Interpretation of lung Function Tests

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MD

Components

- Spirometry
- Reversibilty testing
- Gas transfere(DLCO)
- Bronchoprovocaton studies
- Lung volumes
- MIPS and MEPS.
- Blood gases
- Cardiopulmonary exercise testing

Spirometry

- Measures ??
- Apparatus

- Method
  - Full inspiration, forced maximal expiration
  - Minimum 3 technically acceptable attempts
  - within 5% repeatability FEV1 and FVC
    - Slow Vital Capacity may also be checked

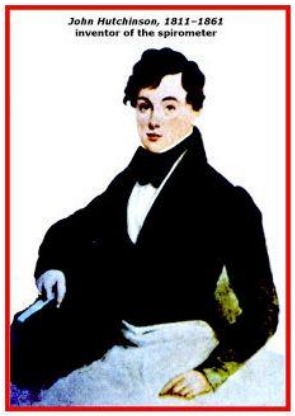
  - Repeatable and acceptable

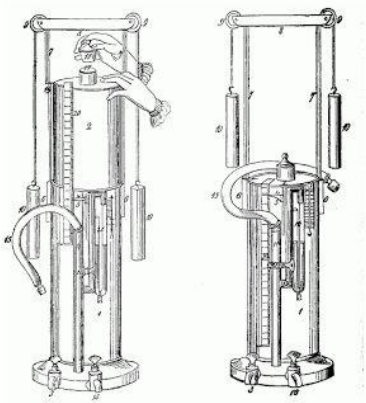
CPC Comprehensive Pneumology Center

History of spirometry

The first effective spirometer was invented in 1846, by John Hutchinson

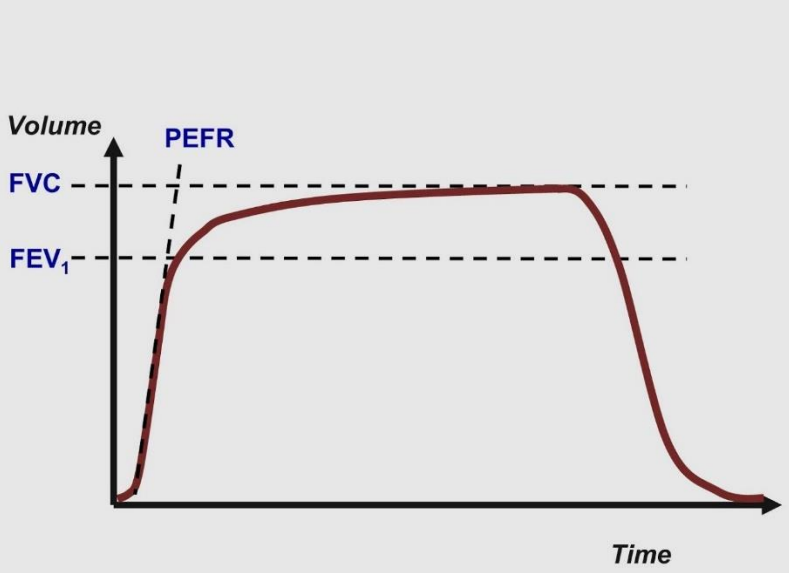
Hutchinson determined that the volume of exhaled air (VC) has a linear relationship with height

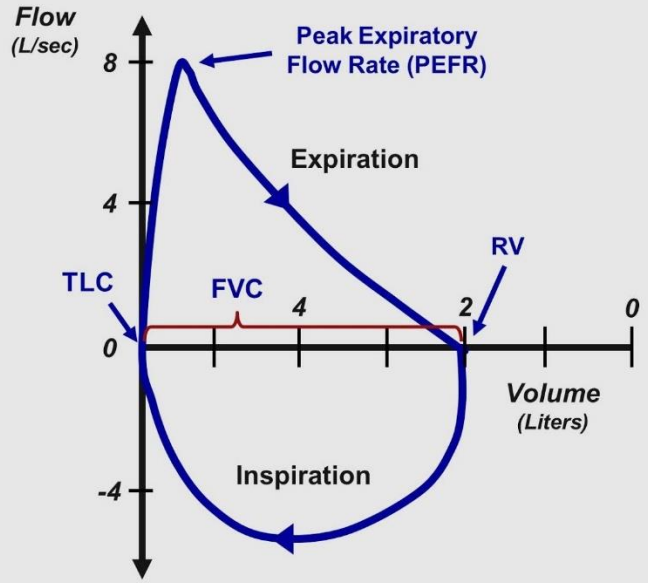


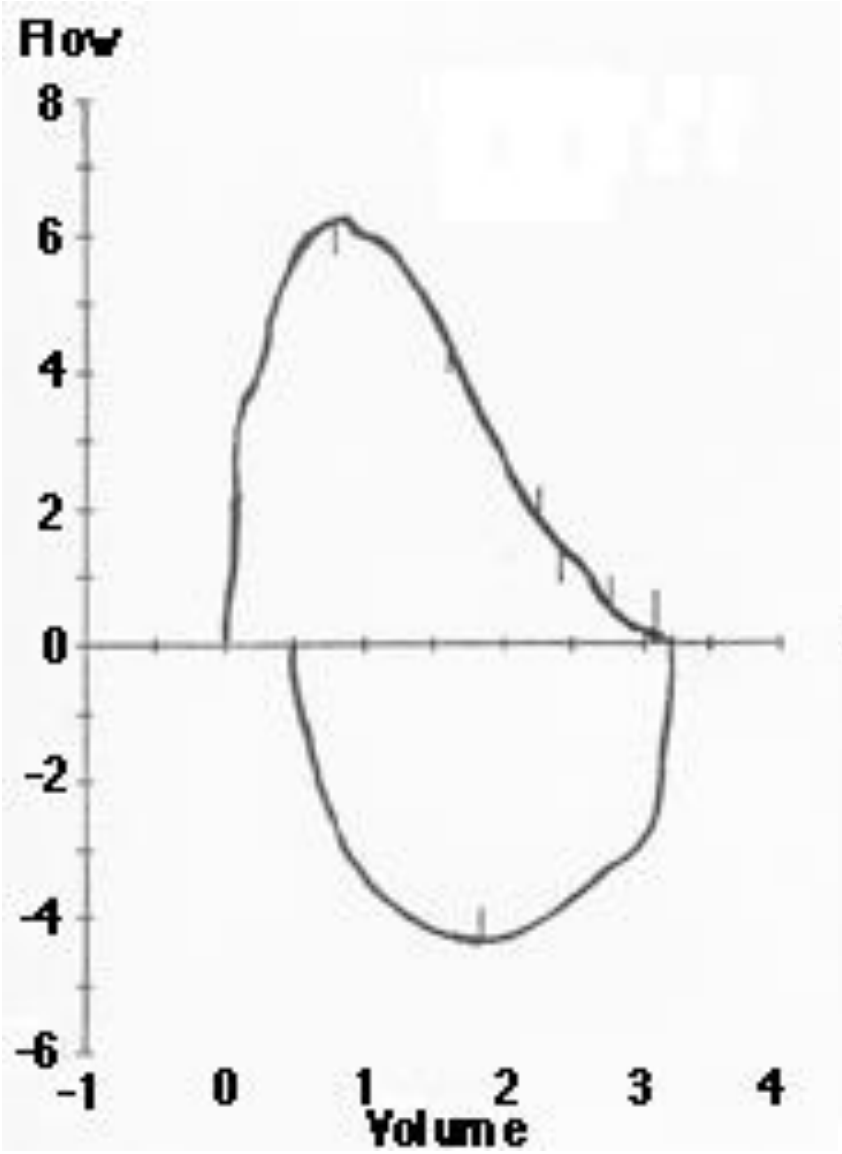


http://hardluckasthma.blogspot.de/2012/02/history-of-spirometry.html

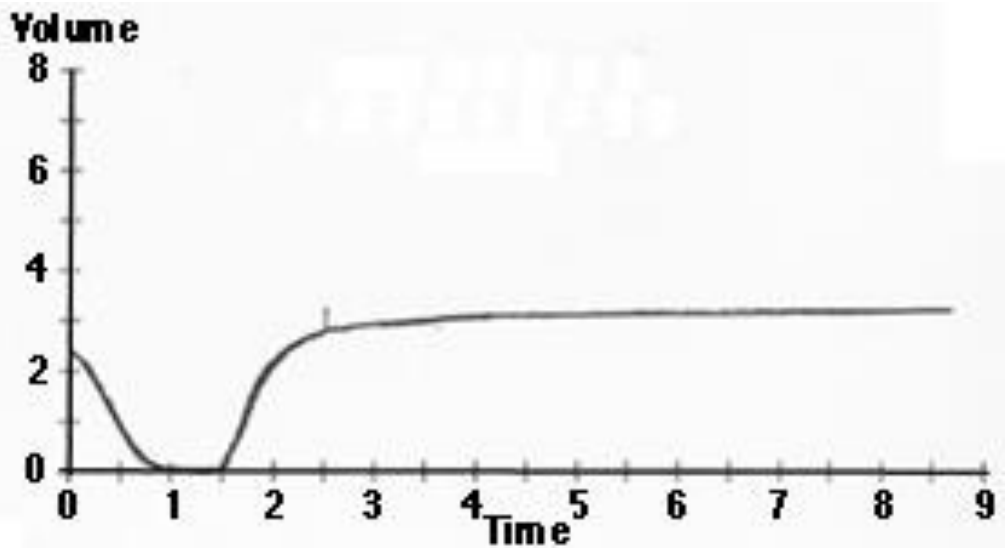
Flow-Volume Loop







NORMAL



Data generated

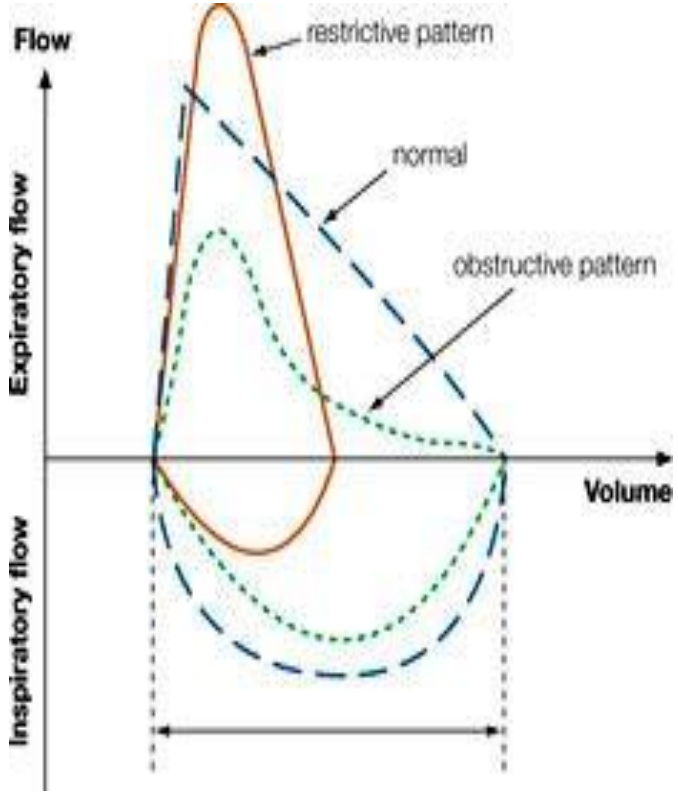
- Volume time curve (spirogram)
  - FEV1, FVC, Ratio
- Flow volume loop
  - Peak flow
  - FVC
  - FEF 25-75%
  - MEF 75, 50, and 25
  - Inspiratory flow data

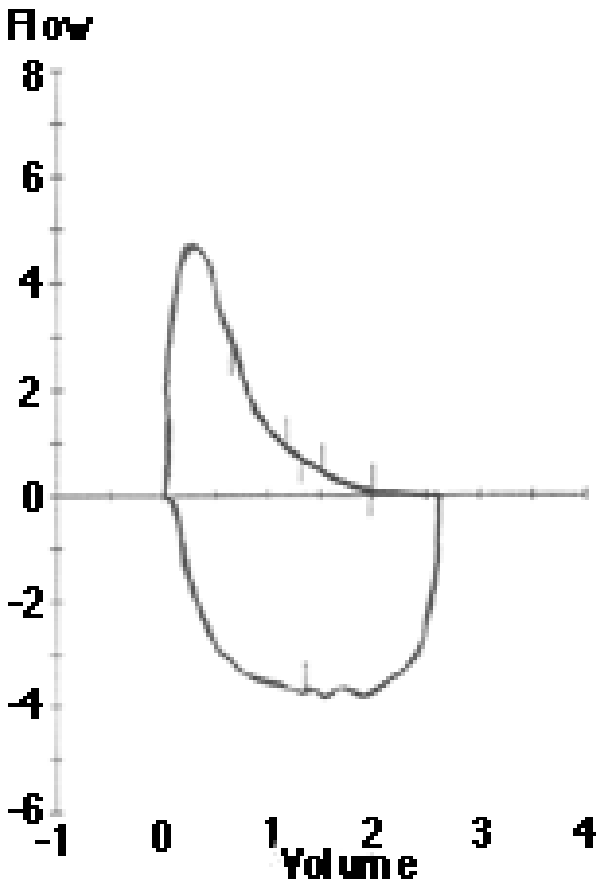
Normal Values of Pulmonary Function Tests

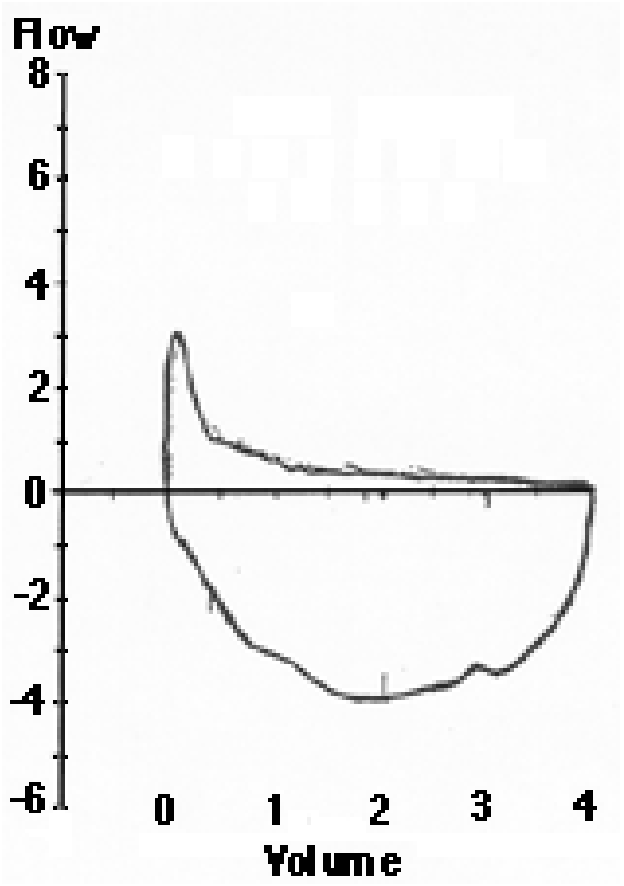
Pulmonary function test	*Normal value (95 percent confidence interval)*
FEV_1	80% to 120%
FVC	80% to 120%
Absolute FEV_1/FVC ratio	Within 5% of the predicted ratio
TLC	80% to 120%
FRC	75% to 120%
RV	75% to 120%
Dlco	>60% to <120%

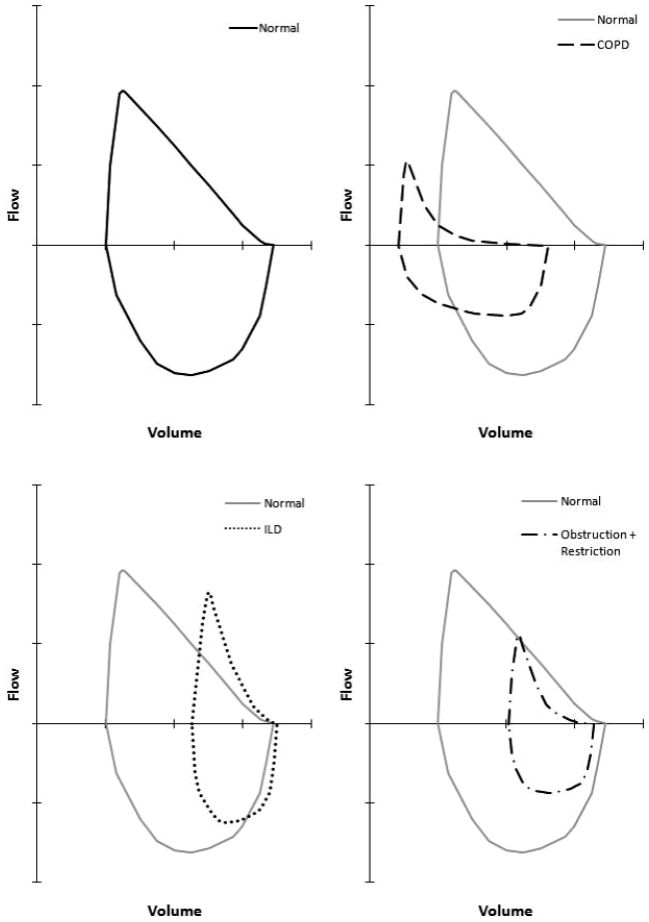
Dlco = diffusing capacity of lung for carbon

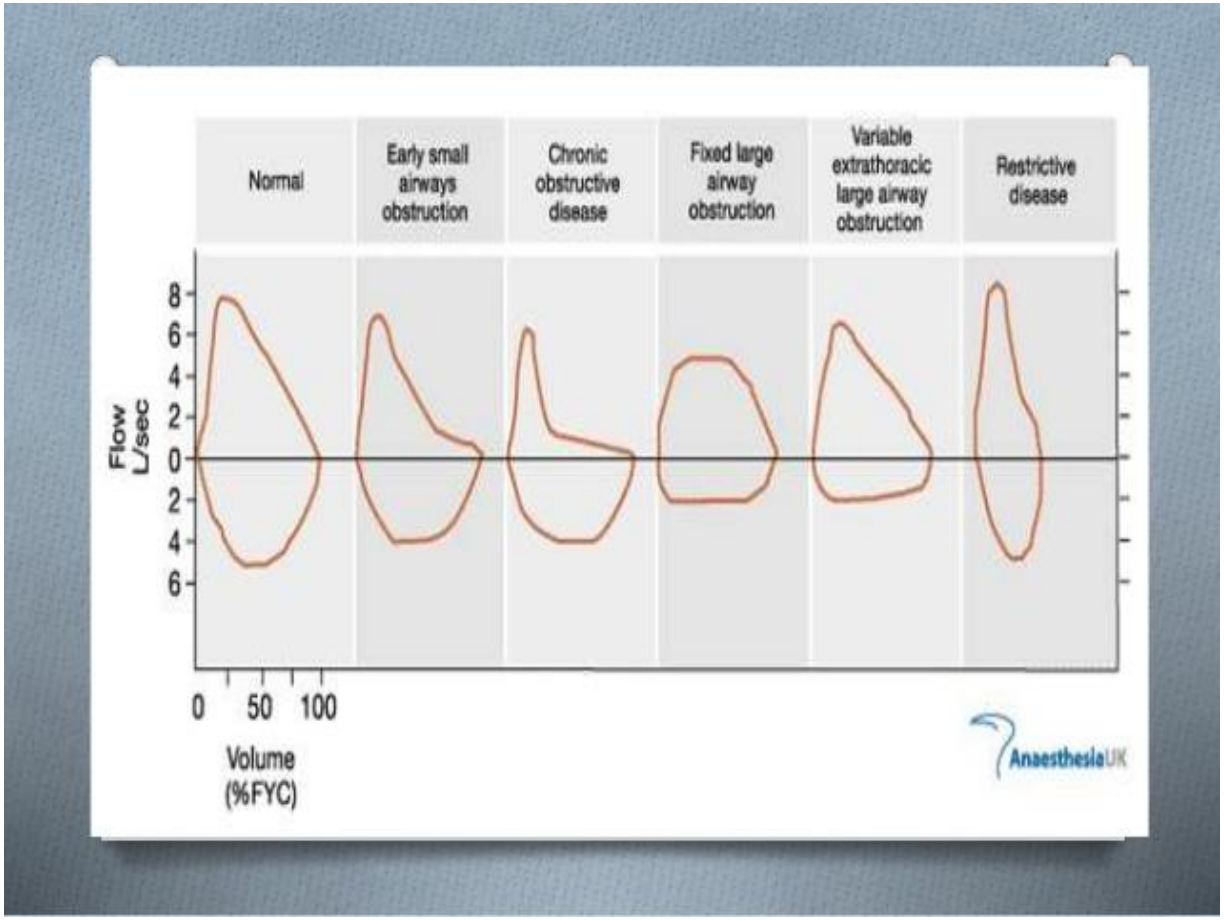
N LFT


Flow
restrictive pattern
normal
obstructive pattern
Expiratory flow
Volume
Inspiratory flow

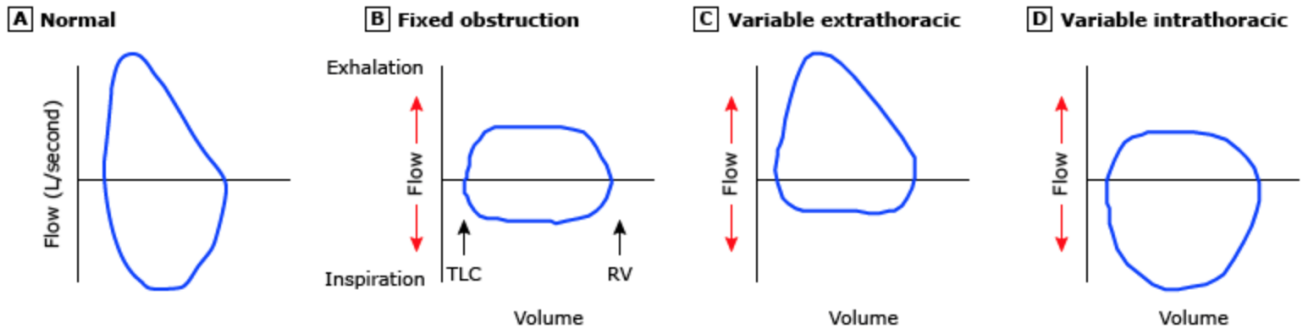

Flow
8
6
4
2
0
-2
-4
-6
-1
0
1
2
3
4
Volume


Flow
8
6
4
2
0
-2
-4
-6
0
1
2
3
4
Volume


Normal
Flow
Volume
Normal
COPD
Flow
Volume
Normal
ILD
Flow
Volume
Normal
Obstruction +
Restriction
Flow
Volume


Normal
Early small airways obstruction
Chronic obstructive disease
Fixed large airway obstruction
Variable extrathoracic large airway obstruction
Restrictive disease
Flow L/sec
8
6
4
2
0
2
4
6
0
50
100
Volume (%FYC)
AnaesthesiaUK

Flow-volume loops in upper airway obstruction

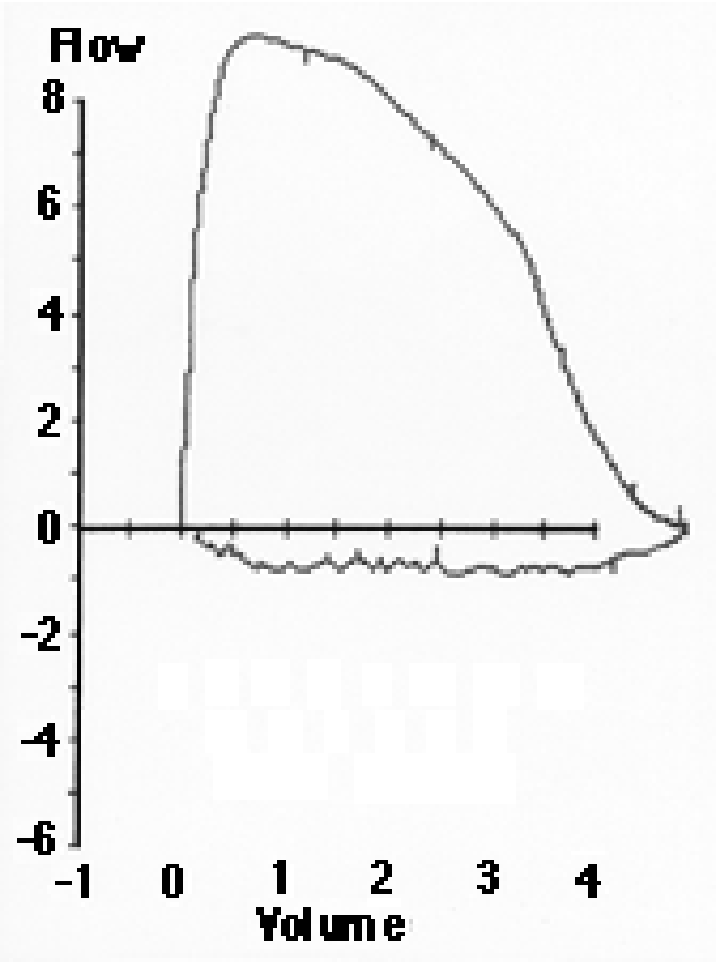


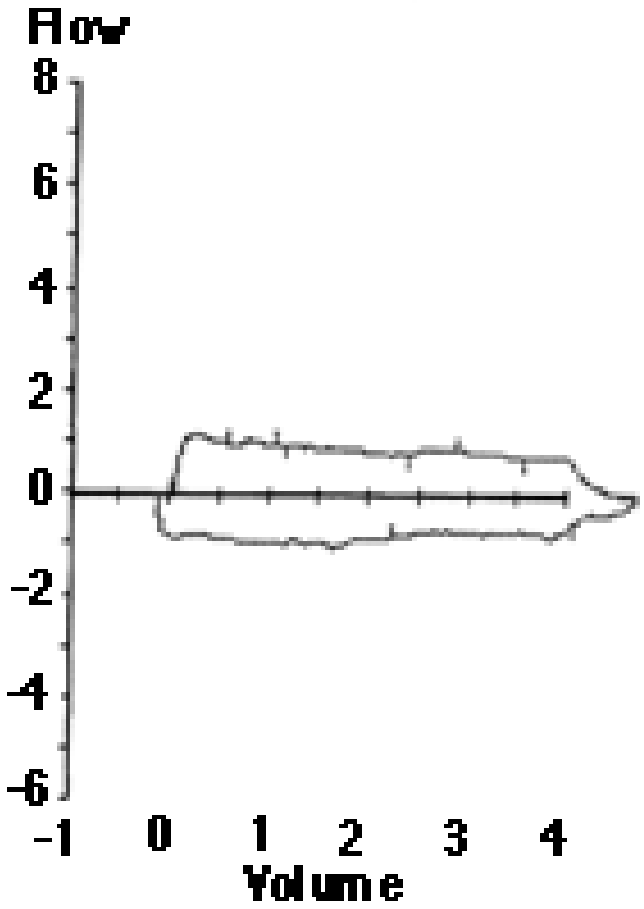
(A) Normal flow-volume loop: the expiratory portion of the flow-volume curve is characterized by a rapid rise to the peak flow rate, followed by a nearly linear fall in flow. The inspiratory curve is a relatively symmetrical, saddle-shaped curve.
(B) Fixed upper airway obstruction (can be intrathoracic or extrathoracic): flow limitation and flattening are noted in both the inspiratory and expiratory limbs of the flow-volume loop.
(C) Dynamic (or variable, nonfixed) extrathoracic obstruction: with flow limitation and flattening are noted on the inspiratory limb of the loop.
(D) Dynamic (or variable, nonfixed) intrathoracic obstruction: flow limitation and flattening are noted on the expiratory limb of the loop.

TLC: total lung capacity; RV: residual volume.

Adapted from: Stoller JK. Cleve Clin J Med 1992; 59:75.

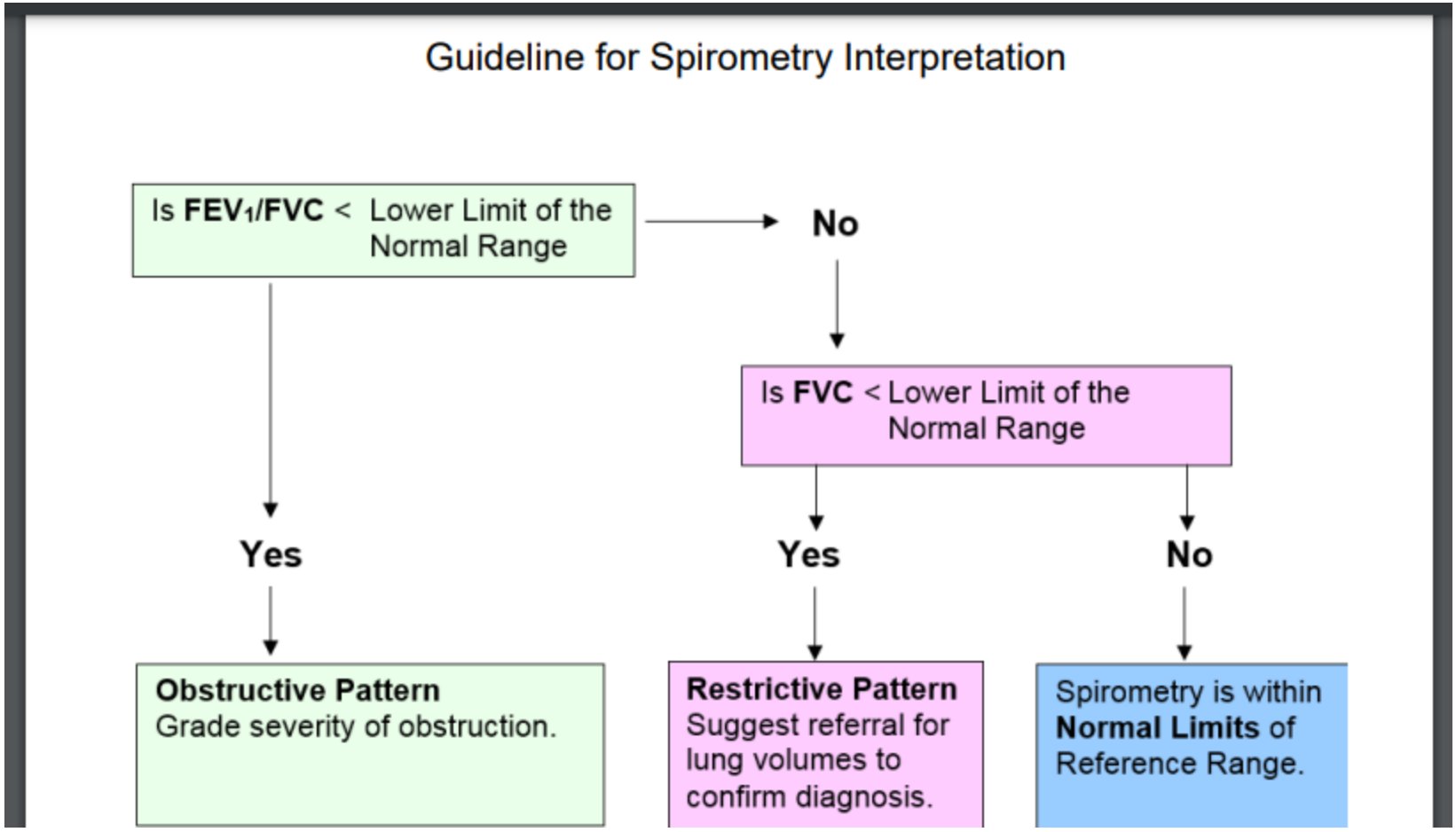
Graphic 76811 Version 4.0





Variable extrathoracic Fixed

Large airway obstruction


Guideline for Spirometry Interpretation
Is FEV1/FVC < Lower Limit of the Normal Range
No
Is FVC < Lower Limit of the Normal Range
Yes
Yes
No
Obstructive Pattern
Grade severity of obstruction.
Restrictive Pattern
Suggest referral for lung volumes to confirm diagnosis.
Spirometry is within Normal Limits of Reference Range.

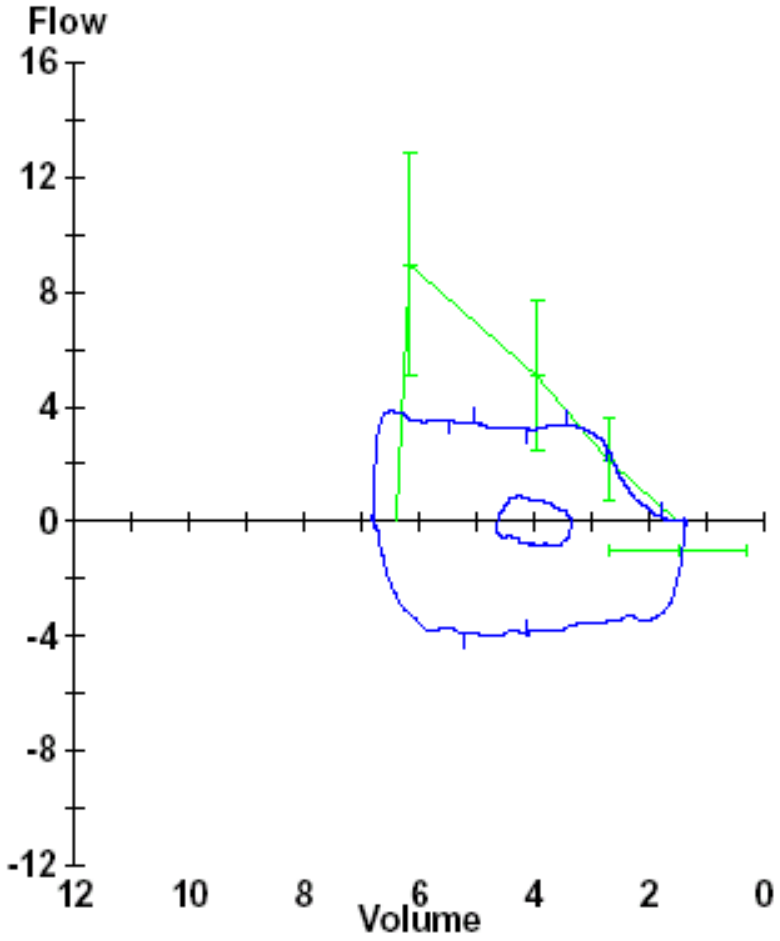
Classification of COPD Severity by Spirometry

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

Fixed Extrathoracic Obstruction PFT

ID: CLV3379 Date: 22/03/01 Gender : Male Age: 30
Weight(kg): 82.0 Height(cm): 171 BMI: 28.04
PB: 765 Temp: 25

Spirometry	Ref	Pre Meas	Pre % Ref	Post Meas
FVC	4.93	5.48	111	
FEV_1	3.94	3.45	88	
FEV_1/FVC	79	(63)		
FEF_{25-75}%	4.31	3.26	76	
PEF	8.95	(3.83)	(43)	
Lung Volumes				
TLC				
RV				
RV/TLC				
FRC PL				
ERV				
VC				
Resistance				
Raw				
sRaw				
Diffusion				
D_{LCO}				
D_{LCO} /V_A				
V_A				



Reversibility

- How?
  - Off inhalers
  - Spiro
  - Inhaled bronchodilator
  - Check spiro again
- Data
  - Absolute and %predicted pre&post FEV_1 & FVC

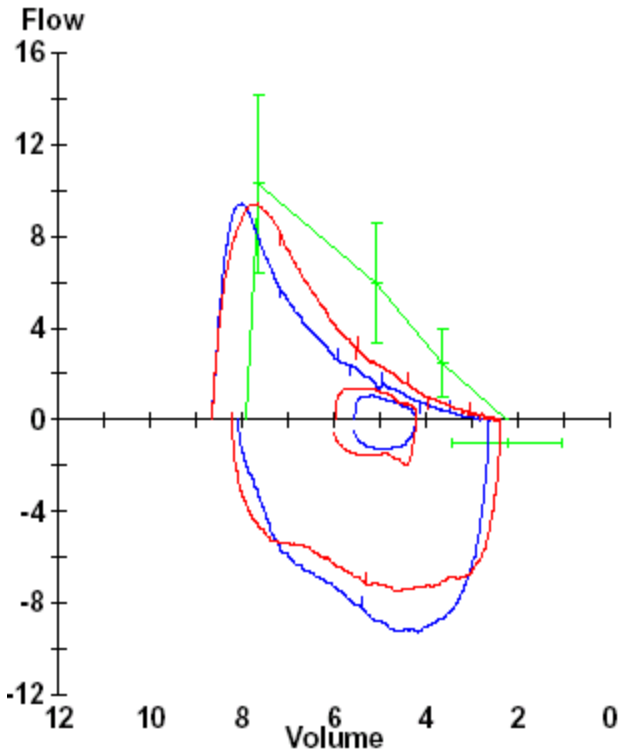
Interpretation

- Definition of significant response
  - FEV1 or FVC inc. by 12% AND 200ml
- What does reversibility mean?
  - Reversible airflow obstruction
  - Asthma
  - COPD with reversibility
  - COPD + asthma(ACO previously ACOS)

Bronchodilator Response PFT

ID: AKC1991 Date: 21/06/04 Gender: Male Age: 40
Weight(kg): 96.0 Height(cm): 189 BMI: 26.87
PB: 745 Temp: 21

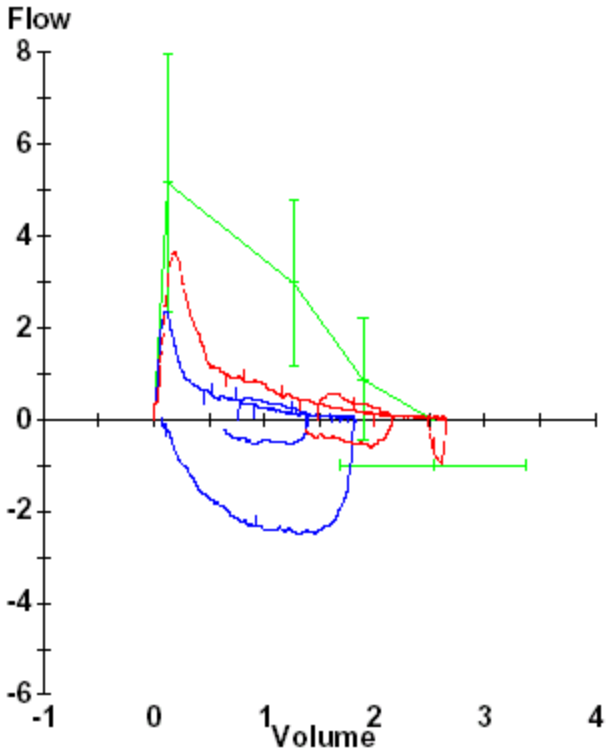
Spirometry	Pre Ref	Pre Meas	Post % Ref	Post Meas	Post % Ref	% Chg
FVC	5.71	6.05	106	6.31	110	4
FEV_1	4.27	3.74	88	4.27	100	14
FEV_1/FVC	74.0	62.0		68		
FEF_{25-75}%	4.19	(1.99)	(47)	2.66	63	33
PEF	10.27	10.19	99	9.4	91	-8
Lung Volumes						
TLC						
RV						
RV/TLC						
FRC PL						
ERV						
VC						
Resistance						
Raw						
sRaw						
Diffusion						
D_{LCO}						
D_{LCO} /V_A						
V_A						



Bronchodilator Response PFT

ID: AQA1519 Date: 16/08/04 Gender Female : Age: 63
Weight(kg): 47.0 Height(cm): 153 BMI: 20.08
PB: 734 Temp: 22

Spirometry	Ref	Pre Meas	Pre % Ref	Post Meas	Post % Ref	Post % Chg
FVC	2.54	1.83	72	2.66	105	45
FEV_1	1.83	(0.76)	(41)	1.17	64	54
FEV_1/FVC	73.0	(41.0)		(44.0)		
FEF_{25-75}%	2.26	(0.25)	(11)	(0.35)	(15.0)	41
PEF	5.15	2.36	46	3.64	71	54
Lung Volumes						
TLC						
RV						
RV/TLC						
FRC PL						
ERV						
VC						
Resistance						
Raw						
sRaw						
Diffusion						
D_{LCO}						
D_{LCO} /V_A						
V_A						



Bronchial challenge testing -

Normal Spirometry and suspected Asthma.

- How?
  - Off inhalers
  - Check spirometry
  - Inhale a bronchoprovocator (histamine, Mannitol, methacholine, saline) at inc. concentrations
  - measure spirometry after each inhalation

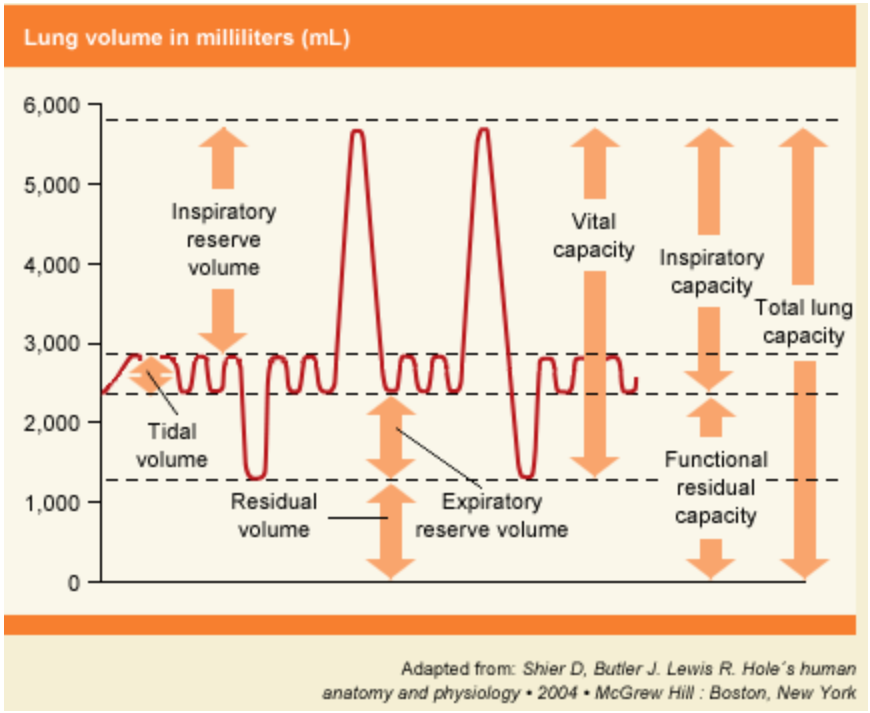
Bronchial challenge testing - Data

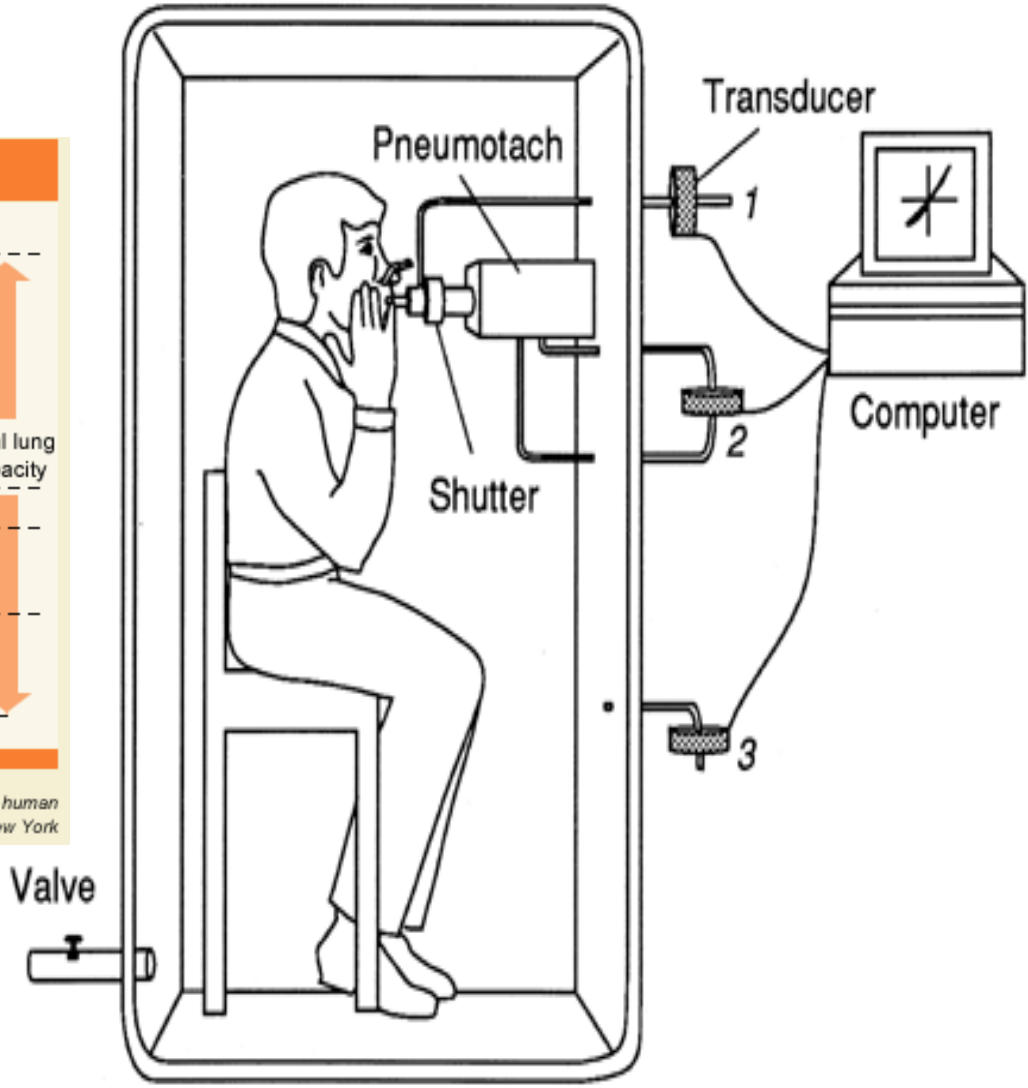
- PD20 = ‘Provocative Dose’ required to produce a 20% drop in FEV1
  - Histamine + if <4micromol
- PC20 = ‘Provocative Concentration’ required to produce a 20% drop in FEV1
  - Histamine + if <8mg/ml
- PC20/PD20 also used for Methacholine
- Hypertonic saline

Interpretation

- Indicates ‘Bronchial hyperresponsiveness’
- Negative test virtually excludes asthma

Volume-constant body plethysmograph





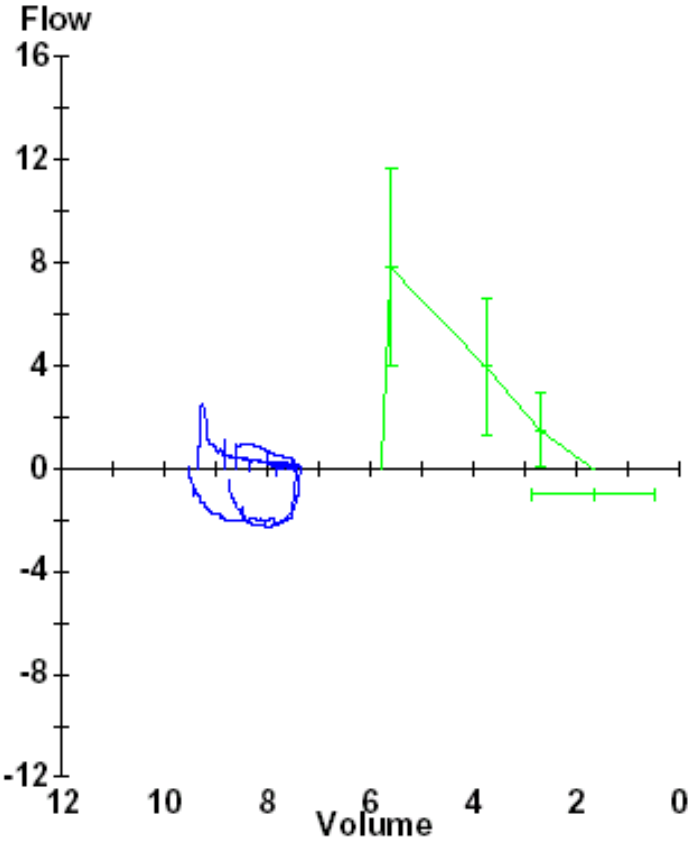
Lung volumes - interpretation

- True restriction - reduced TLC
- Hyperinflation - high TLC
  - Gas trapping - High RV, RV/TLC ratio
- Neuromuscular disease - ↓ TLC, preserved or raised RV

COPD PFT

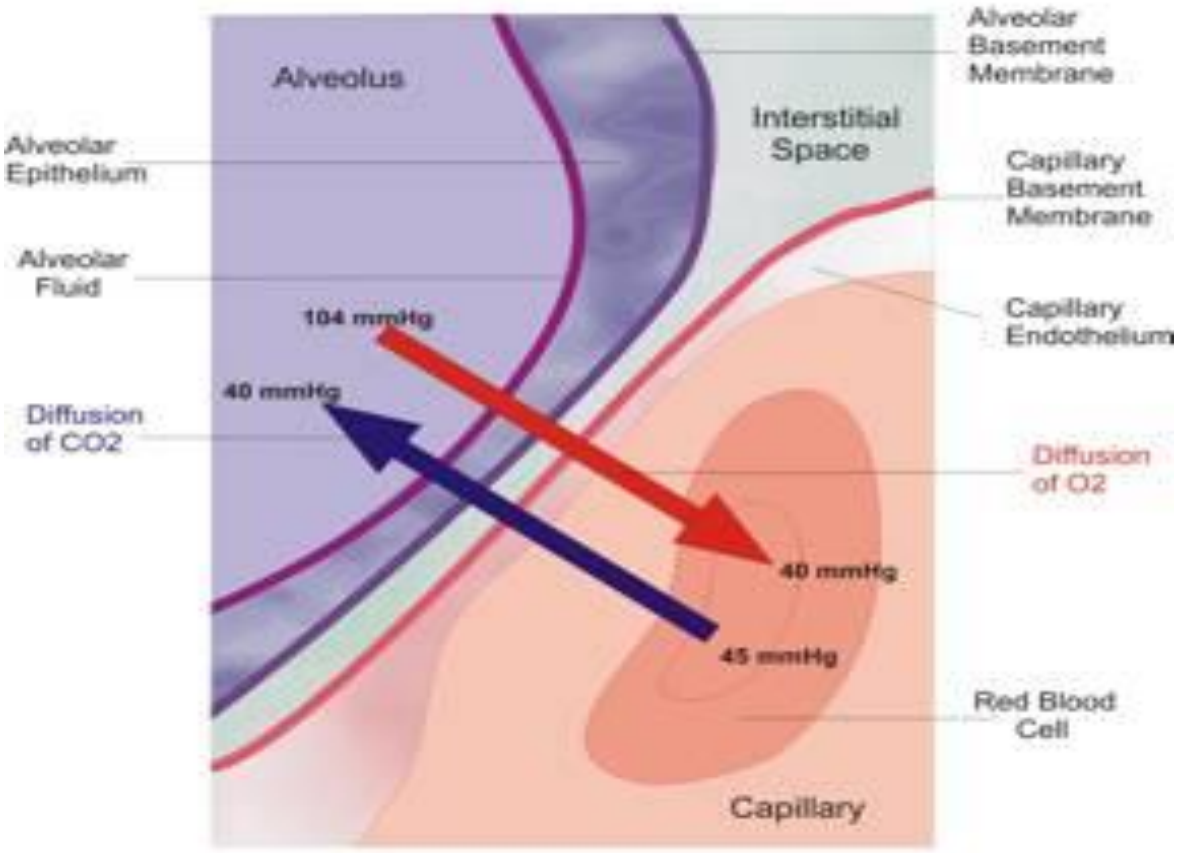
ID: BDD9943 Date: 23/06/04 Gender: Male Age: 55
Weight(kg): 65.0 Height(cm): 168 Race: BMI: 23.03
PB: 754 Temp: 21

Spirometry	Ref	Pre Meas	Pre % Ref	Post Meas	Post % Ref	Post % Chg
FVC	4.2	(2.0)	(48.0)			
FEV_1	3.1	(.8)	(25.0)			
FEV_1/FVC	73.0	(37.0)				
FEF_{25-75}%	3.1	(.3)	(10.0)			
PEF	7.8	(2.6)	(33.0)			
Lung Volumes						
TLC	5.8	(9.3)	(162.0)			
RV	2.0	(7.0)	(346.0)			
RV/TLC	36.0	(75.0)				
FRC PL	3.4	(7.1)	(211.0)			
ERV	1.4	(.3)	(19.0)			
VC	4.2	(2.4)	(57.0)			
Resistance						
Raw	1.4	7.0	518.0			
sRaw	4.6	56.6	1243.0			
Diffusion						
D_{LCO}	20.6	14.7	71.0			
D_{LCO}/V_A	4.0	3.1	78.0			
V_A	6.3	(4.8)	(75.0)			



Comments: The patient could not fully expire during forced and slow expiration, therefore the results were not quite accurate, even though they were repeatable.

DLCO


Alveolus
Interstitial Space
Alveolar Basement Membrane
Alveolar Epithelium
Capillary Basement Membrane
Alveolar Fluid
104 mmHg
Capillary Endothelium
40 mmHg
Diffusion of CO2
Diffusion of O2
40 mmHg
45 mmHg
Red Blood Cell
Capillary

Diffusing Capacity

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

Transfer factor – How?

- Inhale to TLC a gas mix containing known concentrations of CO & He
- Hold breath 10 sec
- Exhale
  - Discard dead space
  - Collect ‘alveolar’ gas
- Use He dilution to calculate V_A & starting Alveolar CO

DL_{CO} – Data generated

- Then DL_{CO} is calculated from the difference between ‘starting’ CO conc., and CO conc. after 10 sec in contact with alveoli
- Expressed in ml/mmHg/min
- V_A = TLC by single breath helium dilution
- DL_{CO}/V_A = transfer coefficient (K_{CO})

Other patterns

- Obesity
  - Restrictive Spirometry and TLC, very reduced FRC, reduced RV. DLCO only reduced in very gross obesity
- Heart Failure
  - Obstructive in Acute, Restrictive in Chronic with decreased gas transfer
- Neuromuscular
  - Decreased FVC, lower when supine, decreased TLC, preserved RV, preserved DLCO

Thank you