BA : Expiration, C : PEFR,
DA : Independent expiratory effort.

effort independent i.e. increase in effort above a certain level will produce no further increase in flow due to the presence of dynamic compression of large airways. Effort dependent portion of the curve is primarily due to the subject's muscular effort rather than on the mechanical characteristics of the lung. The flow rates at lower lung volumes depend on the elastic recoil pressure of lungs and the resistance of the airways upstream or distal to the point at which dynamic compression occurs (6). Changes in this portion (independent) represent changes either in the recoil pressure of the lung or in the resistance of the small airways.

The shape of the flow volume curves gives a clue whether the curves are normal or abnormal. The abnormality can be due to either obstructive or restrictive ventilatory defects. In obstructive ventilatory defect, the level of obstruction i.e., intrathoracic (below 6th tracheal ring) or extrathoracic, fixed or variable and reversibility to bronchodilators can be assessed by FV curves. In restrictive defect, the stage of disease (early or late) may be determined. Flow volume curves depend on the density of gas (1,7,8). 80% of helium and 20% O₂ have been advocated not only to detect early or mild airway obstruc-

tion but also provide a physiologic basis for locating the site of airway obstruction.

Interpretations

Obstructive Ventilatory Defect

a) Peripheral Obstructive Flow Volume curves are recorded in diseases such as asthma, chronic bronchitis and emphysema (Fig.2).

There is a reduction in the peak flow rate but the most characteristic feature is the curvilinear shape (up-

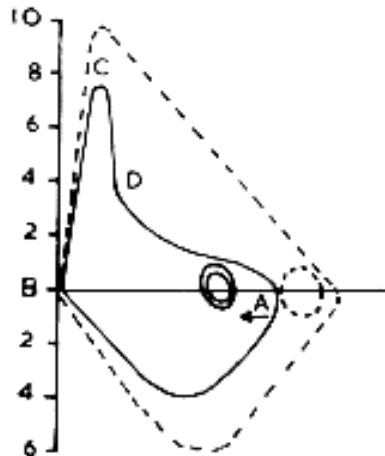


Fig. 2 : Flow volume curve in peripheral airways obstruction C; Reduced PEFR, CD : Period of high flow, CA : Curvilinear shape. Arrow : Tidal volume loop moving towards vital capacity.

ward concavity) of descending limb of curve (1,9). It is probably due to abrupt emptying of large central airways associated with vigorous exhalation that causes these airways to collapse and generate a brief period of high flow. This loss of linearity is related to the severity of the obstruction as well as the type of disease.

When the tidal volume loop is superimposed on the flow-volume curve, comparison of the two may be useful in clinical evaluation (1). The difference between flow during tidal breathing and flow during maximal efforts is a measure of pulmonary reserve with respect to airflow. As the severity of airflow obstruction increases, the expiratory flow during the two manoeuvres becomes superimposed initially at low lung volumes and as the disease becomes more severe, they get superimposed at higher lung volumes.

b) Major central obstructive flow volume curves :

The inspiratory portion of the maximal flow volume curve is more sensitive to major central airways obstruction than the expiratory limb. It has great diagnostic usefulness when central airways obstruction is suspected, a situation in which ordinary spirometry reveals a nonspecific pattern. Some cases of stridor may be

mistaken for wheeze arising from within the chest and in such circumstances, the first indication towards the correct diagnosis may be obtained from the following features of FV curves.

i) Fixed upper airway obstruction (Fig.3): Both the inspiratory and expiratory limbs are truncated. The shape is quite characteristic with more or less equal restriction of both inspiratory and expiratory flow rates (9-11).

ii) Intrathoracic variable obstruction (Fig.3): Obstruction at expiration. Expiratory limb is flattened and inspiratory limb is normal (9-11).

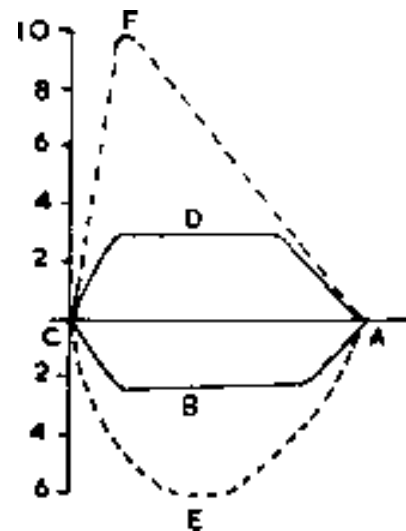


Fig. 3 :

Flow volume curves In central airways obstruction :
Curve ABC - CDA = Fixed obstruction
Curve AEC - CDA = Intrathoracic variable obstruction
Curve ABC - CFA = Extrathoracic variable obstruction

iii) Extra thoracic variable obstruction (Fig.3): Obstruction at inspiratory phase. Inspiratory limb is flattened and expiratory limb is normal (9-11).

Restrictive Ventilatory Defect

Any disease which decreases the lung expansion either by chest wall diseases or by space occupying lesion in the pleural cavity or lung causes restrictive type of abnormality (1,5,7).

The Fig.4 shows the restrictive type where curve 'C' is normal. In early interstitial lung disease (curve a) even before lung volumes are decreased, the FV curves usually show super maximal expiratory airflow associated with a steep descending limb of the curve (due to increase in lung elastic recoil) and the curve becomes tall and narrow or vertically oriented with respect to the volume axis. In severe reduction of lung volumes (curve

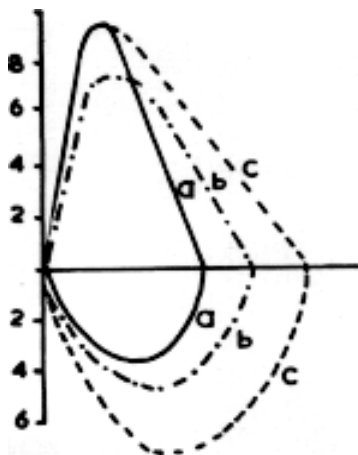


Fig. 4 : Flow volume curve in restrictive airways disease a : early stage of restrictive type, b : late stage of restrictive type, c: normal curve

b), the FV curve may maintain a relatively normal shape but appears miniaturized in all directions.

Mixed Ventilatory Defects

This is a combination of both obstructive and restrictive abnormalities (5,7). Both curvilinear and miniature shapes are seen in these situations, e.g. pneumoconiosis (Fig.5).

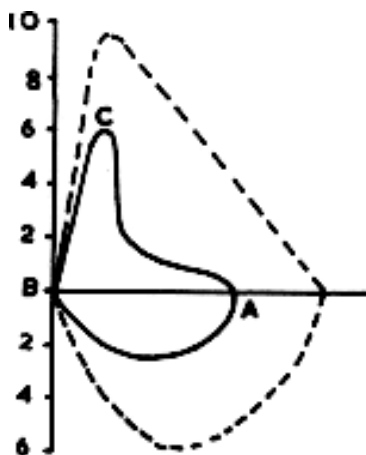


Fig. 5 : Flow volume curve in mixed airways disease (miniature and curvilinear shapes)

Limitations

Because each person's flow volume curve is different and also because disease or drugs may produce changes in the size and shape of the curve, it is extremely difficult to compare flow volume curves between individuals or even within the same individual on different occasions (8). Any form of comparison of flow vol-

ume curve is difficult, although various techniques have been proposed, such measurements from FV curves cannot be routinely recommended for use in lung function laboratories. But the shape of FV curves gives extremely useful information with regard to identification of the cause of airway obstruction and detection of early changes. Lung function studies should be used independently, but should be interpreted in conjunction with other clinical parameters. The variability of the curves at low lung volumes has made it difficult to interpret individual curves even in studies with large population.

Summary

Pulmonary function tests including flow-volume curves are now an essential part of clinical practice as any function tests of other organ systems. But pulmonary function has to be supplemented with other diagnostic procedures. Pulmonary function indicates only how disease has altered the function of lungs. They cannot make a specific pathologic diagnosis and they can reveal alterations only when the lesion disturbs function sufficiently in order to detect the deviation from normal values. Therefore pulmonary function tests supplement a good history, physical examination, radiologic, bacteriologic, bronchoscopic and pathologic studies in arriving at an achievable diagnosis.

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