BIOM9420

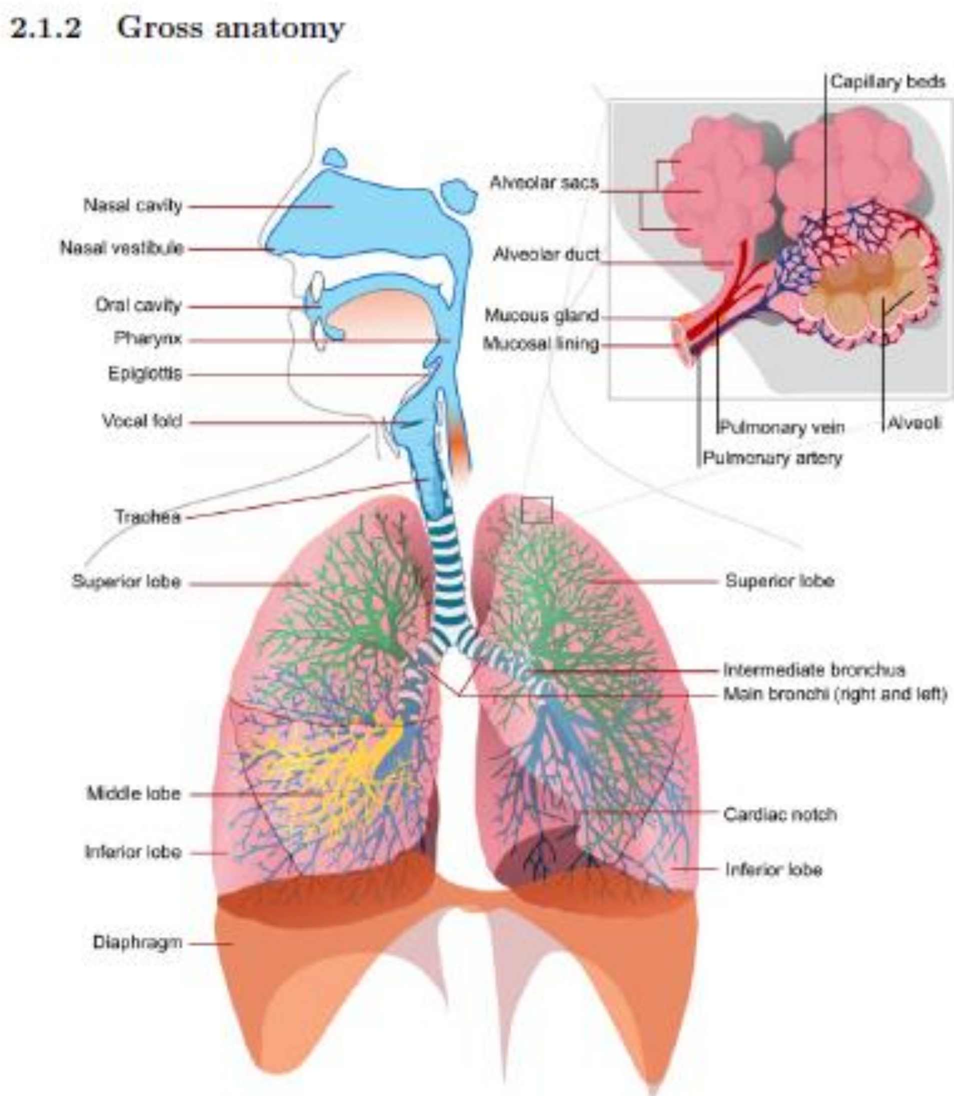
Clinical Laboratory Science

MECHANICAL : PULMONARY FUNCTION

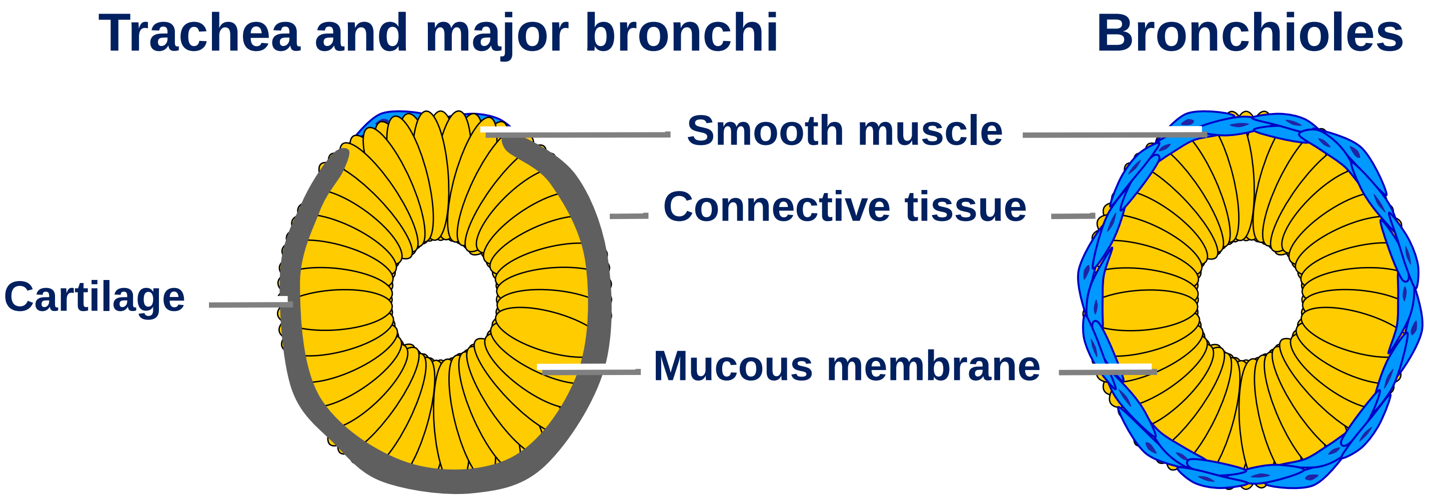
PROF JOHN WHTELOCK

j.whitelock@unsw.edu.au

Pulmonary system



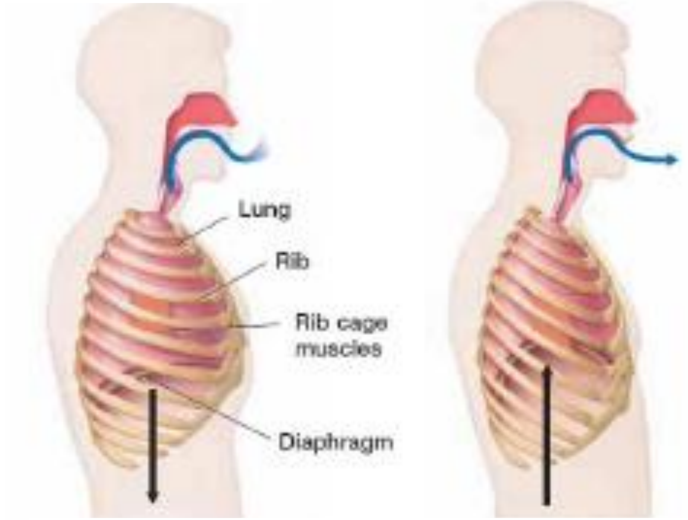
Anatomy of the airways



Breathe in, breathe out

- Inhalation – when the diaphragm contracts, it moves down and air rushes in.
- Exhalation. The diaphragm relaxes, it moves up and it forces air out.

Inhalation **Exhalation**



What do pulmonary function tests tell us?

- How much air volume can be moved in and out of the lungs
- How fast the air in the lungs can be moved in and out
- How stiff are the lungs and chest wall
- The diffusion characteristics of the membrane through which the gas moves (determined by special tests).
- How the lungs respond to chest physical therapy procedures

PFT are specially helpful for patients who are :

- older than 60-65 years of age
- known to have pulmonary disease
- Pathologically obese
- have a history of smoking, cough or wheezing
- under anesthesia for a lengthy period of time
- undergoing an abdominal or a thoracic operation

Variables that impact values of PFT

- **<u>Age:</u>** aging ↓ lung elasticity→ smaller lung volume &capacities.
- **<u>Gender:</u>** volumes & capacities in ♂ > ♀.
- **<u>Body height & size:</u>** ↑
- **<u>Race:</u>** Hispanics,& native Americans differ from Caucasians.

Purpose of pulmonary function tests (PFTs)

- Symptomatic disease – cough, etc
- Screen for early, asymptomatic disease
- Prognostication of known disease
- Monitoring known diseases

- **Obstructive lung disease**
- **Restrictive lung disease**

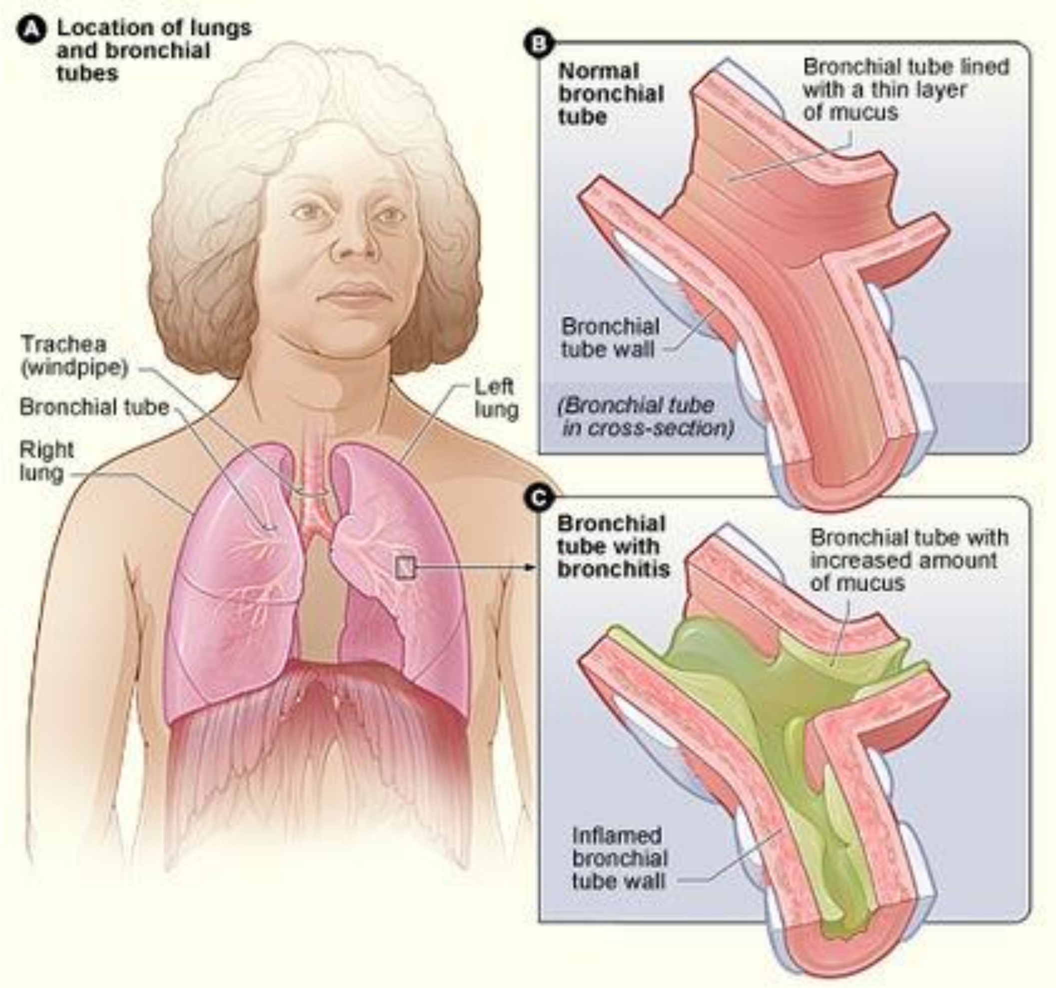
Obstructive lung disease

- Narrowing of the airways
  - Inflammation
  - Swelling
- Material inside the bronchial passageways physically obstructing the flow of air (tumours, foreign object, mucus)
- Destruction of lung tissue
- External compression of the airways

- Characterised by a limitation of expiratory airflow so that airways cannot empty as rapidly as compared to normal.

Obstructive lung disease

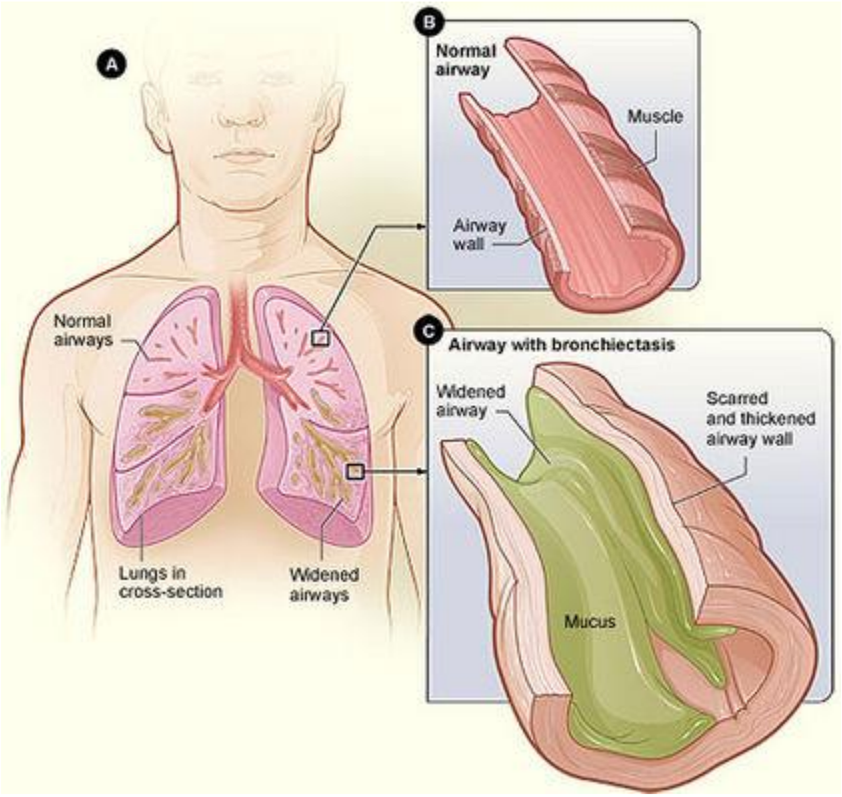
- Chronic bronchitis
- Emphysema (chronic bronchitis),



Obstructive lung disease

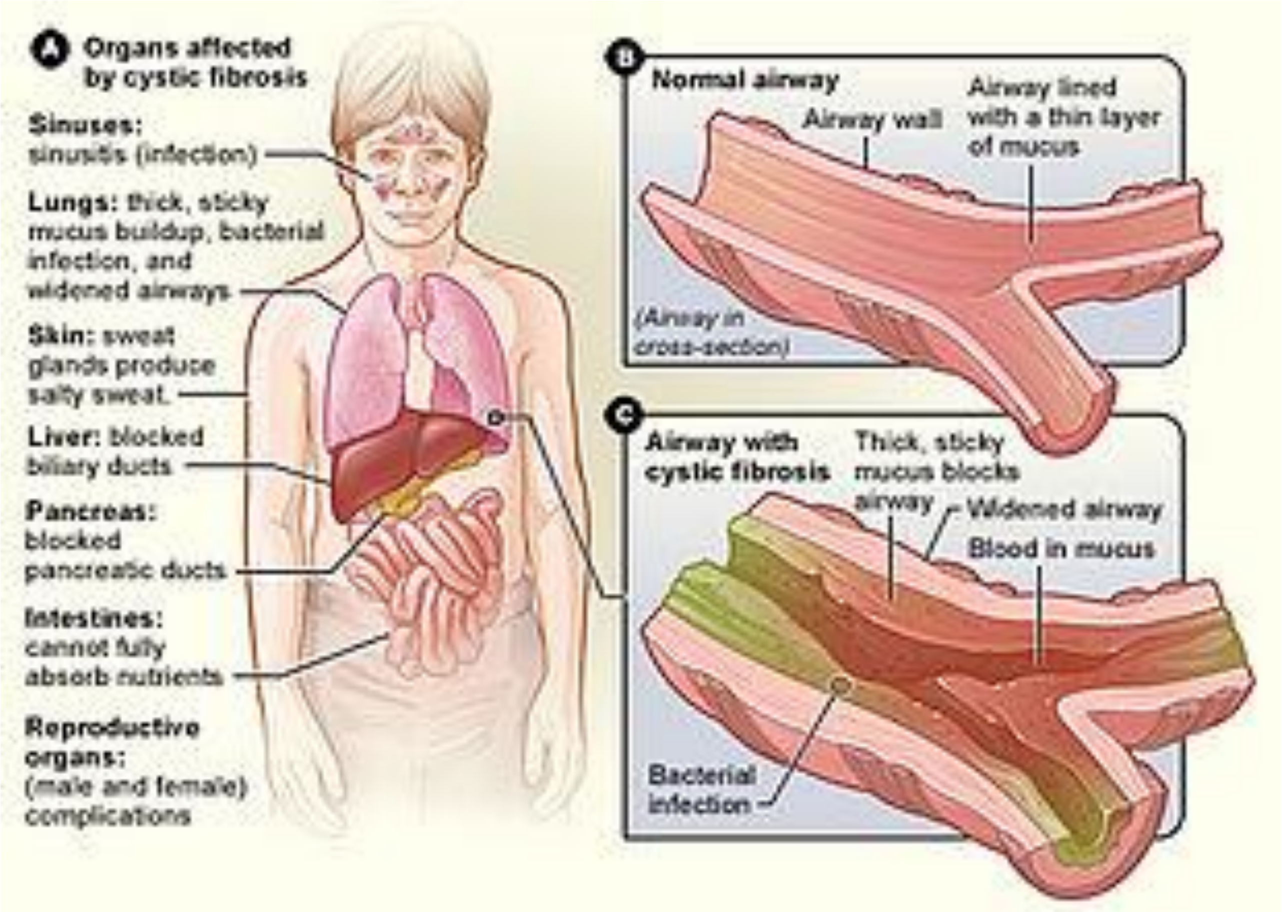
- Asthma,
  - long term inflammation of the airways.
  - Reversible airflow obstruction
  - Bronchospasm

- Bronchiectasis
  - enlargement of airways
  - scarring of airway walls



Obstructive lung disease

- Cystic fibrosis
  - enlargement of airways
  - mucus build up



Restrictive lung disease

- Makes it more difficult to get air into the lungs.
- They “restrict” inspiration.

- Interstitial lung disease
  - Pulmonary fibrosis – scarring of the airway walls leads to thickening of the walls.
  - Sarcoidosis – accumulation of inflammatory cells that form lumps

- Chest wall pathology
  - Kyphosis (roundback)
  - Scoliosis (spine curvature)

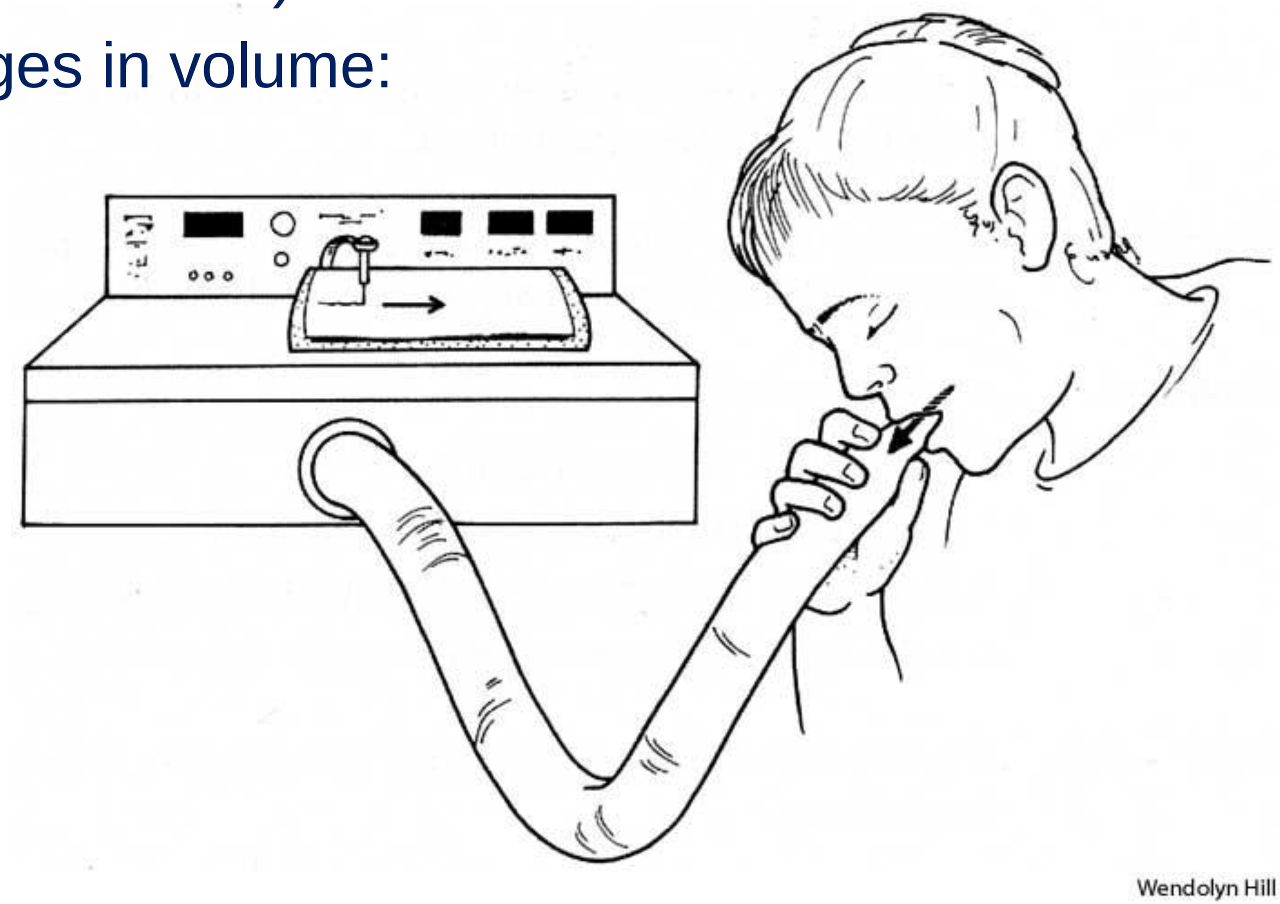
- Obesity

Restrictive lung disease

- Neuromuscular disease
  - Amyotrophic lateral sclerosis (motor neuron disease)
    - Death of neurons that control voluntary muscles.
  - Muscular dystrophy
    - progressive skeletal muscle weakness, defects in muscle proteins, and the death of muscle cells and tissue

Spirometry

- Most common instrument.
- Spirometers with electronic signal outputs also measure flow (volume per unit time).
- Measures changes in volume:



Spirometry measurements

- Vital capacity called forced vital capacity (FVC). After the deepest possible breath, this is the volume of air which can be forcibly and maximally exhaled out of the lungs until no more can be expired.

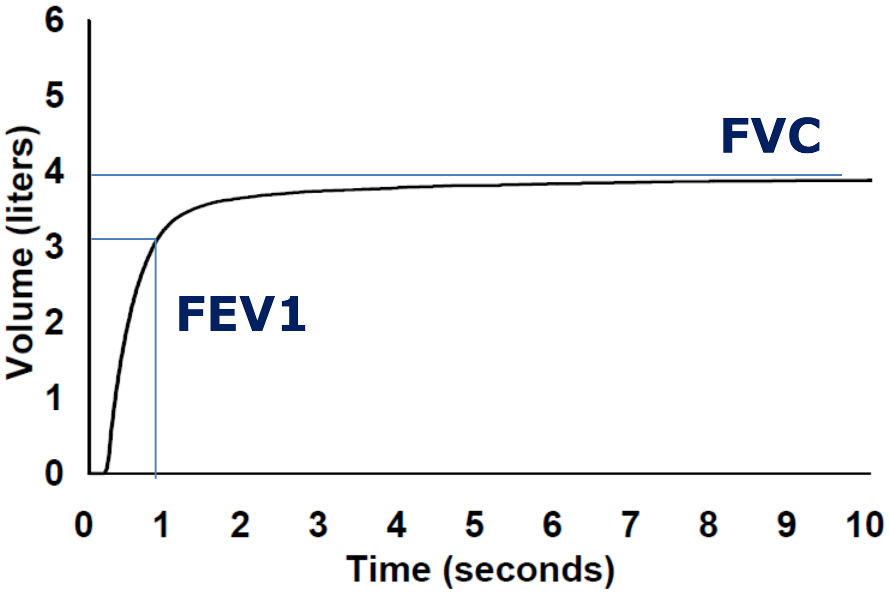
- Forced expiratory volume in 1 second (FEV1). The volume of air which can be forcibly exhaled from the lungs in the first second of a forced expiratory manoeuver.

- FEV1/FVC - FEV1 Percent (FEV1%) – Ratio of FEV1 to FVC - indicates what percentage of the total FVC was expelled from the lungs during the first second of forced exhalation.

- Peak expiratory flow rate (PEFR) – is the maximum speed of expiration.

Spirometry

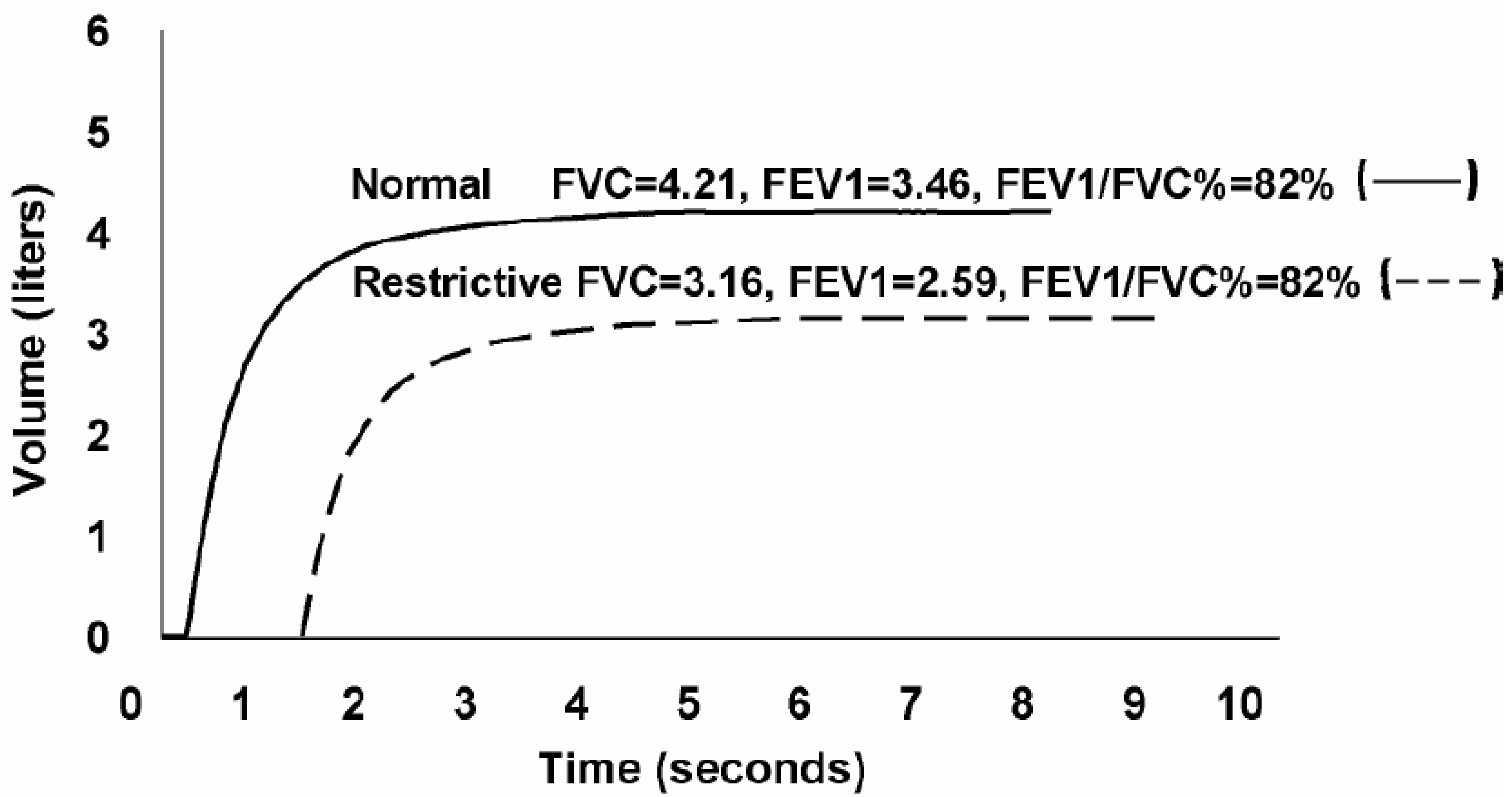
- *Spirometry measures the volume of air an individual inhales or exhales as a function of time.*
- Volume displacement spirometers measure : FVC, FEV1
- When the subject breathes into a mouthpiece, the air moves a cylinder, a plastic bell or a diaphragm, which in turn moves a pen that traces a curve on a moving paper graph.



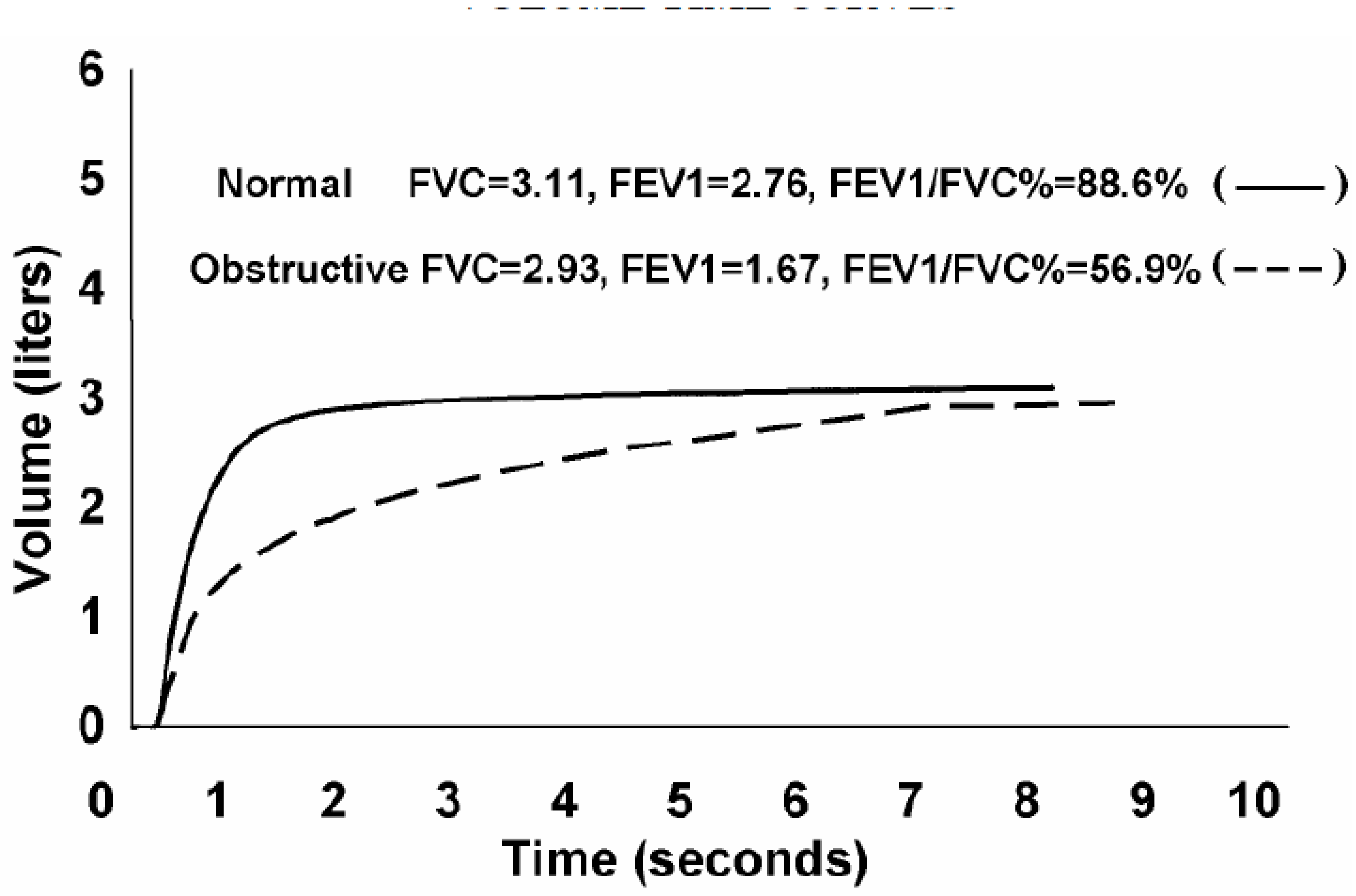
Volume spirometers

- Plots volume (L) versus time.
- Not always portable
- Operate under a variety of environmental conditions
- Need additional electronic circuitry to produce flow/volume curves and loops.
- Long term calibration
- Coughs and submaximal efforts are not as obvious as they are on flow/volume tracings.
- Prone to harbouring mould or bacteria.

Restrictive

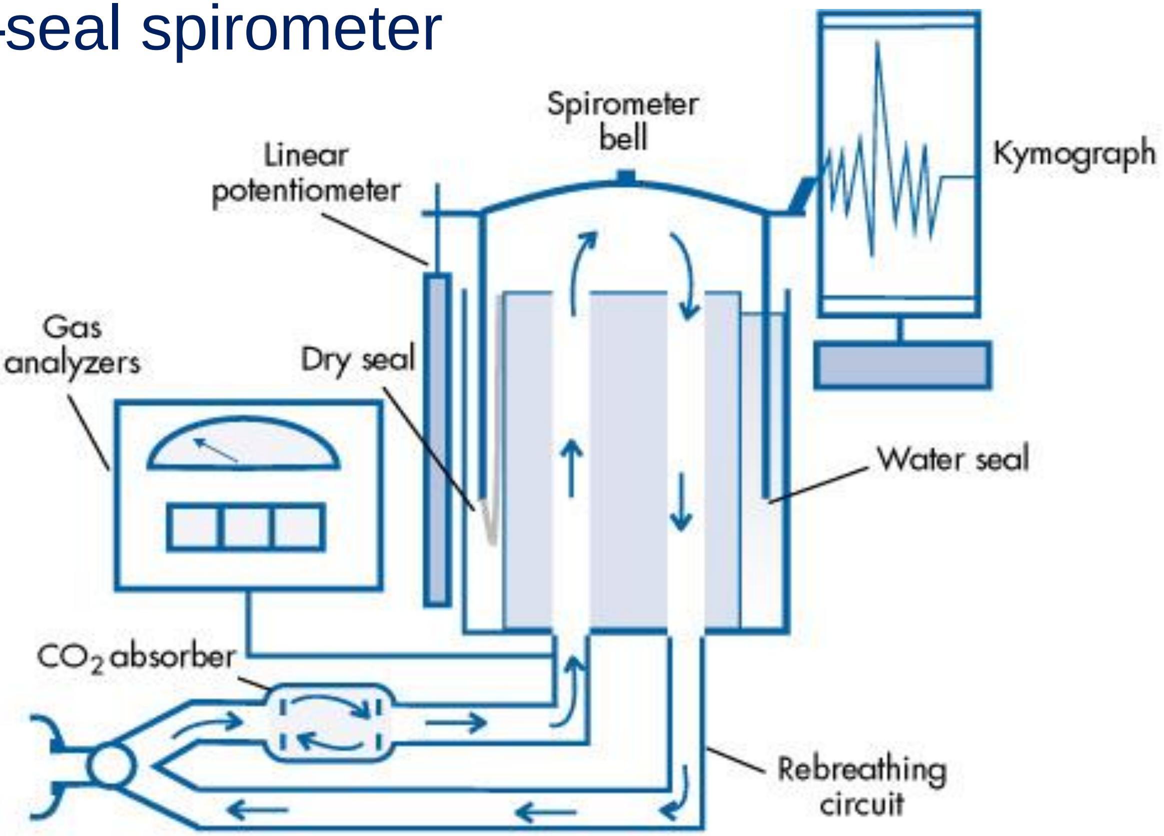


Obstructive



Volume displacement spirometers

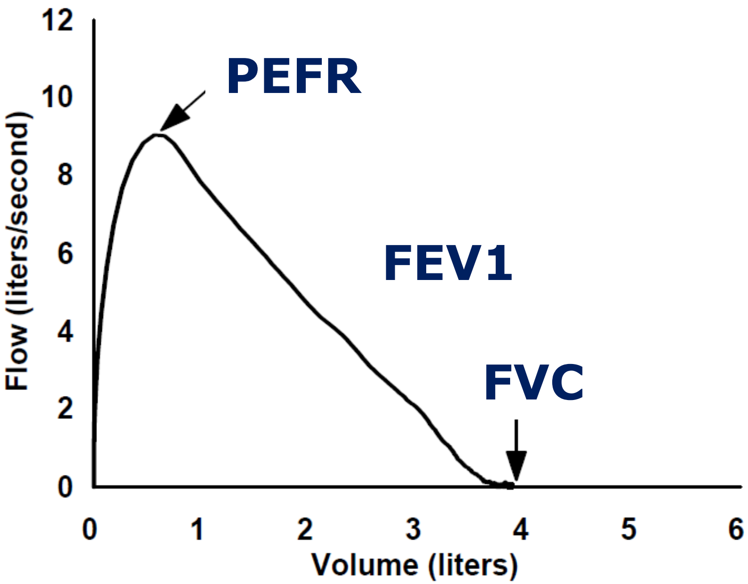
- Water –seal spirometer



Breath pushes the bell that displaces a pen that records the trace on moving paper. Also shown is a CO_2 absorber and a gas analyser.

Spirometry

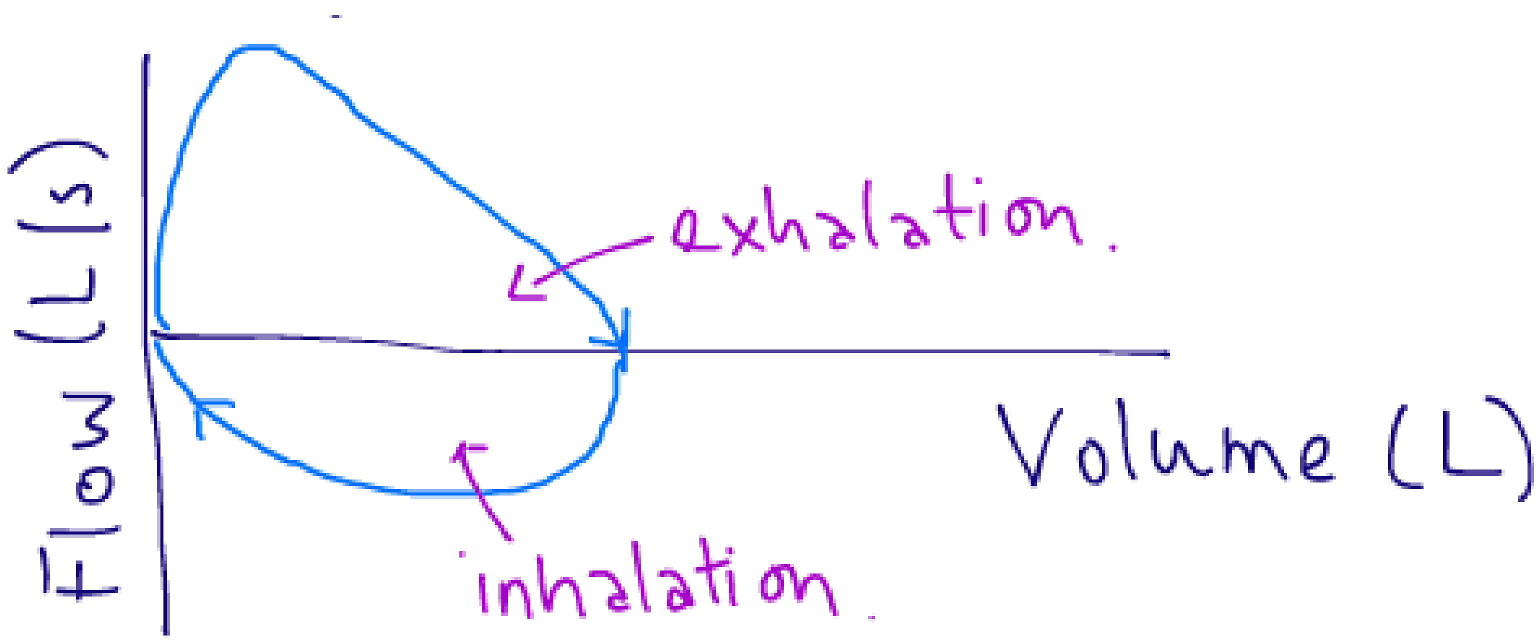
- *Spirometry measures the volume of air an individual inhales or exhales as a function of time.*
- Flow volume spirometers measure : FVC, FEV1, peak expiratory flow rate (PEFR)



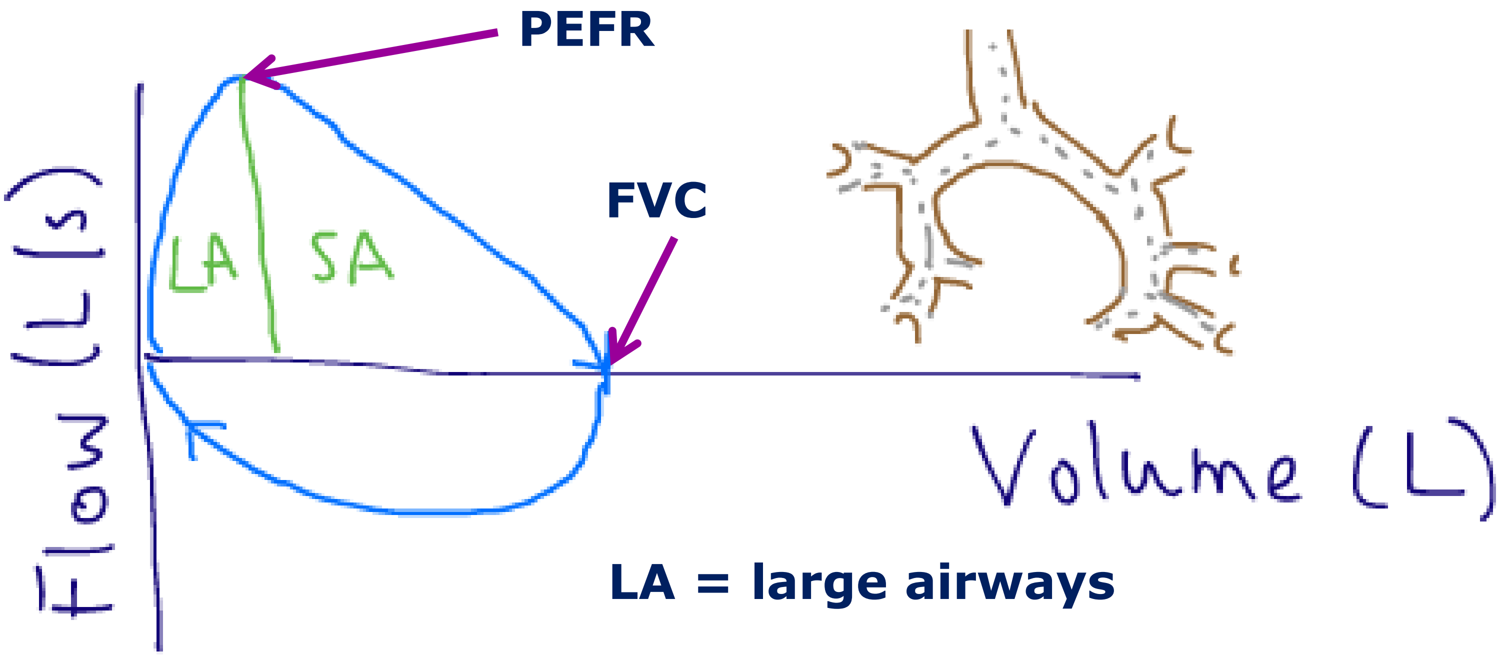
Flow/volume spirometers

- Measure how quickly air flows past a detector
- Trace plots air flow in L/s against volume in L.
- Derive volume by electronic means.
- PEFR and instantaneous flow at any given volume can be determined.
- Easy to detect coughs or submaximal effort or artefacts
- Provide information about inhalation as well as exhalation.
- Lighter and more portable than volume spirometers
- Disposable, single-use flow sensors available to eliminate cross-contamination.
- FEV1 cannot be calculated unless the time is indicated in seconds on a flow-volume tracing.

Flow volume loop



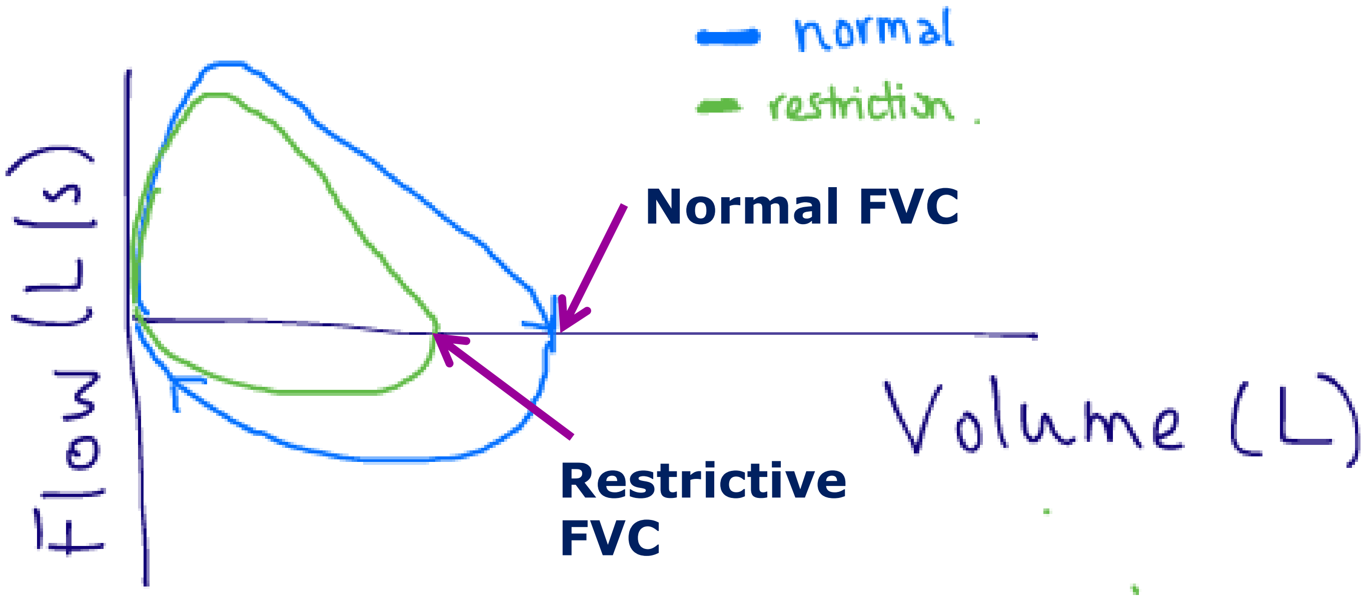
Flow volume loop



LA = large airways

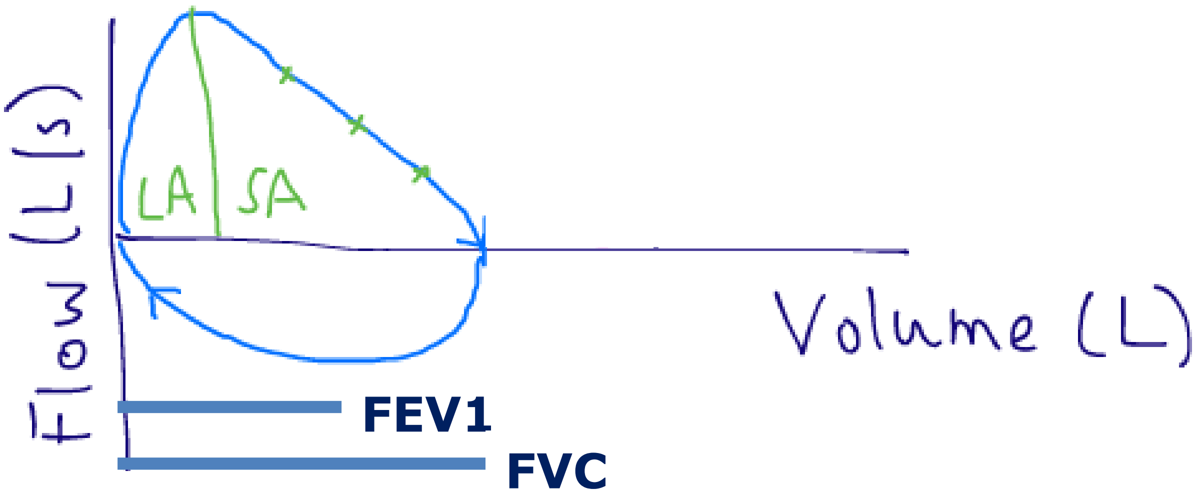
SA = small airways

Flow volume loop



Reduced FVC in restrictive lung disease

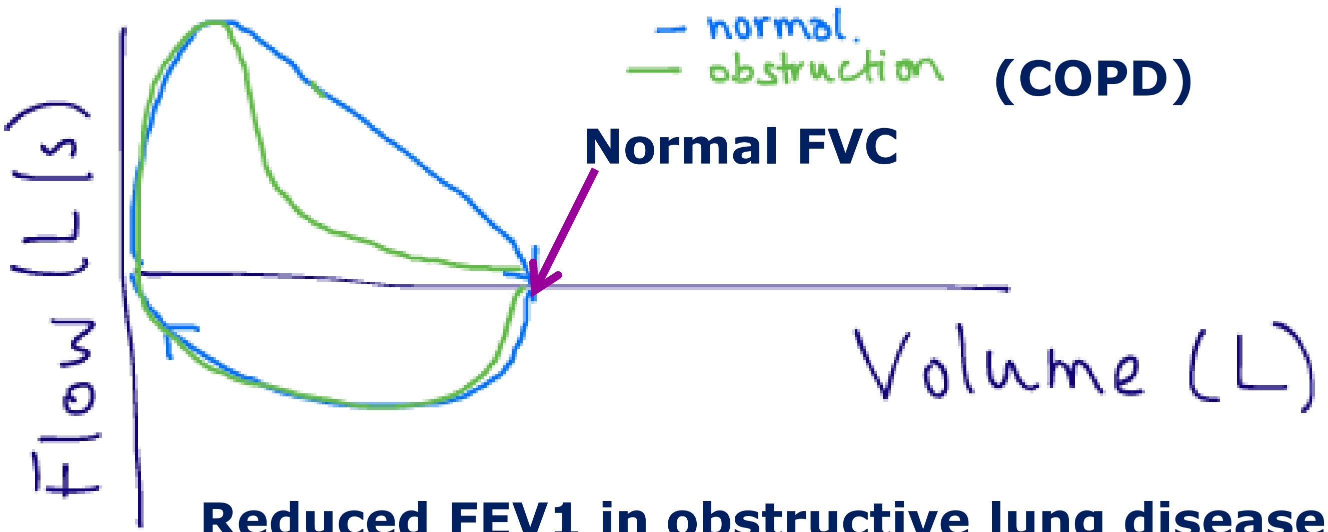
Forced expiratory volume in 1 second



FEV1/FVC interpretation

80 % or higher = normal
79 % or lower = abnormal
70 % or lower = obstruction

Flow volume loop



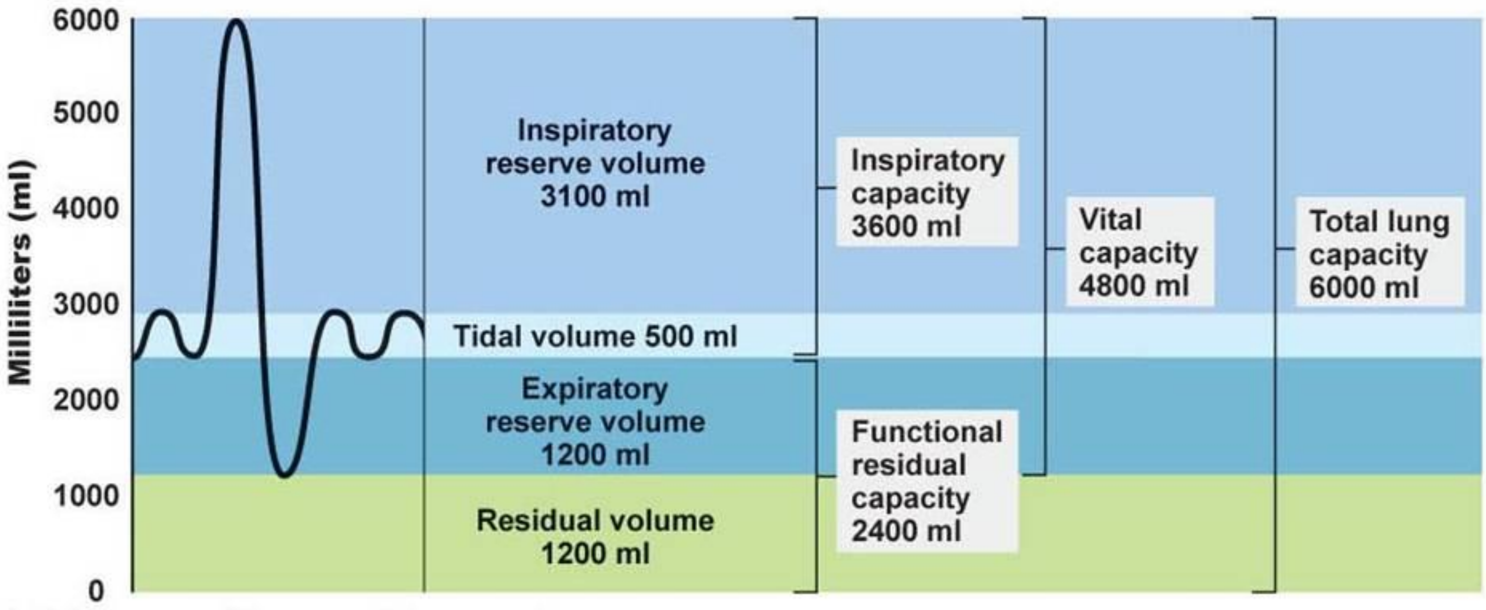
(COPD)

Normal FVC

Reduced FEV1 in obstructive lung disease

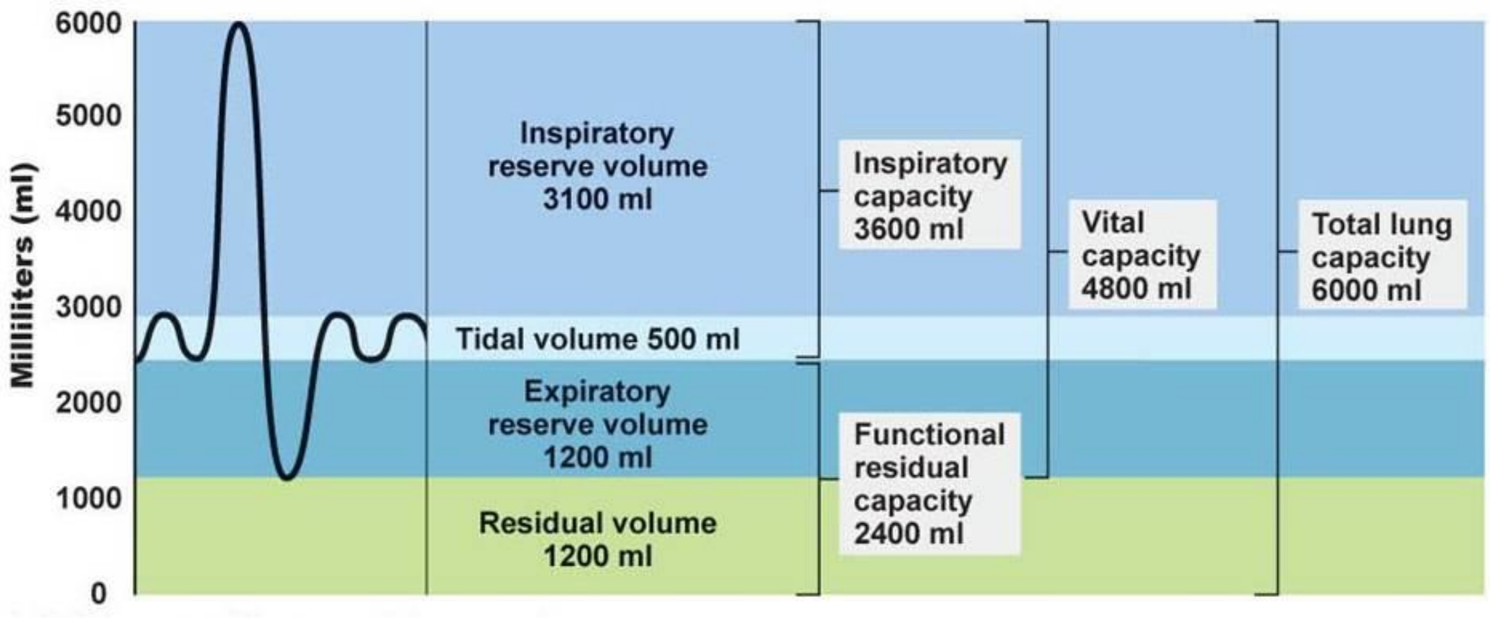
Lung volumes

- Tidal volume (TV) = volume of gas inspired or expired with each normal breath.
- Inspiratory reserve volume (IRV) = maximum volume of additional air that can be inspired from the end of a normal inspiration.
- Expiratory reserve volume (ERV) = maximum volume of additional air that can be expired from the end of a normal expiration.
- Residual volume (RV) = volume of air remaining in the lung after a maximal expiration. Cannot be measured by spirometry.



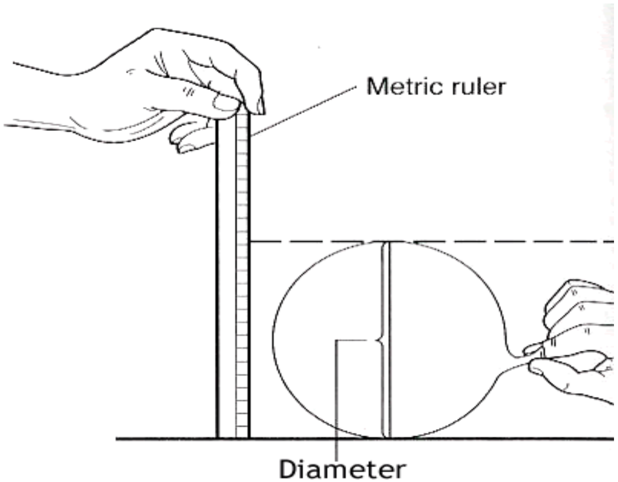
Lung volumes

- Inspiratory capacity (IC) = maximum volume of air that can be inspired from the end of expiratory position.
- Functional residual capacity (FRC) = volume of air remaining in the lung at the end of a normal expiration.
- Vital capacity (VC) = maximum volume of air that can be forcefully expelled from the lungs following a maximal inspiration.
- Total lung capacity (TLC) = volume of air contained in the lungs.



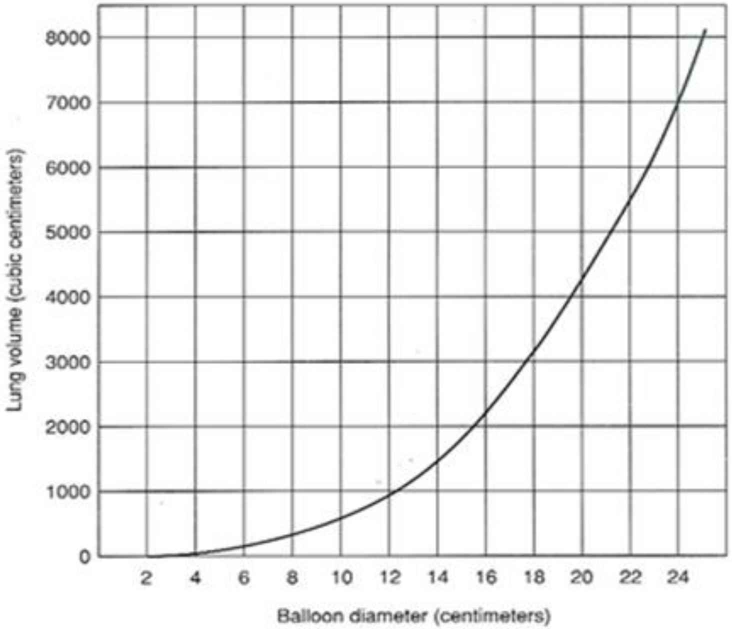
Lung capacity demonstration

1. **Tidal Volume**: Take in a normal breath. Exhale into the balloon only as much air as you would normally exhale. DO NOT force your breathing. Pinch the balloon to prevent air from escaping and measure the diameter of the balloon. Deflate the balloon and repeat the measurement.
2. **Expiratory Reserve**: Exhale normally. Then, exhale into the balloon as much air as possible. Measure and record the diameter of the balloon.
3. **Vital Capacity**: Take as deep a breath as possible. Then exhale all the air you can into the balloon. Measure and record the diameter of the balloon.



Lung capacity demonstration

	Balloon Diameter (cm)			Lung Volume (cm^3)		
	Tidal Volume	Expiratory Reserve	Vital Capacity	Tidal Volume	Expiratory Reserve	Vital Capacity



Spirometry interpretation

	Obstructive	Restrictive
FVC	Decreased or Normal	Decreased
FEV1	Decreased	Decreased
FEV1/FVC	Decreased	Normal or increased

- Interpretation of % predicted FVC
  - 80 – 120% normal
  - 70-79% mild reduction
  - 50-69 % moderate reduction
  - <50% severe reduction

- Interpretation of % predicted FEV1
  - >75 % normal
  - 60-75% mild obstruction
  - 50-59% moderate obstruction
  - <49% severe obstruction

- Interpretation of % predicted FEV1/FVC
  - 80 or higher = normal
  - 79 or lower = abnormal

Examples

	Predicted Values for Tom	Measured Values for Tom	% Predicted for Tom
FVC	6 L	4 L	67 %
FEV1	5 L	2 L	40 %
FEV1/FVC	38 %	50 %	60 %
Diagnosis			

	Predicted Values for Mary	Measured Values for Mary	% Predicted for Mary
FVC	5.7 L	4.43L	78%
FEV1	4.9 L	3.52 L	72%
FEV1/FVC	84%	79%	94%
Diagnosis			

Examples

	Predicted Values for Mia	Measured Values for Mia	% Predicted for Mia
FVC	5.04 L	5.98 L	119%
FEV1	4.11 L	4.98 L	121%
FEV1/FVC	82%	83%	96%
Diagnosis	[redacted]		[redacted]

	Predicted Values for Ben	Measured Values for Ben	% Predicted for Ben
FVC	3.20 L	2.48 L	77%
FEV1	2.51 L	2.19 L	87%
FEV1/FVC	78 %	88%	115%
Diagnosis	[redacted]		[redacted]

More PFTs - Bed side

1. Sabrasez breath holding test:

Ask the patient to take a full but not too deep breath & hold it as long as possible.

> 25 seconds = normal Cardiopulmonary Reserve (CPR)

15-25 seconds = limited CPR

<15 seconds = very poor CPR

25- 30 SEC - 3500 ml VC

20 – 25 SEC - 3000 ml VC

15 - 20 SEC - 2500 ml VC

10 - 15 SEC - 2000 ml VC

5 - 10 SEC - 1500 ml VC

Bed side PFT

2. Snider's match blowing test:

Measures maximum breathing capacity. Ask to blow a match stick from a distance of 15 cm with

- Mouth wide open
- Chin rested/supported
- Lips not pursed
- No head movement
- No air movement in the room
- Mouth and match at the same level

Cannot blow out a match, FEV1 < 1.6L

Able to blow out a match, FEV1 > 1.6L

Bed side PFT

3. Forced expiratory time (FET).

After deep breath, exhale maximally and forcefully and keep stethoscope over trachea and listen.

Normal FET	3 – 5 seconds
Obstructive lung disease	> 6 seconds

Restrictive lung disease < 3 seconds

Bed side PFT

- Wright peak flow meter.
  - Air flow moves needle along the gauge.
  - Measures peak expiratory flow rate
  - Normal males 450 – 700 L/min
  - Normal Females 350 – 500 L/min
  - < 200 L/min = inadequate cough efficiency.

Movie time…

http://youtu.be/M4C8EInOMOI
http://youtu.be/JFUu-pn7Qtg