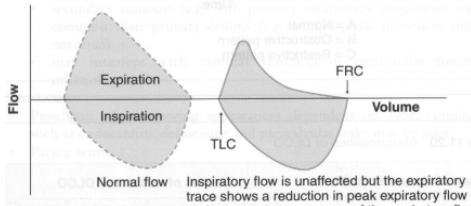
respiratory function tests

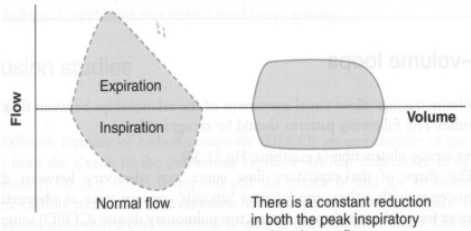
flow-volume loops

lower airway obstruction (eg asthma):
- asthma produces a smooth concave trace as obstruction is more fixed; whereas, COPD sometimes shows an 'angled' appearance due to a more sudden forced end-expiratory collapse



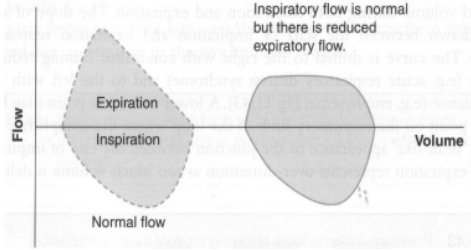
Normal flow — Inspiratory flow is unaffected but the expiratory trace shows a reduction in peak expiratory flow and a concave appearance of the expiratory flow trace. The total lung capacity (TLC) and functional residual capacity (FRC) will also be increased.

fixed upper airway obstruction (eg tracheal stenosis):



Normal flow — There is a constant reduction in both the peak inspiratory and expiratory flows.

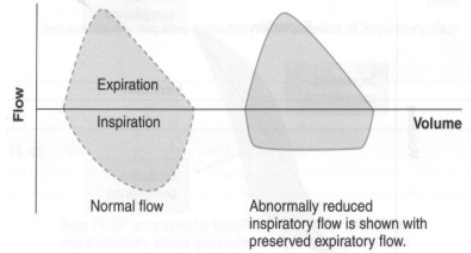
variable intrathoracic upper airway obstruction (eg tumour in the lower trachea):
- normal inspiratory flow with a constant reduction in expiratory flow



Inspiratory flow is normal but there is reduced expiratory flow.

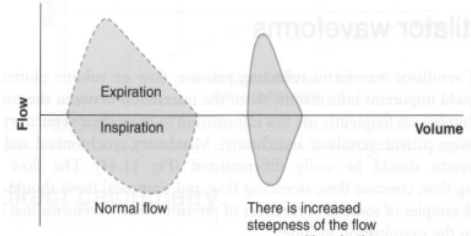
Normal flow

variable extrathoracic upper airway obstruction (eg vocal cord paralysis)
- normal expiratory flow with a constant reduction in inspiratory flow



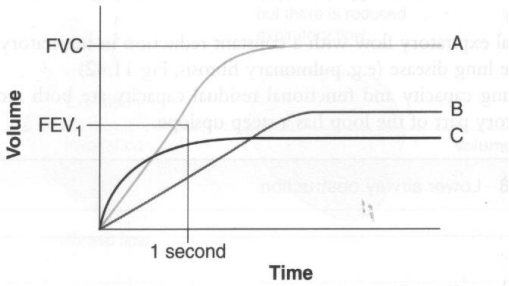
Normal flow — Abnormally reduced inspiratory flow is shown with preserved expiratory flow.

restrictive lung disease (eg pulmonary fibrosis)
- total lung capacity and FRC are both reduced and the expiratory part of the loop has a steep upslope



Normal flow — There is increased steepness of the flow curves, with reductions in both TLC and FRC.

spirometry



A = Normal
B = Obstructive pattern
C = Restrictive pattern

- forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC) and the ratio of FEV1/FVC are the primary measurements

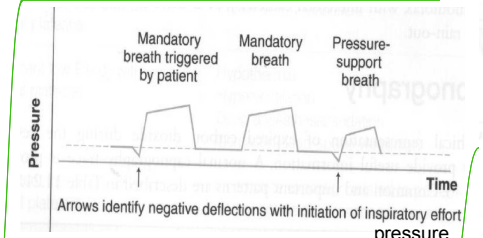
abnormalities of DLCO

Causes of increased DLCO	Causes of decreased DLCO
Pulmonary haemorrhage	Interstitial lung diseases
Polycythaemia	Emphysema
Asthma	Congestive cardiac failure
Early congestive cardiac failure	Pulmonary vascular diseases (e.g. emboli)
Left to right intracardiac shunt	Severe anaemia
Severe obesity	Increased carboxyhaemoglobin
High altitude	Hypothyroidism
Exercise just prior to the session	Hypothermia
Hyperthyroidism	

- the diffusion capacity of carbon monoxide assesses the transfer of gas from the alveoli to the pulmonary capillaries. A low concentration of CO is inspired and the breath is held for 10 seconds. The expired CO concentration is measured and the difference between the inspired and expired concentrations is used to calculate the DLCO

ventilator waveforms

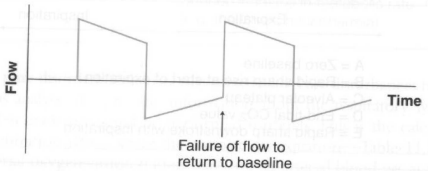
Pressure-time waveform showing SIMV plus pressure support



Arrows identify negative deflections with initiation of inspiratory effort

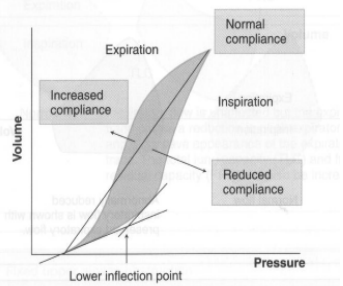
Flow-time waveform in a patient with auto-PEEP

Auto PEEP is caused by trapping of gas in the airways at end-expiration, which generates a positive pressure—this is reflected as a failure of expiratory flow to return to basline prior to onset of the next breath.



Failure of flow to return to baseline

pressure volume loop



- a graphical representation of the relationship between pressure and volume during inspiration and expiration
- the slope of an imaginary line drawn between the start of inspiration and expiration represents lung compliance
- the curve is shifted to the right with conditions causing reduced lung compliance (eg ARDS) & to the left with increased lung compliance (eg empysema)
- a lower inflection point on the inspiratory limb of the loop where the compliance suddenly increases may be recognised
- a 'beak-like' appearance to the junction between the end of inspiration and the start of expiration represents over-distension as too much volume is delivered

Other examples of abnormal ventilator waveforms include:
(i) circuit leaks - the baseline of the pressure-time waveform drifts down
(ii) cardiac oscillations - the baseline of the pressure-time waveform shows slight up and down movement with heartbeat; these may trigger breaths
(iii) inadequate inspiratory flow rate - on the pressure-time waveform there will be a 'scooped-out' appearance to the synchronised breaths