

PRACTICAL APPLICATIONS OF PULMONARY FUNCTION TESTS



MODERATOR : DR.G.P SINGH
PRESENTERS : DR.SWATI
AGGARWAL

PONNAPPAN

DR.KARTHIK

DR.JOKHOORAM

GOALS OF PREOPERATIVE PULMONARY EVALUATION

1. To predict likelihood of pulmonary complications
2. Obtain quantitative baseline information which can help in decision making
3. Identify patients who may benefit from ???
bronchodilator therapy
4. To ascertain predictive benefit in pneumonectomy patients

INDICATIONS OF PRE-OP SPIROMETRY

Patient

- Known pulmonary dysfunction
- Currently smoking, especially if >1 pack per day
- Chronic productive cough
- Recent respiratory infection
- Advanced age
- Obesity $>30\%$ over ideal weight
- Thoracic cage deformity, such as kyphoscoliosis
- Neuromuscular disease, such as amyotrophic lateral sclerosis or myasthenia gravis

Procedure

- Thoracic or upper abdominal operation
- Pulmonary resection
- Prolonged anesthesia

Contraindications for Spirometry

- Recent myocardial infarction
- Unstable angina
- Recent thoraco abdominal surgery
- Recent ophthalmic surgery
- Thoracic / Abdominal / Cerebral aneurysm
- Pneumothorax

WHAT TESTS SHOULD BE DONE....???

Preoperative pulmonary evaluation must include:

1. History & physical examination
2. Chest x rays
3. ABG : chronic hypoxemics :- to guide ventilatory management goals
4. Screening spirometry
5. Maximum voluntary ventilation
6. DLCO
7. Quantitative radionuclide scintigraphy
8. Maximum cardiopulmonary exercise studies

EFFECTS OF ANESTHESIA AND SURGERY ON LUNG VOLUMES

- TLC : decreases after abdominal surgery
- VC: 25 to 50 % decrease within 1-2 days
postop , returns to normal in 1-2 weeks
- RV : increases by 13 %
- ERV :decreases by 25% after LAS
60% after UAS & thoracic Surg
- TV :decreases by 20% within first 24 hours
returns to normal within 2 weeks
- Pulmonary Compliance : Decreases by 33%

APPLIED ASPECTS OF SOME LUNG CAPACITIES

VITAL CAPACITY

It reflects the patients ability to take

- Deep breath
- Cough
- Clear excessive secretions
- Vital capacity may be reduced by :
 - a. Alterations in muscle power
 - b. Pulmonary disease
 - c. Abdominal tumors (* pregnancy)
 - d. Abdominal pain
 - e. Abdominal splinting
 - f. Alterations in posture

POSITION	LOSS OF VITAL CAPACITY (in percent)
Tredelenburg	14.5
Lithotomy	18
Left lateral	10
Right lateral	12
Bridge in dorsal	12.5
Prone position , unsupported	10

During anesthesia vital capacity reductions are of little significance , during controlled ventilation lungs feel stiff .

It evaluates patient condition for weaning from ventilator should be >10-15 ml/kg of body weight

Importance in post op period :

(if VC falls about $3 \times TV$ - artificial help may be needed to clear secretions)

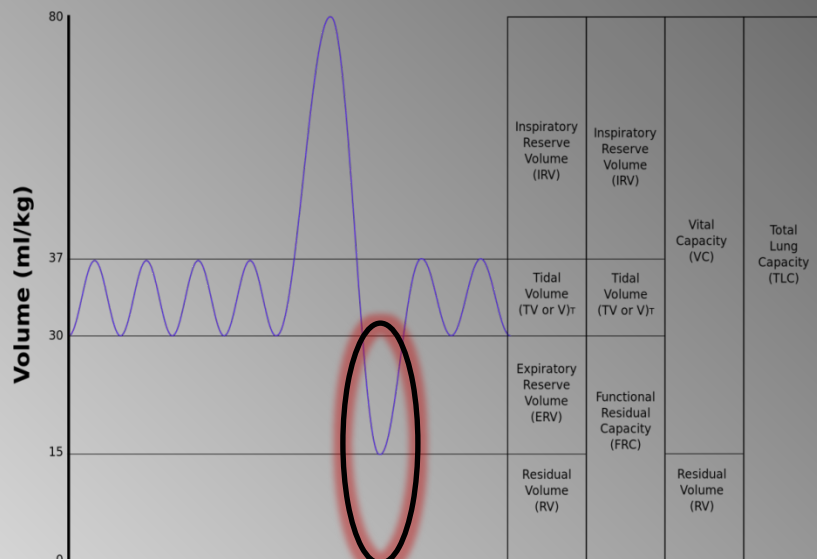
RESIDUAL VOLUME

Depends on limits of chest wall expansion and small airways collapse

Any increase in it signifies lung is larger than usual and cannot empty adequately occurs in

- After thoracic operations
- OAD

FUNCTIONAL RESIDUAL CAPACITY



Normally FRC is 40-50% of the TLC (30ml/kg IBW)

FRC determines two primary physiologic functions

1. **the elastic pressure-volume relationships within the lung.**
At FRC chest wall and the lung are in equilibrium with each other

It greatly influences ventilation-perfusion relationships within the lung (when FRC is reduced, oxygen reserve when apnea occurs, venous admixture increases & results in arterial hypoxemia , mechanism can be understood by its relationship with closing capacity)

FACTORS AFFECTING FRC

INCREASE

1. Age
2. OAD
3. Position

DECREASE

4. Age
5. Position
6. RLD
7. Anesthetic agents
8. Post operative period : upper abdominal : 40-50 %
Lower abdominal n thoracic : 30 %
Other : 15 - 20 %

Maximum Voluntary Ventilation (MVV)

The subject is instructed to breathe as hard and fast as possible for 10 to 15 seconds. The result is extrapolated to 60 seconds and reported in liters per minute.

A low MVV can occur in obstructive disease, in restrictive disease, in neuromuscular disease, in heart disease, in a patient who does not try or who does not understand, or in a frail patient.

- **MVV measures the endurance of the ventilatory muscles and indirectly reflects lung-thorax compliance and airway resistance**

Maximum Voluntary Ventilation (MVV)

- **MVV is the best ventilatory endurance test that can be performed in the laboratory. Values that vary by as much as 30% from predicted values may be normal, so only large reductions in MVV are significant**
- **Healthy, young adults average ~170 L/min. Values are lower in women and decrease with age in both sexes**
- **Because this manoeuvre exaggerates air trapping and exerts the ventilatory muscles, MVV is decreased greatly in patients with moderate-to-severe obstructive disease**
- **MVV is usually normal in patients with restrictive**

PFT IN THORACIC SURGERIES

Three Goals :

1. Identify the patient at risk of increased postoperative morbidity and mortality
2. Identify patients who will need short term or long term post-op ventilatory support
3. To evaluate beneficial effect and reversibility of airway obstruction with use of bronchodilators

The 3 aspects of respiratory function need to be assessed pre operatively and these form a 3 legged stool :

- Lung Mechanics
- Lung parenchymal function
- Cardiopulmonary Interaction

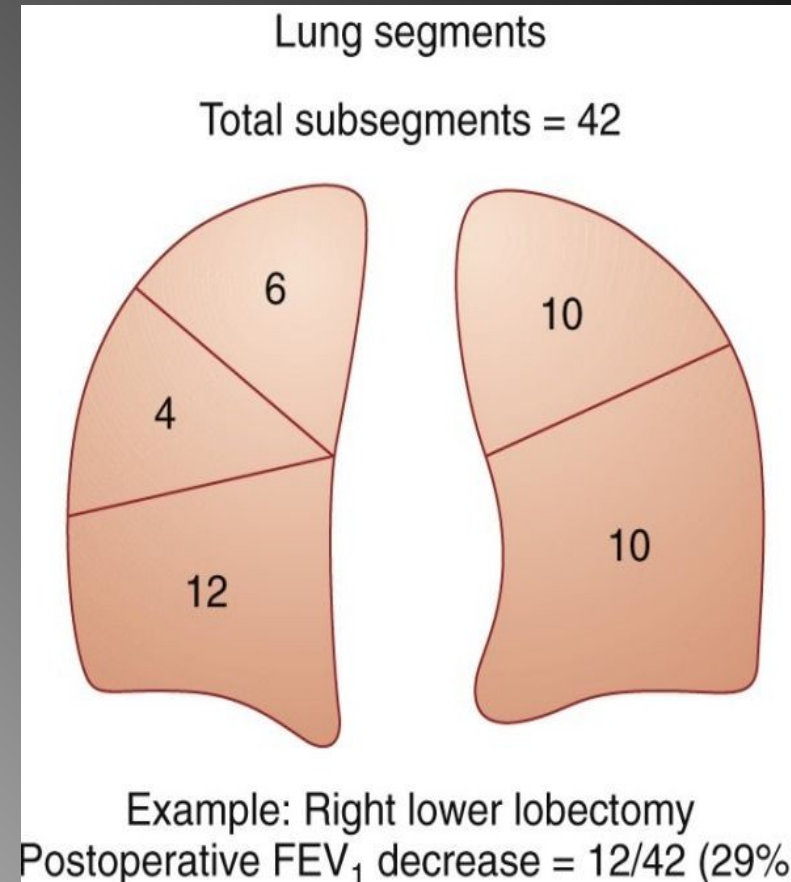
1. RESPIRATORY MECHANICS

- Many tests correlate with post thoracotomy outcome :- FEV1, FVC, MVV, RV/TLC
- Most important of these is predicted post operative (PPO) FEV1
- $\text{PPO FEV1} = \text{preop FEV1 \%} * (1 - \text{no of subsegments removed} / 42)$

> 40% ~ low risk

30 to 40 % ~ moderate risk

< 30% ~ high risk



2. LUNG PARENCHYMAL FUNCTION

The lungs ability to exchanger O₂ and CO₂ between pulmonary vascular bed and alveoli is assessed by :

1.ABG : cut offs PaO₂ < 60 mmHg, PaCO₂ > 45 mmHg , the patients who do not meet these warning criterias are at increased risk

2.DLCO : correlates with total functioning cross sectional area of alveolar capillary interface, corrected DLCO can be used to calculate post transection DLCO

ppoDLCO <40 % - correlates with increased respiratory and cardiac complications

<20 %- unacceptably high periop mortality rate

3. CARDIOPULMONARY INTERACTION

- **Laboratory exercise testing - gold standard**
- **Maximal O₂ Consumption (VO_{2max}) - most useful predictor of post-thoracotomy outcome**
- **Stair climbing**
 - **1 flight means 20 steps with 6 inches/step**
 - **5 flights - VO_{2max} > 20 mL/kg/min**
 - **2 flights - VO_{2max} > 12 mL/kg/min**

- **6MWT - 6 Minute Walk Test**
 - **Less than 2000 feet (610 m) correlates to $\text{VO}_{2\text{max}} < 15 \text{ mL/kg/min}$**
- **Fall in SpO_2 more than 4 % during exercise**
- **Estimated $\text{ppoVO}_{2\text{max}} < 10 \text{ mL/kg/min}$ is an absolute contraindication for pulmonary resection**

V/Q SCINTIGRAPHY

- **Assessment of preoperative contribution of lobe or lung resected**
- **For any patient whose preoperative FEV1 and/or less than 80%**

Postthoracotomy anesthetic management:

Predicted postoperative FEV₁ (ppoFEV₁ %)

>40%

Extubate in operating room if:
patient AWaC
(alert, warm, and comfortable)

30%–40%

Consider extubation based on:
Exercise tolerance
DLCO
 $\dot{V}/\dot{Q}$ scan
Associated diseases

<30%

Staged weaning from mech. ventilation
Consider extubation if >20% plus:
Thoracic epidural analgesia

APPROACH TO PFT

Spirometry is an effort dependent test therefore it is important to ensure that subject gives his best while performing this test

Way of doing this is to look at the acceptability and repeatability criteria

ACCEPTABILITY

1. No inadequate inspiratory effort
2. No slow / hesitated start
3. No cough
4. No poor effort
5. No early termination (i.e FET $\geq$ 6 seconds)
6. No glottic closure / obstruction of mouth piece due to tongue

REPEATABILITY

Difference between two best FEV1 and FVC must show minimum variability. It should be within 200 ml

HOW MANY BLOWS.....????

- Atleast 3 acceptable / repeatable readings
- Upto maximum of 8 blows are needed

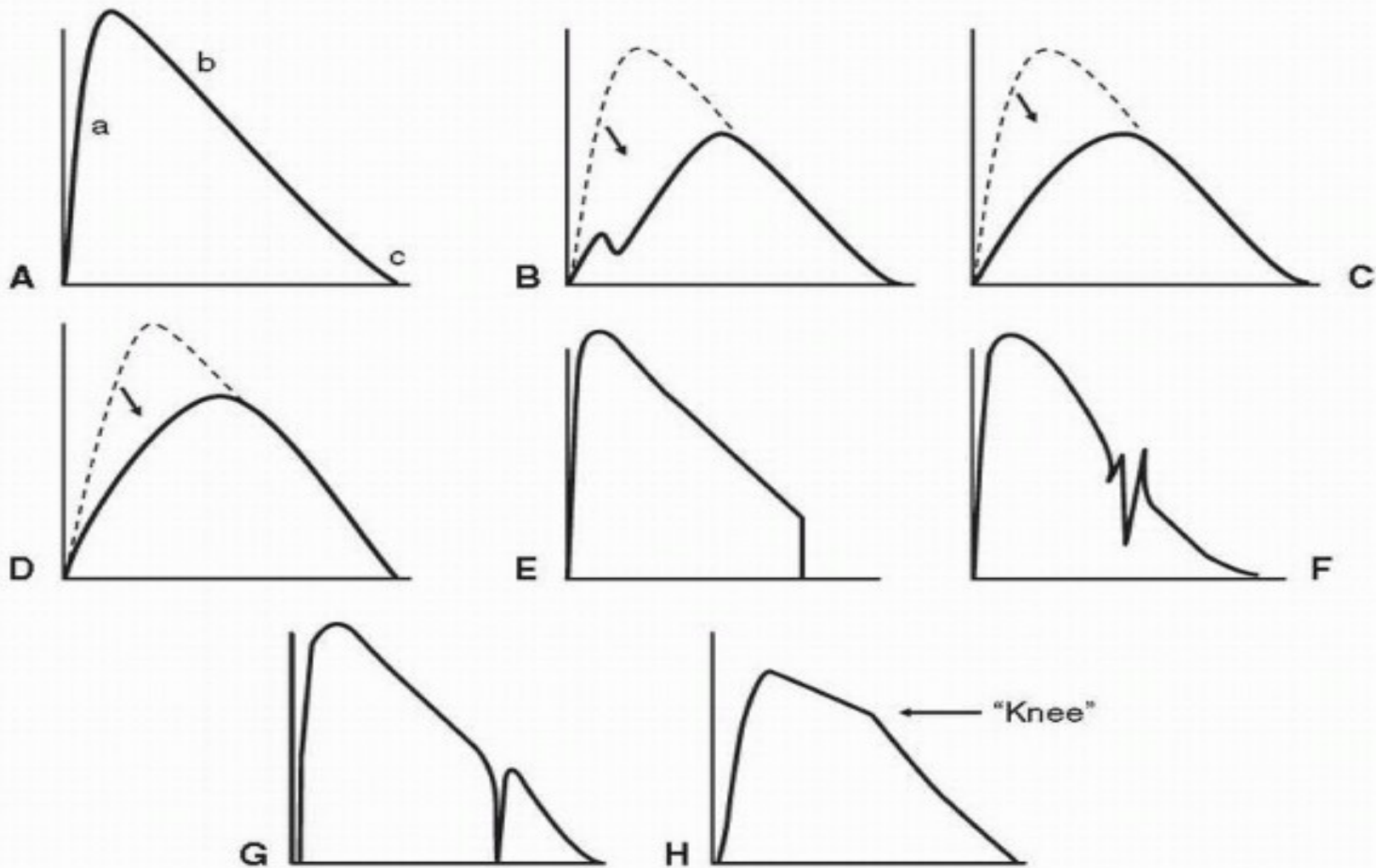
CUT OFF VALUES

FVC >80%

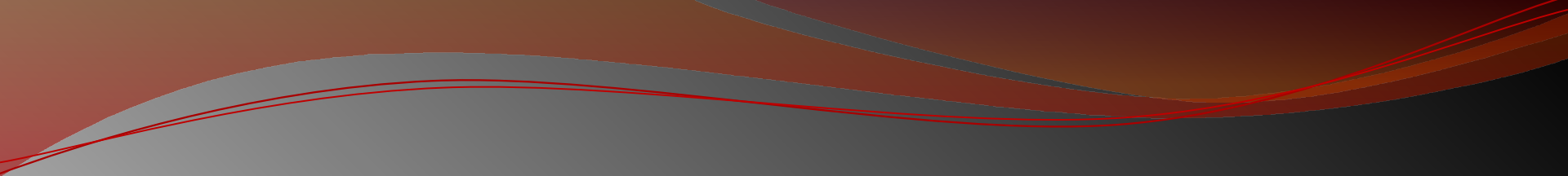
FEV1 >70%

FEV1/ FVC >80 %

FEF25 - 75 > 60 %



Any suboptimal test must be interpreted with caution because it may suggest the presence of disease when none exists



STEPS FOR PFT INTERPRETATION

Step 1 *SPIROMETRY INTERPRETATION*

Look at the flow-volume curve, the FVC, and the FEV₁/FVC ratio:

- Does the curve suggest obstruction, restriction
- Is the FEV₁/FVC ratio reduced < 70 % - Obstruction
- If the FEV₁/FVC ratio is normal and the TLC is below the lower limit of normal → restriction
- Examine expiratory flow values FEF 25-75% : indicator of early airway obstruction
- Bronchodilator response is positive if either the FEV₁ or FVC increases $\geq 12\%$ and ≥ 200 mL.



Morgan Scientific, Inc
PULMONARY ASSOCIATES

151 Essex Street.
Haverhill, MA 01832
TEL: (978) 521-4440
FAX: (978) 531-4445

Name: **Morgan E. Davis**

ID: **008**

DOB: **11/12/1954**

Height: **75 in**

Race: **W**

PHN #: **456**

Age: **57**

Gender: **M**

BMI: **28.3**

Pack yrs: **68**

Referred by:

Date & Time: **05/10/2012**

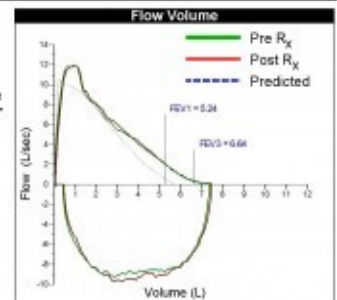
Test Site:

Technician: **Patrick Morgan**

Interpreted By: **Colin D. Chapman, M.D.**

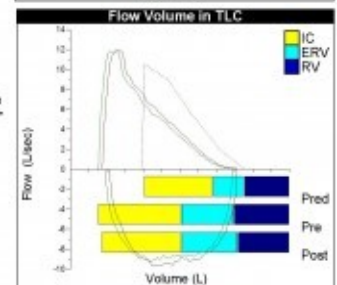
Dynamic Spirometry

		Predicted	Pre Bronchodilator Actual	% Pred	Post Bronchodilator Actual	% Pred	% Change
FVC	L	5.67	7.38	130	7.46	132	1
FEV ₁	L	4.31	5.24	122	5.36	124	2
FEV ₁ / FVC	%	76	71	---	72	---	---
FEF ₂₅₋₇₅ [ISO]	L/s	3.55	3.62	102	3.93	111	9
FEF ₅₀ [ISO]	L/s	5.34	4.36	82	4.72	88	6
FEV ₆	L	5.44	7.13	131	7.23	133	1
PEFR	L/s	10.50	12.02	114	11.94	114	-1
PIFR	L/s	7.00	9.28	133	9.70	139	5



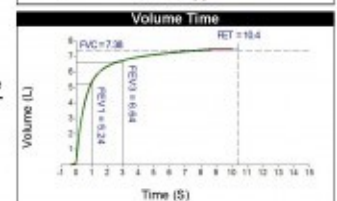
Lung Volumes (by Plethysmography)

		Predicted	Pre Bronchodilator Actual	% Pred	Post Bronchodilator Actual	% Pred	% Change
TLC	L	7.96	10.48	132	10.30	129	-2
SVC	L	5.51	7.43	135	---	---	---
IC	L	3.77	4.66	121	4.40	117	-4
FRC	L	4.20	5.92	141	5.90	140	0
ERV	L	1.74	2.87	165	3.06	176	7
RV	L	2.46	3.06	124	2.84	115	-7
RV/TLC	%	32	29	91	28	88	-3



Plethysmography

		Predicted	Pre Bronchodilator Actual	% Pred	Post Bronchodilator Actual	% Pred	% Change
Raw	cmH2O/	0.99	1.11	112	1.13	114	2
Gaw	cmH2O/	1.01	0.90	89	0.89	88	-1
sRaw	L/s/cmH	---	6.61	---	6.83	---	3
sGaw	L/s/cmH	0.24	0.15	62	0.15	62	0



PF Reference: Spirometry (3-5yrs): Eigen/Bieler, (6-7yrs): Dockery/Weng, (8-80yrs): NHANESIII & Knudson; Lung Volumes: Crapo; DLCO: Cotes

Calibration Date: 05/10/2012

Calibration Data: Temp: 24°C PBar: 756mmHg BTPS: 1.086

Patient: Davis, Morgan E.

Test Date: 05/10/2012

Page: 1 of 7

Step 2 *FLOW-VOLUME CURVE*

Gives clues about the presence of obstruction or restriction.

Gives clues about unusual conditions, such as the following:
central airway obstructive process ,
Neuromuscular weakness



Morgan Scientific, Inc
PULMONARY ASSOCIATES

151 Essex Street.
Haverhill, MA 01832
TEL: (978) 521-4440
FAX: (978) 531-4445

Name: **Morgan E. Davis**

ID: **008**

DOB: **11/12/1954**

Age: **57**

Height: **75 in**

Weight: **225 lb**

Race: **W**

Smoker: **S**

PHN #: **456**

Gender: **M**

BMI: **28.3**

Pack yrs: **68**

Referred by:

Date & Time: **05/10/2012**

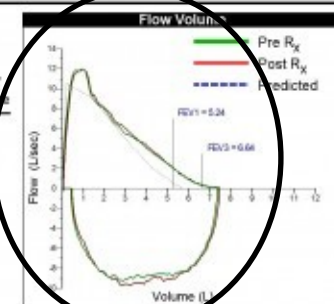
Test Site:

Technician: **Patrick Morgan**

Interpreted By: **Colin D. Chapman, M.D.**

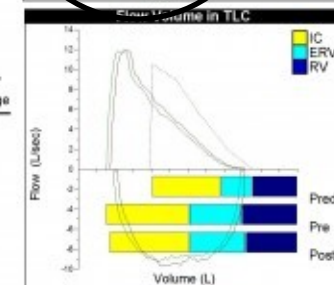
Dynamic Spirometry

			Pre Bronchodilator			Post Bronchodilator		
			Predicted	Actual	% Pred	Actual	% Pred	% Change
FVC	L	5.67	7.38	130	7.46	132	1	
FEV ₁	L	4.31	5.24	122	5.36	124	2	
FEV ₁ / FVC	%	78	71	---	72	---		
FEF ₂₅₋₇₅ [ISO]	L/s	3.55	3.62	102	3.93	111	9	
FEF ₅₀ [ISO]	L/s	5.34	4.36	82	4.72	88	6	
FEV ₆	L	5.44	7.13	131	7.23	133	1	
PEFR	L/s	10.50	12.02	114	11.94	114	-1	
PIFR	L/s	7.00	9.28	133	9.70	139	5	



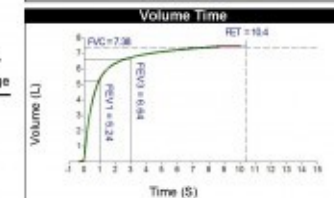
Lung Volumes (by Plethysmography)

			Pre Bronchodilator			Post Bronchodilator		
			Predicted	Actual	% Pred	Actual	% Pred	% Change
TLC	L	7.96	10.48	132	10.30	129	-2	
SVC	L	5.51	7.43	135	---	---		
IC	L	3.77	4.66	121	4.40	117	-4	
FRC	L	4.20	5.92	141	5.90	140	0	
ERV	L	1.74	2.87	165	3.06	176	7	
RV	L	2.46	3.06	124	2.84	115	-7	
RV/TLC	%	32	29	91	28	88	-3	



Plethysmography

			Pre Bronchodilator			Post Bronchodilator		
			Predicted	Actual	% Pred	Actual	% Pred	% Change
Raw	cmH2O/	0.99	1.11	112	1.13	114	2	
Gaw	cmH2O/	1.01	0.90	89	0.89	88	-1	
sRaw	L/s/cmH	---	6.61	---	6.83	---	3	
sGaw	L/s/cmH	0.24	0.15	62	0.15	62	0	



PF Reference: Spirometry (3-5yrs): Eigen/Bieler, (6-7yrs): Dockery/Weng, (8-80yrs): NHANESIII & Knudson; Lung Volumes: Crapo; DLCO: Cotes

Calibration Date: 05/10/2012

Calibration Data: Temp: 24°C PBar: 756mmHg BTPS: 1.086

Patient: Davis, Morgan E.

Test Date: 05/10/2012

Page: 1 of 7

Step 3 *LUNG VOLUMES*

- Obstructive disorders have a TLC that is high (hyperinflation) or normal
- An increased residual volume (RV) (air trapping) and an increased RV/TLC ratio
- Restrictive disorders have a reduced TLC



Morgan Scientific, Inc
PULMONARY ASSOCIATES

151 Essex Street.
Haverhill, MA 01832
TEL: (978) 521-4440
FAX: (978) 531-4445

Name: **Morgan E. Davis**

ID: **008**

DOB: **11/12/1954**

Age: **57**

Height: **75 in**

Weight: **225 lb**

Race: **W**

Smoker: **S**

PHN #: **456**

Gender: **M**

BMI: **28.3**

Pack yrs: **68**

Referred by:

Date & Time: **05/10/2012**

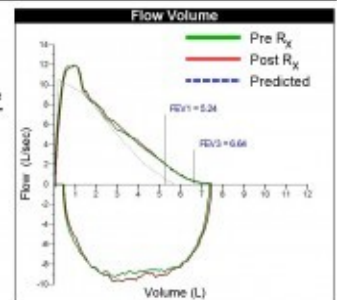
Test Site:

Technician: **Patrick Morgan**

Interpreted By: **Colin D. Chapman, M.D.**

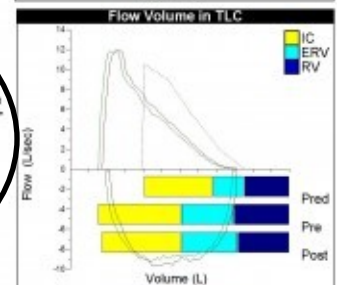
Dynamic Spirometry

			Pre Bronchodilator			Post Bronchodilator		
			Predicted	Actual	% Pred	Actual	% Pred	% Change
FVC	L	5.67	7.38	130	7.46	132	1	
FEV ₁	L	4.31	5.24	122	5.36	124	2	
FEV ₁ / FVC	%	78	71		72			
FEF ₂₅₋₇₅ [ISO]	L/s	3.55	3.62	102	3.93	111	9	
FEF ₅₀ [ISO]	L/s	5.34	4.36	82	4.72	88	6	
FEV ₆	L	5.44	7.13	131	7.23	133	1	
PEFR	L/s	10.50	12.02	114	11.94	114	-1	
PIFR	L/s	7.00	9.28	133	9.70	139	5	



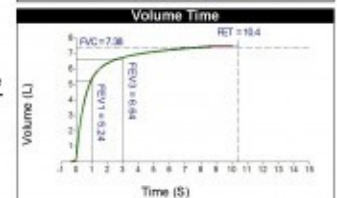
Lung Volumes (by Plethysmography)

			Pre Bronchodilator			Post Bronchodilator		
			Predicted	Actual	% Pred	Actual	% Pred	% Change
TLC	L	7.96	10.48	132	10.30	129	-2	
SVC	L	5.51	7.43	135				
IC	L	3.77	4.66	121	4.40	117	-4	
FRC	L	4.20	5.92	141	5.90	140	0	
ERV	L	1.74	2.87	165	3.06	176	7	
RV	L	2.46	3.06	124	2.84	115	-7	
RV/TLC	%	32	29	91	28	88	-3	



Plethysmography

			Pre Bronchodilator			Post Bronchodilator		
			Predicted	Actual	% Pred	Actual	% Pred	% Change
Raw	cmH ₂ O/	0.99	1.11	112	1.13	114	2	
Gaw	cmH ₂ O/	1.01	0.90	89	0.89	88	-1	
sRaw	L/s/cmH	---	6.61	---	6.83	---	3	
sGaw	L/s/cmH	0.24	0.15	62	0.15	62	0	



Step 4 *DLCO*

Normal : in normal lungs , major airways lesion

Decreased : parenchymal , restrictive disorders , copd

Increased : alveolar hemorrhage , very obese , asthma



Morgan Scientific, Inc.

Pulmonary Function Testing

151 Essex Street

Haverhill, MA 01832

Phone: (978) 521-4440

Date: 25-Apr-13

Temp: 24°C

Pressure: 763mmHg

Humidity: 50%

BTPS: 1.039

Name: **Richard Hawkins** DOB: **09-Oct-39** Age: **73** ID: **123321123**
Sex: **M** Height: **70 in** Smoker: **X** Pack yrs: **11** Technician: **Ralph E. Browning, BS, RPFT**
Race: **W** Weight: **230 lb** Pulmonologist: **Josh Jones, M.D.**
BMI: **33.0** Referring:

Spirometry

		Ref	Pre	% Ref	Post	% Ref	% Chg
FVC	L	4.31	2.44	57	2.55	59	5
FEV ₁	L	3.13	1.81	58	1.96	63	8
FEV ₁ / FVC	%	73	74	77	77		
FEF ₂₅₋₇₅ [ISO]	L/s	2.30	1.26	55	2.50	109	98
PEFR	L/s	8.01	7.71	96	6.32	79	-18

Lung Volumes Box

		Ref	Pre	% Ref	Post
TLC	L	7.05	4.86	69	
VC	L	4.46	2.73	61	
RV	L	2.53	2.13	84	
RV/TLC	%	37	44	119	
FRC	L	3.77	3.18	84	
ERV	L	1.24	1.05	85	
Raw	cmH ₂ O/L/s	1.13	1.21	107	
sGaw	L/s/cmH ₂ O	0.23	0.31	135	

Diffusing Capacity

		Ref	Pre	% Ref	Post
DLCO	mL/min/mmHg	26.38	21.50	81	
DLCO [Hb]	mL/min/mmHg	26.58	21.50	81	
DLCO/VA	mL/min/mmHg/L	3.77	4.94	131	
VA [BTPS]	L	7.05	4.35	62	
VI [BTPS]	L	4.46	2.61	59	
Diffusion Time	sec		10.07		

Pulmonary Function Testing

➤ **Ventilation**

- Forced Expiration
- Lung Volumes

➤ **Diffusion**

➤ **Blood Flow**

➤ **Ventilation-Perfusion Relationships**

- Topographical Distribution of Ventilation and Perfusion
- Inequality of Ventilation
- Inequality of Ventilation-Perfusion
- Ratios

➤ **Blood Gases and pH**

➤ **Mechanics of Breathing**

- Lung Compliance
- Airway Resistance
- Closing Volume

➤ **Control of Ventilation**

➤ **Exercise Testing**

Ventilation

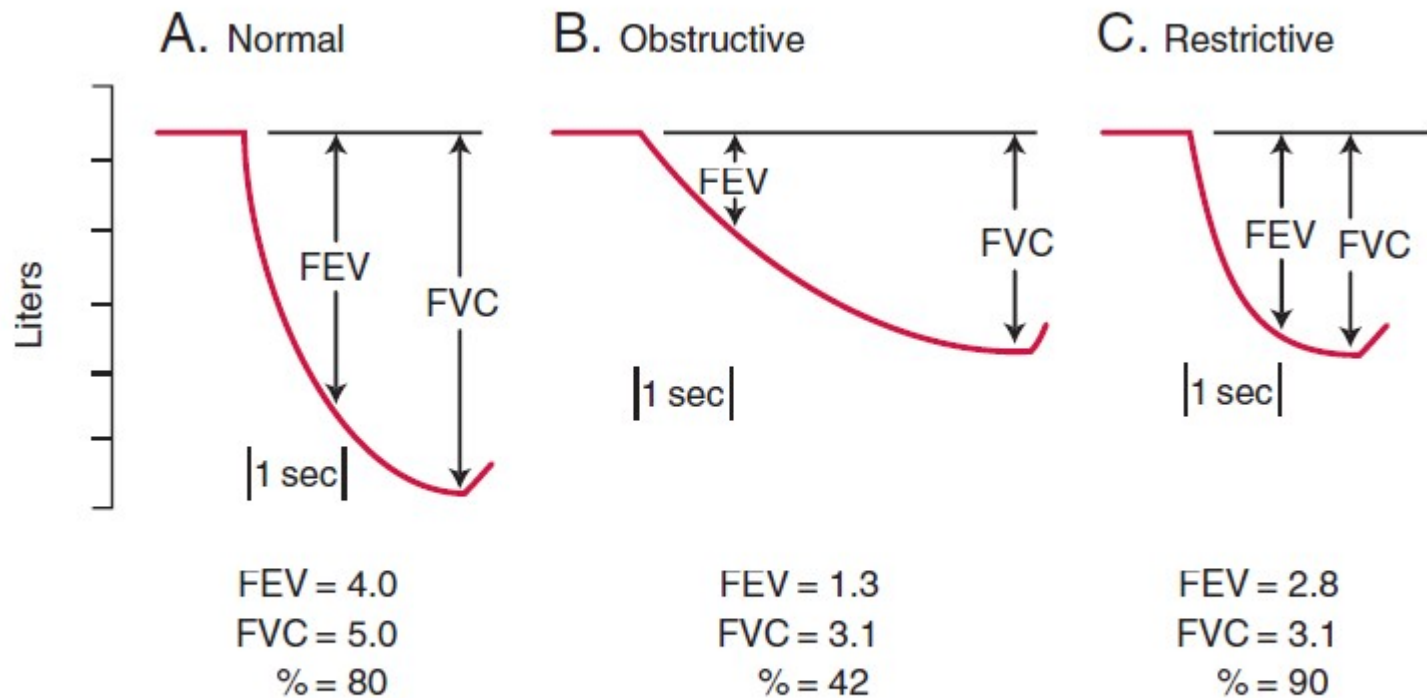


Figure 7-19. Measurement of forced expiratory volume ($FEV_{1.0}$) and forced vital capacity (FVC).

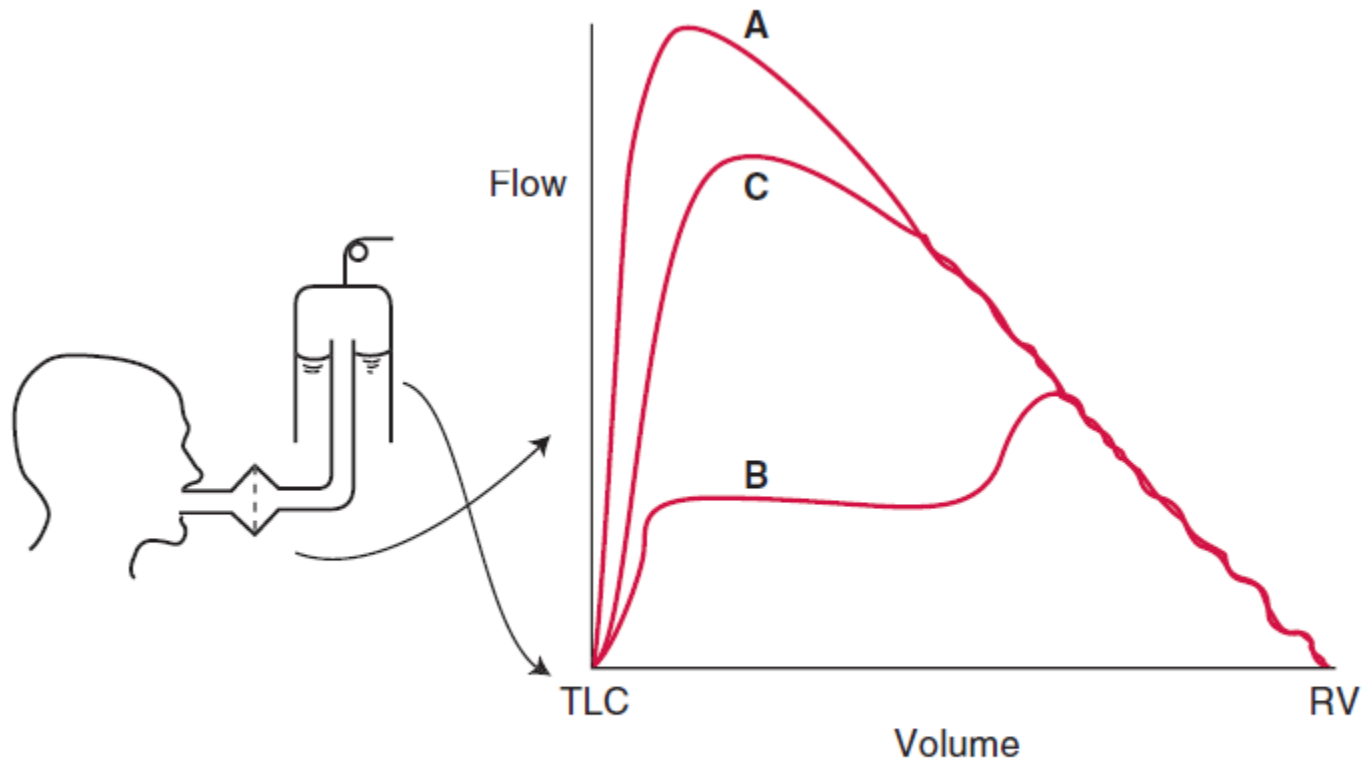


Figure 7-16. Flow-volume curves. In A, a maximal inspiration was followed by a forced expiration. In B, expiration was initially slow and then forced. In C, expiratory effort was submaximal. In all three, the descending portions of the curves are almost superimposed.

Dynamic Compression of Airways

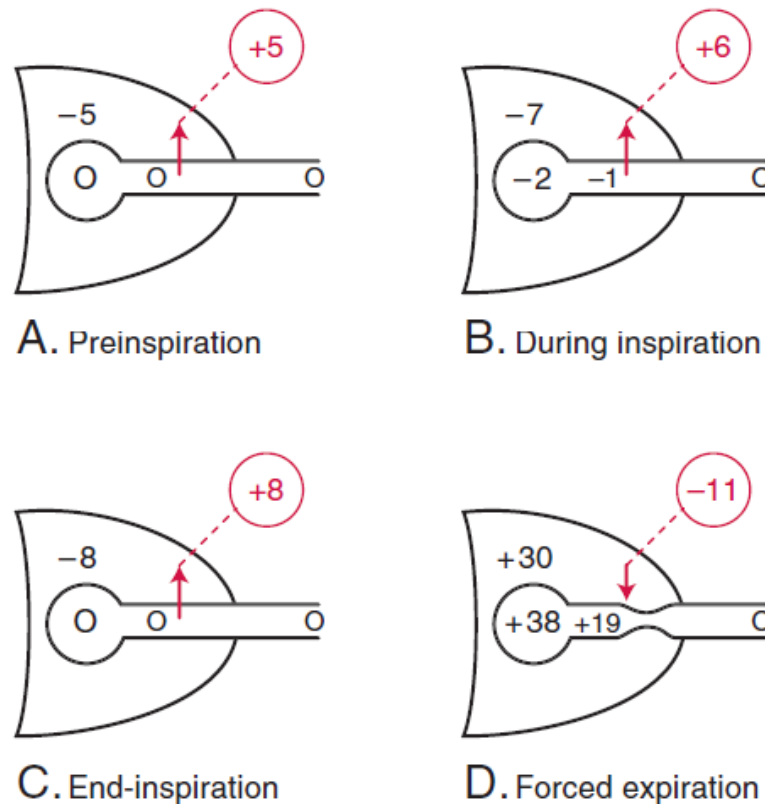


Figure 7-18. Scheme showing why airways are compressed during forced expiration. Note that the pressure difference across the airway is holding it open, except during a forced expiration. See text for details.

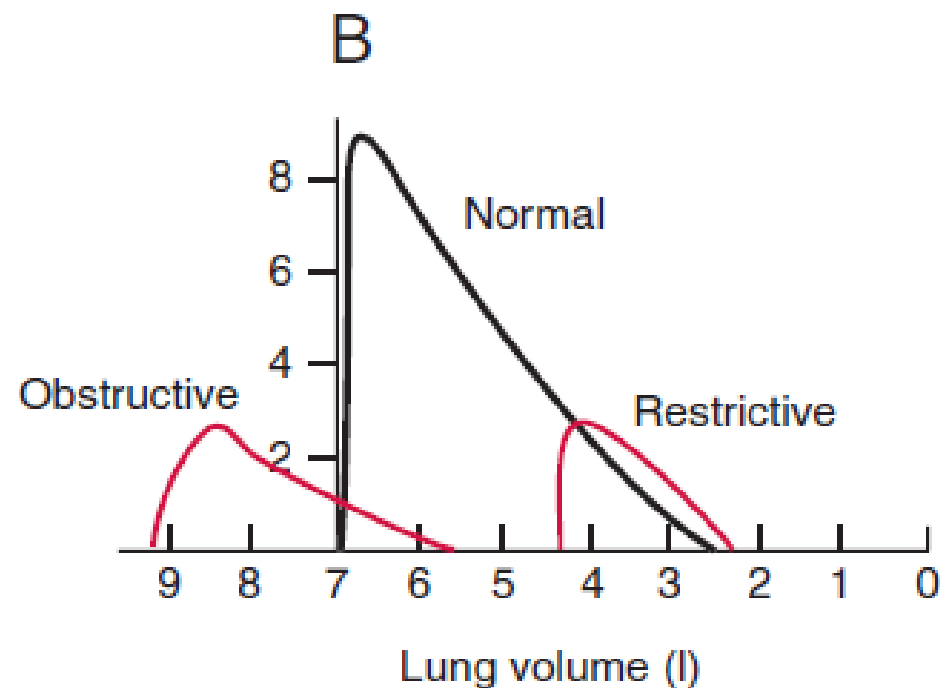
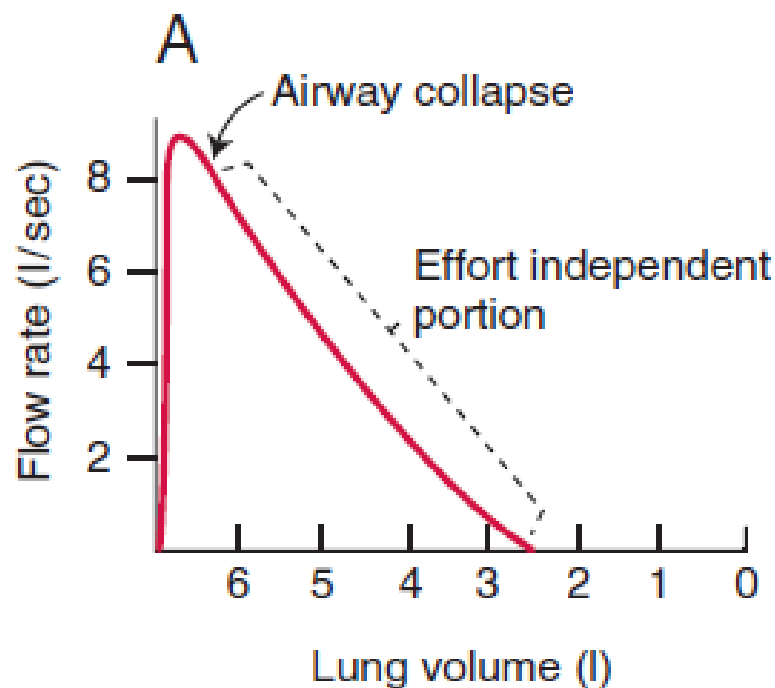


Figure 10-1. Flow-volume curves obtained by recording flow rate against volume during a forced expiration from maximum inspiration. The figures show absolute lung volumes, although these cannot be measured from single expirations. See text for details.

OBSTRUCTIVE v/s RESTRICTIVE

Obstructive Disorders

- Characterized by a limitation of expiratory airflow so that airways cannot empty as rapidly compared to normal (such as through narrowed airways from bronchospasm, inflammation, etc.)

Examples:

- Asthma
- Emphysema

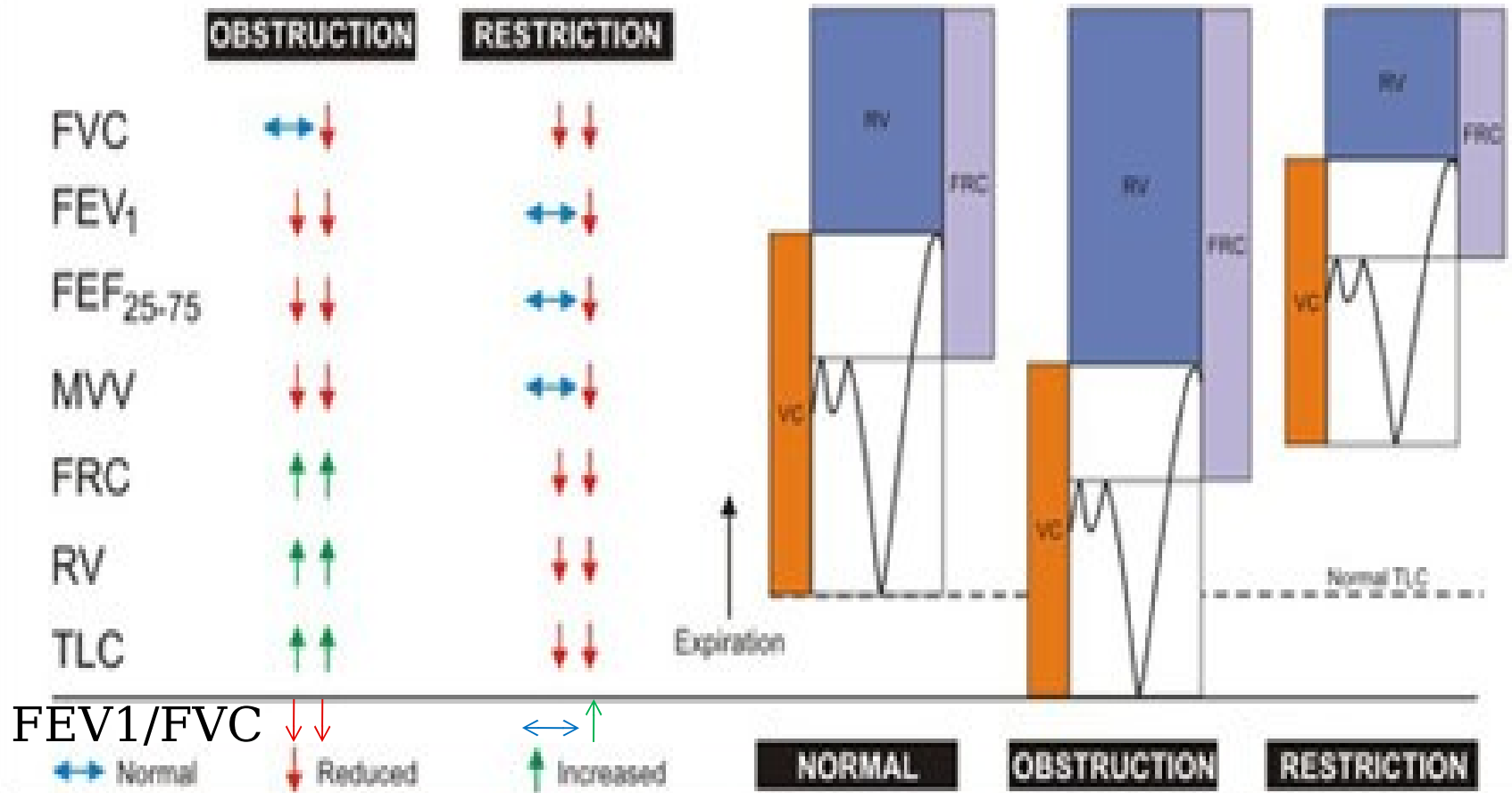
Restrictive Disorders

- Characterized by reduced lung volumes/decreased lung compliance

Examples:

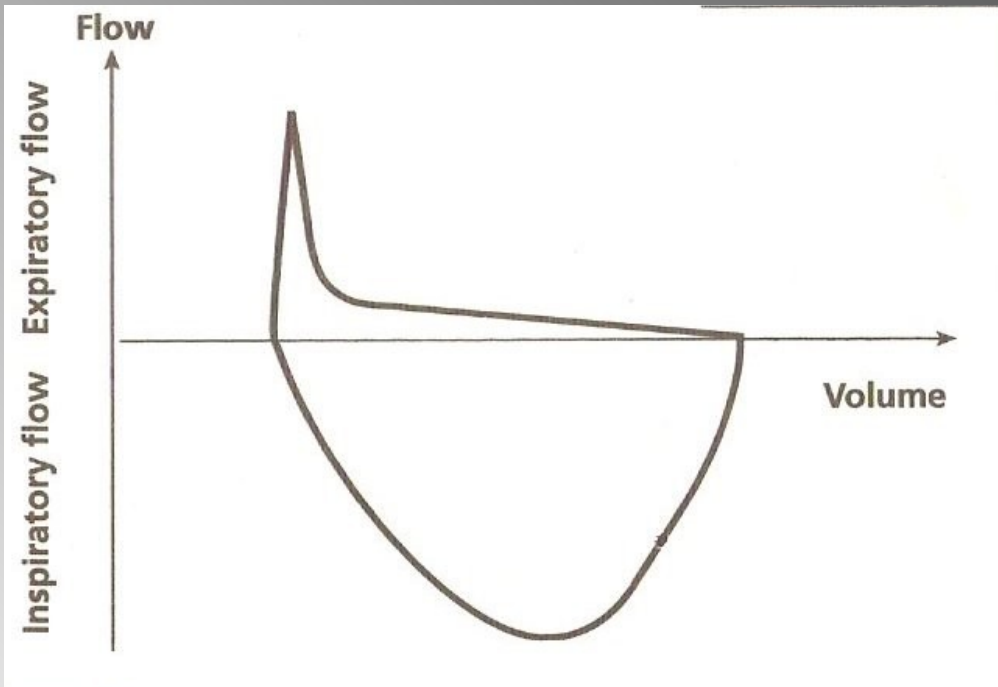
- Interstitial Fibrosis
- Scoliosis
- Obesity
- Lung Resection
- Neuromuscular diseases
- Cystic Fibrosis

Typical Results of Disease on Ventilatory Function and Lung Volumes



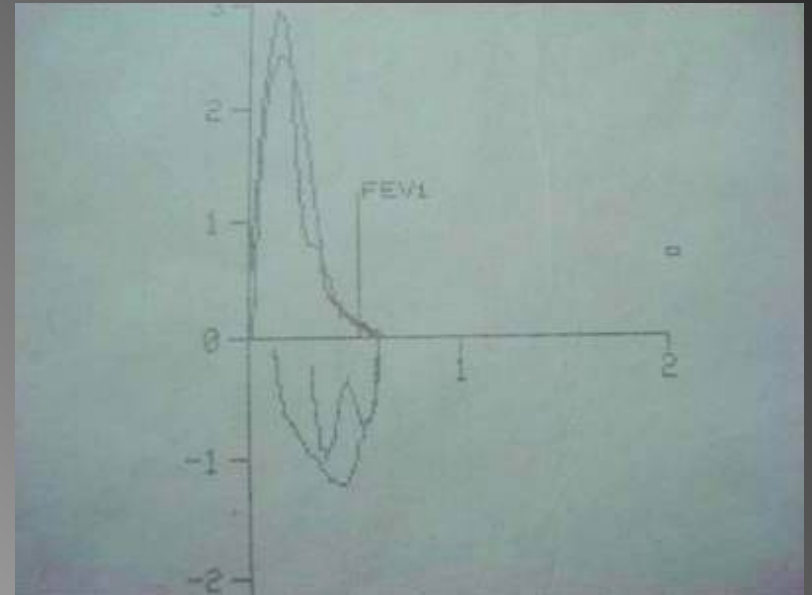
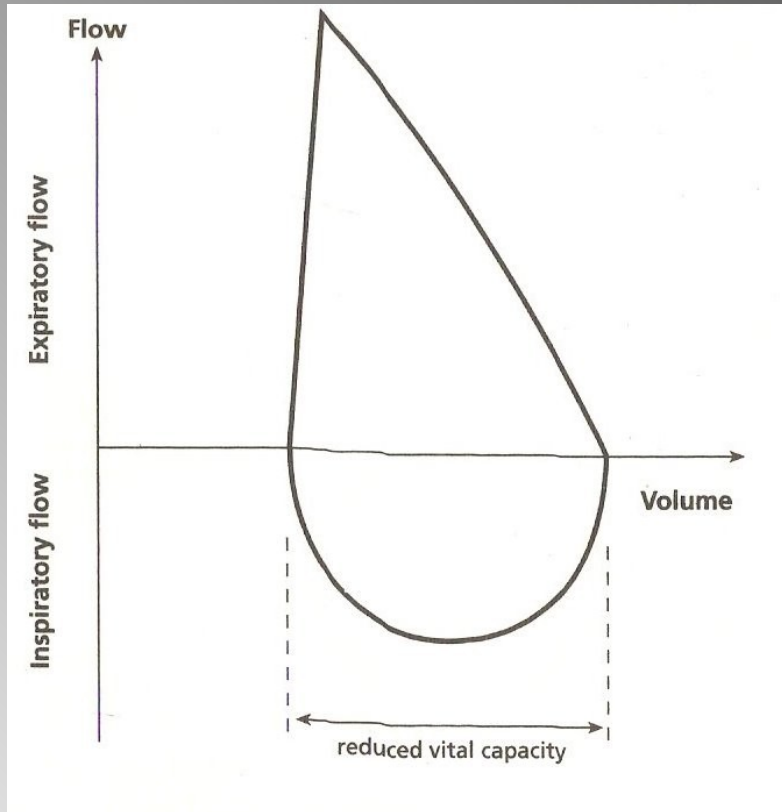
- In ***restrictive*** diseases, the maximum flow rate is reduced, as is the total volume exhaled.
- The flow rate is often abnormally high during the latter part of expiration because of the increased lung recoil.
- By contrast, in ***obstructive*** diseases, the flow rate is very low in relation to lung volume, and a **scooped-out appearance** is seen.

OBSTRUCTIVE DISORDER



- Rat tail appearance
- Dog tail appearance

RESTRICTIVE DISORDER



Tall and narrow with steep end-expiratory phase.

- In *obstructive* disease, the total lung capacity is typically abnormally large, but expiration ends prematurely.
- The early airway closure is due to
 1. increased smooth muscle tone of the bronchi, as in **asthma**,
 2. loss of radial traction from surrounding parenchyma, as in **emphysema**.
- Other causes include edema of the bronchial walls, or secretions within the airways.
- In *restrictive* diseases, inspiration is limited by the reduced compliance of the lung or chest wall, or weakness of the inspiration muscles.

- The FEV1.0 (or FEF25–75%) is reduced by an **increase in airway resistance** or a **reduction in elastic recoil** of the lung.
- It is independent of expiratory effort due to the **dynamic compression of airways**.
- The increase in airway resistance and the reduction of lung elastic recoil pressure can be important factors in the reduction of the FEV1.0, as, for example, in **pulmonary emphysema**.



Classification of COPD Severity by Spirometry

Stage I: Mild

$FEV_1/FVC < 0.70$

$FEV_1 \geq 80\%$ predicted

Stage II: Moderate

$FEV_1/FVC < 0.70$

$50\% \leq FEV_1 < 80\%$ predicted

Stage III: Severe

$FEV_1/FVC < 0.70$

$30\% \leq FEV_1 < 50\%$ predicted

Stage IV: Very Severe

$FEV_1/FVC < 0.70$

$FEV_1 < 30\%$ predicted *or*

$FEV_1 < 50\%$ predicted *plus*

chronic respiratory failure

Bronchial challenge testing -

- Often used for asthma diagnosis
- How?
 - Off inhalers
 - Check spirometry
 - Inhale a bronchoprovocator (histamine, methacholine, saline) at inc. concentrations
 - measure spirometry after each inhalation
- N.B. exercise as a bronchoprovocator

Bronchial challenge - interpretation

- Threshold for positive may vary centre to centre
- Indicates 'Bronchial hyperresponsiveness'
- Negative test virtually excludes asthma
- False positives post-infection

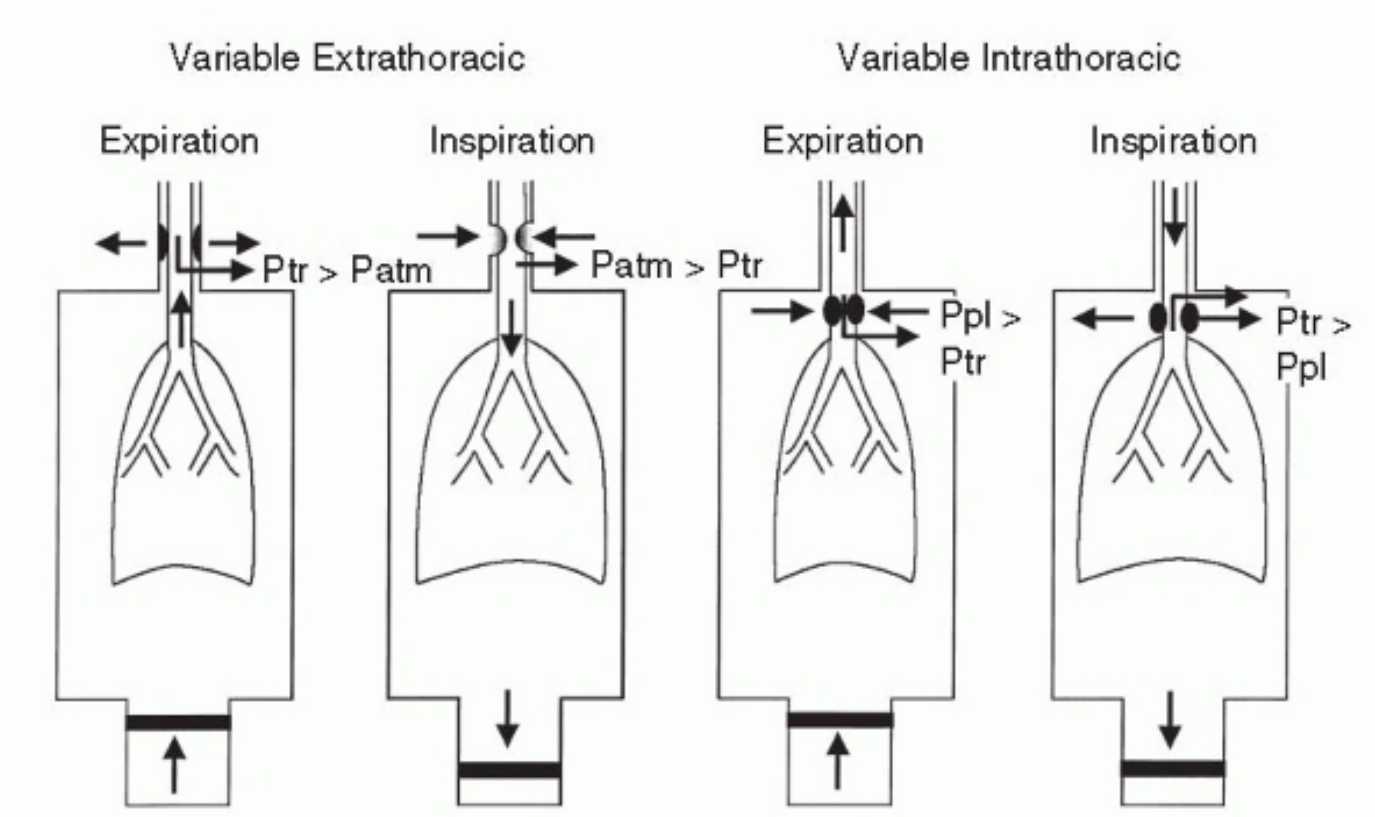
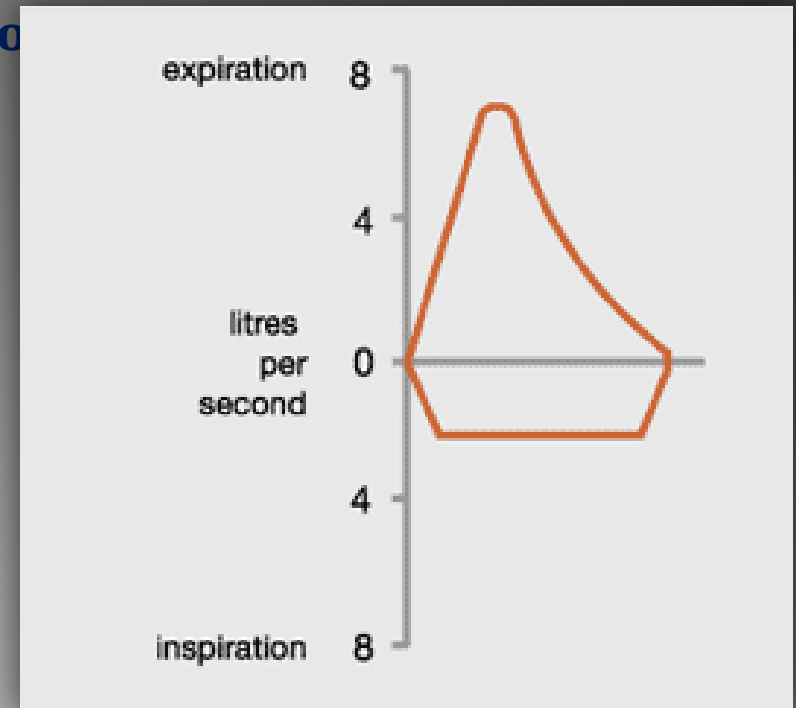


FIG. 2-8. Model explaining the pathophysiology of the variable lesion of the major airway. P_{atm} , atmospheric pressure acting on the extrathoracic trachea; P_{pl} , pressure in the pleural cavity that acts on the intrathoracic trachea; P_{tr} , lateral, intratracheal airway pressure

Variable Extra-thoracic Airway Obstruction

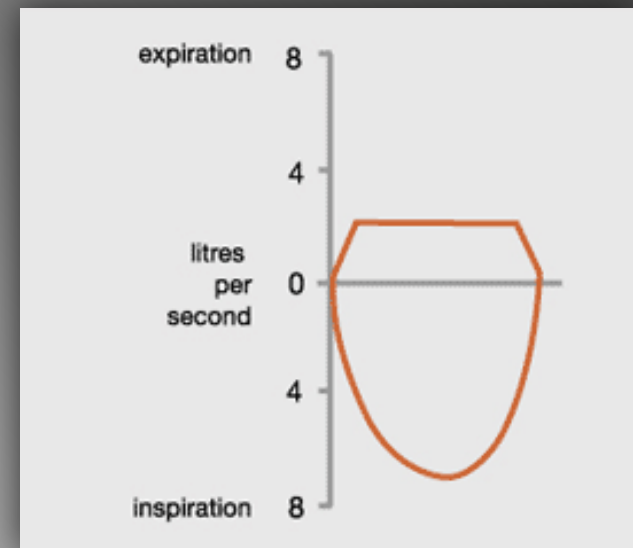
- It is characterized by reduction of inspired flows during forced inspiration with preservation of expiratory flows
- The causes are unilateral and bilateral vocal cord paralysis, vocal cord adhesions, vocal cord cancer and obstructive sleep apnea

- Surrounding soft tissue unsupporting
- Collapses during inspiration
- Expands during expiration



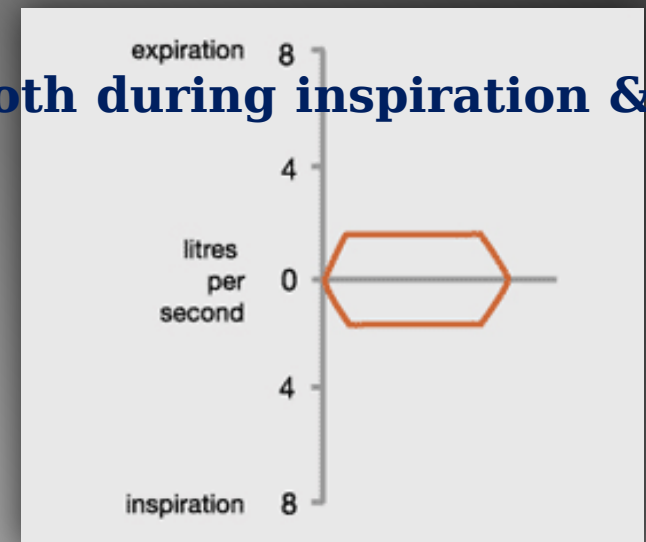
Variable Intra-thoracic Obstruction

- It is produced by localized tumors of the lower trachea or main stem bronchus, tracheomalacia , & airway changes associated with polychondritis
- In these obstructions, there is reduction of airflow during forced expiration with preservation of a normal inspiratory flow configuration.
- Outer surface exposed to pleural pressure
- Expands during inspiration
- Collapses during expiration



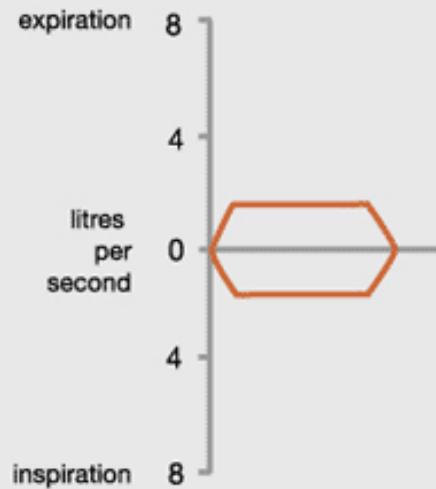
Fixed Upper Airway Obstruction

- It is characterized by plateaus of flow during both forced inspiration & expiration
- The causes include goitres, endotracheal neoplasms, stenosis of both main bronchi, post intubation stenosis & performance of the test through a tracheostomy tube or other fixed orifice device
- In these, there is reduction in airflow both during inspiration & expiration

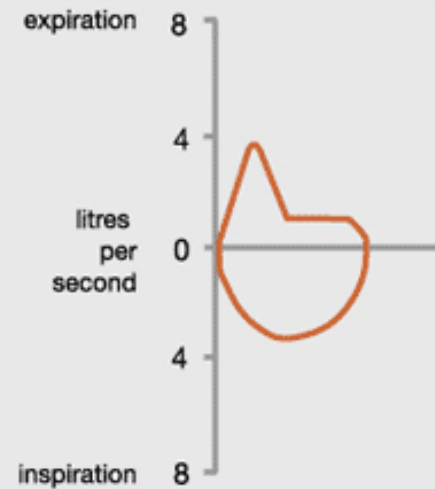


Flow - volume loops in various pathologies

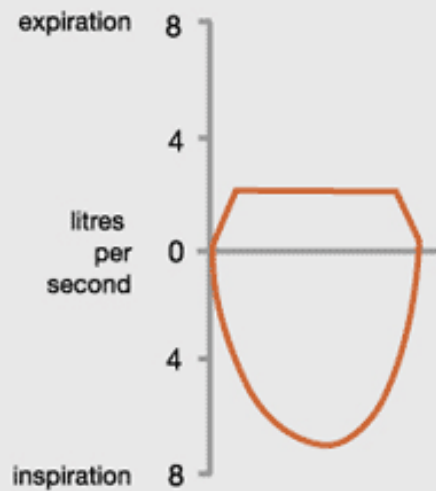
Fixed upper airway obstruction



**Intrapulmonary obstruction
e.g emphysema**



Intrathoracic bronchial obstruction



Extrathoracic bronchial obstruction



TABLE 10-2. Guidelines for estimating risk for postoperative respiratory complications

<i>Test</i>	<i>Increased risk</i>	<i>High risk</i>
FVC	<50% predicted	≤1.5 L
FEV ₁	<2.0 L or <50% predicted	<1.0 L
MVV		<50% predicted
PaCO ₂		≥45 mm Hg

FEV₁, forced expiratory volume in 1 second; FVC, forced vital capacity; MVV, maximal voluntary ventilation; PaCO₂, arterial tension of carbon dioxide.

LUNG VOLUMES

- Lung volumes by spirometry, and
- functional residual capacity (FRC) by helium dilution and body plethysmography

Lung Volumes

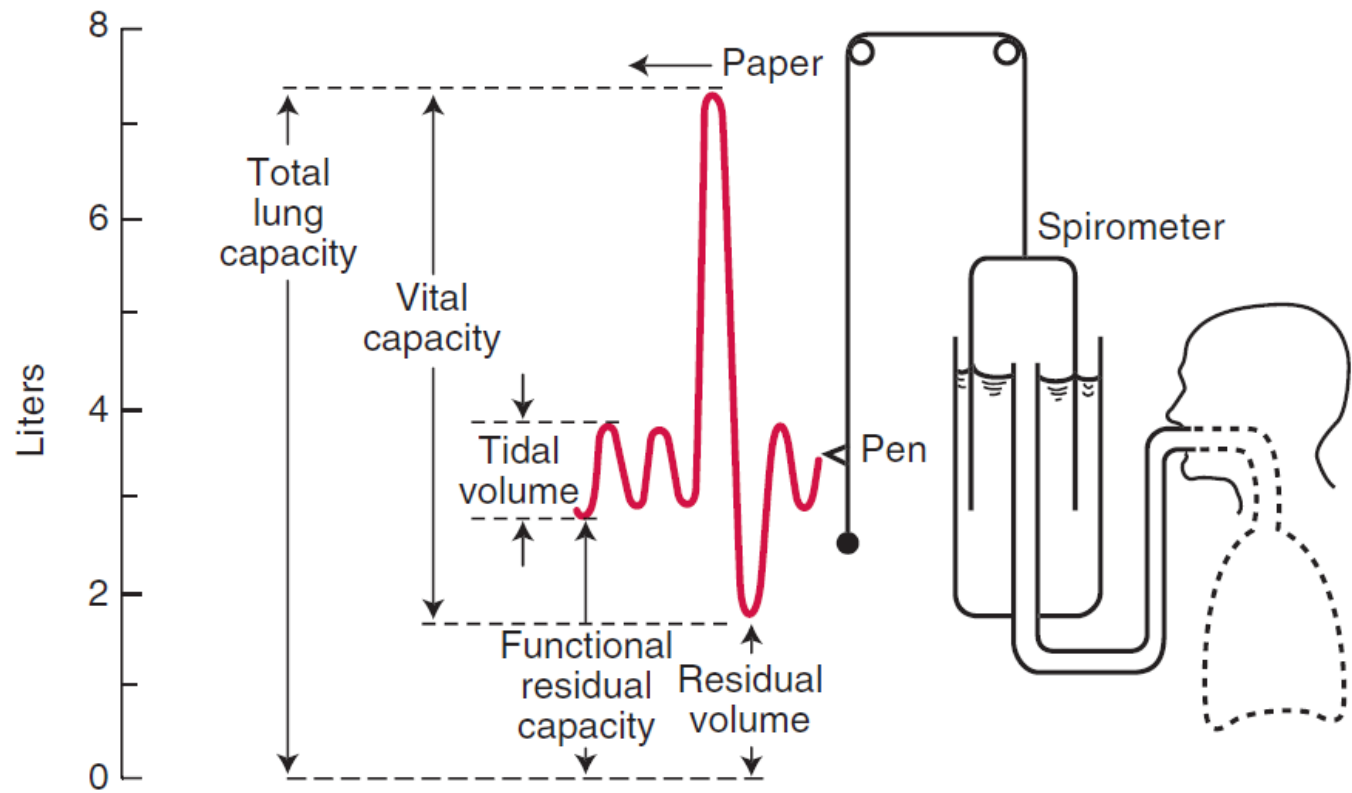


Figure 2-2. Lung volumes. Note that the total lung capacity, functional residual capacity, and residual volume cannot be measured with the spirometer.

Helium Dilution

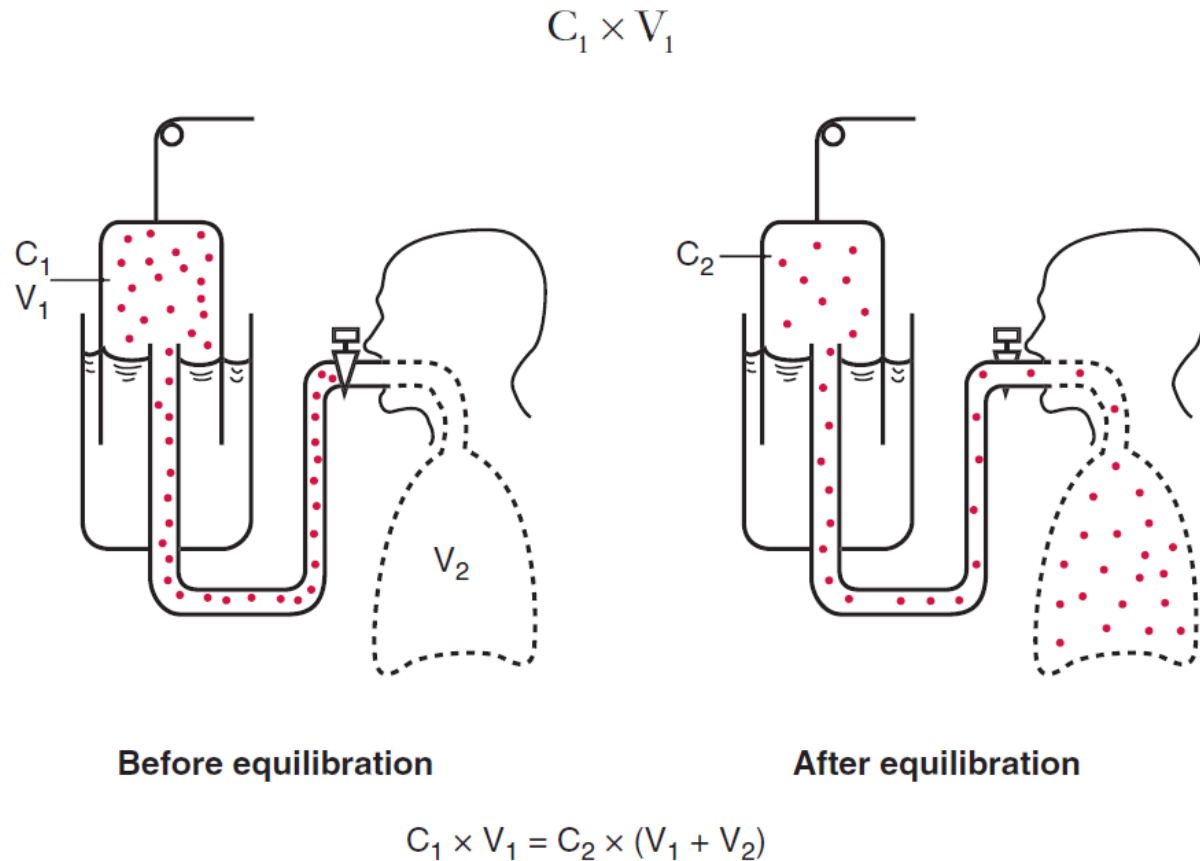


Figure 2-3. Measurement of the functional residual capacity by helium dilution.

Body Plethysmograph

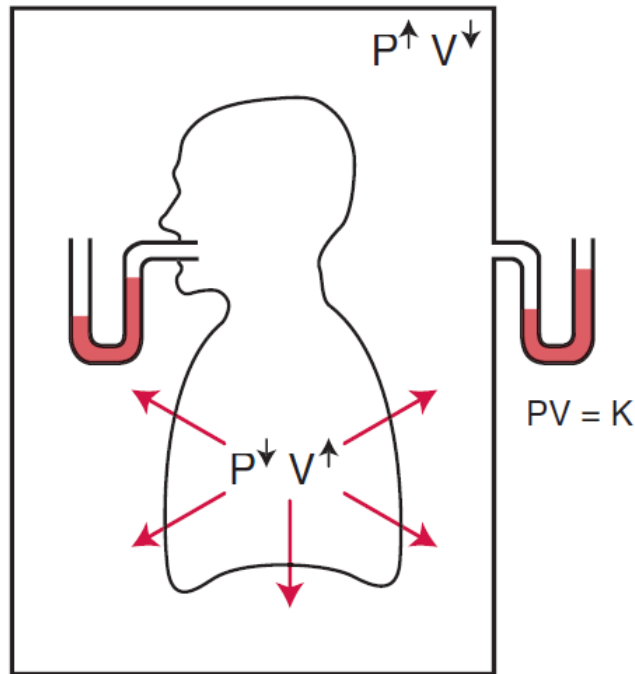


Figure 2-4. Measurement of FRC with a body plethysmograph. When the subject makes an inspiratory effort against a closed airway, he slightly increases the volume of his lung, airway pressure decreases, and box pressure increases. From Boyle's law, lung volume is obtained (see text).

Single Breath Nitrogen Washout

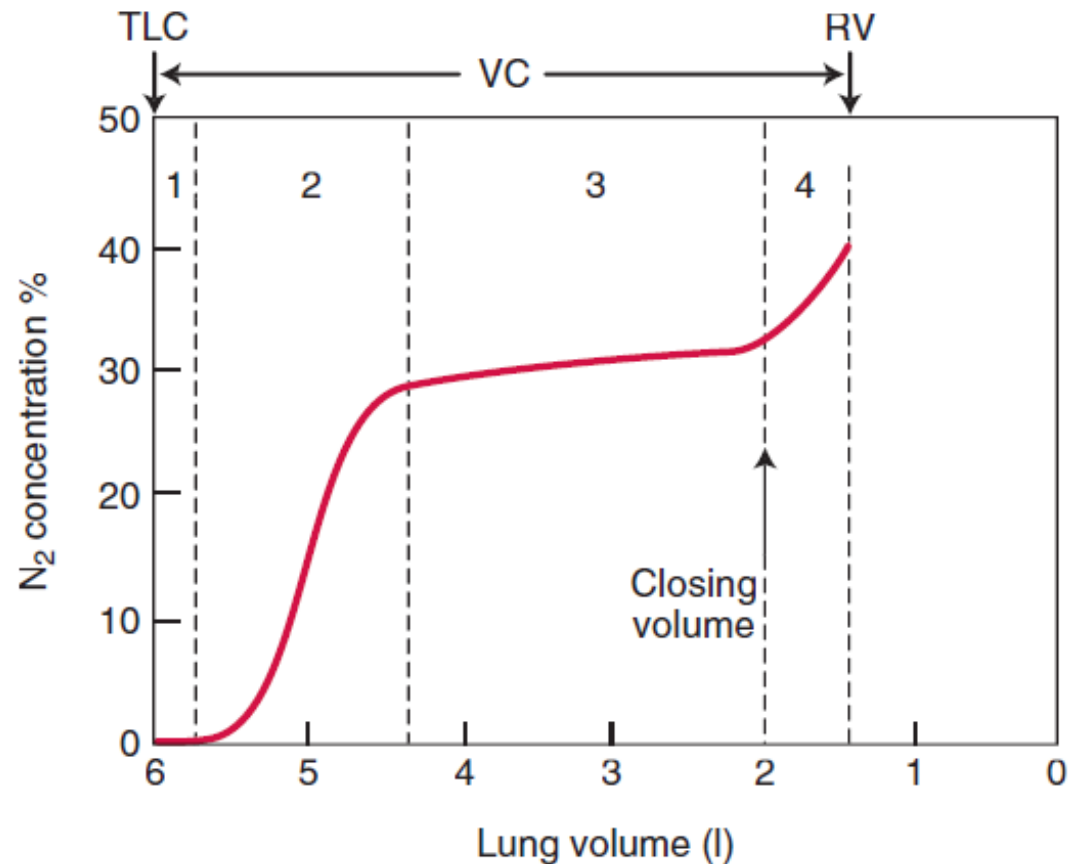
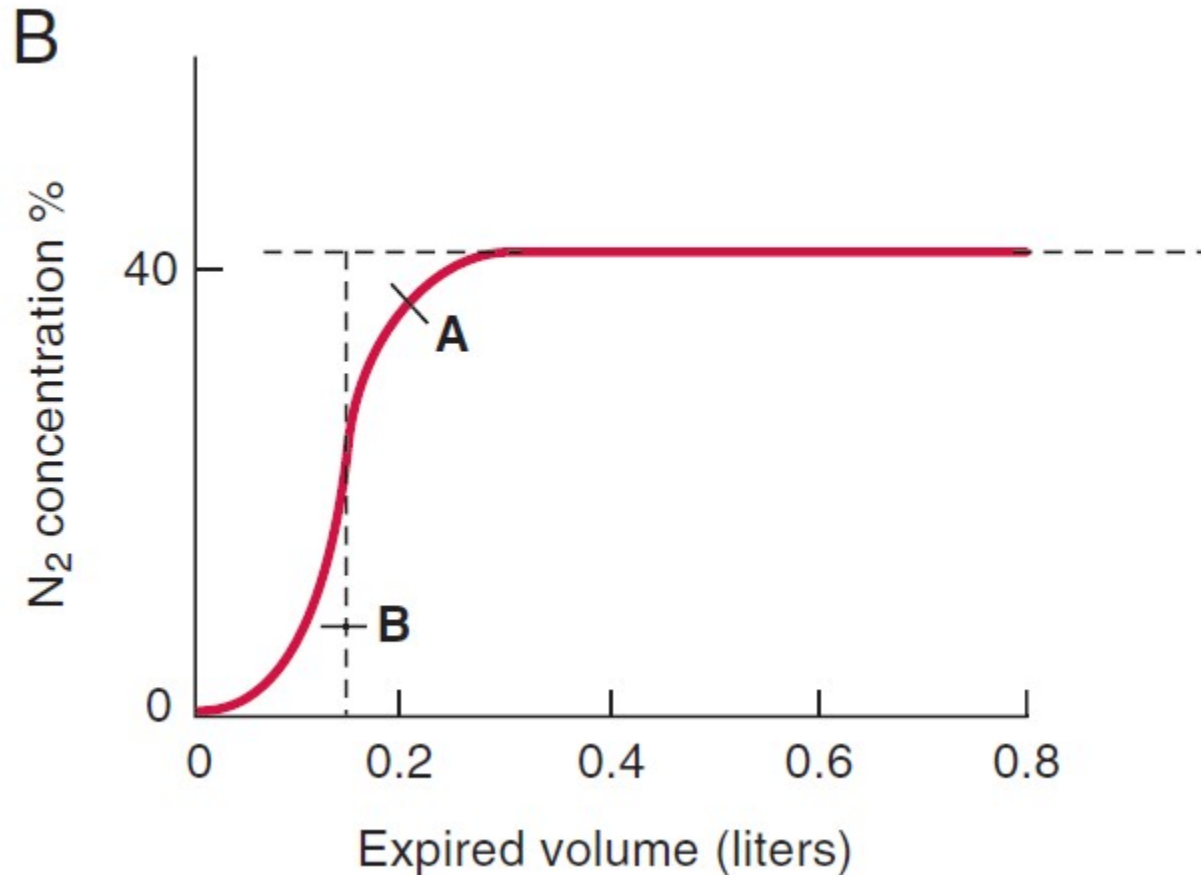


Figure 10-6. Measurement of the closing volume. If a vital capacity inspiration of 100% O_2 is followed by a full expiration, four phases in the N_2 concentration measured at the lips can be recognized (see text). The last is caused by preferential emptying of the upper part of the lung after the lower-zone airways have closed.

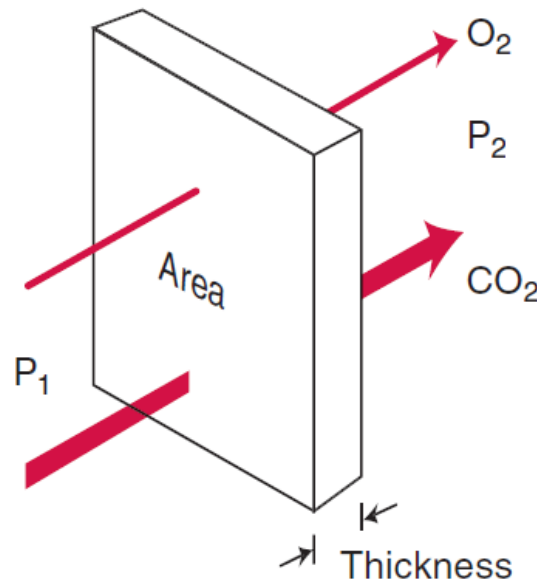
Fowler's method for VD (Anatomical)



Bohr equation V_D Physiological

$$\frac{V_D}{V_T} = \frac{P_{A_{CO_2}} - P_{E_{CO_2}}}{P_{A_{CO_2}}}$$

Fick's Diffusion law



$$\dot{V}_{\text{gas}} \propto \frac{A}{T} \cdot D \cdot (P_1 - P_2)$$

$$D \propto \frac{\text{Sol}}{\sqrt{\text{MW}}}$$

Figure 3-1. Diffusion through a tissue sheet. The amount of gas transferred is proportional to the area (A), a diffusion constant (D), and the difference in partial pressure ($P_1 - P_2$), and is inversely proportional to the thickness (T). The constant is proportional to the gas solubility (Sol) but inversely proportional to the square root of its molecular weight (MW).

- Examples of diffusion- and perfusion-limited gases are carbon monoxide and nitrous oxide, respectively.
- Oxygen transfer is normally perfusion limited, but some diffusion limitation may occur under some conditions, including intense exercise, thickening of the blood-gas barrier, and alveolar hypoxia.

DLCO

$$D_L = \frac{\dot{V}_{CO}}{P_{A_{CO}}}$$

Measurement of Diffusing Capacity

- Carbon monoxide is used because the uptake of this gas is diffusion limited
- Normal diffusing capacity is about $25 \text{ ml} \cdot \text{min}^{-1} \cdot \text{mm Hg}^{-1}$
- Diffusing capacity increases on exercise

DL_{CO} - interpretation

- DL_{CO} ↓ by:
 - Pulmonary vascular diseases
 - Conditions affecting alveoli
 - Cardiac diseases
 - Anaemia
 - Pregnancy
 - Recent smoking

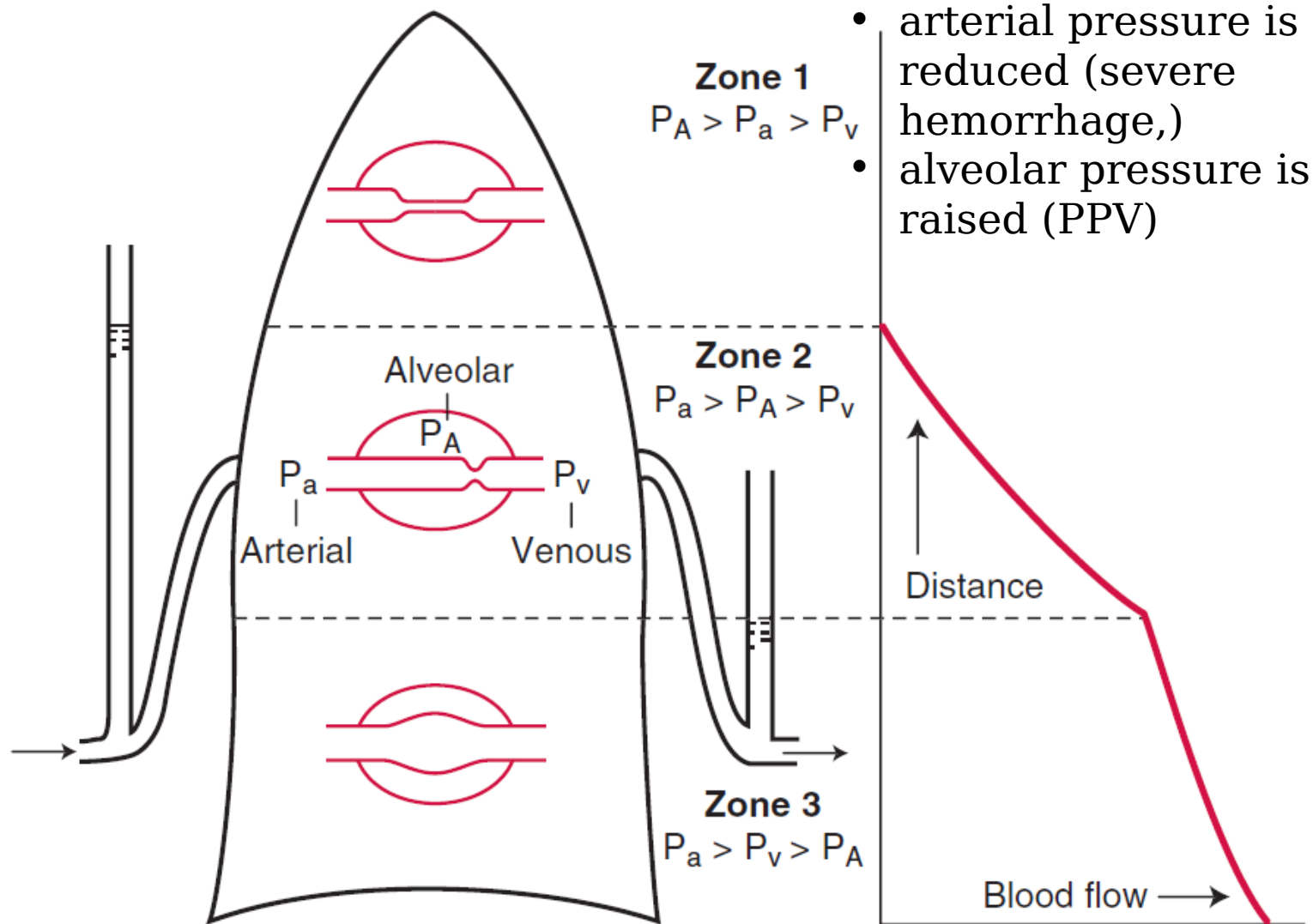
DL_{CO} - interpretation

- DL_{CO} ↑ by
 - Polycythaemia
 - Pulmonary haemorrhage
 - L to R shunt
 - Exercise

Blood Flow

- The volume of blood passing through the lungs each minute (Q) can be calculated using the ***Fick principle***.
- This states that the O_2 consumption per minute (VO_2) measured at the lungs is equal to the product of blood flow and A-V concentration gradient of O_2 .

Blood Flow



Hypoxic Pulmonary Vasoconstriction

- Alveolar hypoxia constricts small pulmonary arteries
- Probably a direct effect of the low P_{O_2} on vascular smooth muscle
- Its release is critical at birth in the transition from placental to air breathing
- Directs blood flow away from poorly ventilated areas of the diseased lung in the adult

Ventilation Perfusion Relationship

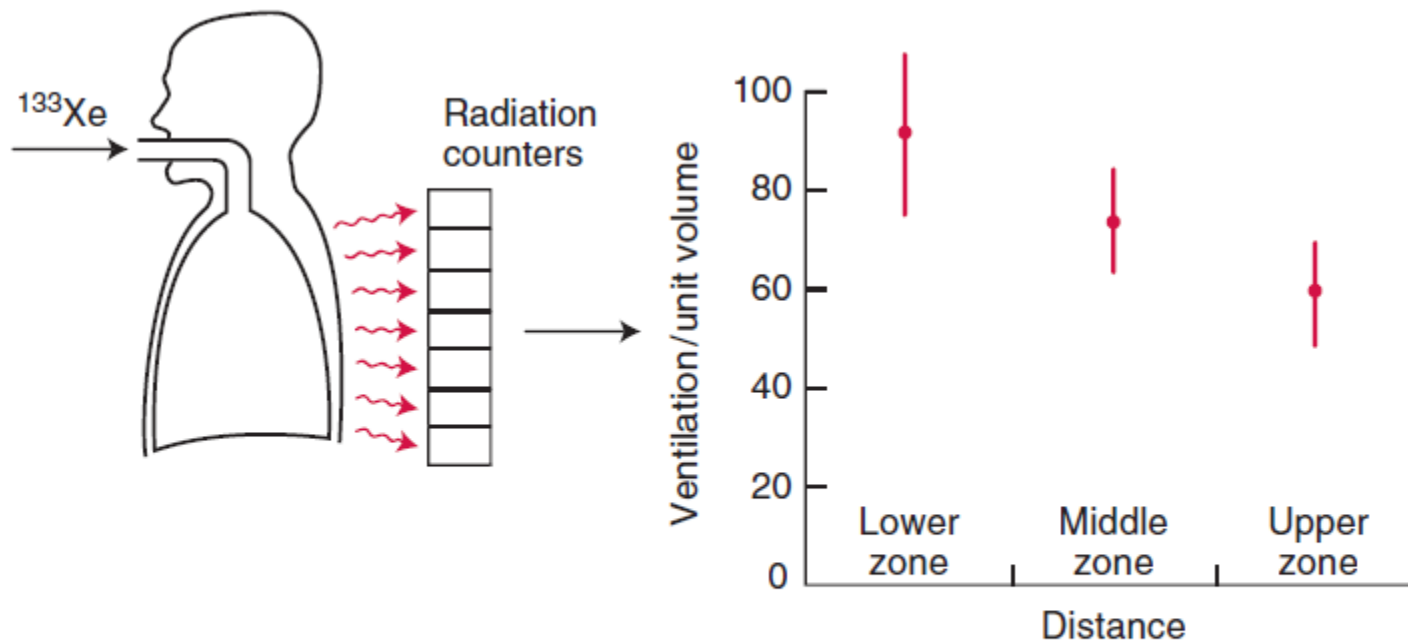


Figure 2-7. Measurement of regional differences in ventilation with radioactive xenon. When the gas is inhaled, its radiation can be detected by counters outside the chest. Note that the ventilation decreases from the lower to upper regions of the upright lung.

V-P ratio

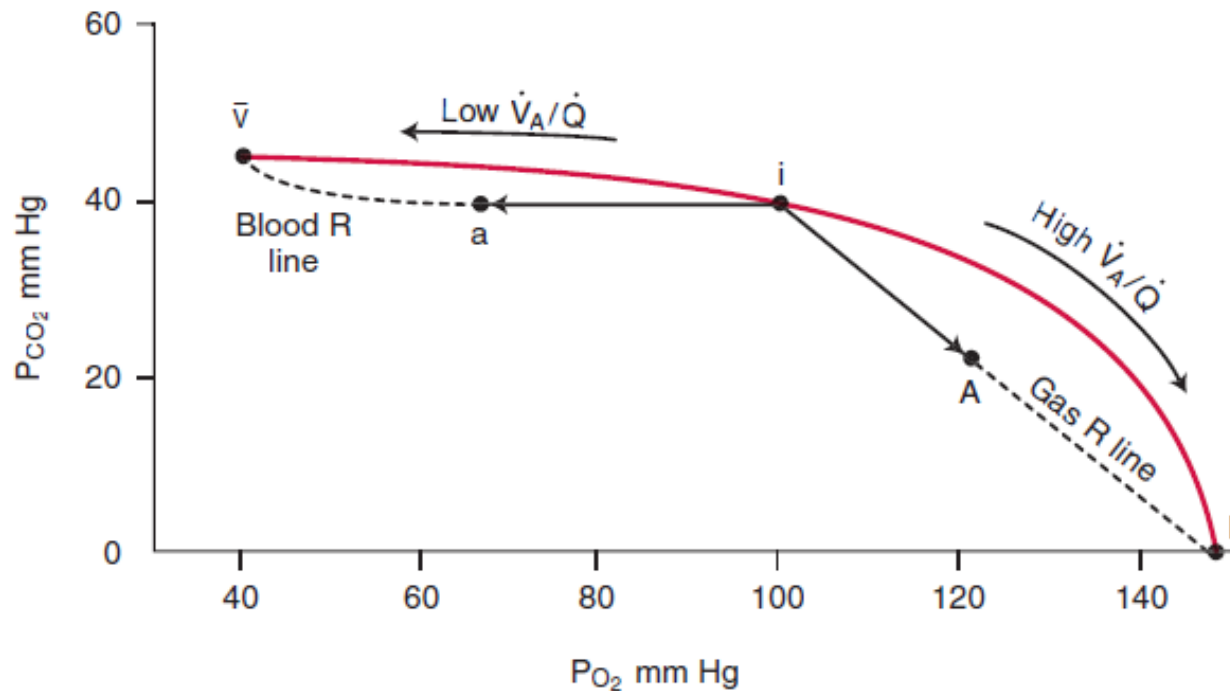


Figure 10-3. O_2 - CO_2 diagram showing the ideal point (i), that is, the hypothetical composition of alveolar gas and end-capillary blood when no ventilation-perfusion inequality is present. As inequality develops, the arterial (a) and alveolar (A) points diverge along their respective R (respiratory exchange ratio) lines. The mixed alveolar-arterial PO_2 difference is the horizontal distance between the points.

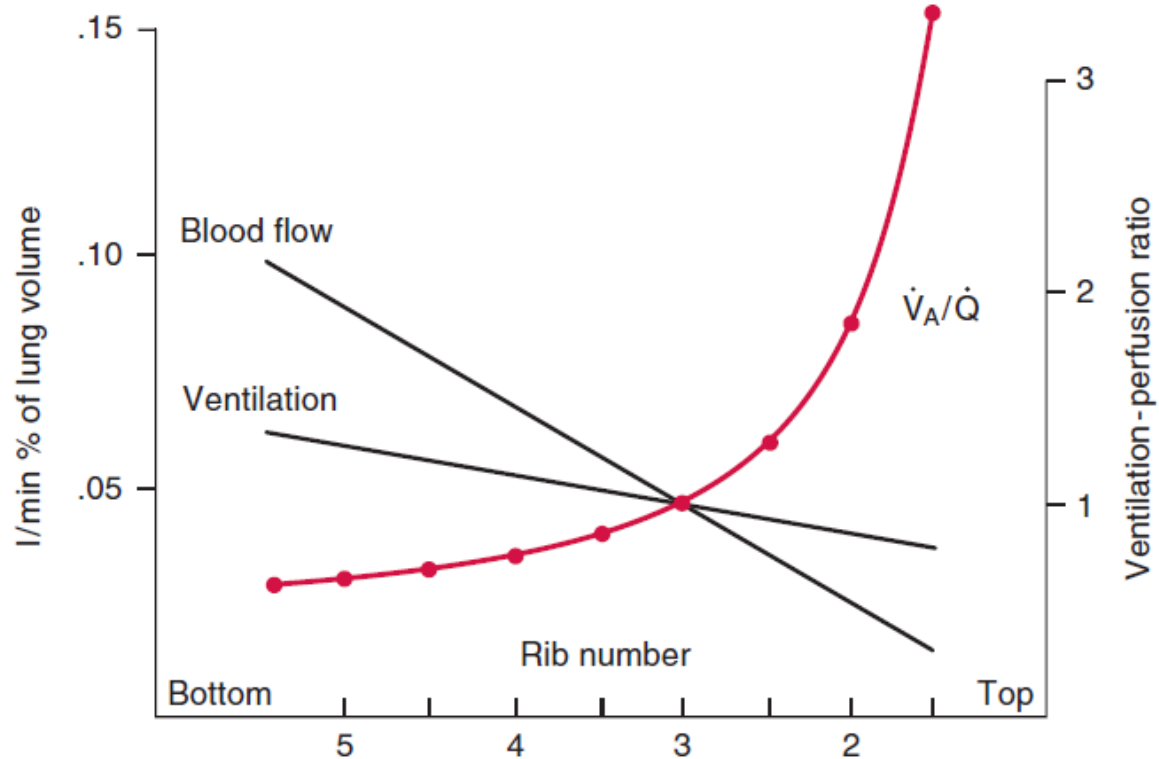
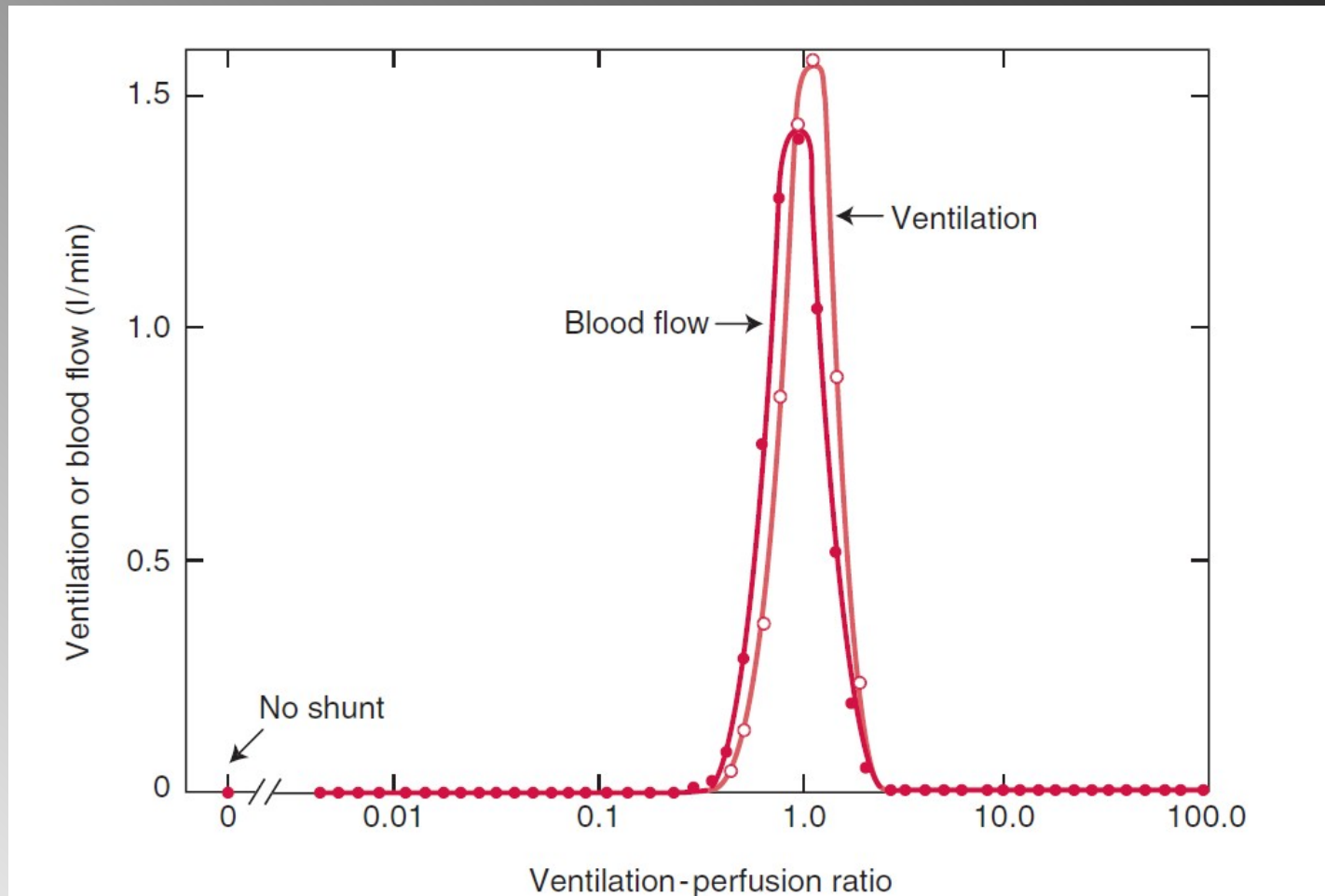
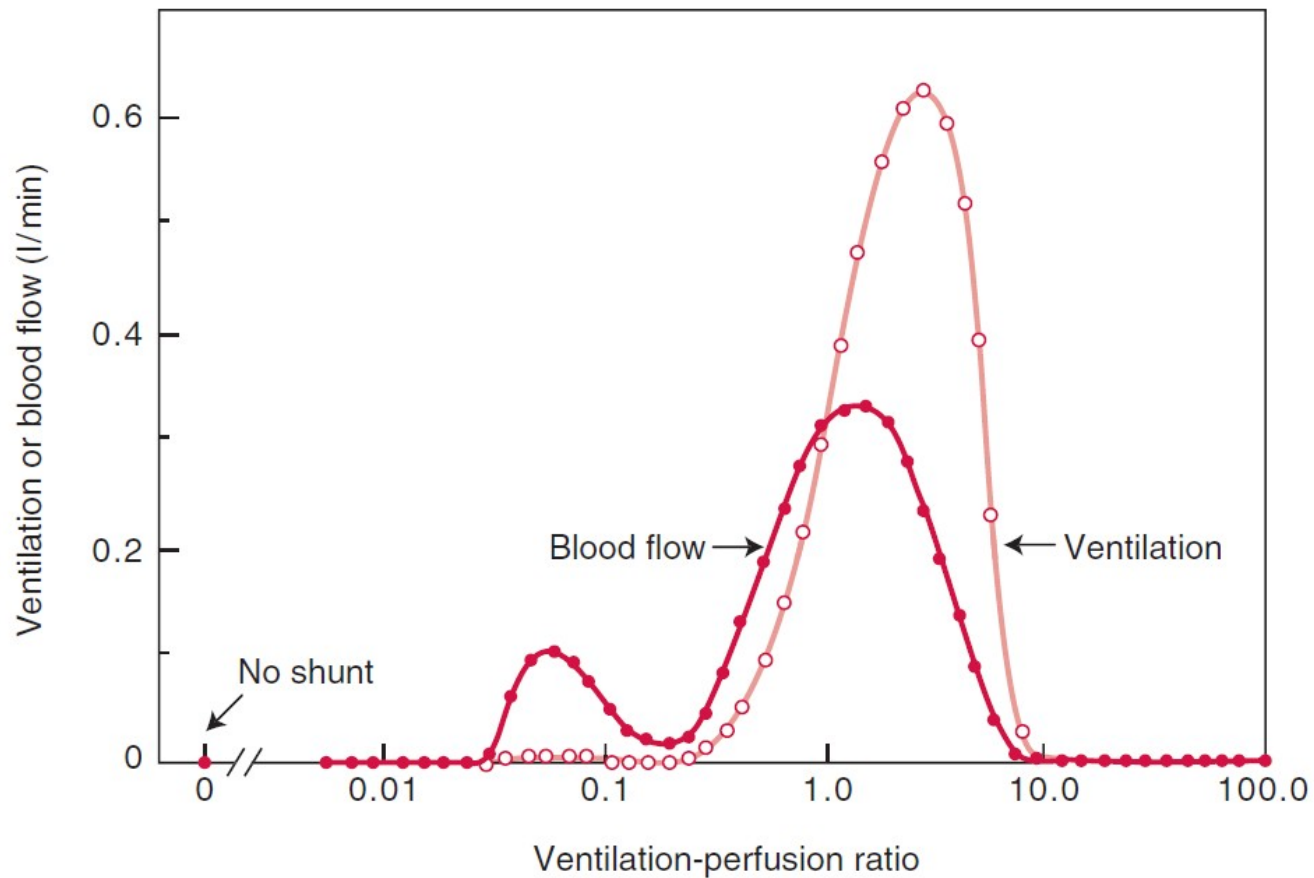


Figure 5-8. Distribution of ventilation and blood flow down the upright lung (compare Figures 2-7 and 4-7). Note that the ventilation-perfusion ratio decreases down the lung.

VP in Normal



V-P in disease



TESTS FOR GAS EXCHANGE FUNCTION

1) ALVEOLAR-ARTERIAL O₂ TENSION GRADIENT:

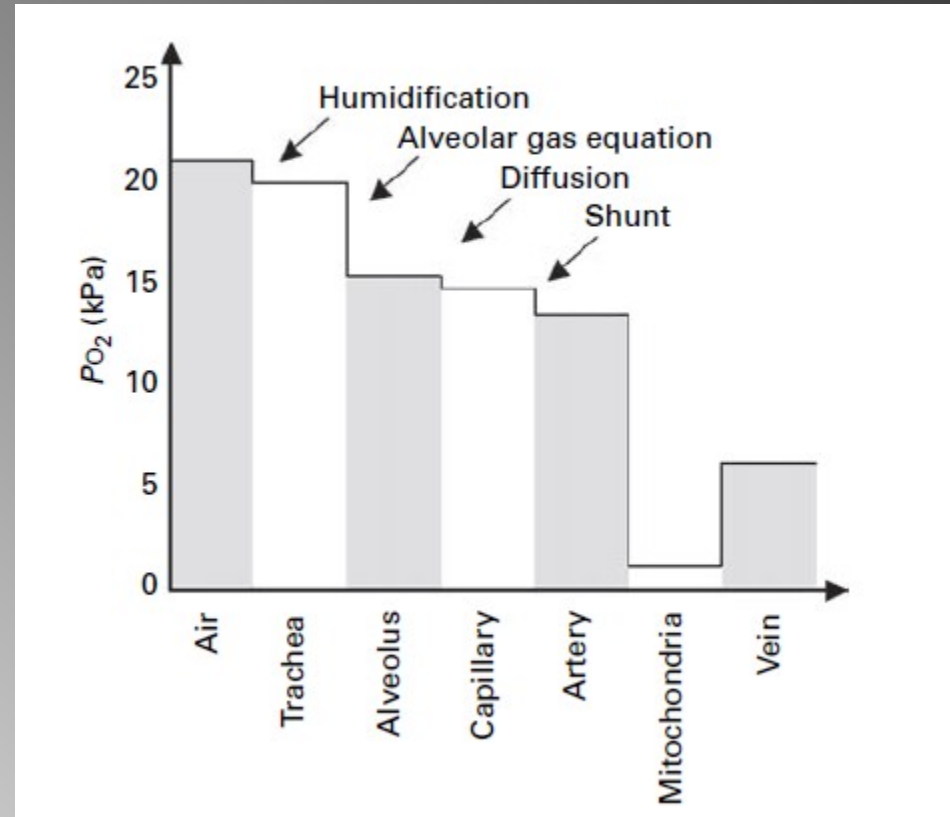
- High values at room air is seen in asymptomatic smokers & chronic. Bronchitis (min. symptoms)

$$PAO_2 = PIO_2 - \frac{PaCO_2}{R}$$

Blood Gases and pH

- causes of low arterial P_{O_2} , or hypoxemia:
- (1) hypoventilation,
- (2) diffusion impairment,
- (3) shunt, and
- (4) ventilation-perfusion inequality

Oxygen cascade



Stage	Process	Notes and equations
Air	–	$P_{O_2} = F_{IO_2} \cdot P_{ATM}$
Trachea	Humidification	$P_{O_2} = F_{IO_2} (P_{ATM} - P_{H_2O})$
Alveolus	Ventilation	$P_{AO_2} = [F_{IO_2} (P_{ATM} - P_{H_2O})] - (P_{ACO_2} / R)$
Capillary	Diffusion	Diffusion barrier negligible for O_2
Artery	Shunt, $\dot{V}/\dot{Q}$ mismatch	A–a gradient usually < 2 kPa
Mitochondria	–	Low P_{O_2} of around 1.5 kPa is usual
Veins	–	Normal $P\bar{v}O_2 = 6.3$ kPa

- causes of an increased arterial P_{CO_2} :
- (1) hypoventilation
- (2) ventilation-perfusion inequality

Mechanics of Breathing

● Lung Compliance

Compliance is defined as the volume change per unit of pressure change across the lung.

To obtain this, we need to know intrapleural pressure

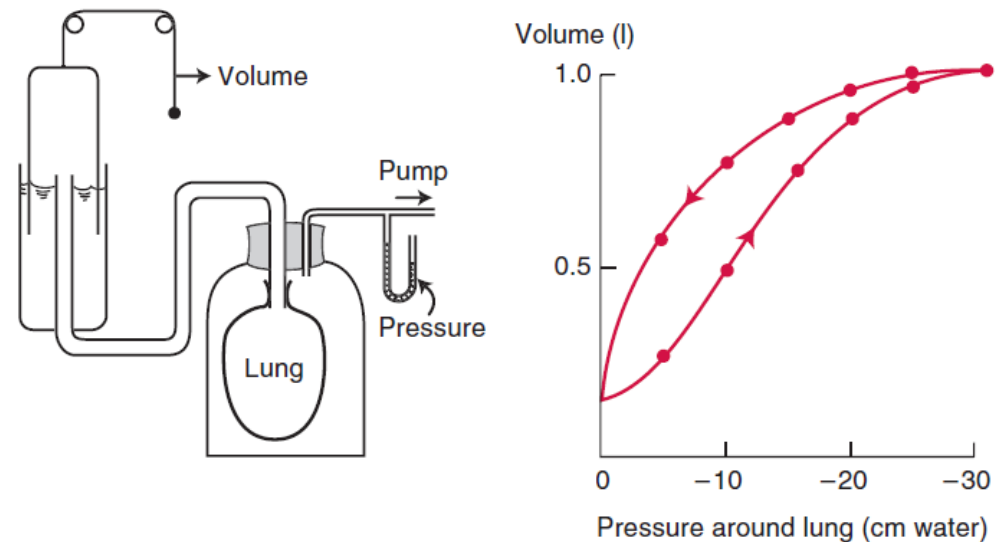


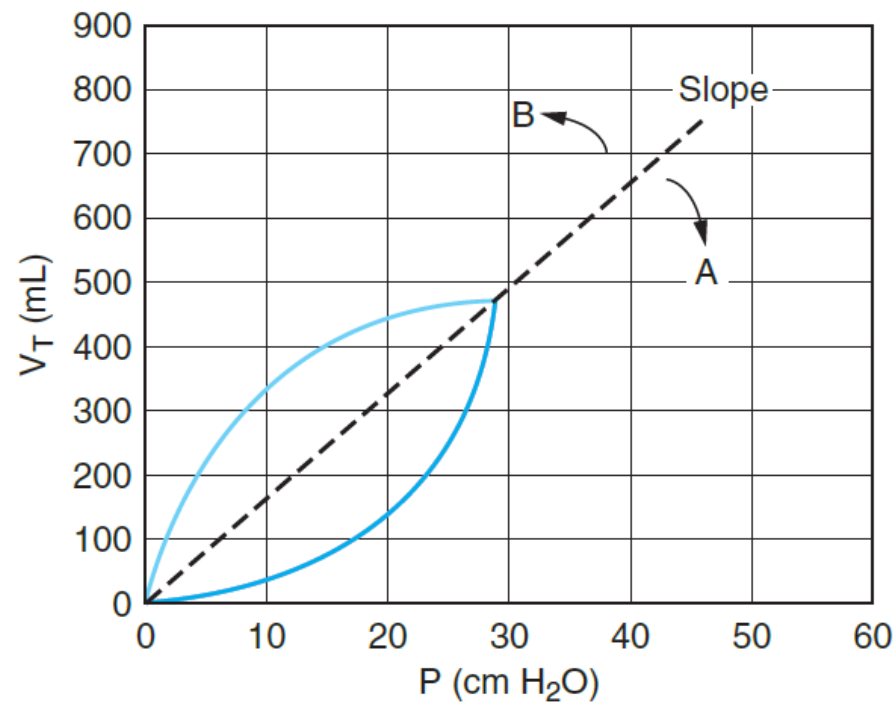
Figure 7-3. Measurement of the pressure-volume curve of excised lung. The lung is held at each pressure for a few seconds while its volume is measured. The curve is nonlinear and becomes flatter at high expanding pressures. Note that the inflation and deflation curves are not the same; this is called hysteresis.

$$C_{ST} = \frac{\text{Corrected Tidal Volume}}{(\text{Plateau Pressure} - \text{PEEP})}$$

$$C_{DYN} = \frac{\text{Corrected Tidal Volume}}{(\text{Peak Inspiratory Pressure} - \text{PEEP})}$$

TABLE 1-3 Clinical Conditions That Decrease the Compliance

Type of Compliance	Clinical Conditions
Static compliance	ARDS Atelectasis Tension pneumothorax Obesity Retained secretions
Dynamic compliance	Bronchospasm Kinking of ET tube Airway obstruction



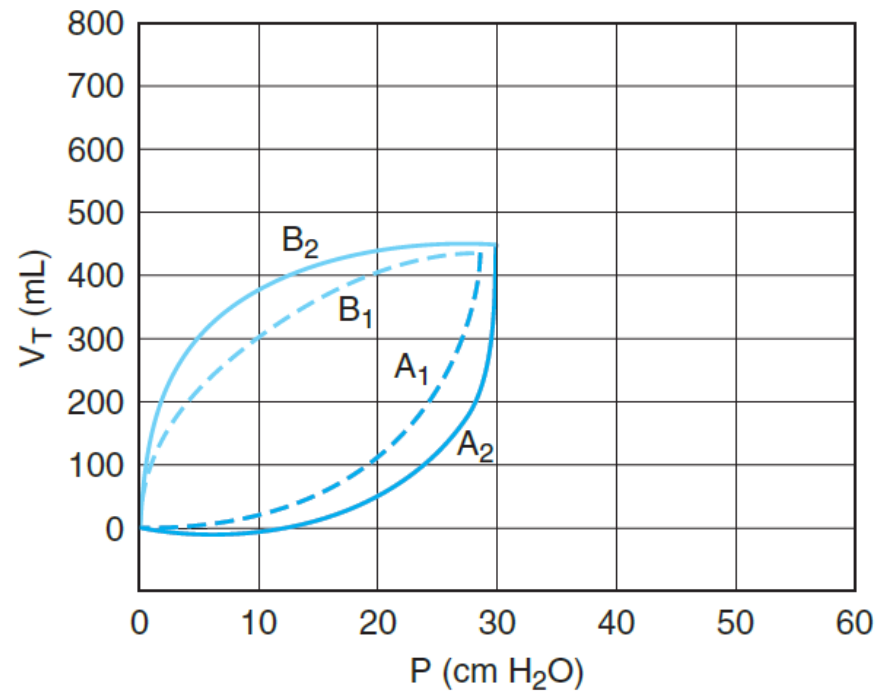
© Cengage Learning 2014

FIGURE 1-4 Shifting of the P-V slope toward the pressure axis (A) indicates a decrease in compliance. Shifting of the P-V slope toward the volume axis (B) indicates an increase in compliance.

● **Airway Resistance**

- Airway resistance is the pressure difference between the alveoli and the mouth per unit of airflow.
- Airway resistance is the pressure difference between the alveoli and the mouth divided by a flow rate.
- Mouth pressure is easily measured with a manometer.
- Alveolar pressure can be deduced from measurements made in a body plethysmograph.

Airflow Resistance



© Cengage Learning 2014

FIGURE 1-1 Increased bowing (from dotted to solid lines) of the pressure–volume loop suggests an increase in airflow resistance. Bowing of inspiratory limb (from A₁ to A₂) may be caused by excessive inspiratory flow. Bowing of the expiratory limb (from B₁ to B₂) may be caused by an increase in expiratory flow resistance such as bronchospasm.

Closing Volume

- The volume of lungs above the RV at which the small airways close is the closing volume.
- In young normal subjects, the closing volume is about 10% of the vital capacity (VC).
- It increases steadily with age and is equal to about 40% of the VC, that is, the FRC, at about the age of 65 years.
- Relatively small amounts of disease in the small airways apparently increase the closing volume.

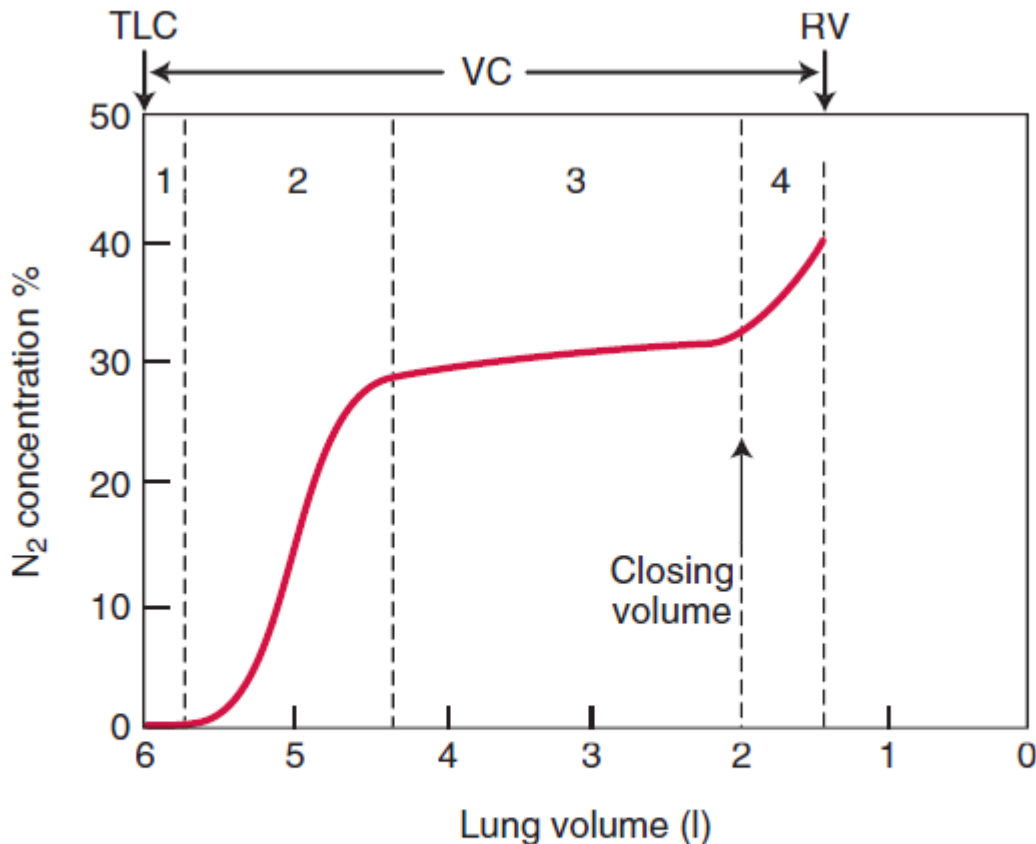


Figure 10-6. Measurement of the closing volume. If a vital capacity inspiration of 100% O_2 is followed by a full expiration, four phases in the N_2 concentration measured at the lips can be recognized (see text). The last is caused by preferential emptying of the upper part of the lung after the lower-zone airways have closed.

- pure dead space(1),
- a mixture of dead space and alveolar gas (2),
- pure alveolar gas (3)
- end of expiration, an abrupt increase in N_2 (4)

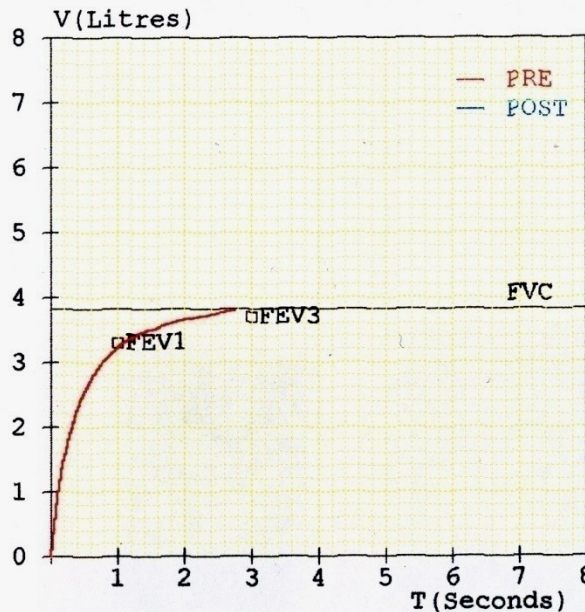
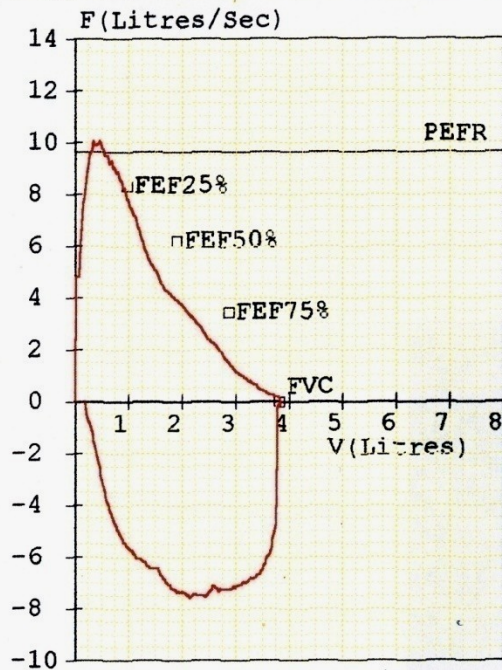
Control of Ventilation

- The responsiveness of the chemoreceptors and respiratory center to CO_2 can be measured by having the subject rebreathe into a rubber bag.
- The ventilatory response to hypoxia can be measured in a similar way if the subject rebreathes from a bag with a low Po_2 but constant Pco_2 .

Exercise Testing

Exercise testing can be valuable in detecting small amounts of lung disease.

Patient: Mr. Kushagra Mathur Age : 24 years Sex : Male BSA : 1.8 m²
 Refd. By: Height : 173 Cms Smoker : No Temp : 30 degrees
 Pred.Eqns: RECORDERS ID: ** Weight : 68 Kgs Eth. Corr: 100 Date : 30/09/2004



Peak/Descent/
Cough /Loop

Expl time/FET/
Reproducibility

FVC Results

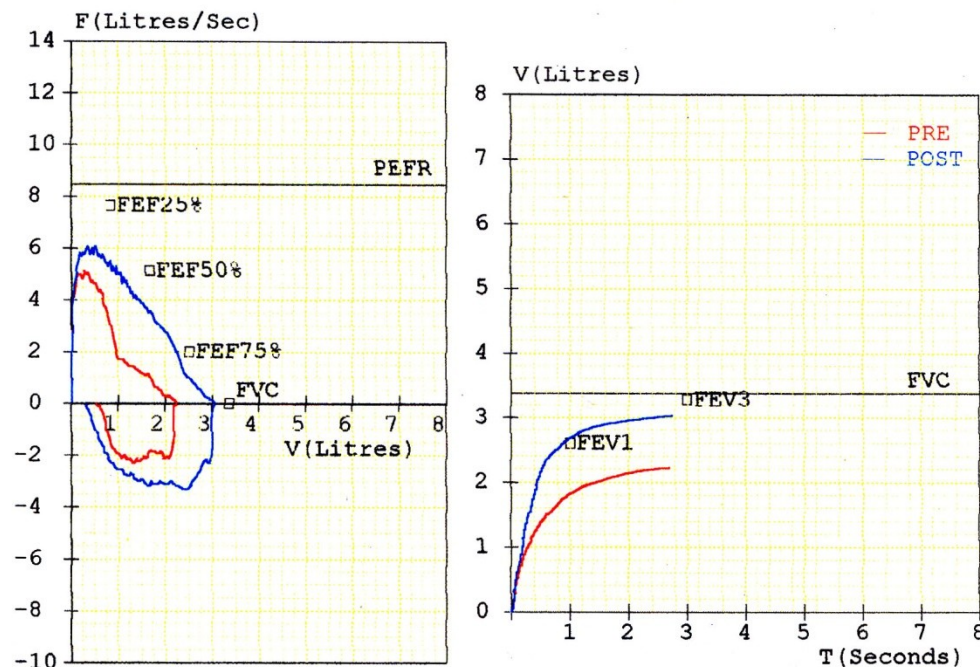
Parameter	Pred	Pre	%Pred	Post	%Pred	%Imp
FVC (L)	03.82	03.83	100	-----	---	---
FIVC (L)	-----	03.62	---	-----	---	---
FEV.5 (L)	-----	02.56	---	-----	---	---
FEV1 (L)	03.29	03.24	098	-----	---	---
FEV3 (L)	03.71	03.83	103	-----	---	---
PEFR (L/s)	09.62	09.98	104	-----	---	---
PIFR (L/s)	-----	07.50	---	-----	---	---
FEF25-75 (L/s)	04.72	03.38	072	-----	---	---
FEF75-85 (L/s)	-----	01.05	---	-----	---	---
FEF.2-1.2 (L/s)	08.13	08.49	104	-----	---	---
FEF 25% (L/s)	08.31	07.84	094	-----	---	---
FEF 50% (L/s)	06.18	03.87	063	-----	---	---
FEF 75% (L/s)	03.42	01.48	043	-----	---	---
FEV.5/FVC (%)	-----	66.84	---	-----	---	---
FEV1/FVC (%)	86.13	84.60	098	-----	---	---
FEV3/FVC (%)	97.12	100.00	103	-----	---	---
FVC Time (Sec)	-----	02.86	---	-----	---	---
ExplTime (Sec)	-----	00.04	---	-----	---	---

Patient: Mr. Padam Kothari
 Refd. By: Dr. Dinesh Sharma
 Pred. Eqns: RECORDERS
 Date : 09/08/2004

ID: 1892

Age : 59 Years
 Height : 174 Cms
 Weight : 76 Kgs
 BSA : 1.9 m2

Sex : Male
 Smoker : No
 Eth. Corr: 100
 Temp : 25 degrees



FVC Results

Parameter	Pred	Pre	%Pred	Post	%Pred	%Imp
FVC (L)	03.38	02.23	066	03.04	090	+36
FIVC (L)	-----	01.69	---	02.71	---	+60
FEV.5 (L)	-----	01.37	---	02.14	---	+56
FEV1 (L)	02.59	01.84	071	02.71	105	+47
FEV3 (L)	03.28	02.23	068	03.04	093	+36
PEFR (L/s)	08.47	05.09	060	06.13	072	+20
PIFR (L/s)	-----	02.30	---	03.30	---	+43
FEF25-75 (L/s)	03.16	01.70	054	03.51	111	+106
FEF75-85 (L/s)	-----	00.65	---	01.12	---	+72
FEF.2-1.2 (L/s)	05.80	02.88	050	05.34	092	+85
FEF 25% (L/s)	07.64	04.40	058	05.39	071	+22
FEF 50% (L/s)	05.15	01.65	032	03.84	075	+133
FEF 75% (L/s)	02.00	01.08	054	01.95	098	+81
FEV.5/FVC (%)	-----	61.43	---	70.39	---	+15
FEV1/FVC (%)	76.63	82.51	108	89.14	116	+08
FEV3/FVC (%)	97.04	100.00	103	100.00	103	+00
FVC Time (Sec)	-----	02.71	---	02.86	---	---
ExplTime (Sec)	-----	00.03	---	00.04	---	---

Day-1 :

FEV1/FVC : 82.51 (108%)

FVC : 2.23 (66%)

FEV1 : 1.84 (71%)

What is the
 diagnosis?
 : Restrictive
 Pathology

Day 14 :

FEV1/FVC : 89%

FVC : 3.04 L.(90%)

FEV1 : 2.71 (105%)

: Normal

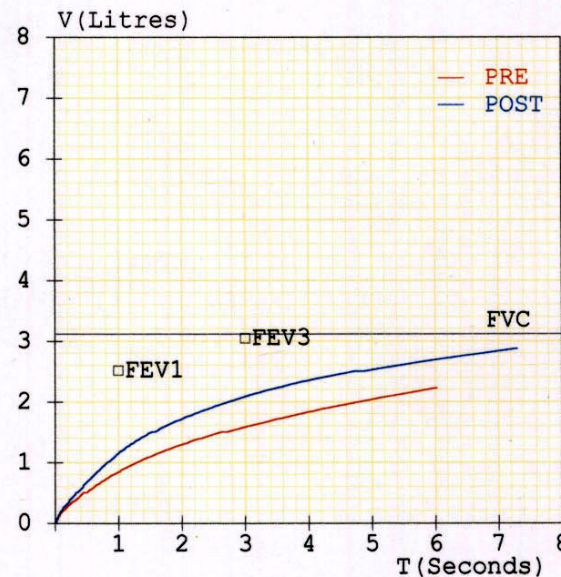
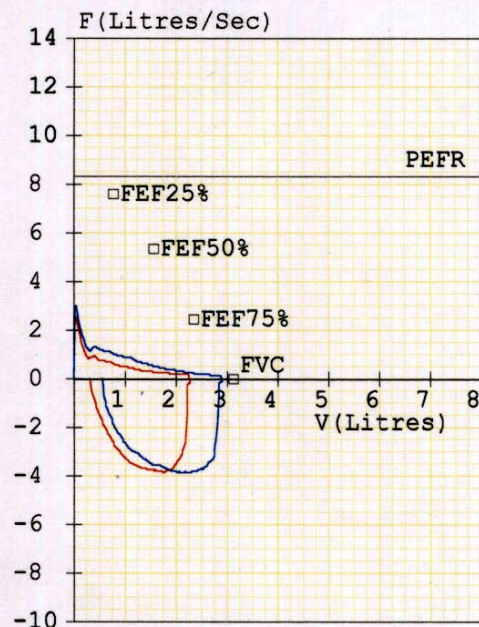
Patient: Mr. Jagmeet
 Refd. By:
 Pred.Eqns: RECORDERS

ID: 504

Age : 45 Years
 Height : 165 Cms
 Weight : 64 Kgs

Sex : Male
 Smoker : No
 Eth. Corr: 100

BSA : 1.7 m2
 Temp : 25 degrees
 Date : 08/09/2004



FVC Results

Parameter		Pred	Pre	%Pred	Post	%Pred	%Imp
FVC	(L)	03.13	02.24	072	02.89	092	+29
FIVC	(L)	-----	01.93	---	02.33	---	+21
FEV.5	(L)	-----	00.54	---	00.69	---	+28
FEV1	(L)	02.53	00.86	034	01.15	045	+34
FEV3	(L)	03.04	01.60	053	02.10	069	+31
PEFR	(L/s)	08.32	02.69	032	03.13	038	+16
PIFR	(L/s)	-----	03.82	---	03.85	---	+01
FEF25-75	(L/s)	03.62	00.40	011	00.53	015	+32
FEF75-85	(L/s)	-----	00.22	---	00.22	---	+00
FEF.2-1.2	(L/s)	06.29	00.61	010	01.03	016	+69
FEF 25%	(L/s)	07.61	00.72	009	01.07	014	+49
FEF 50%	(L/s)	05.34	00.43	008	00.59	011	+37
FEF 75%	(L/s)	02.44	00.25	010	00.28	011	+12
FEV.5/FVC	(%)	-----	24.11	---	23.88	---	-01
FEV1/FVC	(%)	80.83	38.39	047	39.79	049	+04
FEV3/FVC	(%)	97.12	71.43	074	72.66	075	+02
FVC Time	(Sec)	-----	06.12	---	07.35	---	---
ExptTime	(Sec)	-----	00.02	---	00.02	---	---

Pre-bronchodilator
 spiograph

shows :

FEV1/FVC : 38.39%(Very
 low)

FVC : 2.24 (72 %
 pred.)

FET : 6.12 sec.

Diagnosis ?

Obstructive airway
 disease

Post- bronchodilatation
 spiograph

shows:

Δ FVC : 650 ml (29 %)

Δ FEV1 : 290 ml (34%)

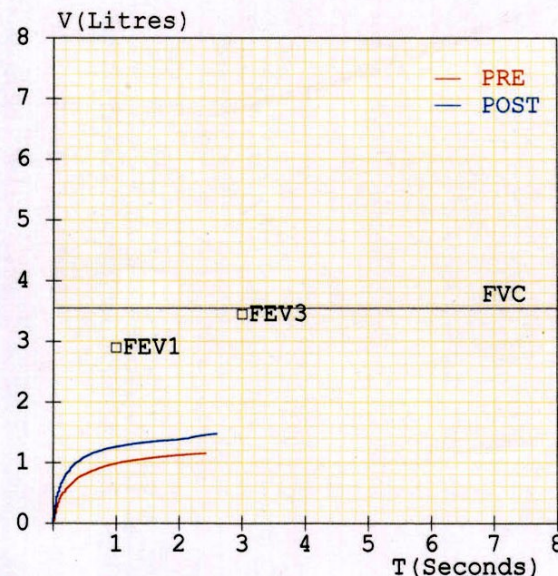
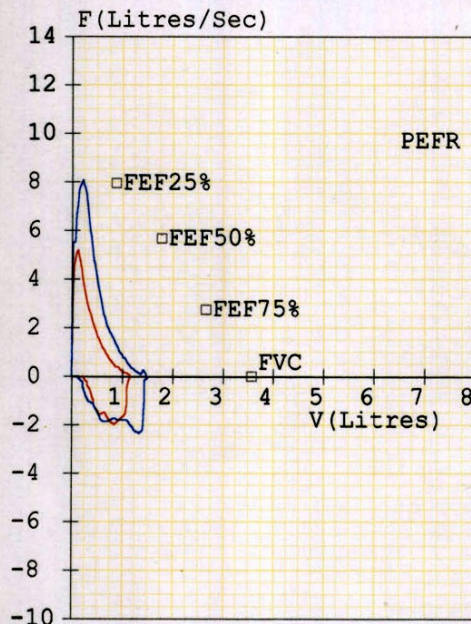
What is your final

diagnosis?airway

obstruction-**Bronchial**

Asthma

Patient: Mr. Prem Prakash Age : 40 Years Sex : Male BSA : 1.9 m2
 Refd. By: Dr. M. L. Gupta (D. M.) Height : 172 Cms Smoker : No Temp : 25 degrees
 Pred.Eqns: RECORDERS ID: 1906 Weight : 76 Kgs Eth. Corr: 100 Date : 20/08/2004



FVC Results

Parameter	Pred	Pre	%Pred	Post	%Pred	%Imp
FVC (L)	03.55	01.15	032	01.47	041	+28
FIVC (L)	-----	00.91	---	01.37	---	+51
FEV.5 (L)	-----	00.82	---	01.10	---	+34
FEV1 (L)	02.91	00.99	034	01.26	043	+27
FEV3 (L)	03.44	01.15	033	01.47	043	+28
PEFR (L/s)	08.99	05.11	057	08.02	089	+57
PIFR (L/s)	-----	01.95	---	02.32	---	+19
FEF25-75 (L/s)	03.98	01.08	027	01.53	038	+42
FEF75-85 (L/s)	-----	00.30	---	00.33	---	+10
FEF.2-1.2 (L/s)	06.99	00.42	006	01.34	019	+219
FEF 25% (L/s)	07.95	03.15	040	06.01	076	+91
FEF 50% (L/s)	05.67	01.34	024	01.93	034	+44
FEF 75% (L/s)	02.75	00.43	016	00.55	020	+28
FEV.5/FVC (%)	-----	71.30	---	74.83	---	+05
FEV1/FVC (%)	81.97	86.09	105	85.71	105	+00
FEV3/FVC (%)	96.90	100.00	103	100.00	103	+00
FVC Time (Sec)	-----	02.41	---	02.59	---	---
ExptTime (Sec)	-----	00.02	---	00.03	---	---

This patient came with history of proxysmal cough, breathlessness. Pre bronchodilator spirometry findings are:

FEV1/FVC : 86.09 % (normal)

FVC : 1.15 L.(32% of Pred)

Diagnosis :

Restrictive

But Pathology

bronchodilator reading shows:

Δ FVC : 320 ml (28%)

Δ FEV1 : 270 ml (27%)

How to explain Now diagnosis is.....

Normal FEV1/FVC ratio

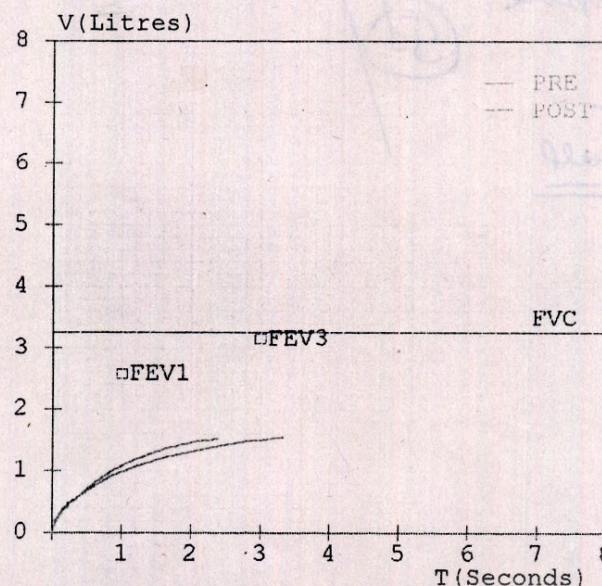
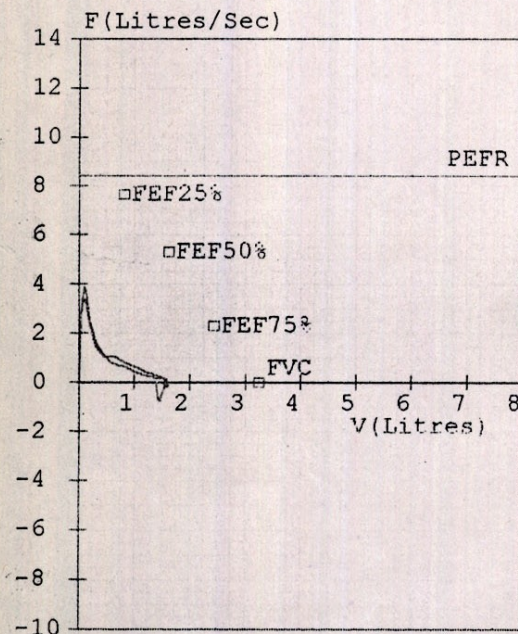
Inadequately expiratory

time result in false increase

in FEV1 ratio. Pearl : Obst.

Disease FET

Patient: mr kamruddin Age : 50 Years Sex : Male BSA : 1.6 m2
 Refd. By: dr manohar gupta Height : 169 Cms Smoker : No Temp : 22 degrees
 Pred.Eqns: RECORDERS ID: 111 Weight : 54 Kgs Eth. Corr: 100 Date : 28/10/2001



FVC Results

Parameter		Pred	Pre	%Pred	Post	%Pred	%Imp
FVC	(L)	03.26	01.59	049	01.56	048	-02
FIVC	(L)	-----	00.07	---	00.16	---	+129
FEV.5	(L)	-----	00.71	---	00.73	---	+03
FEV1	(L)	02.58	01.00	039	01.10	043	+10
FEV3	(L)	03.16	01.53	048	01.57	050	+03
PEFR	(L/s)	08.43	03.84	046	03.37	040	-12
PIFR	(L/s)	-----	00.18	---	00.72	---	+300
FEF25-75	(L/s)	03.47	00.60	017	00.81	023	+35
FEF75-85	(L/s)	-----	00.25	---	00.40	---	+60
FEF.2-1.2	(L/s)	06.16	00.67	011	00.87	014	+30
FEF 25%	(L/s)	07.65	01.33	017	01.22	016	-08
FEF 50%	(L/s)	05.29	00.68	013	00.88	017	+29
FEF 75%	(L/s)	02.30	00.31	013	00.48	021	+55
FEV.5/FVC	(%)	-----	44.65	---	46.79	---	+05
FEV1/FVC	(%)	79.14	62.89	079	70.51	089	+12
FEV3/FVC	(%)	96.93	96.23	099	100.64	104	+05
FVC Time	(Sec)	-----	03.38	---	02.44	---	---
ExplTime	(Sec)	-----	00.03	---	00.03	---	---

This spirometry has

▪ FVC : ↓ (1.59 L.49 pred)

▪ FEV1/FVC : 62%

Post-bronchodilation

FVC - ↓ 2 %

FEV1 - No Change

What is the diagnosis?

-Irreversible airway

obstruction

What is the cause of disproportionate decrease in FVC

Inadequate expiratory time

Loss of lung tissue

▪ Bullae/Pneumothorax
 Associated restrictive pathology

✓ **Repeat PFT with long FET**

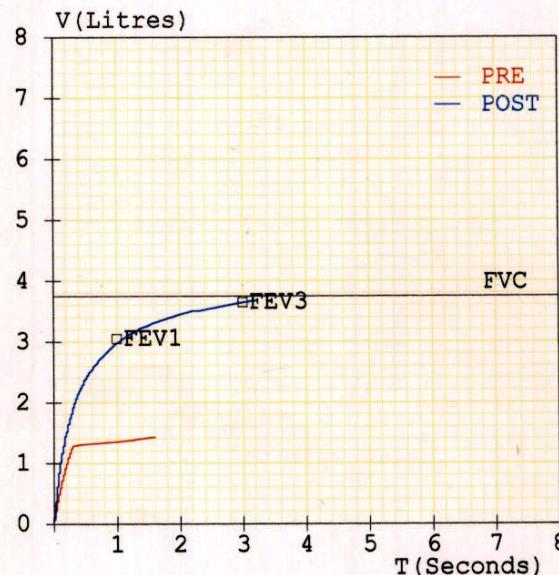
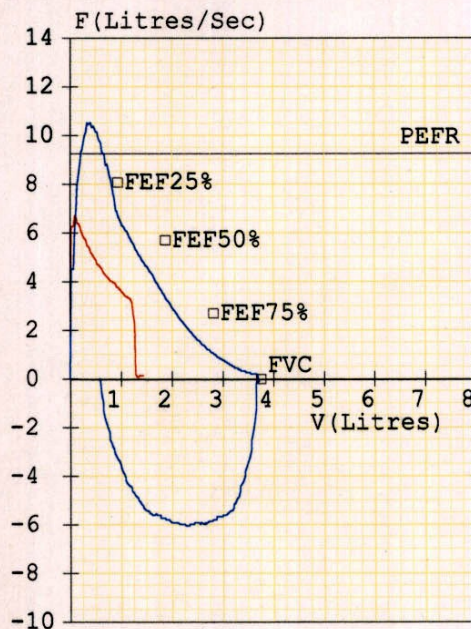
Patient: Dr Mahesh Goyal
 Refd. By: Dr M L Gupta
 Pred.Eqns: RECORDERS

ID: **

Age : 43 Years
 Height : 177 Cms
 Weight : 75 Kgs

Sex : Male
 Smoker : No
 Eth. Corr: 100

BSA : 1.9 m2
 Temp : 30 degrees
 Date : 14/09/2004



FVC Results

Parameter	Pred	Pre	%Pred	Post	%Pred	%Imp
FVC (L)	03.76	01.44	038	03.70	098	+157
FIVC (L)	-----	-----	---	03.11	---	-99
FEV.5 (L)	-----	01.31	---	02.38	---	+82
FEV1 (L)	03.05	01.35	044	02.98	098	+121
FEV3 (L)	03.65	01.44	039	03.66	100	+154
PEFR (L/s)	09.24	06.61	072	10.46	113	+58
PIFR (L/s)	-----	-----	---	06.00	---	-98
FEF25-75 (L/s)	03.94	04.13	105	02.71	069	-34
FEF75-85 (L/s)	-----	03.23	---	00.77	---	-76
FEF.2-1.2 (L/s)	07.04	04.20	060	07.96	113	+90
FEF 25% (L/s)	08.07	05.38	067	06.80	084	+26
FEF 50% (L/s)	05.71	04.20	074	03.41	060	-19
FEF 75% (L/s)	02.69	03.39	126	01.08	040	-68
FEV.5/FVC (%)	-----	90.97	---	64.32	---	-29
FEV1/FVC (%)	81.12	93.75	116	80.54	099	-14
FEV3/FVC (%)	97.07	100.00	103	98.92	102	-01
FVC Time (Sec)	-----	01.73	---	03.29	---	---
ExplTime (Sec)	-----	00.02	---	00.03	---	---

Red spirograph shows-

FEV1/FVC : Normal (93.75)

FVC : low (38%)

Diagnosis ?

Restrictive

disorder because

Patient has stopped expiring suddenly as evident by vertical drop

Blue flow volume graph shows :

FEV1/FVC : NORMAL(80%)

FVC : NORMAL (3.70)

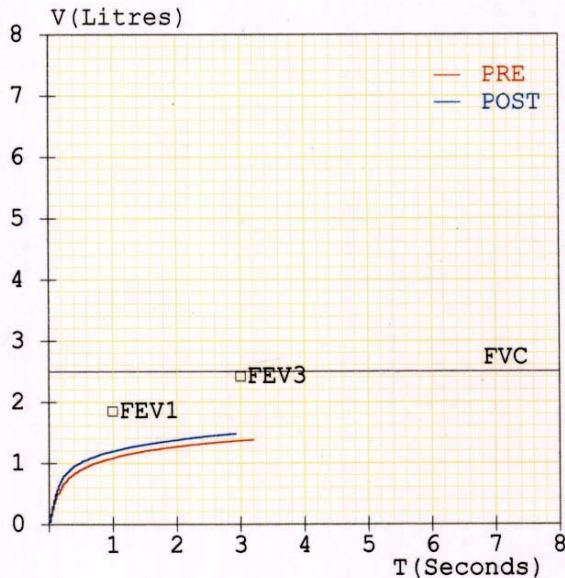
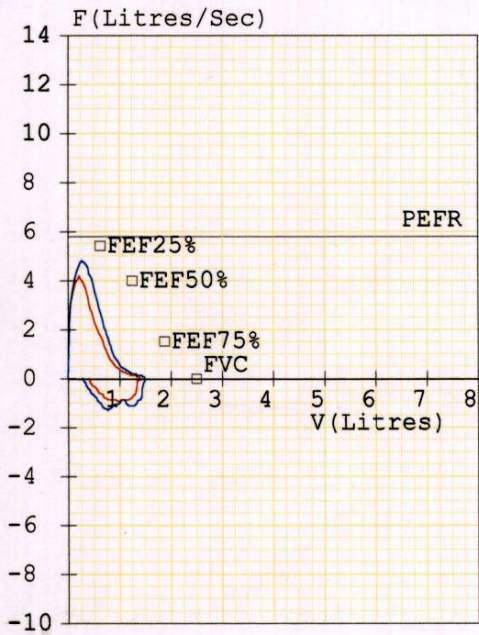
FET : NORMAL

NORMAL SPIROMETRY

• **PEARL** : Vertical drop in expiratory flow volume loop is unacceptable.

• Inadequately effort will result in false increase in FEV1/FVC

Patient: Mrs. Raghuraj Kumari Age : 62 Years Sex : Female BSA : 1.7 m2
Refd. By: Dr. Manohar Gupta (D.M.) Height : 165 Cms Smoker : No Temp : 20 degrees
Pred.Eqns: RECORDERS ID: 1204 Weight : 67 Kgs Eth. Corr: 100 Date : 23/12/2003



This non smoker female came with symptoms of cough and breathlessness following coryza

Spirometric findings are:

FEV1/FVC : 78.42% (normal)
FVC : 60% of predicted
FEV1 : 65% of predicted
Restrictive disorder

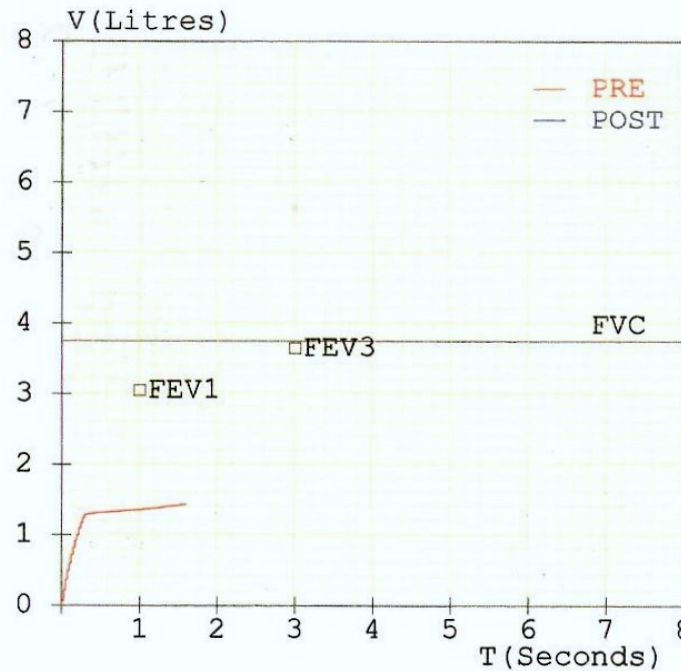
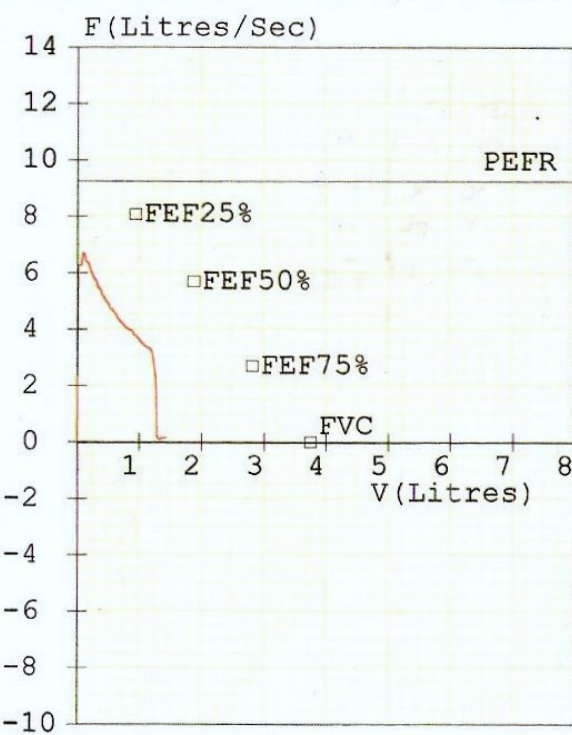
But, what about the disproportionate low reading of FEF 25-75 %:

:0.92 L/S. (only 36% of pred.)
Due to small airway disease (Bronchiolitis Obliterans)

Reduced in FEF 25-75 % with normal

FVC Results

Parameter	Pred	Pre	%Pred	Post	%Pred	%Imp
FVC (L)	02.49	01.39	056	01.49	060	+07
FIVC (L)	-----	00.99	---	01.20	---	+21
FEV.5 (L)	-----	00.90	---	01.02	---	+13
FEV1 (L)	01.84	01.09	059	01.20	065	+10
FEV3 (L)	02.42	01.37	057	01.48	061	+08
PEFR (L/s)	05.80	04.14	071	04.78	082	+15
PIFR (L/s)	-----	00.91	---	01.27	---	+40
FEF25-75 (L/s)	02.53	00.92	036	01.14	045	+24
FEF75-85 (L/s)	-----	00.23	---	00.24	---	+04
FEF.2-1.2 (L/s)	03.88	00.66	017	01.01	026	+53
FEF 25% (L/s)	05.43	03.59	066	04.54	084	+26
FEF 50% (L/s)	03.99	01.35	034	01.79	045	+33
FEF 75% (L/s)	01.53	00.30	020	00.36	024	+20
FEV.5/FVC (%)	-----	64.75	---	68.46	---	+06
FEV1/FVC (%)	73.90	78.42	106	80.54	109	+03
FEV3/FVC (%)	97.19	98.56	101	99.33	102	+01
FVC Time (Sec)	-----	03.44	---	03.15	---	---
ExplTime (Sec)	-----	00.05	---	00.06	---	---

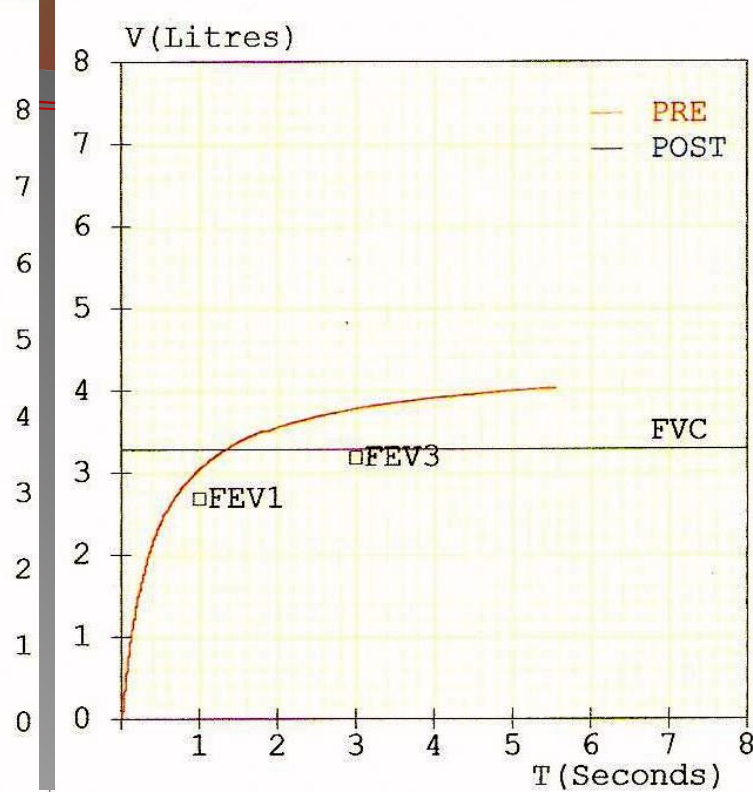
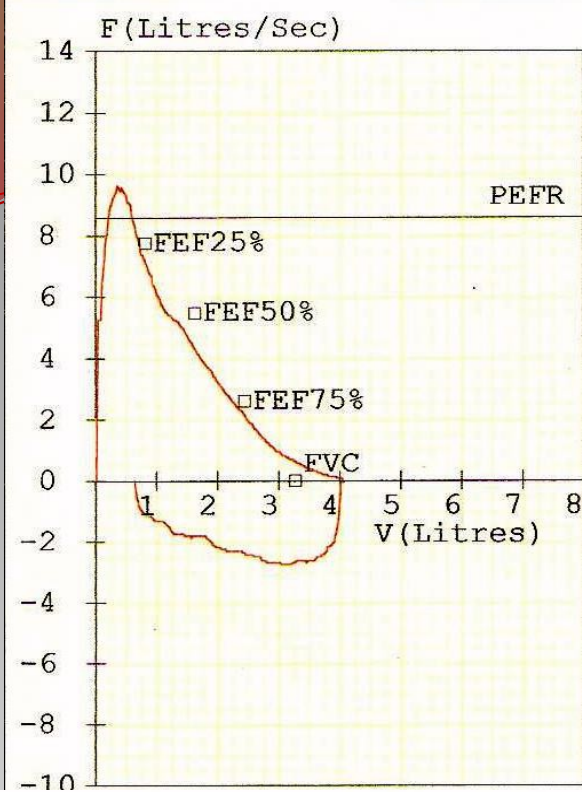


Vertical
drop in
expiratory
flow
volume
loop

FVC Results

Parameter		Pred	Pre	%Pred	Post	%Pred	%Imp
FVC	(L)	03.76	01.44	038	-----	----	----
FIVC	(L)	-----	-----	---	-----	----	----
FEV.5	(L)	-----	01.31	---	-----	----	----
FEV1	(L)	03.05	01.35	044	-----	----	----
FEV3	(L)	03.65	01.44	039	-----	----	----
PEFR	(L/s)	09.24	06.61	072	-----	----	----
PIFR	(L/s)	-----	-----	---	-----	----	----
FEF25-75	(L/s)	03.94	04.13	105	-----	----	----
FEF75-85	(L/s)	-----	03.23	---	-----	----	----
FEF.2-1.2	(L/s)	07.04	04.20	060	-----	----	----
FEF 25%	(L/s)	08.07	05.38	067	-----	----	----
FEF 50%	(L/s)	05.71	04.20	074	-----	----	----
FEF 75%	(L/s)	02.69	03.39	126	-----	----	----
FEV.5/FVC	(%)	-----	90.97	---	-----	----	----
FEV1/FVC	(%)	81.12	93.75	116	-----	----	----
FEV3/FVC	(%)	97.07	100.00	103	-----	----	----
FVC Time	(Sec)	-----	01.73	---	-----	----	----
ExplTime	(Sec)	-----	00.02	---	-----	----	----

SUDDEN CESSATION
OF EXPIRATION

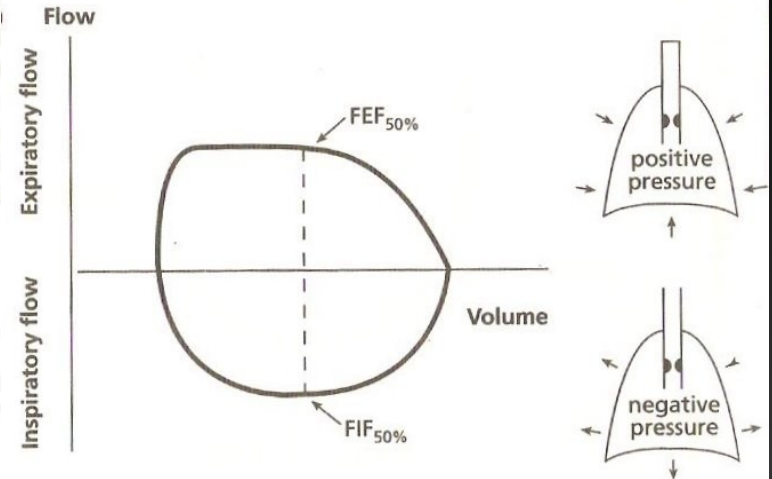
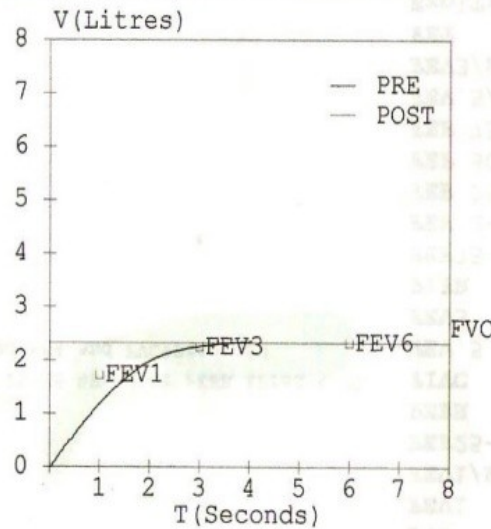
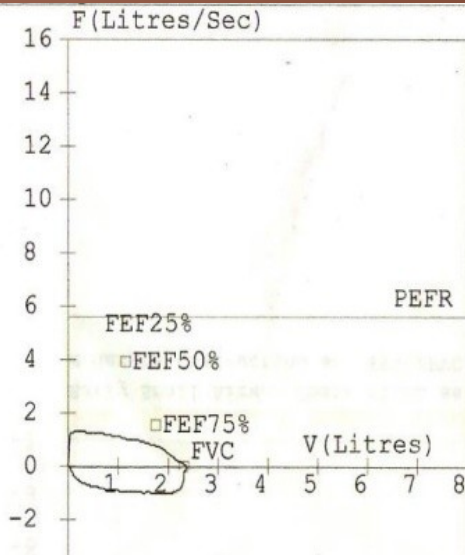


FVC Results

Parameter		Pred	Pre	%Pred	Post	%Pred	%Imp
FVC	(L)	03.27	04.04	124	-----	---	---
FIVC	(L)	-----	03.42	---	-----	---	---
FEV.5	(L)	-----	02.40	---	-----	---	---
FEV1	(L)	02.67	03.06	115	-----	---	---
FEV3	(L)	03.17	03.80	120	-----	---	---
PEFR	(L/s)	08.57	09.59	112	-----	---	---
PIFR	(L/s)	-----	02.73	---	-----	---	---
FEF25-75	(L/s)	03.79	02.37	063	-----	---	---
FEF75-85	(L/s)	-----	00.61	---	-----	---	---
FEF.2-1.2	(L/s)	06.60	07.26	110	-----	---	---
FEF 25%	(L/s)	07.74	06.02	078	-----	---	---
FEF 50%	(L/s)	05.48	03.11	057	-----	---	---
FEF 75%	(L/s)	02.60	00.86	033	-----	---	---
FEV.5/FVC	(%)	-----	59.41	---	-----	---	---
FEV1/FVC	(%)	81.65	75.74	093	-----	---	---
FEV3/FVC	(%)	96.94	94.06	097	-----	---	---
FVC Time	(Sec)	-----	05.71	---	-----	---	---
ExplTime	(Sec)	-----	00.04	---	-----	---	---

Incomplete flow volume loop

LEAK AROUND THE MOUTH



Flattening of both inspiratory & expiratory flow volume loops

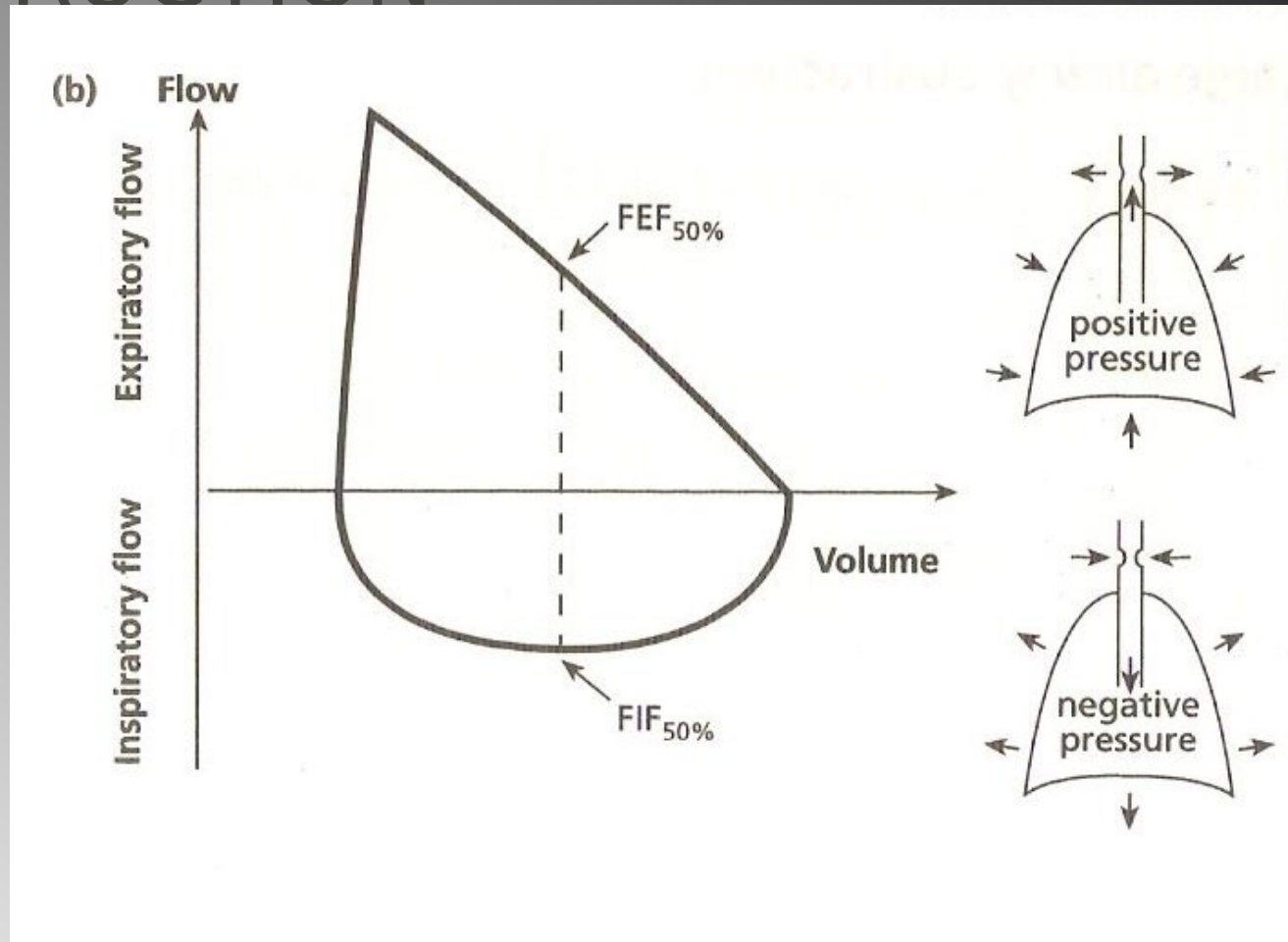
FIXED UPPER AIRWAY OBSTRUCTION

FVC Results						
Parameter		Pred	M.Pre%Pred	M.Post	%Pred	%Imp
FVC	(L)	02.32	02.36	102	----	---
FEV1	(L)	01.73	01.19	069	----	---
FEV1/FVC	(%)	74.57	50.42	068	----	---
FEF25-75	(L/s)	01.98	00.99	050	----	---
PEFR	(L/s)	05.59	01.29	023	----	---
FIVC	(L)	----	02.32	---	----	---
FEV.5	(L)	----	00.63	---	----	---
FEV3	(L)	02.25	02.27	101	----	---
PIFR	(L/s)	----	01.00	---	----	---
FEF75-85	(L/s)	----	00.63	---	----	---
FEF.2-1.2	(L/s)	03.80	01.17	031	----	---
FEF 25%	(L/s)	05.33	01.24	023	----	---
FEF 50%	(L/s)	03.92	01.02	026	----	---
FEF 75%	(L/s)	01.56	00.76	049	----	---
FEV.5/FVC	(%)	----	26.69	---	----	---
FEV3/FVC	(%)	96.98	96.19	099	----	---
FET	(Sec)	----	04.14	---	----	---
ExptTime	(Sec)	----	00.12	---	----	---
Lung Age	(Yrs)	060	079	132	----	---
FEV6	(L)	02.32	----	---	----	---
FIF25%	(L/s)	----	00.99	---	00.73	--09
FIF50%	(L/s)	----	00.94	---	01.60	+86
FIF75%	(L/s)	----	00.81	---	01.38	+116

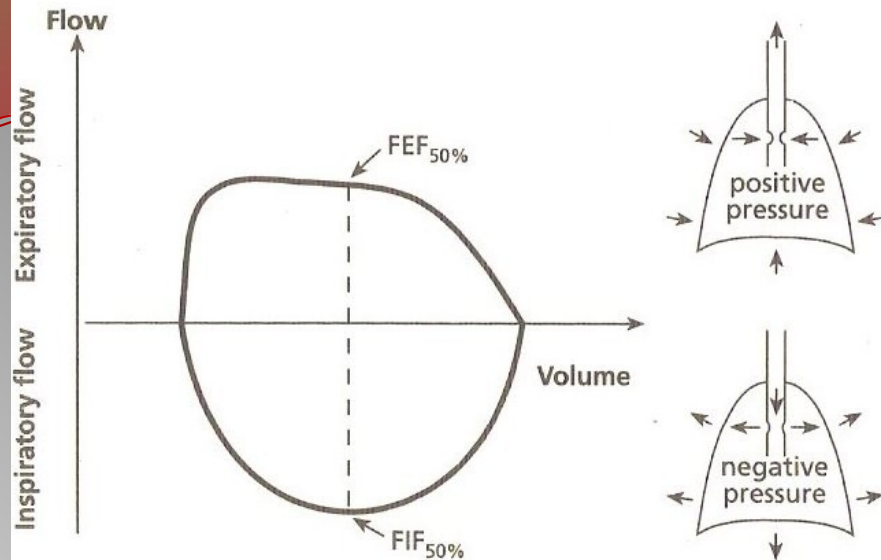
clinical co-relation before any clinical action.

Version 3

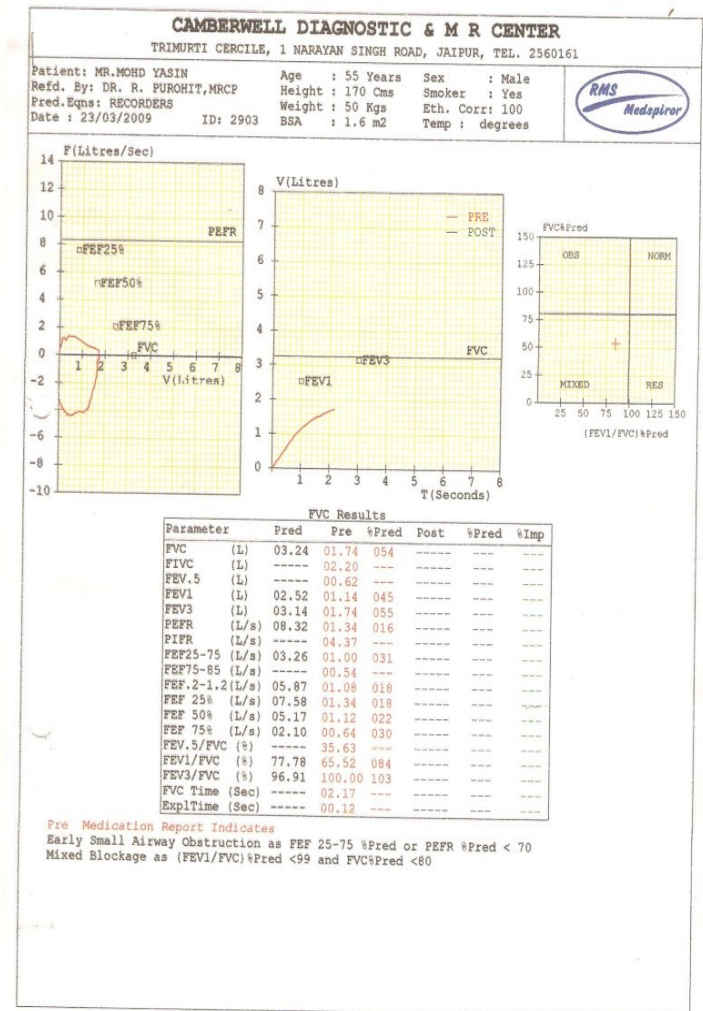
VARIABLE EXTRA THORACIC AIRWAY OBSTRUCTION



Flattening of inspiratory loop



VARIABLE INTRA THORACIC AIRWAY OBSTRUCTION



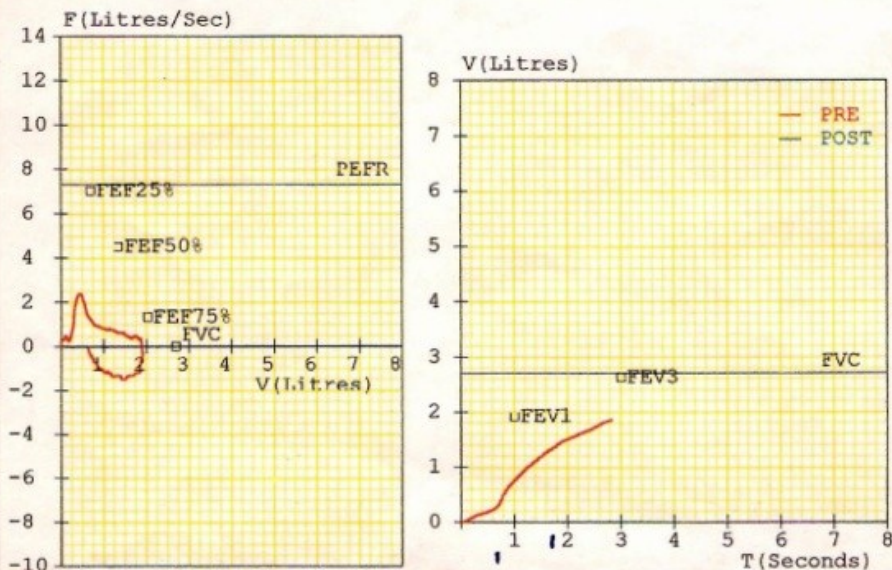
Flattening of expiratory loop of flow volume curve

Patient: NANU
 Refd. By:
 Pred.Eqns: USER 6
 Date : 07/01/2002

ID: 04

Age : 72 Years
 Height : 164 Cms
 Weight : 70 Kgs
 BSA : 1.8 m2

Sex : Male
 Smoker : No
 Eth. Corr: 100
 Temp : 11 degrees

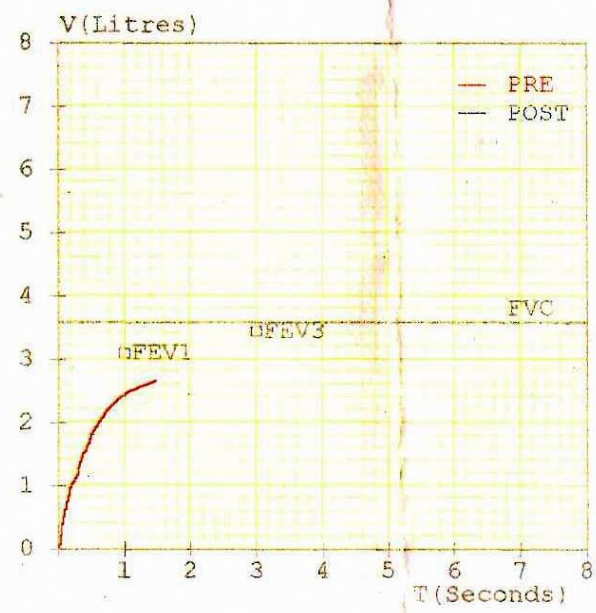
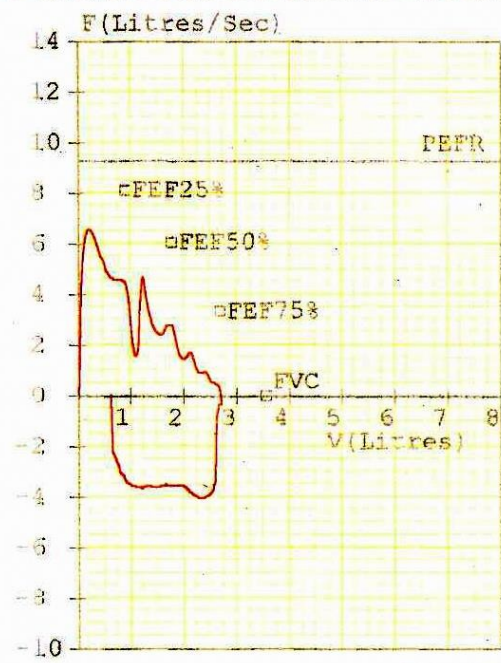


FVC Results

Parameter	Pred	Pre	%Pred	Post	%Pred	%Imp
FVC (L)	02.70	01.88	070	-----	---	---
FIVC (L)	-----	01.24	---	-----	---	---
FEV.5 (L)	-----	00.20	---	-----	---	---
FEV1 (L)	01.92	00.80	042	-----	---	---
FEV3 (L)	02.62	01.88	072	-----	---	---
PEFR (L/s)	07.30	02.34	032	-----	---	---
PIFR (L/s)	-----	01.49	---	-----	---	---
FEF25-75 (L/s)	02.39	00.91	038	-----	---	---
FEF75-85 (L/s)	-----	00.52	---	-----	---	---
FEF.2-1.2 (L/s)	04.41	01.01	023	-----	---	---
FEF 25% (L/s)	07.03	02.34	033	-----	---	---
FEF 50% (L/s)	04.50	00.85	019	-----	---	---
FEF 75% (L/s)	01.32	00.65	049	-----	---	---
FEV.5/FVC (%)	-----	10.64	---	-----	---	---
FEV1/FVC (%)	71.11	42.55	060	-----	---	---
FEV3/FVC (%)	97.04	100.00	103	-----	---	---
FVC Time (Sec)	-----	02.86	---	-----	---	---
ExplTime (Sec)	-----	00.22	---	-----	---	---

Increased back
 extrapolated time
 (>0.05 sec)

HESITANT START/
 TECHNICALLY
 UNACCEPTABLE

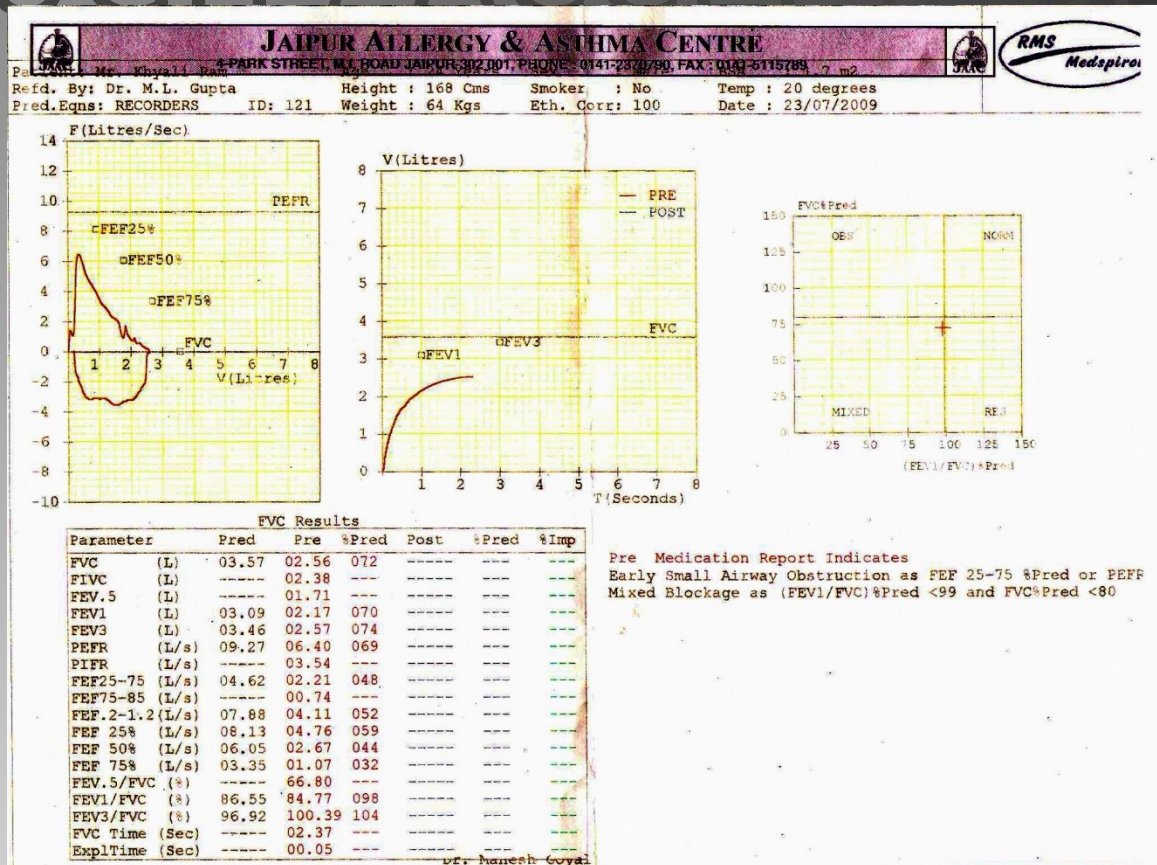


Large undulations during early part of expiration

FVC Results							
Parameter		Pred	Pre	%Pred	Post	%Pred	%Imp
FVC	(L)	03.57	02.68	075	-----	---	---
FIVC	(L)	-----	02.09	---	-----	---	---
FEV.5	(L)	-----	01.80	---	-----	---	---
FEV1	(L)	03.09	02.45	079	-----	---	---
FEV3	(L)	03.46	02.69	078	-----	---	---
PEFR	(L/s)	09.27	06.50	070	-----	---	---
PIFR	(L/s)	-----	04.02	---	-----	---	---
FEF25-75	(L/s)	04.62	02.63	057	-----	---	---
FEF75-85	(L/s)	-----	01.39	---	-----	---	---
FEF.2-1.2	(L/s)	07.88	03.82	048	-----	---	---
FEF 25%	(L/s)	08.13	04.55	056	-----	---	---
FEF 50%	(L/s)	06.05	03.27	054	-----	---	---
FEF 75%	(L/s)	03.35	01.41	042	-----	---	---
FEV.5/FVC	(%)	-----	67.16	---	-----	---	---
FEV1/FVC	(%)	86.55	91.42	106	-----	---	---
FEV3/FVC	(%)	96.92	100.37	104	-----	---	---
FVC Time	(Sec)	-----	01.49	---	-----	---	---
ExptTime	(Sec)	-----	00.03	---	-----	---	---

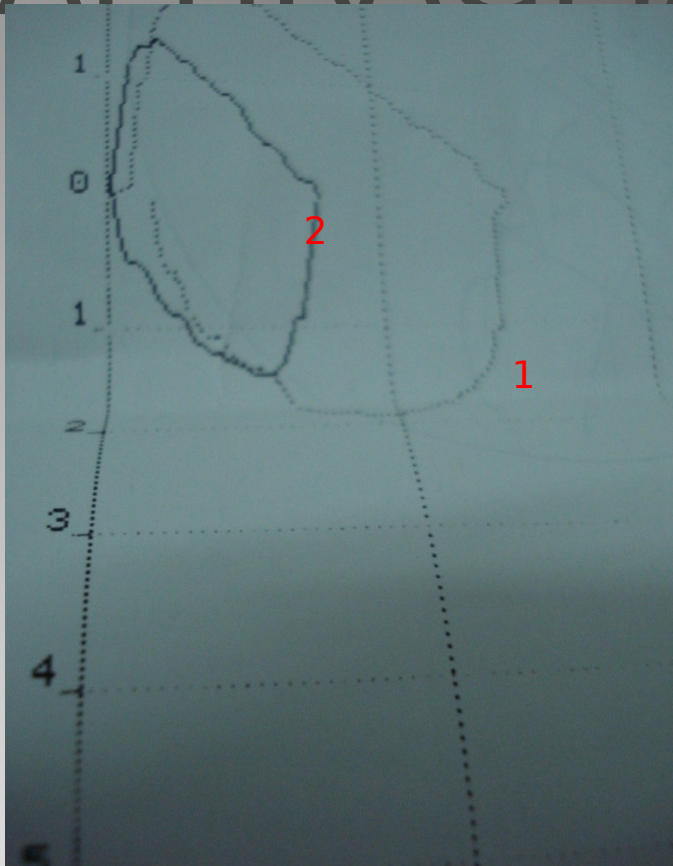
COUGH/ UNACCEPTABLE TRACING

COUGH / ACCEPTABLE



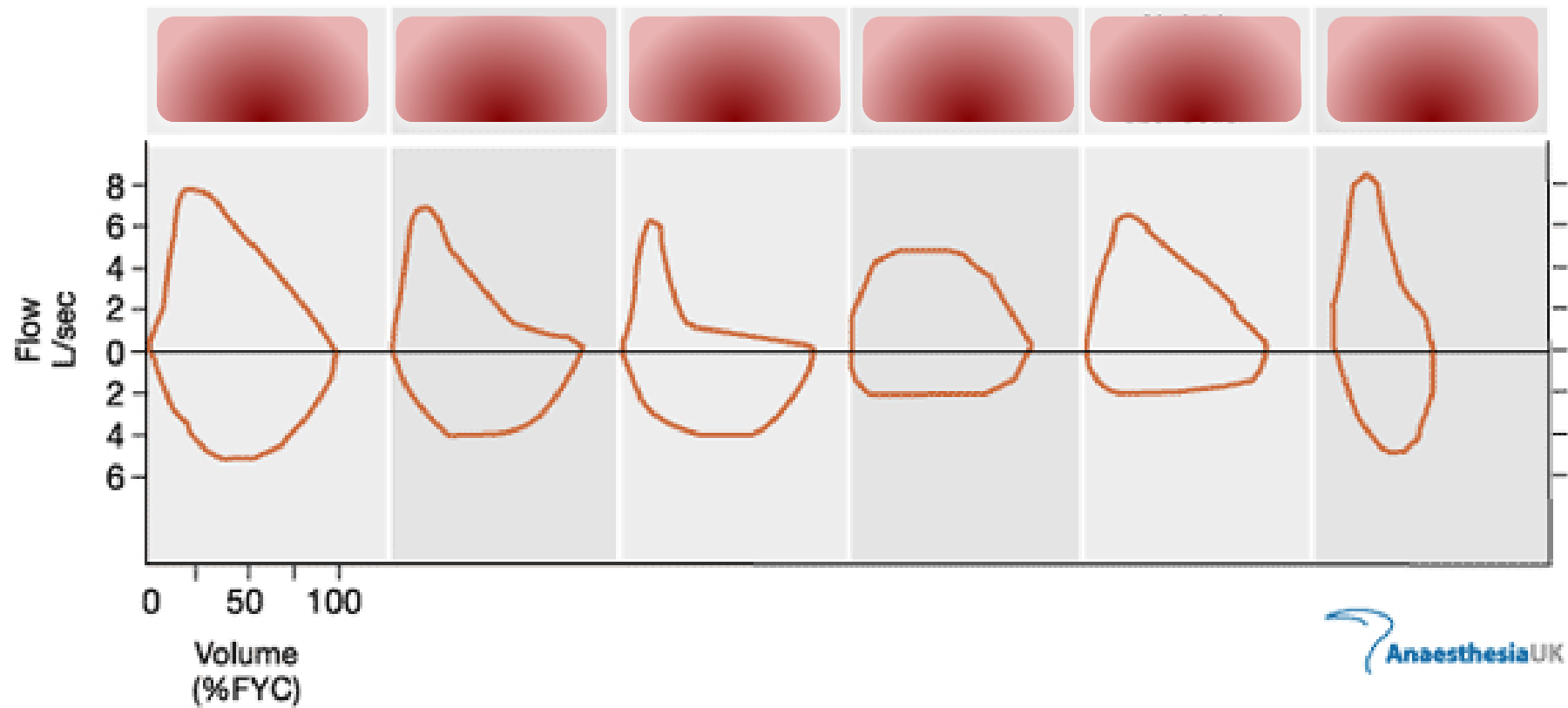
Small undulations in the later part of expiration

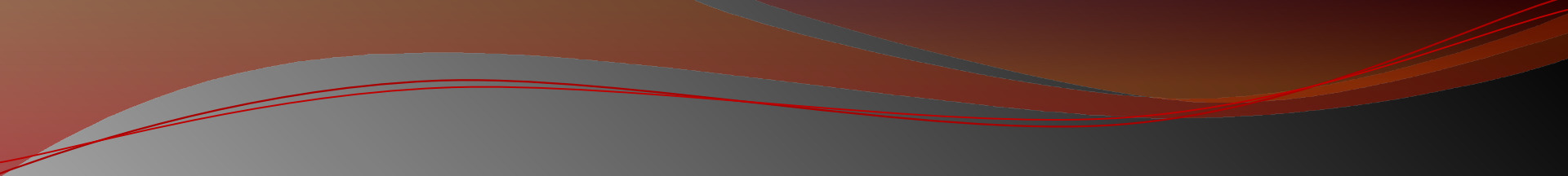
DIAPHRAGMATIC PALSY



		FEV1% %		83.3	82.8	+ 1
PARAMETER		PRE	%PRE	POST#1	%POST	DIFF
FVC	L	1.51	36	.78	18	-48
FEV1	L	1.25	36	.65	19	-48
FEV1%	%	82.8	105	83.3	106	+ 1
PEF	L/s	1.97	22	1.39	15	-29
FEF2575	L/s	1.35	32			
FEF25%	L/s	1.91	24	.80	10	-58
FEF50%	L/s	1.30	26	.62	12	-52
FEF75%	L/s	.64	30			
FET	s	3.48		2.70		-22
FIV1%	%	98.5	125	96.0	122	- 3

Spirometry in sitting (1) & supine(2)
position





THANK YOU!