PULMONARY FUNCTION TESTS

Dr. T. Rajavardhan

Definition

- Pulmonary function tests are a group of procedures that measure the function of the lungs, revealing problems in the way a patient breathes. The tests can determine the cause of shortness of breath and may help confirm lung diseases, such as asthma, bronchitis or emphysema. The tests also are performed before any major lung surgery to make sure the person won't be disabled by having a reduced lung capacity.

Pulmonary test can assess

- The amount of air moving in & out of lungs
- Speed with which it is moving in and out
- Diffusion characteristics of the membrane through which gas moves

DESCRIPTION

- Spirometry
- Flow Volume Loop
- Bronchodilator response
- Lung volumes
- Diffusion capacity (DLCO)
- Bronchoprovocation testing

VOLUMES

TEST	DESCIPTION	NORMAL VALUE
1) Tidal volume	Vol of air breathed in and out during normal quiet breathing	500 ml
2) Minute volume of respiration	Total air taken in during one min	6000 ml/min
3) Residual volume	Vol remaining after maximal expiration	1200 ml

4) Inspiratory reserve volume	Air breathed in by max inspiratory effort	3600 ml
5) Expiratory reserve volume	Air breathed out by max expiratory effort	1200 ml

LUNG CAPACITIES

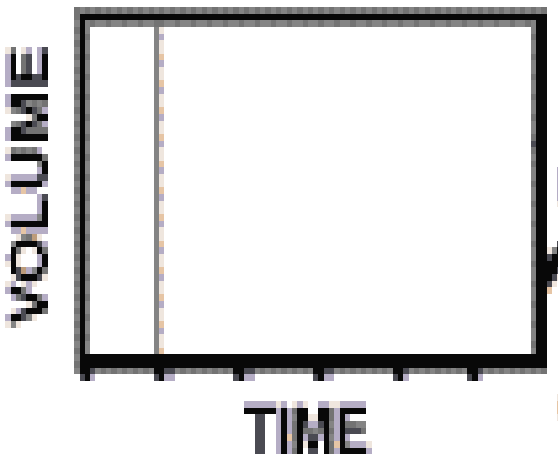
TEST	DESCIPTION	NORMAL VALUE
1) Inspiratory capacity	Tidal vol + inspiratory reserve vol	3600 ml
2) Vital capacity	Inspiratory reserve vol + tidal vol + expiratory reserve vol	4800 ml
3) Total lung capacity	Sum of all vol	6000 ml
4) Forced vital capacity(FVC)	Max vol exhaled with max effort	4800 ml
5) Forced expiratory volume(FEV)	Amt of air exhaled after max inspiration	

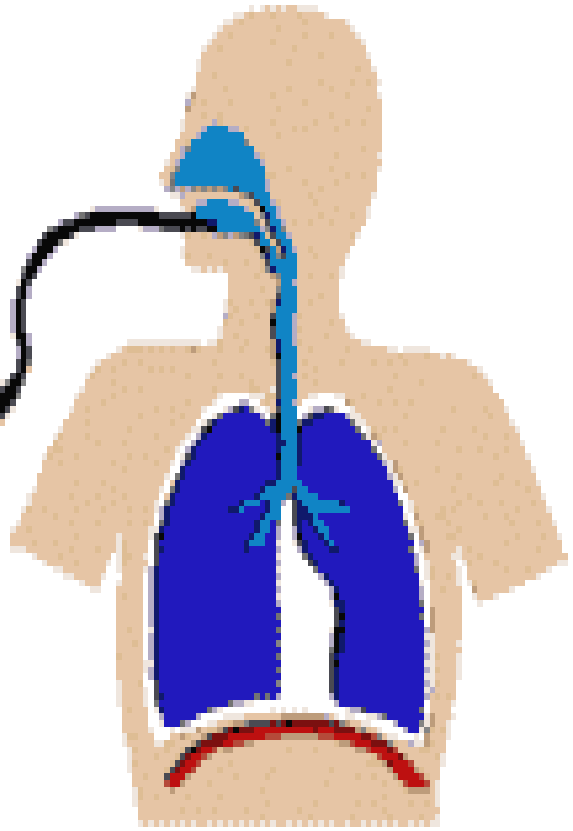
6) Forced expiratory volume(FEV1)	Forced Expired Volume in one second is the volume expired in the first second of maximal expiration after a full inspiration	
7) FEV1%	FEV1/FVC	80%
8) Peak expiratory flow rate(PEFR)	Max flow rate	
9) Forced expiratory flow rate(FEF)	Mean forced expiratory flow rate found out from flow-vol curve	
10) FEF25%	Amt of air forcibly exhaled in 1st 25% of FVC test	
11)Slow vital capacity	Amt of air slowly exhaled after deep inhalation	

SPIROMETRY

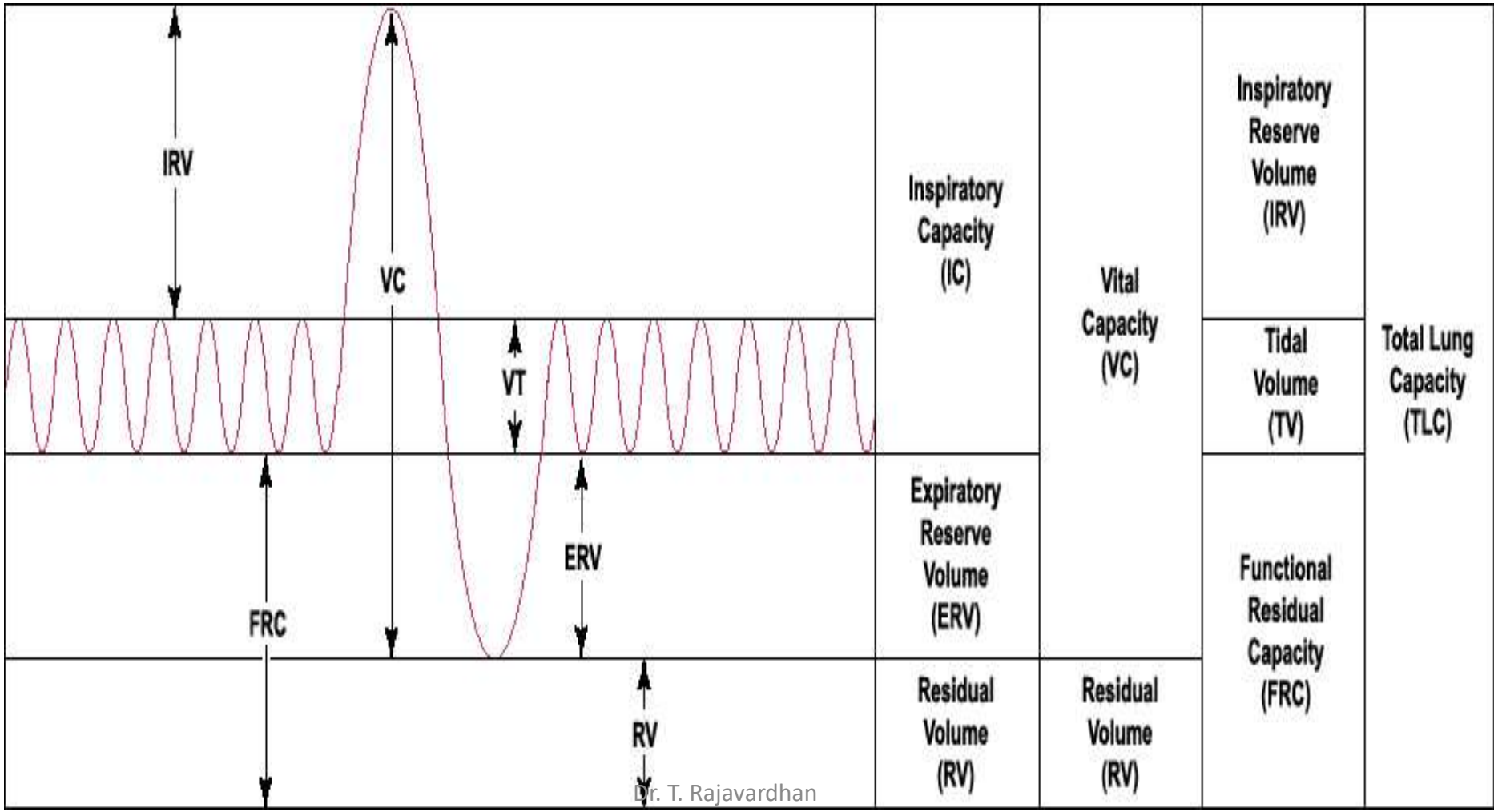
- Spirometer is the primary instrument used in pulmonary function testing.
- It is designed to measure changes in volume.
- The device usually attached to spirometer, which measures movement of gas in and out of chest, is referred to as spirograph.

- Simple, office-based
- Measures flow, volumes
- Volume vs. Time
- Can determine:
  - Forced expiratory volume in one second (FEV_1)
  - Forced vital capacity (FVC)
  - FEV_1/FVC
  - Forced expiratory flow 25%-75% (FEF_{25-75})

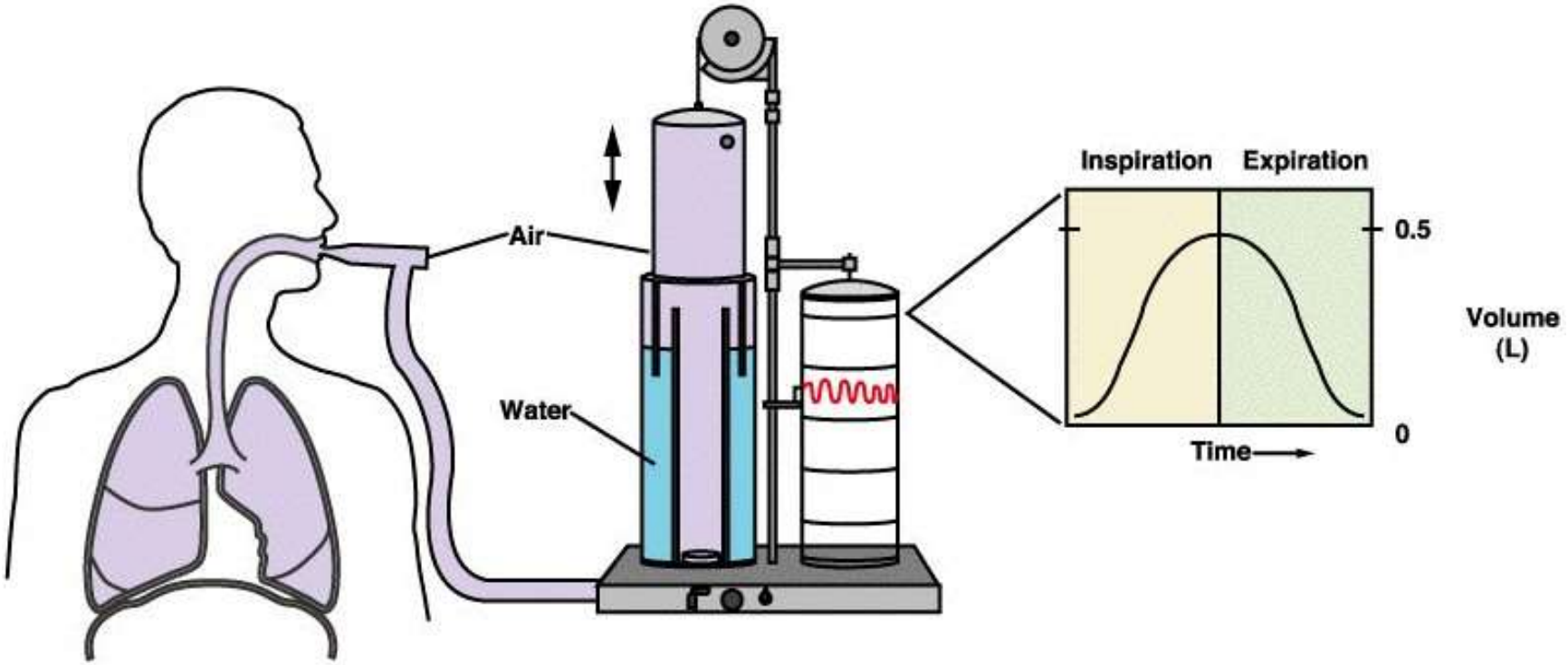




Lung Volumes



SPIROMETER

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Procedure

- The basic forced volume vital capacity (FVC) test varies slightly depending on the equipment used.
- Generally, the patient is asked to take the deepest breath they can, and then exhale into the sensor as hard as possible, for as long as possible. Sometimes, the test will be preceded by a period of quiet breathing in and out from the sensor (tidal volume).
- During the test, soft nose clips may be used to prevent air escaping through the nose. Filter mouthpieces may be used to prevent the spread of microorganisms, particularly for inspiratory maneuvers.

Disadvantage of spirometry

- Due to the patient cooperation required, spirometry can only be used on children old enough to comprehend and follow the instructions given (typically about 4-5 years old), and only on patients who are able to understand and follow instructions.

Lung volumes

Indication for lung volume test :

- Low FVC :

  -? Restrictive

  -? Obstructive with hyperinflation and air trapping

  -? Mixed pattern

  -? Equivocal spirometry findings (FEV1&FVC at lower limit of normal)

- To differentiate chronic bronchitis from emphysema.

Measurment of lung volumes requires a method of estimating the volume of gas inside the thorax

The most common methods of assessing lung volumes are:

1. Gas dilution tests.
2. Body plethysmography (Body Box).

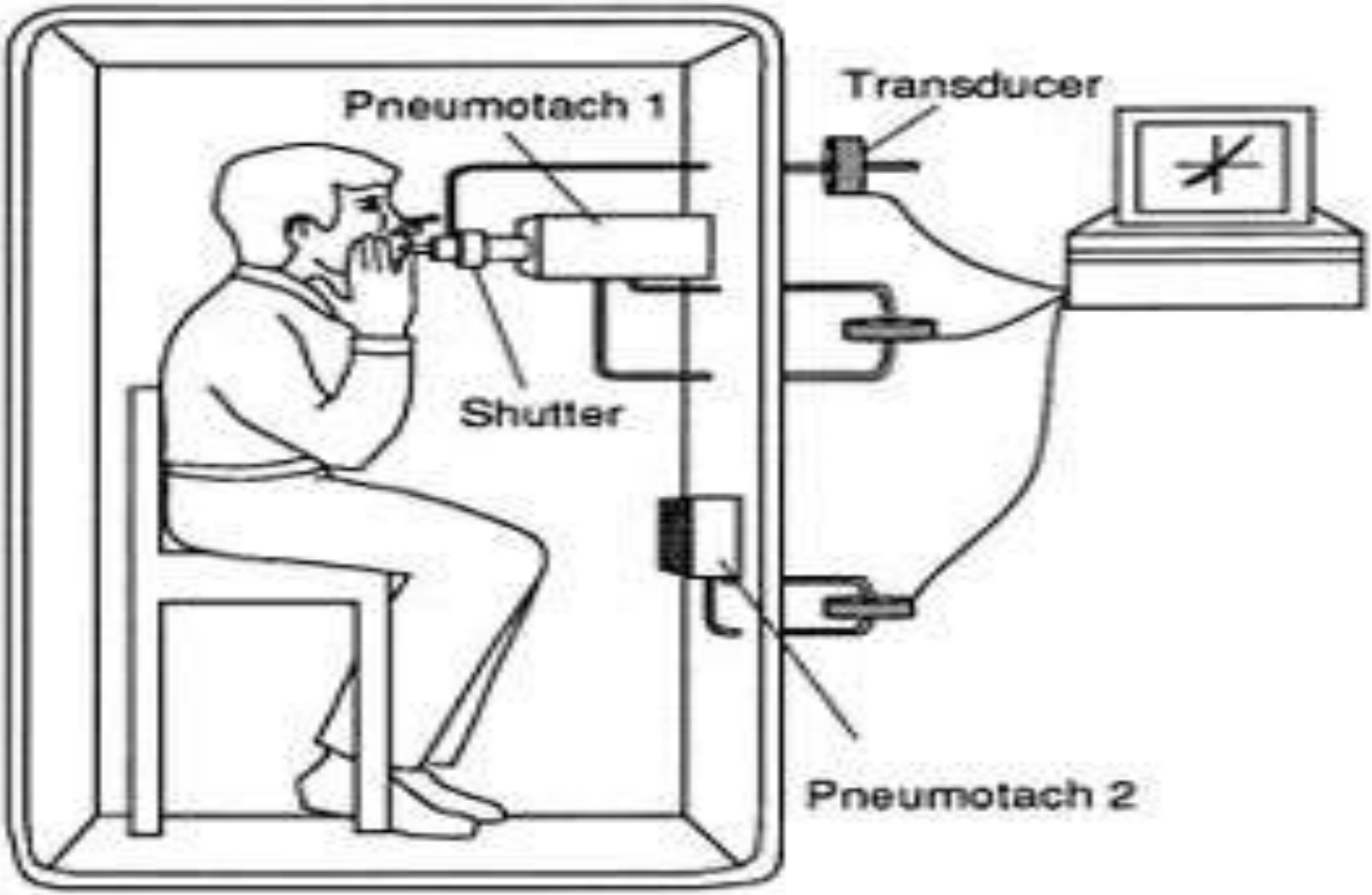
1.Gas dilution tests:

- Lung volume can be measured when a person breathes nitrogen or helium gas through a tube for a specified period of time.

The final dilution of the gas used to calculate the volume of air in the thorax.

2.Body plethysmography

- The most accurate way
- The patient sits inside a fully enclosed rigid box and breath through mouthpiece connected through a shutter to the internal volume of the box
- The subject makes respiratory efforts against the closed shutter (like panting), causing their chest volume to expand and decompressing the air in their lungs.
- while breathing in and out again into a mouthpiece. The volume of all gas within the thorax can be measured by Changes in pressure inside the box and allow determination of the lung volume.

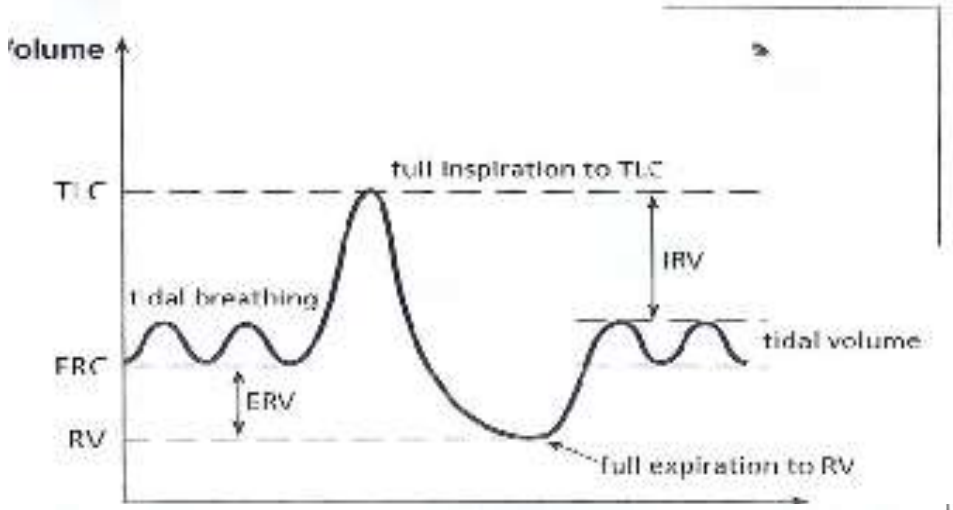

Pneumotach 1
Transducer
Shutter
Pneumotach 2

Body plethysmography

- Using the data from the plethysmography requires use of Boyles Law.
- P1V1=P2V2: A volume of gas in a closed system varies inversely with the pressure applied to it.

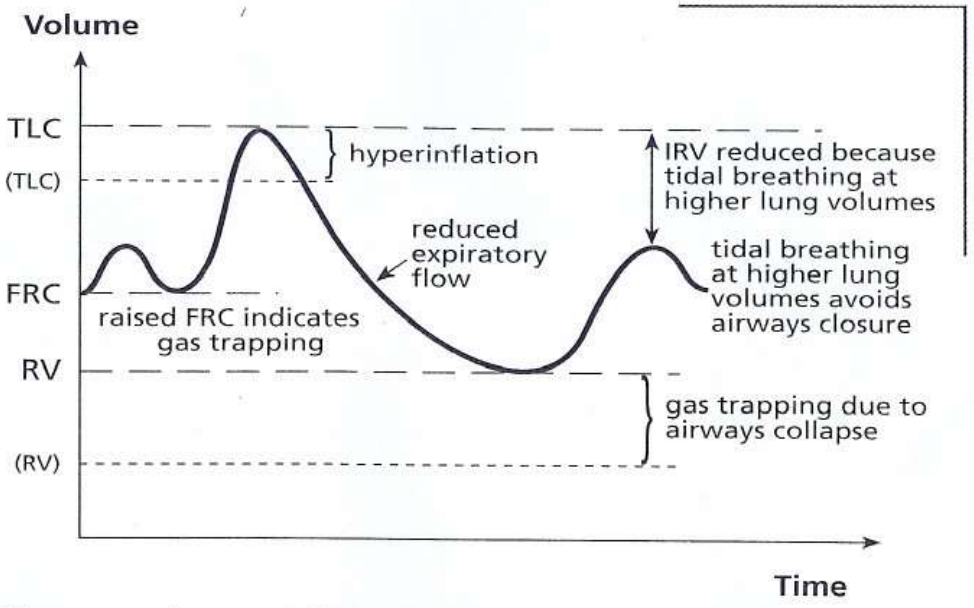
Obstructive Lung Disease

- Narrowing and closure of airways during expiration tends to lead to gas trapping within the lungs and hyperinflation of the chest.
- Air trapping → increase in RV
- Hyperinflation → increases TLC
- RV tends to have a greater percentage increase than TLC
- RV/TLC ratio is therefore increased (nl 20-35%)
- Gas trapping may occur without hyperinflation (increase in RV & normal TLC)



Lung volumes

41



Obstructive Lung Disease

RV increased

TLC Nl/increased

RV/TLC increases

FRC increased

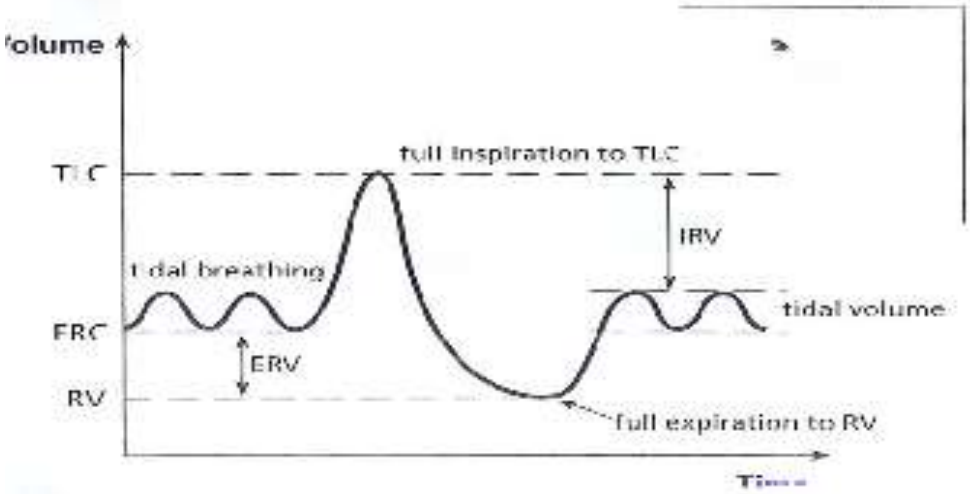
VC decreased

*Air trapping :Normal TLC with

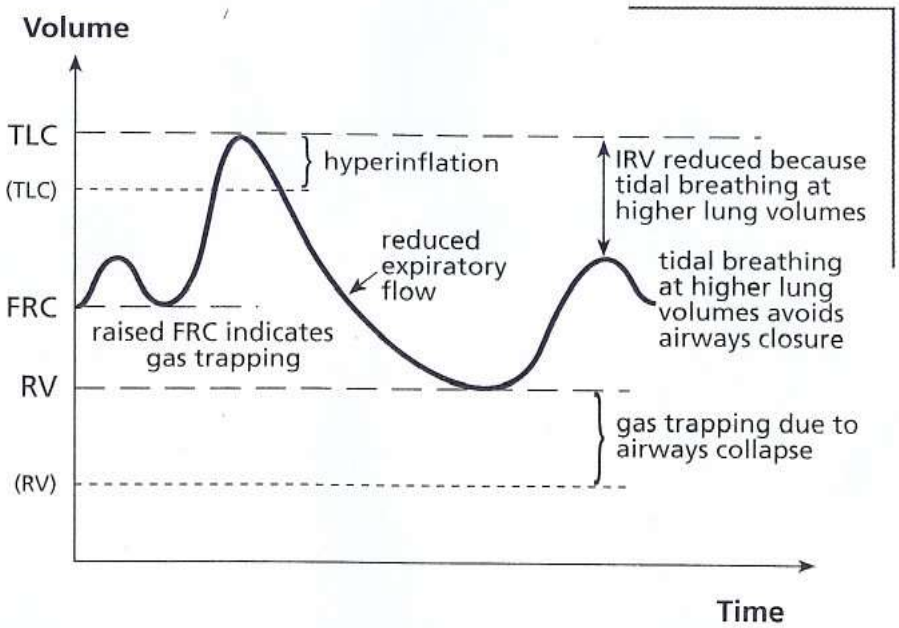
increase RV/TLC

*Hyperinflation: Increase in both

TLC and RV/TLCl/



Lung volumes 41



Obstructive lung disease

FEV1 ≥ 80% Normal

FEV1 60-80% mild obst.

FEV1 40-60% moderate

FEV1 ≤ 40% severe

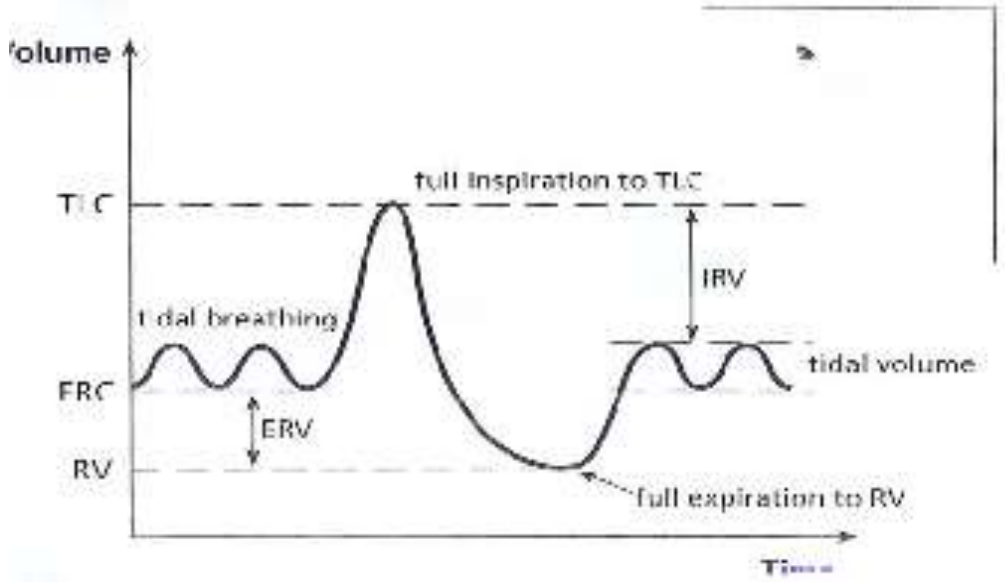
The cardinal feature is FEV1/FVC ratio If <70 consider obstructed

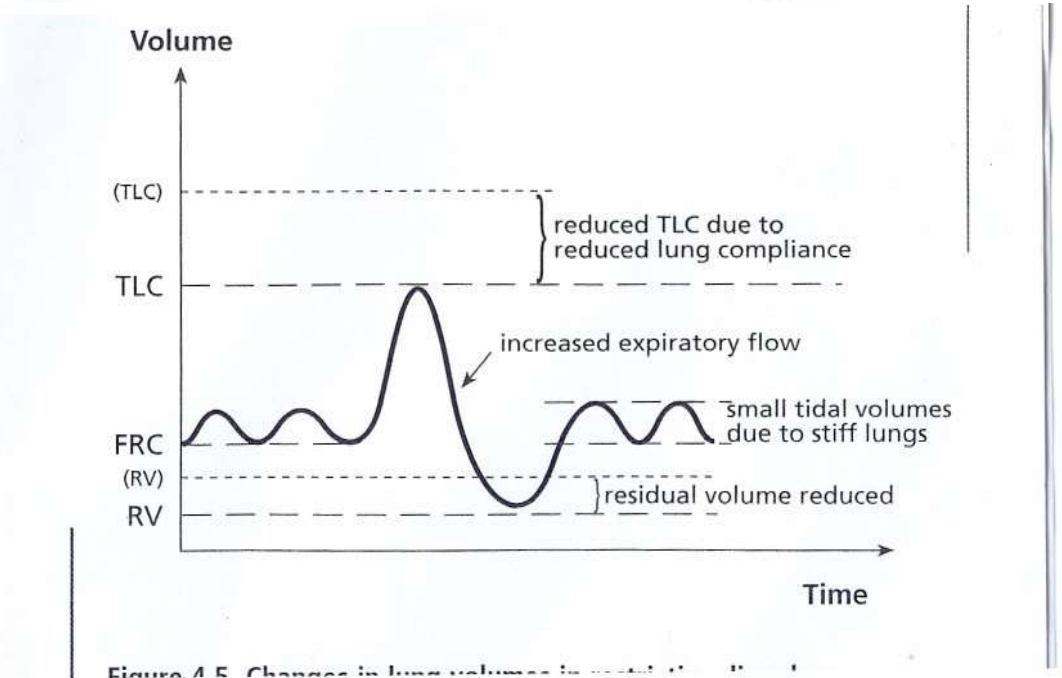
*Predictors: Sex, Age, Ht

Lung Volume in Restrictive Lung Disease

1. In Intrinsic RLD (Interstitial Lung Disease)

- TLC will decrease
- RV will decrease because of increased elastic recoil (stiffness) of the lung and loss of the alveoli.
- Breathing take place at low FRC because of the increased effort needed to expand the lung .
- RV/TLC normal



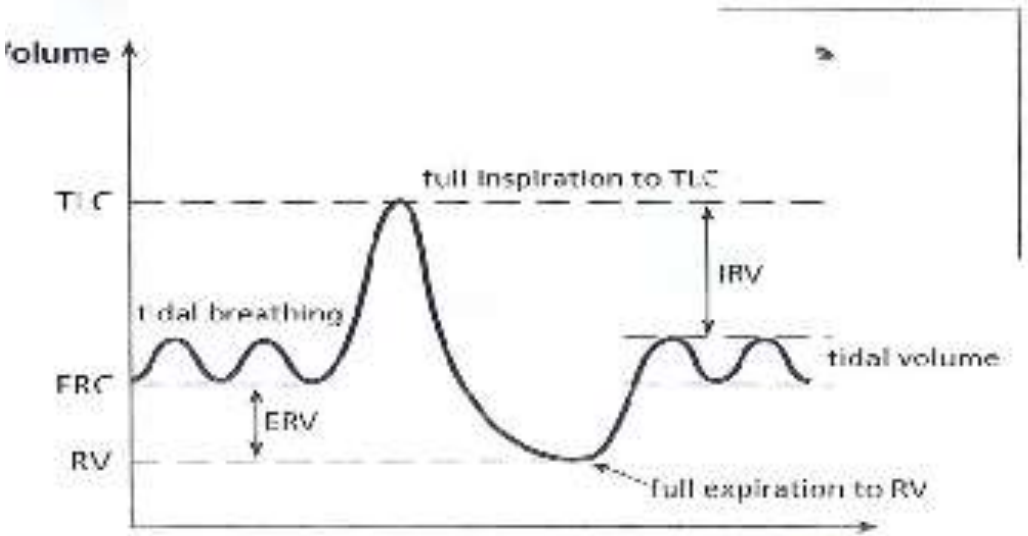


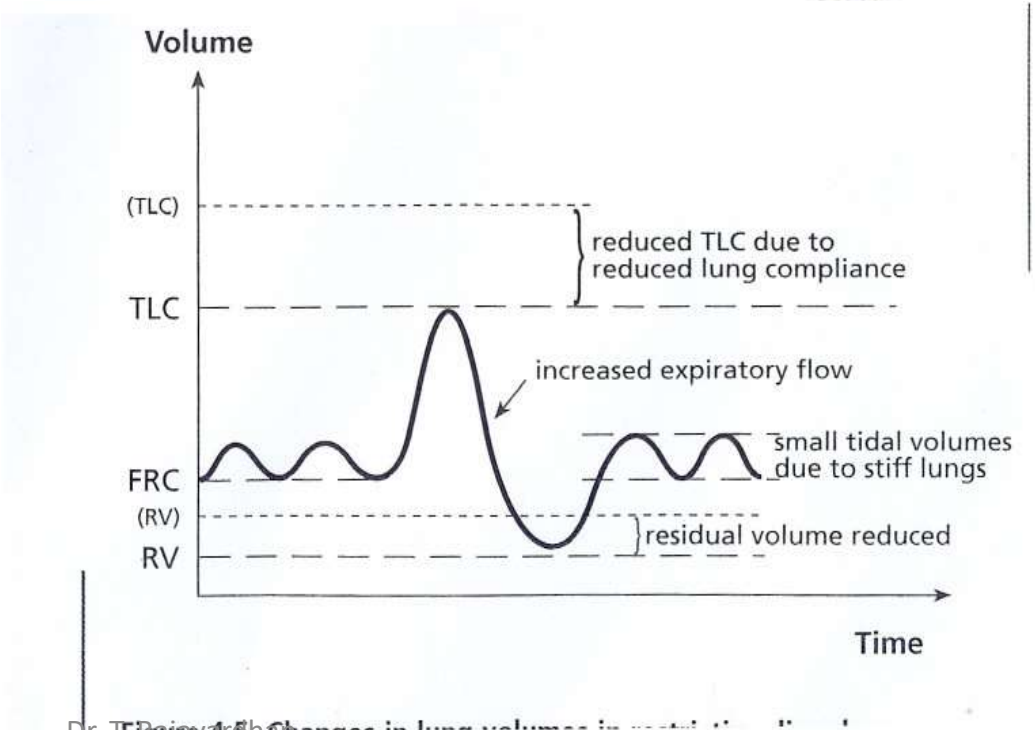
2. In extrinsic RLD (chest wall disease :kyphoscoliosis or neuromuscular disease.

- TLC is reduced either because of mechanical limitation to chest wall expantion or because of respiratory muscle weakness
- RV is Normal because Lung tissue and elastic recoil is normal

So RV/TLC ratio will be high

- Breathing take place at low FRC because of the increased effort needed to expand the lung .





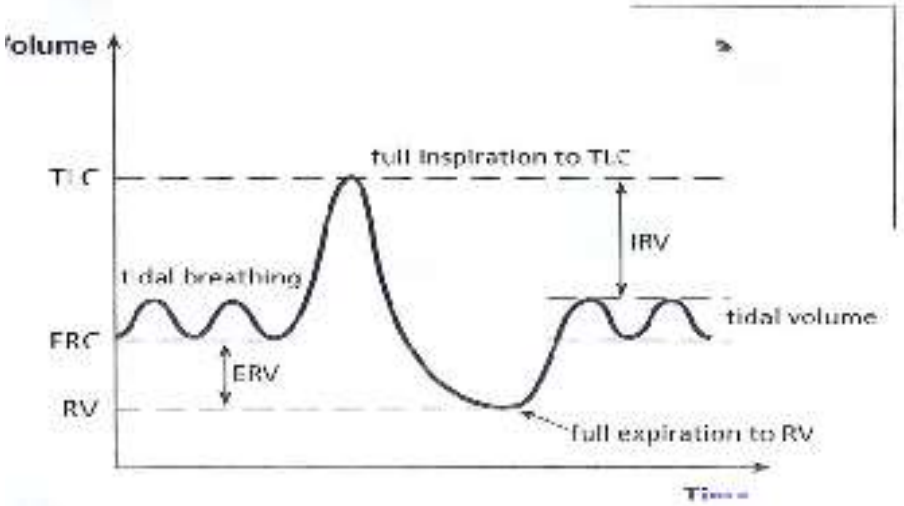
Restrictive Lung Disease:

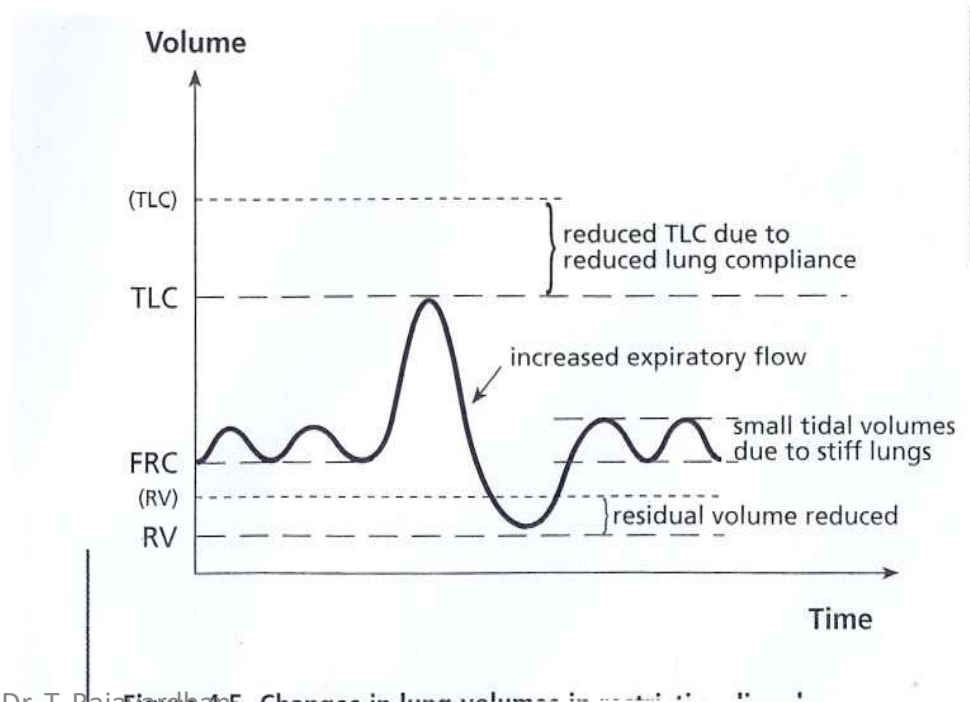
RLD Intrinsic & severe chest wall dis (pleural and skeletal)

TLC decreased
RV decreased
RV/TLC normal
FRC decreased
VC decreased

Extrinsic RLD

TLC decreased
RV normal
RV/TLC High
VC decreased
FRC decreased





Other type

3. In combined obstructive and restrictive disease(e,g.sarcoidosis ,COPD+IPF)

Obstructive pattern on spirometry and

Reduced lung volume

Bronchodilator Response

- Degree to which FEV_1 improves with inhaled bronchodilator

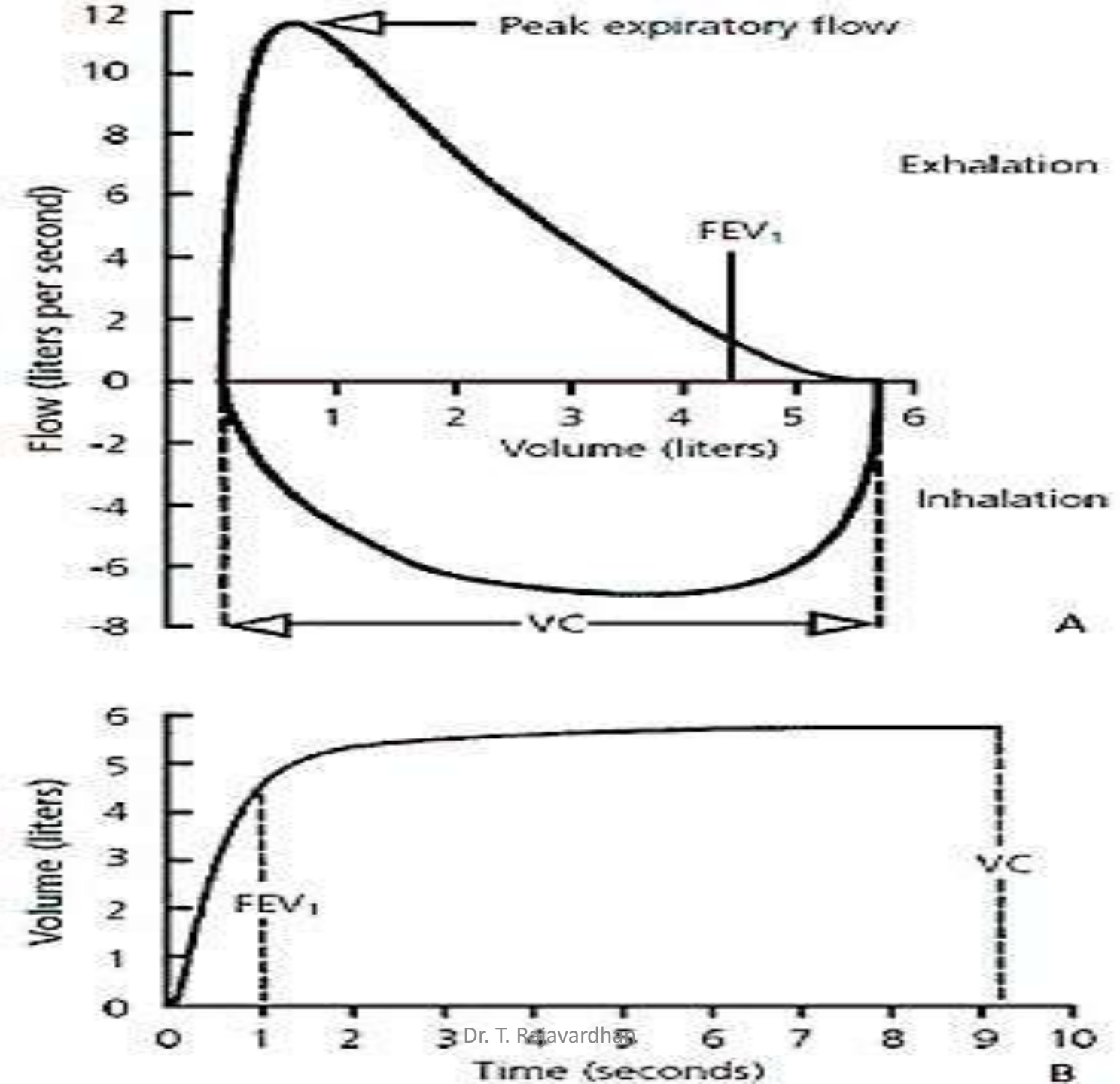
- Documents *reversible* airflow obstruction

- Significant response if:

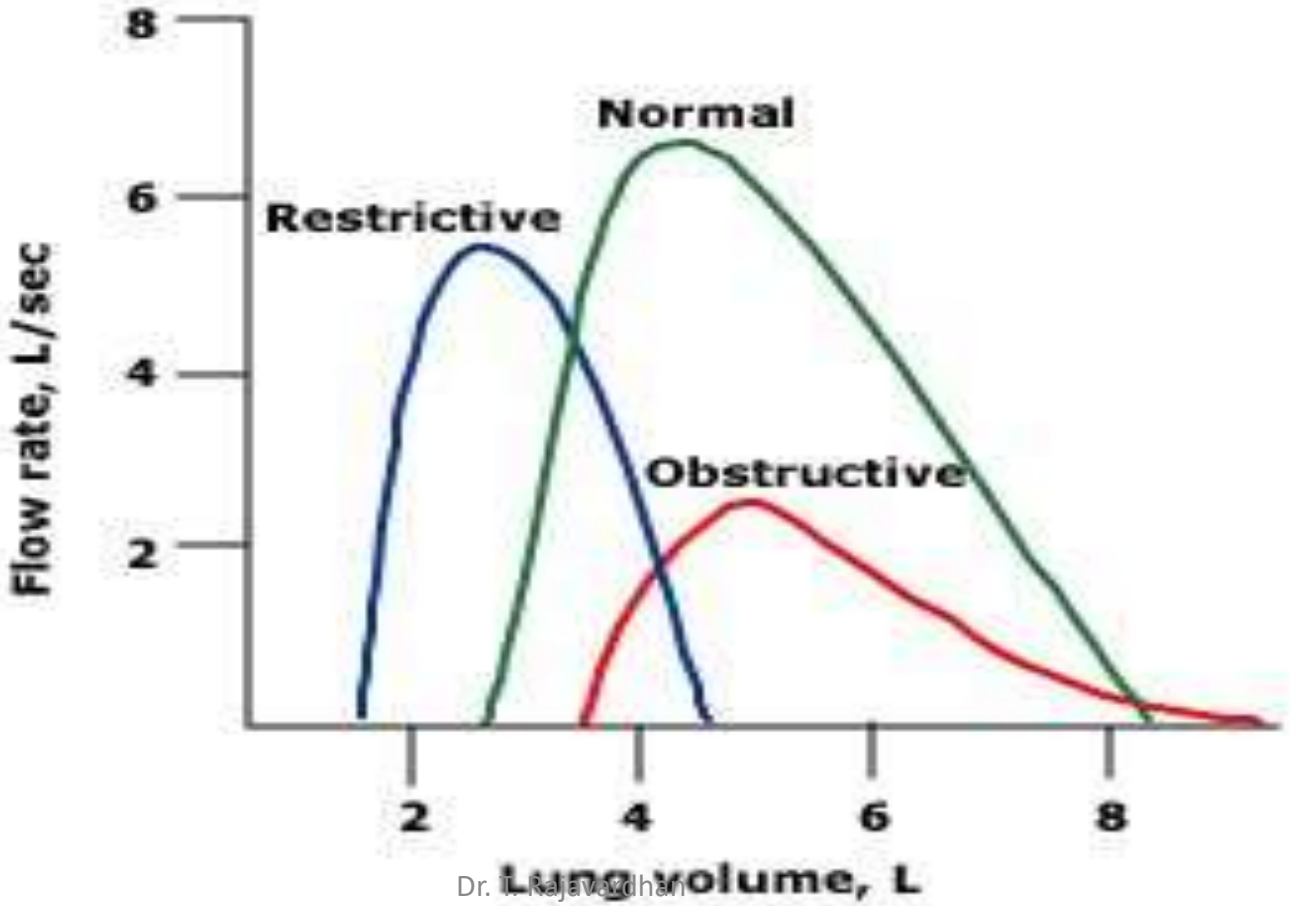
  - FEV_1 increases by 12% and >200ml

Flow Volume Loop

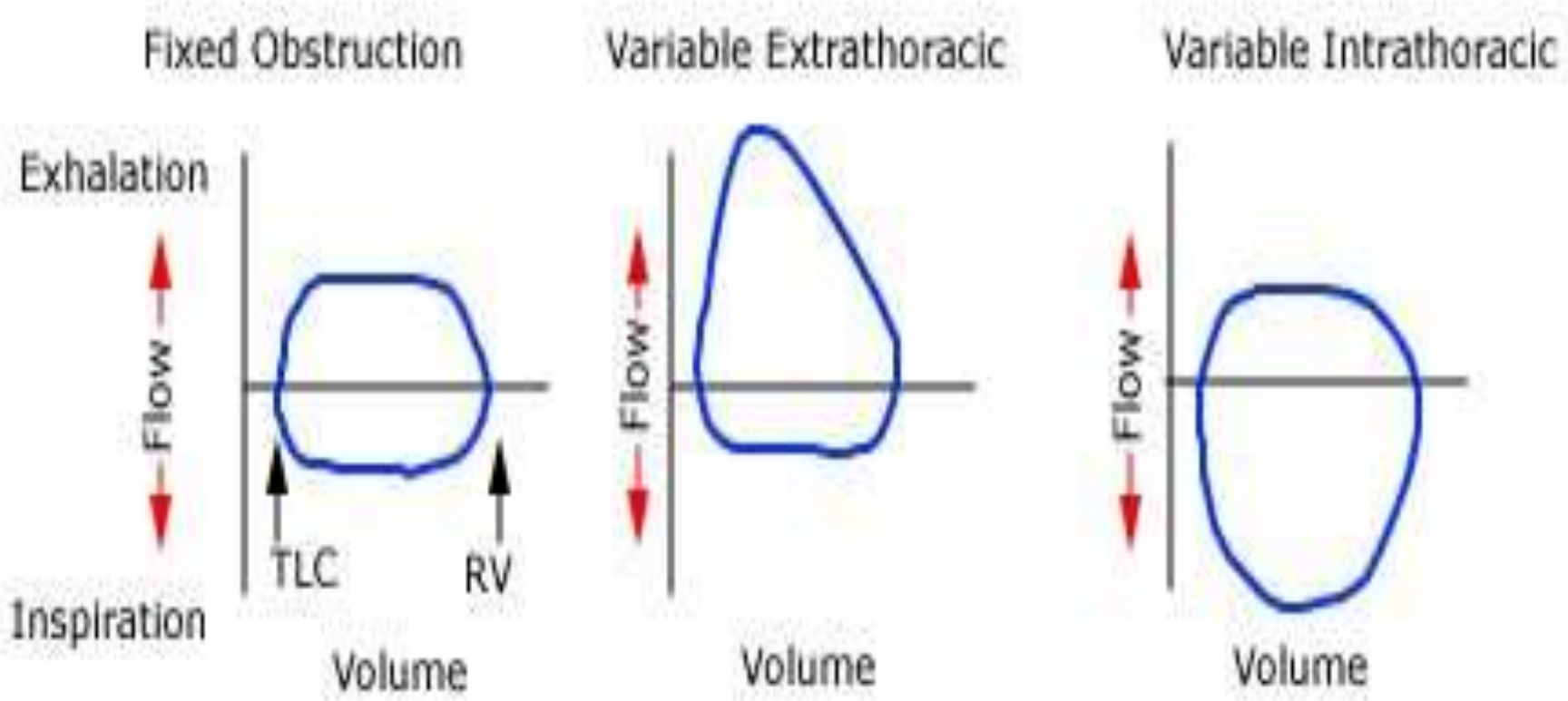
- “Spirogram”
- Measures forced inspiratory and expiratory flow rate
- Augments spirometry results
- Indications: evaluation of upper airway obstruction



Spirometry Patterns



Upper Airway Obstruction



Diffusing Capacity

- Diffusing capacity of lungs for CO
- Measures ability of lungs to transport inhaled gas from alveoli to pulmonary capillaries
- Depends on:
  - alveolar—capillary membrane
  - hemoglobin concentration
  - cardiac output

Diffusing Capacity

- **Decreased DLCO** (<80% predicted)
  - Obstructive lung disease
  - Parenchymal disease
  - Pulmonary vascular disease
  - Anemia
- **Increased DLCO** (>120-140% predicted)
  - Asthma (or normal)
  - Pulmonary hemorrhage
  - Polycythemia
  - Left to right shunt

DLCO — Indications

- Differentiate asthma from emphysema
- Evaluation and severity of restrictive lung disease
- Early stages of pulmonary hypertension
- Expensive!

Bronchoprovocation

- Useful for diagnosis of asthma in the setting of *normal* pulmonary function tests

- Common agents:

  - Methacholine, Histamine, others

- Diagnostic if: ≥20% decrease in FEV_1

REFERENCES

- Pharmacotherapy – 5th edition – by Joseph T Dipiro.
- Basic skills in interpreting laboratory data – 4th edition – Mary Lee.