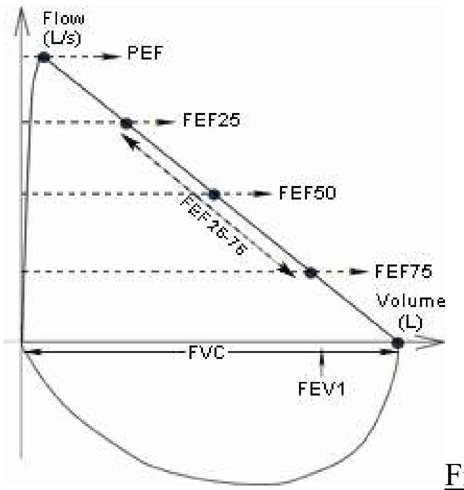
Determination of Flow-Volume loop



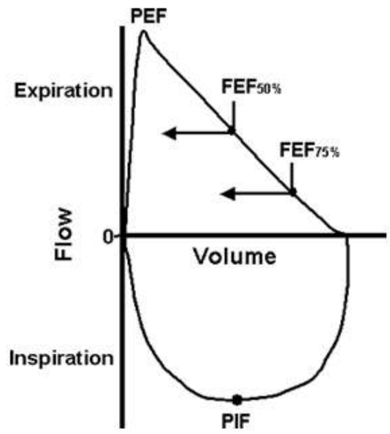


Fig. 1, Fig. 2

Flow-Volume (F-V) loop is the most important curve in spirometry.
A normal F-V loop (Fig. 1, Fig. 2) begins on the X-axis (Volume axis): at the start of the test both flow and volume are equal to zero. Directly after this starting point the curve rapidly mounts to a peak: Peak Expiratory Flow (**PEF**). If the test is performed correctly, this PEF is attained within the first 150 ms of the test. PEF is a measure for the air expired from the large upper airways (trachea-bronchi).
After the PEF the curve descends (i.e. the flow diminishes) as more air is expired. After 25% of the total expired volume, the parameter **FEF_{25}** is reached. Halfway the curve (when the patient has expired half of the volume) the **FEF_{50}** is reached: Forced Expiratory Flow at 50% of the FVC. After 75% the parameter **FEF_{75}** is reached.
The mean flow between the points FEF_{25} and FEF_{75} (**FEF_{25-75})** is very sensitive indicator of small airways narrowing. This is actually the first parameter that will decline in many respiratory diseases.
When the flow reaches zero, the **FVC** is reached (Force Vital Capacity): the patient has blown out as much air as he can.
Thus, the first ***ascending part of F-V loop*** links the maximum TLC and the value of PEF. It depends on the expiratory effort, the velocity and the force of the expiratory muscle contraction, on the lung elastic recoil and the patency of central airways.
The second ***descending part of F-V curve*** links the value of PEF and the value of residual volume. It is relatively effort-independent and it reflects the peripheral airway resistance and lung elastic recoil.

After completion of forced expiration, it is recommended that the patient makes a complete and forced inspiration (with Peak Inspiratory Flow, **PIF**), but the test can be interpreted without this as well.
Inspiratory part of F-V curve depends on airway resistance and strength of inspiratory muscles. It is less influenced by airway obstruction than expiratory flow, its reduction indicates airway obstruction from extrathoracic reasons.

Basic parameters:

VC (vital capacity): maximum volume of air exhaled or inspired during maximally forced (FVC) or slow (VC) manoeuvre, VC is normally equal to FVC unless airflow obstruction is present, in which case VC is usually higher than FVC

FEV_1 (forced expiratory volume in 1 second): volume expired in the first second of maximal expiration after a maximal inspiration and indicates how quickly full lungs can be emptied

FEV_1/FVC: gives a clinically useful index of airflow limitation

FEF_{25-75}: average expired flow over the middle half of the FVC manoeuvre, more sensitive indicator of small airways narrowing than FEV_1, but difficult to interpret if the VC (or FVC) is reduced or increased

FEF_{50} and **FEF_{75}** (forced expiratory flow at 50% or 75% FVC): maximal expiratory flow measured at the point where 50% or 75% of the FVC has been expired (FEF_{50}, FEF_{75})

PEF (peak expiratory flow): maximal expiratory flow rate achieved (8-14 L/s)

MEF_{25} (maximum expiratory flow at 25% VC): maximum expiratory flow at 25 % of vital capacity (1.5-2.5 L/s)

MEF_{50} (maximum expiratory flow at 50% VC): maximum expiratory flow at 50 % of vital capacity (3.5-5.5 L/s)

MEF_{75} (maximum expiratory flow at 75% VC): maximum expiratory flow at 75 % of vital capacity (4.5-8.5 L/s)

FVC_6 (forced expiratory volume during the first 6 seconds): alternative of FVC, expiratory manoeuvre after 6 s is easier to perform for patients with airflow obstruction and the elderly

$Area_{ex}$, **$Area_{in}$** (area of expiratory resp. inspiratory part of the F-V curve)

PIF (peak inspiratory flow): maximum flow of inspired air

MIF_{25} (maximum inspiratory flow at 25% VC): maximum inspiratory flow at 25 % of VC

MIF_{50} (maximum inspiratory flow at 50% VC): maximum inspiratory flow at 50 % of VC

MIF_{75} (maximum inspiratory flow at 75% VC): maximum inspiratory flow at 75 % of VC

MIF_{50}/MEF_{50} (maximum inspiratory:expiratory flow at 50% VC)

Shape of F-V varies considerably between different lung diseases (Fig. 3, Fig. 4):

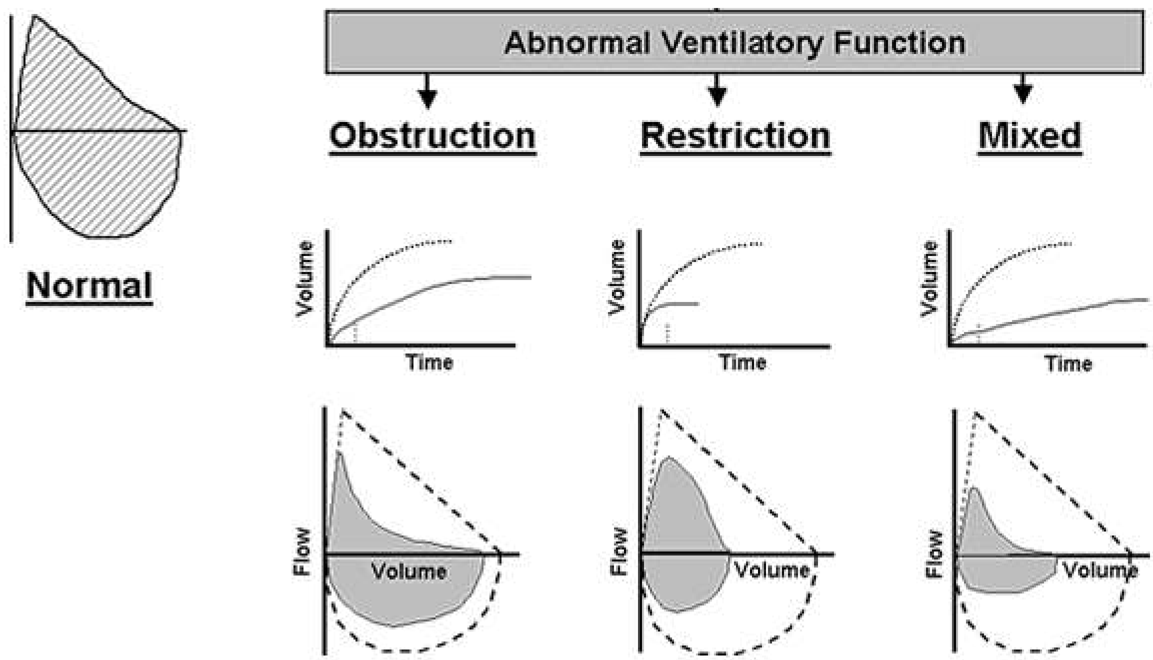


Fig. 3.

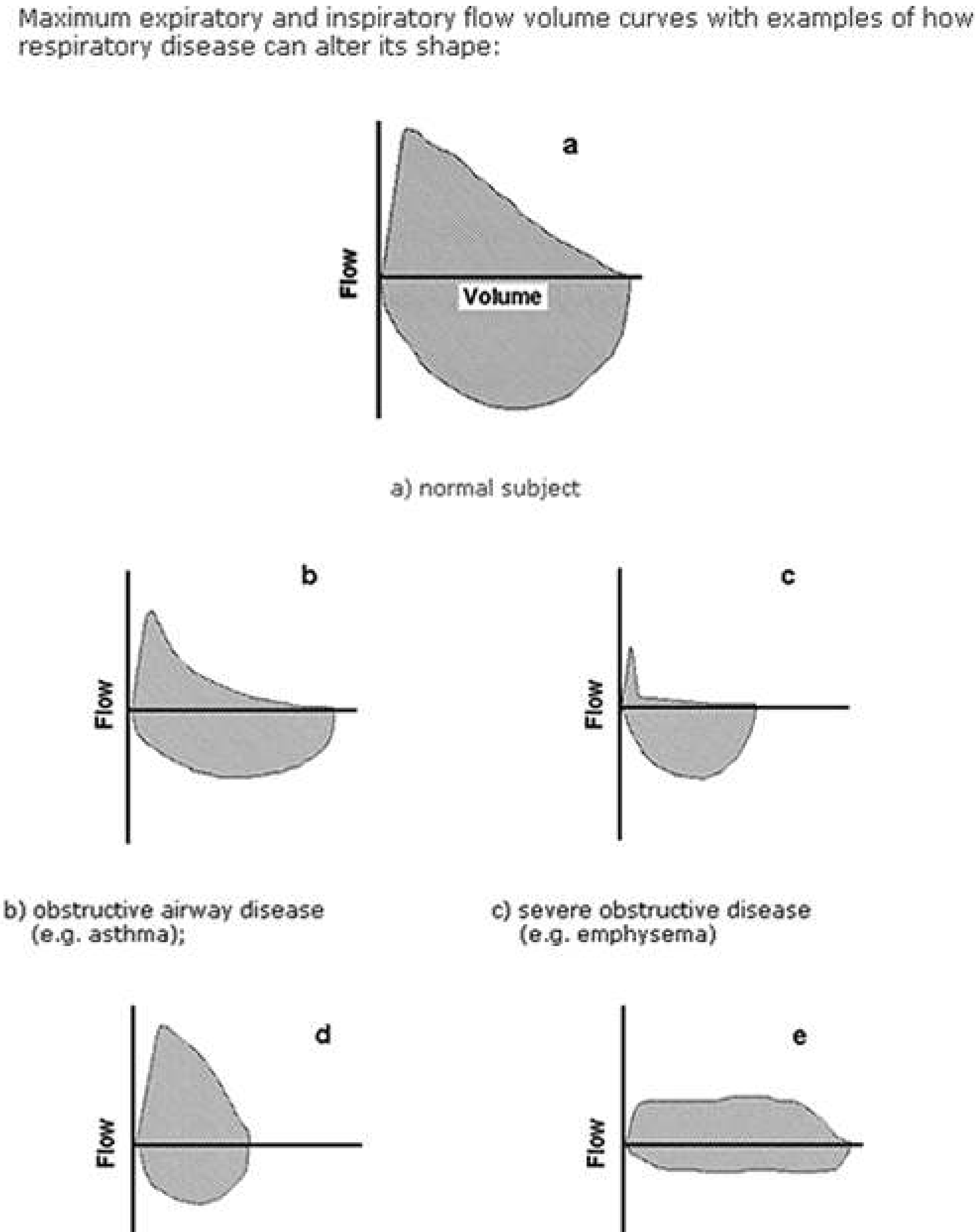


Fig. 4. Maximum expiratory and inspiratory flow volume curves with examples of how respiratory disease can alter its shape.

The shape of the expiratory flow-volume curve varies between obstructive ventilatory defects where maximal flow rates are diminished and the expiratory curve is scooped out or concave to the x-axis, and restrictive diseases where flows may be increased in relation to lung volume (convex). A "tail" on the expiratory curve as residual volume is approached is suggestive of obstruction in the small peripheral airways. Examination of the shape of the flow-volume curve can help to distinguish different disease states, but note that the inspiratory curve is effort-dependent. For example, a plateau of inspiratory flow may result from a floppy extra-thoracic airway, whereas both inspiratory and expiratory flow are truncated for fixed lesions. Expiratory flows alone are reduced for intra-thoracic obstruction.