



# PULMONARY FUNCTION TESTS AND THEIR IMPLICATION IN ANAESTHESIA

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# INTRODUCTION

- Pulmonary function tests is a generic term used to indicate a battery of studies or maneuvers that may be performed using standardized equipment to measure lung function.

Evaluates one or more aspects of the respiratory system

- ✓ Respiratory mechanics
- ✓ Lung parenchymal function/ Gas exchange
- ✓ Cardiopulmonary interaction

# INDICATIONS

DIAGNOSTIC	PROGNOSTIC
Evaluation of signs & symptoms- breathlessness, chronic cough, exertional dyspnea	Assess severity
Screening at risk pts	Follow response to therapy
Measure the effect of drugs on pulmonary function	Determine further treatment goals
To assess preoperative risk	Evaluating degree of disability
Monitor pulmonary drug toxicity	



# Tisi GUIDELINES

- Age > 70
- Obese patients
- Thoracic surgery
- Upper abdominal surgery
- History of cough/ smoking
- Any pulmonary disease



# American College of Physicians Guidelines

- Lung resection
- H/o smoking, dyspnoea
- Cardiac surgery
- Upper abdominal surgery
- Lower abdominal surgery
- Uncharacterized pulmonary disease (defined as history of pulmonary Disease or symptoms and no PFT in last 60 days)



# Contraindications

- Recent eye surgery
- Thoracic , abdominal and cerebral aneurysms
- Active hemoptysis
- Pneumothorax
- Unstable angina/ recent MI within 1 month



# INDEX

1. Categorization of PFT's
2. Bedside pulmonary function tests
3. Static lung volumes and capacities
4. Measurement of FRC, RV
5. Dynamic lung volumes/forced spirometry
6. Flow volume loops and detection of airway obstruction
7. Flow volume loop and lung diseases
8. Tests of gas exchange function
9. Tests for cardiopulmonary reserve
10. Preoperative assessment of thoracotomy patients

# CATEGORIZATION OF PFT

## **MECHANICAL VENTILATORY FUNCTIONS OF LUNG / CHEST WALL:**

- BED SIDE PULMONARY FUNCTION TESTS
- STATIC LUNG VOLUMES & CAPACITIES – VC, IC, IRV, ERV, RV, FRC.
- DYNAMIC LUNG VOLUMES –FVC, FEV1, FEF 25-75%, PEFr, MVV, RESP. MUSCLE STRENGTH



## **GAS- EXCHANGE TESTS**

:

- A) Alveolar-arterial  $po_2$  gradient
- B) Diffusion capacity
- C) Gas distribution tests- 1) single breath  $N_2$  test. 2) Multiple Breath  $N_2$  test 3) Helium dilution method 4) Radio Xe scintigram.

## **CARDIOPULMONARY INTERACTION:**

- Qualitative tests:
  - 1) History , examination
  - 2) ABG
- Quantitative tests
  - 1) 6 min walk test
  - 2) Stair climbing test
  - 3) Shuttle walk
  - 4) CPET(cardiopulmonary exercise testing)



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# Bed side pulmonary function tests

## 1) **SABRASEZ BRAETH HOLDING TEST:**

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

- >25 SEC.-NORMAL Cardiopulmonary Reserve (CPR)
- 15-25 SEC- LIMITED CPR
- <15 SEC- VERY POOR CPR (Contraindication for elective surgery)

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 pulmonary function tests

## **2) SCHNEIDER'S MATCH BLOWING TEST: MEASURES Maximum Breathing Capacity.**

Ask to blow a match stick from a distance of 6" (15 cms) with-

- Mouth wide open
- Chin rested/supported
- No purse lipping
- No head movement
- No air movement in the room
- Mouth and match at the same level

# Bed side pulmonary function tests

- **Can not blow out a match**
  - $\text{MBC} < 60 \text{ L/min}$
  - $\text{FEV1} < 1.6\text{L}$
- **Able to blow out a match**
  - $\text{MBC} > 60 \text{ L/min}$
  - $\text{FEV1} > 1.6\text{L}$
- **Modified match test:**

DISTANCE

9"

6"

3"

MBC

$>150 \text{ L/MIN.}$

$>60 \text{ L/MIN.}$

$> 40 \text{ L/MIN}$

# Bed side pulmonary function tests

## **3) COUGH TEST: DEEP BREATH F/BY COUGH**

- ABILITY TO COUGH
- STRENGTH
- EFFECTIVENESS

**INADEQUATE COUGH IF: FVC < 20 ML/KG**

FEV1 < 15 ML/KG

PEFR < 200 L/MIN.

VC ~ 3 TIMES TV FOR EFFECTIVE COUGH.

\*A wet productive cough / self propagated paroxysms of coughing – patient susceptible for pulmonary Complication.



# Bed side pulmonary function tests

## **4) FORCED EXPIRATORY TIME:**

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

N FET – 3-5 SECS.

OBS.LUNG DIS. - > 6 SEC

RES. LUNG DIS.- < 3 SEC

## **5) SINGLE BREATH COUNT:**

After deep breath, hold it and start counting till the next breath.

- N- 30-40 COUNT
- Indicates vital capacity



# Bed side pulmonary function tests

**6) WRIGHT PEAK FLOW METER:** Measures PEFR  
(Peak Expiratory Flow Rate)

N – MALES- 450-700 L/MIN.

FEMALES- 350-500 L/MIN.

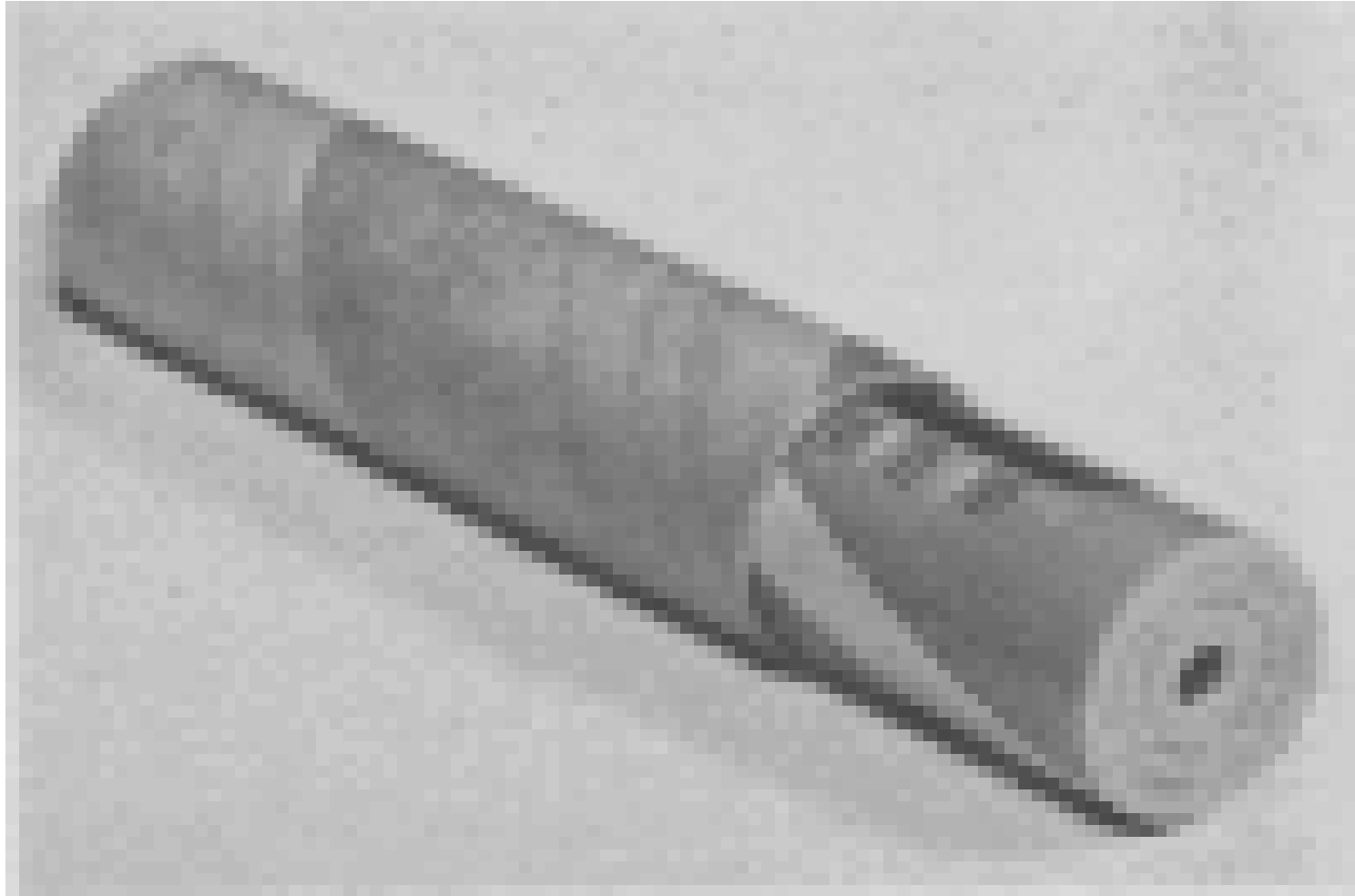
**7) DE-BONO WHISTLE BLOWING TEST:**  
MEASURES PEFR.

Patient blows down a wide bore tube at the end of which is a whistle, on the side is a hole with adjustable knob.

As subject blows → whistle blows, leak hole is gradually increased till the intensity of whistle disappears.

At the last position at which the whistle can be blown , the PEFR can be read off the scale.

# DEBONO'S WHISTLE





## 8) **WRIGHT RESPIROMETER** : measures TV, MV

Instrument- compact, light and portable.

- Can be connected to endotracheal tube or face mask
- MV- instrument record for 1 min. And read directly
- TV-calculated and dividing MV by counting Respiratory Rate.
- Disadvantage: It under- reads at low flow rates and over- reads at high flow rates.

# Bed side pulmonary function tests

- MICROSPIROMETERS – MEASURE FEV<sub>1</sub>,FVC



- BED SIDE PULSE OXIMETRY.
- ABG.



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# STATIC LUNG VOLUMES AND CAPACITIES

- **SPIROMETRY : CORNERSTONE OF ALL PFTs.**
- John hutchinson – invented spirometer.
- “Spirometry is a medical test that measures the volume of air an individual inhales or exhales as a function of time.”
- **CAN'T MEASURE – FRC, RV, TLC**



# SPIROMETRY-Acceptability Criteria

- Good start of test- without any hesitation
- No coughing / glottic closure
- No variable flow
- No early termination(> 6 sec)
- No air leak
- Reproducibility- The test is without excessive variability

The two largest values for FVC and the two largest values for  $FEV_1$  should vary by no more than 0.2L.

# SPIROMETRY-Acceptability Criteria

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AMERICAN JOURNAL OF RESPIRATORY AND CRITICAL CARE MEDICINE VOL 152 1995

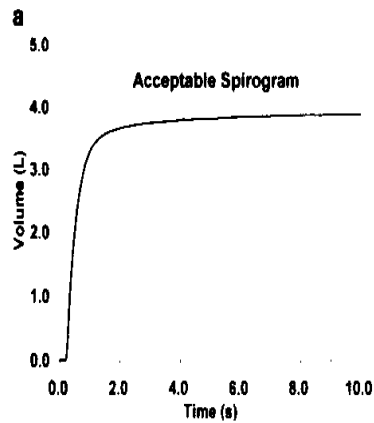


Figure A1a. Acceptable volume-time spirogram.

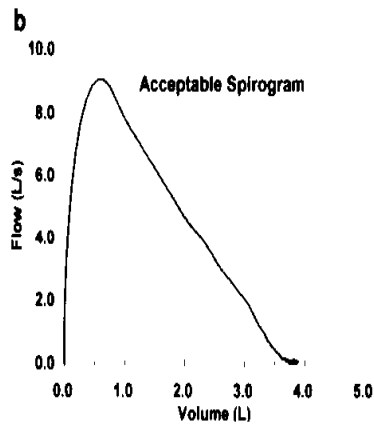


Figure A1b. Acceptable flow-volume spirogram.

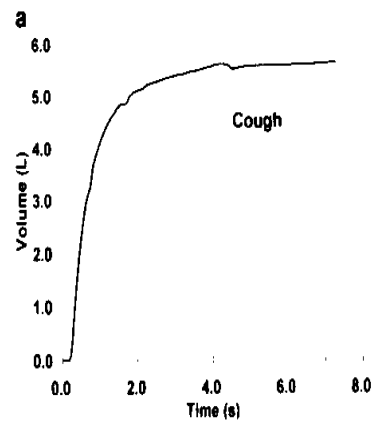


Figure A2a. Volume-time spirogram with a cough during the first second of exhalation.

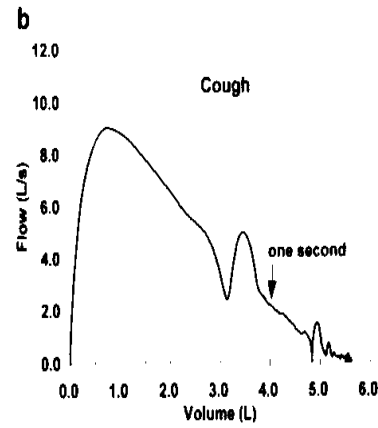


Figure A2b. Flow-volume spirogram with a cough during the first second of exhalation.

American Thoracic Society

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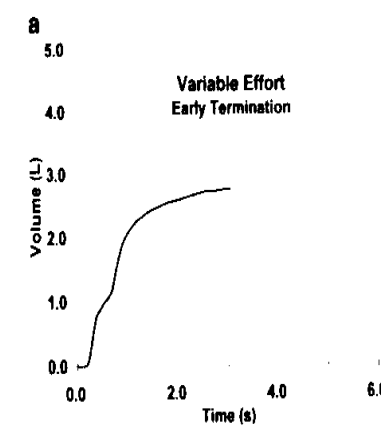


Figure A3a. Unacceptable volume-time spirogram due to variable effort and early termination.

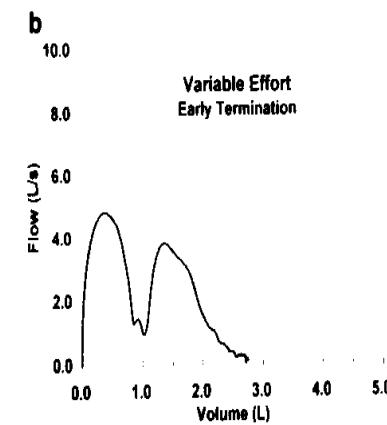


Figure A3b. Unacceptable flow-volume spirogram due to variable effort and early termination.

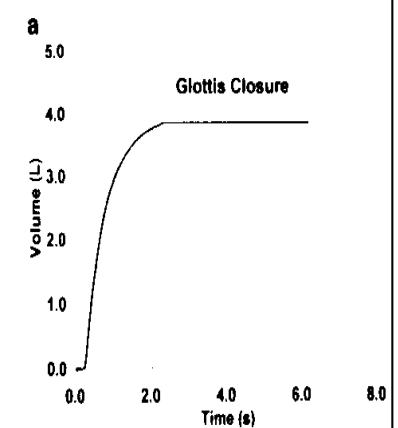


Figure A4a. Unacceptable volume-time spirogram due to possible glottis closure.

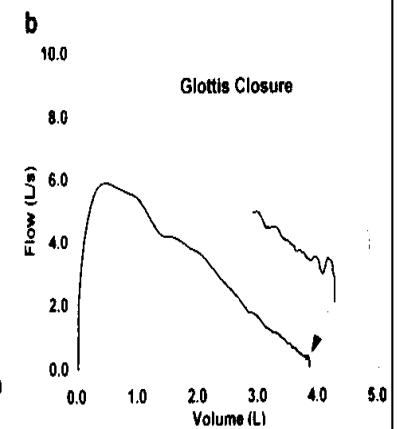


Figure A4b. Unacceptable flow-volume spirogram due to possible glottis closure.





# Spirometry Interpretation: So what constitutes normal?

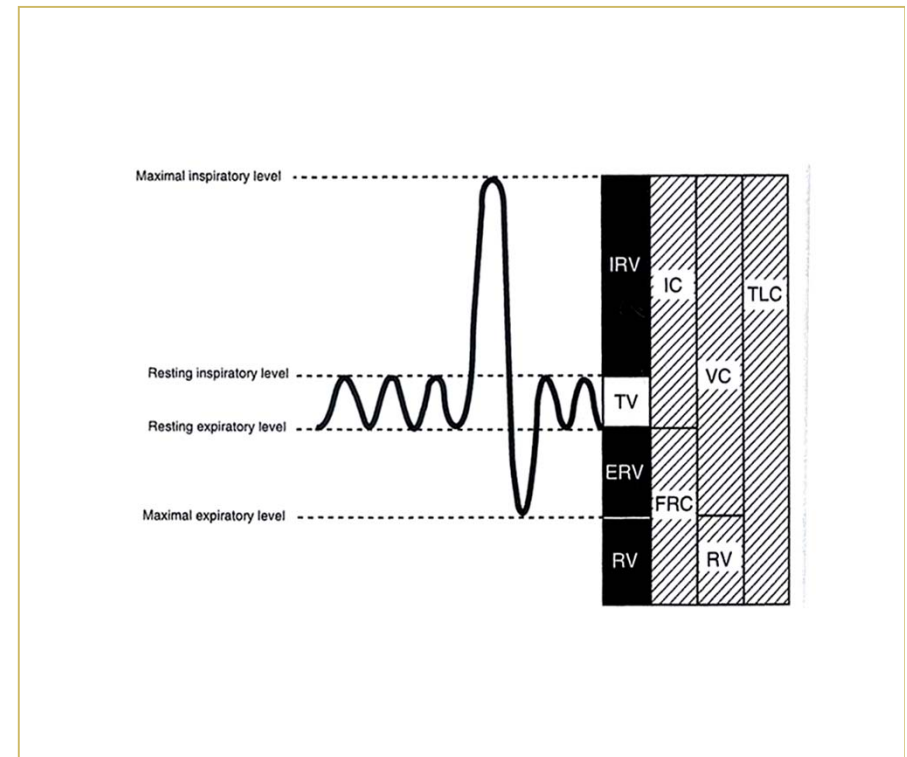
- Normal values vary and depend on:
  - I. Height – Directly proportional
  - II. Age – Inversely proportional
  - III. Gender
  - IV. Ethnicity

# LUNG VOLUMES AND CAPACITIES

## **PFT tracings have:**

➤ Four Lung volumes: tidal volume, inspiratory reserve volume, expiratory reserve volume, and residual volume

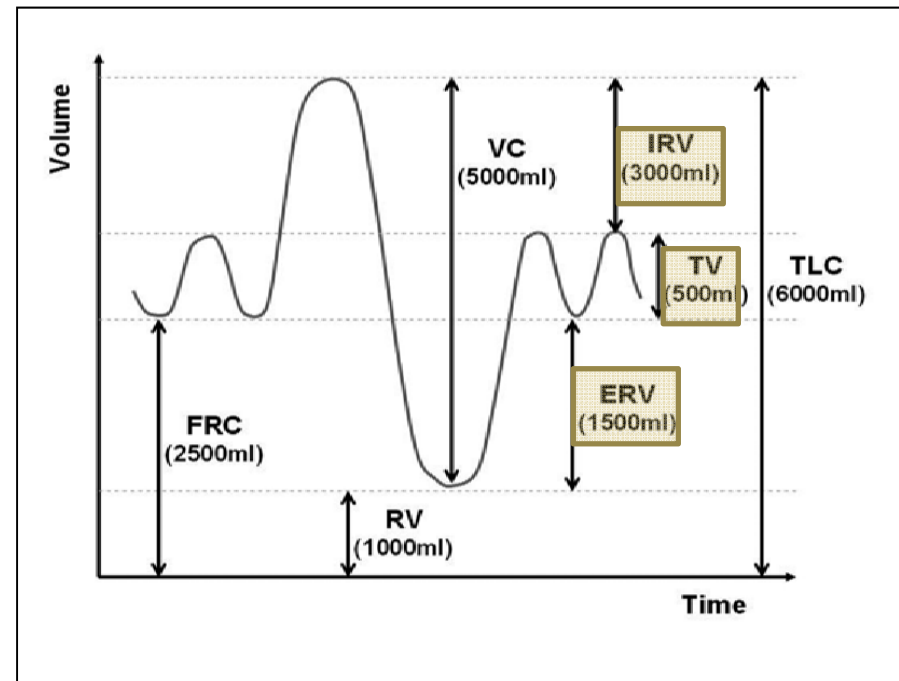
➤ Five capacities: inspiratory capacity, expiratory capacity, vital capacity, functional residual capacity, and total lung capacity



Addition of 2 or more volumes comprise a capacity.

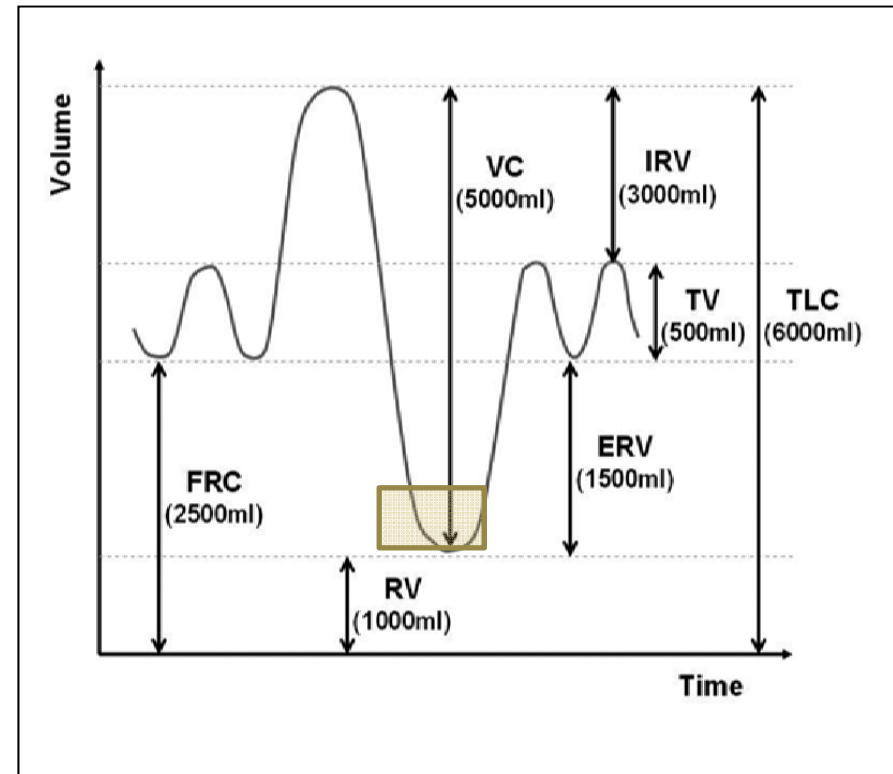
# LUNG VOLUMES

- **Tidal Volume (TV):** volume of air inhaled or exhaled with each breath during quiet breathing (6-8 ml/kg) 500 ml
- **Inspiratory Reserve Volume (IRV):** maximum volume of air inhaled from the end-inspiratory tidal position. 3000 ml
- **Expiratory Reserve Volume (ERV):** maximum volume of air that can be exhaled from resting end-expiratory tidal position. 1500 ml



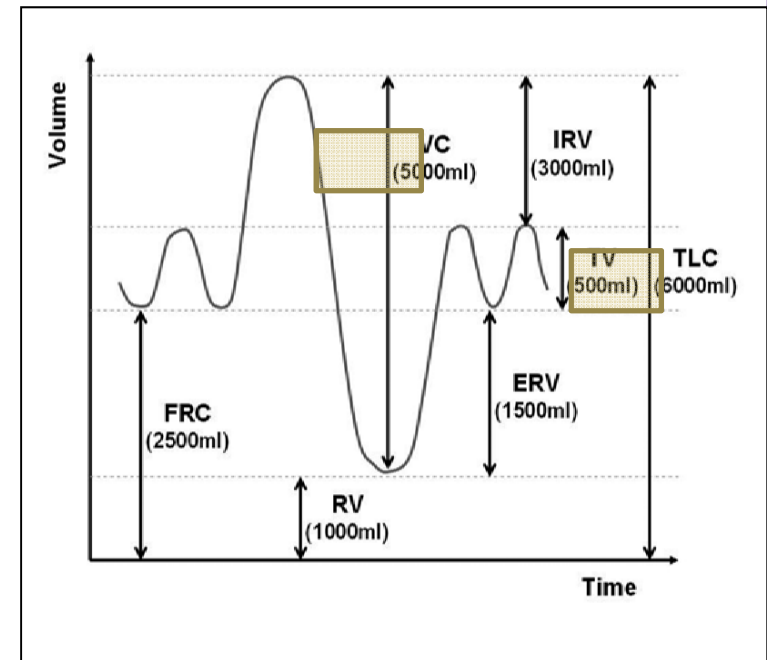
# LUNG VOLUMES

- **Residual Volume (RV):**
  - Volume of air remaining in lungs after maximum exhalation (20-25 ml/kg) 1200 ml
  - Indirectly measured (FRC-ERV)
  - It can not be measured by spirometry .



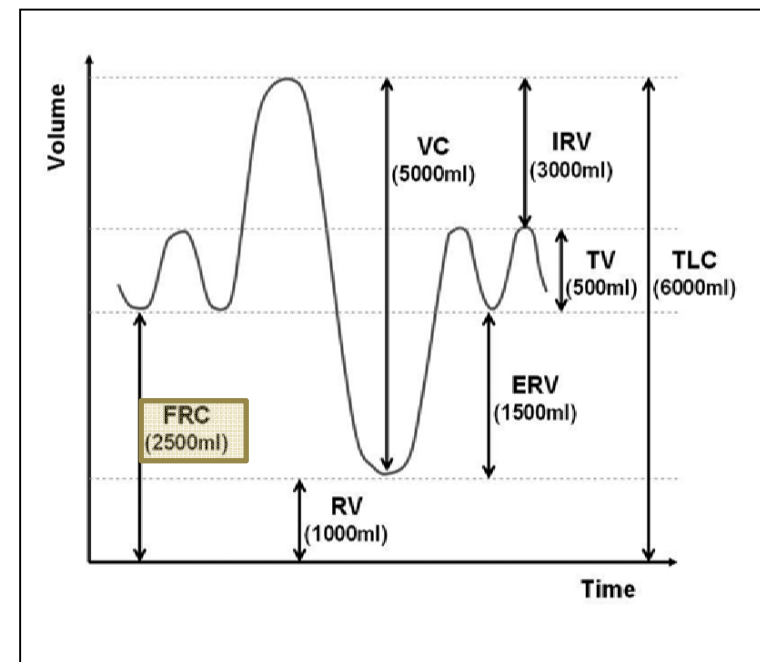
# LUNG CAPACITIES

- **Total Lung Capacity (TLC):** Sum of all volume compartments or volume of air in lungs after maximum inspiration (4-6 L)
- **Vital Capacity (VC):** TLC minus RV or maximum volume of air exhaled from maximal inspiratory level. (60-70 ml/kg) 5000ml.
- **Inspiratory Capacity (IC):** Sum of IRV and TV or the maximum volume of air that can be inhaled from the end-expiratory tidal position. (2400-3800ml).
- **Expiratory Capacity (EC):** TV+ ERV



# LUNG CAPACITIES

- **Functional Residual Capacity (FRC):**
  - Sum of RV and ERV or the volume of air in the lungs at end-expiratory tidal position. (30-35 ml/kg) 2500 ml
  - Decreases
    1. In supine position (0.5-1L)
    2. Obese pts
    3. Induction of anesthesia: ↓ by 16-20%





# FUNCTION OF FRC

- Oxygen store
- Buffer for maintaining a steady arterial  $pO_2$
- Partial inflation helps prevent atelectasis
- Minimizes the work of breathing





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# Measuring RV, FRC

It can be measured by

- Nitrogen washout technique
- Helium dilution method
- Body plethysmography



# N<sub>2</sub> Washout Technique

- The patient breathes 100% oxygen, and all the nitrogen in the lungs is washed out.
- The exhaled volume and the nitrogen concentration in that volume are measured.
- The difference in nitrogen volume at the initial concentration and at the final exhaled concentration allows a calculation of intrathoracic volume, usually FRC.

# Helium Dilution technique

- Pt breathes in and out from a reservoir with known volume of gas containing trace of helium.
- Helium gets diluted by gas previously present in lungs.
- eg: if 50 ml Helium introduced and the helium concentration is 1% , then volume of the lung is 5L.

# Body Plethysmography

- Plethysmography (derived from greek word meaning enlargement). Based on principle of **BOYLE'S LAW**( $P*V=k$ )
- A patient is placed in a sitting position in a closed body box with a known volume
- The patient pants with an open glottis against a closed shutter to produce changes in the box pressure proportionate to the volume of air in the chest.
- As measurements done at end of expiration, it yields FRC

## Body Plethysmograph Method for Determination of FRC

### Mouth pressure ( $P_m$ )

Change in mouth pressure ( $\Delta P_m$ )  
reflects change in alveolar pressure



### Box pressure ( $P_b$ )

Change in box pressure ( $\Delta P_b$ )  
reflects change in lung volume



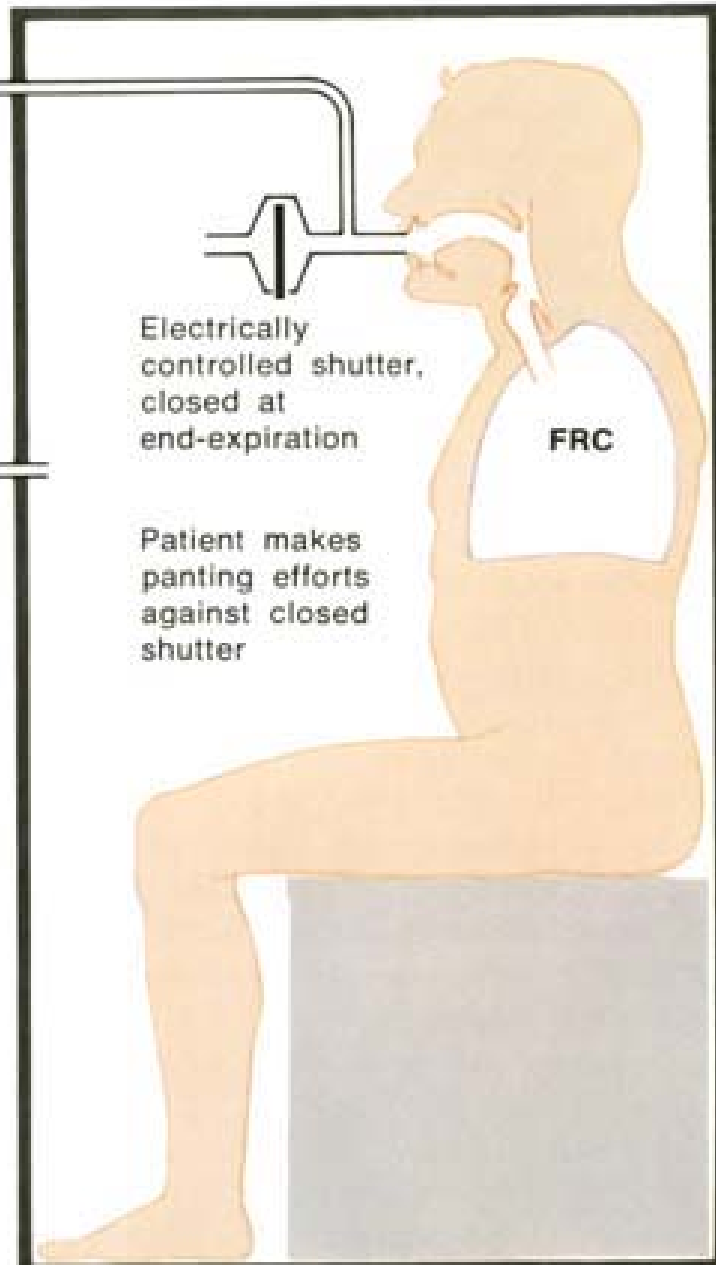
Electrically  
controlled shutter,  
closed at  
end-expiration

Patient makes  
panting efforts  
against closed  
shutter

FRC

*F. Netter M.D.*  
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$$\text{FRC} = \text{atmospheric pressure} \times \frac{\Delta P_b}{\Delta P_m}$$





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# FORCED SPIROMETRY/TIMED EXPIRATORY SPIROGRAM

Includes measuring:

- Pulmonary mechanics – to assess the ability of the lung to move large vol of air quickly through the airways to identify airway obstruction
- FVC
- FEV<sub>1</sub>
- Several FEF values
- Forced inspiratory rates(FIF's)
- MVV



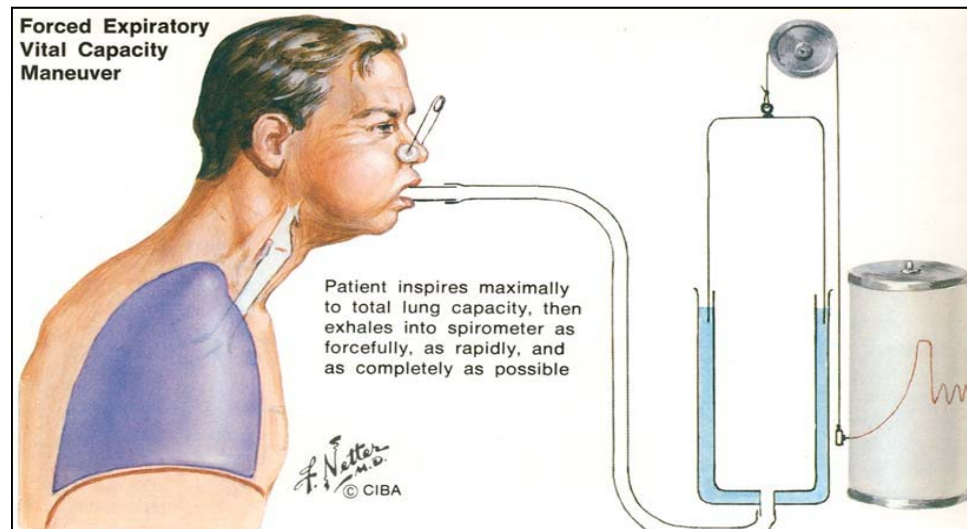
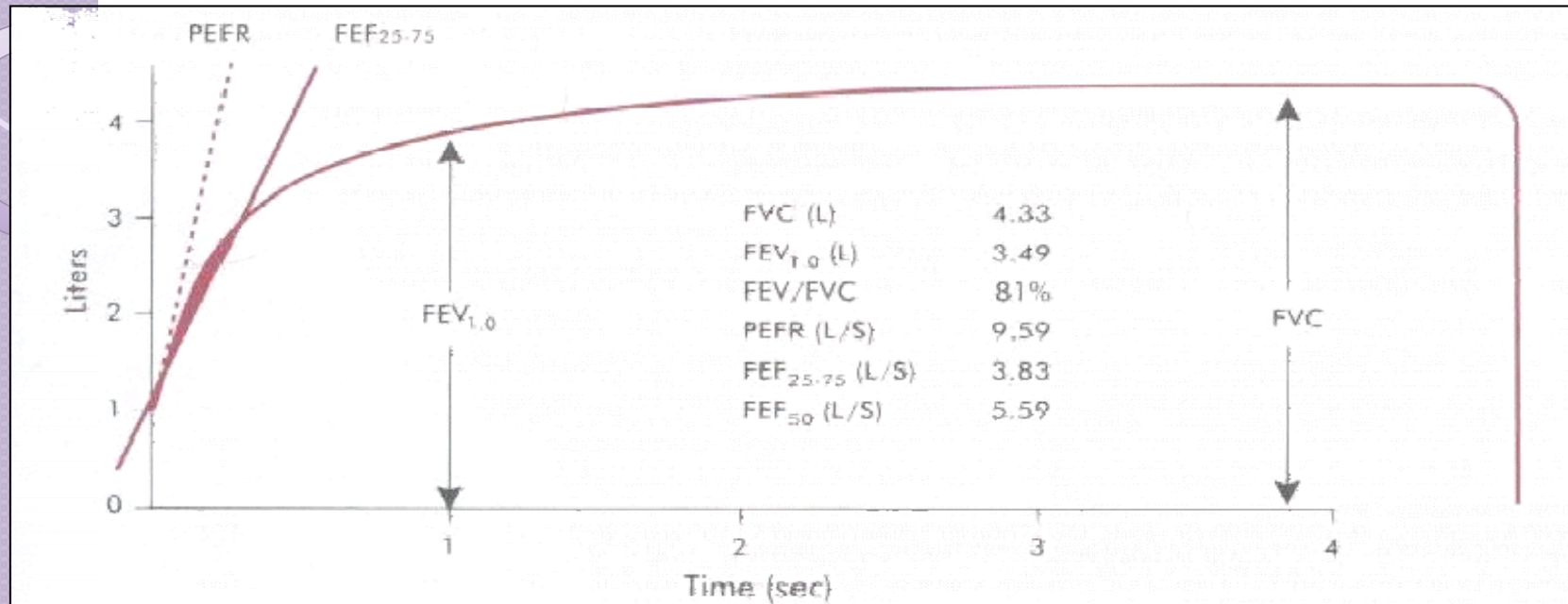


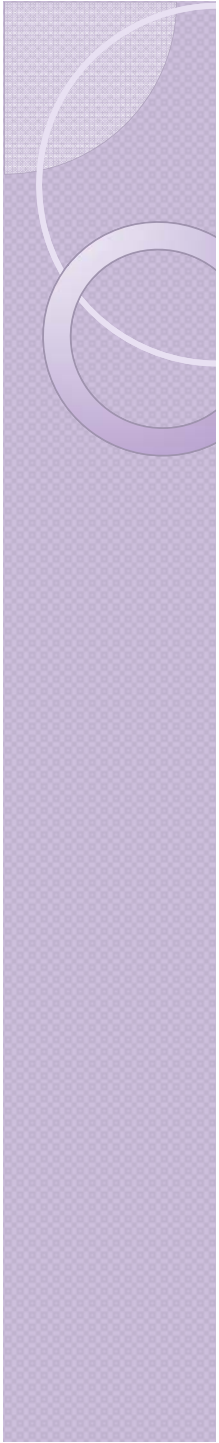
# FORCED VITAL CAPACITY

- The FVC is the maximum volume of air that can be breathed out as forcefully and rapidly as possible following a maximum inspiration.
- Characterized by full inspiration to TLC followed by abrupt onset of expiration to RV
- Indirectly reflects flow resistance property of airways.



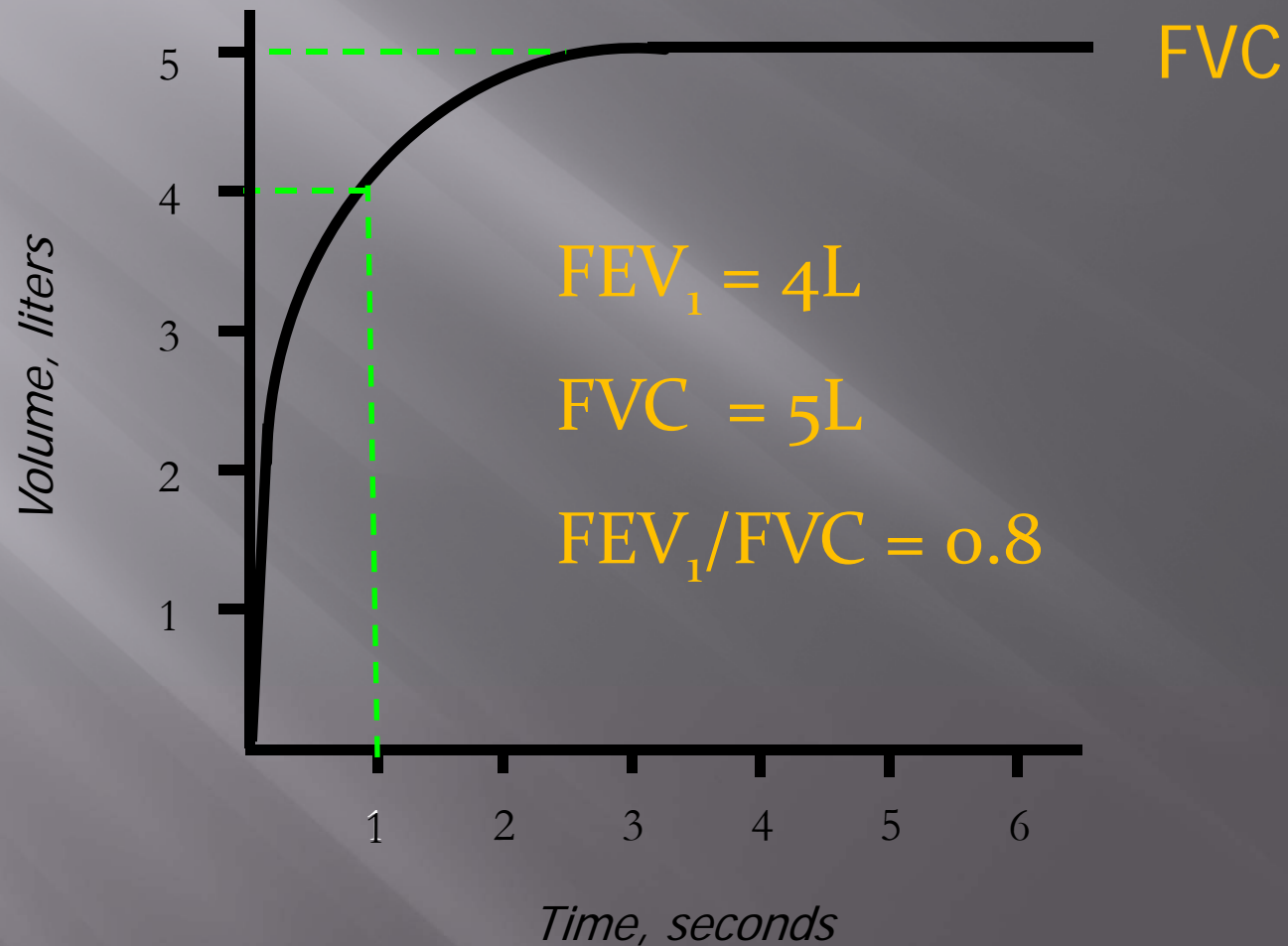
# FORCED VITAL CAPACITY





# Normal Trace Showing FEV<sub>1</sub> and FVC

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# Measurements Obtained from the FVC Curve and their significance

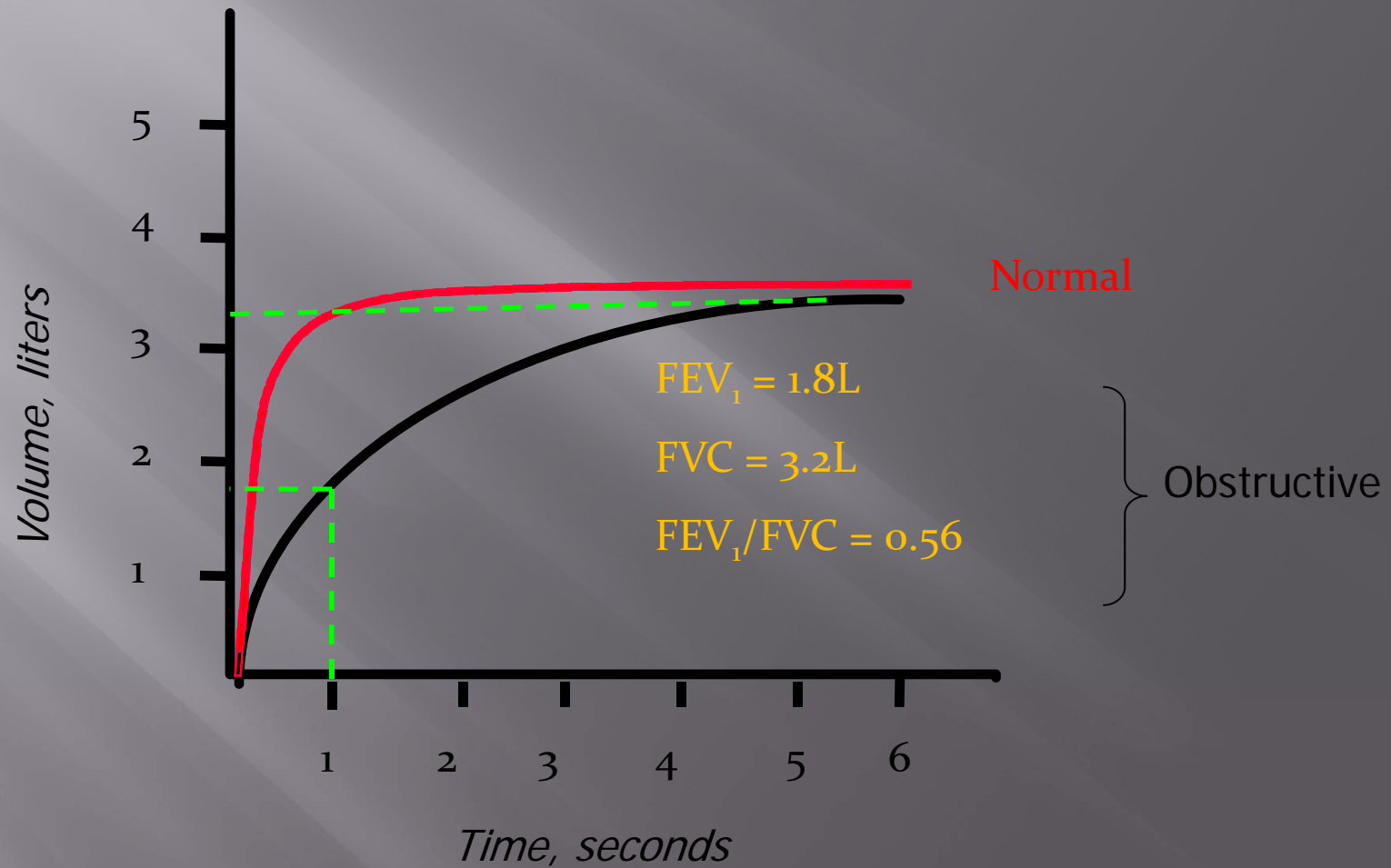
**FEV1** – Decreased in both obstructive & restrictive lung disorders

**FEV1/FVC** – Reduced in obstructive disorders.

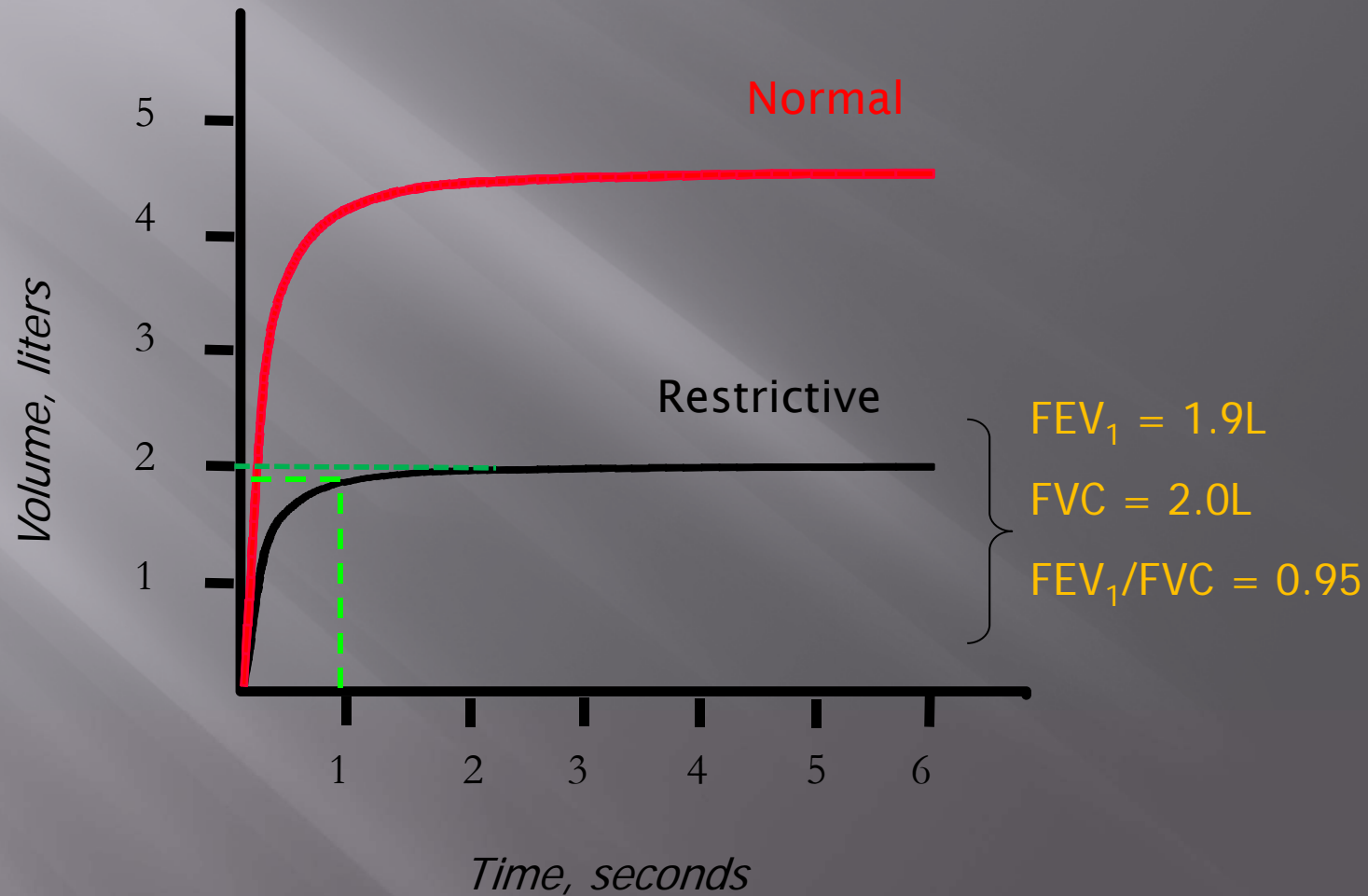
Interpretation of % predicted:

- $>75\%$  Normal
- $60\%-75\%$  Mild obstruction
- $50-59\%$  Moderate obstruction
- $<49\%$  Severe obstruction

# Spirometry: Obstructive Disease

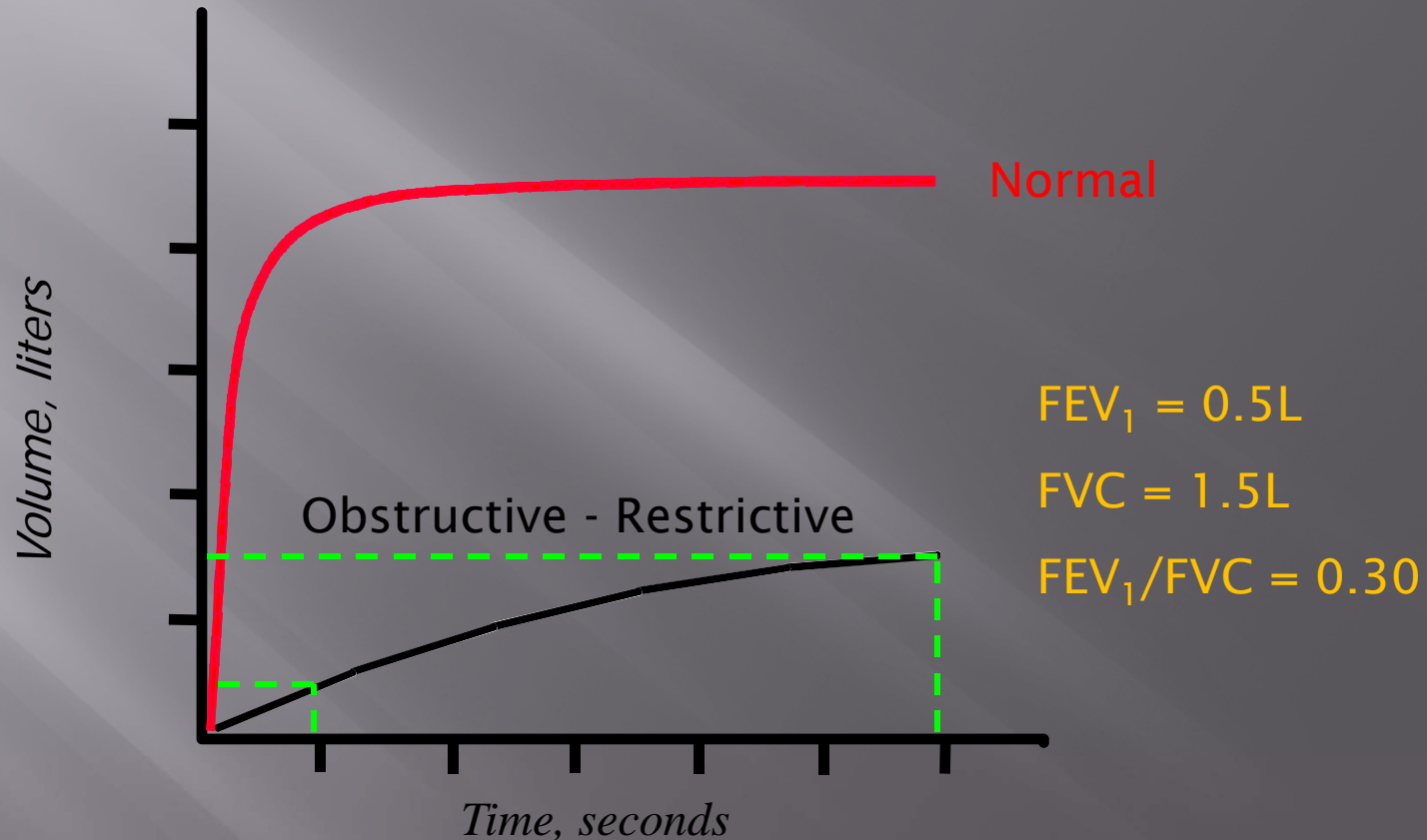


# Spirometry: Restrictive Disease





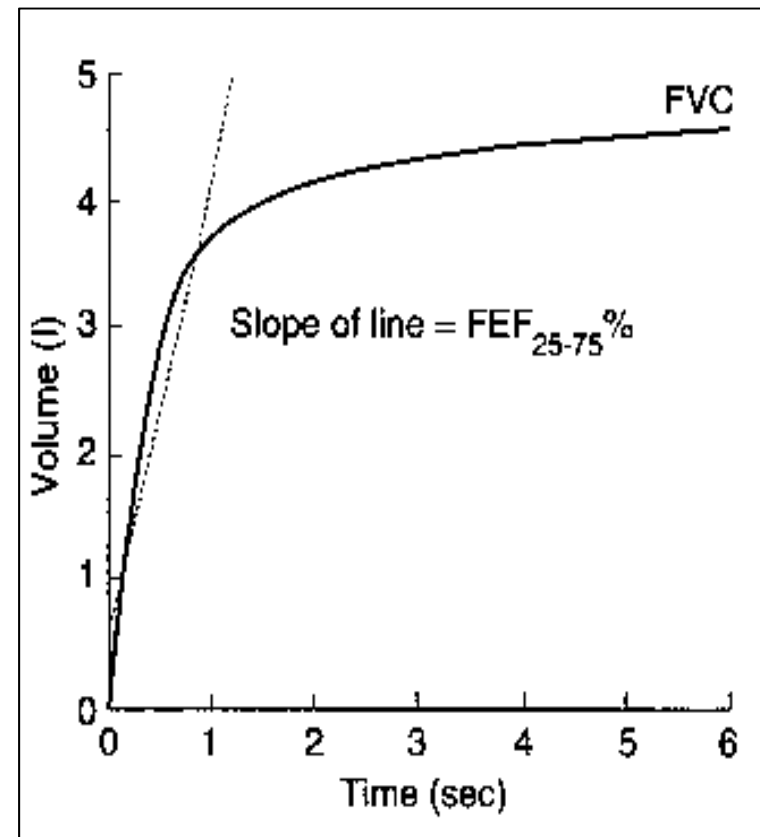
# Mixed Obstructive and Restrictive



Restrictive and mixed obstructive-restrictive are difficult to diagnose by spirometry alone; full respiratory function tests are usually required (e.g., body plethysmography, etc)

# Forced midexpiratory flow 25-75% ( $FEF_{25-75}$ )

- Max. Flow rate during the mid-expiratory part of FVC maneuver.
  - Measured in L/sec
  - May reflect effort independent expiration and the status of the small airways
  - Highly variable
  - Depends heavily on FVC
- N value – 4.5-5 l/sec. Or 300 l/min.



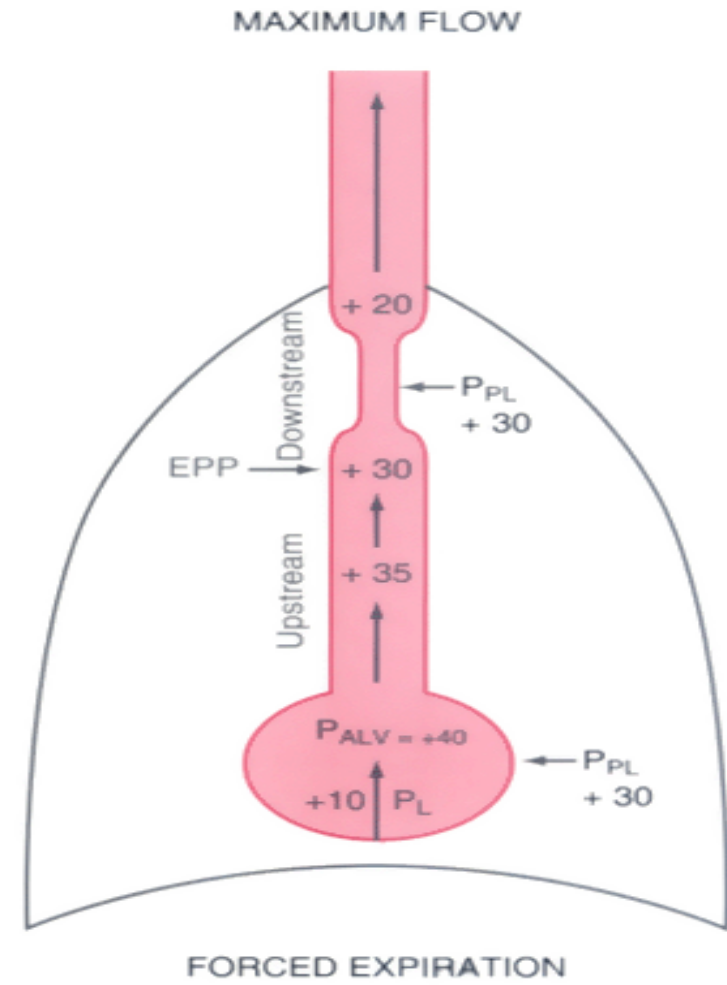
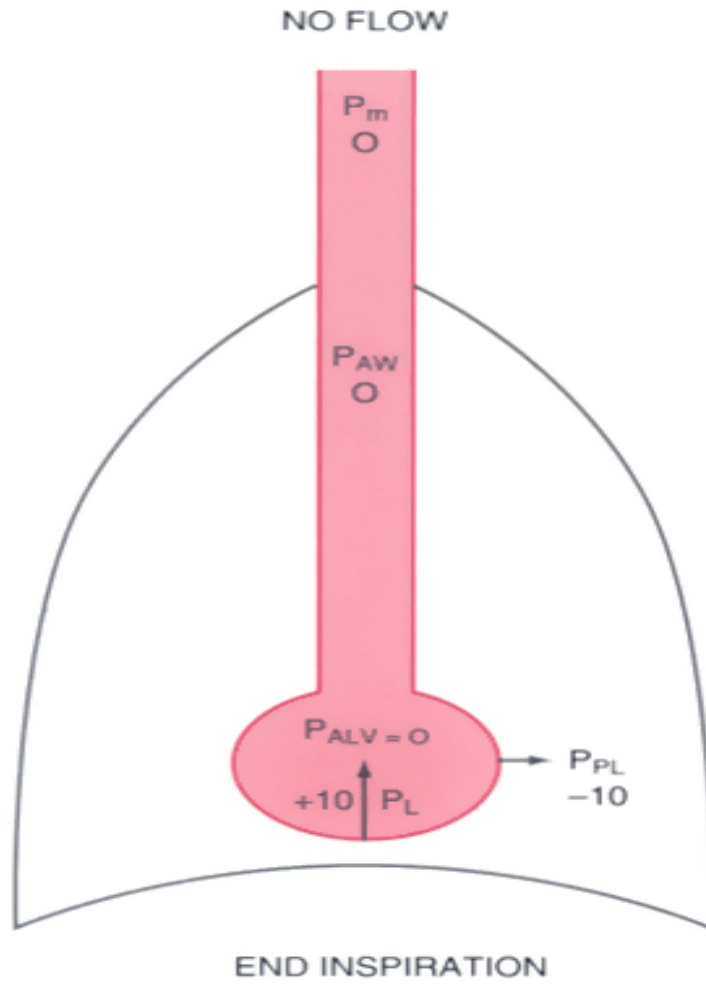


# Forced midexpiratory flow 25-75% (FEF<sub>25-75</sub>)

Interpretation of % predicted:

- >60%                      Normal
- 40-60%                    Mild obstruction
- 20-40%                    Moderate obstruction
- <10%                      Severe obstruction

# DYNAMIC COMPRESSION OF AIRWAY



# EQUAL PRESSURE POINT

- Slowed expiration reduces the decrease in pressure from the alveoli toward the mouth because lower flow requires less driving pressure.
- By this means the point along the airway tree where pressure inside the airway has dropped to below that outside the airway (equal to pleural pressure) is moved toward the mouth
- Thus, slow expiratory flow may make it possible to move the “equal pressure point,” where inside and outside airway pressure is equal, up to the larger airways or the mouth, which will prevent floppy airways from collapsing.



# Peak expiratory flow rates

- Maximum flow rate during an FVC maneuver occurs in initial 0.1 sec
- After a maximal inspiration, the patient expires as forcefully and quickly as he can and the maximum flow rate of air is measured.
- It gives a crude estimate of lung function, reflecting larger airway function.
- Effort dependent but is highly reproducible.

# Peak expiratory flow rates

- It is measured by a **peak flow meter**, which measures how much air (litres per minute) is being blown out or by spirometry
- The peak flow rate in normal adults varies depending on age and height.
- Normal : 450 - 700 l/min in males  
300-500 l/min in females
- Clinical significance - values of <200L/min- impaired coughing & hence likelihood of post-op complication



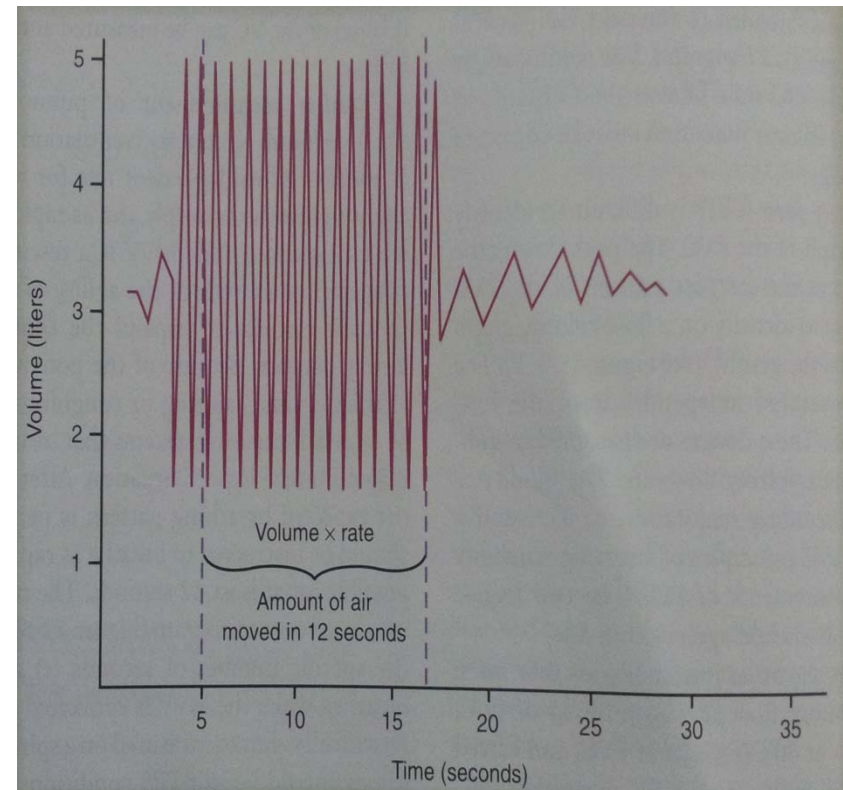
# Maximum Voluntary Ventilation (MVV) or maximum breathing capacity (MBC)

- Measures - speed and efficiency of filling & emptying of the lungs during increased respiratory effort
- Maximum volume of air that can be breathed in and out of the lungs in 1 minute by maximum voluntary effort
- It reflects peak ventilation in physiological demands
- Normal : 150 -175 l/min.
- <80% - gross impairment



# Maximum Voluntary Ventilation (MVV) or maximum breathing capacity (MBC)

- The subject is asked to breathe as quickly and as deeply as possible for 12 secs and the measured volume is extrapolated to 1min.
- MVV is markedly decreased in patients with
  - A. Emphysema
  - B. Airway obstruction
  - C. Poor respiratory muscle strength





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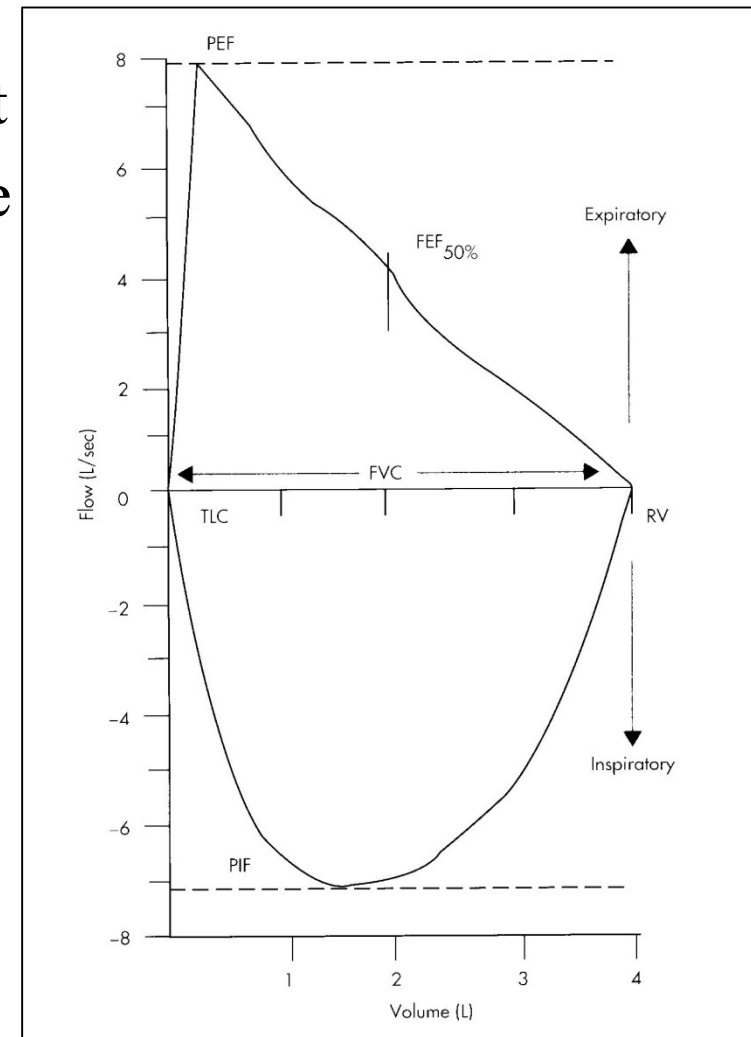


# FLOW VOLUME LOOPS

- ❑ “Spirogram” Graphic analysis of flow at various lung volumes
- ❑ Tracing obtained when a maximal forced expiration from TLC to RV is followed by maximal forced inspiration back to TLC
- ❑ Measures forced inspiratory and expiratory flow rate
- ❑ Augments spirometry results
- ❑ Principal advantage of flow volume loops vs. typical standard spirometric descriptions - identifies the probable obstructive flow anatomical location.

# FLOW VOLUME LOOPS

- First 1/3<sup>rd</sup> of expiratory flow is effort dependent and the final 2/3<sup>rd</sup> near the RV is effort independent
- Inspiratory curve is entirely effort dependent
- Ratio of
  - maximal expiratory flow(MEF) /maximal inspiratory flow(MIF)
  - mid VC ratio and is normally 1

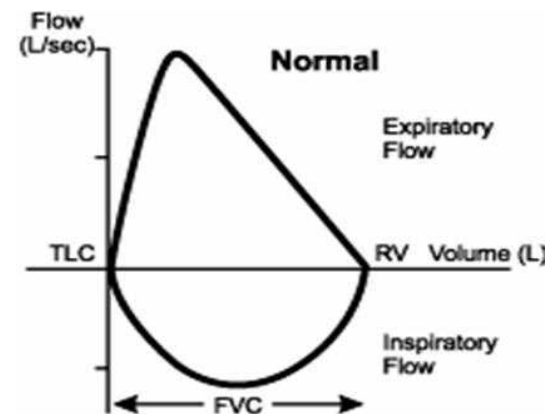
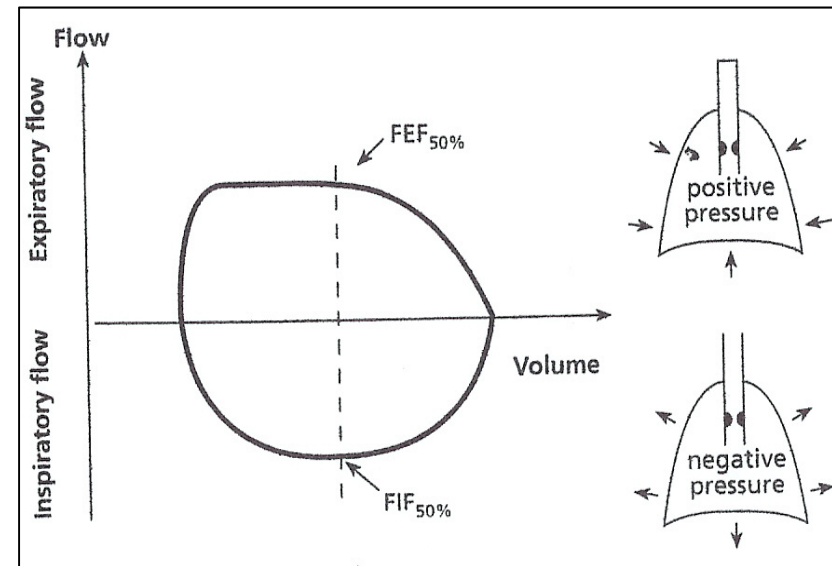


# FLOW VOLUME LOOPS and DETECTION OF UPPER AIRWAY OBSTRUCTION

- Flow-volume loops provide information on upper airway obstruction:

**Fixed obstruction:** constant airflow limitation on inspiration and expiration—such as

1. Benign stricture
2. Goiter
3. Endotracheal neoplasms
4. Bronchial stenosis

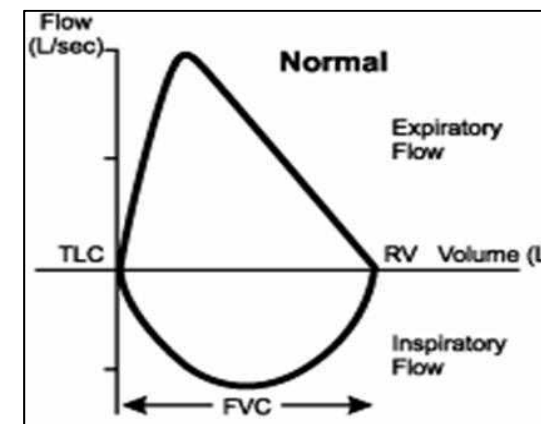
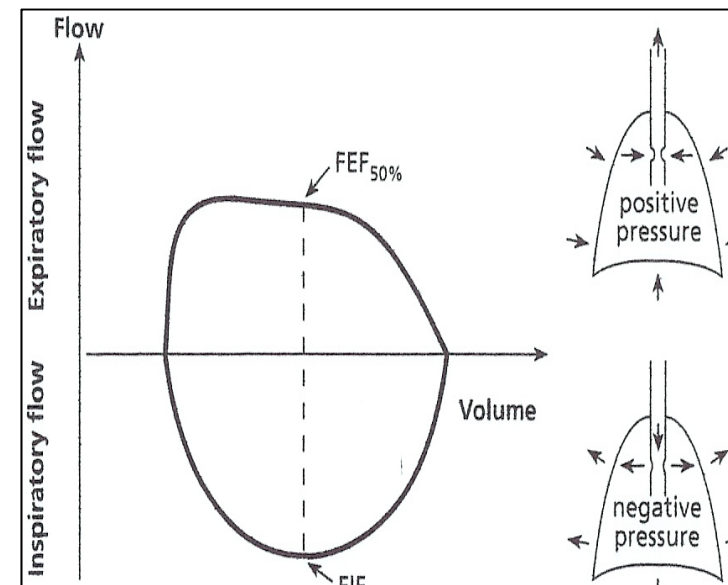


# FLOW VOLUME LOOPS and DETECTION OF UPPER AIRWAY OBSTRUCTION

Variable intrathoracic obstruction: flattening of expiratory limb.

1. Tracheomalacia
2. Polychondritis
3. Tumors of trachea or main bronchus

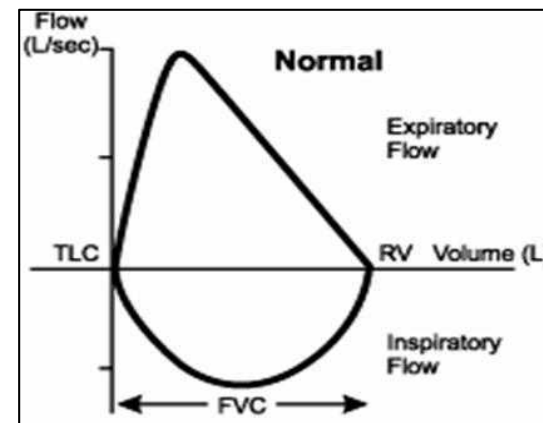
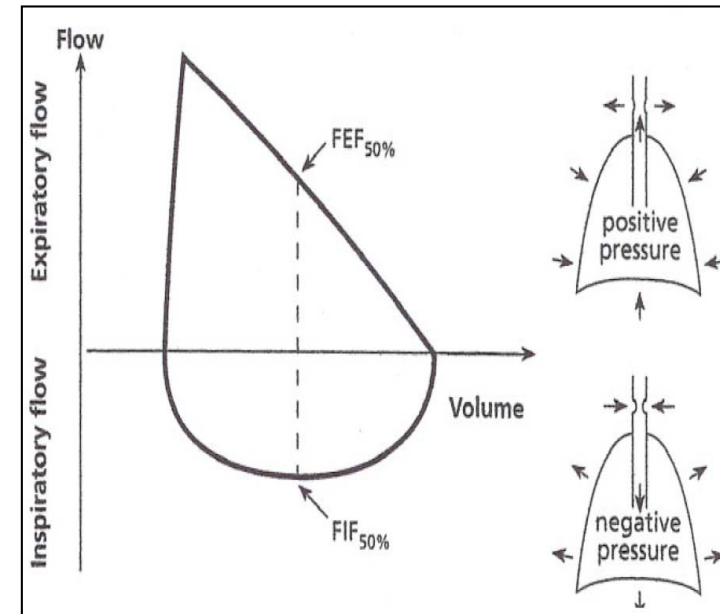
- During forced expiration – high pleural pressure – increased intrathoracic pressure - decreases airway diameter. The flow volume loop shows a greater reduction in the expiratory phase
- During inspiration – lower pleural pressure around airway tends to decrease obstruction



# FLOW VOLUME LOOPS and DETECTION OF UPPER AIRWAY OBSTRUCTION

## Variable extrathoracic obstruction:

1. Bilateral and unilateral vocal cord paralysis
  2. Vocal cord constriction
  3. Chronic neuromuscular disorders
  4. Airway burns
  5. OSA
- Forced inspiration- negative transmural pressure inside airway tends to collapse it
  - Expiration – positive pressure in airway decreases obstruction
  - inspiratory flow is reduced to a greater extent than expiratory flow





# INDEX

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6. **Flow volume loop and lung diseases**
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8. Tests for cardiopulmonary reserve
9. Preoperative assessment of thoracotomy patients





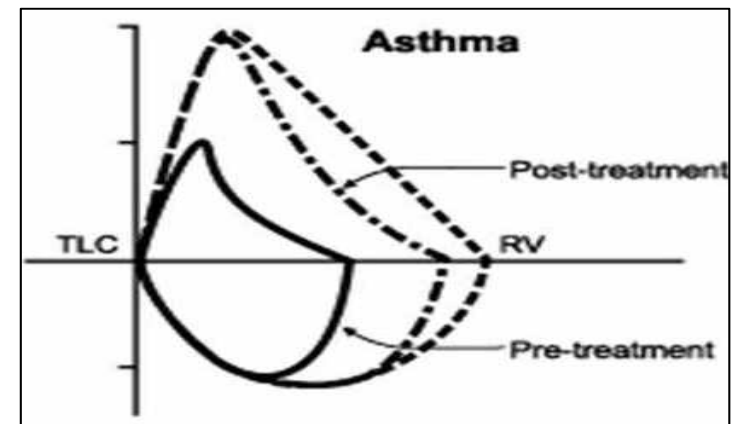
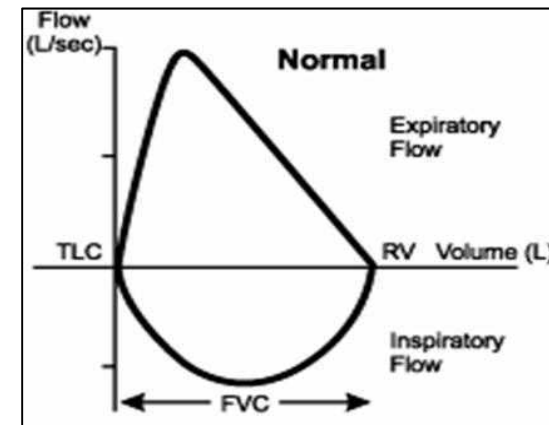
# Obstructive Pattern — Evaluation

Common obstructive lung diseases

- Asthma
- COPD (chronic bronchitis, emphysema)
- Cystic fibrosis

# ASTHMA

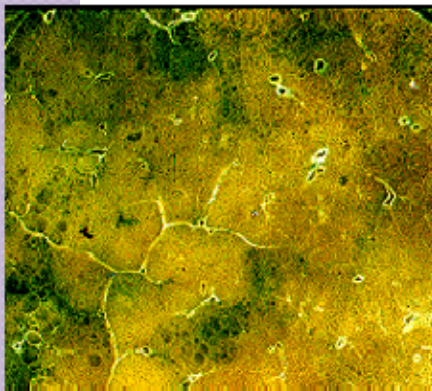
- ❑ Peak expiratory flow reduced so maximum height of the loop is reduced
- ❑ Airflow reduces rapidly with the reduction in the lung volumes because the airways narrow and the loop become concave
- ❑ Concavity may be the indicator of airflow obstruction and may present before the change in FEV1 or FEV1/FVC



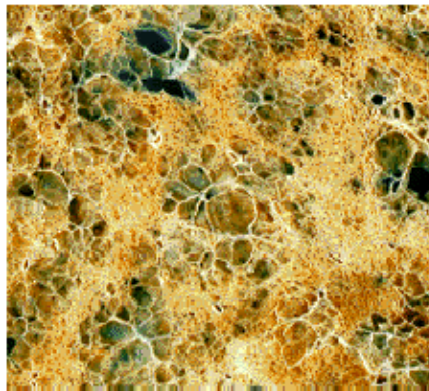


# EMPHYSEMA

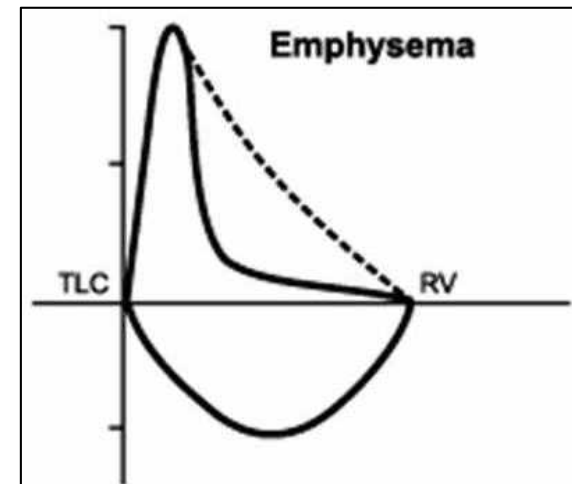
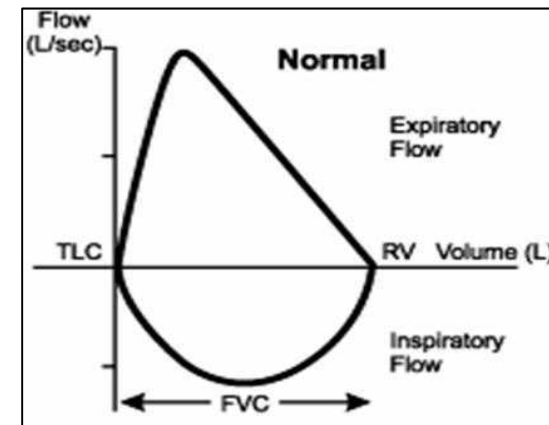
❑ Airways may collapse during forced expiration because of destruction of the supporting lung tissue causing very reduced flow at low lung volume and a characteristic (dog-leg) appearance to the flow volume curve



*Normal Lung - Gross*

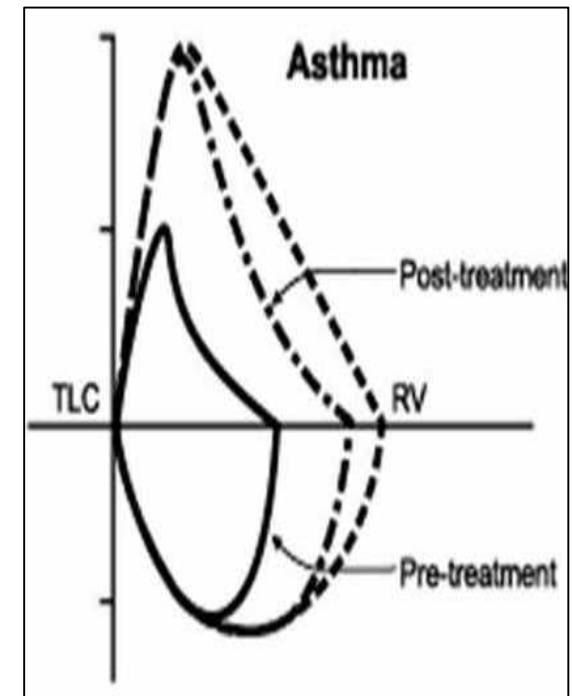


*Emphysematous Lung - Gross*



# REVERSIBILITY

- Improvement in FEV1 by 12-15% or 200 ml in repeating spirometry after treatment with Sulbutamol 2.5mg or ipratropium bromide by nebuliser after 15-30 minutes
- Reversibility is a characteristic feature of B.Asthma
- In chronic asthma there may be only partial reversibility of the airflow obstruction
- While in COPD the airflow is irreversible although some cases showed significant improvement



# RESTRICTIVE PATTERN

Characterized by reduced lung volumes/decreased lung compliance

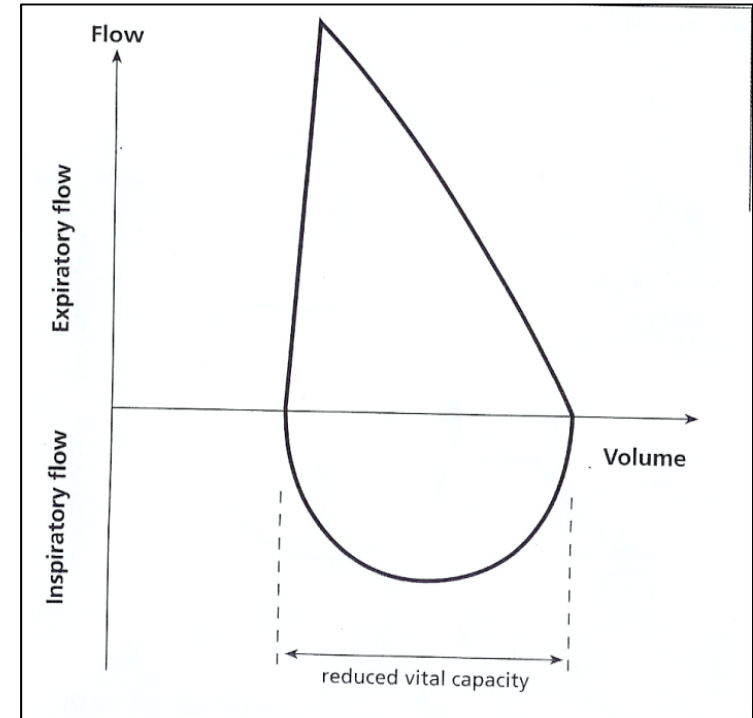
Examples:

- Interstitial Fibrosis
- Scoliosis
- Obesity
- Lung Resection
- Neuromuscular diseases
- Cystic Fibrosis



# RESTRICTIVE PATTERN-flow volume loop

- low total lung capacity
- low functional residual capacity
- low residual volume.
- Forced vital capacity (FVC) may be low; however,  $FEV_1/FVC$  is often normal or greater than
- Peak expiratory flow may be preserved or even higher than predicted leads to tall, narrow and steep flow volume loop in expiratory phase.

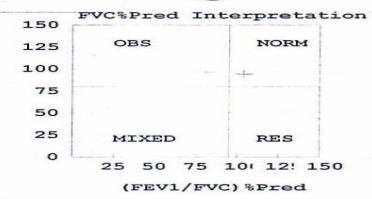
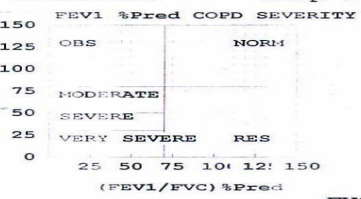
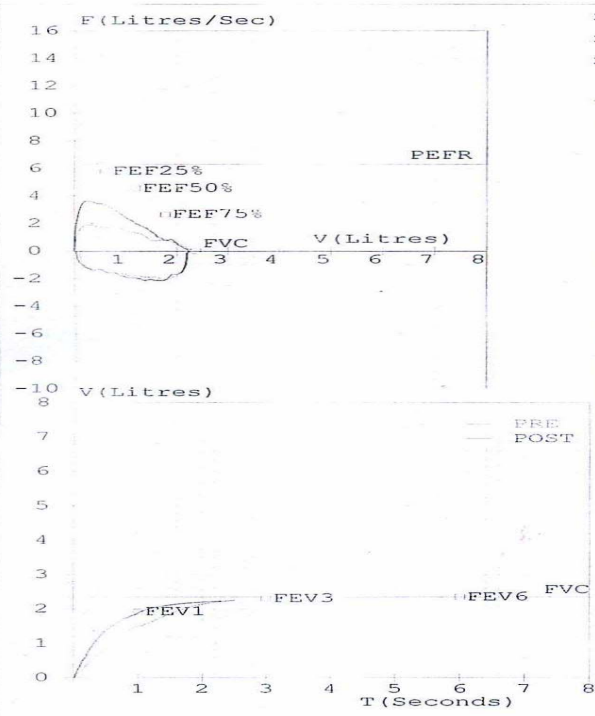




GOVERNMENT MEDICAL COLLEGE & HOSPITAL  
DEPARTMENT OF PULMONARY MEDICINE SECTOR 32 CHANDIGARH

Patient: MEENA  
Refd. By: DR RAHUL  
Pred.Eqns: RECORDERS  
Date : 20-01-2014 01:15 PM

Age : 28 Years Gender : Female  
Height : 155 Cms Smoker : No  
Weight : 47 Kgs Eth. Corr: 100  
ID: 140107366 Temp : degrees



Parameter	Pred	FVC Results			%Imp	
		M. Pre	%Pred	M. Post		
FVC (L)	02.36	02.27	096	02.23	094	-02
FEV1 (L)	01.92	01.50	078	01.89	098	+26
FEV1/FVC (%)	81.36	66.08	081	84.75	104	+28
FEF25-75 (L/s)	02.88	01.18	041	01.92	067	+63
PEFR (L/s)	06.31	01.89	030	03.62	057	+82
FIVC (L)	-----	02.19	---	02.21	---	+01
FEV.5 (L)	-----	00.89	---	01.38	---	+55
FEV3 (L)	02.29	02.27	099	02.23	097	-02
PIFR (L/s)	-----	02.05	---	02.13	---	+04
FEF75-85 (L/s)	-----	00.72	---	00.79	---	+10
FEF.2-1.2 (L/s)	05.25	01.62	031	02.87	055	+77
FEF 25% (L/s)	05.80	01.74	030	03.38	058	+94
FEF 50% (L/s)	04.54	01.35	030	02.21	049	+64
FEF 75% (L/s)	02.64	00.81	031	00.96	036	+19
FEV.5/FVC (%)	-----	39.21	---	61.88	---	+58
FEV3/FVC (%)	97.03	100.00	103	100.00	103	---
FET (Sec)	-----	02.69	---	02.29	---	---
ExptTime (Sec)	-----	00.13	---	00.07	---	---
Lung Age (Yrs)	028	034	121	029	104	-15
FEV5 (L)	02.36	-----	---	-----	---	---
FIF25% (L/s)	-----	02.05	---	02.13	---	+04
FIF50% (L/s)	-----	01.78	---	01.91	---	+07
FIF75% (L/s)	-----	01.46	---	01.48	---	+01

Pre Post COPD Severity  
Restrictive stage COPD as FEV1/FVC >= 70% and FEV1 < 80%  
Post Test COPD Severity  
Test within normal limits

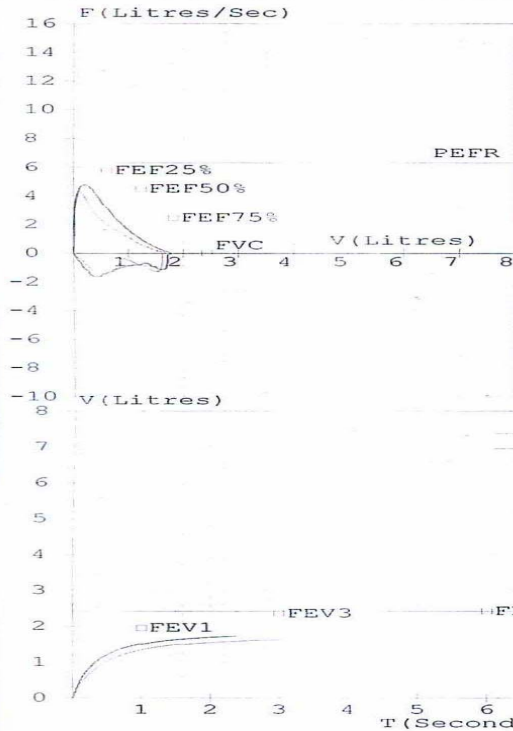
Pre Medication Report Indicates  
Early Small Airway Obstruction as FEF 25-75 %Pred or PEFR %Pred < 70  
Moderate Obstruction as (FEV1/FVC)%Pred < 81 and FVC%Pred > 80  
Post Medication Report Indicates  
Early Small Airway Obstruction as FEF 25-75 %Pred or PEFR %Pred < 70  
Spirometry within normal limits as (FEV1/FVC)%Pred > 97 and FVC%Pred > 80.

MED LAB TECHNOLOGIST

GOVERNMENT MEDICAL COLLEGE & HOSPITAL  
DEPARTMENT OF PULMONARY MEDICINE SECTOR 32 CHANDIGARH

Patient: Neeru  
Refd. By: DR KRANTI  
Pred.Eqns: RECORDERS  
Date : 02-01-2014 01:26 PM

Age : 34 Years Gender : Female  
Height : 158 Cms Smoker : No  
Weight : 58 Kgs Eth. Corr: 100  
ID: 140100522 Temp : degrees



FEV1 %Pred	COPD SEVERITY
125	OBS
100	NORM
75	MODERATE
50	SEVERE
25	VERY SEVERE
0	RES

FVC%Pred	Interpretation
125	OBS
100	NORM
75	MIXED
50	RES
25	
0	

Parameter	Pred	M.Pre%Pred	M.Post	%Pred	%Imp
FVC (L)	02.43	01.66	068	01.76	072
FEV1 (L)	01.94	01.35	070	01.52	078
FEV1/FVC (%)	79.84	81.33	102	86.36	108
FEF25-75 (L/s)	02.76	01.24	045	01.68	061
PEFR (L/s)	06.29	04.26	068	04.71	075
FIVC (L)	-----	01.63	-----	01.77	-----
FEV.5 (L)	-----	01.04	-----	01.22	-----
FEV3 (L)	02.36	01.64	069	01.76	075
PiFR (L/s)	-----	01.44	-----	01.64	-----
FEF75-85 (L/s)	-----	00.41	-----	00.51	-----
FEF.2-1.2 (L/s)	05.05	01.50	030	02.25	045
FEF.25 (L/s)	05.77	02.66	046	03.91	068
FEF.50 (L/s)	04.47	01.48	033	02.00	045
FEF.75 (L/s)	02.45	00.57	023	00.75	031
FEV.5/FVC (%)	-----	62.65	-----	69.32	-----
FEV3/FVC (%)	97.12	98.80	102	100.00	103
PET (Sec)	-----	03.47	-----	02.64	-----
ExptTime (Sec)	-----	00.02	-----	00.04	-----
Lung Age (Yrs)	034	044	129	041	121
FEV6 (L)	02.43	-----	-----	-----	-----
FIF25 (L/s)	-----	00.91	-----	00.67	-----
FIF50 (L/s)	-----	00.38	-----	00.98	-----
FIF75 (L/s)	-----	01.42	-----	01.64	-----

Pre Post COPD Severity  
Restrictive stage COPD as FEV1/FVC >= 70% and FEV1 < 80%  
Post Post COPD Severity  
Restrictive stage COPD as FEV1/FVC >= 70% and FEV1 < 80%

Pre Medication Report Indicates  
Early Small Airway Obstruction as FEF 25-75 < Pred or PEFR %Pred < 70  
Mild Restriction as (FEV1/FVC)%Pred >95 and FVC%Pred >80  
Post Medication Report Indicates  
Early Small Airway Obstruction as FEF 25-75 < Pred or PEFR %Pred < 70  
Mild Restriction as (FEV1/FVC)%Pred >95 and FVC%Pred >80

MED LAB TECHNOLOGIST



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# TESTS FOR GAS EXCHANGE FUNCTION

## **ALVEOLAR-ARTERIAL O<sub>2</sub> TENSION GRADIENT:**

- Sensitive indicator of detecting regional V/Q inequality
- AbN high values at room air is seen in asymptomatic smokers & chr. Bronchitis (min. symptoms)

$$\mathbf{A-a\ gradient = PAO_2 - PaO_2}$$

\* PAO<sub>2</sub> = alveolar PO<sub>2</sub> (calculated from the alveolar gas equation)

\* PaO<sub>2</sub> = arterial PO<sub>2</sub> (measured in arterial gas)



# TESTS FOR GAS EXCHANGE FUNCTION

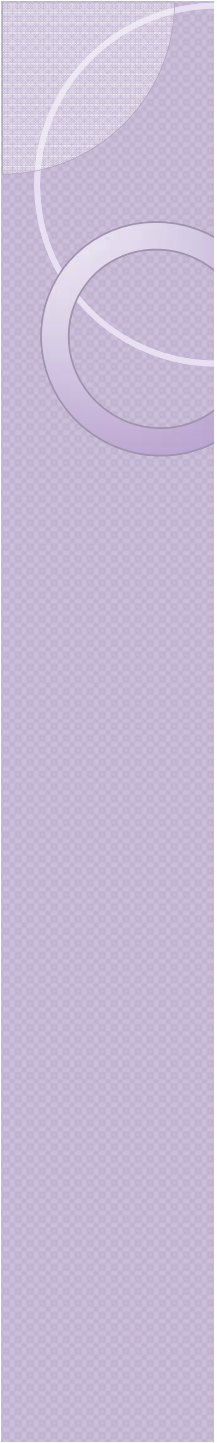
## DIFFUSING CAPACITY

- Rate at which gas enters the blood divided by its driving pressure ( gradient – alveolar and end capillary tensions)
- Measures ability of lungs to transport inhaled gas from alveoli to pulmonary capillaries
- Normal- 20-30 ml/min/mm Hg
- Depends on:
  - thickness of alveolar—capillary membrane
  - hemoglobin concentration
  - cardiac output

# TESTS FOR GAS EXCHANGE FUNCTION

## SINGLE BREATH TEST USING CO

- Pt inspires a dilute mixture of CO and hold the breath for 10 secs.
- CO taken up is determined by infrared analysis:
- $$DLCO = \frac{CO \text{ ml/min/mmhg}}{PACO - PcCO}$$
- $DLO_2 = DLCO \times 1.23$
- Why CO?
  - A) High affinity for Hb which is approx. 200 times that of O<sub>2</sub> , so does not rapidly build up in plasma
  - B) Under N condition it has low bld conc  $\approx 0$
  - C) Therefore, pulm conc.  $\approx 0$

- 
- The DLCO is low in ILD, but normal in disorders of pleura, chest and neuromuscular disorder causing restrictive lung function.
  - DLCO is also useful for following the course of or response to therapy in ILD.

# FACTORS AFFECTING DLCO

<b>DECREASE(&lt; 80% predicted)</b>	<b>INCREASE(&gt; 120-140% predicted)</b>
Anemia	Polycythemia
Carboxyhemoglobin	Exercise
Pulmonary embolism	Congestive heart failure
Diffuse pulmonary fibrosis	
Pulmonary emphysema	

Predicted DLCO for Hb= Predicted DLCO \* (1.7 Hb/10.22 + Hb)



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# CARDIOPULMONARY INTERACTION

- **Stair climbing and 6-minute walk test**
- This is a simple test that is easy to perform with minimal equipment. Interpreted as in the following table:

Performance	VO <sub>2</sub> max(ml/kg/min)	Interpretation
>5 flight of stairs	> 20	Low mortality after pneumonectomy, FEV <sub>1</sub> >2l
>3 flight of stairs		Low mortality after lobectomy, FEV <sub>1</sub> >1.7l
<2 flight of stairs		Correlates with high mortality
<1 flight of stairs	<10	
6 min walk test <600 m	<15	

# CARDIOPULMONARY INTERACTION

- **Shuttle walk**
- The patient walks between cones 10 meters apart with increasing pace.
- The subject walks until they cannot make it from cone to cone between the beeps.
- Less than 250m or decrease SaO<sub>2</sub> > 4% signifies high risk.
- A shuttle walk of 350m correlates with a VO<sub>2</sub> max of 11ml.kg<sup>-1</sup>.min<sup>-1</sup>





# Cardiopulmonary Exercise Testing

- ❑ Non invasive technique :cycling or treadmill
- ❑ To test ability of subjects physiological response to cope with metabolic demands
- ❑ CPET involves the measurement of respiratory gas exchange: oxygen uptake carbon dioxide output, and minute ventilation
- ❑ In addition- monitor electrocardiography, blood pressure and pulse oximetry,

# Basic Physiological Principles

- Exercising muscle gets energy from 3 sources- stored energy (creatine phosphate), aerobic metabolism of glucose, anaerobic metabolism of glucose
- In exercising muscle when oxygen demand exceeds supply- lactate starts accumulating- lactate anaerobic threshold ( LAT)
- With incremental increase in exercise – expired minute volume, oxygen consumption per minute, CO<sub>2</sub> production per minute increases
  - Anaerobic threshold ( $> 11$  ml/kg/min)
  - Maximum oxygen utilization VO<sub>2</sub> ( $>20$ ml/kg/min)



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# Assessment of lung function in thoracotomy pts

- As an Anesthesiologist our goal is to :
  - 1) To identify pts at risk of increased post-op morbidity & mortality
  - 2) To identify pts who need short-term or long term post-op ventilatory support.

Lung resection may be f/by – inadequate gas exchange, pulm HTN & incapacitating dyspnoea.

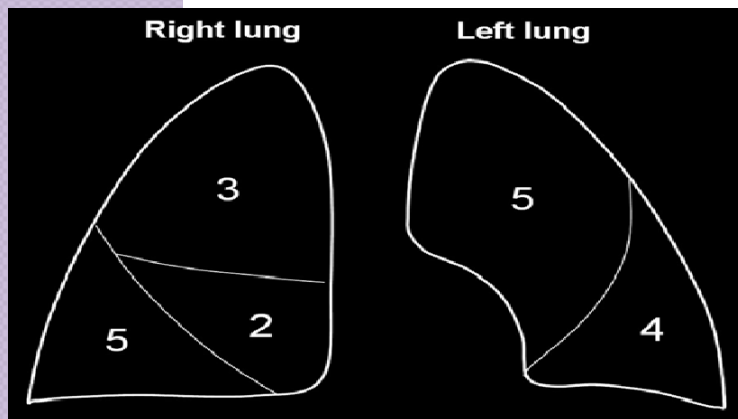
# Assessment of lung function in thoracotomy pts

## Calculating the predicted postoperative FEV1 (ppoFEV1) and DLCO (ppoDLCO):

There are 5 lung lobes containing 19 segments in total with the division of each lobe.

$$\text{Ppo FEV1} = \text{preoperative FEV1} * \frac{\text{no. of segments left after resection}}{19}$$

- Can be assessed by ventilation perfusion scan. For eg:



A 57-year-old man is booked for lung resection. His CT chest show a large RUL mass confirmed as carcinoma:  
 $\text{ppoFEV1} = 50 * 16 / 19 = 42\%$

# Assessment of lung function in thoracotomy pts

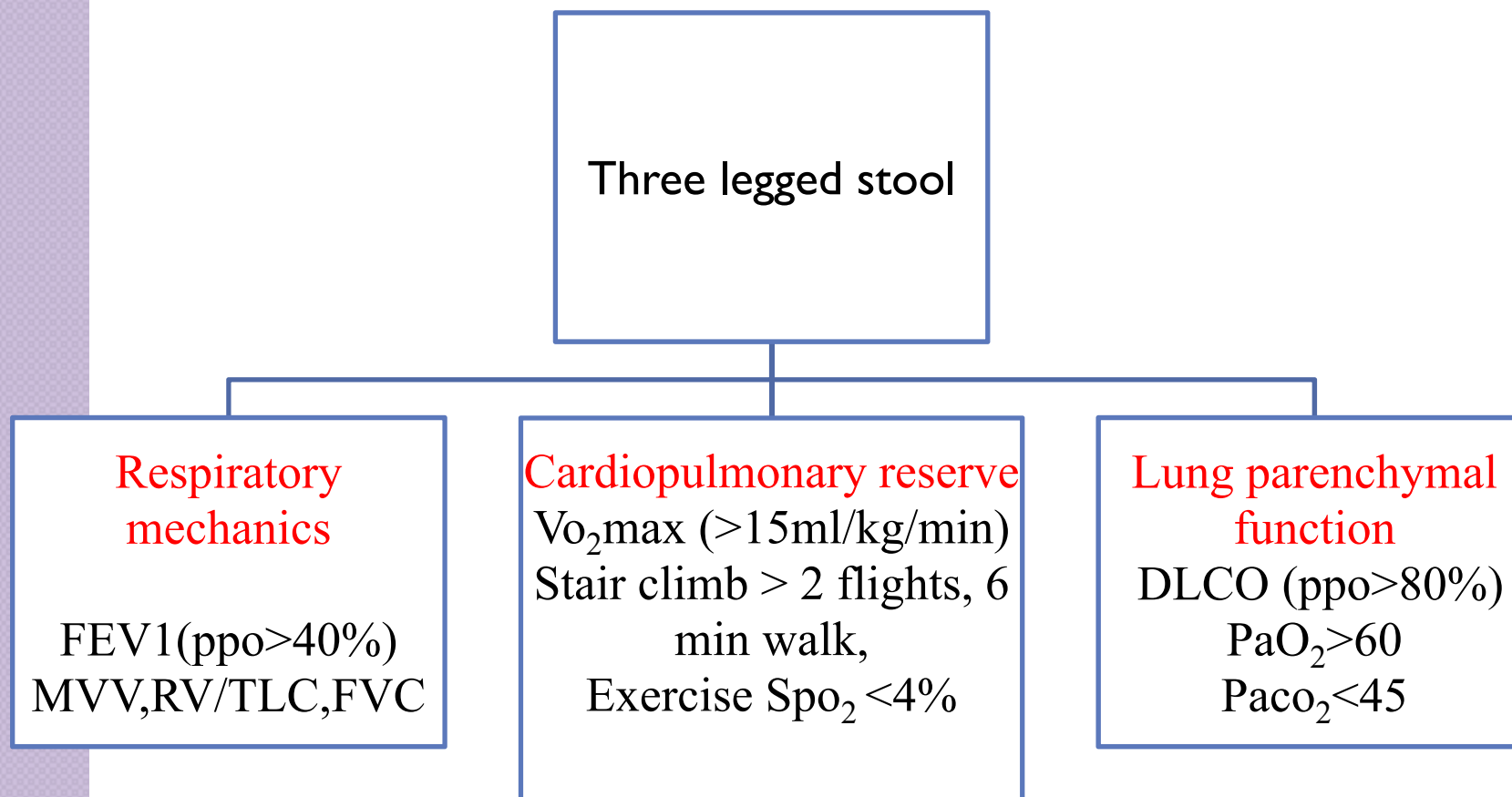
ppoFEV1(% predicted)	Interpretation
> 40	No or minor respiratory complications anticipated
< 40	Likely to require postoperative ventilation/increased risk of death/complication
< 30	Non surgery management should be considered

ppoDLCO(% predicted)	Interpretation
> 40,ppoFEV1> 40%,SaO2>90% on air	Intermediate risk , no further investigation needed
< 40	Increased respiratory and cardiac morbidity
< 40 and ppoFEV1<40%	High risk- require cardiopulmonary exercise test

## Combination tests


- There is no single measure that is a 'Gold standard' in predicting post-op complications





## Pulmonary function criteria suggesting increased risk of post-operative pulmonary complications for various surgeries

Parameters	Abdominal	Thoracic
FVC	< 70 % predicted	< 2 lit. or < 70% predicted
FEV1	< 70 % predicted	< 2 lit. – pneumonectomy < 1 lit. – lobectomy < 0.6 lit. – wedge or segmentectomy
FEV1/FVC	< 65 % predicted	< 50 % predicted
FEF 25-75 %	< 50 % predicted	< 1.6 lit. – pneumonectomy < 0.6 lit.- lobectomy/segmentectomy
MVV/MBC	< 50 % predicted	< 50 % predicted
PaCO <sub>2</sub>	> 45 mm Hg	> 45 mm Hg

- 
- They act only to support or exclude a diagnosis.
  - A combination of a thorough history and physical exam, as well as supporting laboratory data and imaging is helpful in developing a anaesthetic plan for pt with pulmonary dysfunction.



***THANK YOU***