ARF, Mechanical Ventilation and PFTs: ACOI Board Review 2017

Thomas F. Morley, DO, FACOI, FCCP, FAASM
Professor of Medicine
Chairman Department of Internal Medicine
Director of the Division of Pulmonary, Critical Care and Sleep Medicine
Rowan University - SOM

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No Disclosures

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Acute Respiratory Failure (ARF)

DEFINITION

ARF is the clinical state which occurs when the respiratory system (ie circulatory and lungs) is not able to meet the metabolic requirements of the organism.

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Acute Respiratory Failure

- ✓ Anatomic- Etiologic
- ✓ Physiologic- Etiologic
- ✓ Blood Gas
- ✓ Radiologic
- ✓ Tissue Oxygenation

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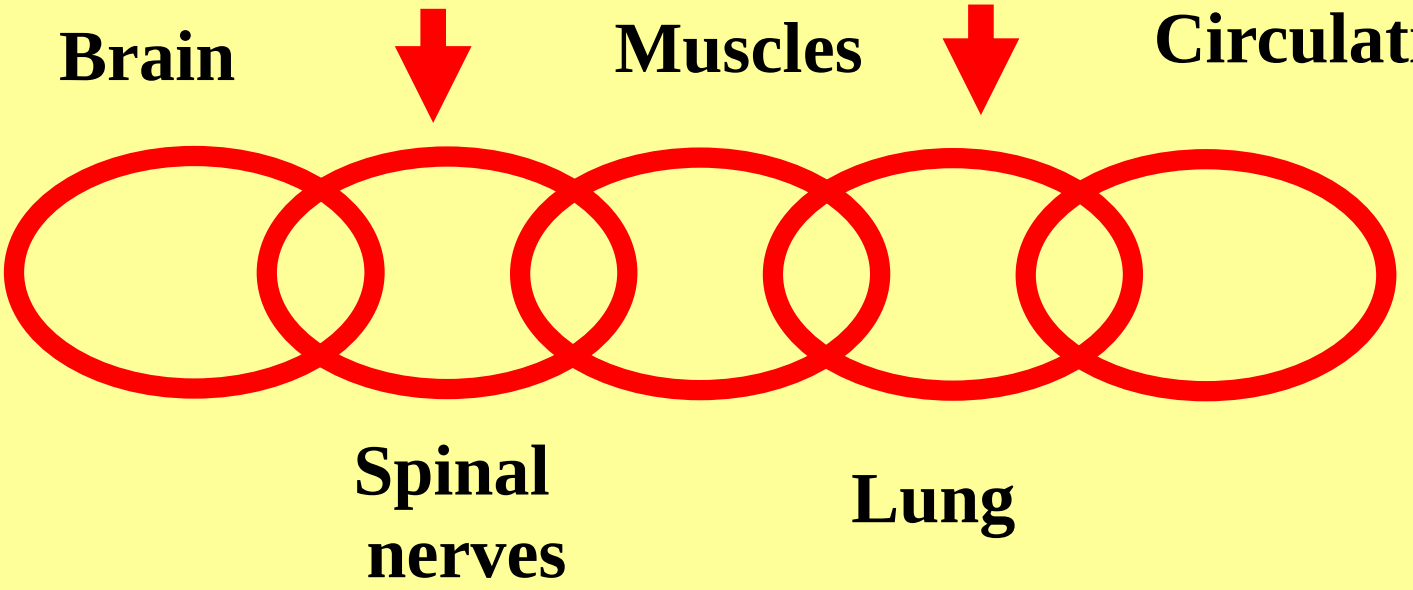
Anatomic Etiologic Classification



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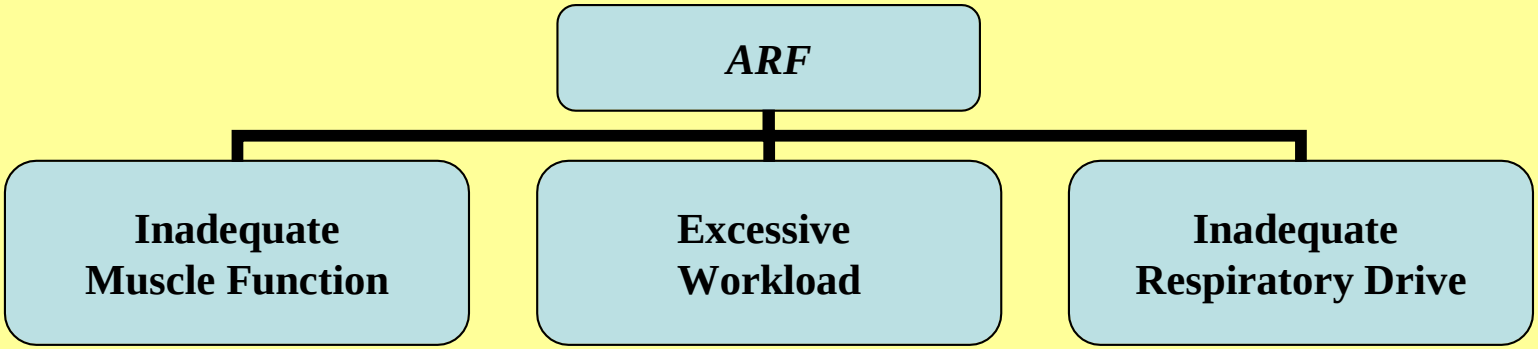
Physiologic Etiologic Classification



Neuro Muscular Disease

ARDS

COPD

IPF

OD

CVA

Alkalosis

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Blood Gas Classification

Hypoxemic/Hypercapnic

- ✓ Clinically useful
- ✓ Can be used to divide patients into distinct ETIOLOGIC and TREATMENT groups
- ✓ Readily available

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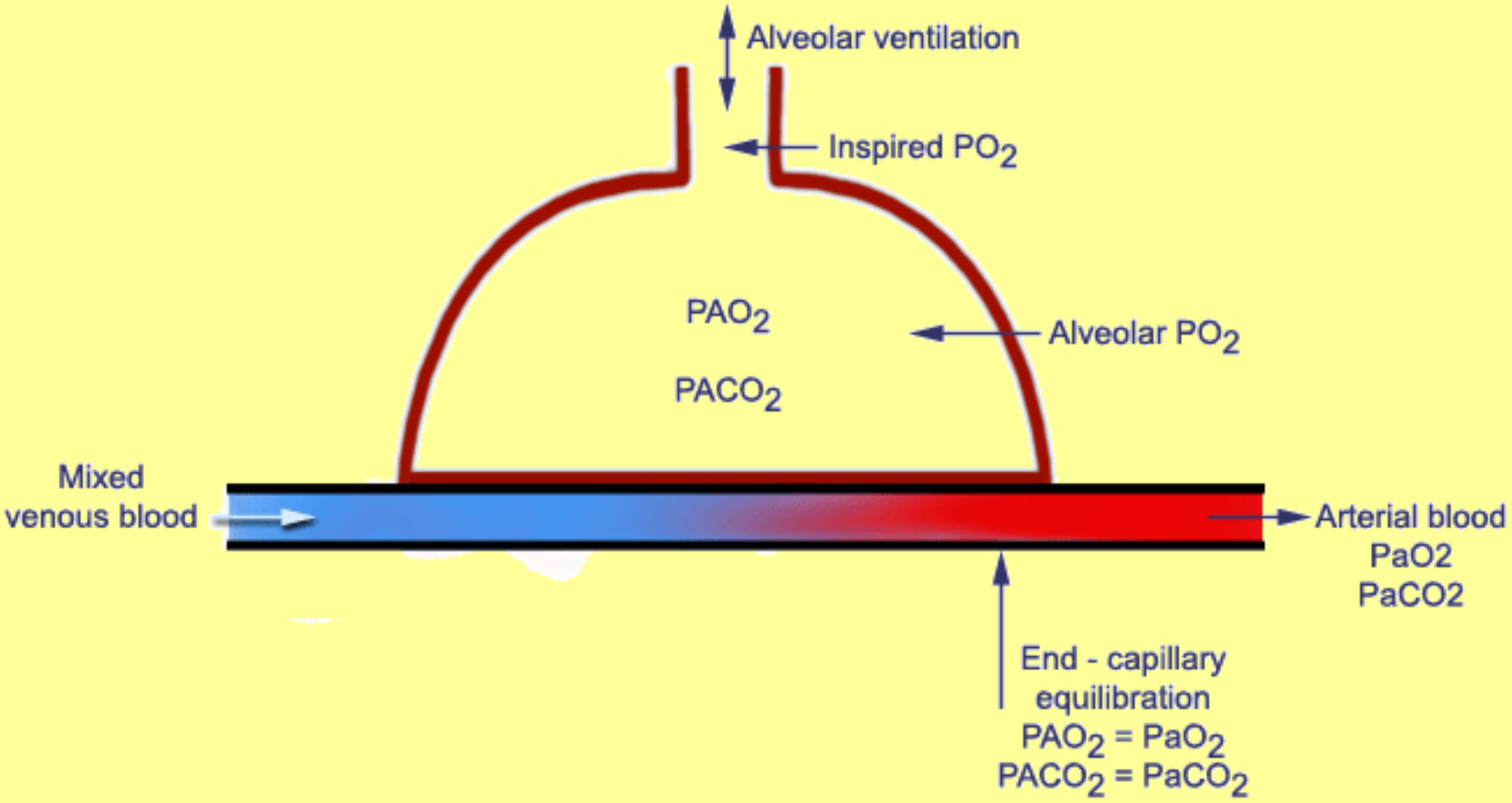

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Calculation of the A-a Gradient

$PAO_2 = FIO_2 (Pb - 47) - 1.25\ PaCO_2$

PaO_2 = measured

A-a gradient should be less than 20 mmHg breathing room air OR
Less than 100 mmHg on 100 % O_2

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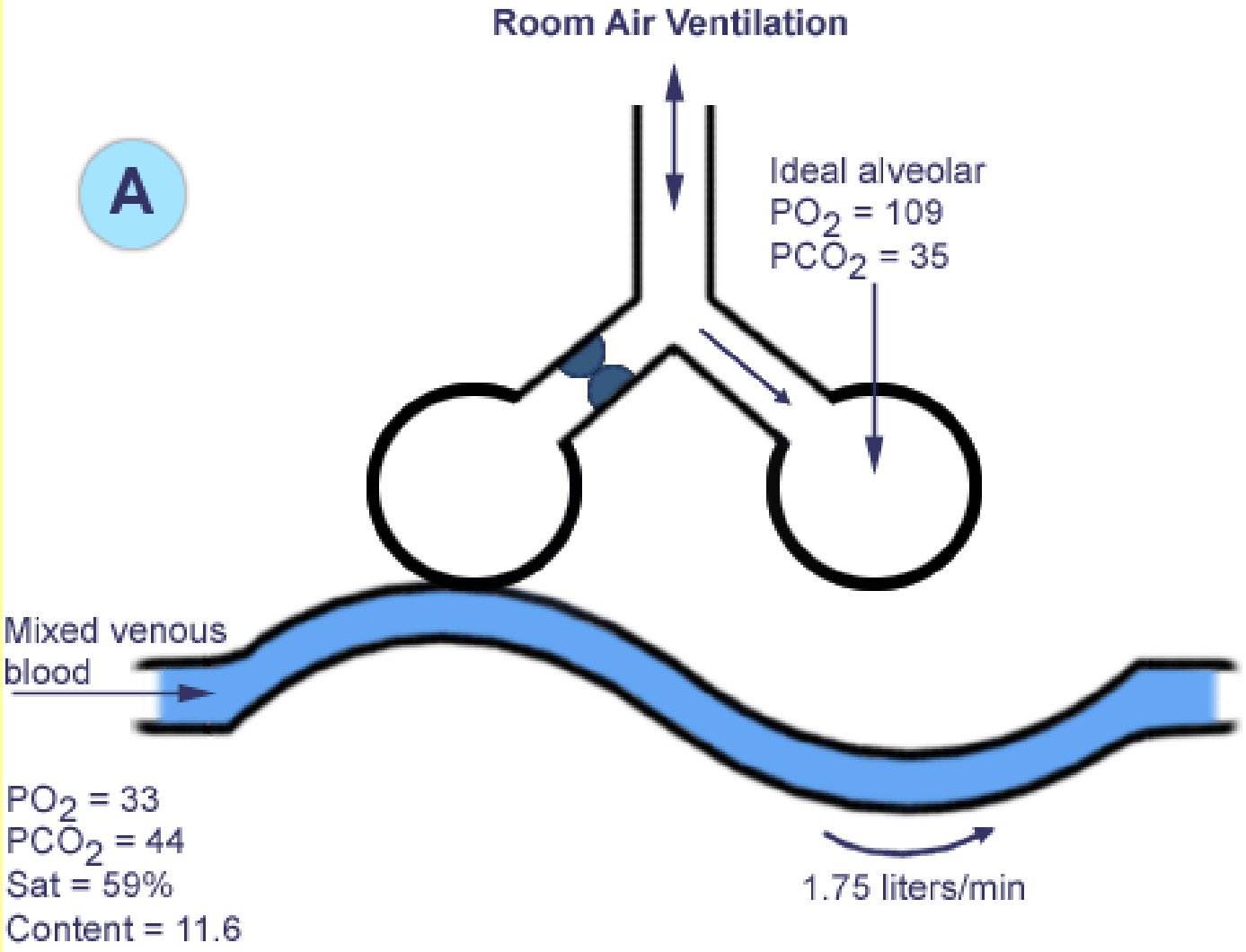
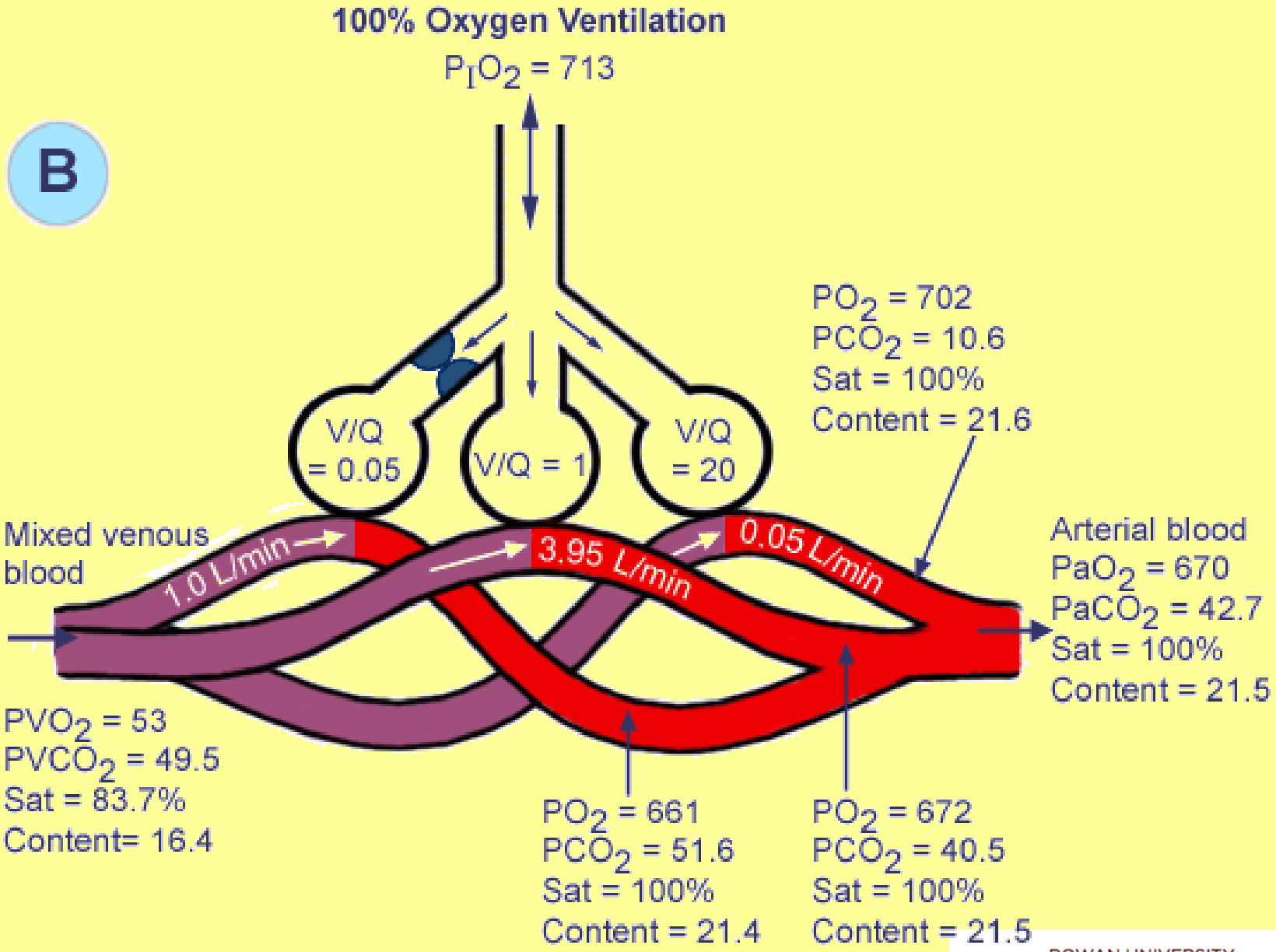
100% Oxygen and Pulmonary Shunt





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Causes of Hypoxemia

CAUSE	A-a Gradient	PaCO2	Response to 100 % Oxygen
Low FIO2	Normal	Normal	Improved
Hypoventilation	Normal	Increased	Improved
Diffusion Impair	Increased	Normal	Improved
Low V/Q	Increased	Normal	Improved
Shunt	Increased	Normal	NOT Improved
Low PvO2	Increased	Normal	? Improved

Mechanisms of Hypercapnia

$$PaCO_2 = K \frac{VCO_2}{Va}$$

PaCO2 = arterial CO2 tension

K = proportionality constant

VCO2 = CO2 production

Va = Alveolar ventilation

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Causes of Hypercapnia

1. **Alterations in CO_2 production**
2. **Disturbances in the Gas Exchanger (the lungs)**
3. **Abnormalities in the mechanical system (the bellows)**
4. **Changes in ventilatory control**

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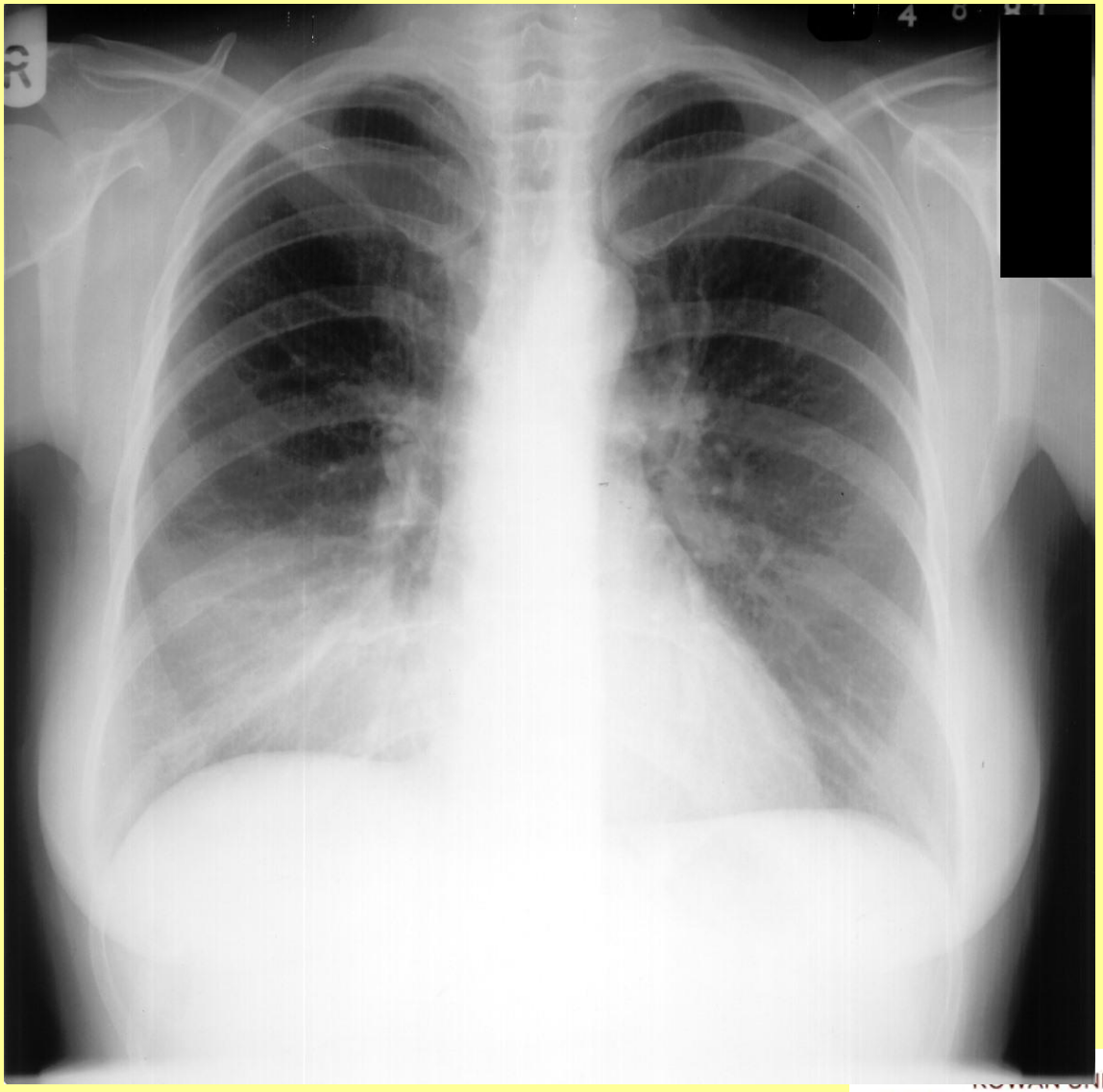
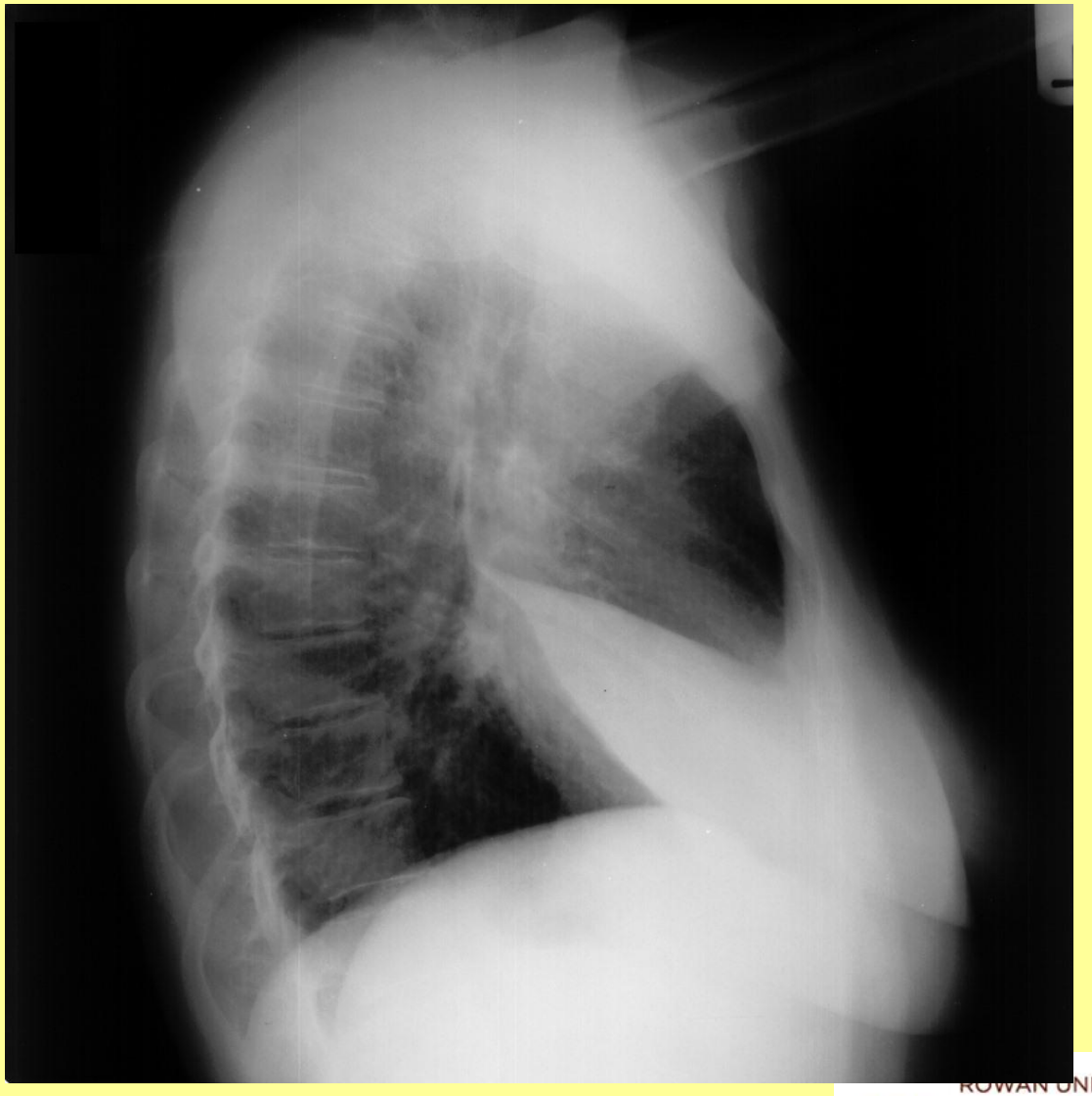
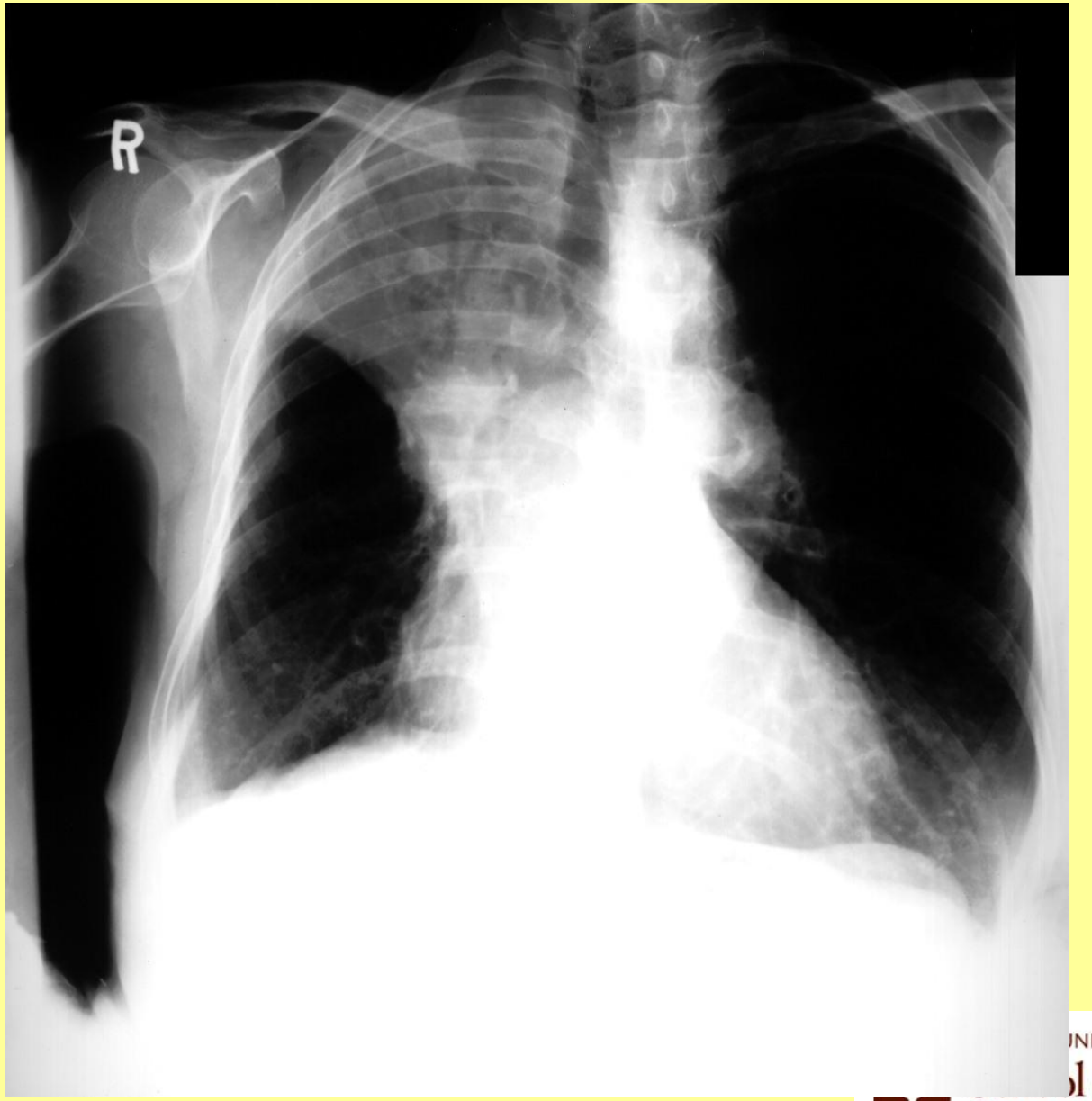
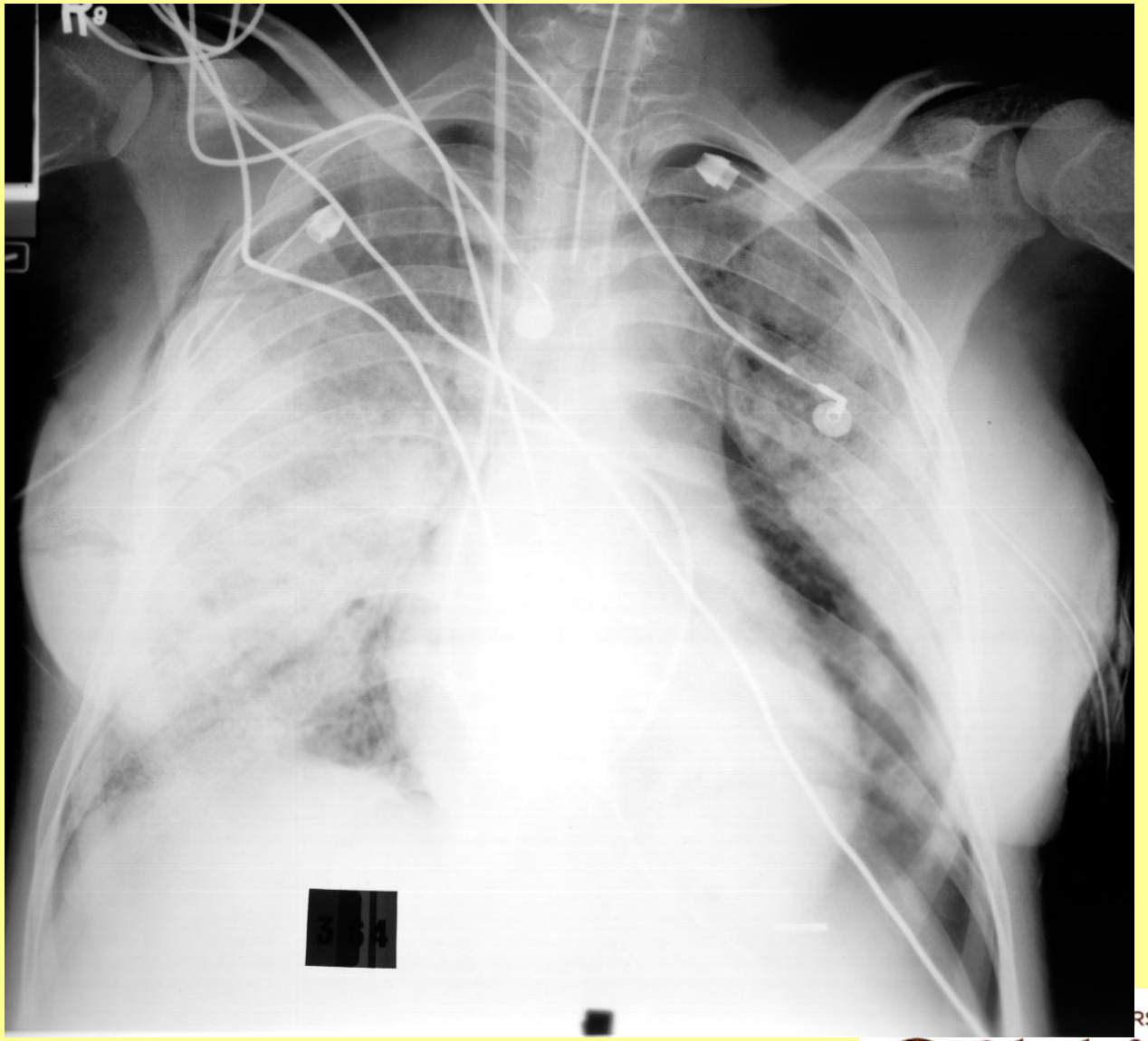
Radiographic Classification of ARF

WHITE LUNG	BLACK LUNG
Pneumonia	Asthma
Pulmonary edema	emphysema
Atelectasis	PE
Interstitial disease	microatelectasis
	R to L Shunt
	Ventilatory failure









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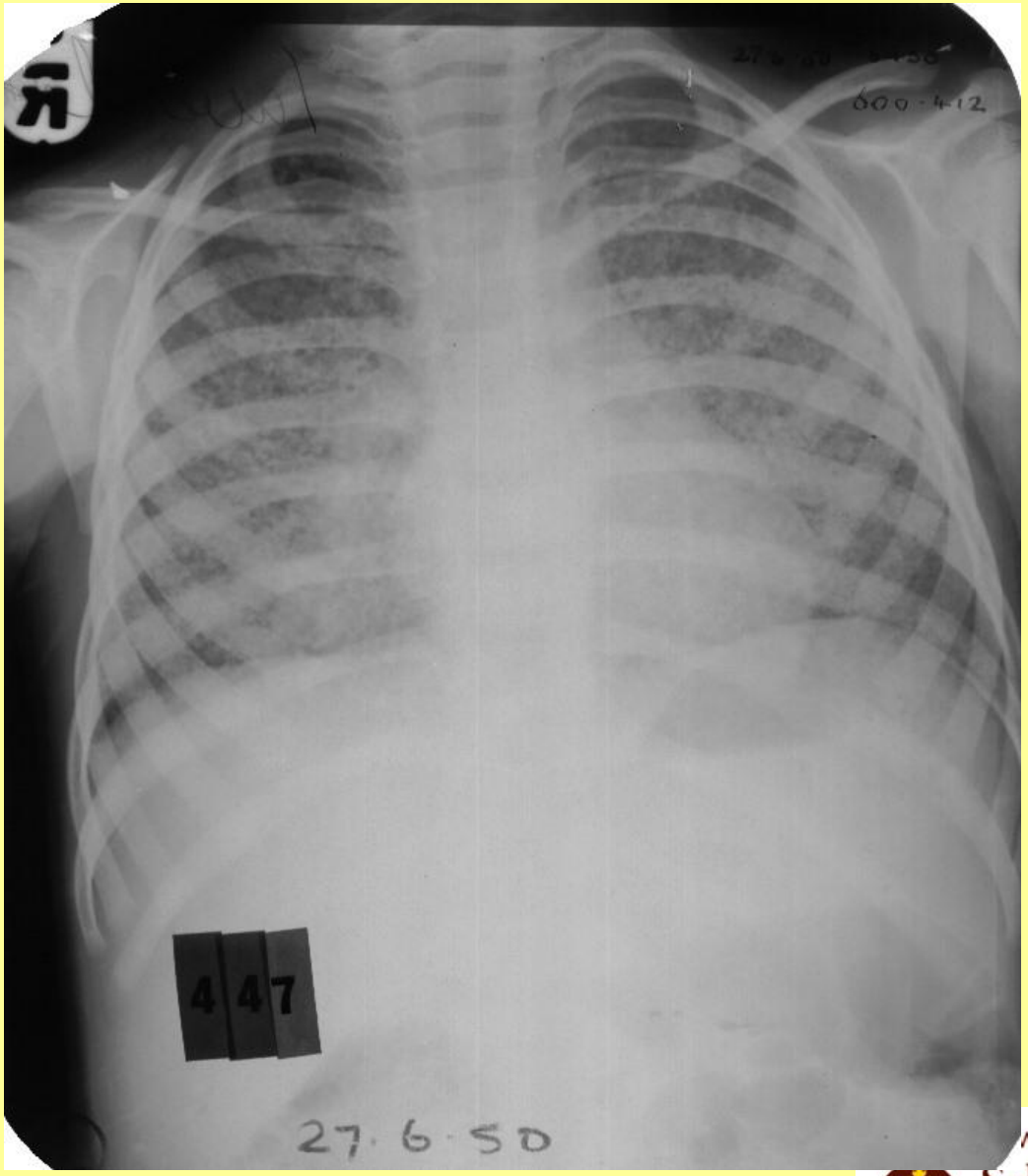
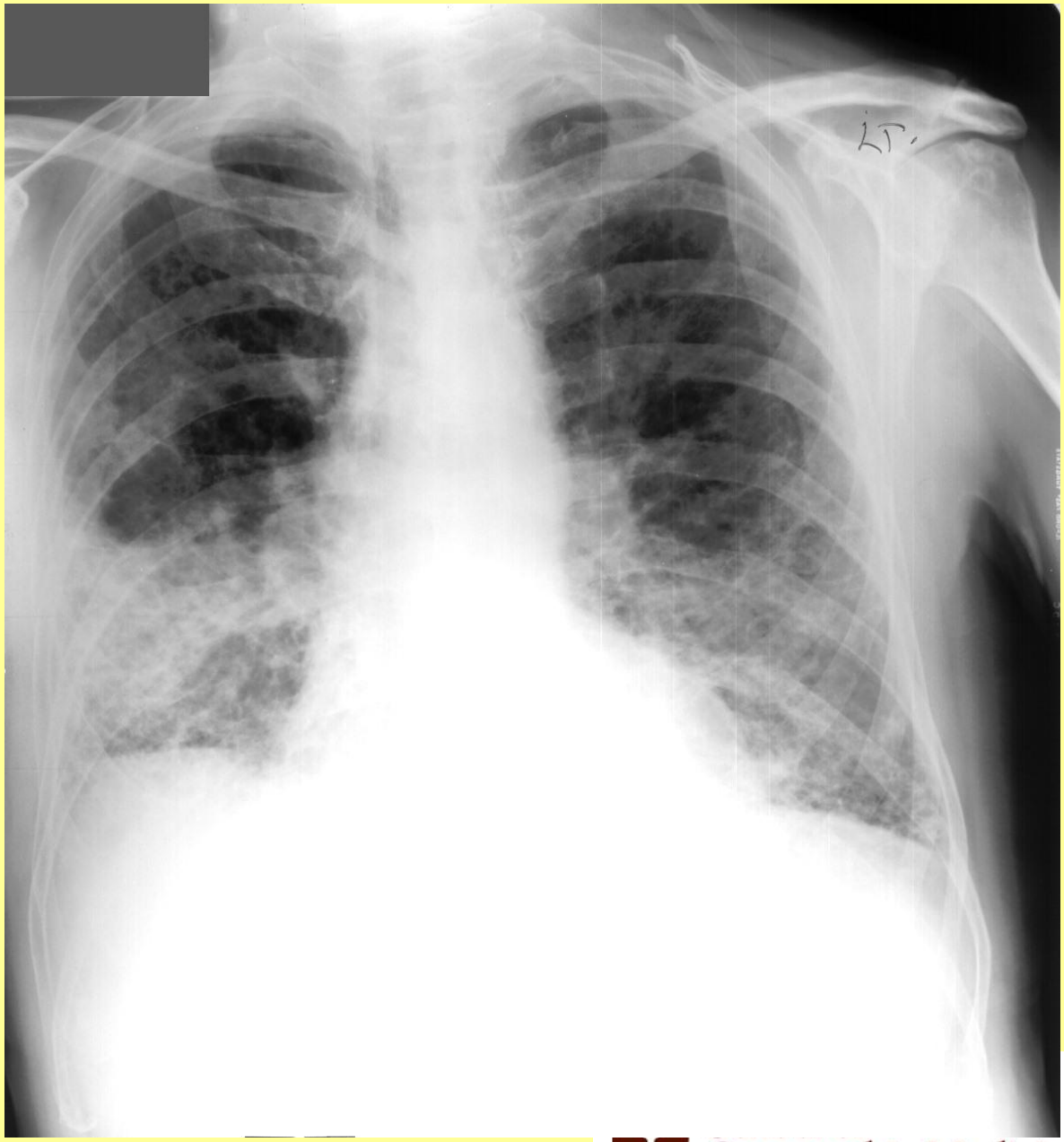


pulmonary fibrosis due to RA



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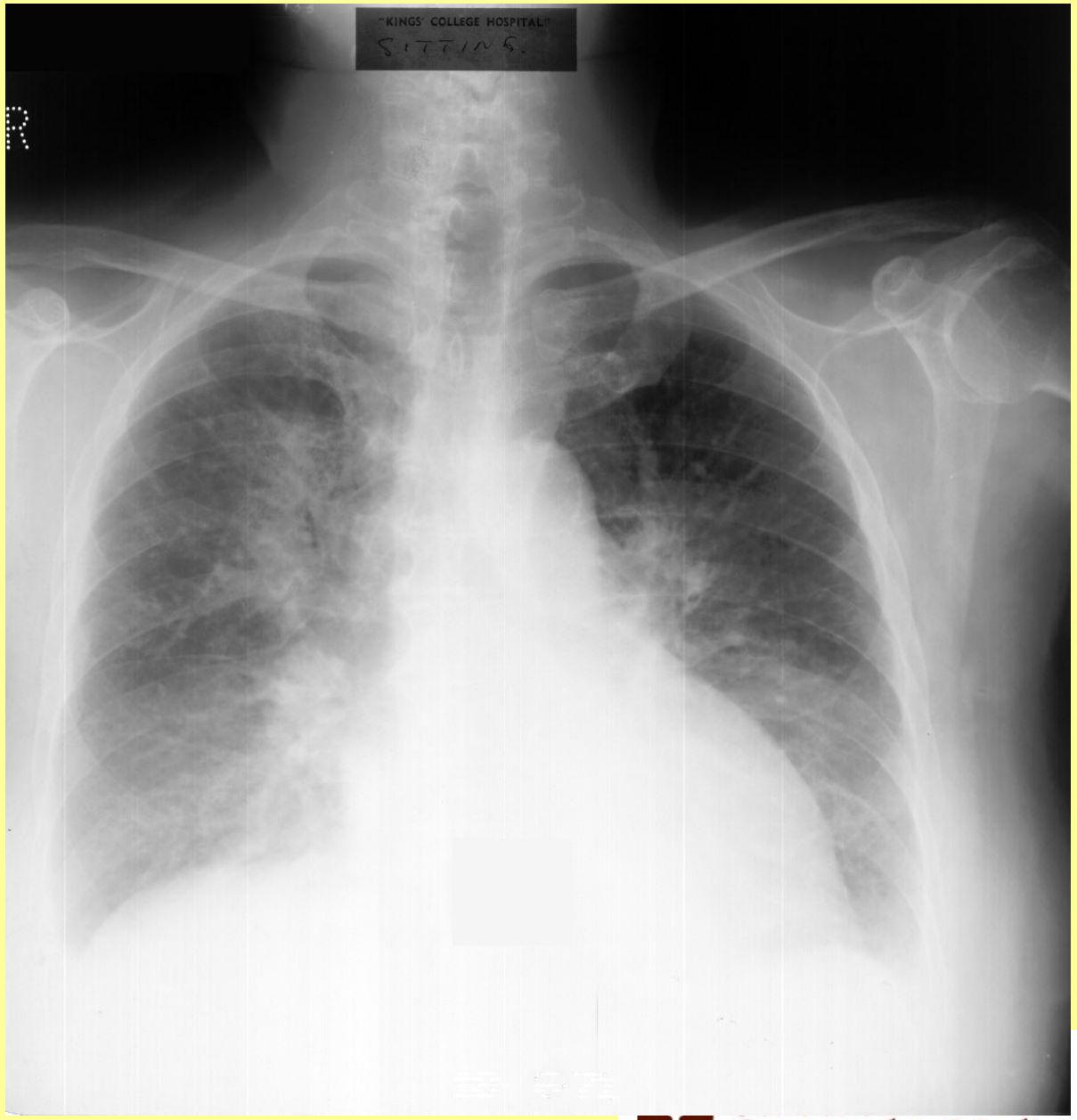
76 yo
Female

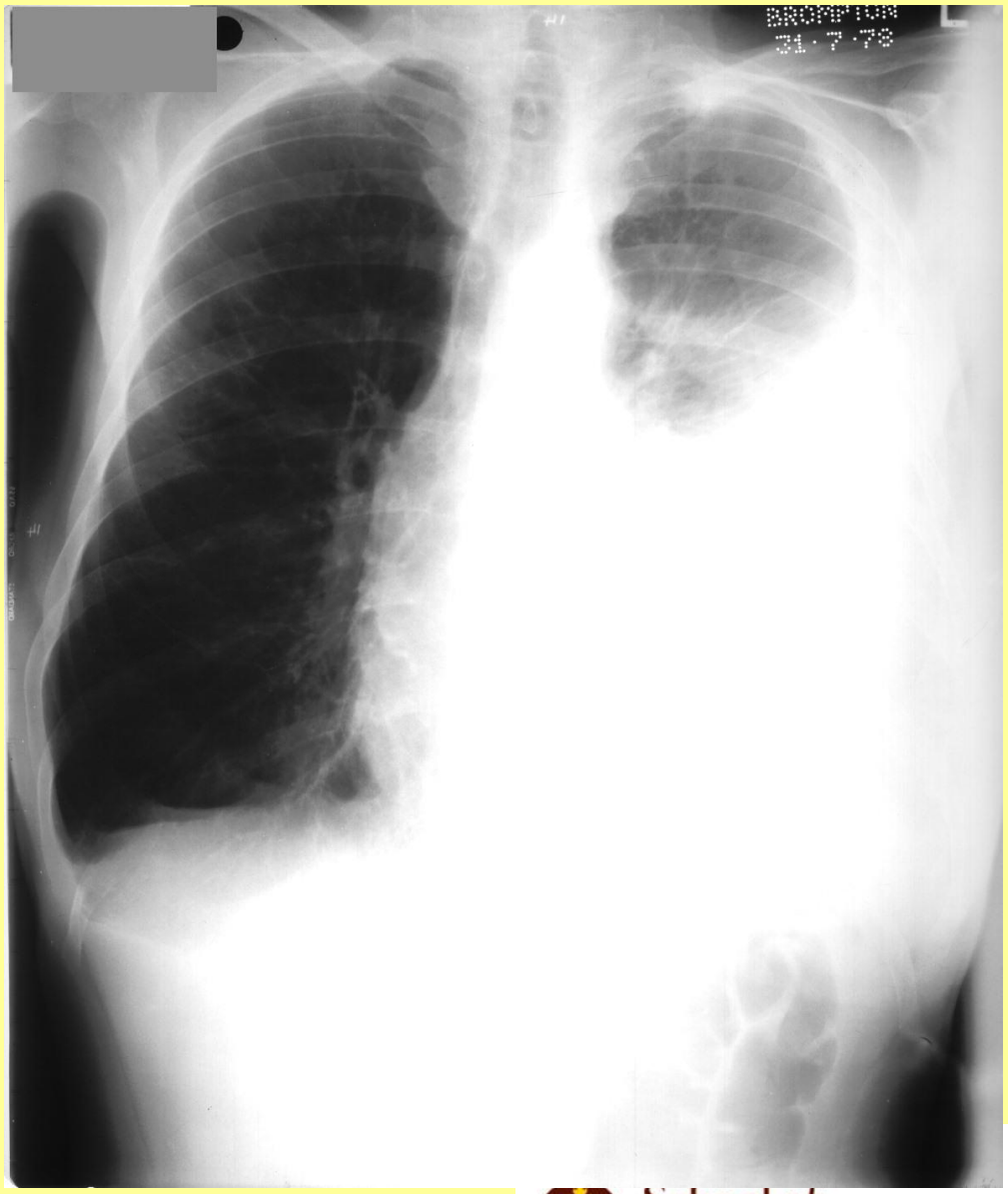
SOB
Edema
Orthopnea



Osteopathic Medicine

Male

SOB



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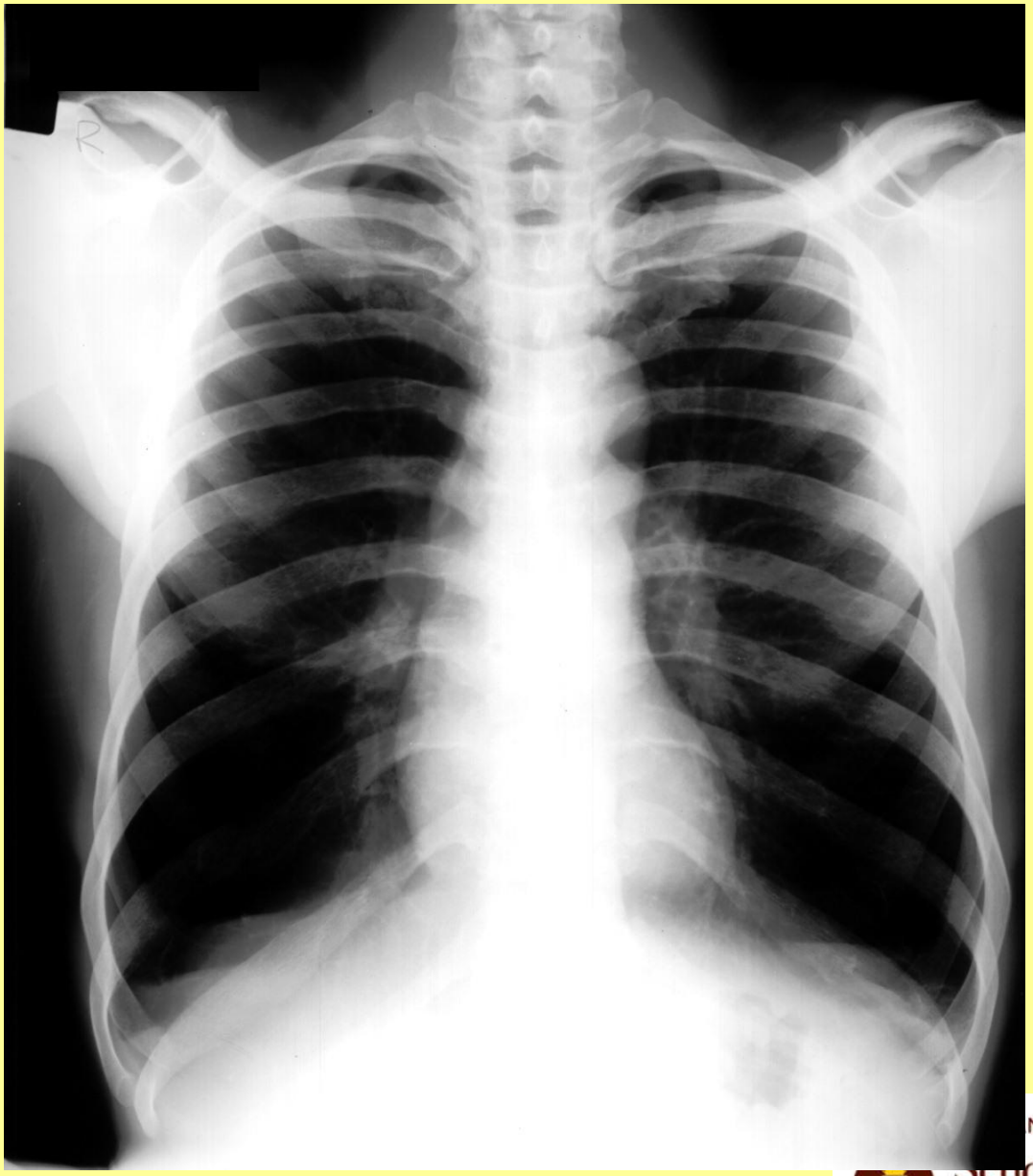
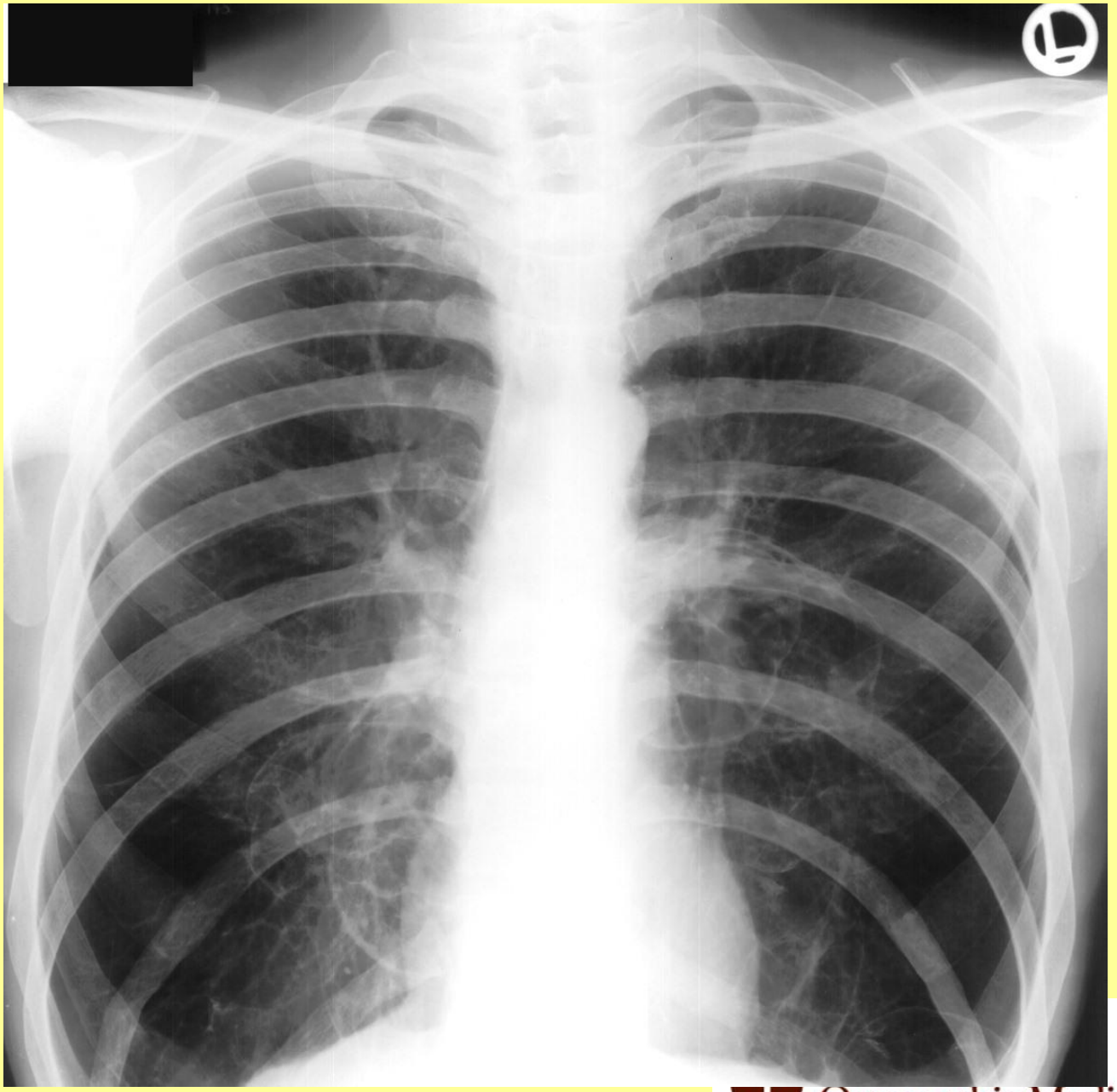


Male 40 yo

Dyspnea



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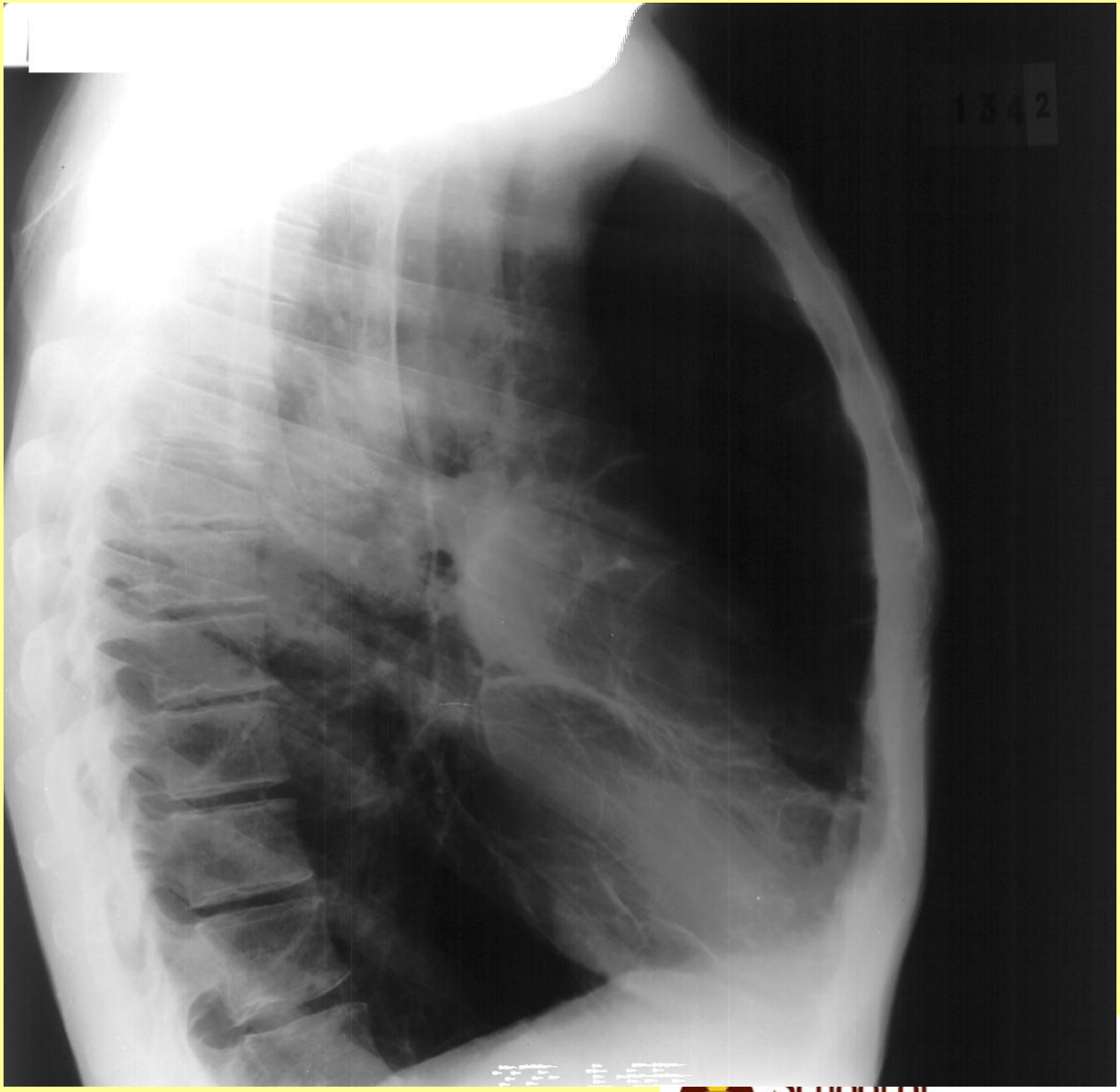
Male 40 yo

Dyspnea



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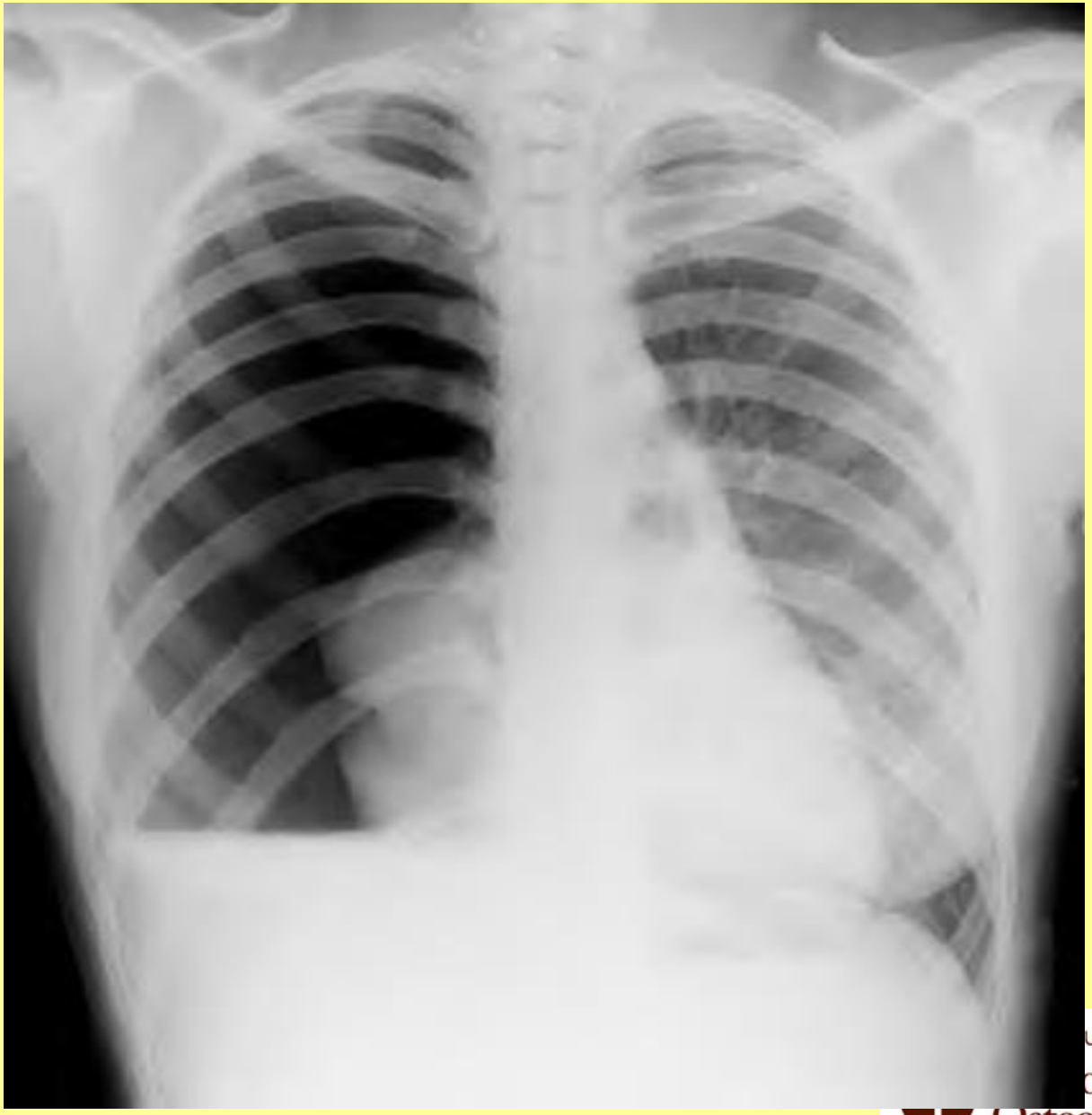

CONDITION	DEFINITION	EXAMPLE	ABNORMALITY
Ventilatory Failure	Abnormal CO2 elimination by lungs	Drug overdose Asthma	$PaCO_2$ > 50 mmHg
Failure of Arterial Oxygenation	Abnormal O_2 uptake by lung	Pneumonia, ARDS	PaO_2 < 50 mm Hg
Failure of Oxygen Delivery	Abnormal O_2 delivery to the tissues	Cardiogenic shock Anemia, CO poisoning	CvO_2< 18 cc/dl PvO_2< 30 mmHg SvO_2< 60 %
Failure of Oxygen Utilization	Failure of O_2 uptake by tissues	Cyanide poisoning septic shock	CvO_2> 18 cc/dl PvO_2> 60 mmHg SvO_2> 80 %

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Objectives of Mechanical Ventilation
Tobin MJ. NEJM 1994; 330:1056-61

- **Improve pulmonary gas exchange**
  - **Reverse hypoxemia**
  - **Relieve acute respiratory acidosis**
- **Relieve respiratory distress**
  - **Decrease the O2 cost of breathing**
  - **Reverse respiratory muscle fatigue**
- **Alter pressure-volume relations**
  - **Prevent/reverse atelectasis**
  - **Improve compliance**
  - **Prevent further lung injury**
- **Permit lung and airway healing**
- **Avoid complications**

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Treatment of ARF
Noninvasive Methods

CPAP

Pressure applied during entire respiratory cycle
Does NOT AUGMENT TIDAL VOLUME
Splint open the upper airway
Recruit collapsed alveoli

BiPAP

* Different pressure during Ins and Exp
I-PAP can AUGMENT tidal Volume
E-PAP can prevent airway closure and recruit collapsed alveoli

USEFUL FOR CHF, COPD, - May prevent need for INTUBATION

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Barotrauma

- Until recently it was believed that alveolar rupture was due to excessive proximal airway pressure

- If peak airway pressure exceeded 50 cm H_2O then the patient was considered to be at high risk for alveolar rupture.

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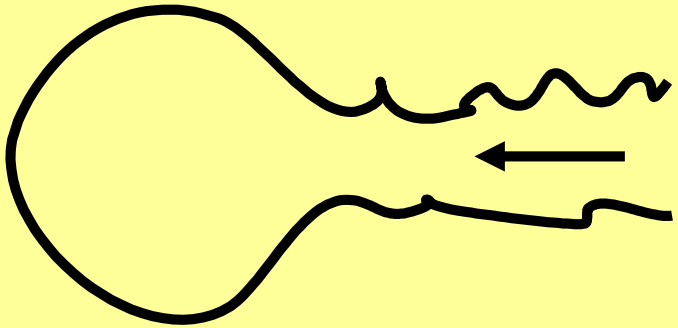
Barotrauma

- **If inspiratory resistance is HIGH DISTAL ALVEOLAR PRESSURE may be LOWER than PEAK AIRWAY PRESSURE !**

Alveolar Pres = 20 cm H20



PAP = 50 cm H2O

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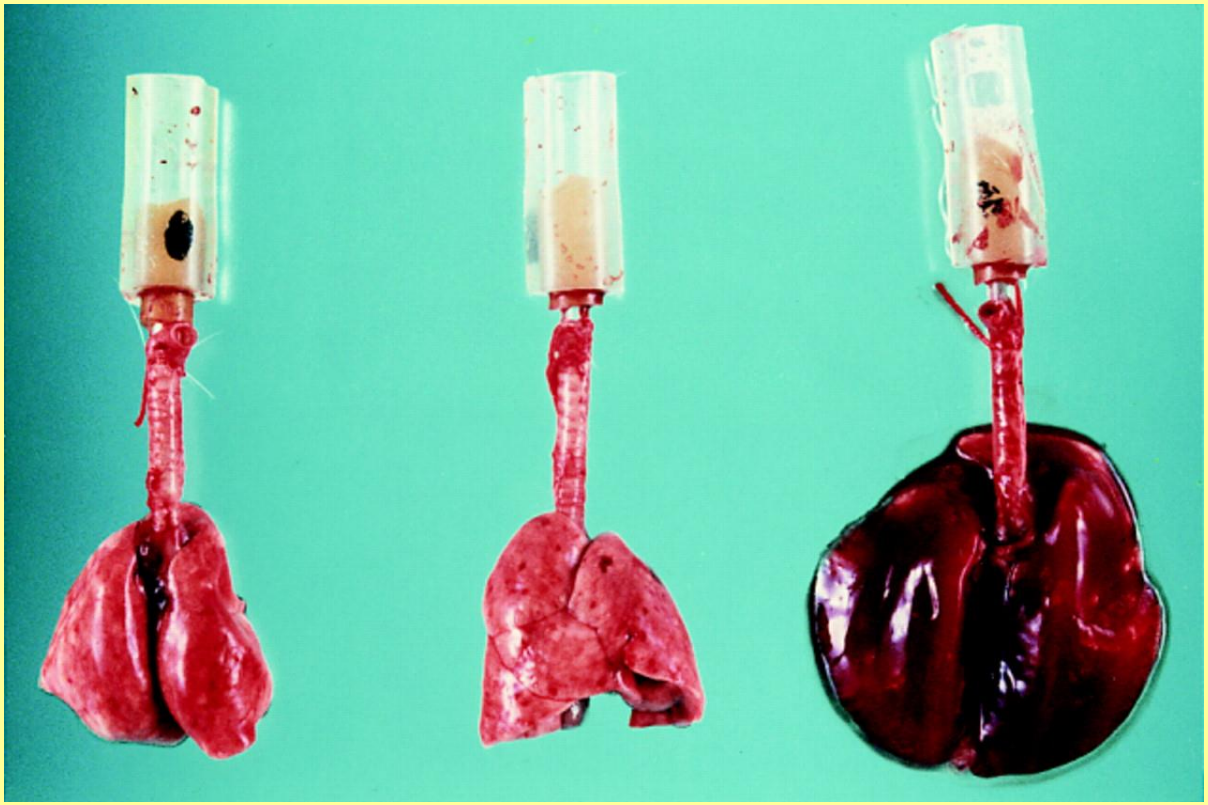
Ventilator-induced Lung Injury

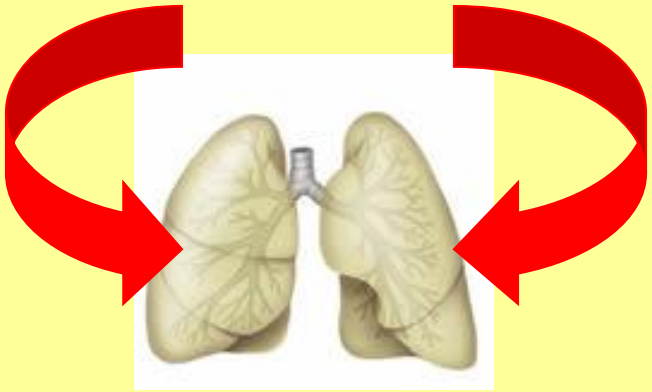
Dreyfuss D, Saumon G. Ventilator induced lung injury: lessons from experimental studies. Am J Respir Crit Care Med 1998;157:294-323.
Mead J, Takishima



- **Macroscopic aspect of rat lungs after mechanical ventilation at 45 cm H2O peak airway pressure. *Left*: normal lungs; *middle*: after 5 min of high airway pressure mechanical ventilation. Note the focal zones of atelectasis (in particular at the left lung apex); *right*: after 20 min, the lungs were markedly enlarged and congestive; edema fluid fills the tracheal cannula.**

Animal Experiment – Same pressure is applied to both animal lungs

Banded lungs



Un-Banded lungs

VOLUTRAUMA

- Recent studies in animals with normal and diseased lungs suggest that it is alveolar ***OVERDISTENTION*** and ***NOT EXCESSIVE PRESSURE*** which leads to alveolar rupture.
- VOLUME NOT PRESSURE Causes alveolar rupture

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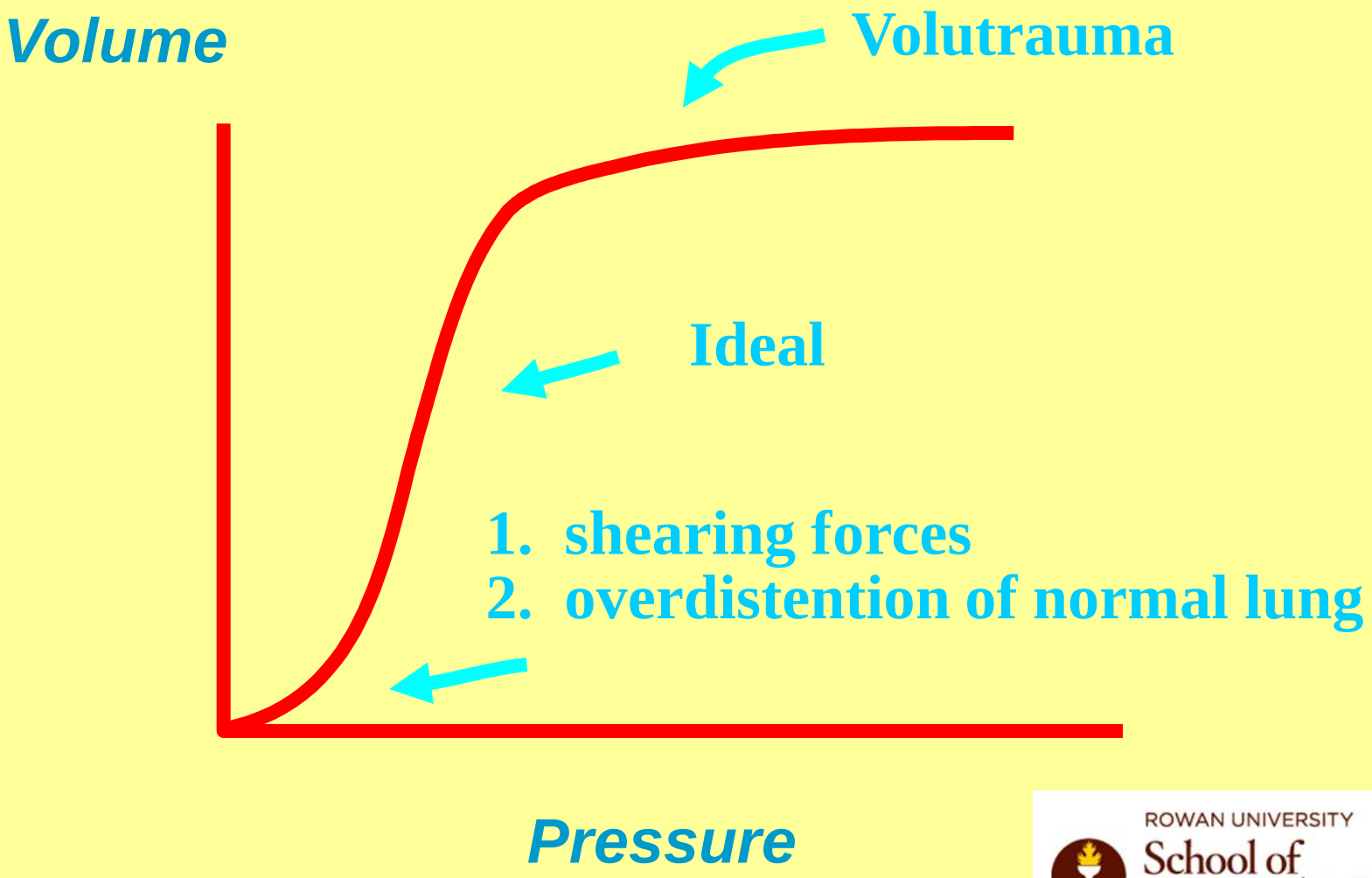
VOLUTRAUMA

What volume do we want ?



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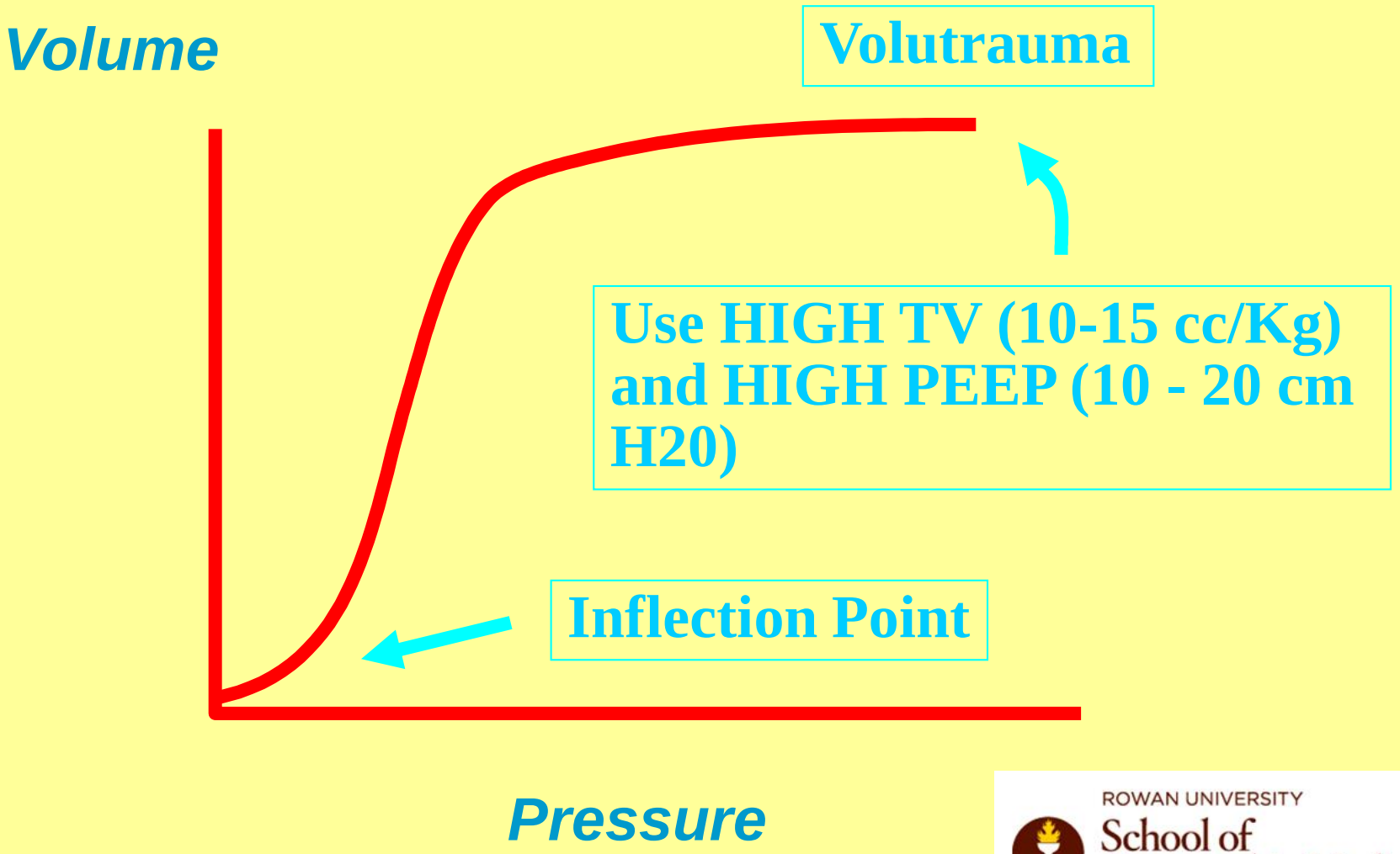
Classic Approach to MV
in Acute Lung Injury



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How do we measure Plateau Pressure

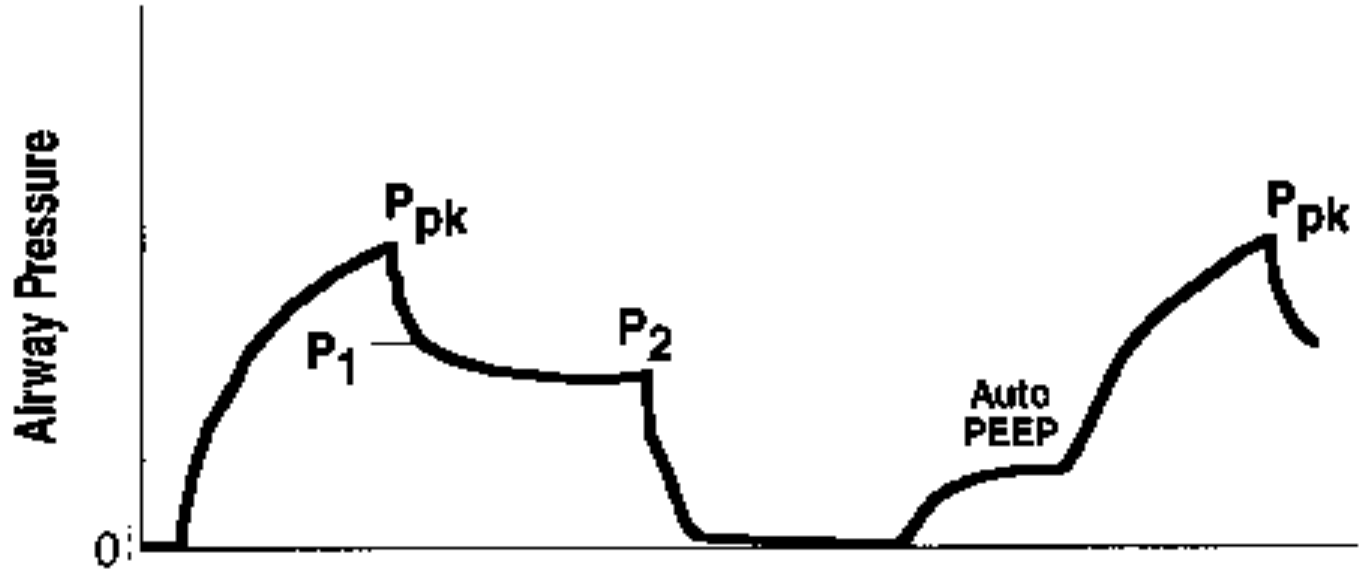

Figure 1. Proximal airway pressure recording during an end-inspiratory airway occlusion and during an end-expiratory occlusion.

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How should we approach MV in ARDS TODAY ?

- **TV smaller (5 cc/Kg) ideal body weight**
- **PEEP (above inflection point)**
- **Keep plateau pressure < 30 cm H20**
- **THIS MAY RESULT IN HYPERCAPNIA !**

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AutoPEEP

Definition

- AutoPEEP is a pressure gradient between the alveoli and the central airways due to INSUFFICIENT EXPIRATORY TIME.
- Unlike applied PEEP which is deliberately set, AUTO-PEEP is inadvertent.

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AutoPEEP

Incidence

- Reported in 47 % of patients in medical ICU's (Wright. Heart and Lung 1990; 19:352-357)
- Occurs in 100 % of MV patients with Ve above 20 L/min (Brown. Respir Care 1986; 31:1069-74)

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AutoPEEP (AP)

Causes

Type of AP	Causes
AP with Hyperinflation and Airway obstruction	Dynamic airway closure
AP with Hyperinflation and NO Airway obstruction	High Ve vent circuitry, valves or filters which delay exhalation
AP with NO Hyperinflation and NO Airway obstruction	Forced exhalation

AutoPEEP
Methods for Detection

- Use of Flow Waveform (qualitative)
- Esophageal Balloon or inductive waveforms
- Block exhalation and allow alveolar and central pressures to equilibrate equilibrate (Total PEEP)

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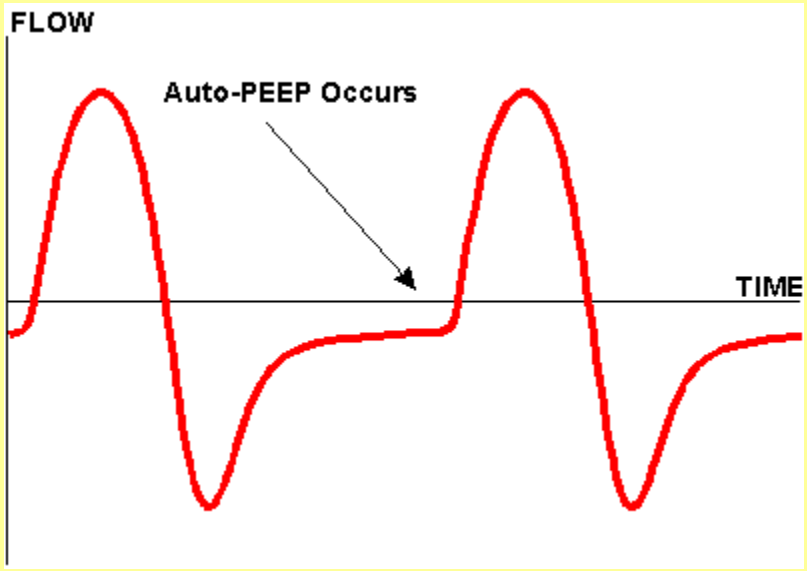
Auto PEEP detection



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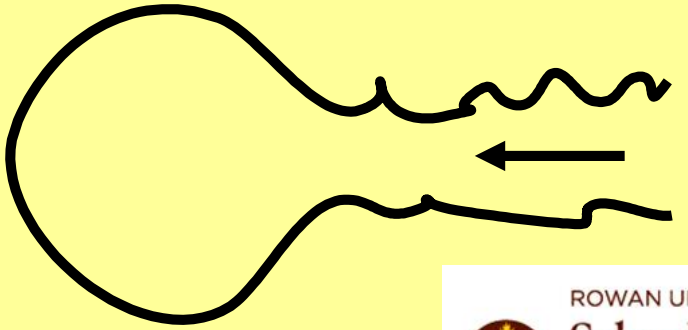
AutoPEEP

- AutoPEEP can be measured by blocking the airway at the END OF EXHALATION
- This allows the distal alveolar pressure to equilibrate with the Proximal airway pressure



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How do we measure AutoPEEP

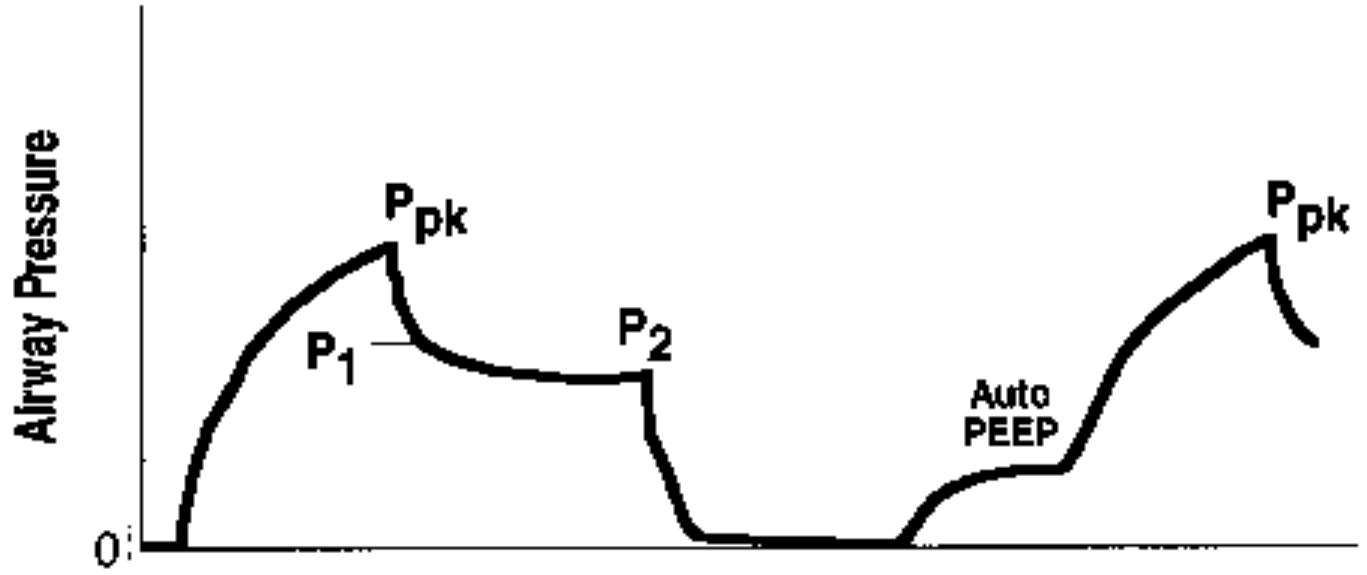

Figure 1. Proximal airway pressure recording during an end-inspiratory airway occlusion and during an end-expiratory occlusion.

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AutoPEEP

Adverse Effects

Effect	*Mechanism*	*Treatment*
"Routine"	*↑ PVR, ↓CO* *↑ Vd/Vt*	*Decrease RR* *Increase Vt/Ti* *Decrease Vt*
Triggering	*Patient has to create a - pressure greater than AP to trigger a MV breath*	*Extrinsic PEEP to = AP*

AutoPEEP
Methods to Reduce

Increase Expiratory Time	*Decrease Minute Ventilation*	*Decrease Expiratory Resistance*
Increase peak flow	*Decrease Rate*	*Medications*
Square Wave	*Decrease Tidal Volume*	*Remove kinks, secretions, casts*
		Larger ET tube
		Change filters

"New Berlin definition" ARDS

- **Predicted mortality is slightly better than the existing definition (created at the 1994 American-European Consensus Conference/AECC), when applied to a cohort of 4,400 patients from past randomized trials.**

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New ARDS Definition

ARDS Severity	PaO2/FiO2*	Mortality**
Mild	**200 – 300**	**27%**
Moderate	**100 – 200**	**32%**
Severe	**< 100**	**45%**
***on PEEP 5+; **observed in cohort**		

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"Berlin definition"

- **Onset of ARDS (diagnosis) must be acute, as defined as within 7 days**
- **Bilateral opacities may be detected on CT or chest X-ray**
- **"not fully explained by cardiac failure or fluid overload"**
- **JAMA online May 21, 2012.**

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Pulmonary Function Tests

1. Spirometry
2. Determination of Reversibility
3. Lung Volume
4. Bronchial Hyperreactivity (Methacholine Challenge)
5. Diffusing Capacity for CO
6. Exercise

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Pulmonary Function Tests

WHY ?

1. To determine if lung disease is present
2. To screen for subclinical disease
3. To determine severity of known disease
4. To determine reversibility
5. To follow disease course
6. Pre-operative evaluation

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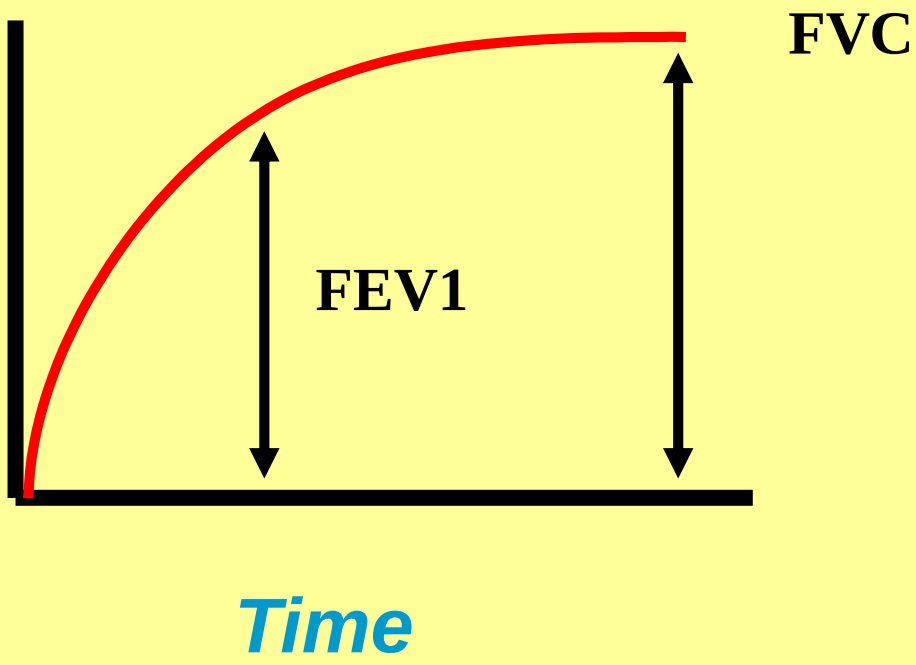
Volume/Time Curves

Definitions



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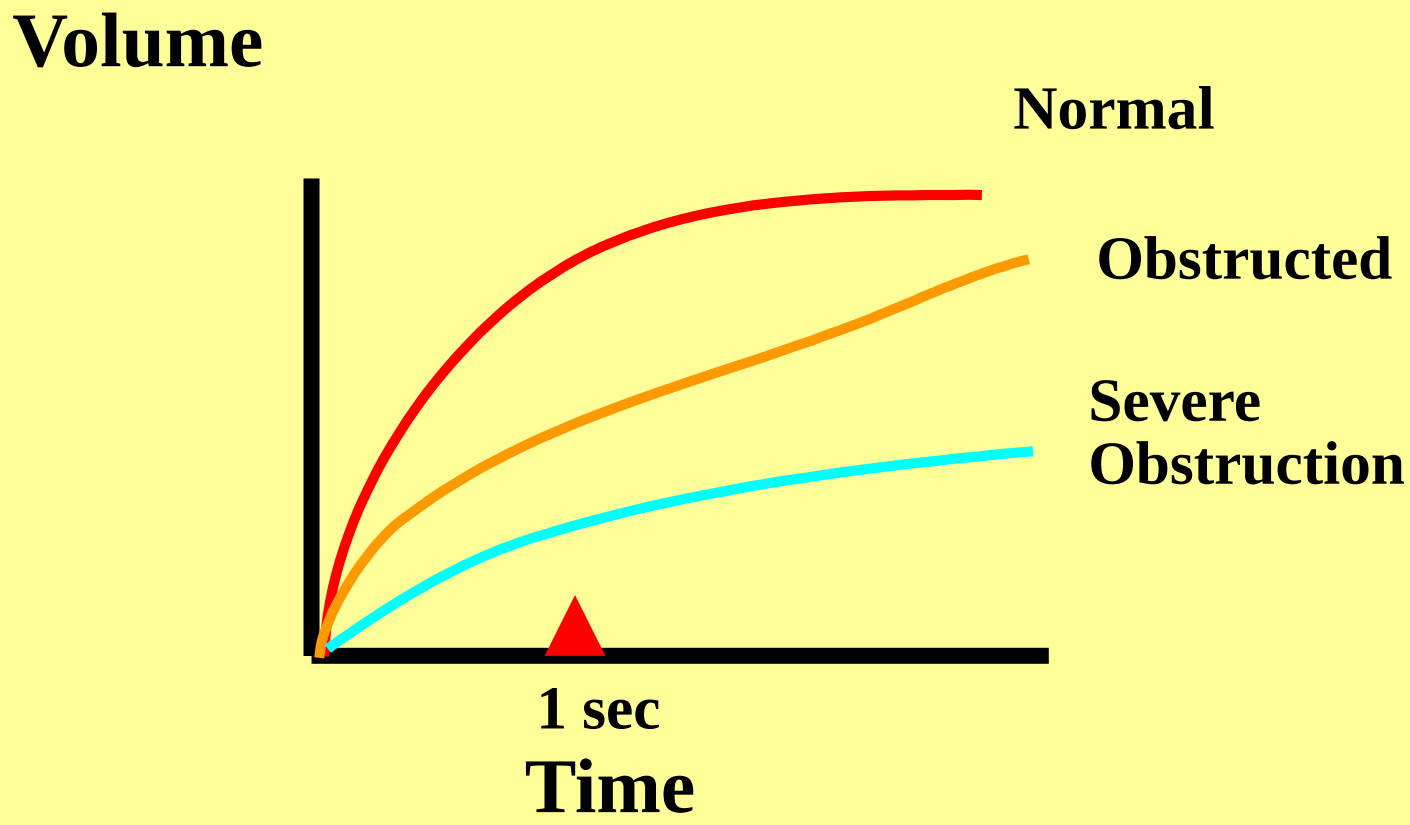
Volume/Time Curves

Obstruction



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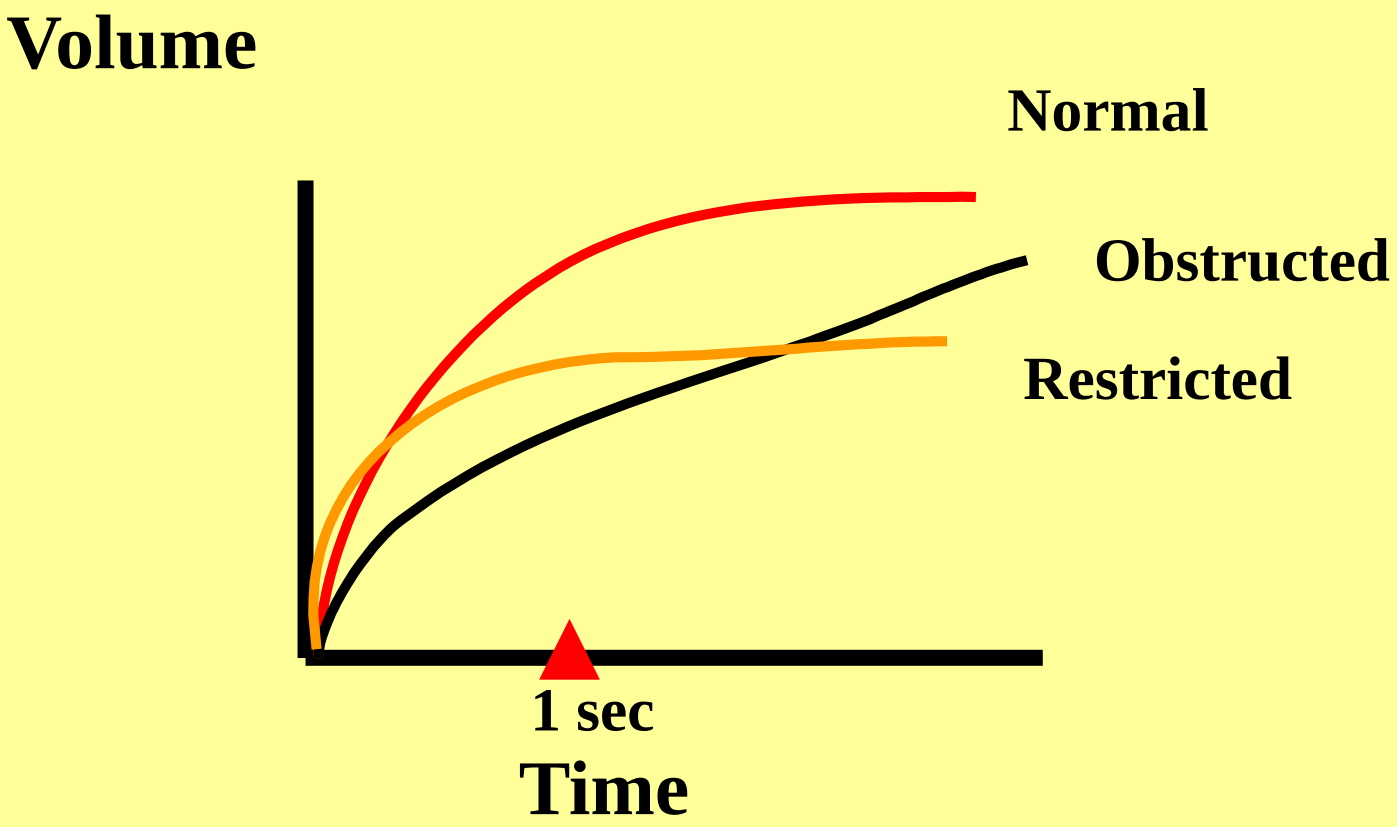
Volume/Time Curves

Obstruction versus Restriction



FEV1 can be reduced by Obst or Rest disease

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Differentiation of Obstruction from Restriction

VARIABLE	*RESTRICTION*	*OBSTRUCTION*
FVC	*Reduced*	*N or Reduced*
FEV1	*Reduced*	*Reduced*
FEV1/FVC	*Normal*	*Reduced*
TLC/RV/FRC	*Reduced*	*N or Increased*

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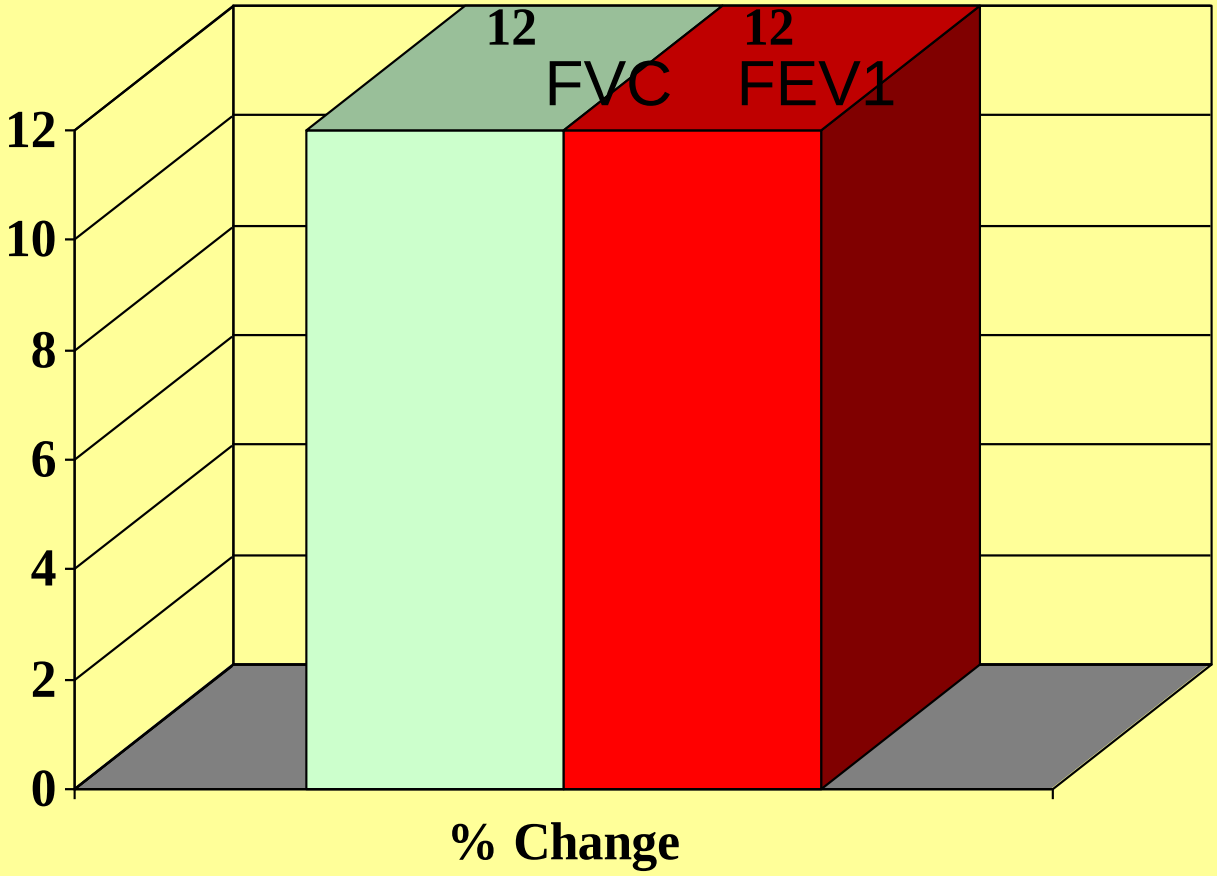
Response to Bronchodilator



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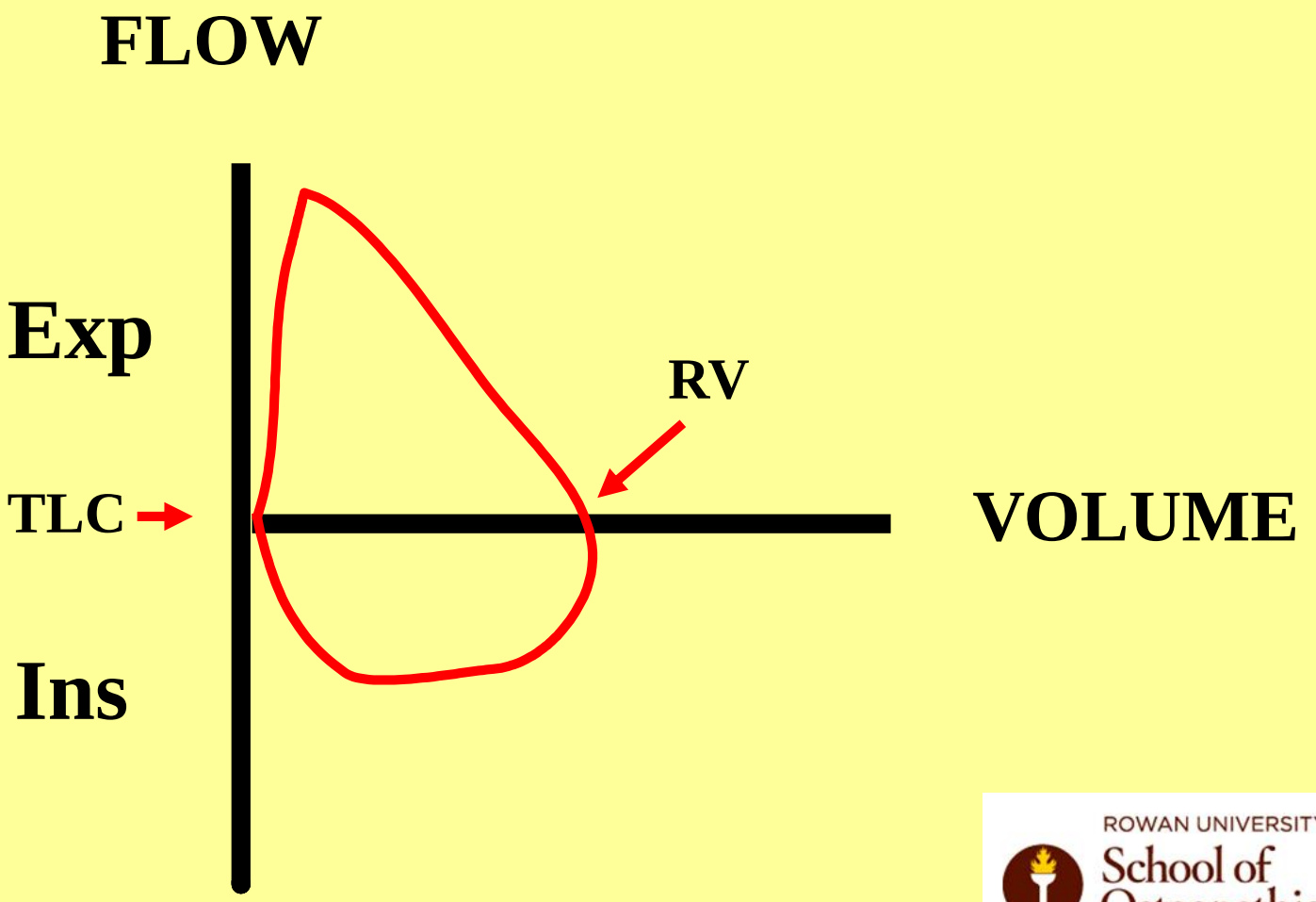
Flow-Volume Curve

Definitions



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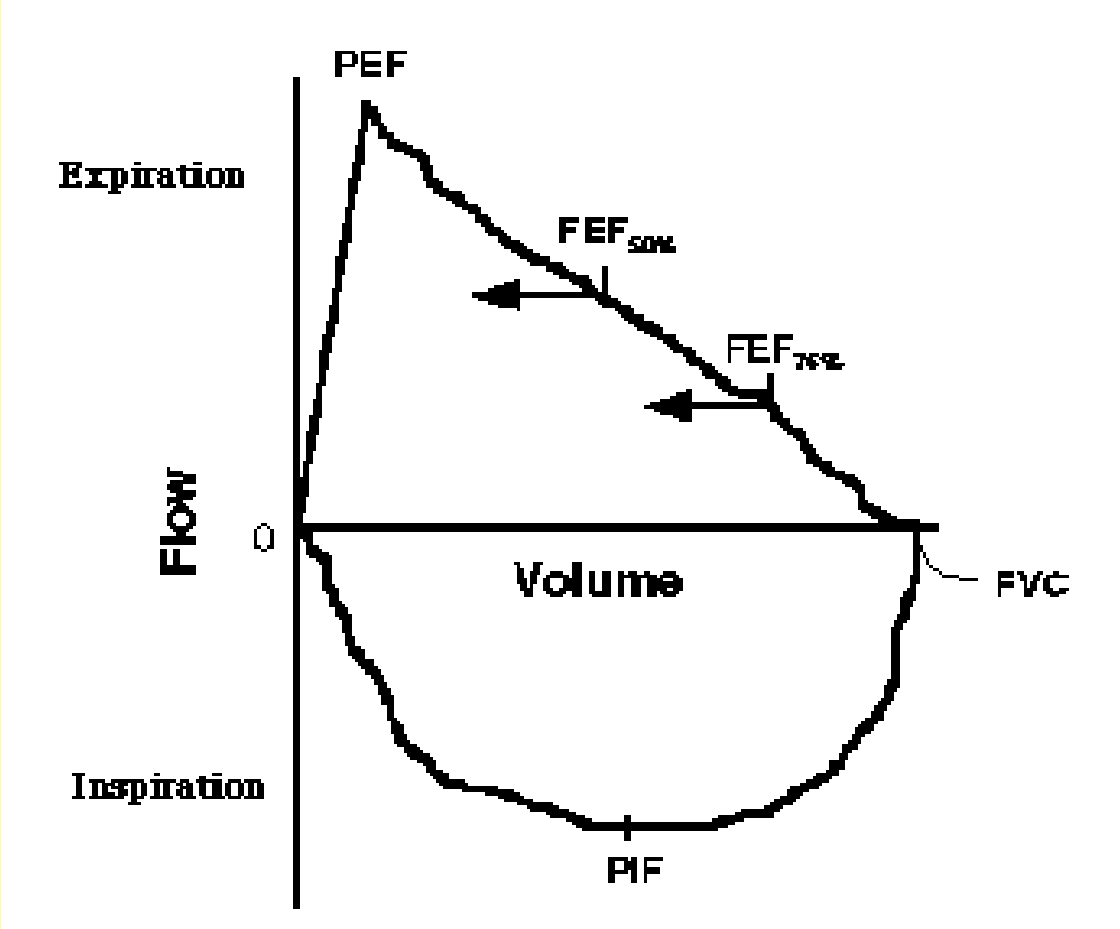
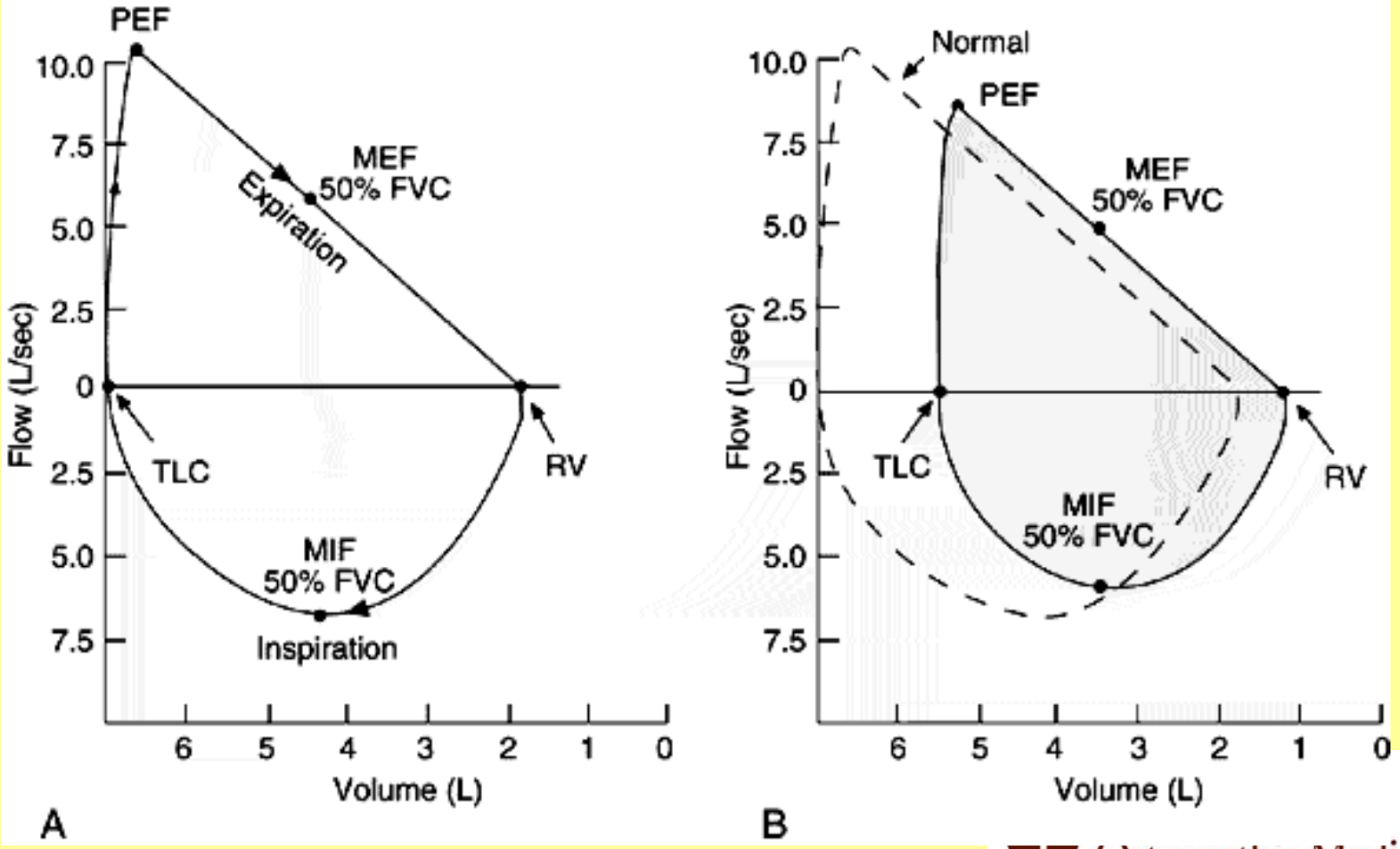
Flow-Volume Loop



Normal and Restrictive FVL



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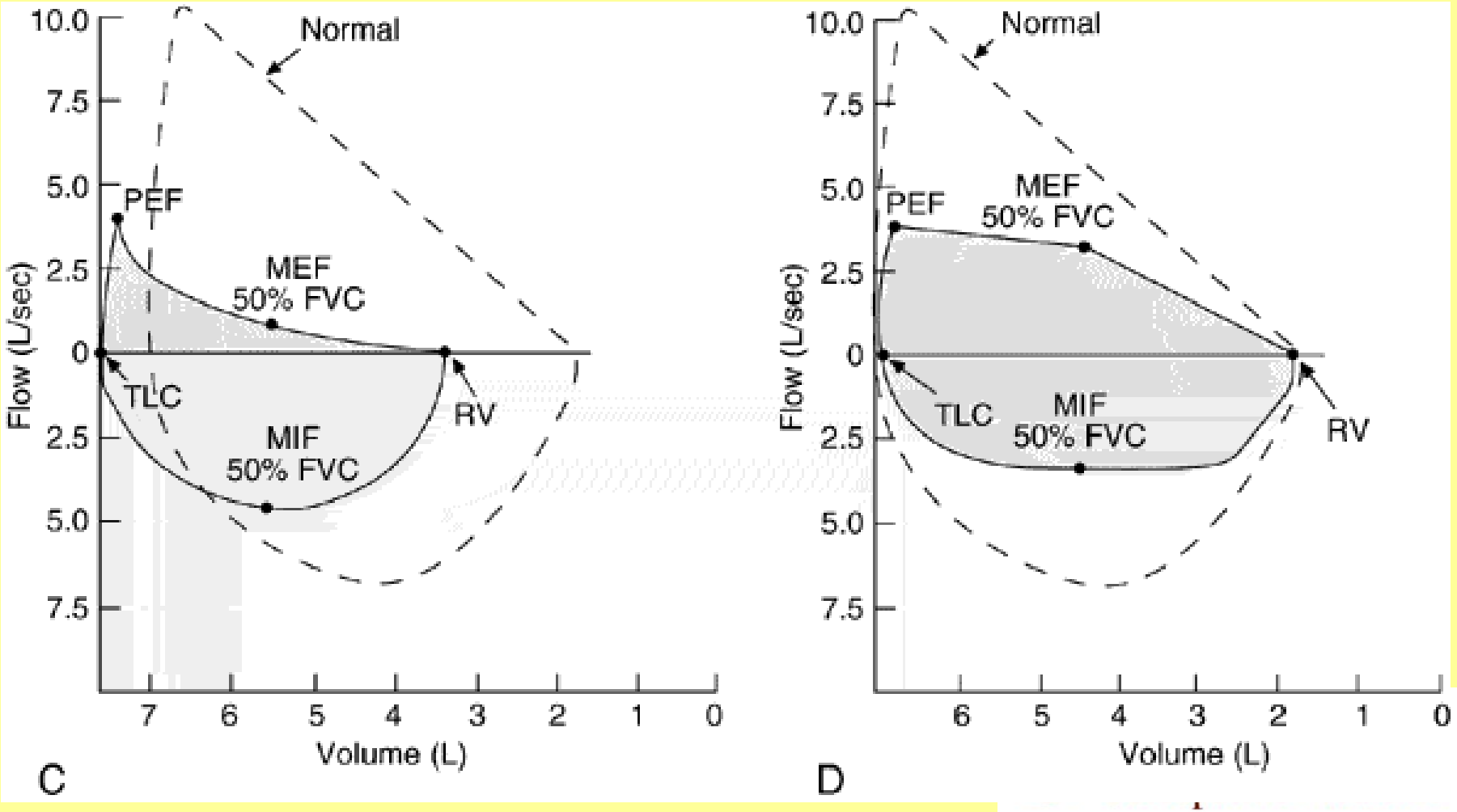
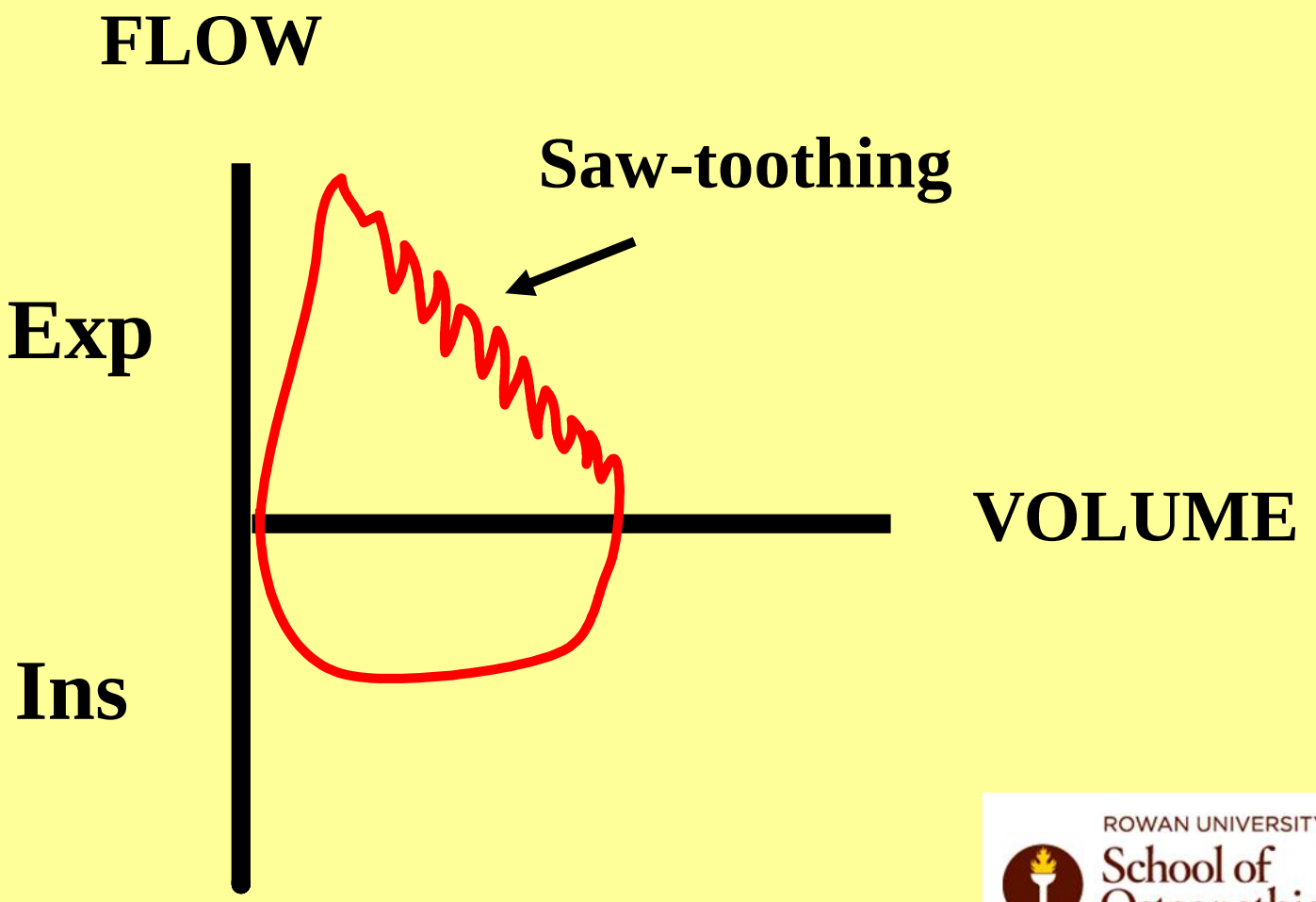
Obstructive FVL



Flow-Volume Curve

Sleep Apnea/ OHS



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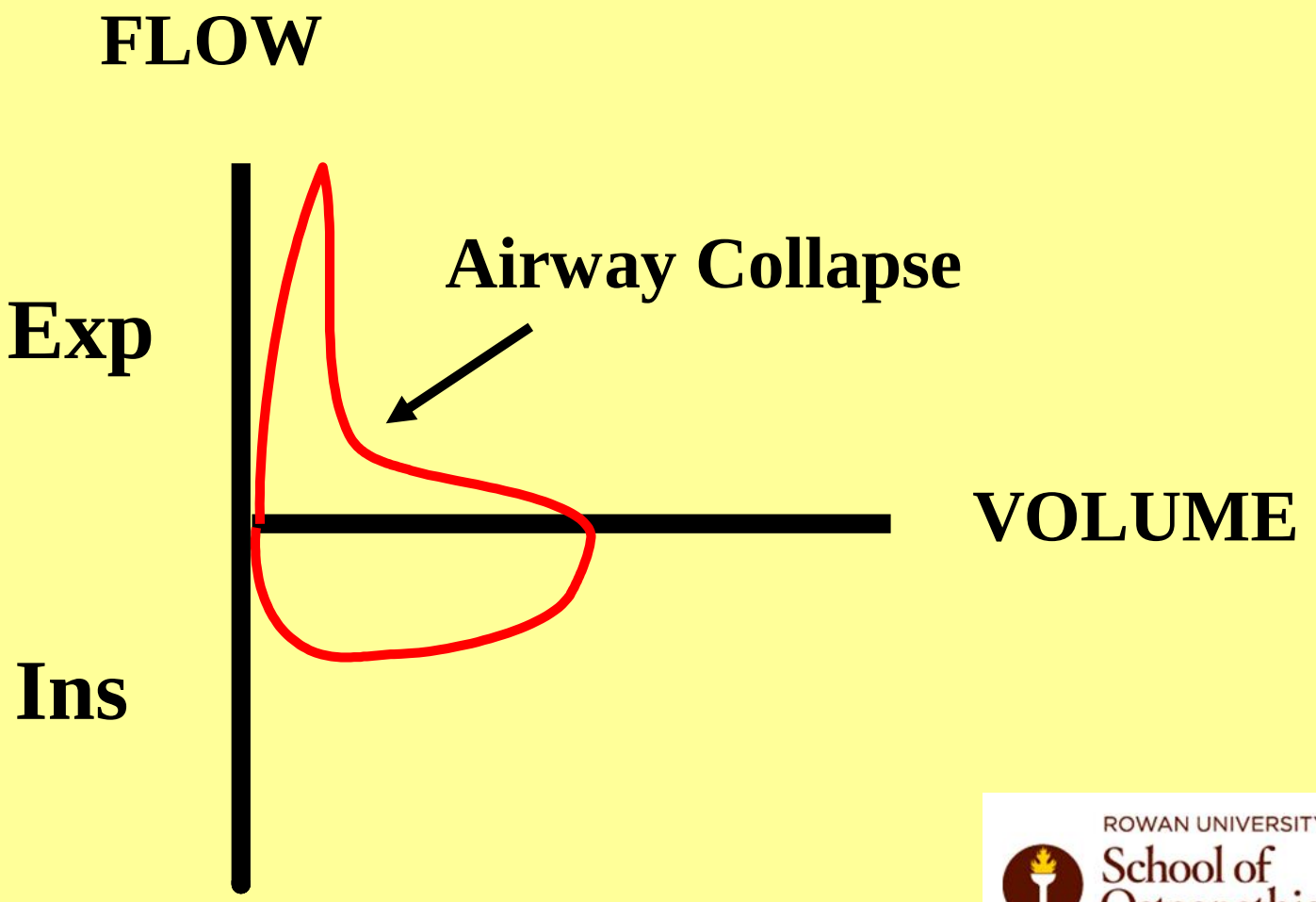
Flow-Volume Curve

Severe Airway Obstruction



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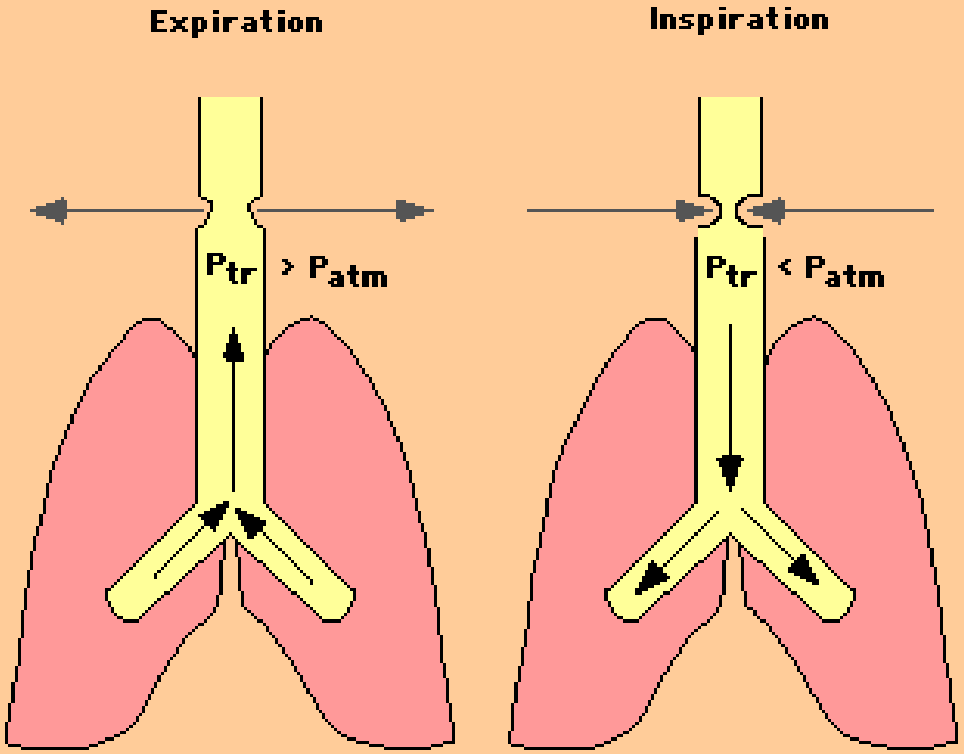
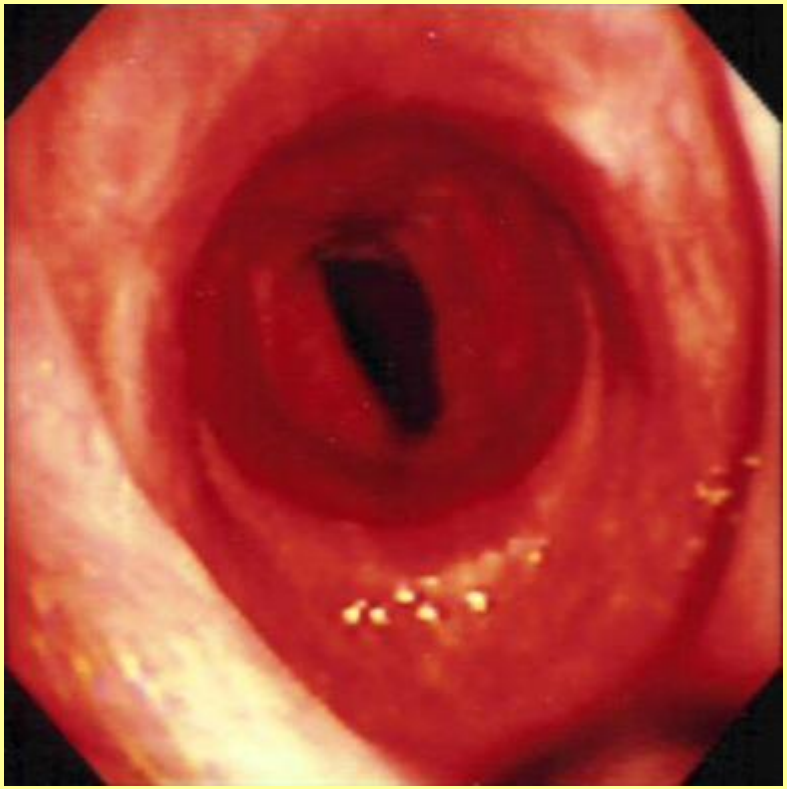
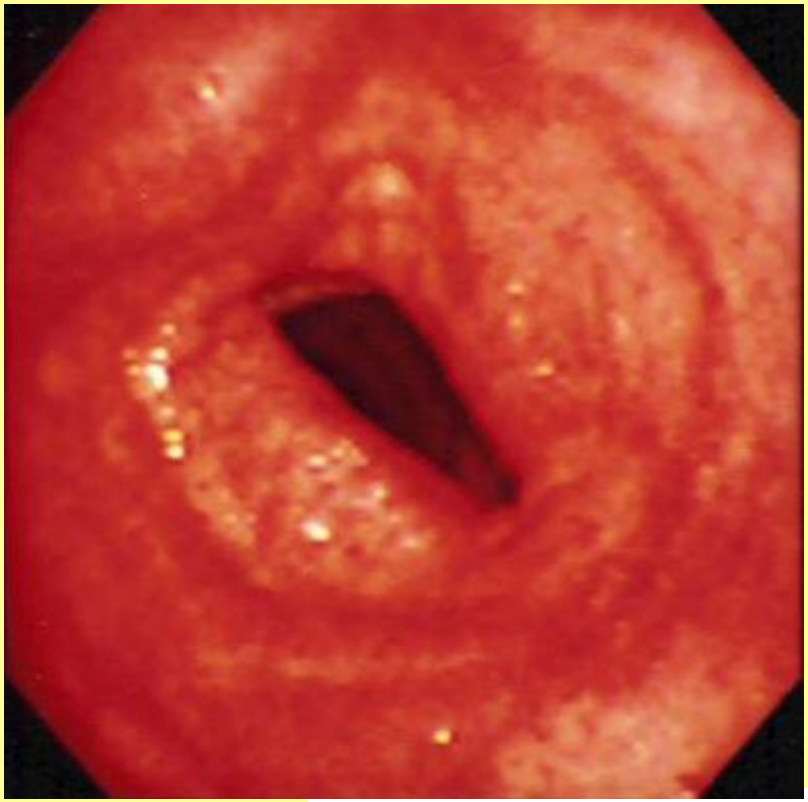


Effect of dynamic extrathoracic airway obstruction Effects of forced expiration and inspiration in dynamic extrathoracic airway obstruction. Left, during forced expiration, intratracheal pressure (Ptr) exceeds the pressure around the airway (Patm), lessening the obstruction. Right, during forced inspiration, when intratracheal pressure falls below the atmospheric pressure, the obstruction worsens resulting in flow limitation. (Redrawn from Kryger, M, Bode, F, Antic, R, et al, Am J Med 1976; 61:85.)

Subglottic Stenosis





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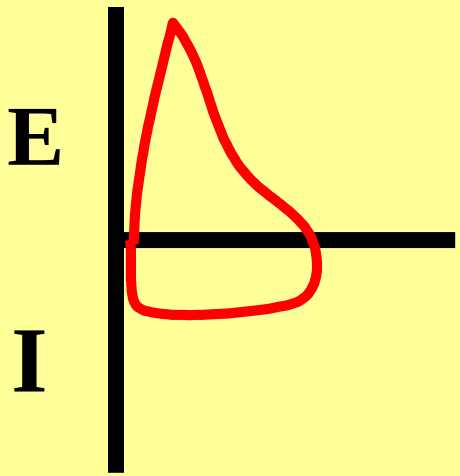
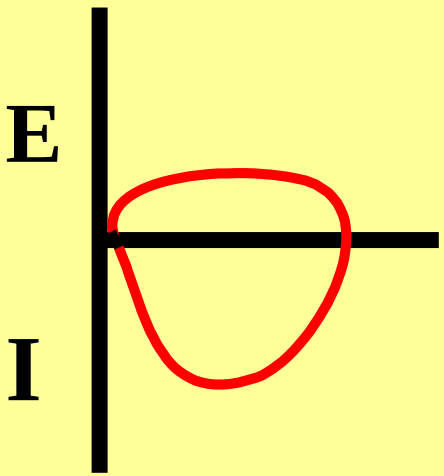
Intra and Extra Thoracic Obstructions

VARIABLE



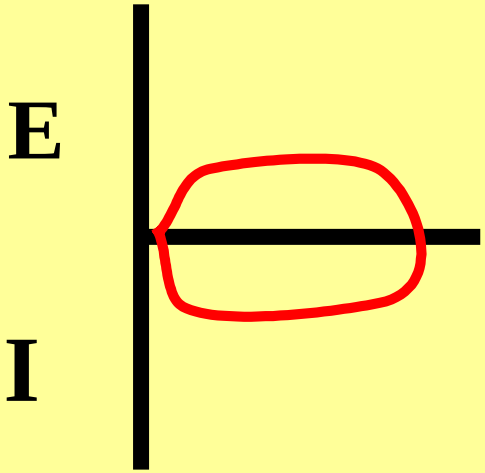
Extrathoracic

VARIABLE



Intrathoracic

FIXED



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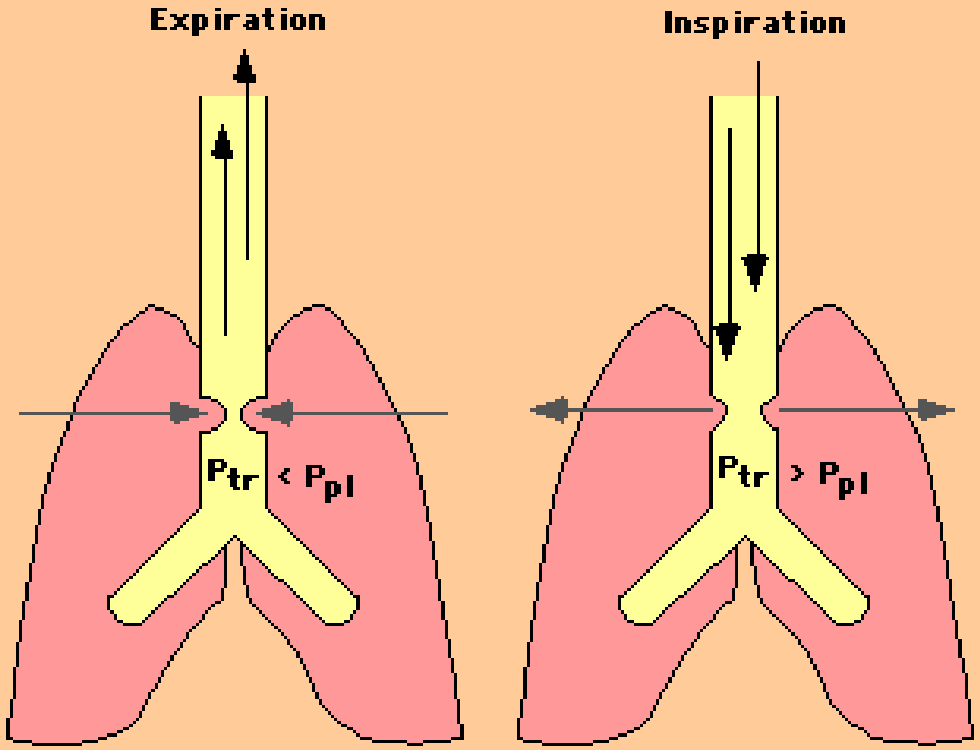
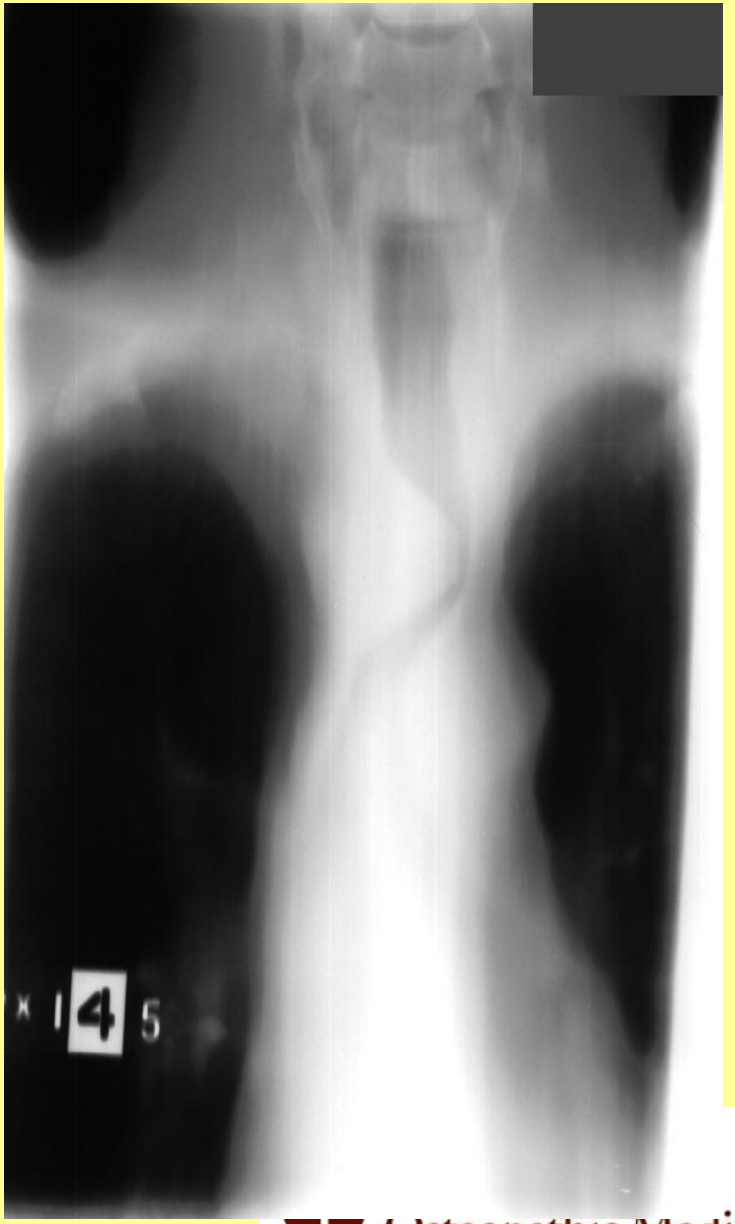


Effects of dynamic intrathoracic airway obstruction Left panel, during forced expiration, the intrathoracic intratracheal pressure (Ptr) is less than the pressure in the pleural pressure (Ppl), worsening the obstruction. Right, during forced inspiration, intratracheal pressure exceeds the pleural pressure, lessening the degree of obstruction. (Redrawn from Kryger, M, Bode, F, Antic, R, et al, Am J Med 1976; 61:85.)

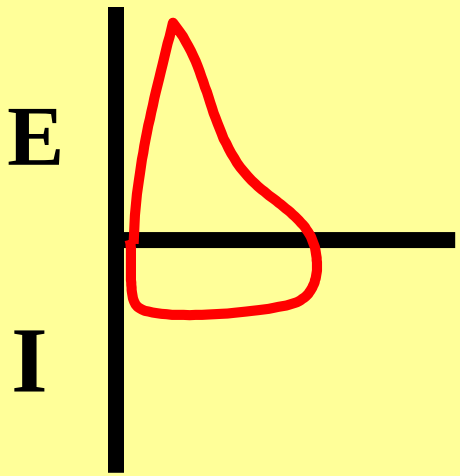
Intrathoracic

Tracheal Compression



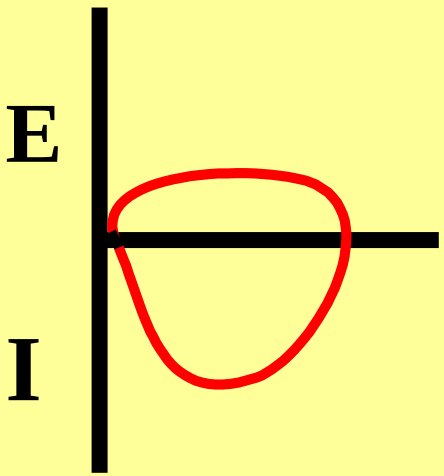
Intra and Extra Thoracic Obstructions

VARIABLE



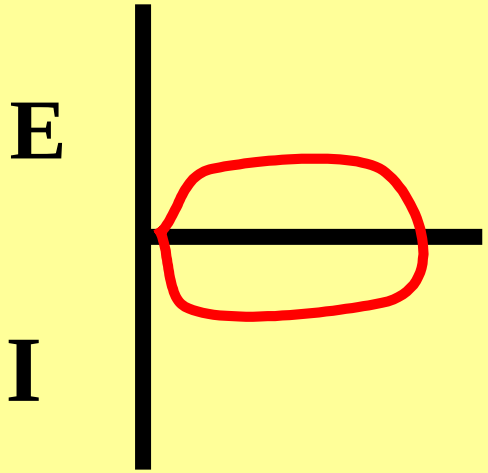
Extrathoracic

VARIABLE



Intrathoracic

FIXED



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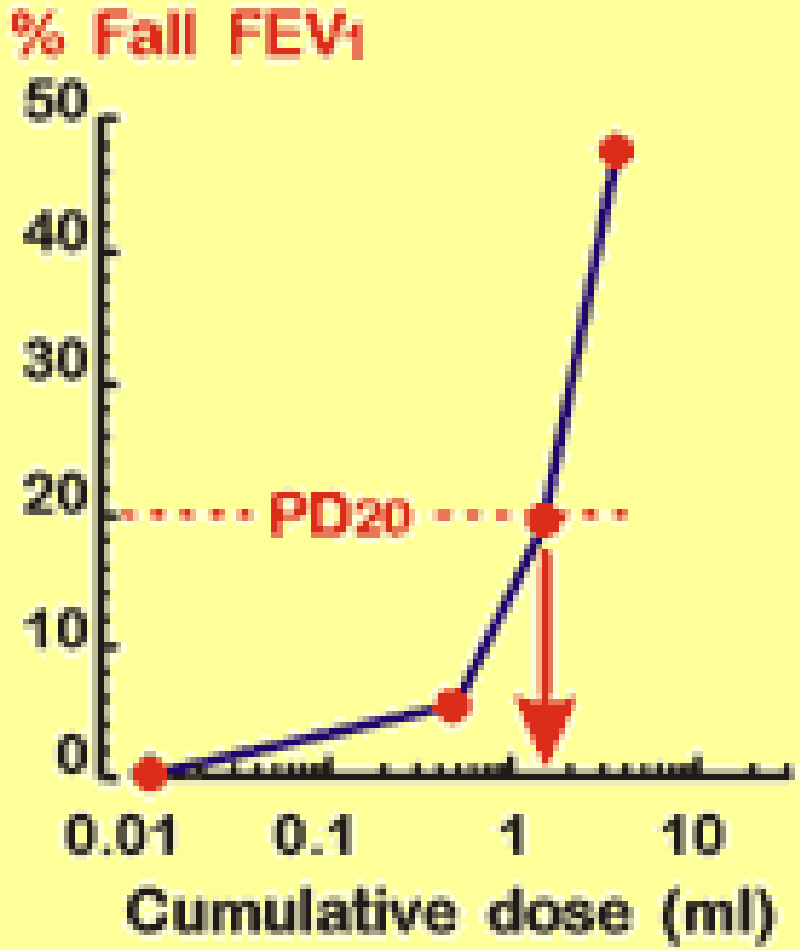
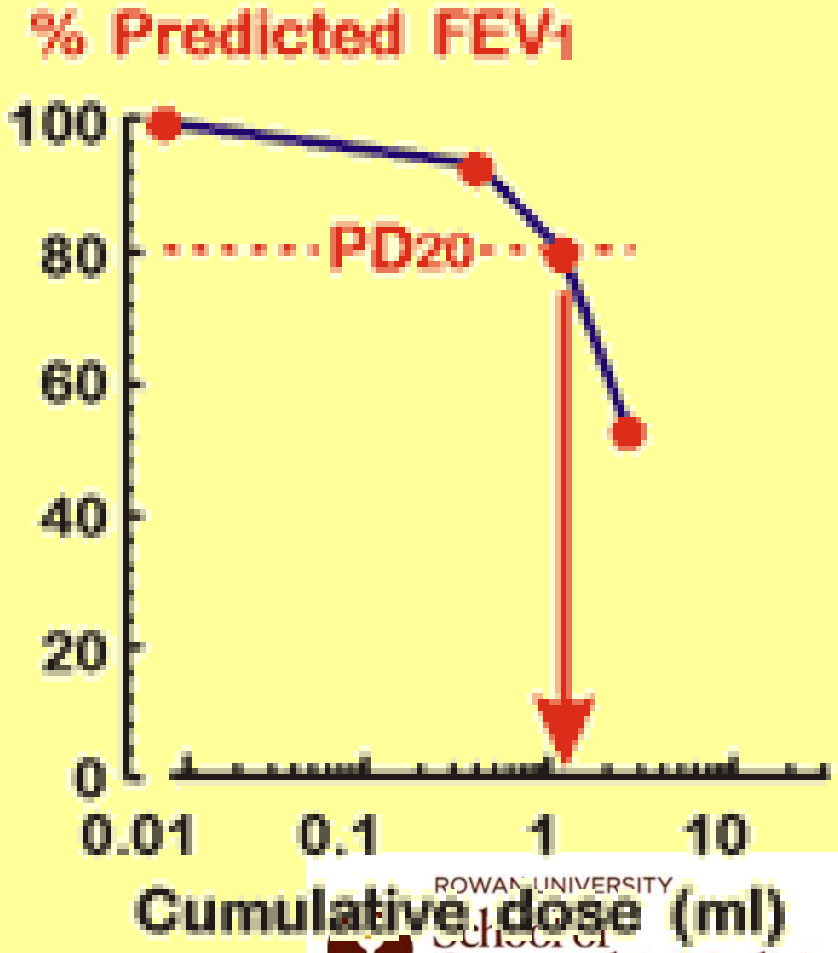
Bronchial Provocation Testing





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Diseases associated with Nonspecific Bronchial Hyperresponsiveness

Asthma
COPD
Bronchiolitis
Viral URI
Hay Fever
Cystic Fibrosis
Foreign body aspiration
Near drowning
Smoke inhalation
Sarcoidosis
Post ARDS

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PFTs
ACOI Board Review 2017

Thomas F. Morley, DO, FACOI, FCCP, FAASM
Professor of Medicine
Chairman Department of Internal Medicine
Director of the Division of Pulmonary, Critical Care and Sleep Medicine
NOW ROWAN SOM

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No Disclosures

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In order to compute normal predicted values you need THREE things

- **Age** — **Lungs get smaller with age**
- **Gender** — **Men have bigger lungs**
- **Height** — **Tall people have bigger lungs**
- **Actually you need Air temp, Baro Pressure, and race too**

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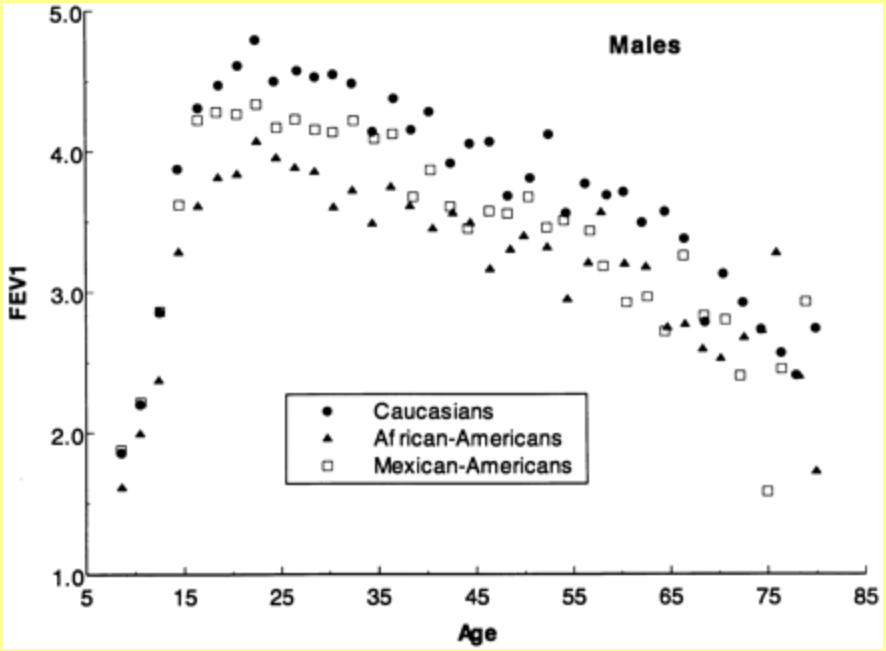
Prediction Equations



Hankinson JL et al.
Am. J. Respir Crit. Care Med.
Jan 1, 1999; 159(1):179-187

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Crapo RO, Morris AH, Clayton PD, and Nixon CR. Lung Volumes in Healthy Nonsmoking Adults. Bull. Europ. Physiopathol. Respir. 1982; 8:419-425.

FVC = 0.1524*Height(inches) - 0.0214*Age(years) - 4.6500 [Men]
FVC = 0.1247*Height(inches) - 0.0216*Age(years) - 3.5900 [Women]
FEV1 = 0.1052*Height(inches) - 0.0244*Age(years) - 2.1900 [Men]
FEV1 = 0.0869*Height(inches) - 0.0255*Age(years) - 1.5780 [Women]

FEV1% = Predicted FEV1 / Predicted FVC
RV = 0.0495*Height(inches) + 0.0246*Age(years) - 2.6830 [Men]
RV = 0.0251*Height(inches) + 0.0216*Age(years) - 0.9470 [Women]
TLC = 0.2019*Height(inches) + 0.0032*Age(years) - 7.333 [Men]
TLC = 0.1499*Height(inches) - 4.5370 [Women]

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To read spirometry you only really need THREE numbers

- **FVC predicted** — **80% or >**
- **FEV1 predicted** — **80% or >**
- **FEV1/FVC ratio** — **75% or greater**

Data for spirometry can be presented in THREE ways

- **Volume time curve**
- **Flow-Volume loop**
- **Numerical data**

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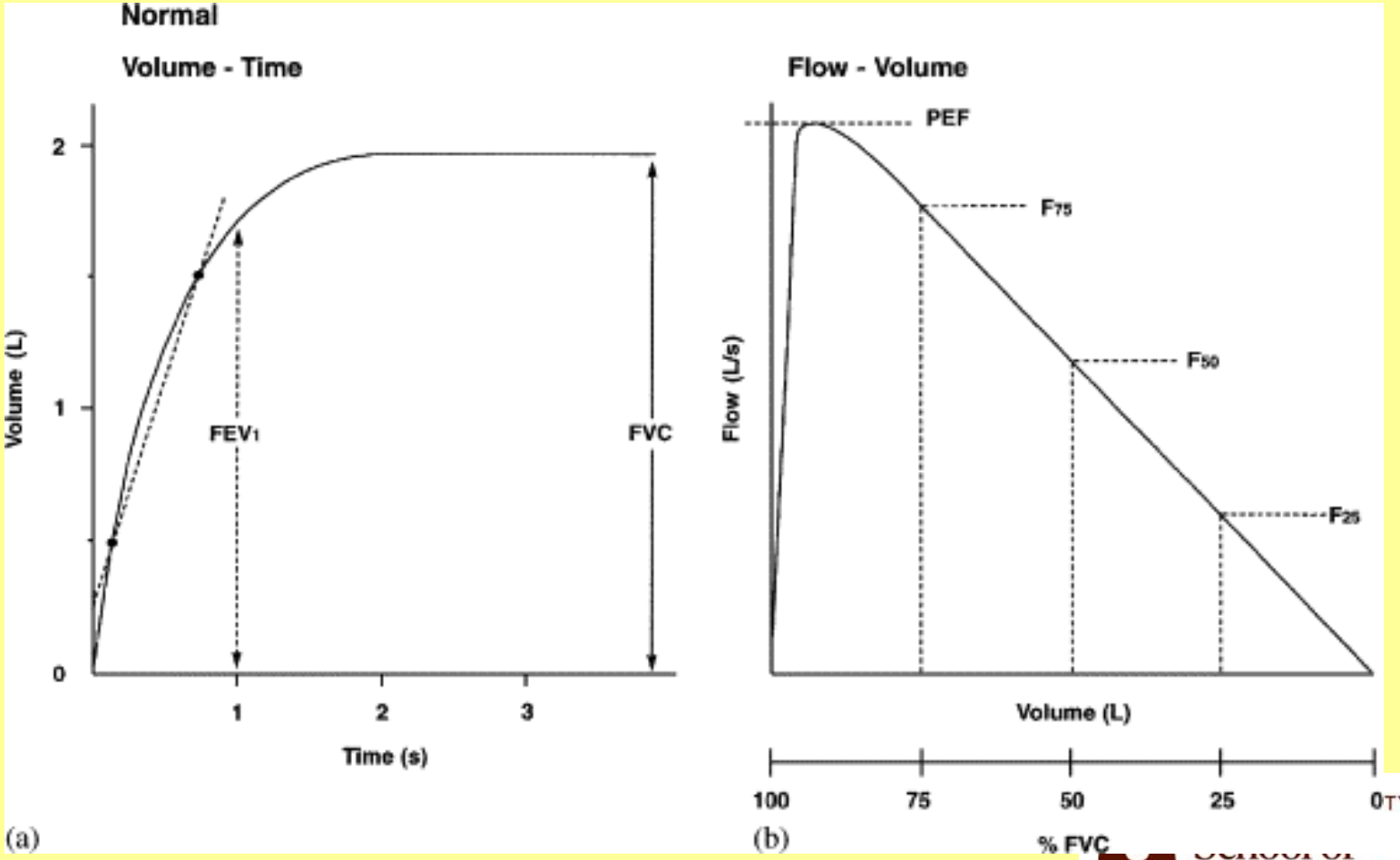
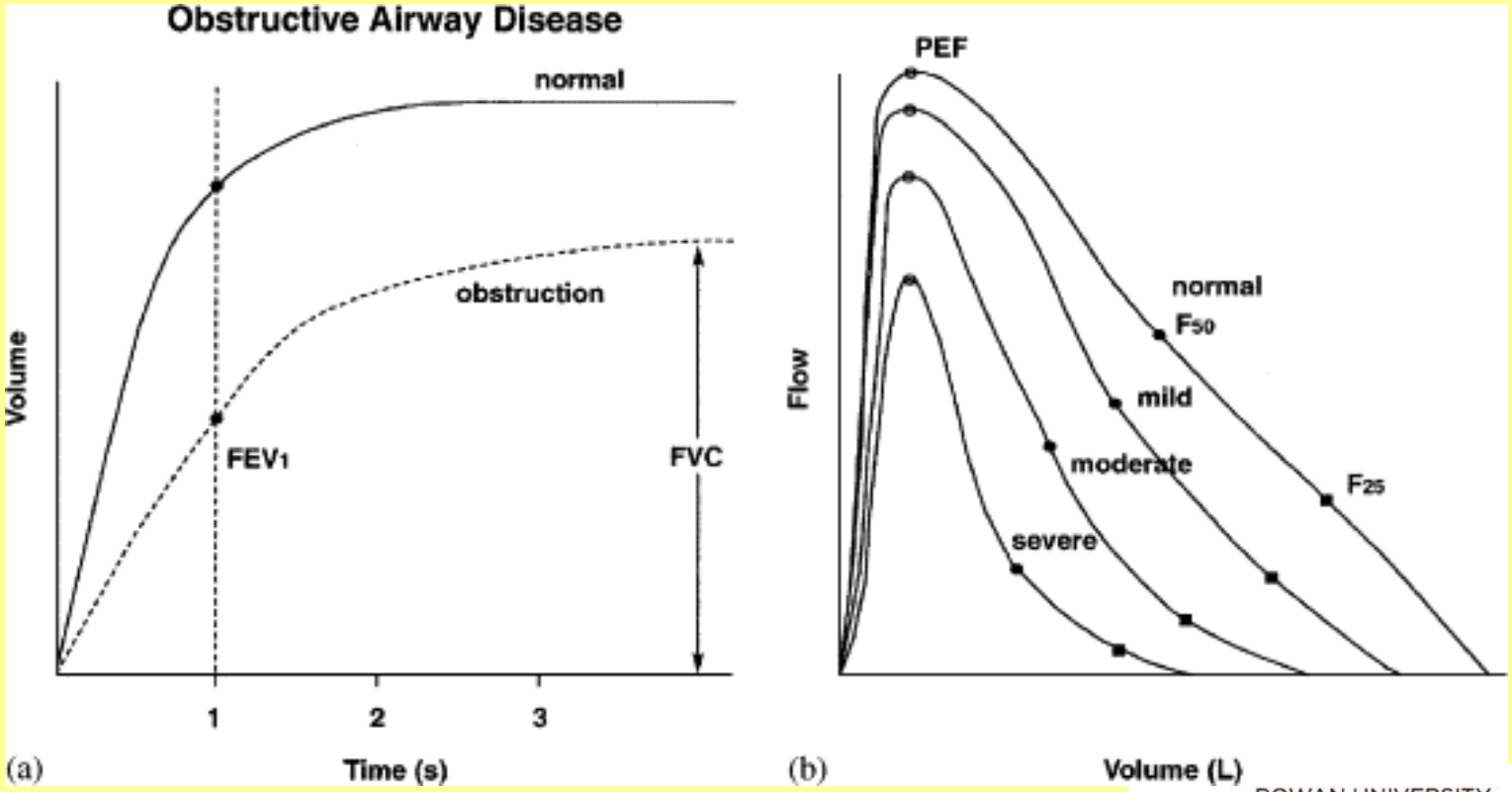
Normal VTC and FVL



Obstructed VTC and FVL



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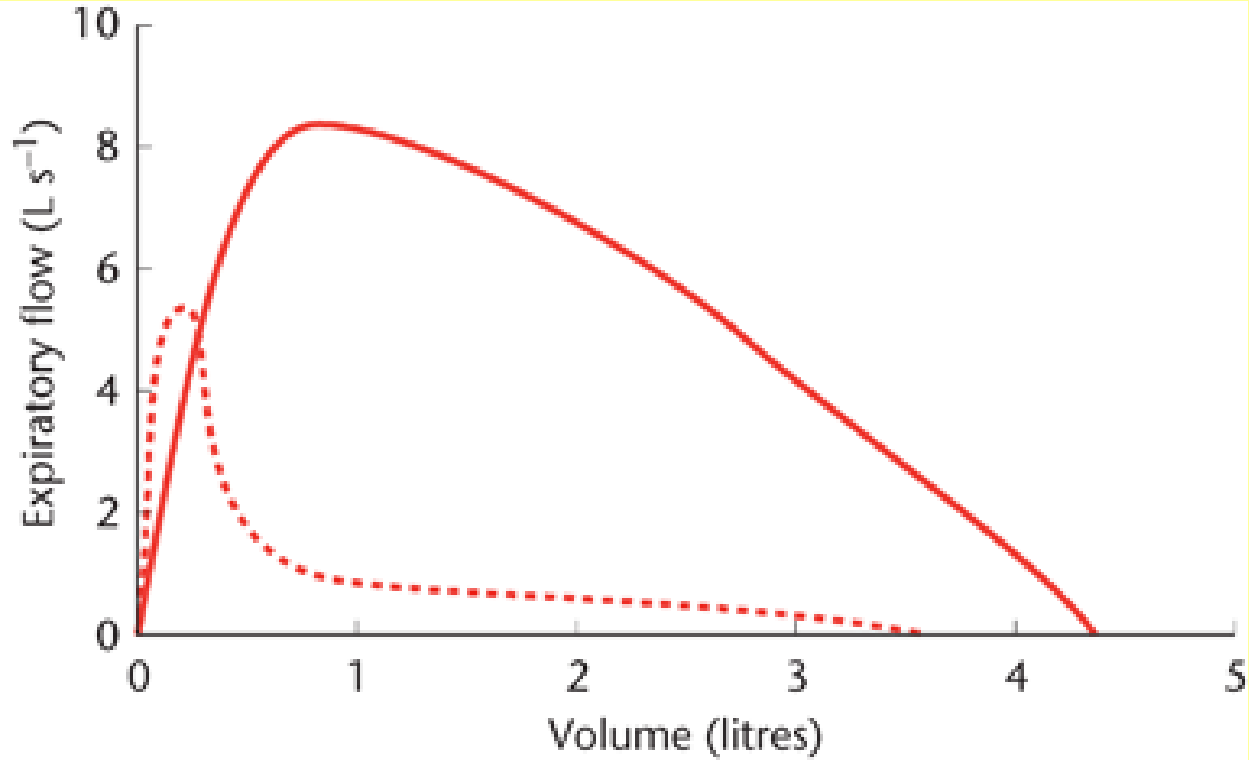
Obstruction – Airway Collapse



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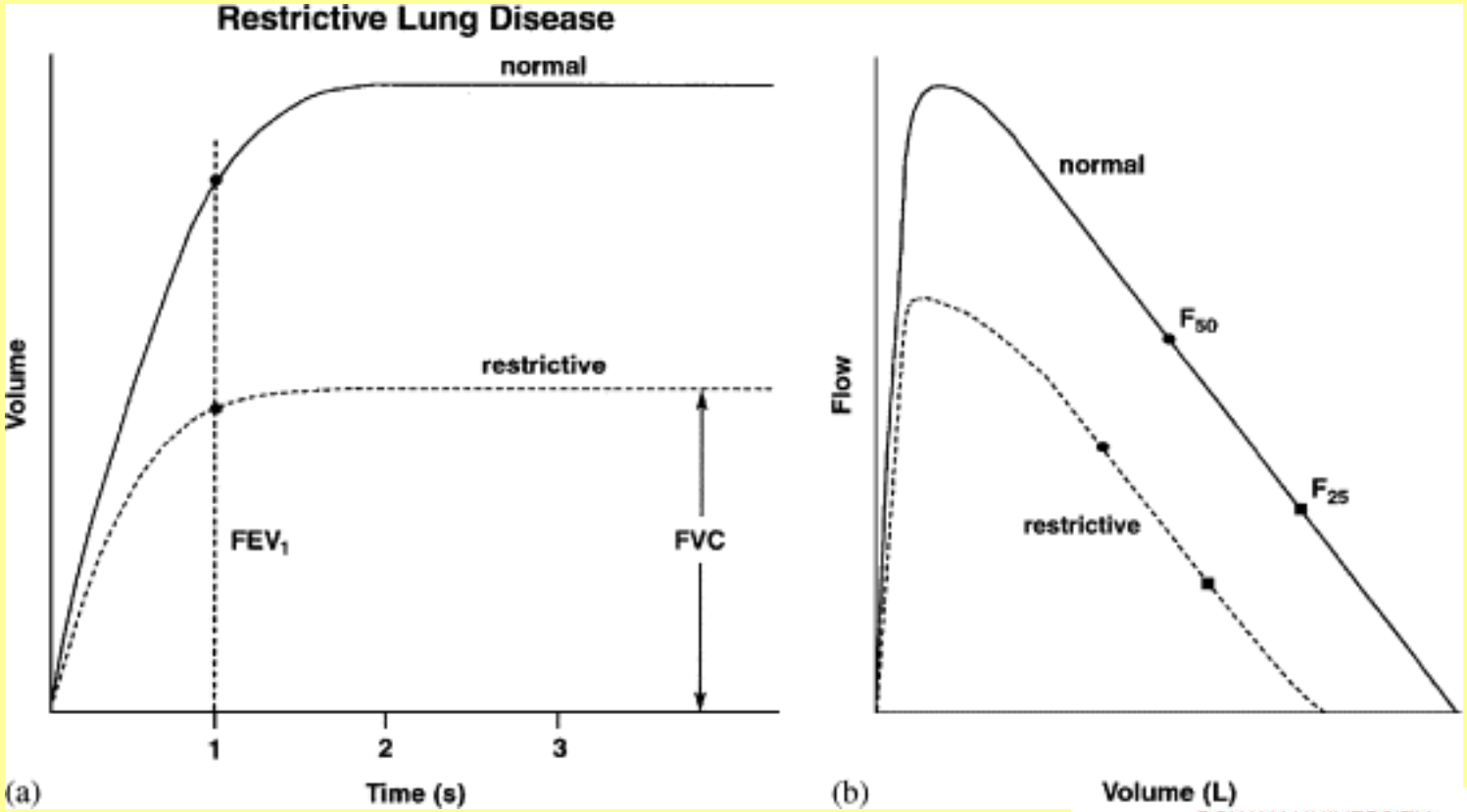
Restricted VTC and FVL



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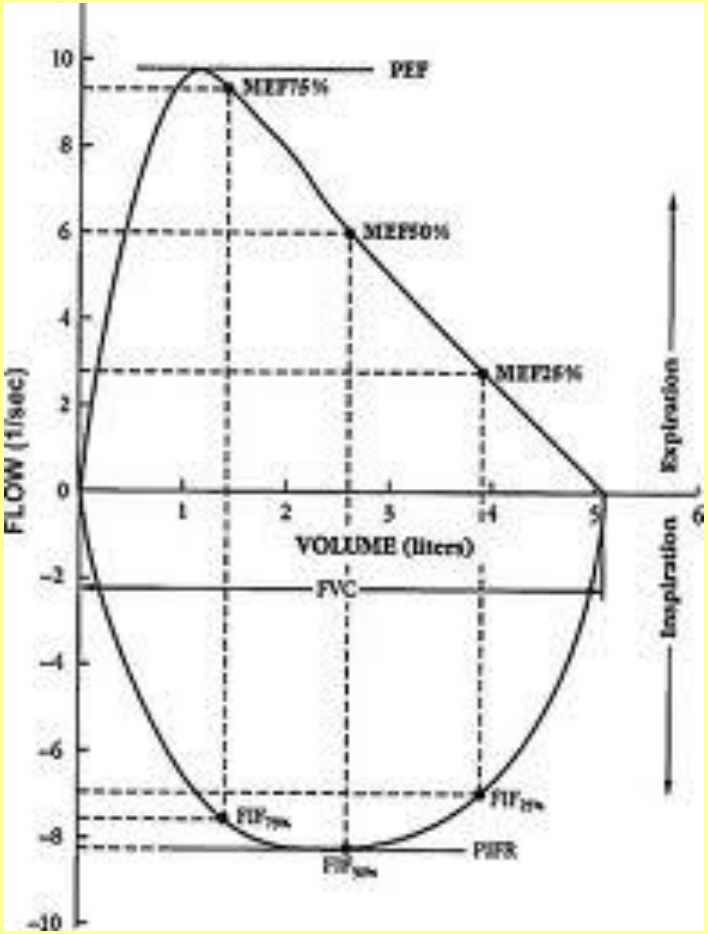
Normal Flow Volume Loop



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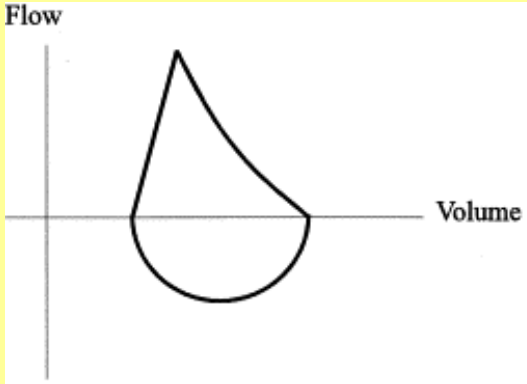
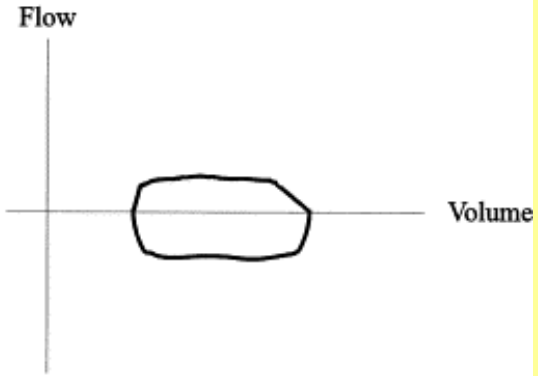
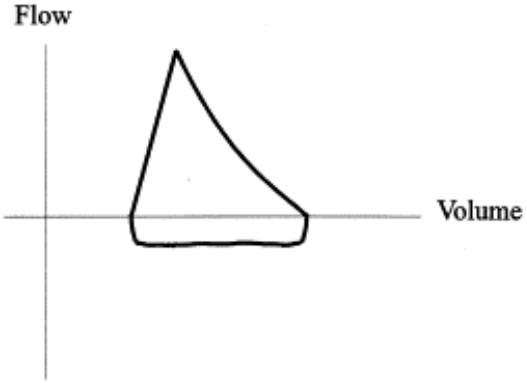


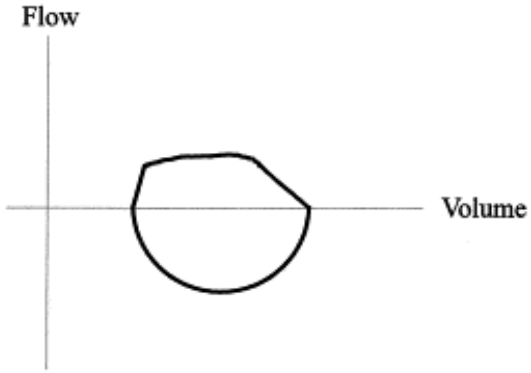
Normal Flow-Volume Loop



Fixed Large Airway Obstruction



Variable Extrathoracic Large Airway Obstruction



Variable Intrathoracic Large Airway Obstruction

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Cases

- Normal
- Restricted
- Obstructed
- Combined

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Patient 1

Gender: Female Room: Out-Pt

Age: 59 Race: Caucasian

Height(in): 58 Weight(lb): 183

Any Info: ASTHMA

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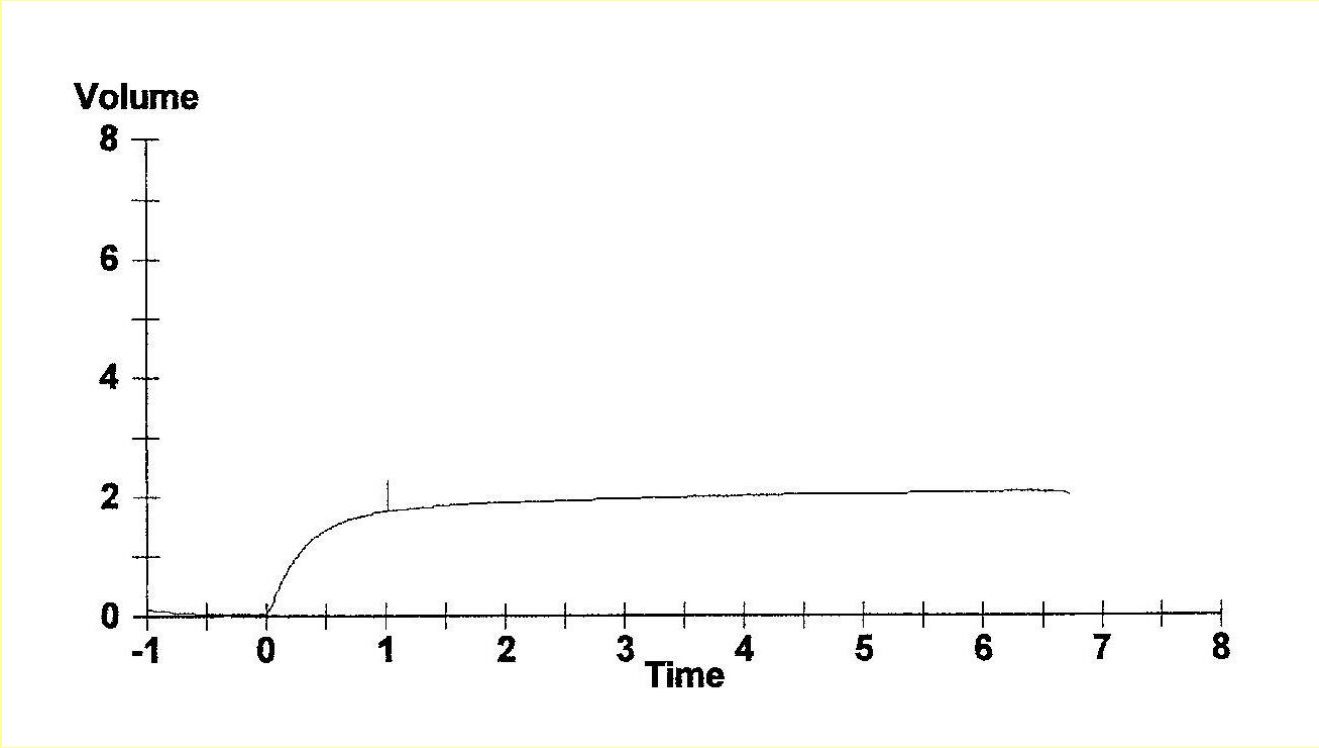
Patient 1



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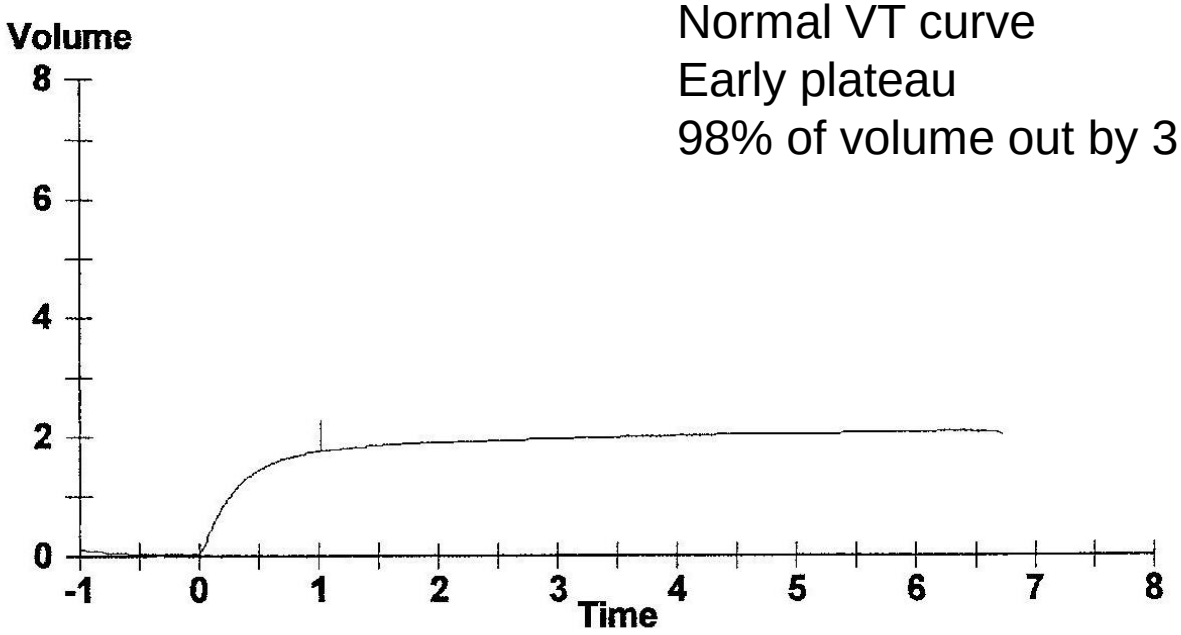
Patient 1



Normal VT curve
Early plateau
98% of volume out by 3 seconds

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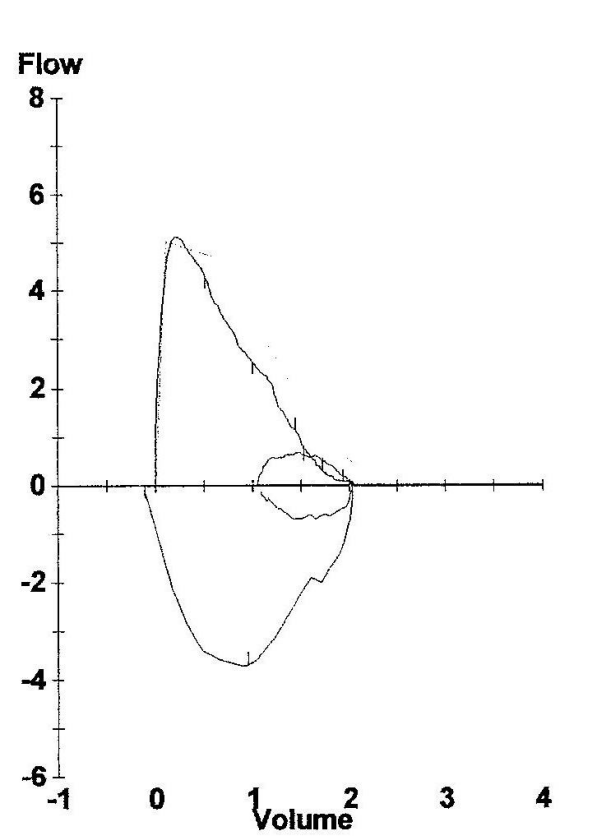
Patient 1



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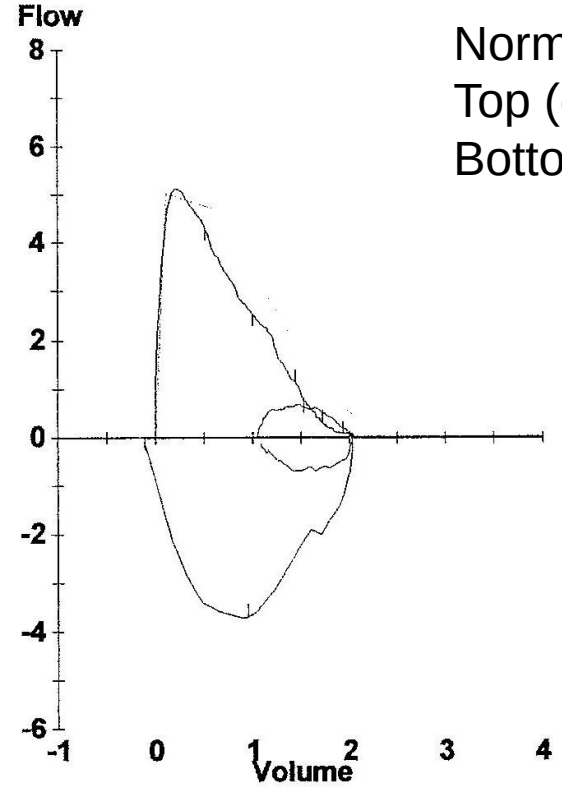
Patient 1



Normal FVL
Top (exp) looks like triangle
Bottom (inspir) looks like semi-circle

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Patient 1

F/V Parameters		BEST	PRE-RX %PRED	PRE-RX PRED
FVC	Liters	2.04	88	2.34
FEV1	Liters	1.72	89	1.94
FEV1/FVC	%	84		85
FEV3	Liters	1.94	89	2.17
FEV3/FVC	%	95		81
FEF25-75%	L/sec	2.09	96	2.18
PEF	L/sec	5.12	102	5.01
FEF25%	L/sec	4.28	91	4.72
FEF50%	L/sec	2.51	88	2.87
FEF75%	L/sec	0.74	84	0.88
PIF	L/sec	3.78		
FIF50%	L/sec	3.72		
SVC Parameters				
VC	Liters	2.16	92	2.34
ERV	Liters			
IC	Liters	2.05		

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Patient 1

FRC Parameters

FRC	Liters	1.37	81	1.68
TLC	Liters	3.41	92	3.70
FRC Time		1.0		
RV	Liters	1.26	93	1.35
RV/TLC%		37		37

DLCO/sb Parameters

DLCOsb/STPD	17.0	82	20.7
VA/BTPS	3.31		
DLCOsb/VA	5.12	130	3.94

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Patient 1

- **Normal – no obstructive or restrictive defect**

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Patient 2

Gender: Male Room: Out-Pt

Age: 57 Race: Caucasian

Height(in): 73 Weight(lb): 205

Any Info: PULM FIBROSIS

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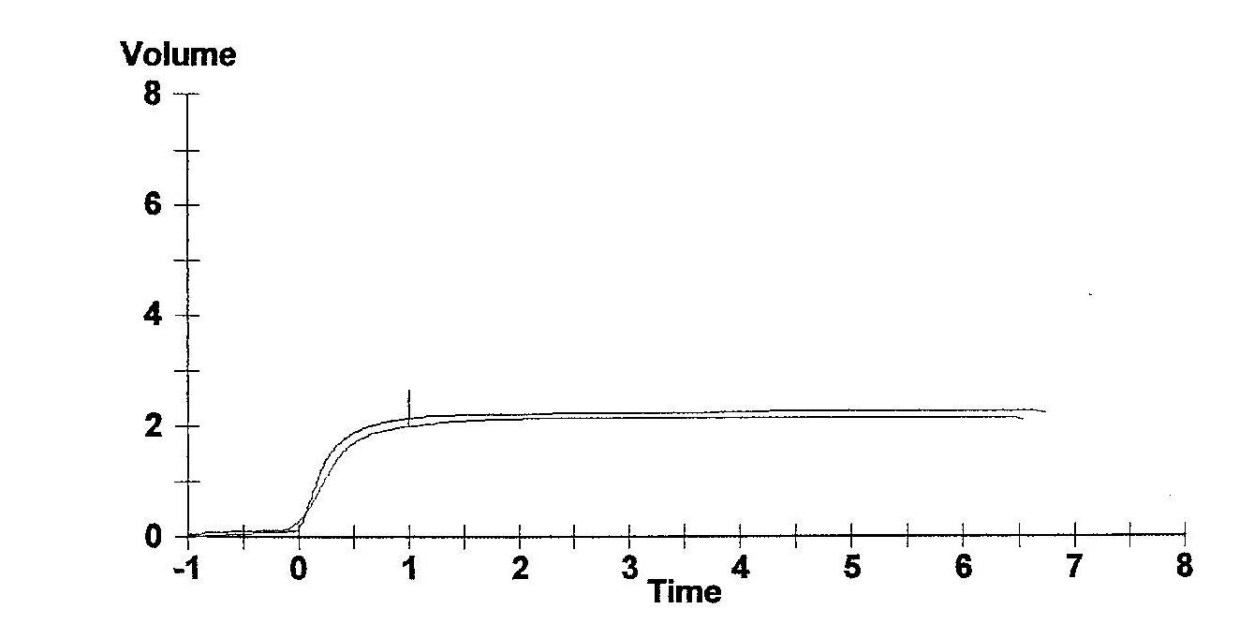
Patient 2



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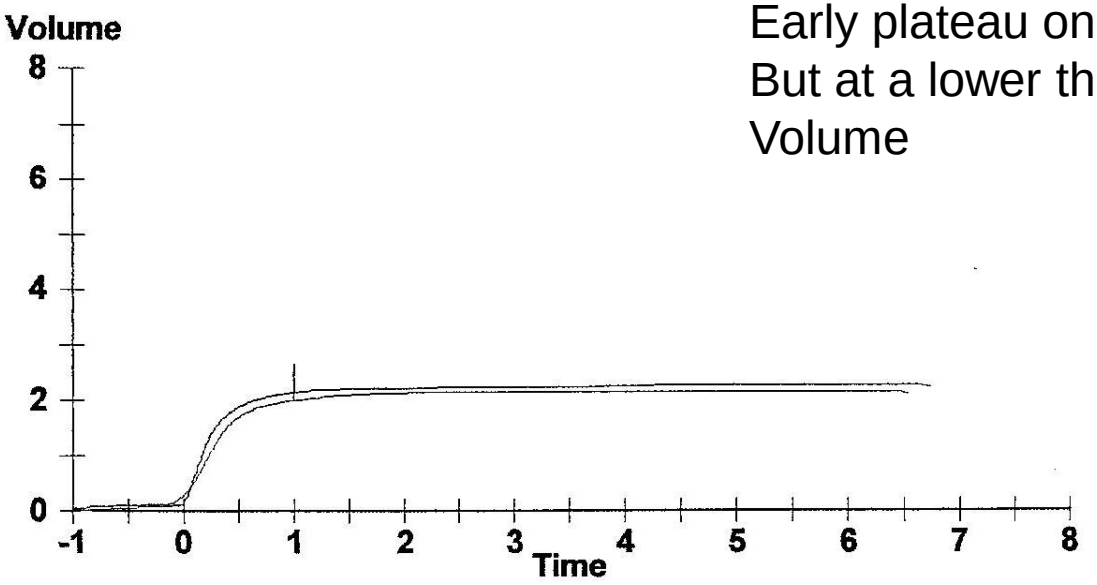
Patient 2



Early plateau on VTC
But at a lower than predicted Volume

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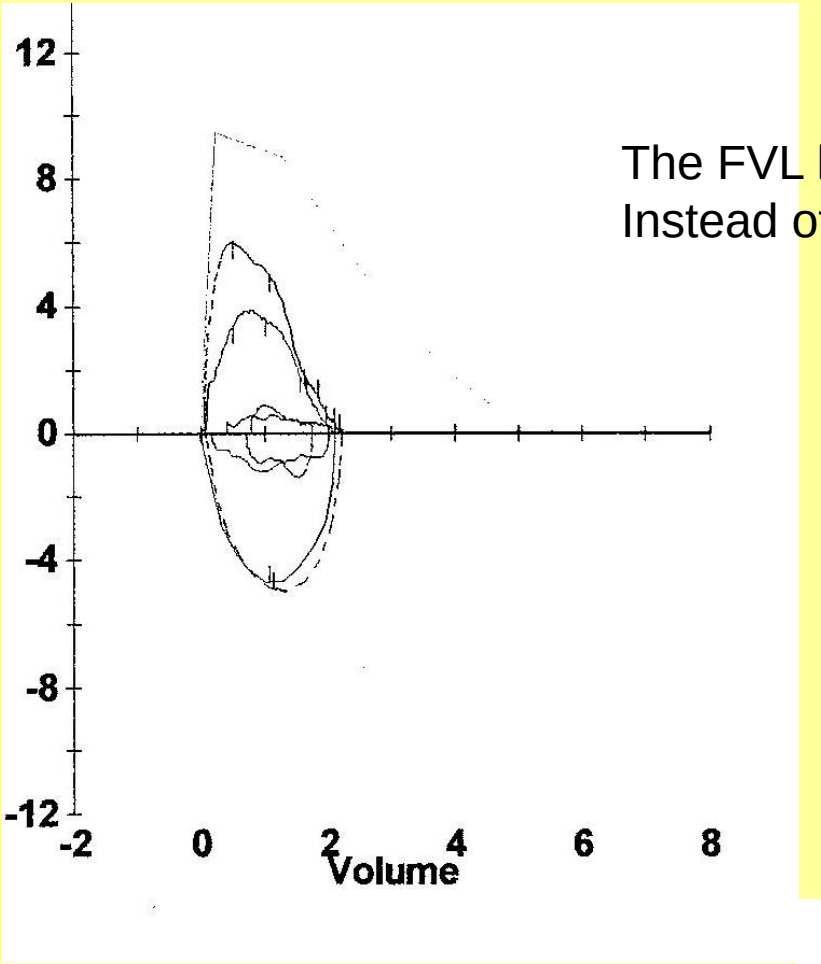
Patient 2



The FVL look like a cone
Instead of a right triangle

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Patient 2

F/V Parameters		BEST	PRE-RX %PRED
FVC	Liters	2.11	41
FEV1	Liters	1.96	48
FEV1/FVC	%	93	
FEV3	Liters	** 2.11	** 45
FEV3/FVC	%	100	
FEF25-75%	L/sec	3.17	77
PEF	L/sec	** 3.83	** 41
FEF25%	L/sec	3.29	38
FEF50%	L/sec	3.54	70
FEF75%	L/sec	1.72	89
PIF	L/sec	4.80	
FIF50%	L/sec	4.73	

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Patient 2

FRC Parameters

FRC	Liters	** 1.93	** 48	4.04
TLC	Liters	** 3.81	** 51	7.42
FRC Time		1.4		
RV	Liters	** 1.69	** 67	2.53
RV/TLC%		44		36

DLCO/sb Parameters

DLCOsb/STPD	** 7.6	** 28	26.9
VA/BTPS	3.43		
DLCOsb/VA	2.22	56	3.99

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Patient 2

- **A restrictive defect is present**
- **No obstructive defect**

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Patient 3

Gender: Female Room: Out-Pt

Age: 59 Race: Caucasian

Height(in): 63 Weight(lb): 143

Any Info: ILD,ASTHMA

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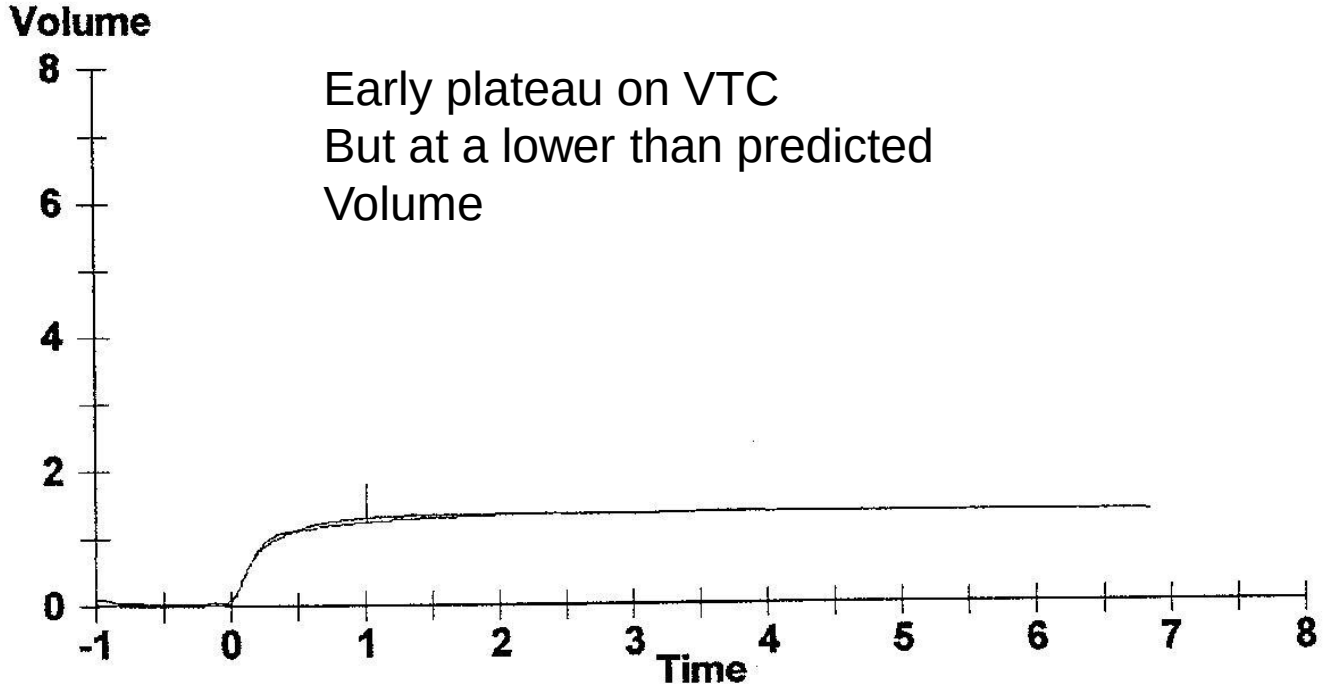
Patient 3



Early plateau on VTC
But at a lower than predicted
Volume

TY

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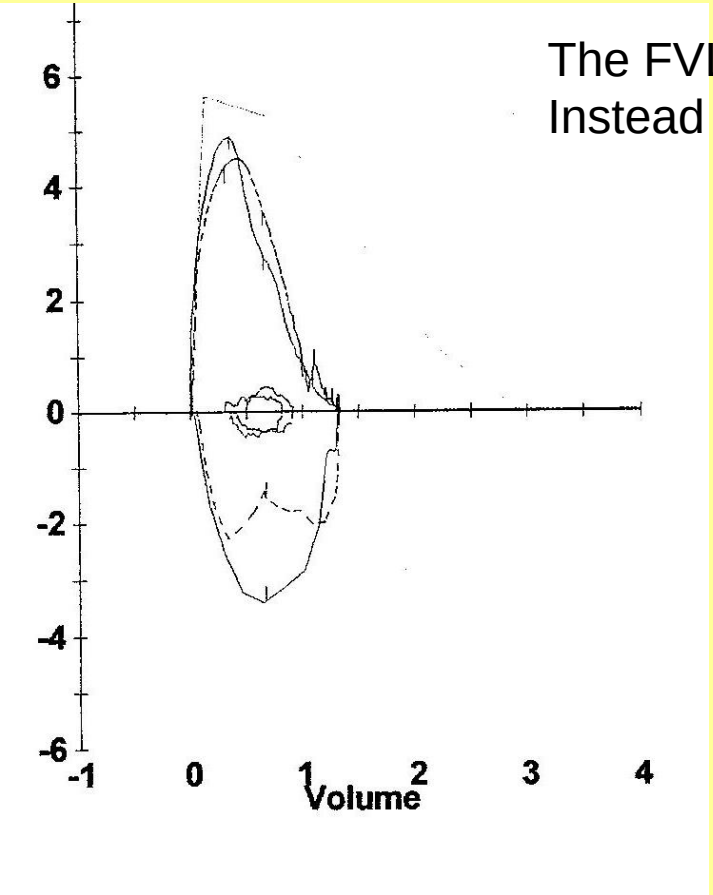
Patient 3



The FVL look like a cone
Instead of a right triangle

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Patient 3

F/V Parameters		BEST	%PRED PRE-RX
FVC	Liters	1.34	46
FEV1	Liters	1.22	51
FEV1/FVC	%	91	
FEV3	Liters	** 1.34	** 51
FEV3/FVC	%	100	
FEF25-75%	L/sec	2.30	89
PEF	L/sec	4.90	87
FEF25%	L/sec	4.85	92
FEF50%	L/sec	2.76	84
FEF75%	L/sec	0.84	76
PIF	L/sec	3.43	
FIF50%	L/sec	3.40	

SVC Parameters			
VC	Liters	1.34	46
ERV	Liters	0.11	
IC	Liters	0.88	

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Patient 3

FRC Parameters

FRC	Liters	** 1.20	** 45
TLC	Liters	** 2.08	** 44
FRC Time		1.1	
RV	Liters	** 0.74	** 42
RV/TLC%		36	

DLCO/sb Parameters

DLCOsb/STPD	** 8.3	** 42
VA/BTPS	1.77	
DLCOsb/VA	4.68	119

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Patient 3

- **A restrictive defect is noted**
- **No obstruction is present**

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Patient 4

Gender: Male Room: Out-Pt

Age: 68 Race: Caucasian

Height(in): 72 Weight(lb): 214

Any Info: COPD

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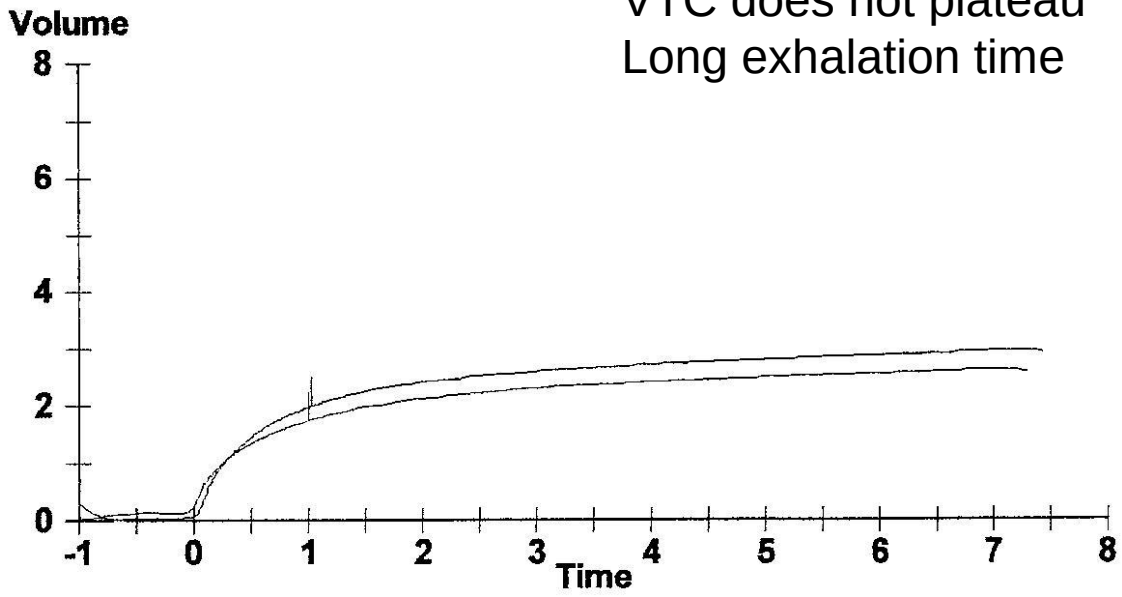
Patient 4

VTC does not plateau
Long exhalation time



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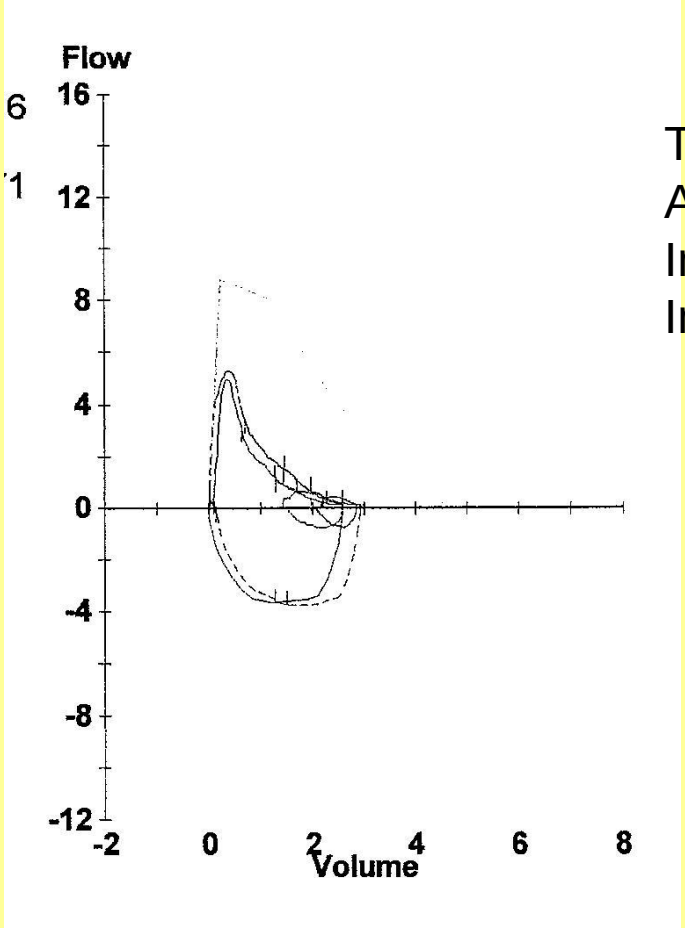
Patient 4



The line between PEF
And RV becomes concave
Instead of straight
Indicates airflow obstruction

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Patient 4

F/V Parameters		BEST	%PRED	PRE-RX
FVC	Liters	2.60	56	
FEV1	Liters	1.69	46	
FEV1/FVC	%	65		
FEV3	Liters	** 2.27	** 55	
FEV3/FVC	%	87		
FEF25-75%	L/sec	0.94	26	
PEF	L/sec	4.97	56	
FEF25%	L/sec	3.06	38	
FEF50%	L/sec	** 1.11	** 25	
FEF75%	L/sec	0.35	22	
PIF	L/sec	3.81		
FIF50%	L/sec	3.70		

SVC Parameters			
VC	Liters	2.61	56
ERV	Liters		
IC	Liters	2.88	

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Patient 4

FRC Parameters

FRC	Liters	3.58	94	3.79
TLC	Liters	6.46	92	7.02
FRC Time		2.0		
RV	Liters	** 3.85	** 145	2.65
RV/TLC%		** 60		40

DLCO/sb Parameters

DLCOsb/STPD	18.9	77	24.6
VA/BTPS	4.97		
DLCOsb/VA	3.82	103	3.71

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Patient 4

- A mild obstructive defect is noted.
- No restriction is identified by TLC
- TLC is used rather than FVC to determine restriction

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Patient 5

Gender: Female Room: Out-Pt

Age: 57 Race: Caucasian

Height(in): 65 Weight(lb): 100

Any Info: COPD

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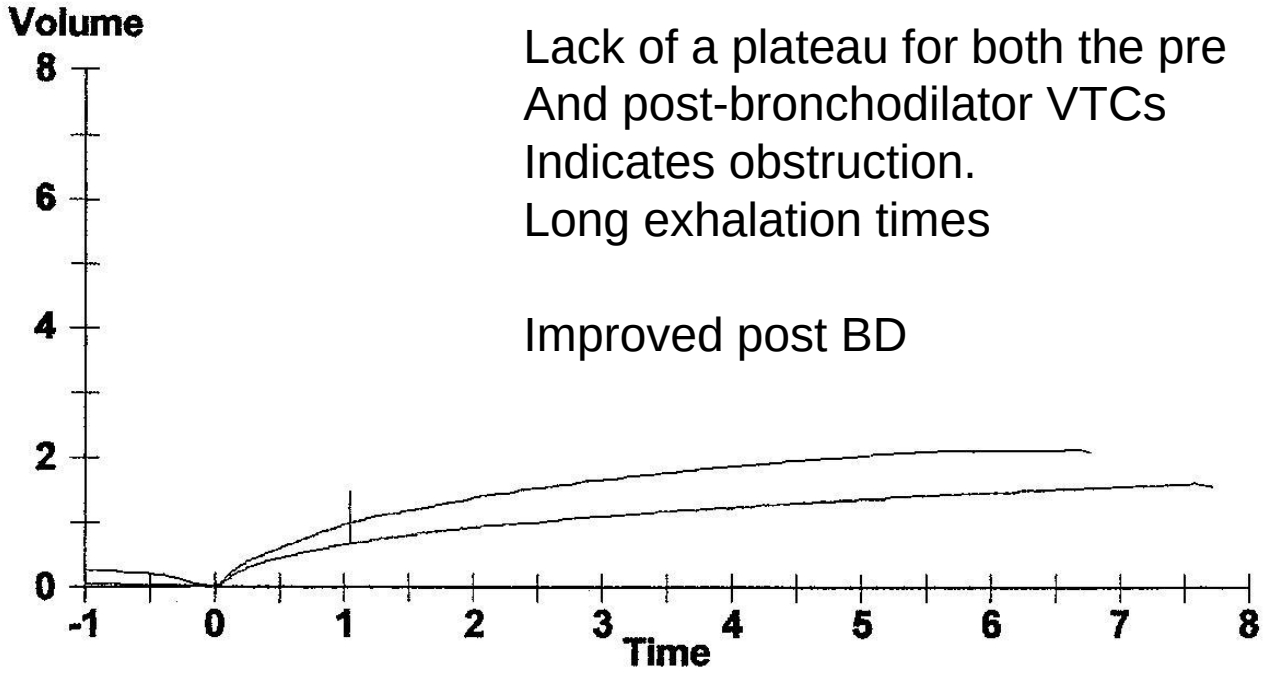
Patient 5

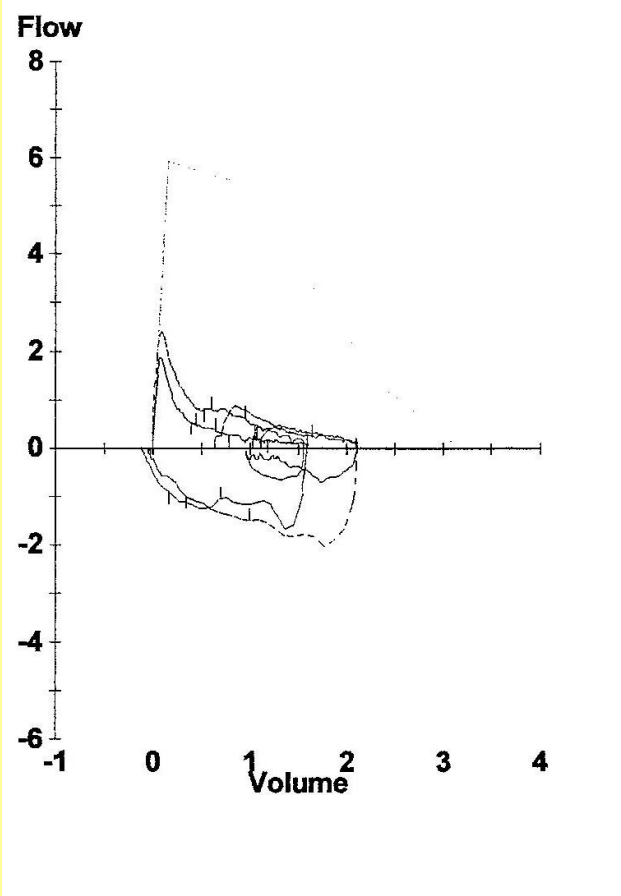


Lack of a plateau for both the pre
And post-bronchodilator VTCs
Indicates obstruction.
Long exhalation times

Improved post BD

School of Osteopathic Medicine

Patient 5



The line between PEF
And RV becomes concave
Instead of straight
Indicates airflow
obstruction.

Improved post BD

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Patient 5

F/V Parameters		BEST	PRE-RX %PRED
FVC	Liters	1.58	50
FEV1	Liters	0.65	25
FEV1/FVC	%	41	
FEV3	Liters	** 1.08	** 38
FEV3/FVC	%	68	
FEF25-75%	L/sec	0.24	9
PEF	L/sec	** 1.88	** 32
FEF25%	L/sec	0.52	9
FEF50%	L/sec	** 0.26	** 7
FEF75%	L/sec	0.15	12
PIF	L/sec	1.70	
FIF50%	L/sec	1.08	

SVC Parameters			
VC	Liters	2.10	66
ERV	Liters	0.29	
IC	Liters	1.81	

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Patient 5

RX	POST-RX			
	PRED	BEST	% PRED	% Chg
	3.17	2.12	67	34
	2.57	0.96	37	48
	83	45		
	2.84	1.65	58	52
	86	78		
	2.78	0.45	16	90
	5.93	** 2.40	** 40	28
	5.53	0.79	14	51
	3.49	** 0.45	** 13	77
	1.24	0.26	21	78
		2.06		21
		1.51		40

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Patient 5

FRC Parameters

FRC	Liters	3.42	105	3.27
TLC	Liters	5.23	102	5.12
FRC Time		2.1		
RV	Liters	** 3.13	** 165	1.90
RV/TLC%		** 60		37

DLCO/sb Parameters

DLCOsb/STPD	12.5	75	16.7
VA/BTPS	3.14		
DLCOsb/VA	3.99	100	3.99

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Patient 5

- Severe obstructive defect with significant improvement after bronchodilator treatment
- Air trapping is present
- No restriction is noted

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Patient 6

Gender: Male Room: Out-Pt

Age: 62 Race: Caucasian

Height(in): 65 Weight(lb): 221

Any Info: COPD

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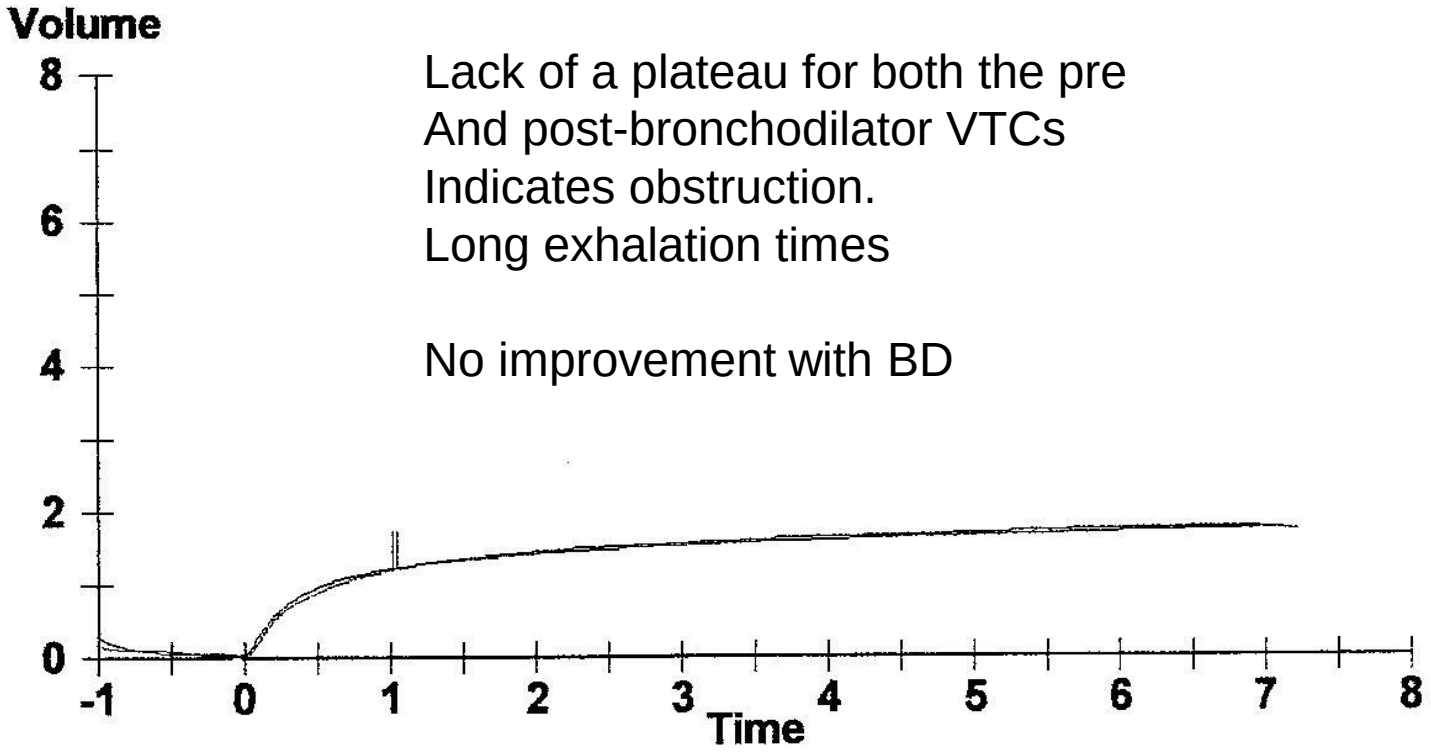
Patient 6



Lack of a plateau for both the pre
And post-bronchodilator VTCs
Indicates obstruction.
Long exhalation times

No improvement with BD

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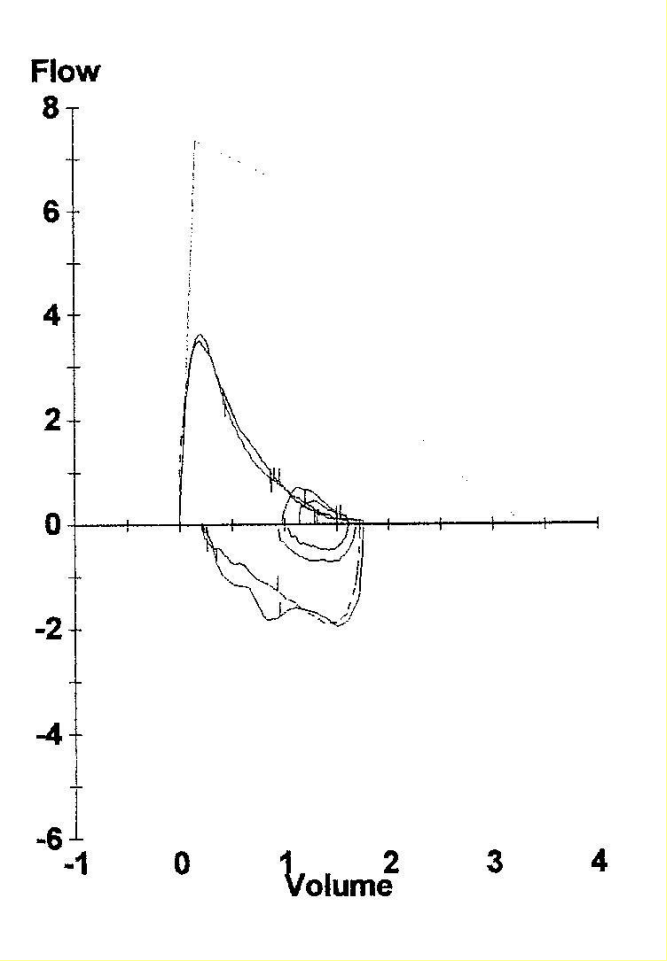
Patient 6



The line between PEF
And RV becomes concave
Instead of straight
Indicates airflow
obstruction.

Not improved post BD

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Patient 6

F/V Parameters		BEST	%PRED	PRE-RX
FVC	Liters	1.76	53	
FEV1	Liters	1.19	45	
FEV1/FVC	%	68		
FEV3	Liters	1.54	47	
FEV3/FVC	%	87		
FEF25-75%	L/sec	0.70	25	
PEF	L/sec	3.62	49	
FEF25%	L/sec	2.31	34	
FEF50%	L/sec	0.86	25	
FEF75%	L/sec	0.24	20	
PIF	L/sec	1.99		
FIF50%	L/sec	1.76		

SVC Parameters				
VC	Liters	1.76	53	
ERV	Liters			
IC	Liters	1.61		

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Patient 6

FRC Parameters

FRC	Liters	2.41	93	2.58
TLC	Liters	** 4.02	** 74	5.44
FRC Time		1.2		
RV	Liters	2.26	109	2.06
RV/TLC%		** 56		38

DLCO/sb Parameters

DLCOsb/STPD	** 15.2	** 63	24.0
VA/BTPS	3.21		
DLCOsb/VA	4.74	123	3.86

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Patient 6

- **Combined obstructive and restrictive defect**

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