

Pulmonary Function Test

By

**Dr. Walid I.
Elgendy**

**Assistant prof. of
Pulmonology
Zagazig University,
Egypt**

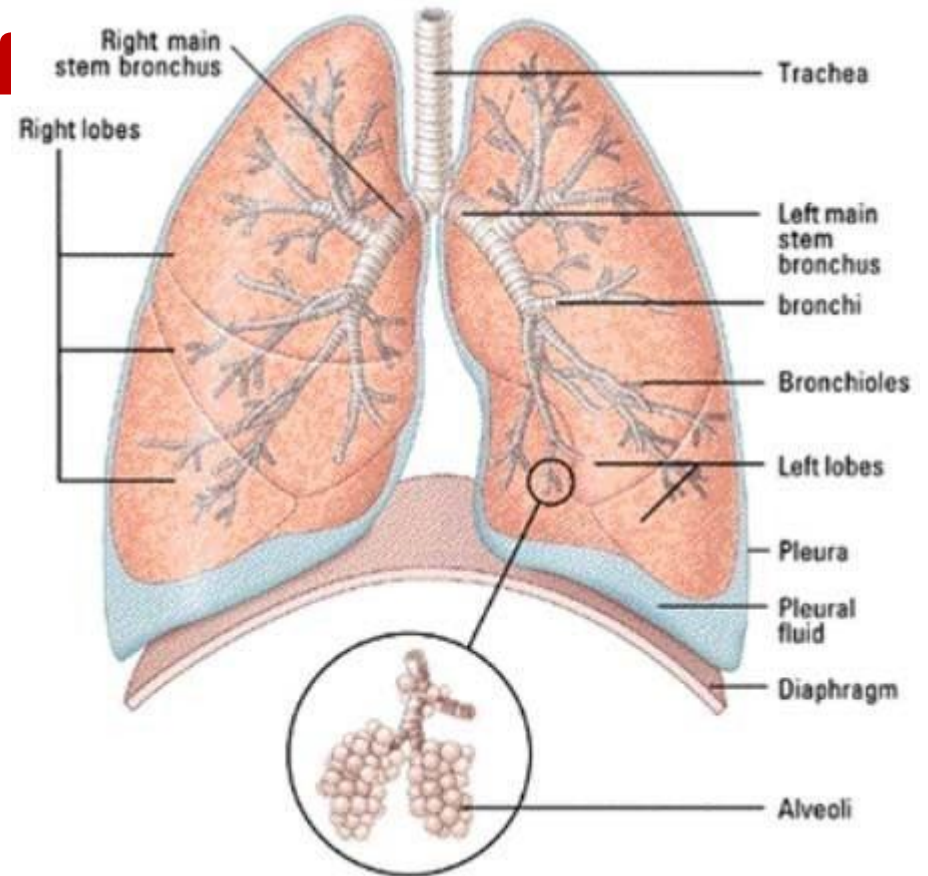


Anatomy

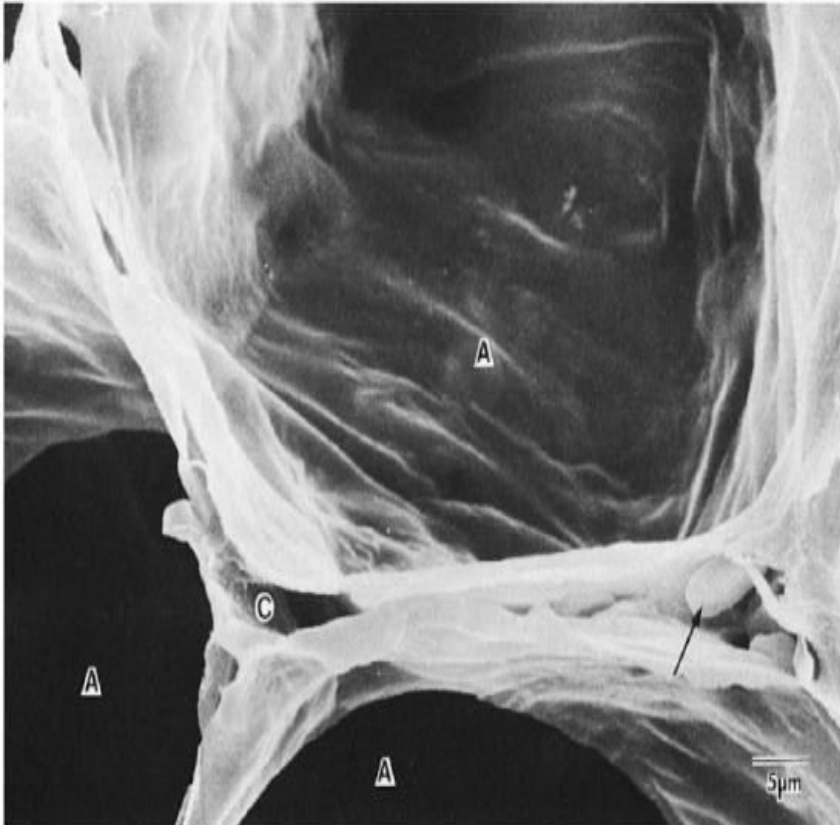
- **Lungs comprised of**

- **Airways**

- **Parenchyma**



The Alveoli



- ~ 300 million alveoli
- 1/3 mm diameter
- Total surface area 85 sq. meters (size of a tennis court)

Murray & Nadel: Textbook of Respiratory Medicine, 3rd ed., Copyright © 2000 W. B. Saunders Company

Pulmonary Functions

- ❑ The primary pulmonary function is gas exchange.
- ❑ It is done by transfer of gas between alveolar air & capillary blood.
- ❑ So it can maintain normal O₂ & CO₂ in the arterial blood in all physiological circumstances.

3 components of pulmonary gas

exchange:

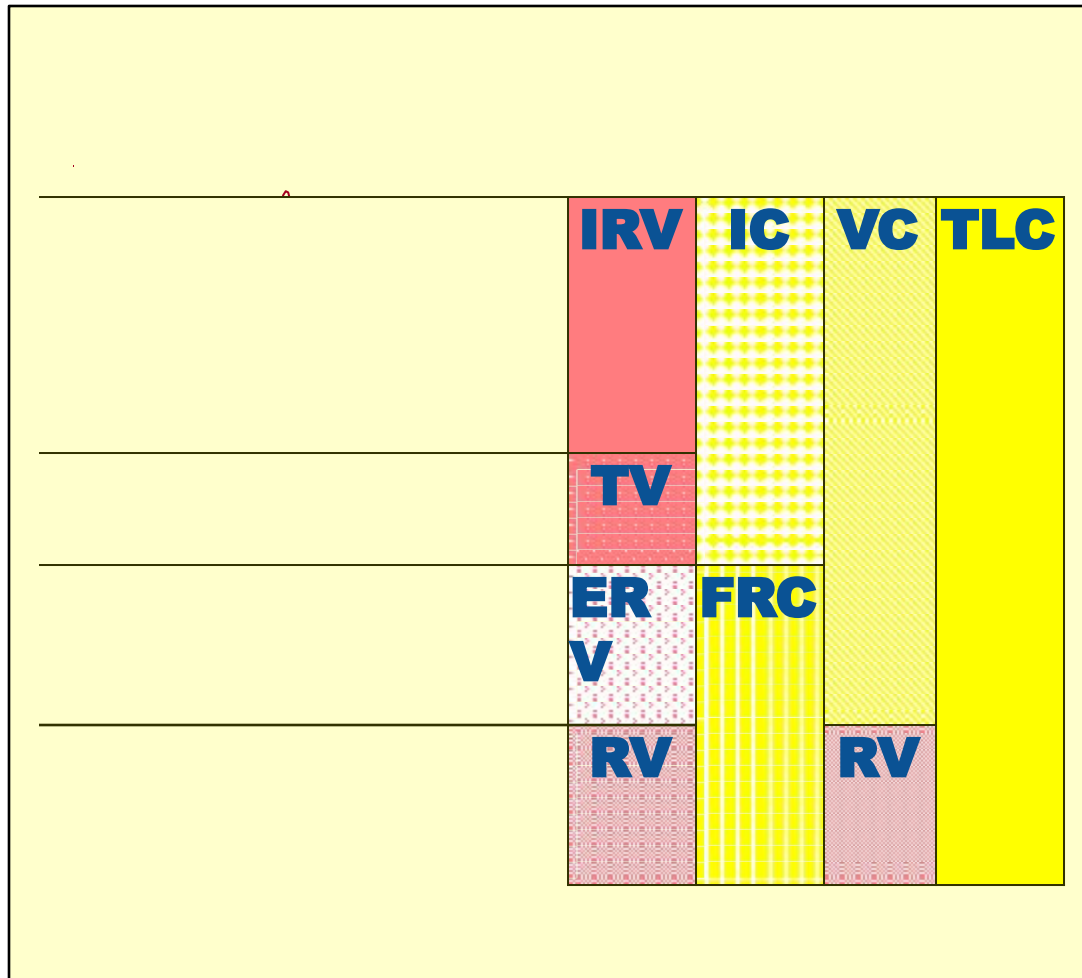
- **Ventilation:** amount of air which ventilates alveoli each min. (4 lit/min). It must be evenly distributed to all perfused alveoli.
- **Perfusion:** amount of blood which pass through pulmonary cap. Per min. = 5 lit/min

$$V/Q \quad 4/5$$

=
0.8

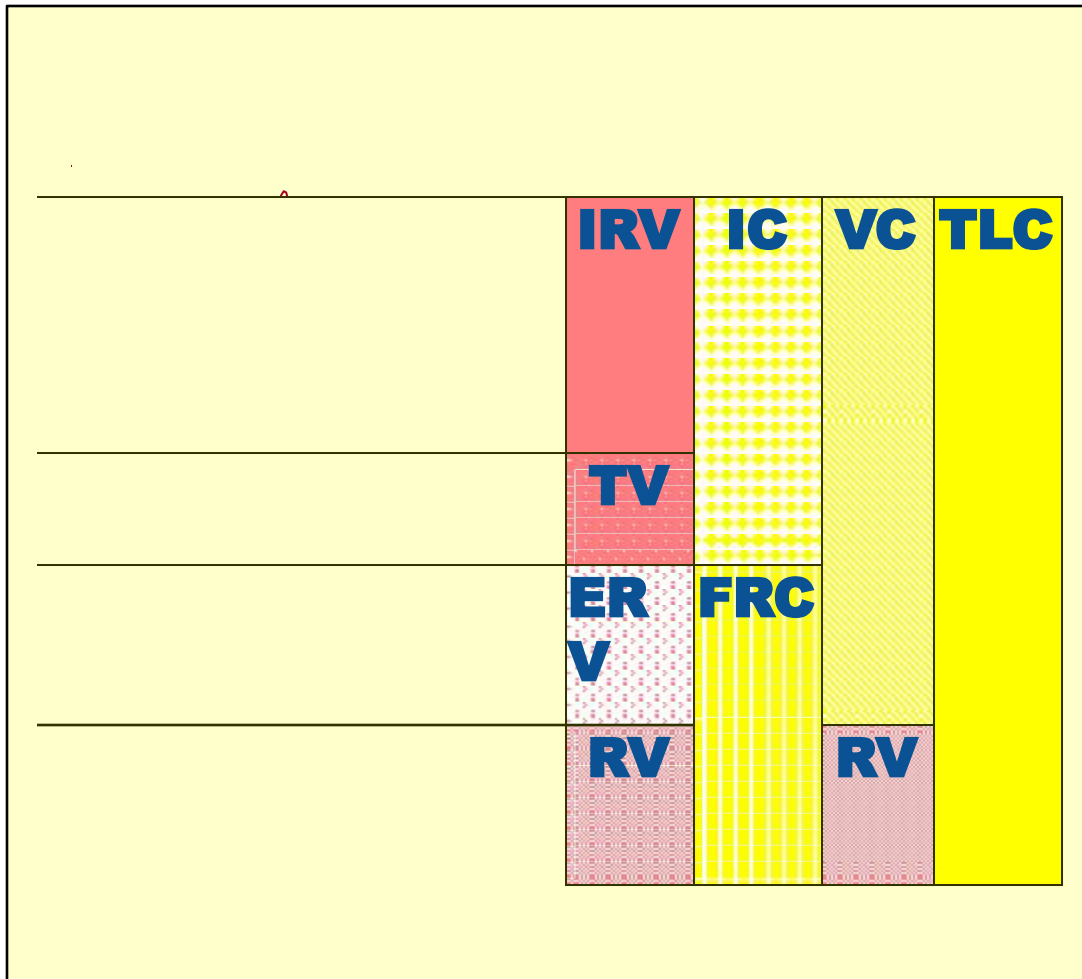
- **Diffusion:** across the alveolar cap. mem., the transfer of gas between alveolar air & pulm. Cap. blood being determined by the gas tension gradients between them
DLCO.

Lung Volumes



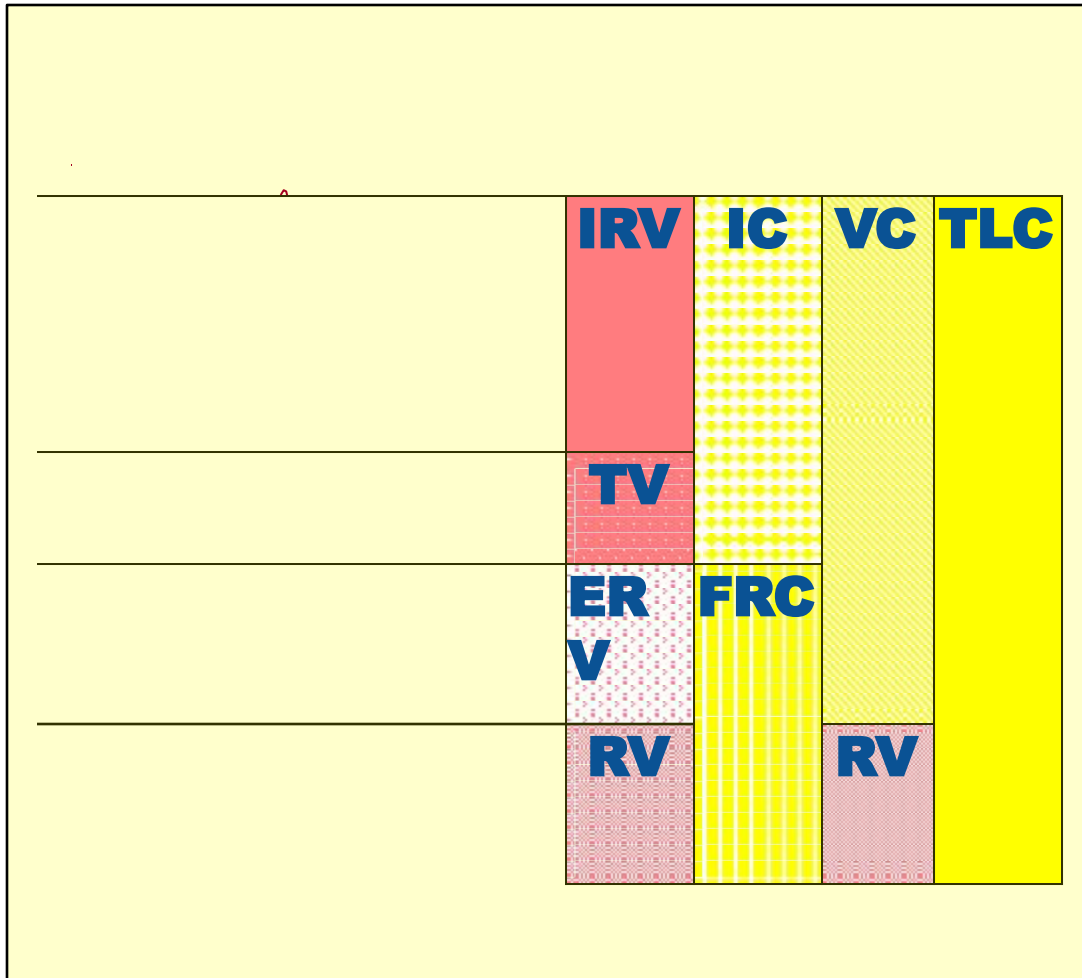
- 4 Volumes
- 4 Capacities
 - Sum of 2 or more lung volumes

Tidal Volume (TV)



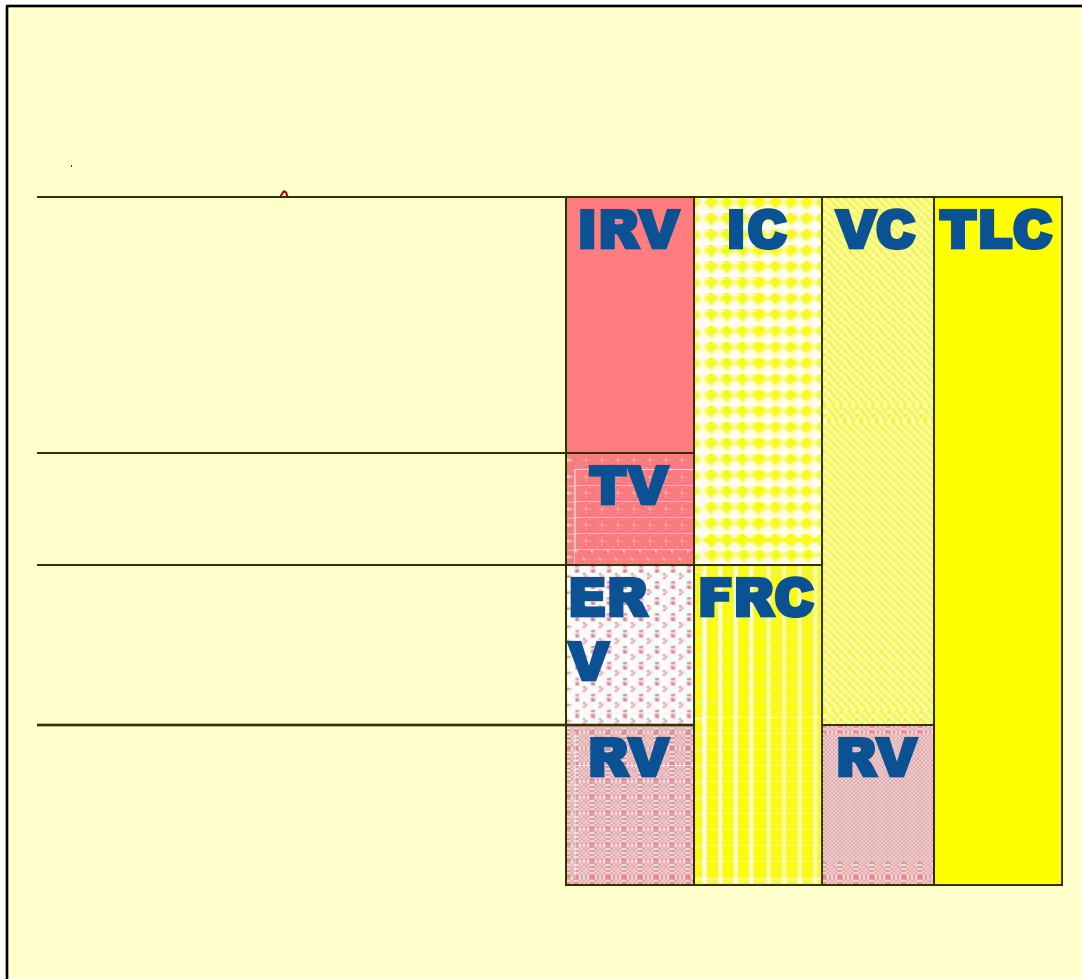
- Volume of air inspired or expired during normal quiet breathing
- **N ~ 6-8 ml/kg.**

Inspiratory Reserve Volume (IRV)



- The maximum amount of air that can be inhaled after tidal volume
- N- 1900 ml- 3300 ml.

Expiratory Reserve Volume (ERV)

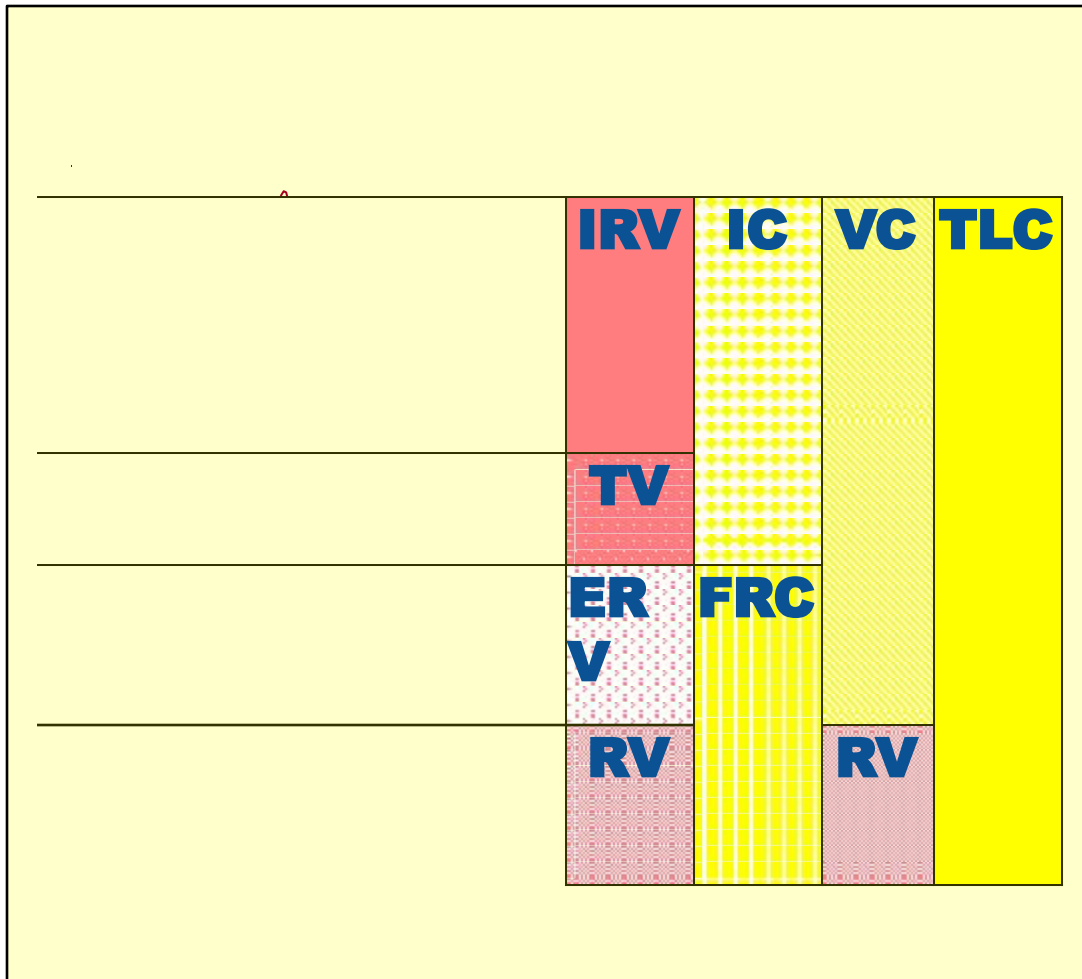


- Maximum amount of air that can be exhaled from the resting expiratory level



N- 700 ml- 1000 ml.

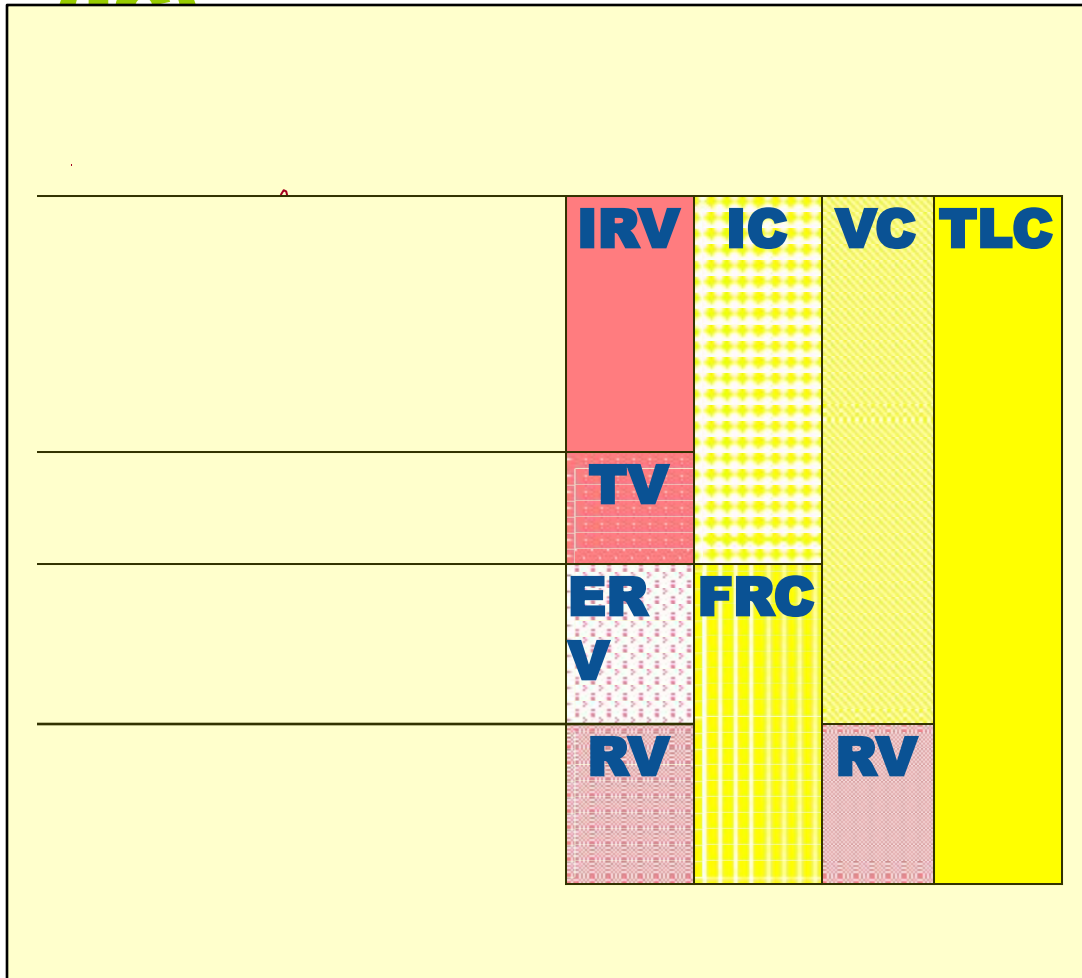
Residual Volume (RV)



- Volume of air remaining in the lungs at the end of maximum expiration
 - N- 1700 ml- 2100 ml. (20-25ml/kg)

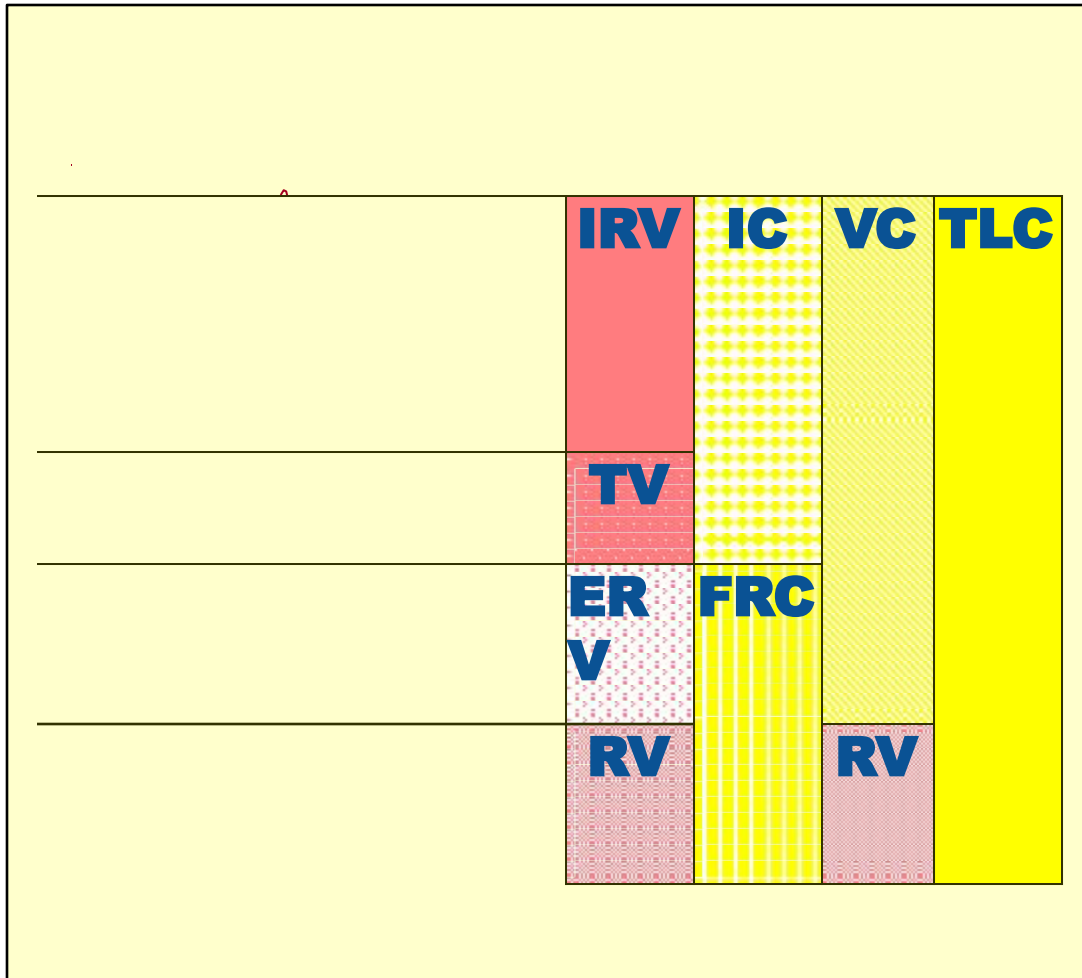
Inspiratory Capacity

(IC)



- Maximum amount of air that can be inhaled from the end of a tidal volume
- $IC = IRV + TV$
- N- 2400 ml- 3800 ml.

Functional Residual Capacity



Volume of air remaining in the lungs at the end of a TV expiration

The elastic force of the chest wall is exactly balanced by the elastic force of the lungs

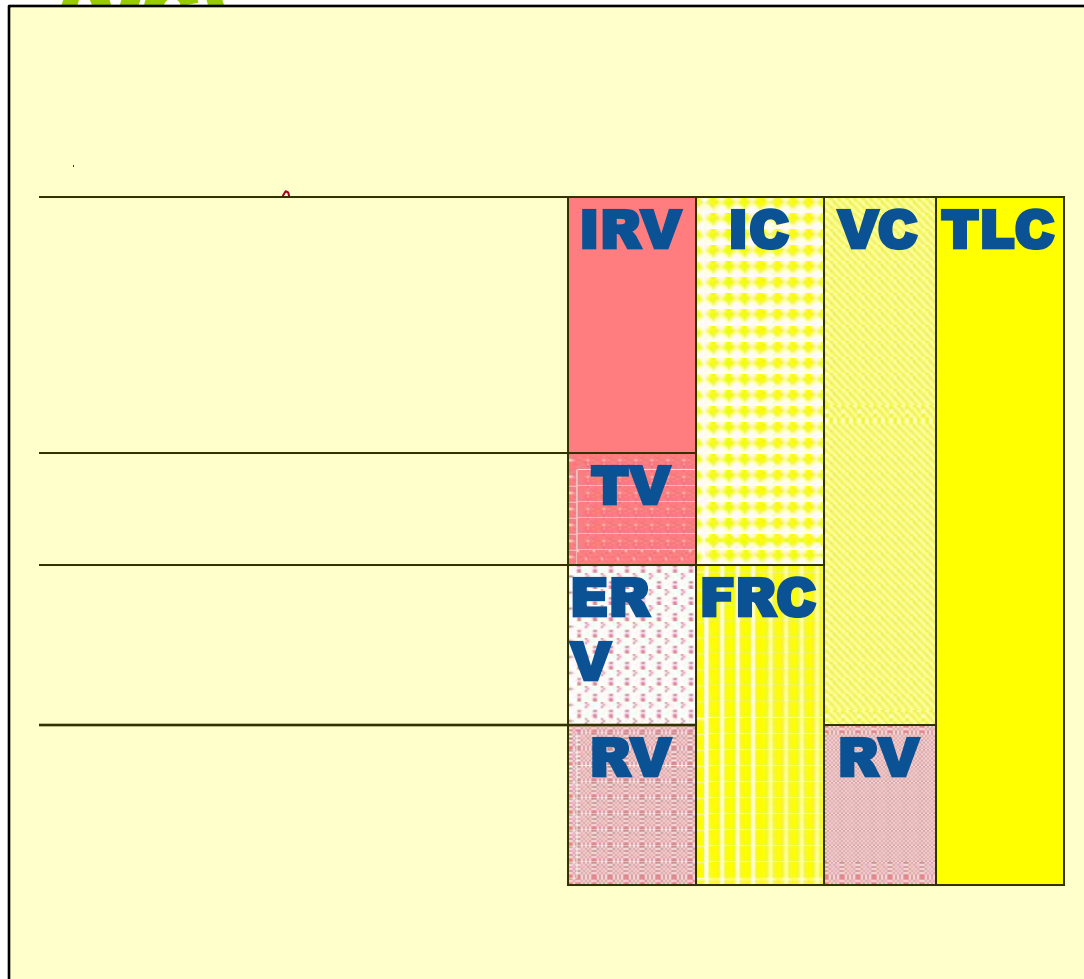
$$\text{FRC} = \text{ERV} + \text{RV}$$

N- 2300 ml- 3300 ml.

(30-35ml/kg)

Vital Capacity

(VO)



Volume of air that can be exhaled from the lungs after a maximum inspiration

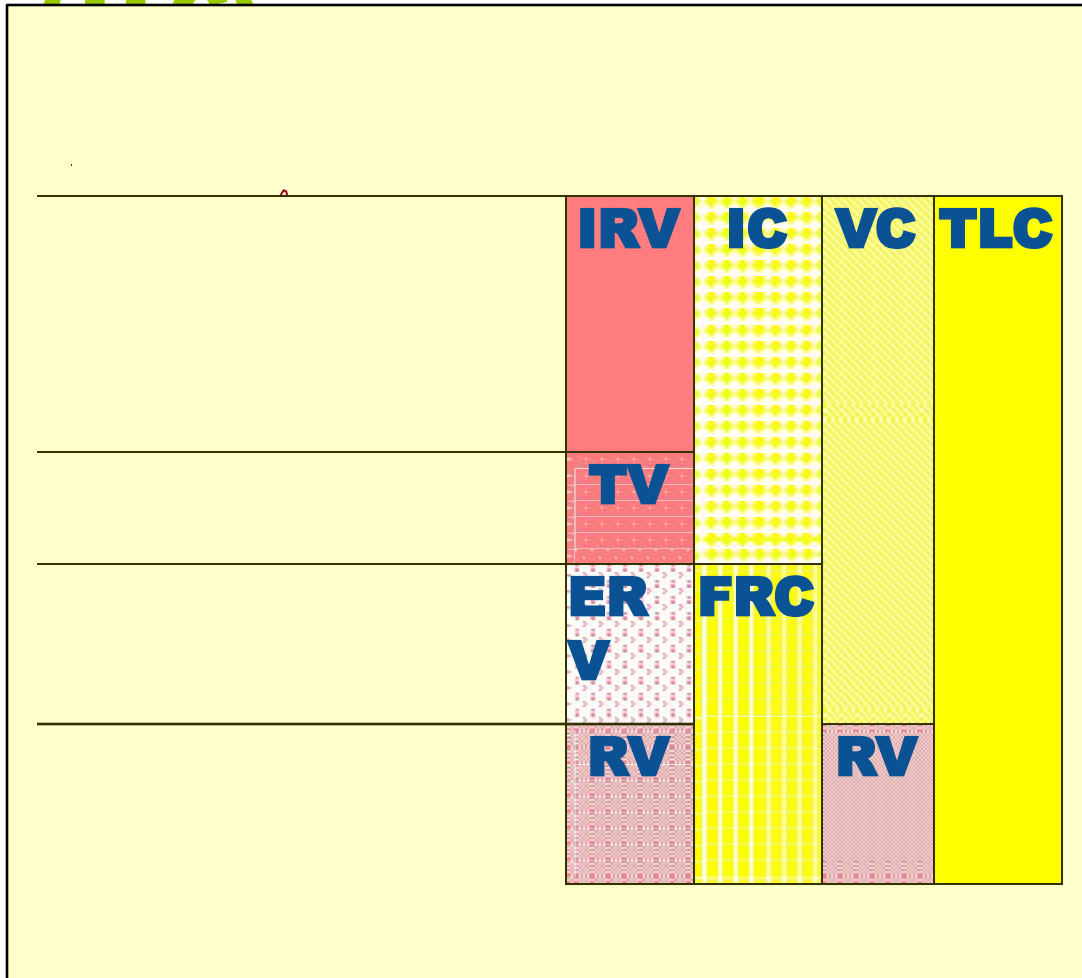
FVC: when VC exhaled forcefully

$$VC = IRV + TV + ERV$$

N- 3100 ml- 4800 L.

(60-70ml/kg)

Total Lung Capacity (TLC)



- Volume of air in the lungs after a maximum inspiration
- $TLC = IRV + TV + ERV + RV$ ($VC + RV$)
- N- 4000 ml- 6000 ml.
(80-100ml/kg)

Indications

1. Diagnostic
2. Monitoring the course of the disease and
Evaluation of treatment
3. Measure effects of exposures
4. Disability/Impairment Evaluations by Measuring
the effect of disease on PFT

5- Assess pre-operative risk:

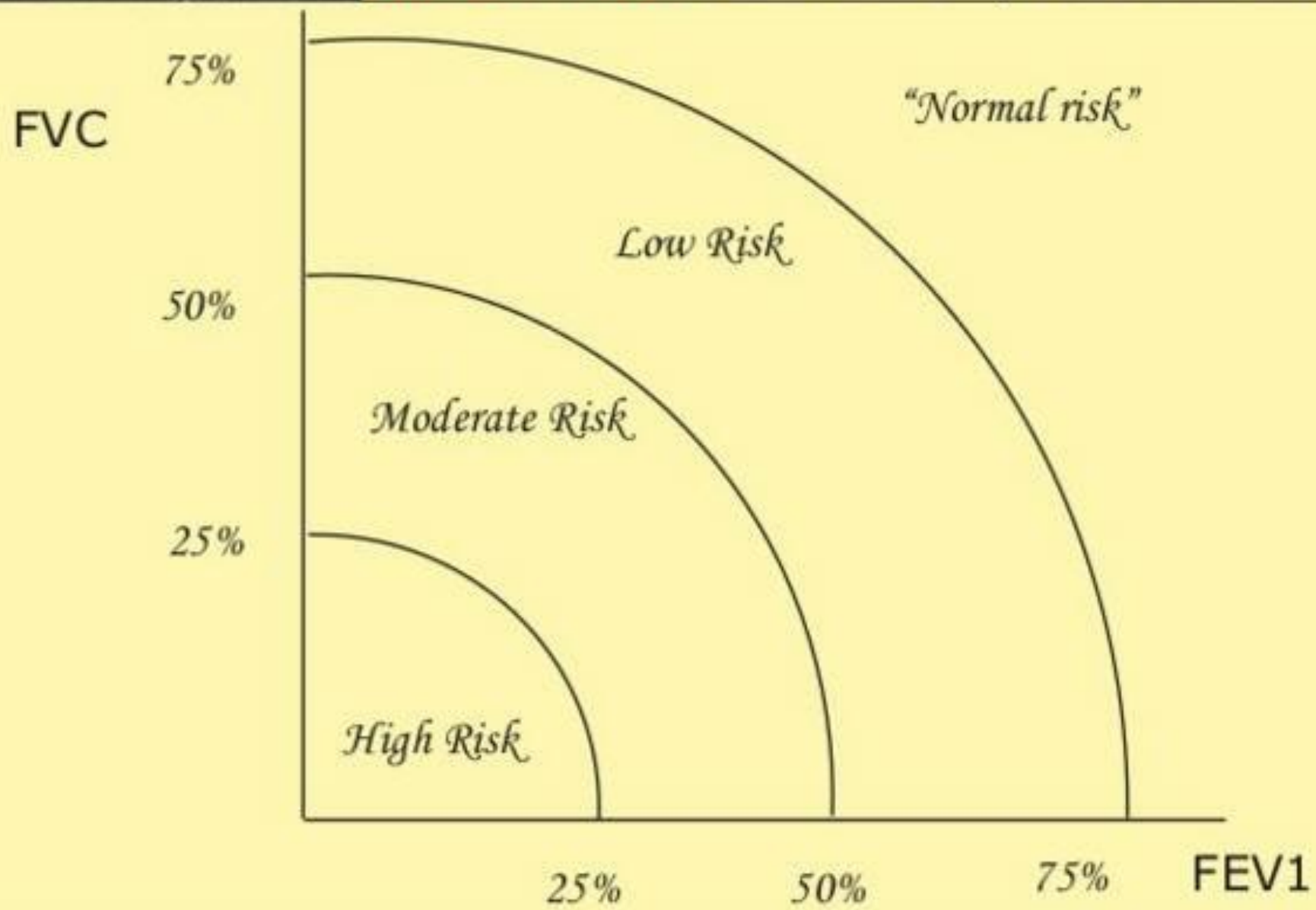
- **Age > 70 yrs.**
- **Morbid obesity**

- **Smoking history and chronic cough**
- **Any known pulmonary disease**

- **Thoracic or Cardiac surgery**
- **Upper abdominal surgery**



Pre-operative Evaluation For Surgery **Other Than** Pulmonary Resection



Relative contraindications for

spirometry

1. **Hemoptysis** of unknown origin (may aggravate underlying condition.)
2. **Pneumothorax**
3. **Recent abdominal or thoracic surgery**
4. **Recent eye surgery** (increases in intraocular pressure during spirometry)
5. **Recent** unstable angina or old myocardial infarction
6. **Thoracic, abdominal, or cerebral aneurysms** (risk of rupture because of increased thoracic pressure)

Only Absolute Contraindication is:

**Recent Myocardial Infarction
within the Previous Month**

Possible side-effects

- 1. Dizziness and Syncope.**
- 2. Bronchospasm (e.g. Asthma)**
- 3. Increased intracranial pressure**
- 4. Pneumothorax (very rare)**
- 5. Nosocomial infections (very rare)**

Preparation & instructions to the patient

- 1- **Information about the purpose of the maneuver.**
2. **Demonstrating of breathing maneuver:** Possible even without spirometer. This can save a lot of time spent on repeated measurements.
3. Tell the pt. that **only the maximal effort** will lead to a reliable result. This may enhance his motivation to follow the instructions correctly.

Guidelines for Holding Medical Drugs before spirometry


Inhaled bronchodilators	
• Short acting	4-8 hours
• long acting	24 hours
Oral short acting B- Agonists	8 hours
Oral long acting B- Agonists	24 hours
Anticholinergic	6 hours
Theophylline	
• twice daily preparations	24 hours
• once daily preparations	48 hours

Patient takes a deep breath
and blows as hard as possible
into tube

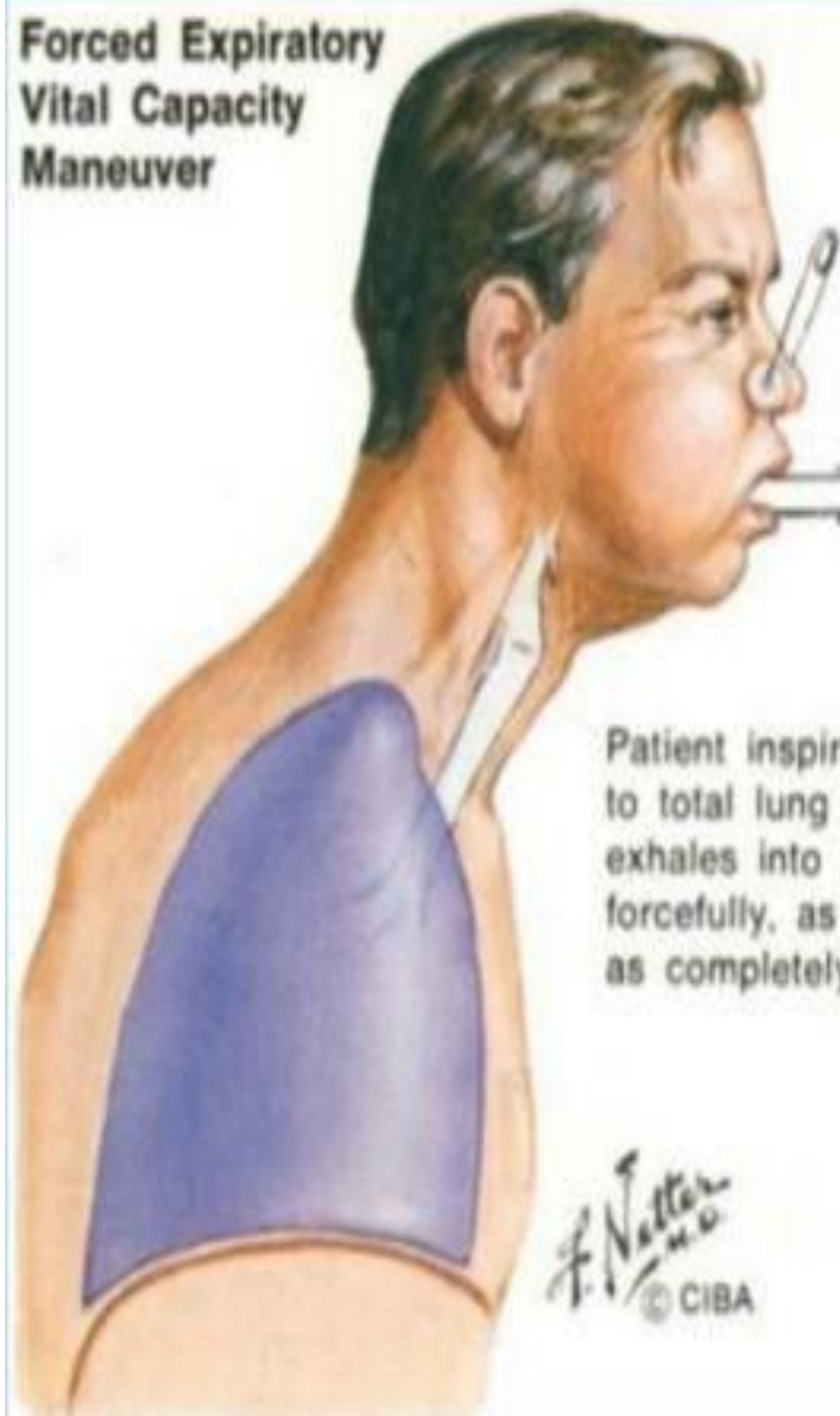
Clip
on nose

Technician monitors
and encourages
patient during test

Machine records
the results of the
spirometry test

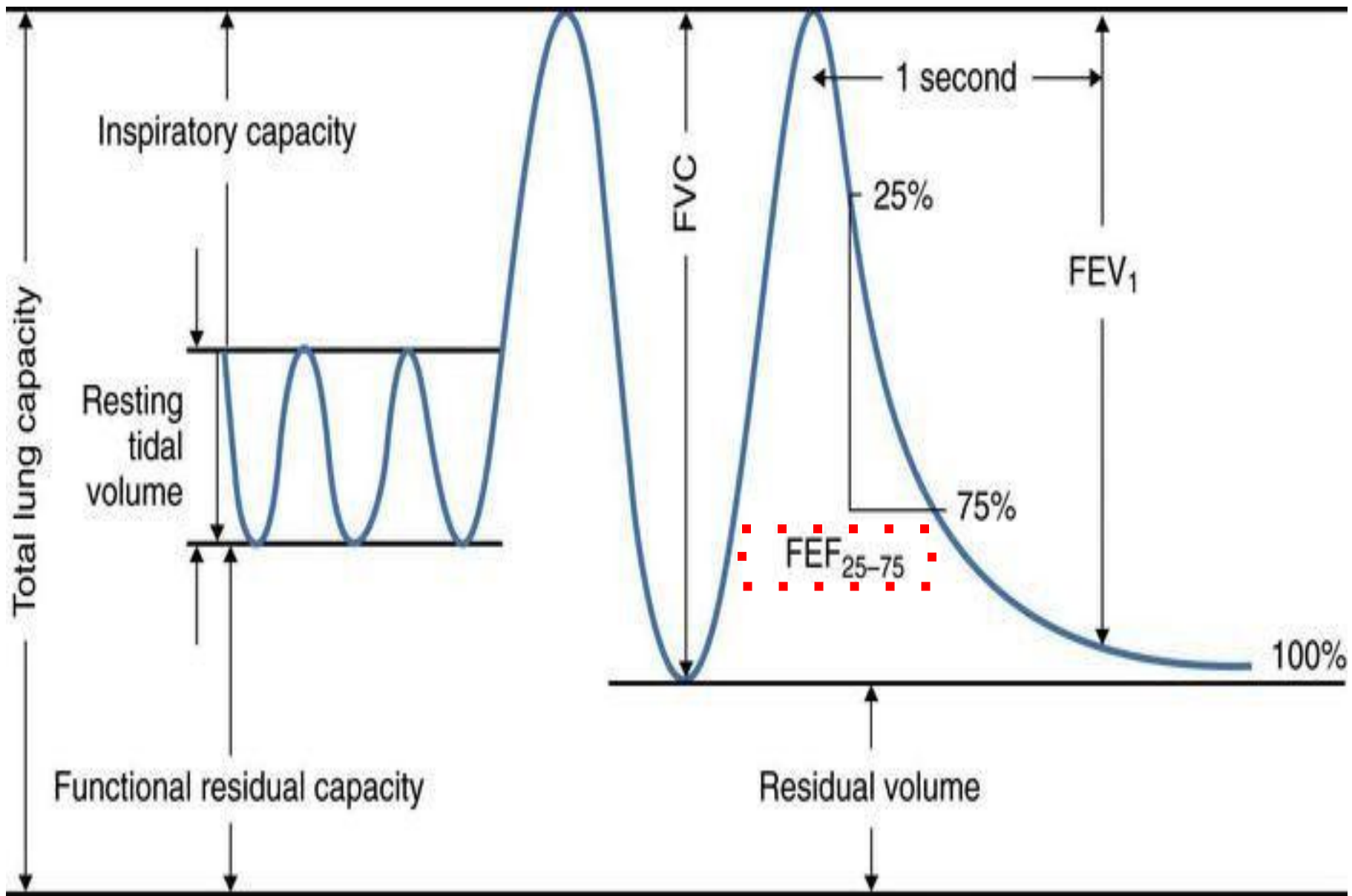
An illustration showing a male patient in a blue polo shirt performing a spirometry test. He is holding a mouthpiece connected to a machine. A clip is attached to his nose. A female technician in light blue scrubs stands behind him, looking at the machine's monitor. The machine is on a stand and has a printer that is printing a sheet of paper. A cable connects the machine to the patient's mouthpiece.

Forced Expiratory Vital Capacity Maneuver



Patient inspires maximally to total lung capacity, then exhales into spirometer as forcefully, as rapidly, and as completely as possible

*F. Netter
M.D.*
© CIBA





JAEGER

VIASYS Healthcare GmbH
 Leibnizstrasse 7
 D-91204 Hoechberg
 www.viasyshealthcare.com

Identifikator: TEST 36
 Name:
 Geburtsdatum: 01.03.1963
 Alter: 43 Jahre

Größe: 178 cm
 Gewicht: 87 kg
 Alter: 43

volume-time curves of all acceptable trials

flow-volume curves of all acceptable trials

source of the used predicted equations

results in percent predicted

numeric results of all volumes and flows

Parameter	Units	Observed		Predicted		% Predicted
		Mean	SD	Mean	SD	
VC	l	1.8	0.2	1.8	0.2	100
FVC	l	1.5	0.2	1.5	0.2	100
FEV1	l	1.2	0.2	1.2	0.2	100
FEV2	l	1.1	0.2	1.1	0.2	100
FEV3	l	1.0	0.2	1.0	0.2	100
PEF	l/s	2.5	0.5	2.5	0.5	100
MEF50	l/s	1.5	0.3	1.5	0.3	100
MEF25	l/s	1.0	0.2	1.0	0.2	100
MEF10	l/s	0.5	0.1	0.5	0.1	100
IRV	l	1.0	0.2	1.0	0.2	100
RV	l	1.5	0.3	1.5	0.3	100
RV(TL)	l	1.8	0.4	1.8	0.4	100

© 2004 Viamedical Systems, Inc. All rights reserved. Inquiries to: sales@viasys.com
 For complete details, please contact your local distributor.

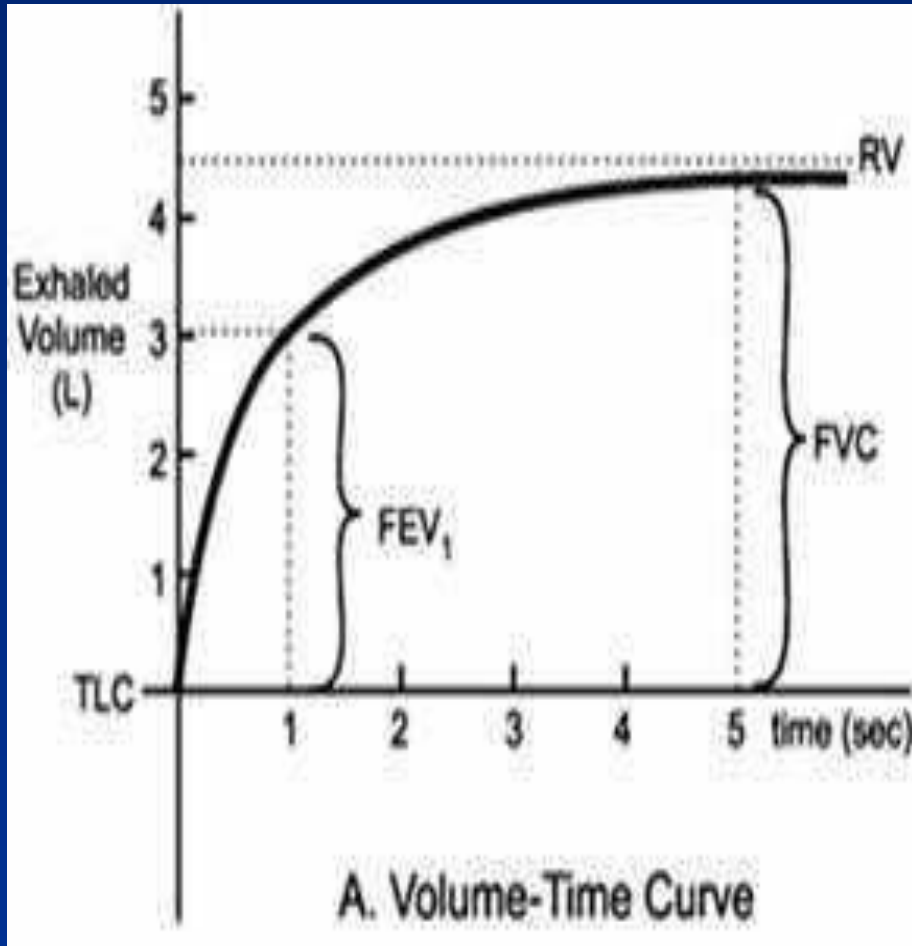
Software: Viasys Spirometry V1.0.0

Factors That Affect predictive values

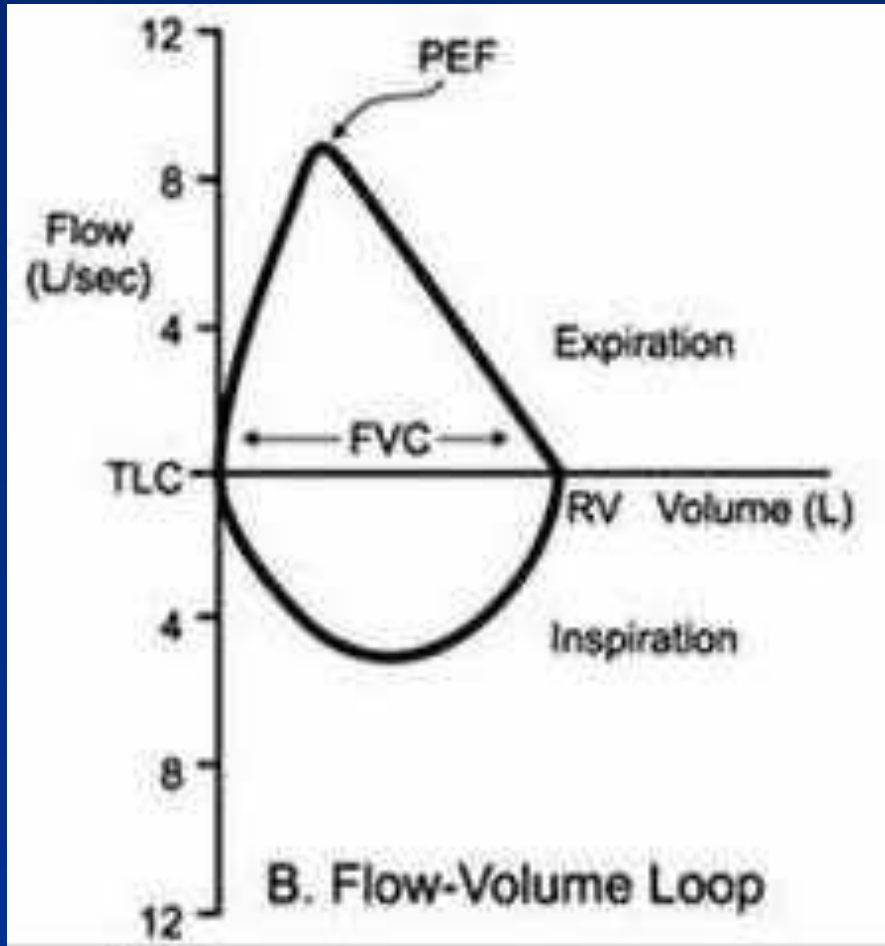
- Age
- Sex
- Height
- Weight
- Race
- Smoking

1. Volume Time Graph

it displays the expiration.

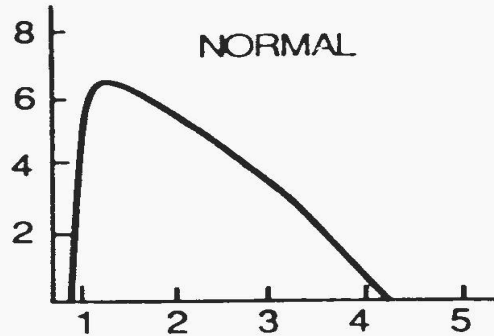


2. Flow-volume loops



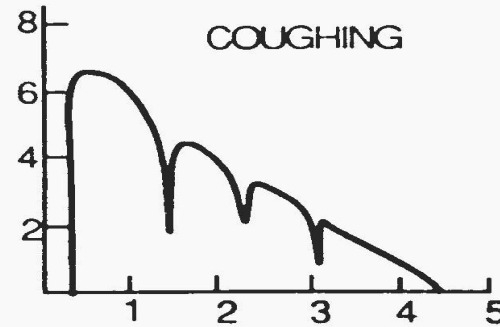
Spirometry Quality

FLOW (L/SEC)



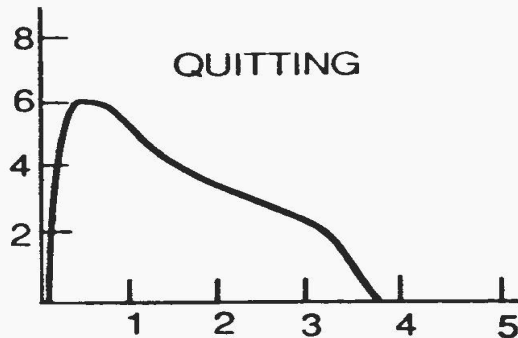
EXHALED VOLUME (LITERS)

FLOW (L/SEC)



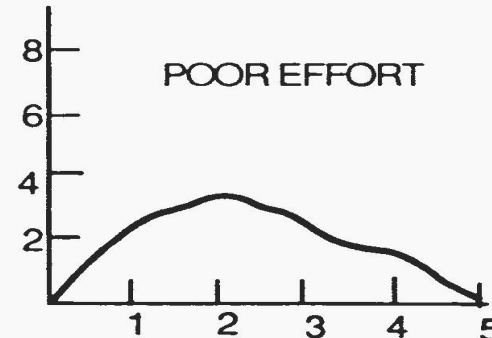
EXHALED VOLUME (LITERS)

FLOW (L/SEC)



EXHALED VOLUME (LITERS)

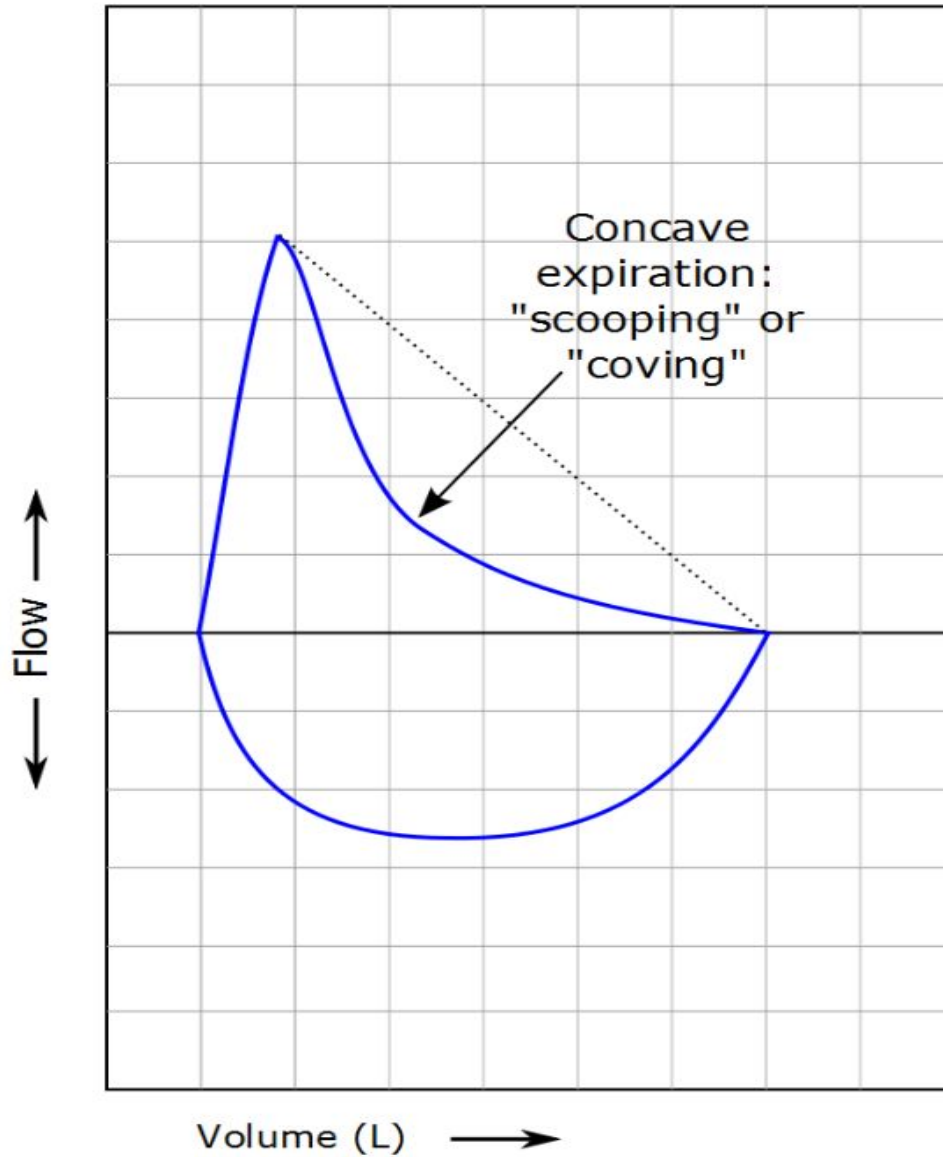
FLOW (L/SEC)



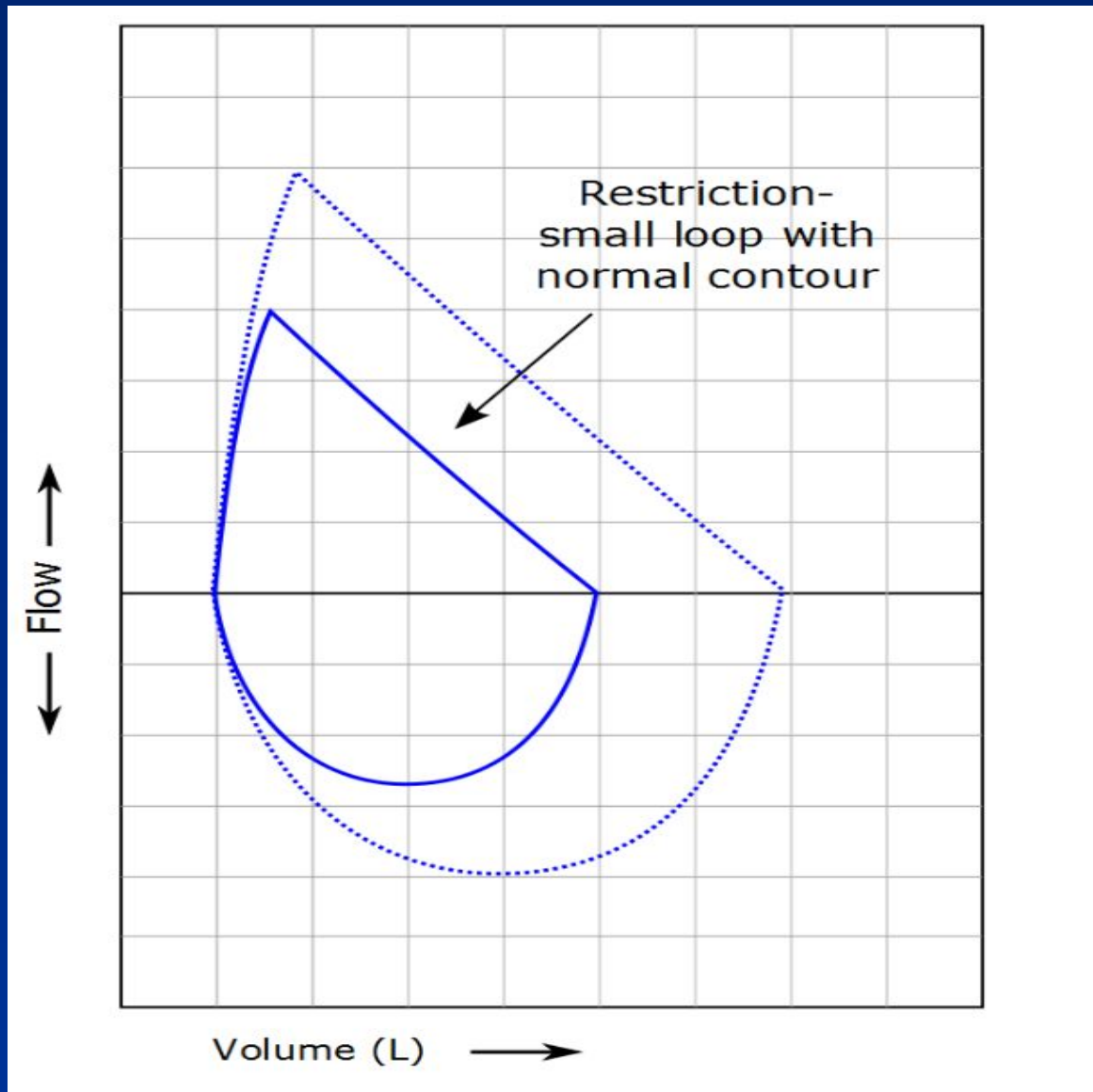
EXHALED VOLUME (LITERS)

Figure 5. Normal versus inadequate spirometry tracings. The value of pattern recognition cannot be overemphasized in the interpretation of spirometry results.

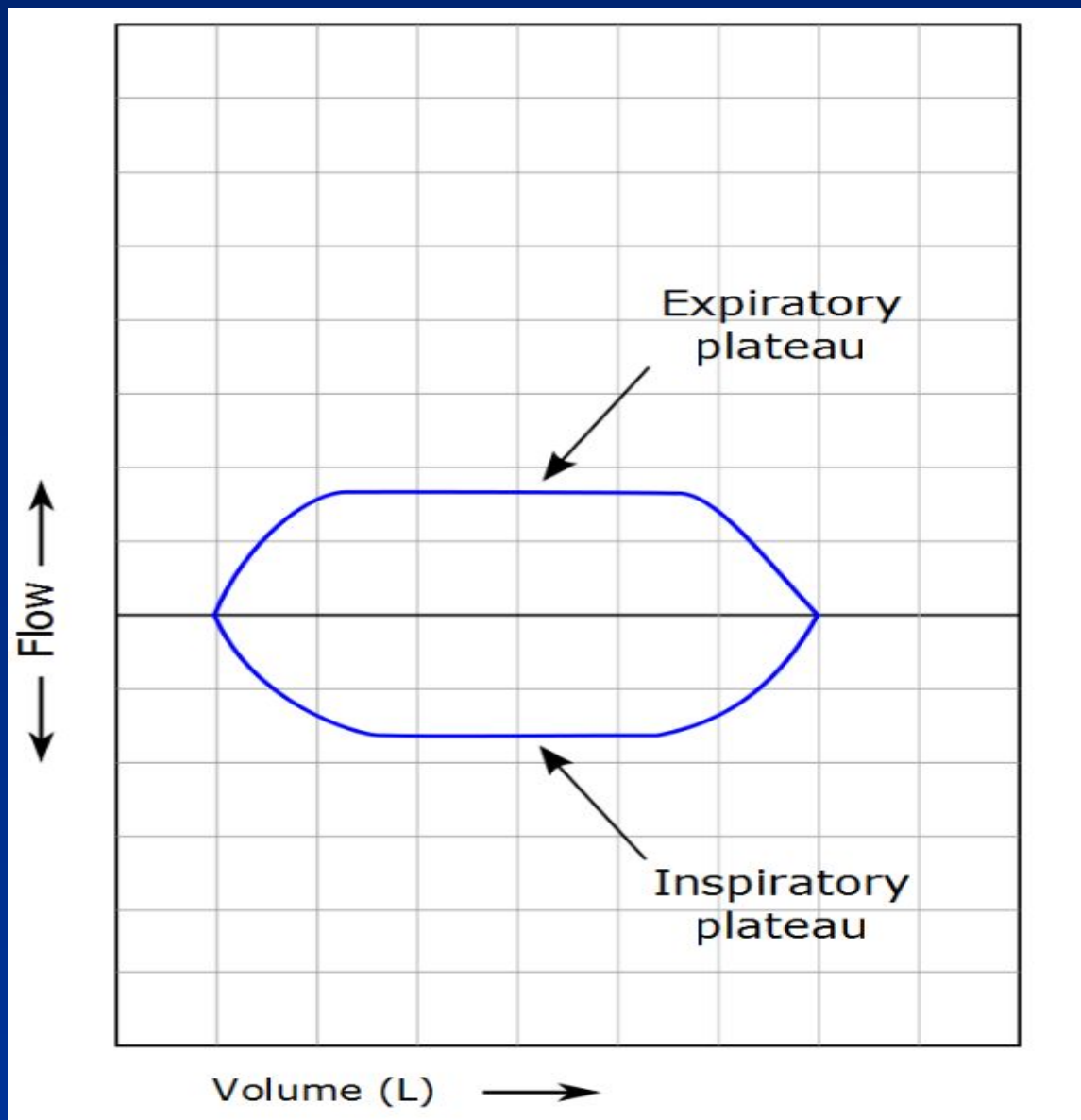
Patterns in obstructive lung disorders.



Patterns in restrictive lung disorders.



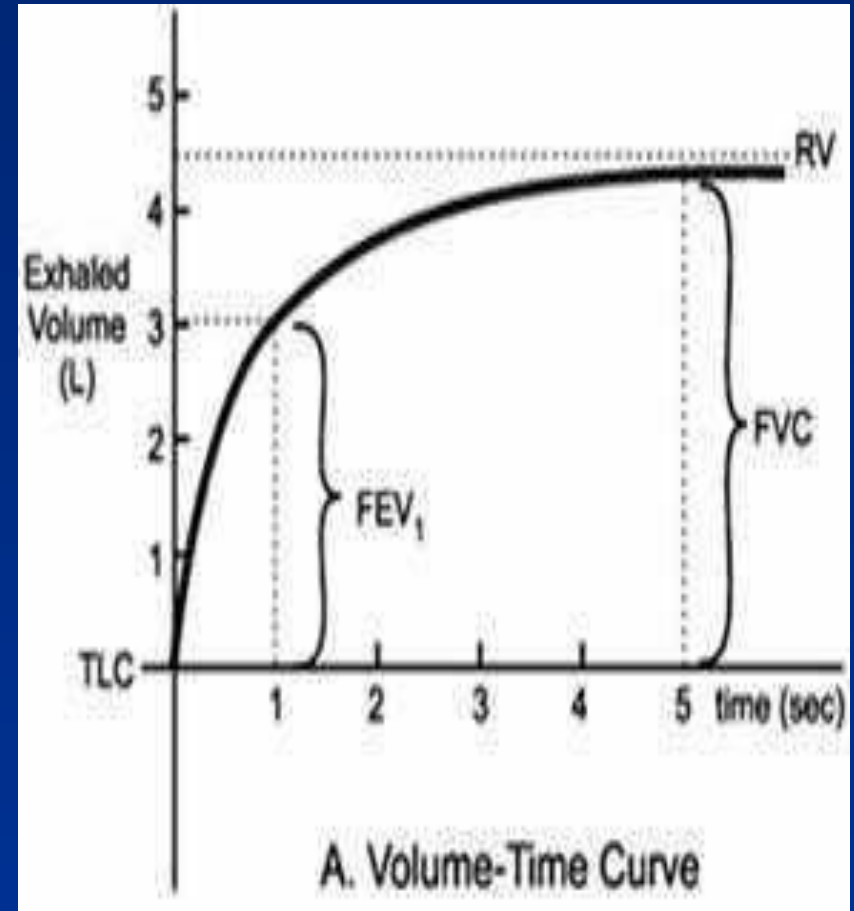
Patterns in fixed UA Obstruction.



1. FVC
2. FEV1
3. FEV1/FVC
4. FEF25%
5. FEF25-75%
6. FEF75%

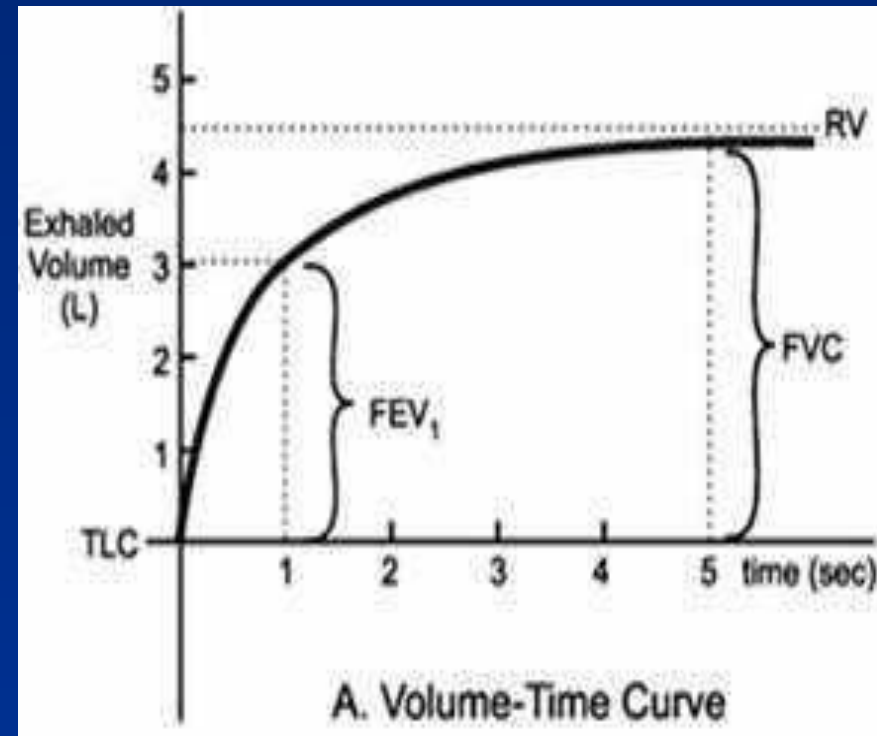
Forced Vital Capacity (FVC)

- The total amount of air expired as quickly and forcefully as possible after deepest breath.
- Normal >80%



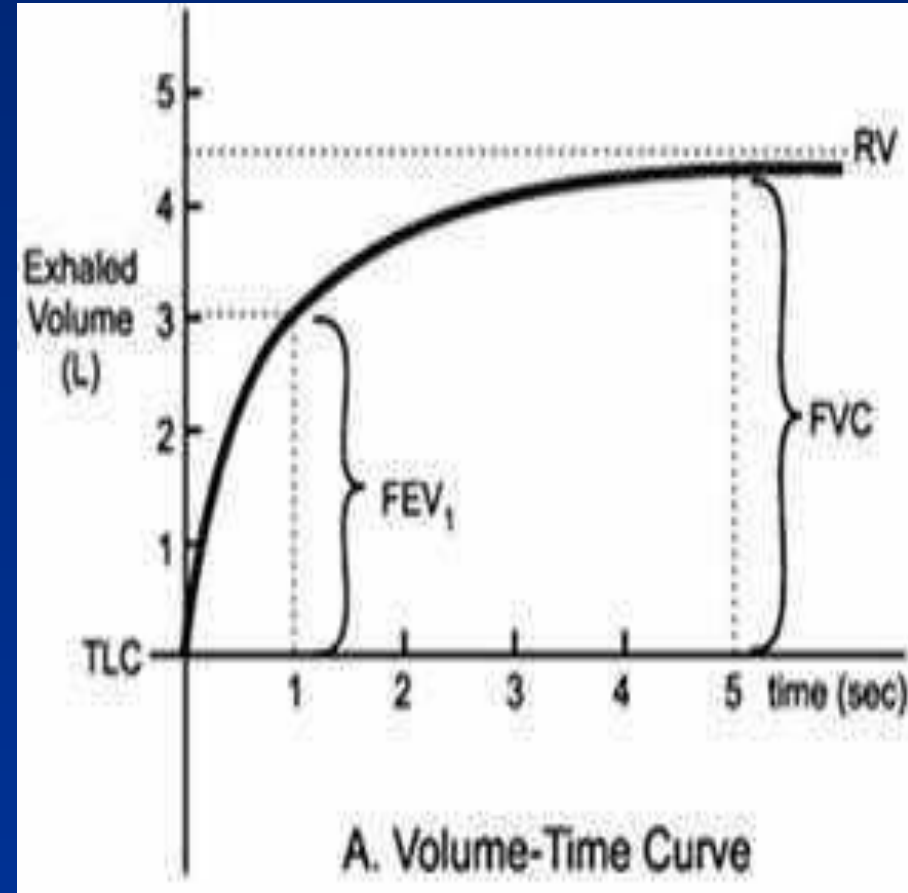
Forced expiratory volume in first second (FEV1) :

- Volume of air which can be exhaled from in the first second of a forced expiratory maneuver.
- Normal people can exhale more than 75% of their FVC in the first second.
- Normal >80%



FEV1/FVC

- Ratio of FEV1 to FVC :
- It indicates what percentage of FVC was expelled during the first second
- **This value is critically important in the diagnosis of obstructive and restrictive diseases**
- **Normal >70%**



P.E.F. – Peak Expiratory Flow

The highest flow achieved from a maximum forced expiratory manoeuvre. Can be expressed in litres per second, or litres per minute.

FEF25%

Mean forced expiratory flow during the first 25 % of FVC.

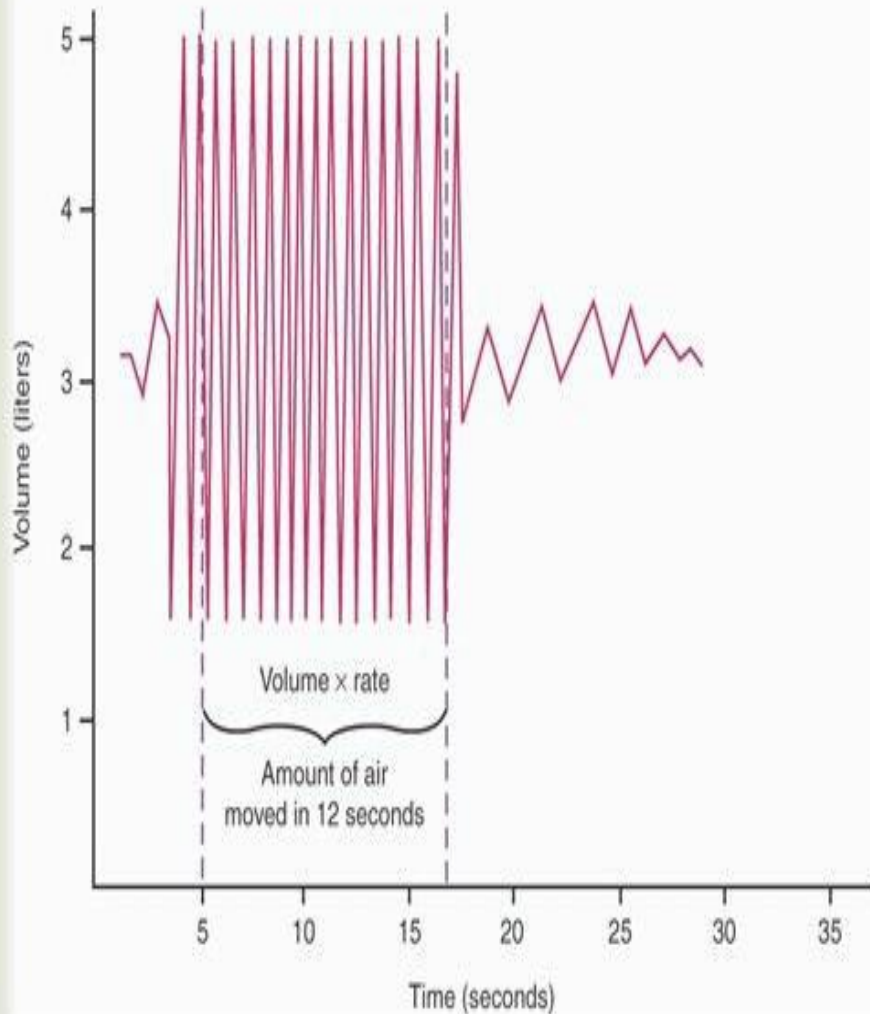
FEF75%

Mean forced expiratory flow during the first 75 % of FVC.

FEF25%-75%

Mean forced expiratory flow during middle half of FVC.

A measure for small airway dysfunction



• MVV

- ***It's*** the maximum volume of air which can be respired in 1min. By deepest and fastest breathing
- Test of entire respiratory system
 - Respiratory Muscles,
 - Compliance,
 - Airway resistance
- N- 150-175 L/min

Normal Values of PFT

- FEV₁ ⇒ 80% to 120%
- FVC ⇒ 80% to 120%
- FEV₁ /FVC ⇒ >70%
- FEF_{25-75%} ⇒ > 80 - 120%

- TLC ⇒ 80 - 120%
- FRC ⇒ 80 - 120%
- RV ⇒ 65 - 135%

- DLCO (Diffusing Capacity for CO) ⇒
(N 15-30 ml/min/mmHg) > 80 - 120%

**Obstructive V/S restrictive
lung disease ???**

Restrictive	Obstructiv e	
	↓	FEV1 ↔ FVC
	↓ ↓	FEV1
	↓	↓ ↓ FVC
	↔ ↓	↓ ↓ VC
	↑	↓ TLC
	↑	↓ RV
	↑	↓ FRC

Interpreting PFTs

- **Look at the Flow-Volume loop**

- Determine acceptability of the test, and look for upper airway obstruction pattern.

- **Look at FEV1/FVC Ratio .**

- <70% = obstructive lung disease

Then FEV1

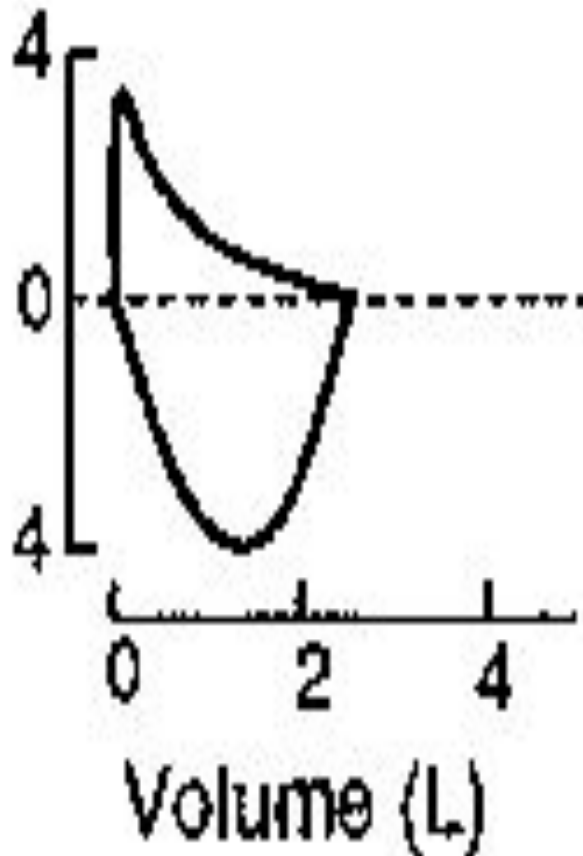
- Grade severity of obstruction
- Check for reversibility

- Normal = restrictive lung disease or normal PFT

Then FVC

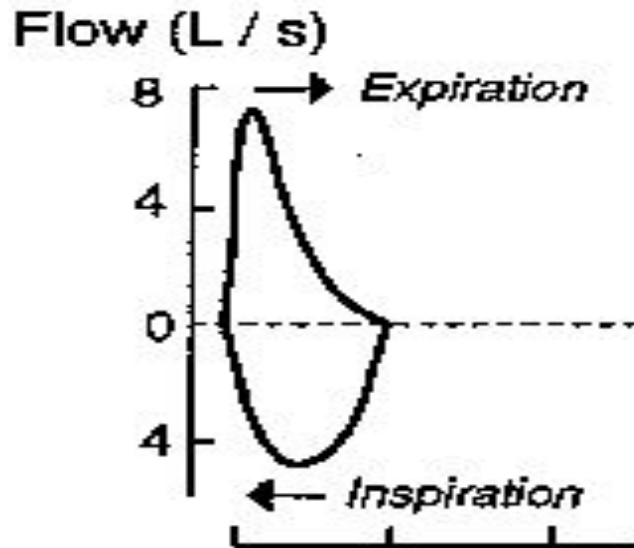
- If FVC is low = Restrictive lung disease
- If Normal = Normal pulmonary function

Obstructive Disorders



- Characterized by a limitation of expiratory airflow
 - Examples: asthma, COPD
- FEV_1/FVC ratio (<0.7)
- FEV_1 , Decreased ($<80\%$)
-

Restrictive Lung Disease



□ Characterized by diminished lung volume due to:

- Change in lung parenchyma (interstitial lung disease)
- Disease of pleura, chest wall, neuromuscular apparatus.

FEV_1/FVC ratio $> 70\%$

Decreased FVC, TLC.

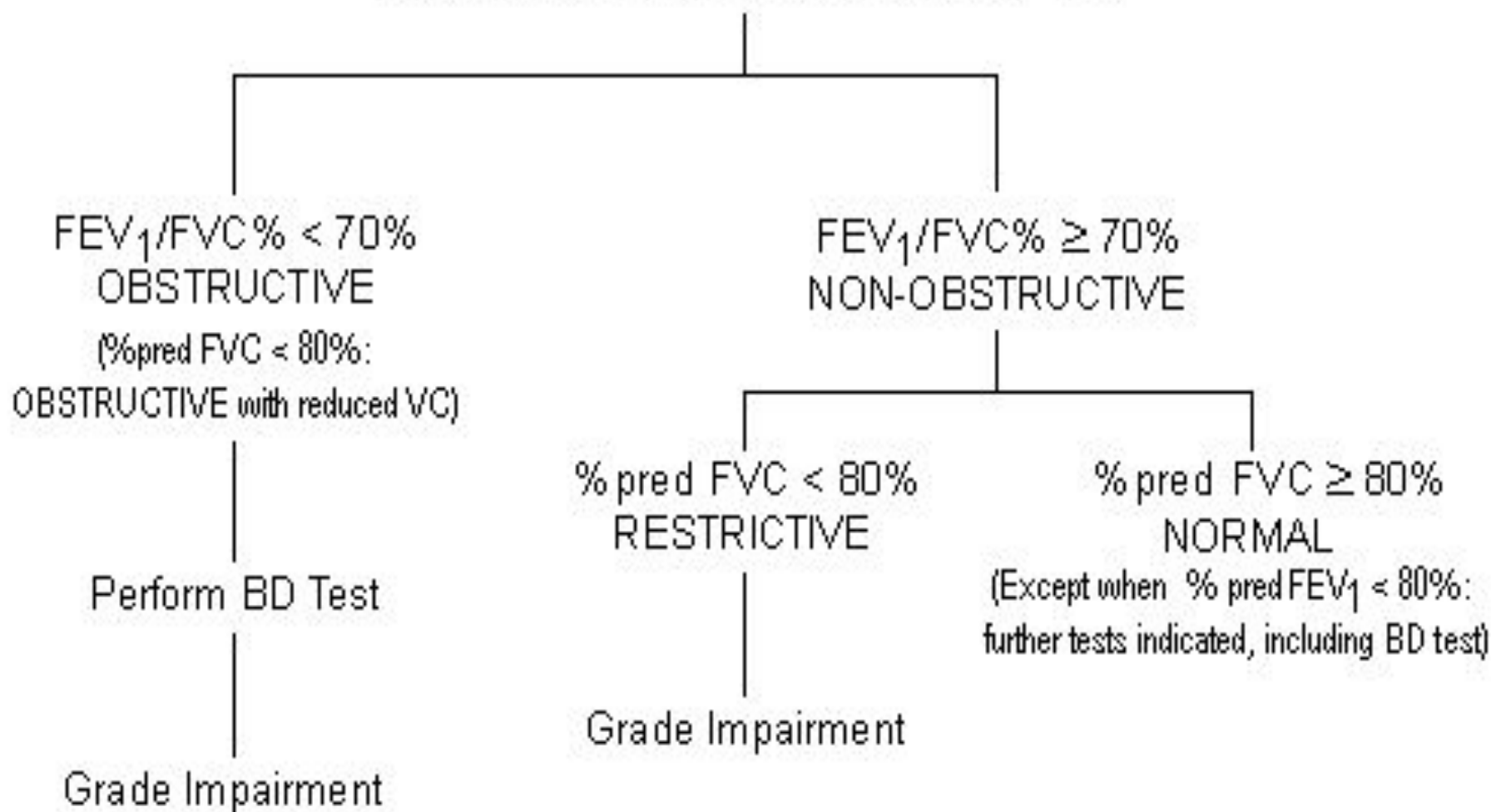
Decreased DLCo

Interpreting Spirometry (SATS)

Is the test acceptable? Yes

Is the test reproducible? Yes

Are the reference values appropriate? Yes



Remember:

Normal reduction of FEV1 is 30mL/yr

Smokers: 90-150 mL/ yr reduction

A stack of several folders, with the top folder being a light brown color. The word "REPORTS" is printed in blue, uppercase letters on the front of the top folder. The folders are stacked on a reflective surface, creating a faint reflection of the word "REPORTS" below it.

REPORTS

REPORTS

PRE Trial date 24/07/2003 14:34:17

Parameters	BTPS 1,092 25°C - 77°F	Pred	PRE	%Pred
------------	---------------------------	------	-----	-------

Best values from all loops

FVC	L	5,43	5,68	105
FEV1	L	4,49	5,12	114
FEV1/FVC	%	83,2	90,1	108
PEF	L/s	9,77	12,90	132

Values from best loop

FEF2575	L/s	4,71	7,33	156
FEF25	L/s	9,07	12,02	133
FEF50	L/s	5,56	7,21	130
FEF75	L/s	2,34	4,00	171
FEV3	L	5,04		
FET	s	6,00	2,06	34
FIVC	L	5,43	5,41	100
FIV1	L	4,49	5,10	114
FIV1/FIVC	%	83,2	94,3	113
PIF	L/s	9,77	6,07	62
ELA	Years	33	33	
EVC	L	5,43	6,11	113
IVC	L	5,43		
FEV1/VC	%	83,2	83,8	101
ERV	L	1,77	2,06	116
IC	L	3,65	4,05	111
MVV	L/min	149,8	164,2	110

Spirometry		(BTPS)	PRED	PRE-RX BEST	%PRED
FVC	Liters		4.42	4.38	99
FEV1	Liters		3.54	3.73	105
FEV1/FVC	%		80	85	
FEF25-75%	L/sec		3.57	4.73	132
IsoFEF25-75	L/sec		3.57	4.73	132
FEF75-85%	L/sec		0.72	1.27	177
PEF	L/sec		8.58	6.49	76
FET100%	Sec			7.05	
FIVC	Liters		4.42	4.00	90
FEV1	Liters		3.54	3.73	105
FIV1	Liters			3.40	
FEF/FIF50			<1.00	1.23	
Vol Extrap	Liters			0.19	
FVL ECode				000010	

Sex: Male Age: 72

Factor: 100(Caucasian)

Height: 163cm Weight: 55kg BMI: 20.7

	FEV1	FVC	PEF	Var	Quality	Time:	Date:
Base	1.21	2.90	161	0%	Good blow	10:03	31-07-09
Base	1.20	2.88	178	0%	Good blow	10:03	31-07-09
Base	1.06	2.72	195	-12%	Good blow	10:03	31-07-09
Post 1	1.63	3.96	236	0%	Good blow	10:28	31-07-09
Post. 1	1.63	3.79	236	0%	Good blow	10:28	31-07-09
Post 1	1.59	3.73	245	-2%	Good blow	10:28	31-07-09

Variation is based on FEV1

Best Spirometry Result:

	Base	%Pr	Min	Pred	Max	Post	%Pr	%Chg	
EVC	2.95	89	2.36	3.28	4.20	3.94	120	34	1
FEV1	1.21	49	1.59	2.43	3.27	1.63	67	35	1
FVC	2.90	91	2.18	3.18	4.18	3.96	124	37	1
PEF	161	37	304	424	543	236	55	47	1/m
FEV1/VC	41.0					41.4		1	%
FEV1/FVC	41.7	56	62.5	74.3	86.1	41.2	55	-1	%
MEF75	1.11	17	3.53	6.34	9.15	1.41	22	27	1/s
MEF50	0.42	11	1.43	3.60	5.77	0.60	16	43	1/s
MEF25	0.14	13		1.04	2.32	0.21	20	50	1/s
OT	10.9					11.6		6	s

Age: 106

Interpretation(NICE): Moderate Obstruct



Spirometry (BTPS)		PRED	PRE-RX		POST-RX		% Chg
			BEST	%PRED	BEST	%PRED	
FVC	Liters	3.69	(2.34)	(63)	(2.26)	(61)	-3
FEV1	Liters	2.34	1.45	62	1.49	64	3
FEV1/FVC	%	67	62		66		
FEF25-75%	L/sec	2.03	0.64	32	0.81	40	27
PEF	L/sec	7.24	5.55	77	5.30	73	-4

Lung Volumes (BTPS)

TLC	Liters	5.70			4.85	85	
RV	Liters	2.54			2.59	102	
RV/TLC	%	44			53		
FRC PL	Liters	3.45			2.81	82	
VC	Liters	3.69			(2.27)	(61)	

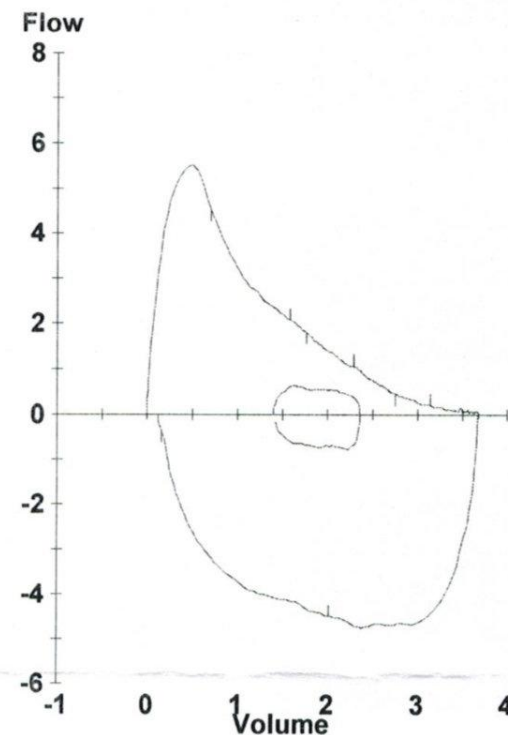
Diffusion

DLCO	mL/mmHg/min	20.9			16.3	78	
DL Adj	mL/mmHg/min	20.9			17.5	83	
DLCO/VA	mL/mHg/min/L	3.33			4.10	123	
DLVA Adj	mL/mHg/min/L				4.39		
VA	Liters				3.98		

Spirometry

Parameter	Units	Ref	Pre	% Ref
FVC	L	2.47	0.62	25
FEV ₁	L	2.14	0.49	23
FEV ₁ / FVC	%	85	79	93
FEF _{25%-75%}	L/s	3.31	0.49	15
PEFR	L/s	5.74	1.27	22
FET	sec		9.38	
FIF _{50%}	L/s		0.58	
FEF _{50%} / FIF _{50%}			1.74	

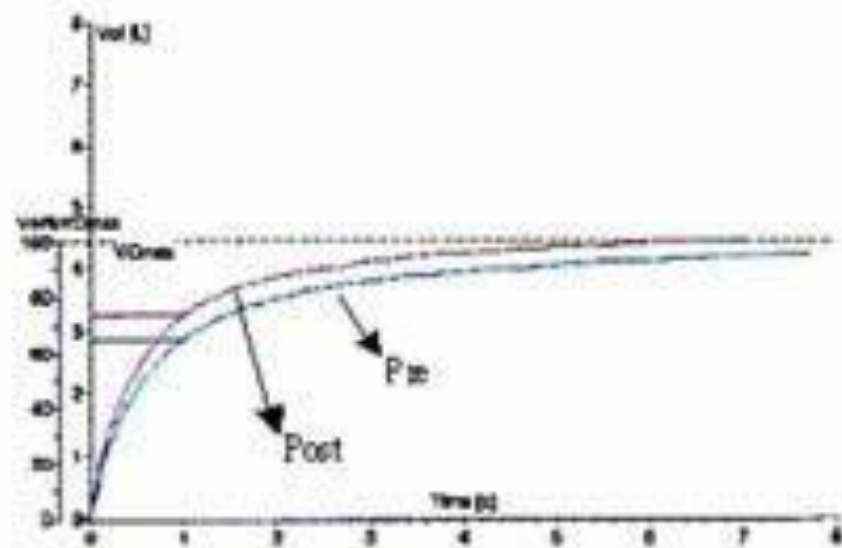
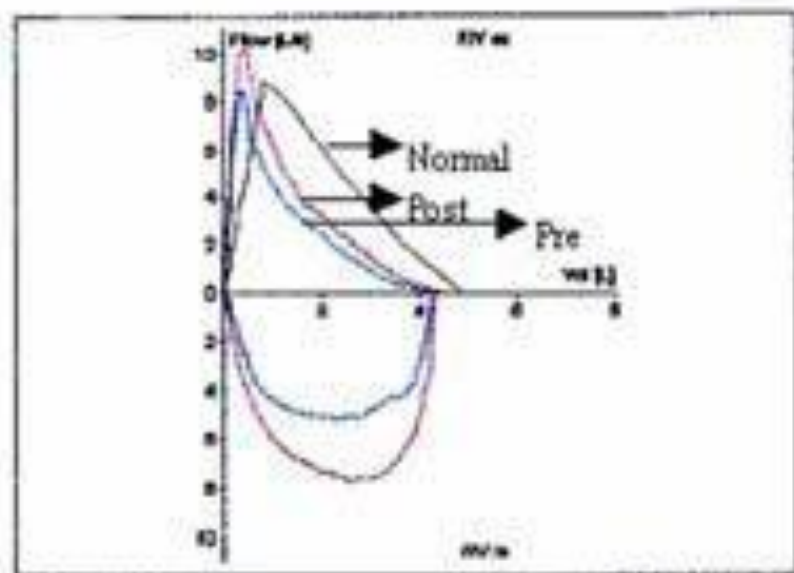
		Ref	(Normal Range)	Pre	% Ref	Post	% Ref	%Chg
Spirometry								
FVC	Liters	3.76	(2.9 - 4.6)	3.69	98			
FEV1	Liters	2.93	(2.3 - 3.5)	2.33	80			
FEV1/FVC	%	78	(68.4 - 87.1)	63				
FEF25-75%	L/sec	2.92	(1.6 - 4.2)	1.25	43			
FEF50%	L/sec	3.63	(3.2 - 4.1)	1.73	48			
FEF75%	L/sec	1.23	(0.6 - 1.8)	0.44	36			
PEF	L/sec	7.10	(5.3 - 8.9)	5.51	78			
FIF50%	L/sec	5.28	(3.4 - 7.1)	4.45	84			
FEF/FIF50		0.67	(0.2 - 1.1)	0.39	58			
Lung Volumes								
TLC	Liters	5.62	(4.7 - 6.6)	6.02	107			
VC	Liters	3.77	(3.0 - 4.5)	3.69	98			
IC	Liters	2.38	(1.9 - 2.8)	2.30	97			
FRC PL	Liters	2.98	(2.2 - 3.8)	3.63	122			
ERV	Liters	1.19	(1.0 - 1.4)	1.29	109			
RV	Liters	1.78	(1.2 - 2.4)	2.34	131			
RV/TLC	%	36	(24.1 - 48.7)	39				



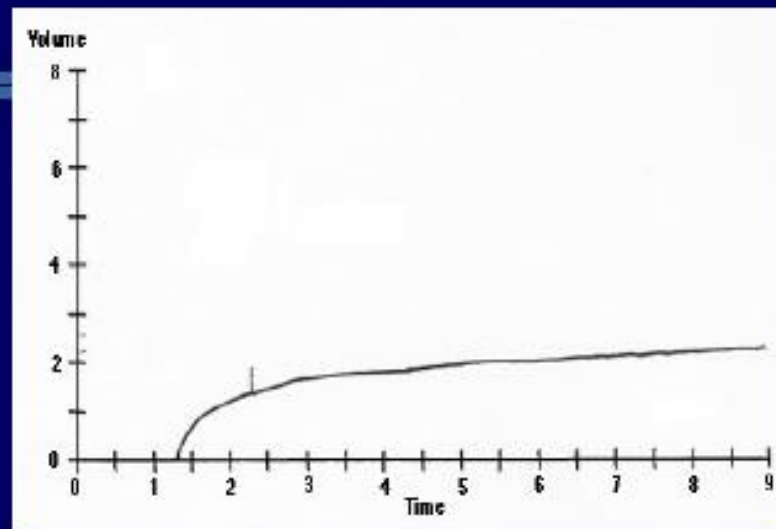
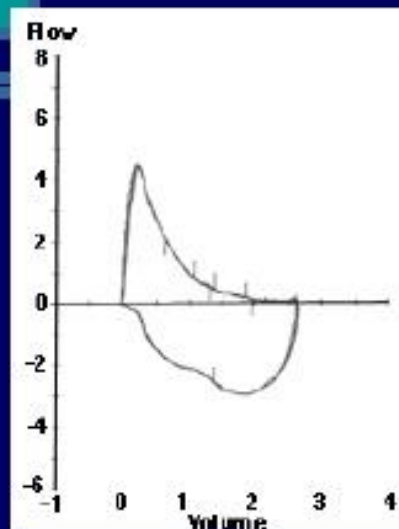
PULMONARY FUNCTION ANALYSIS

Spirometry		Ref	Pre Meas	Pre % Ref	Post Meas	Post % Ref	Post % Chg
FVC	Liters	3.81	3.45	90	3.78	99	10
FEV1	Liters	3.27	2.34	72	2.90	89	24
FEV1/FVC	%	86	68	79	77	89	13
FEF25-75%	L/sec	3.83	1.44	38	2.40	63	67
FEF50%	L/sec	4.11	1.93	47	3.33	81	73
FEF75%	L/sec	1.91	0.57	30	0.98	51	73
PEF	L/sec	6.55	6.08	93	7.57	116	25
PIF	L/sec		3.63		4.53		25

	Pre Bronchodilator			Post Bronchodilator		
	Predicted	Measured	% Predicted	Measured	% Predicted	Percentage Change
FVC	4.85 L	4.19 L	86 %	4.43 L	91%	6%
FEV ₁	4.05 L	2.87 L	71 %	3.24 L	80%	13%
FEV ₁ /FVC (%)	83.35%	68.43%		73.09%		

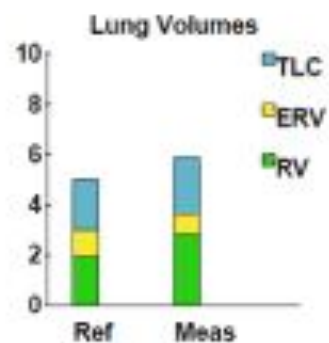
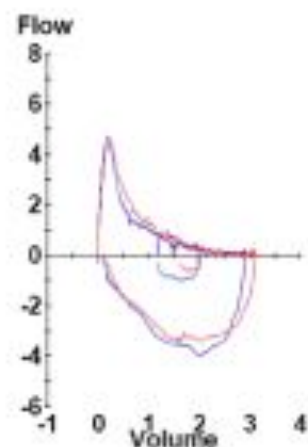


Example 1



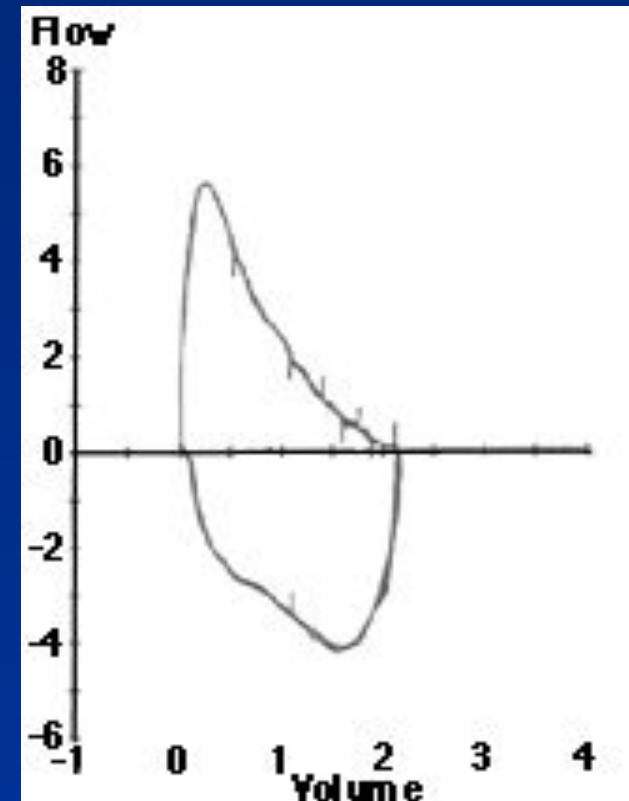
Variable	means	predicted	%pred
FVC	2.62	2.82	93
FEV1	1.45	1.98	73
FEV1/FVC	55	70	
FEF25-75%	0.43	2.20	20
PEF	4.50	5.48	82

			Ref	Pre	% Ref	Post	% Ref	%Chg
Spirometry								
FVC	Liters		3.23	2.91	90	3.12	96	7
FEV1	Liters		2.47	1.31	53	1.42	57	8
FEV1/FVC	%		77	45		45		
FEF25-75%	L/sec		2.16	0.37	17	0.39	18	4
PEF	L/sec		6.08	4.71	77	4.71	78	0
FET100%	Sec			15.05		15.14		1
Lung Volumes								
TLC	Liters		4.97	5.84	117			
VC	Liters		3.23	3.04	94			
FRC PL	Liters		3.04	3.61	119			
ERV	Liters		1.01	0.79	78			
RV	Liters		1.94	2.79	144			
RV/TLC	%		39	48				
Diffusing Capacity								
DLCO	mL/mmHg/min		17.6	9.2	52			
DL Adj	mL/mmHg/min		17.6	9.2	52			
DLCO/VA	mL/mHg/min/L		3.74	1.91	51			
DL/VA Adj	mL/mHg/min/L			1.91				
VA	Liters		4.97	4.84	97			
IVC	Liters			2.91				



A 66 year old female complains of cough after dust exposure

Pred%	Ref	Meas	
85	2.58	2.2	FVC
97	1.85	1.79	FEV1
	72	81	FEV1/FVC
82	2.23	1.82	FEF 25-75
109	5.2	5.67	PEF



Normal Spirometry

- FEV1/FVC: 48%
- FVC: 3.24L (86%)
- FEV1: 1.55L (48%)
- FEF25-75%: 0.64L (28%)

- FEV1/FVC: 48% Severely ↓
- FVC: 3.24L (86%) Normal
- FEV1: 1.55L (48%) Severely ↓
- FEF25-75%: 0.64L (28%) Severely ↓

- Interpretation: Moderate obstruction

- FEV1/FVC: 59%
- FVC: 2.27L (71%)
- FEV1: 1.34L (49%)
- FEF25-75%: 0.95L (22%)

- FEV1/FVC: 59% Moderately ↓
- FVC: 2.27L (71%) Mildly ↓
- FEV1: 1.34L (49%) Severely ↓
- FEF25-75%: 0.95L (22%) Severely ↓

- Interpretation: Moderate obstructive impairment, FVC mildly reduced, can not rule out restrictive impairment

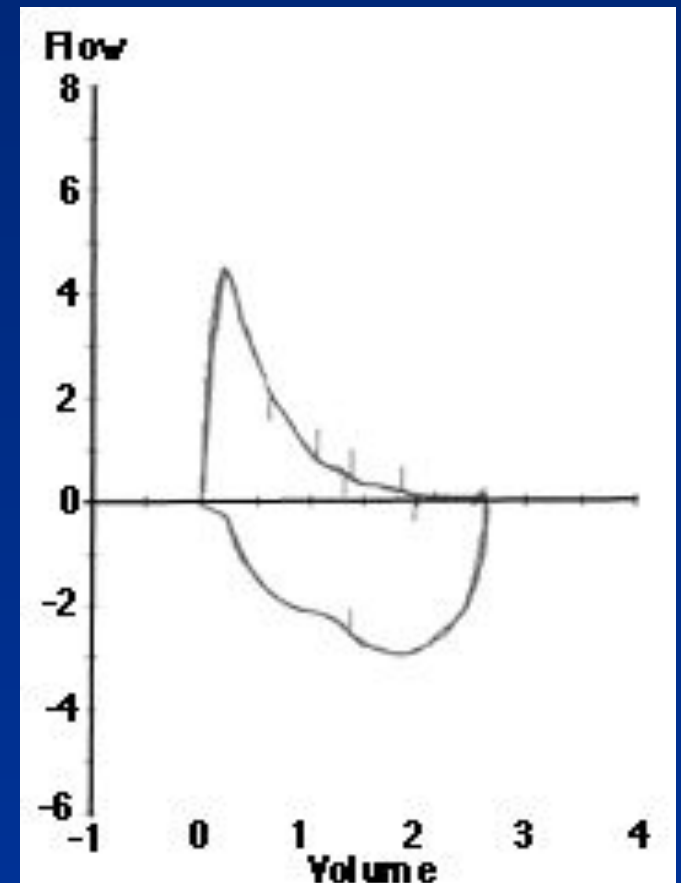
- FEV1/FVC: 86%
- FVC: 2.49 L (61%)
- FEV1: 1.96 L (64%)
- FEF25-75%: 2.83 L (98%)

- FRC: 1.94 L (59%)
- TLC: 4.03 L (70%)
- RV: 1.38 L (65%)
- DLCO: 55%

- Interpretation: Moderate Restrictive pattern with moderately reduced DLCO

**A 75 year old female has a history of
dyspnea and palpitations**

Pred%	Ref	Meas	
93	2.82	2.62	FVC
72	1.98	1.45	FEV1
	69	55	FEV1/FVC
20	2.20	0.43	FEF25-75
82	5.48	4.50	PEF



Mild Obstructive defect

Thank
you!