



**Brigham and Women's Hospital**

Founding Member, Mass General Brigham

# PULMONARY MEDICINE: ADDITIONAL CLINICAL PEARLS AND TAKE-HOME MESSAGES

Elizabeth Gay, MD

Fellowship program directory: pulmonary and critical care fellowship,  
Brigham and Women's Hospital

Assistant professor medicine, Harvard Medical School

**CONTINUING MEDICAL EDUCATION  
DEPARTMENT OF MEDICINE**



**HARVARD MEDICAL SCHOOL  
TEACHING HOSPITAL**

## BIOSKETCH

- New York University School of Medicine
- Residency at University of Washington
- Pulmonary/critical care fellowship at Mount Sinai School of Medicine
- Asst professor of medicine, Harvard medical school
- Fellowship program director, Brigham and Women's hospital pulmonary/critical care fellowship

NO DISCLOSURES

- Thank you to Dr. Chris Fanta!

## LEARNING OBJECTIVES

- Interpret findings on pulmonary testing including flow volume loops
- Highlight useful clues to the diagnosis of pulmonary diseases
- Touch upon some topics in pulmonary medicine not previously discussed

## CASE I

- A 52-year-old man complains of fatigue and early morning headaches over the last 4-6 weeks. On his serum chemistry profile, he is noted to have an elevated serum bicarbonate (35 meq/L). He takes no medications and in particular, no diuretics.
- He has smoked cigarettes (1-2 PPD) since age 13. He reports chronic morning cough and sputum production
- His examination is notable for shallow respirations, clear lung fields, and paradoxical inward movement of his abdomen on inspiration when he lies supine.

## DATA

Recent PFTs (spirometry):

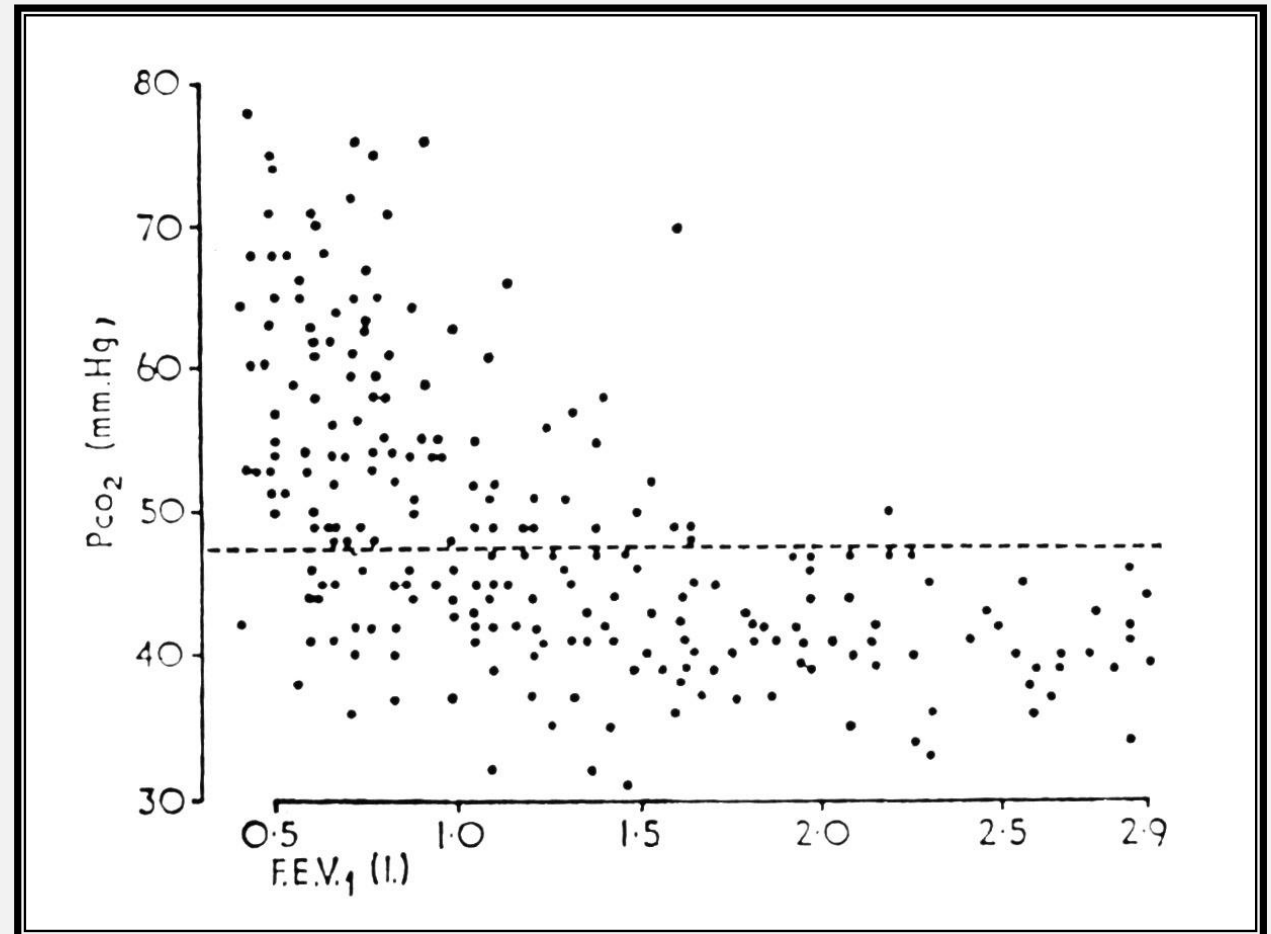
- FVC 3.58 L (70% of pred.)
- FEV<sub>1</sub> 2.02 L (53% of pred.)
- FEV<sub>1</sub>/FVC 0.56
- Arterial oxygen saturation by pulse oximetry is 93-94%.
- For further evaluation, arterial blood gases are obtained:
  - PO<sub>2</sub> 65 mm Hg
  - PCO<sub>2</sub> 60 mm Hg
  - pH = 7.34

## WHAT IS THE MOST LIKELY EXPLANATION FOR HIS HYPERCAPNIA?

1. Asthma
2. COPD
3. Pulmonary embolism
- 4. Respiratory muscle weakness
5. Kyphoscoliosis

## RELATION BETWEEN AIRFLOW OBSTRUCTION AND PACO<sub>2</sub> IN COPD

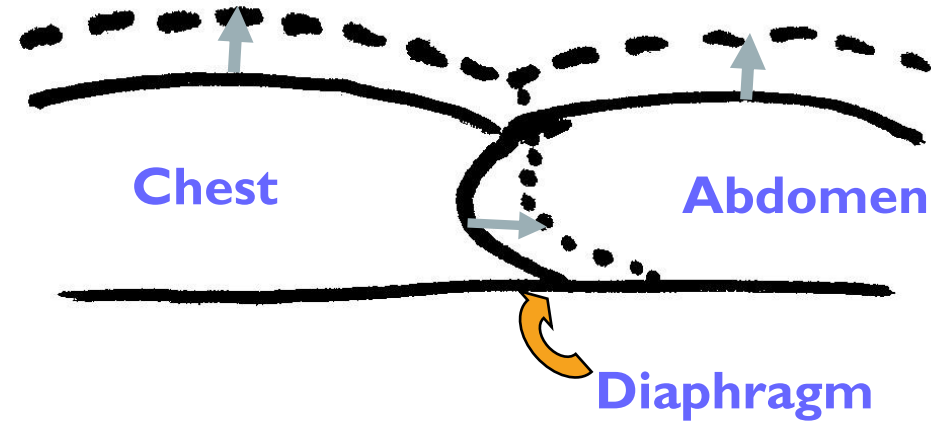
- In the absence of respiratory depressant medications or comorbid illnesses, hypercapnia does not develop in persons with COPD until the FEV<sub>1</sub> falls to below 1.5 L.



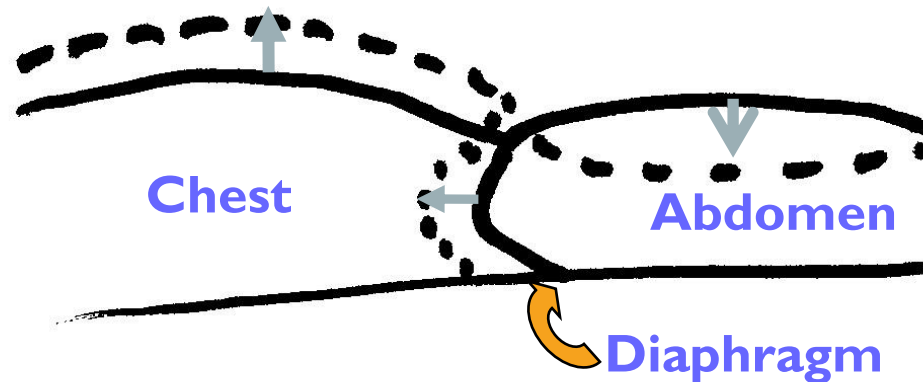


# PEARL 1A: DIAPHRAGMATIC PARADOX INDICATES INSPIRATORY MUSCLE WEAKNESS OR FATIGUE

**Normal**



**Resp. muscle  
weakness**



# PEARL 1B: CHARACTERISTIC PFT PATTERN IN RESPIRATORY MUSCLE WEAKNESS

Restrictive  
pattern with  
decreased TLC,  
increased RV, and  
normal FRC.

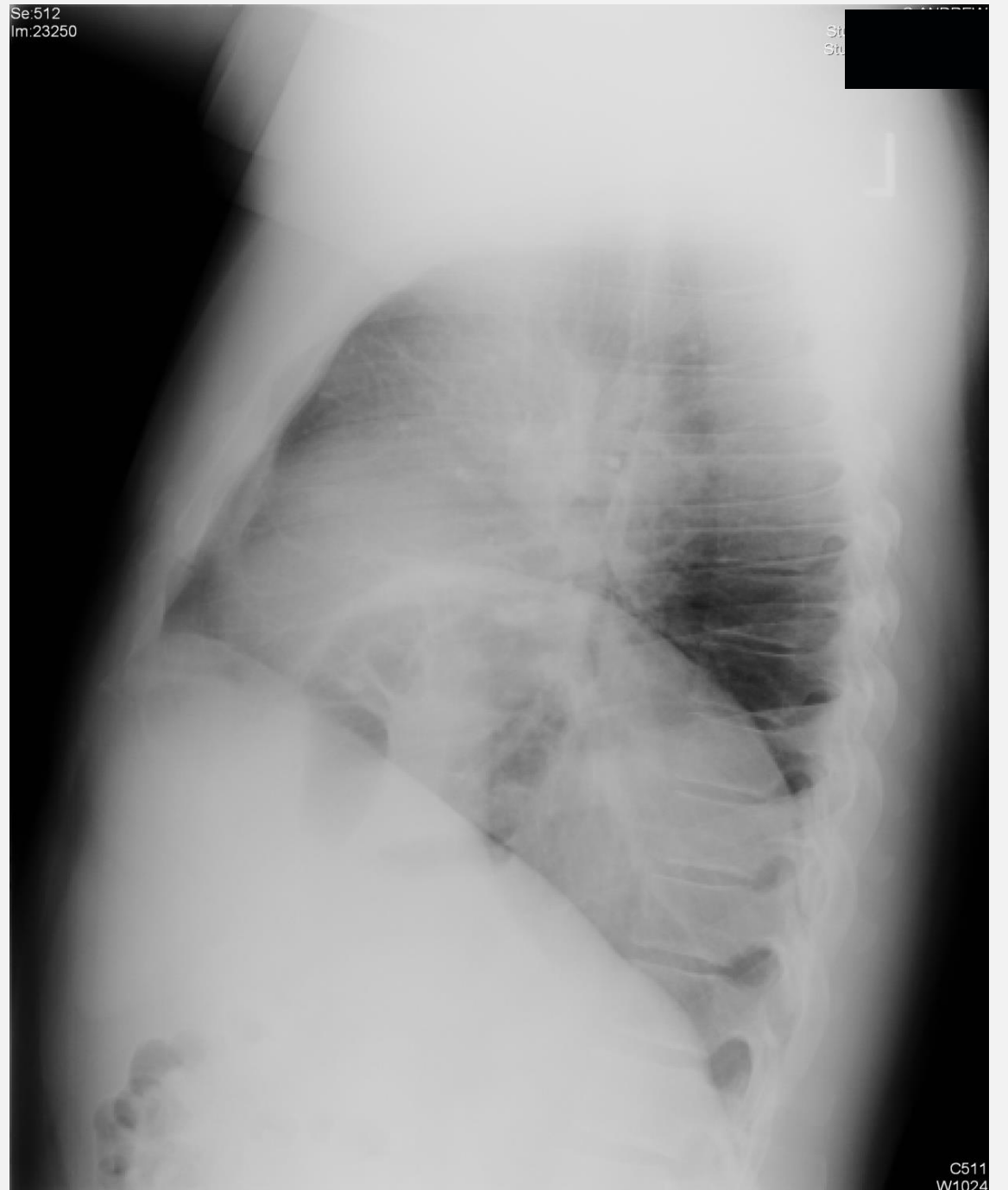
ATS compliant tests are indicated by a ✓: FVC ✓ FRC DLCO ✓ VTG ✓					
Spirometry (BTPS)		Predicted Range		Pre Bronchodilator	
		Mean	95%	Actual	% Pred
FVC Effort Time		----	----	12:39	----
FEV <sub>1</sub>	L	2.96	2.12	1.68	57
FVC	L	3.96	2.84	2.28	58
FEV <sub>1</sub> / FVC	%	76	67	74	97
FEV <sub>6</sub>	L	3.36	2.51	2.26	67
FEV <sub>1</sub> / FEV <sub>6</sub>	%	76	67	74	97
FEF <sub>25-75</sub>	L/s	2.54	0.87	1.20	47
PEFR	L/s	6.56	4.37	6.47	99
FET	sec	----	----	6.17	----
MVV	L/m	107.1	50.3	----	----
Lung Volumes (Box)		Predicted Range		Pre Bronchodilator	
		Mean	95%	Actual	% Pred
VTG Effort Time		----	----	12:45	----
TLC	L	6.54	4.93	5.51	84
FRC	L	3.60	2.14	3.38	94
IC	L	2.95	----	2.13	72
ERV	L	1.01	----	0.18	18
RV	L	2.59	1.83	3.20	124
RV/TLC	%	39	31	58	149
VC	L	3.96	2.84	2.31	58

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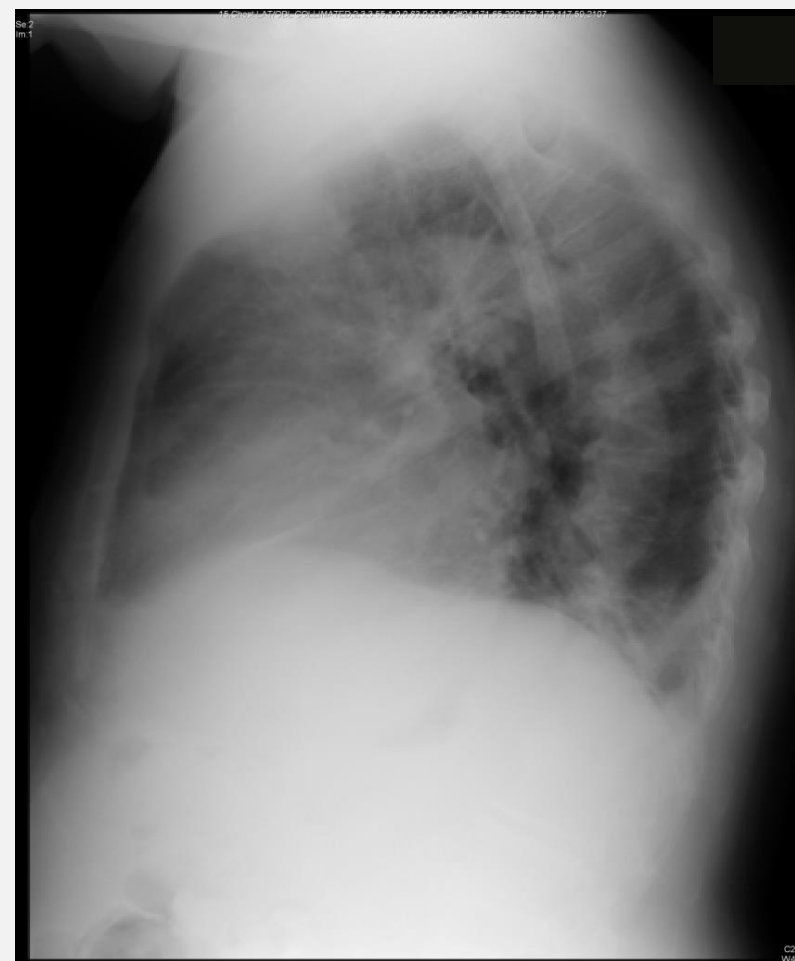


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# PEARL 1C: UNILATERAL HEMIDIAPHRAGMATIC PARALYSIS

- CXR finding: hemidiaphragm displaced cephalad
- PFTs: mild to moderate reduction in FVC (>50% of predicted); reduced maximum inspiratory pressure (MIP)
- Diagnosis: chest fluoroscopy (“sniff test”) or thoracic ultrasound
- Etiologies: chest or neck trauma; surgical injury (e.g., CABG surgery, cervical spine surgery); malignancy along phrenic nerve
- Most often idiopathic (viral)
- Treatment:
  - Respiratory muscle trainer
    - Evaluate for need for PAP
    - Surgical plication

# PEARL ID:ELEVATED HEMIDIAPHRAGM: CONSIDER SUBPULMONIC EFFUSION



## CASE 2

- A 52-year-old woman is referred to you by her hematologist for evaluation of hypoxemia
- She presented with polycythemia (hematocrit consistently 52-55%). The hematologist measured her arterial oxygen saturation at 86% and suggested (politely) that in her opinion the patient's erythrocytosis was not due to polycythemia vera but more likely was secondary to her hypoxemia.
- The patient is a lifelong non-smoker, although both of her parents and her husband smoke cigarettes.
- She has no history of hypertension, diabetes, hyperlipidemia, or known coronary artery disease.

## DATA

- Her examination is notable for obesity (body mass index = 42), jugular venous distention (4 cm above the clavicles), clear chest exam, a prominent second heart sound ( $P_2$ ), and pitting edema to mid-calf bilaterally.
- Chest X-ray is normal.
- Electrolytes: Na 135, K 4.2, Cl 92,  $\text{HCO}_3$  35 meq/L
- You confirm her  $\text{SaO}_2$  at 86%. With voluntary hyperventilation, her  $\text{SaO}_2$  rises to 98%.

## WHAT IS THE MOST LIKELY DIAGNOSIS?

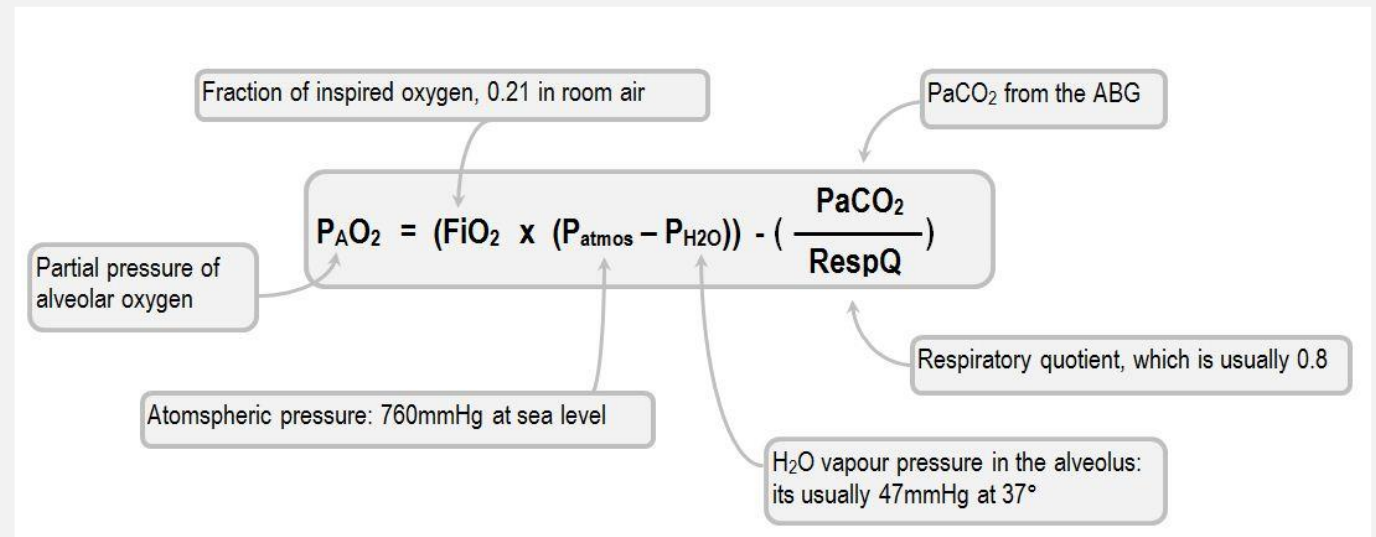
1. COPD due to second-hand smoke exposure
2. Respiratory muscle weakness due to amyotrophic lateral sclerosis
3. Ischemic cardiomyopathy
4. Recurrent pulmonary thromboemboli
5. Obesity-hypoventilation syndrome





## PEARL 2: DIAGNOSTIC UTILITY OF VOLUNTARY HYPERVENTILATION MANEUVER

- A dramatic increase -- to normal -- in arterial oxygenation with voluntary hyperventilation suggests that the etiology of the hypoxemia is hypercapnia with a normal alveolar-arterial gradient for oxygen, as is seen in central alveolar hypoventilation.



# OBESITY HYPOVENTILATION

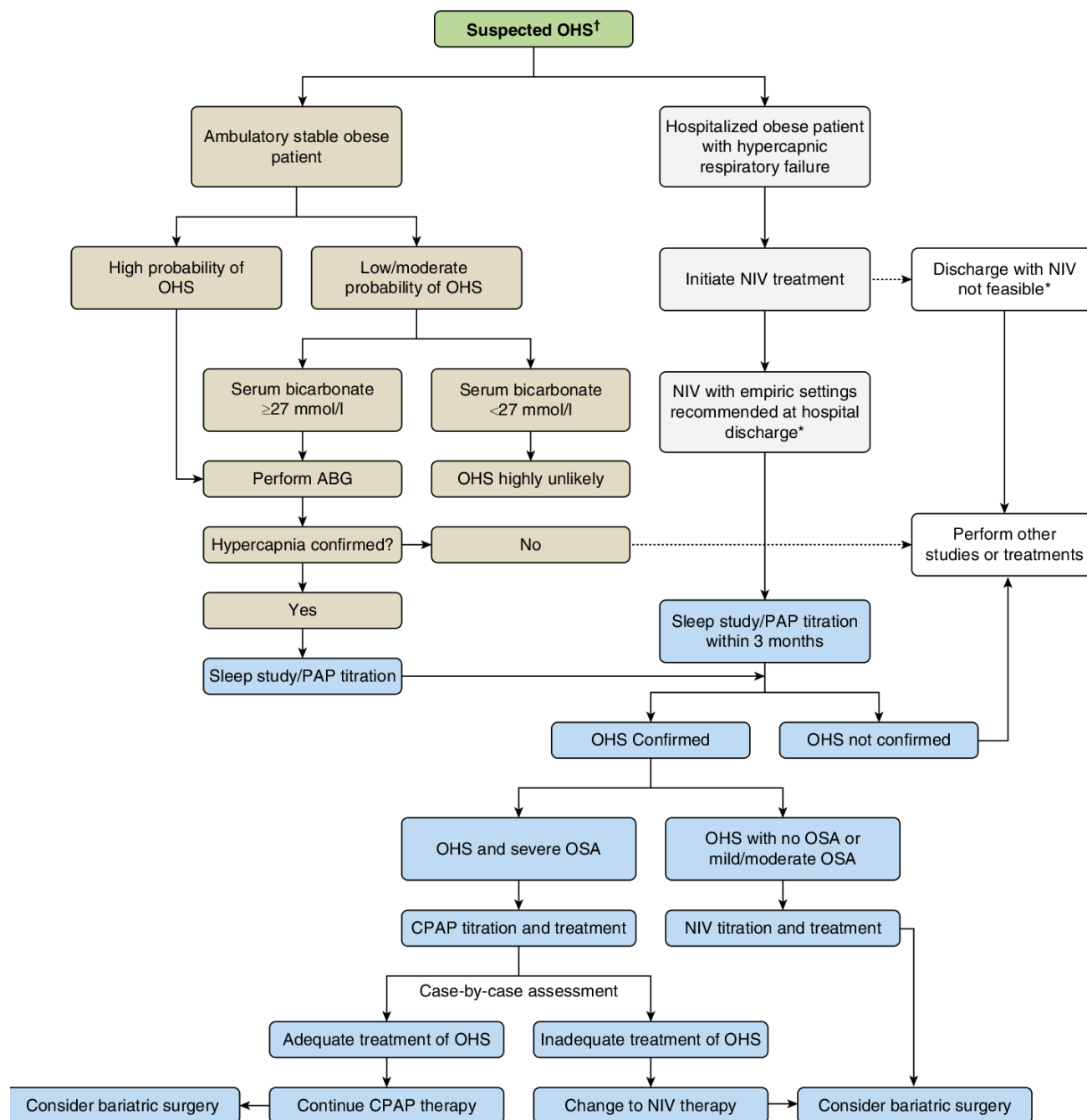
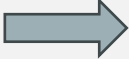


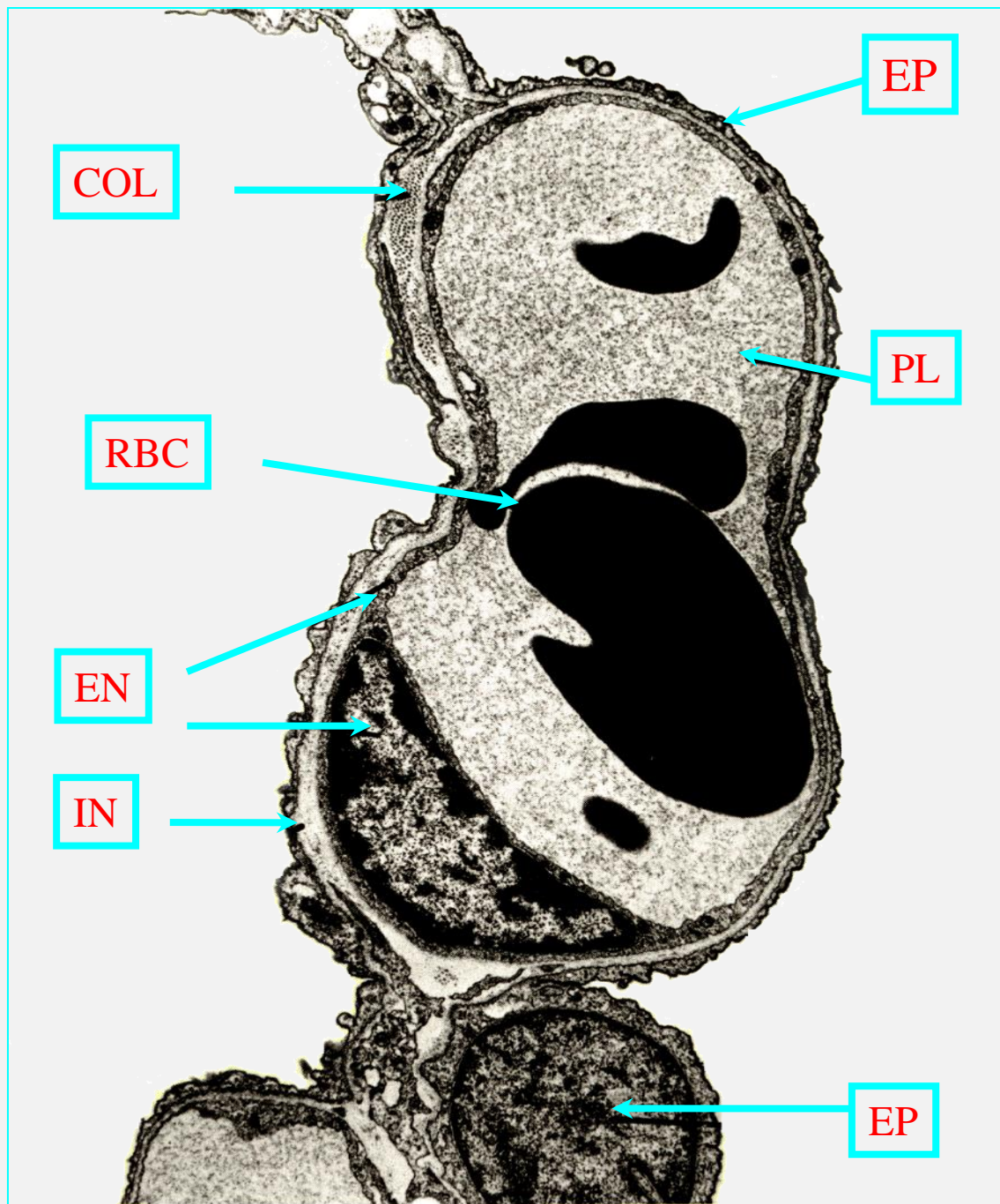
Figure 1. Flowchart summarizing the panel's recommendations. Obesity hypoventilation syndrome (OHS) may be suspected when symptoms lead to

## CASE 3

- A 75-year-old woman complains of dyspnea and fatigue. She had been fully active until 6 months ago. She notes gradual progression of her symptoms and can identify no precipitating event.
- She denies cough, sputum production, wheezing, chest pains, or hemoptysis.
- She smokes approx. 1/4 pack of cigarettes/day
- Her physical examination is normal
- Her chest X-ray is normal.
- PFTs show an isolated reduction of DLCO. She does not desaturate on a walk test.

### CASE 3: WHAT IS THE MOST LIKELY EXPLANATION FOR HER LOW DL<sub>CO</sub>?

- 
1. Anemia
  2. Emphysema
  3. Multiple, recurrent pulmonary emboli
  4. Primary pulmonary hypertension
  5. Atrial septal defect with left-to-right shunt



# ELECTRON MICROGRAPH ALVEOLAR WALL

EP= EPITHELIUM  
COL= COLLAGEN  
PL= PLASMA  
RBC= RED BLOOD CELL  
EN= ENDOTHELIAL CELL  
IN= INTERSTITIUM

## LOW DLCO

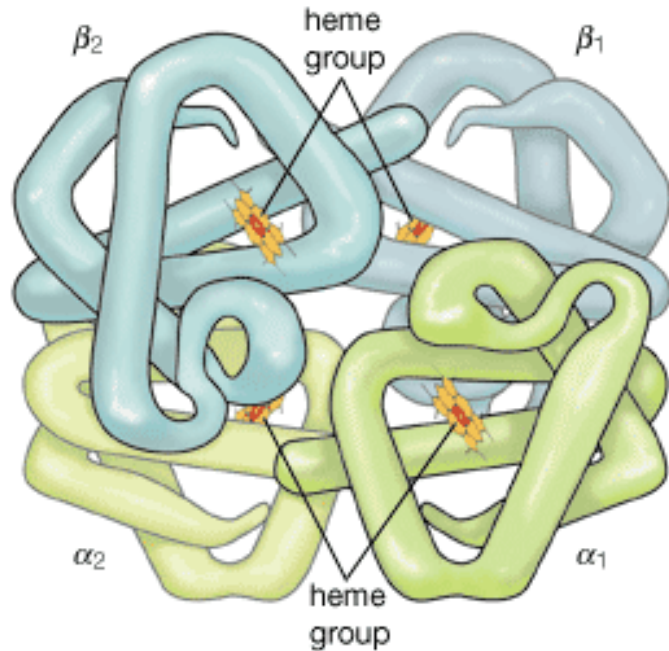
- Thickening of the alveolar-capillary membrane (e.g., interstitial lung disease)
- Destruction of alveolar-capillary membrane (e.g., emphysema)
- Pulmonary vascular obstruction/obliteration
- Decreased pulmonary capillary blood volume (e.g., right-to-left shunt)

## LOW DLCO but normal when corrected for Hb or volume

- Anemia
- Carboxyhemoglobinemia
- Reduced lung volume (e.g., surgical resection) ( $DL_{CO}$  but normal  $DL_{CO}/V_A$ )

## INCREASED DLCO

- Blood in the alveolar spaces (e.g., diffuse alveolar hemorrhage)
- Increased pulmonary capillary blood volume (e.g., acute pulmonary edema, left-to-right shunt)

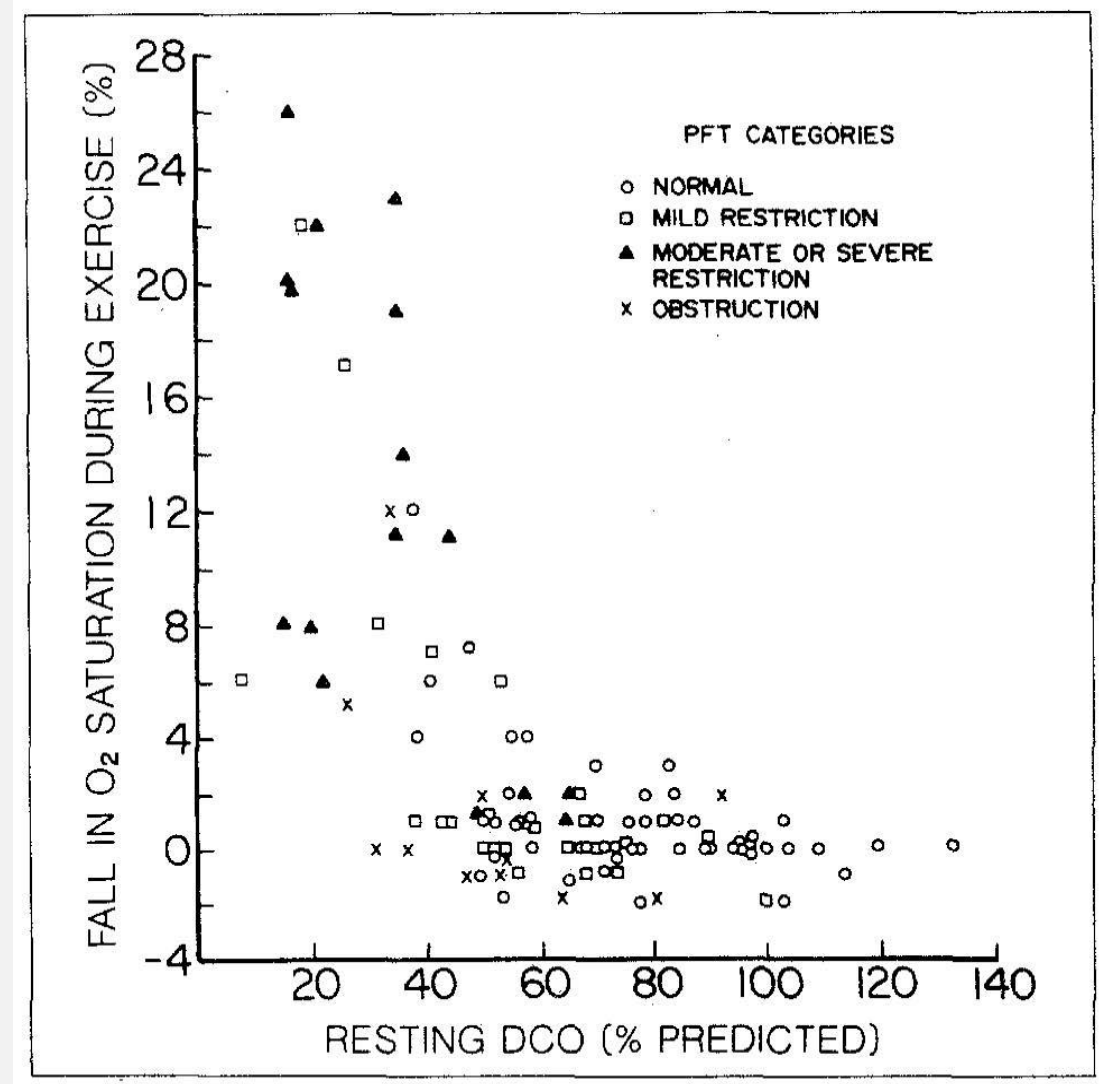


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### PEARL 3: CAUSES OF LOW $DL_{CO}$ IN THE ABSENCE OF CARDIOPULMONARY DISEASE

- Anemia is a cause of low  $DL_{CO}$  if the test results are not corrected for hemoglobin concentration. Similarly, cigarette smoking immediately before testing (and other causes of carboxyhemoglobin) can cause a low  $DL_{CO}$  in the absence of cardiopulmonary disease.
- The absence of oxygen desaturation with exercise argues strongly against diffuse parenchymal lung disease and extensive pulmonary vascular disease

# RELATIONSHIP BETWEEN $DL_{CO}$ AND OXYGEN SATURATION WITH EXERTION





## CASE 4

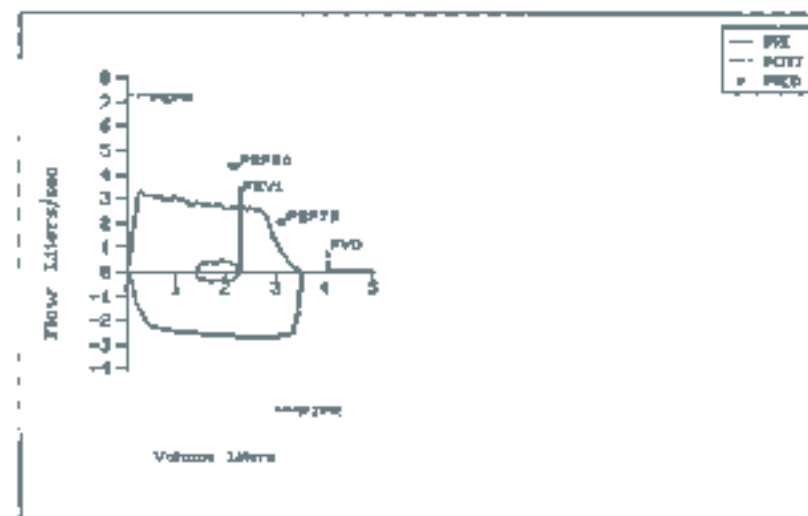
- A 23-year-old woman presents with shortness of breath and wheezing which has not improved with bronchodilators and inhaled corticosteroids.
- She reports asthma of 2 years duration, progressively worsening over the last 6 months. Her breathing is labored, particularly at night; and her husband reports hearing loud wheezing from her chest when she sleeps. She is short of breath after climbing 1 flight of stairs
- Her medications include high-dose inhaled steroids, a long-acting inhaled beta-agonist bronchodilator, and a leukotriene receptor antagonist. A two-week course of oral corticosteroids brought only minimal benefit.
- Physical examination reveals inspiratory and expiratory wheezing

Brigham and Women's Hospital  
 75 Francis St., Boston MA 02115 (617) 732-7424  
 Medical Director: EDUARDO R. INGEMITO, MD

Height: 70 in  
 Weight: 130 lb

Sex: F  
 Age: 24  
 Race: M

Date: 09/12/2000  
 Physician: Fanta



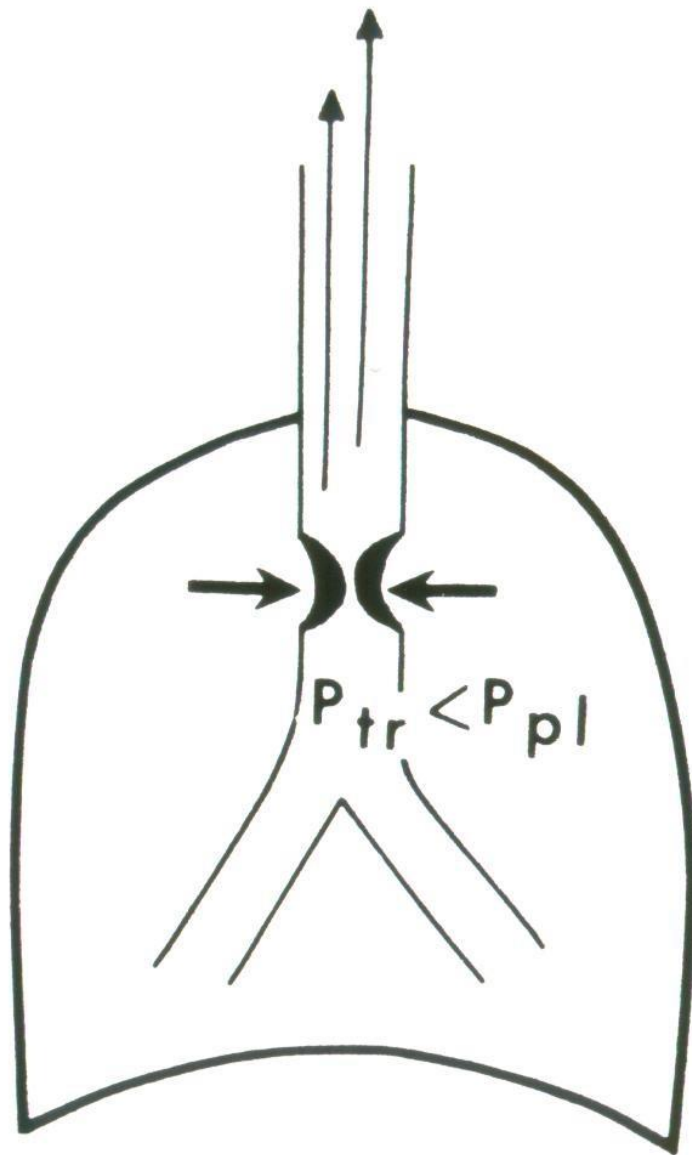
### SPIROMETRY (BTPS)

		<i>Pre Bronchodilator</i>		<i>Predicted Range</i>	
		<i>Actual</i>	<i>%Pred</i>	<i>Mean</i>	<i>95% CI</i>
FVC	(Lts)	3.42	80	4.27	3.46
FEV1	(Lts)	2.39	66	3.61	2.97
FEV1/FVC	(%)	70	82	85	76
FEF25-75	(L/s)	2.46	61	4.02	
PEFR	(L/s)	2.80	38	7.38	
FET	(Secs)	6.25			

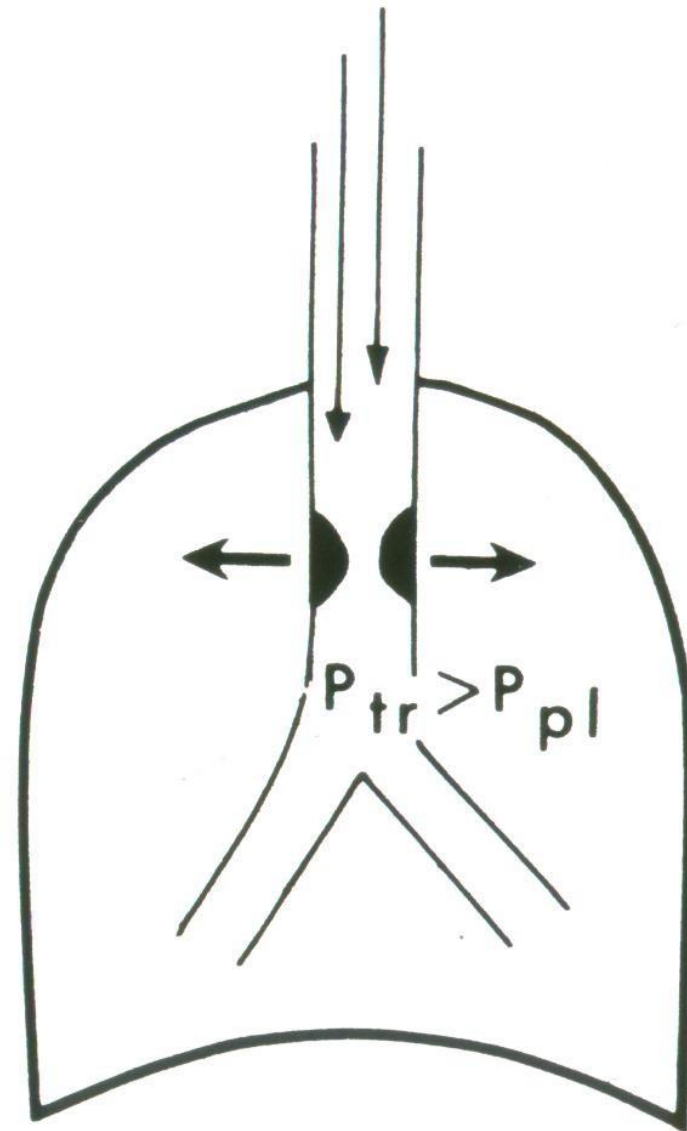
## WHAT IS THE MOST LIKELY EXPLANATION FOR HER REFRACTORY ASTHMA?

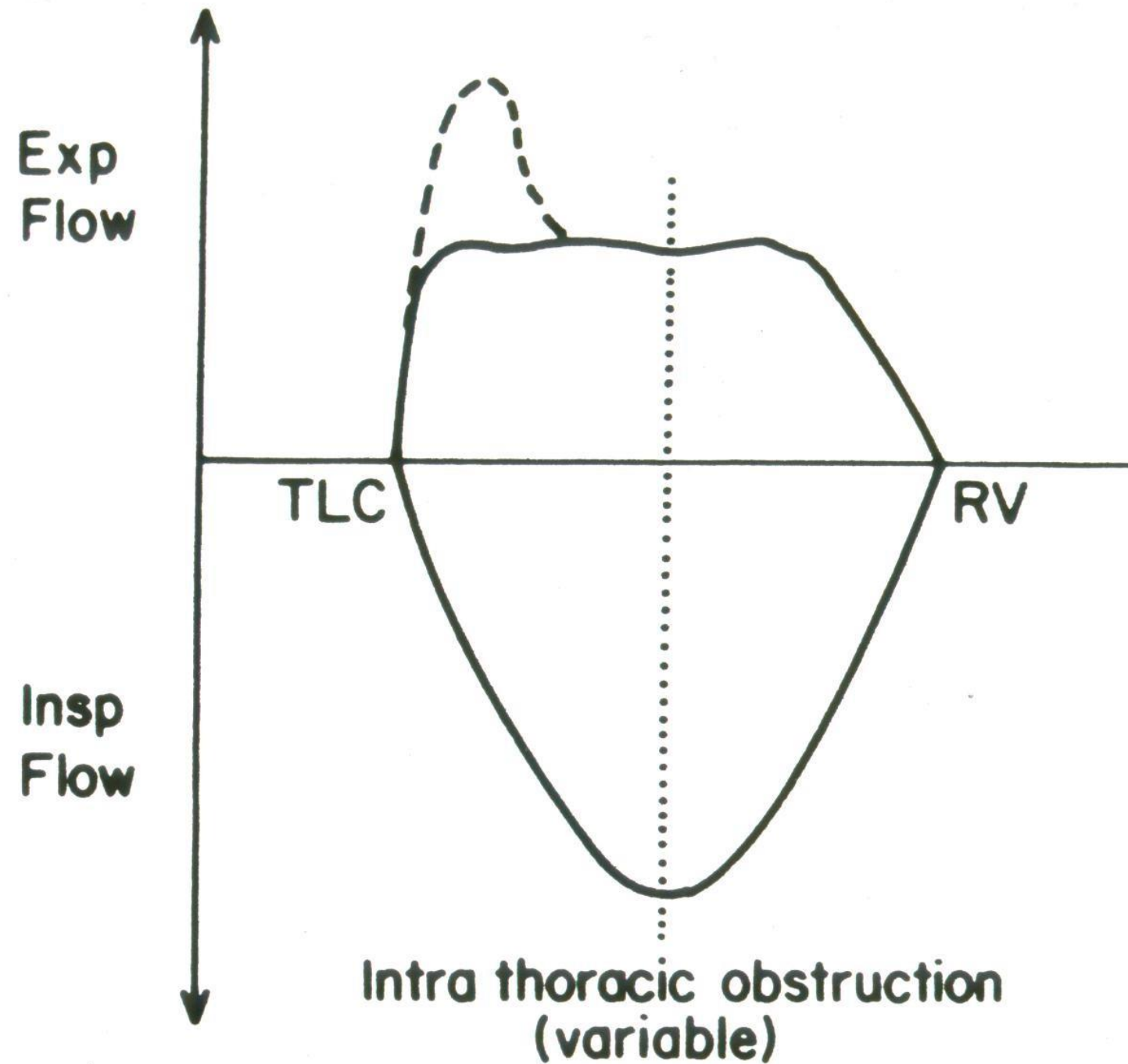
1. Gastroesophageal reflux
2. Allergen exposure in the bedroom
3. Occupational asthma with continued work-related exposure
- ➔ 4. Upper airway obstruction mimicking asthma
5. Sinusitis

expiration

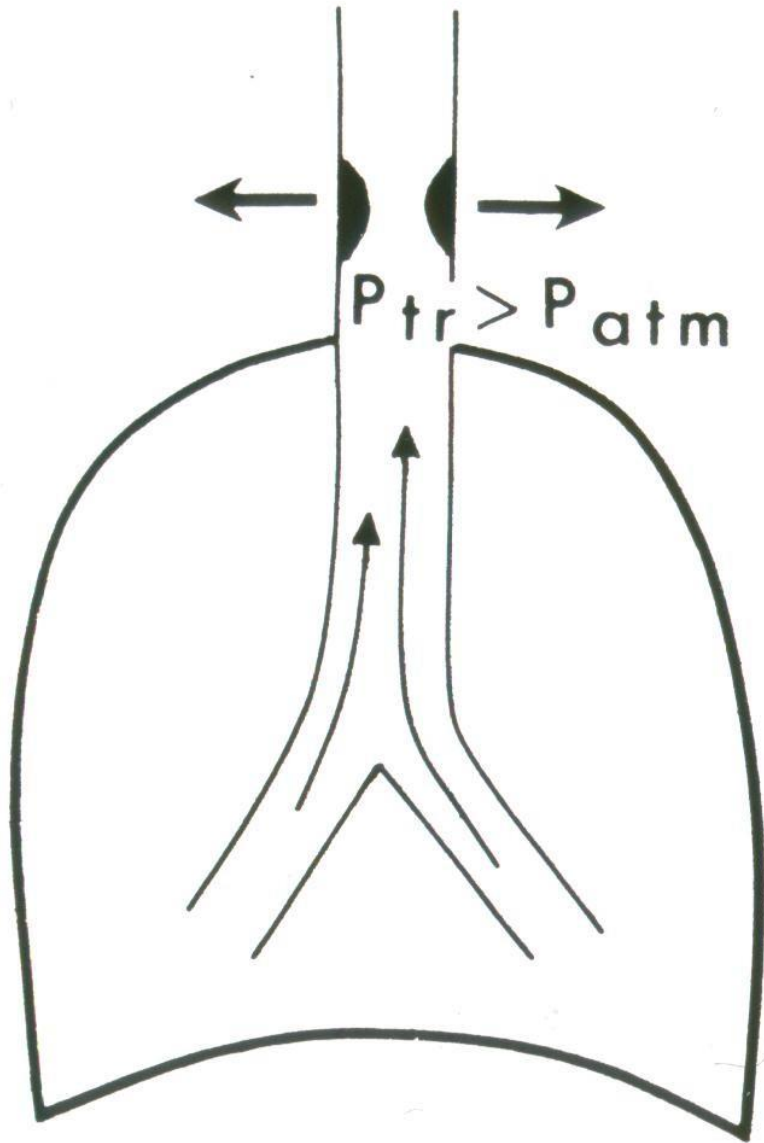


inspiration

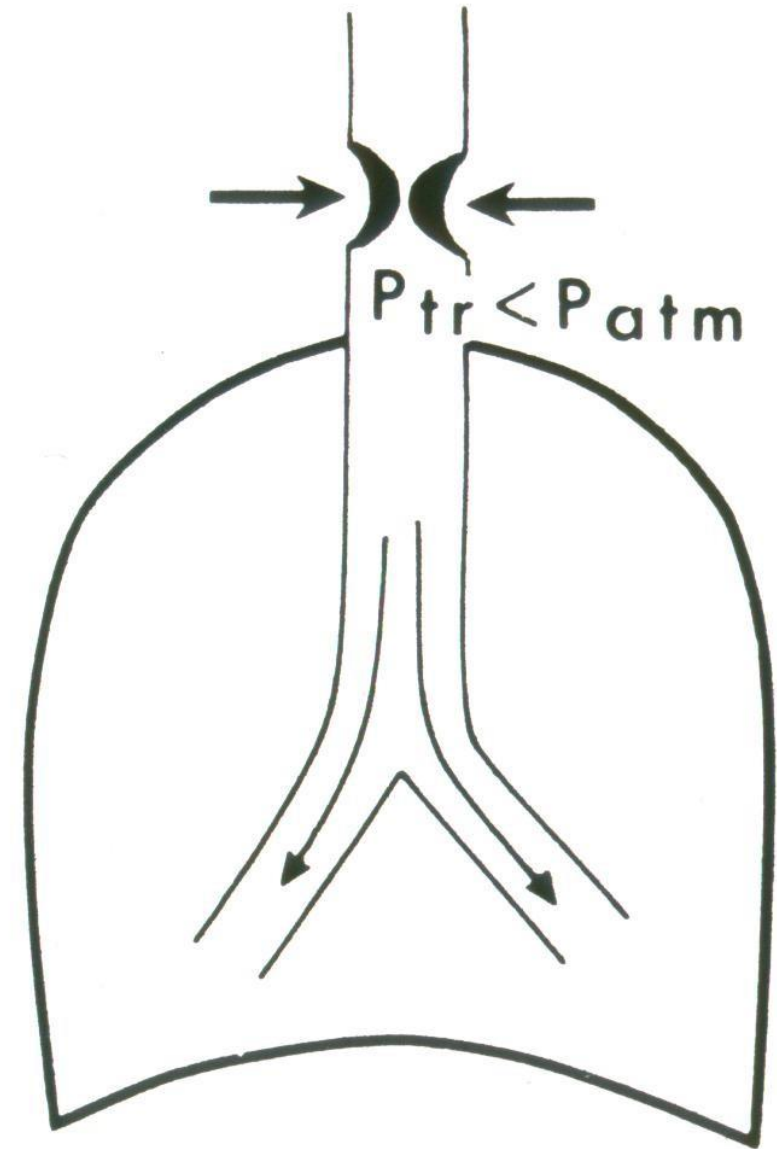


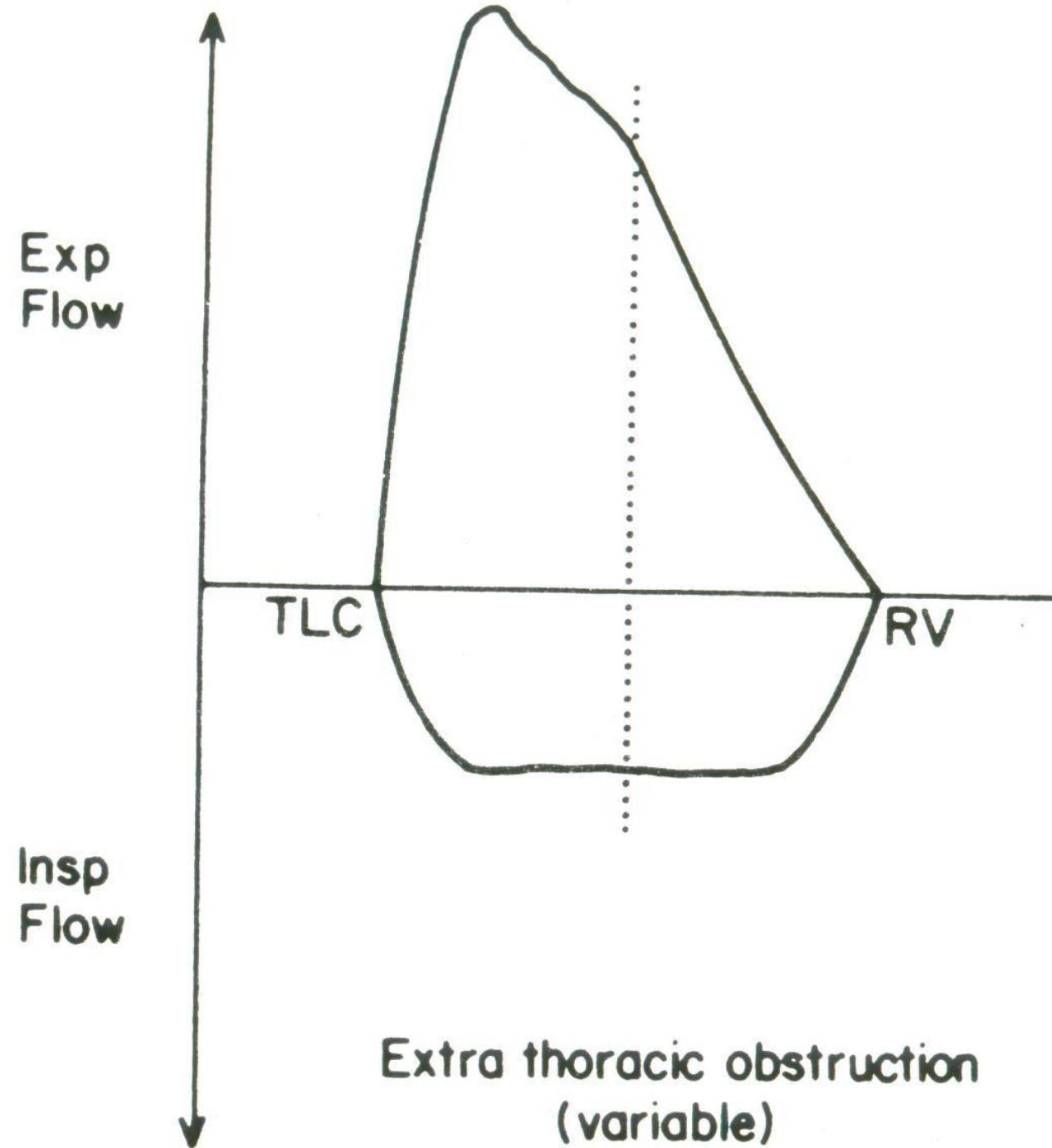


expiration

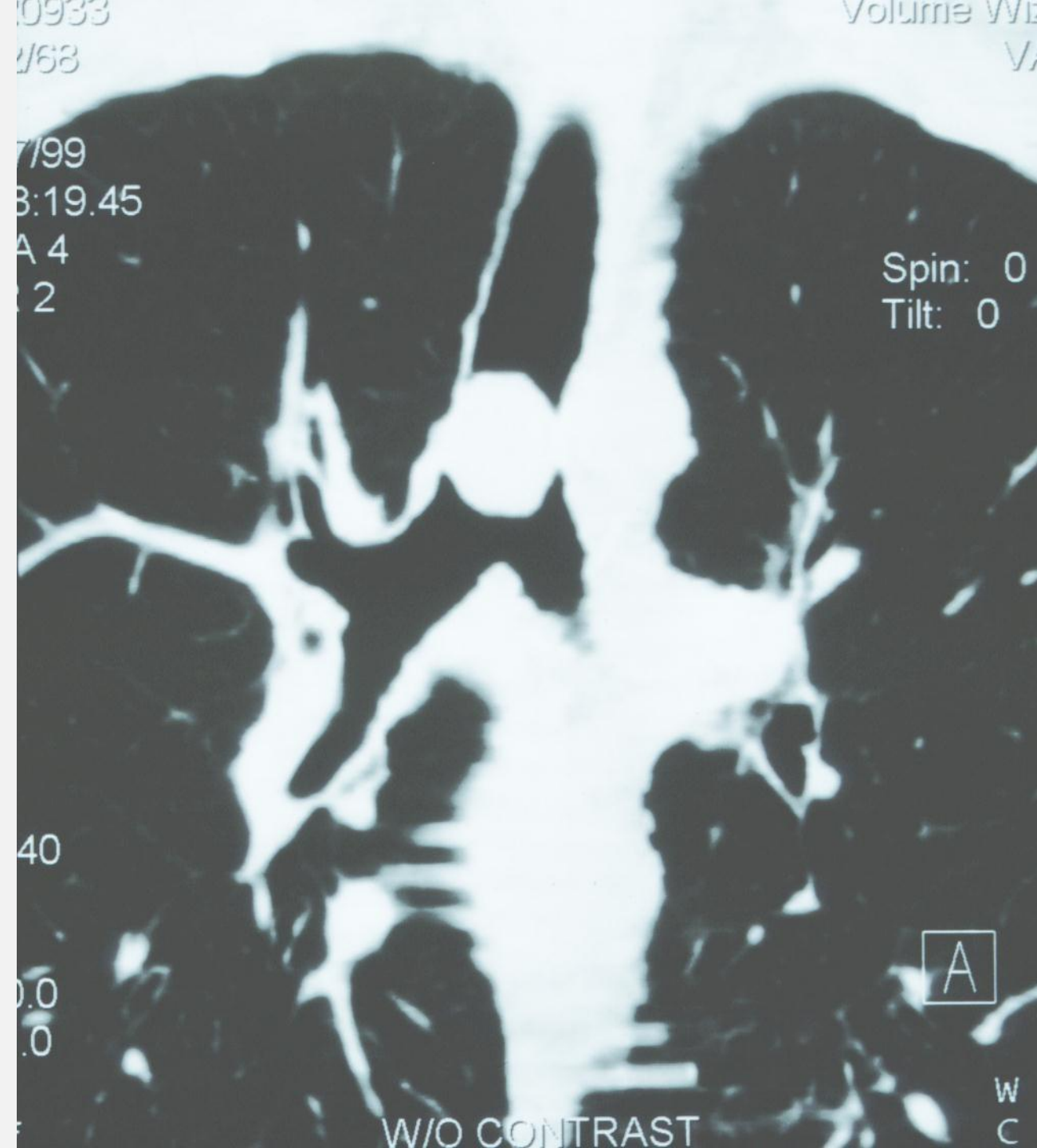


inspiration





PEARL 4: EXAMINATION  
OF THE FLOW-VOLUME  
CURVE CAN PROVIDE A  
CLUE TO THE ETIOLOGY  
OF OBSTRUCTIVE  
PULMONARY DISEASE





PEARL 4A: EXERCISE-INDUCED  
BRONCHOCONSTRICTION SHOULD BE  
DISTINGUISHED FROM DYSPNEA ON EXERTION

PEARL 4B: FAILURE TO RESPOND TO HIGH DOSE STEROIDS  
SHOULD SUGGEST AN ALTERNATIVE DIAGNOSIS AS  
STEROID REFRACTORY ASTHMA IS VERY RARE

## TAKE HOME POINTS

- Respiratory muscle weakness can present as orthopnea with restrictive PFTs and abdominal paradox on physical exam.
- Hypoxemia secondary to hypoventilation presents with a normal A-a gradient and corrects with voluntary hyperventilation.
- Anemia is a common cause of both dyspnea and isolated low diffusion on pulmonary function testing.
- The flow volume loop can provide valuable clues to the etiology of dyspnea.

## REFERENCES

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