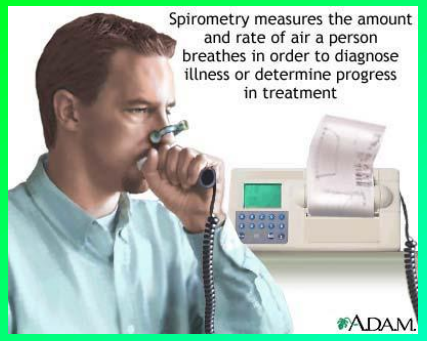
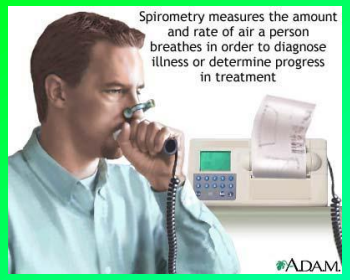



# Pulmonary Function Tests

## Spirometry



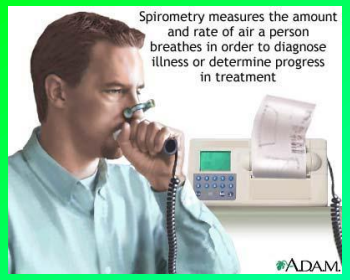

# COPD

- The most common respiratory disease
- One of the leading causes of death in the United Sates

***Spirometry*** is the preferred test for the diagnosis of COPD...

... the results must be correlated carefully with clinical and rentgenographic data for optimal clinical application.

(Barreido TJ, Perillo I: An Approach to Interpreting Spirometry, AmFamPhysician2004;69)




The maneuver may be performed

- in **a forceful manner** to generate

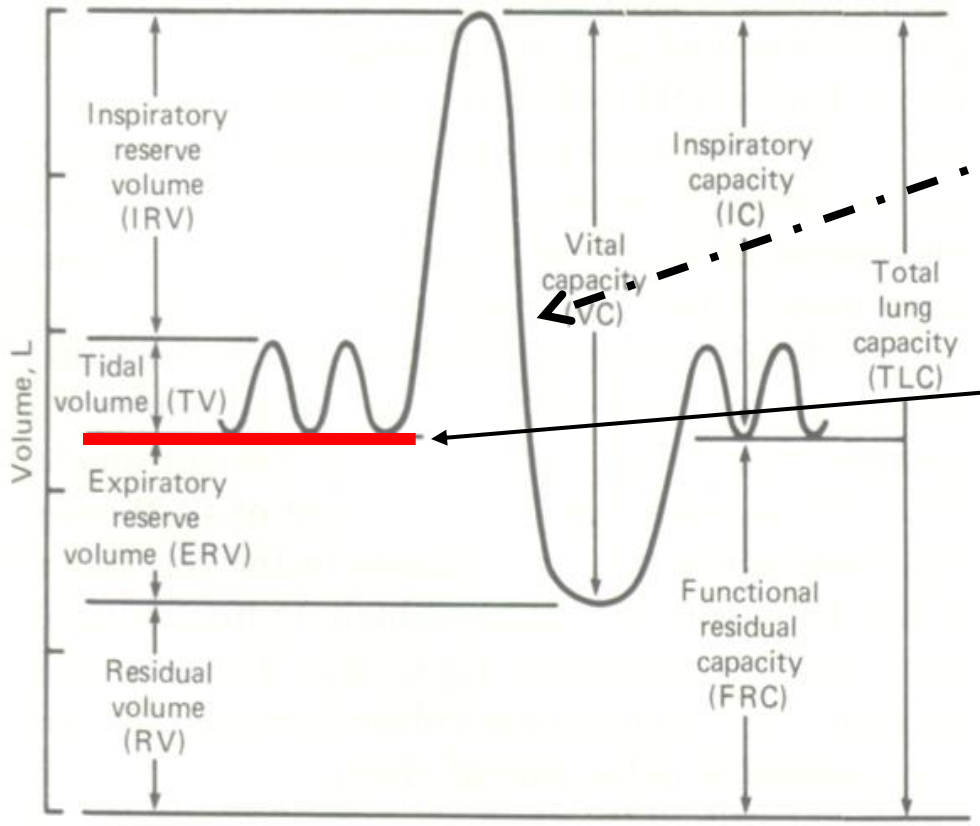
  a forced vital capacity (**FVC**)

- in **a more relaxed manner** to generate

  a slow vital capacity (**SVC**)

# (Slow) VITAL CAPACITY TEST

VC - Maximum volume of air expired from the point of maximum inspiration




VC EXP

Resting - end expiratory level

**Figure 19-1** The subdivisions of the lung volume. The term *capacity* is applied to a subdivision composed of two or more *volumes*. The definitions of these subdivisions are found in Table 19-1.

***MEASUREMENT OF RV (FRC, TLC)***

***- impossible by a direct method /spirometry/!***

***MEASUREMENT OF RV (FRC, TLC) -***

***INDIRECT !***

***(Closed-Circuit Helium Method)***

# Is the test normal?

- **Effects of physical characteristics:**

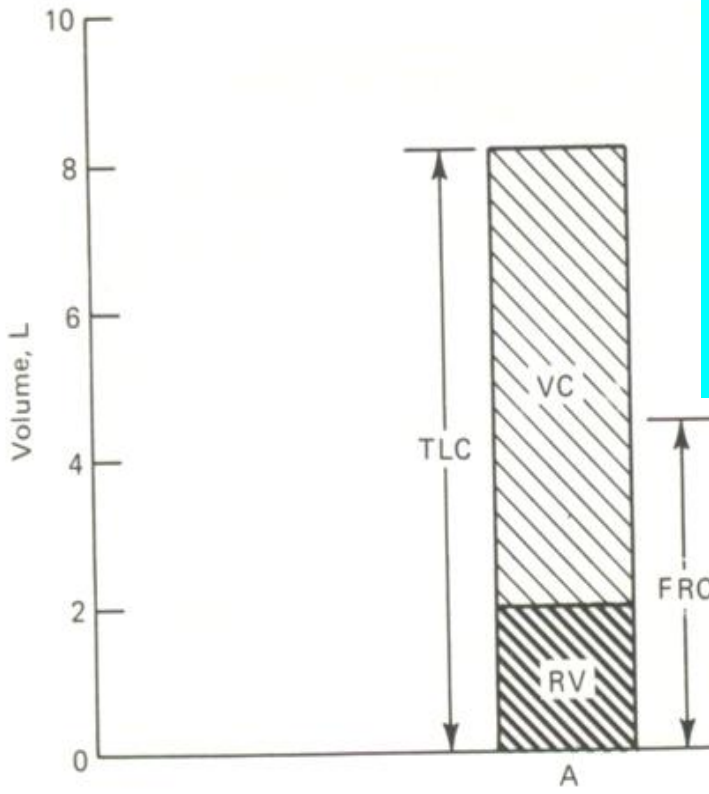



**Figure 19-7** The combined effects of height, age, and sex on lung volumes. *A*. Male, 190 cm (75 in) tall, 20 years old; VC = 6.20 L, FRC = 4.50 L, RV = 2.00 L, TLC = 8.20 L. *B*. Female, 150 cm (59 in) tall, 70 years old; VC = 1.90 L, FRC = 1.96 L, RV = 1.40 L, TLC = 3.30 L.

- **Sex**
- **Age**
- **Height**
- **Weigh**

- **Sporting activity**

**Is the Test Normal ?**

***Parameters <u>below</u> the Lower Limits of Normal (LLN)***

***indicate a possible lung disease***

What is LLN?

Fixed value for the lower limit of normal

80% of predicted

**(F)VC ≥ 80% of predicted - Normal**

# Restrictive Pattern

A restrictive disease is like a lock on the chest cage

or the elastic tissue of the lungs,

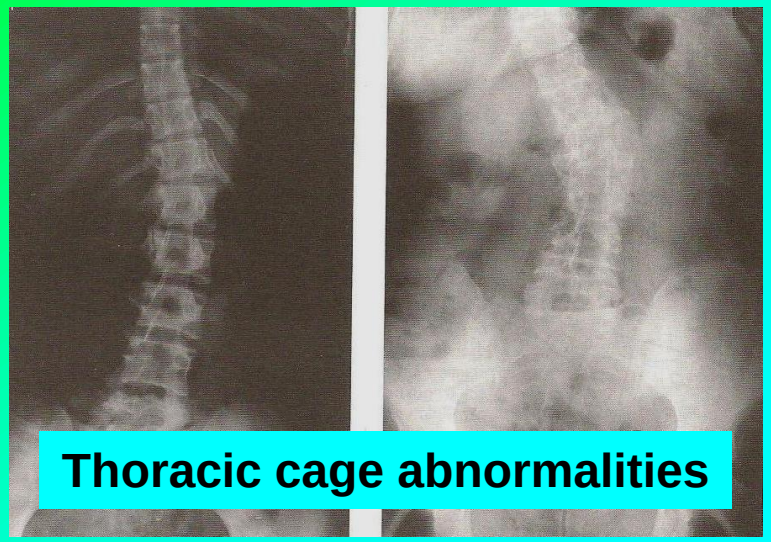
which limits the expansion of the lung,

thus interferes with respiration

It does not increase and may even decrease the airway resistance,
but limits the lung volume from increasing

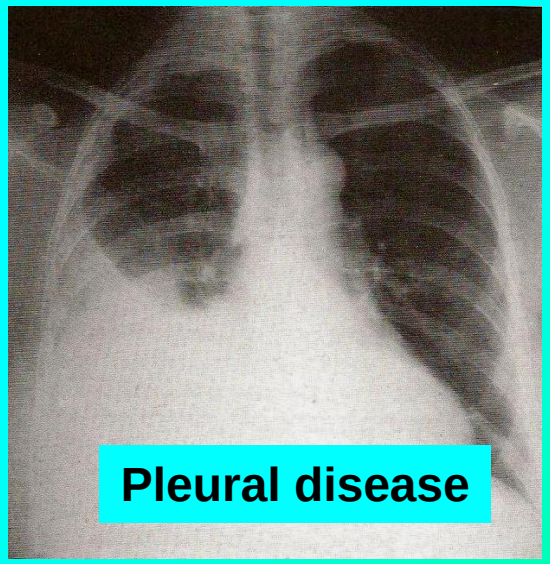
# Restrictive Pattern

## ↓ ability of the lungs to expand

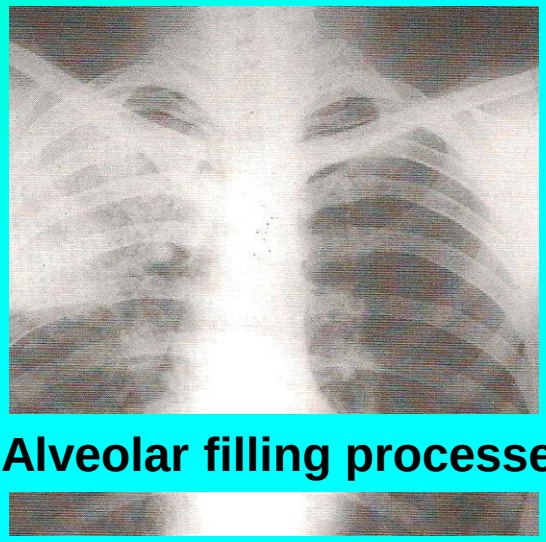


**Thoracic cage abnormalities**

**Neuromuscular involvement of the respiratory muscles**

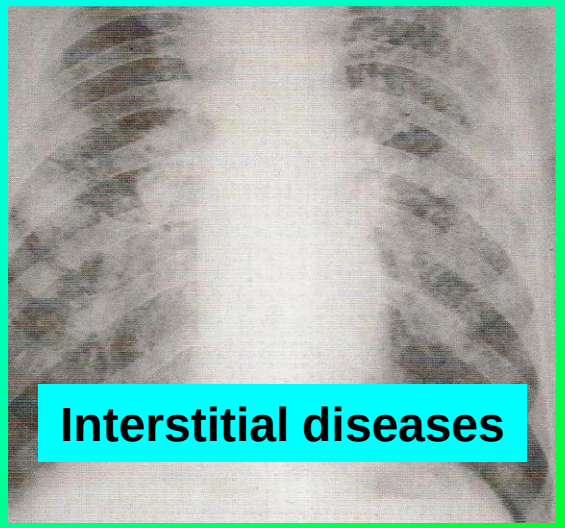


**Pleural disease**



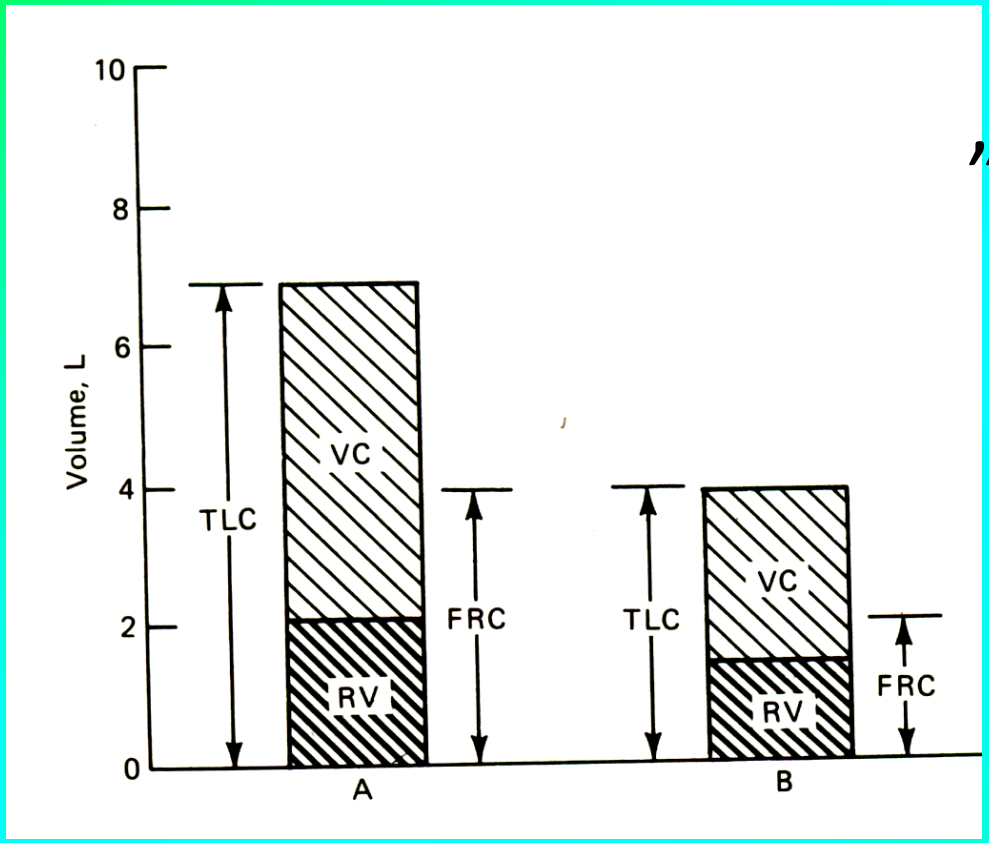
**Alveolar filling processes**

- ↓ amount of normally ventilated lung tissue
- ↓ compliance



**Interstitial diseases**

# Restrictive Pattern:




Restrictive pattern

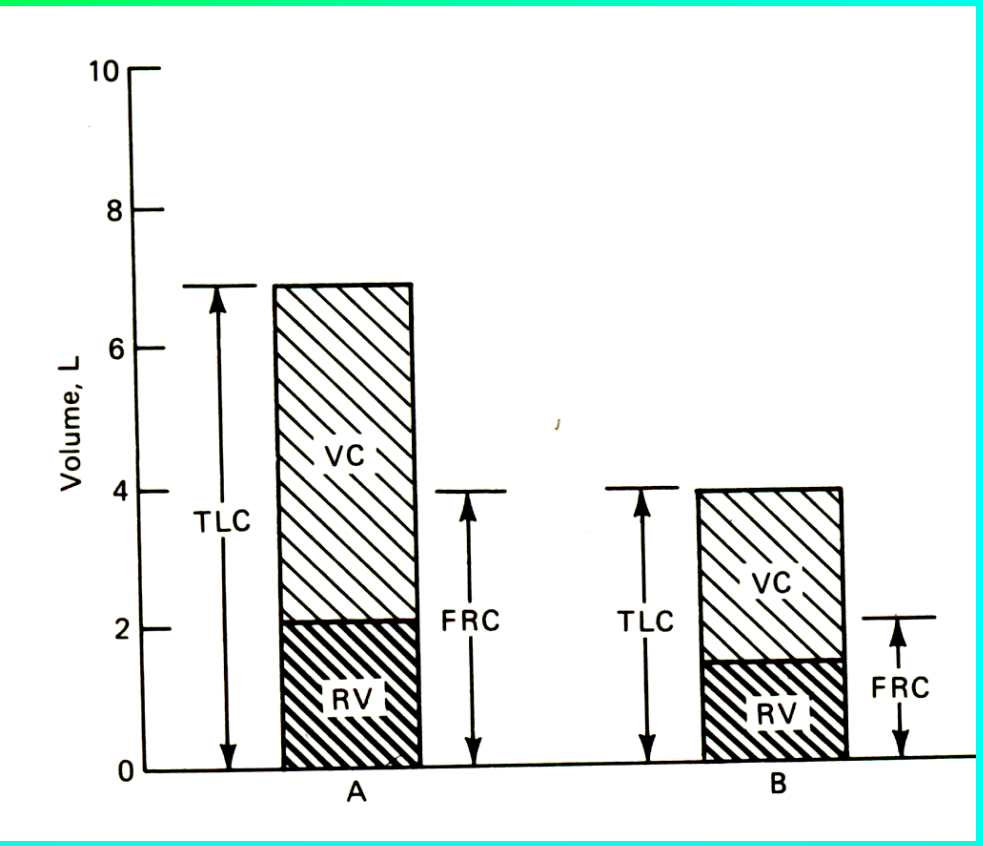
„less air in the lungs”

**VC ?**

**RV ?**

**FRC ?**

**TLC ?**



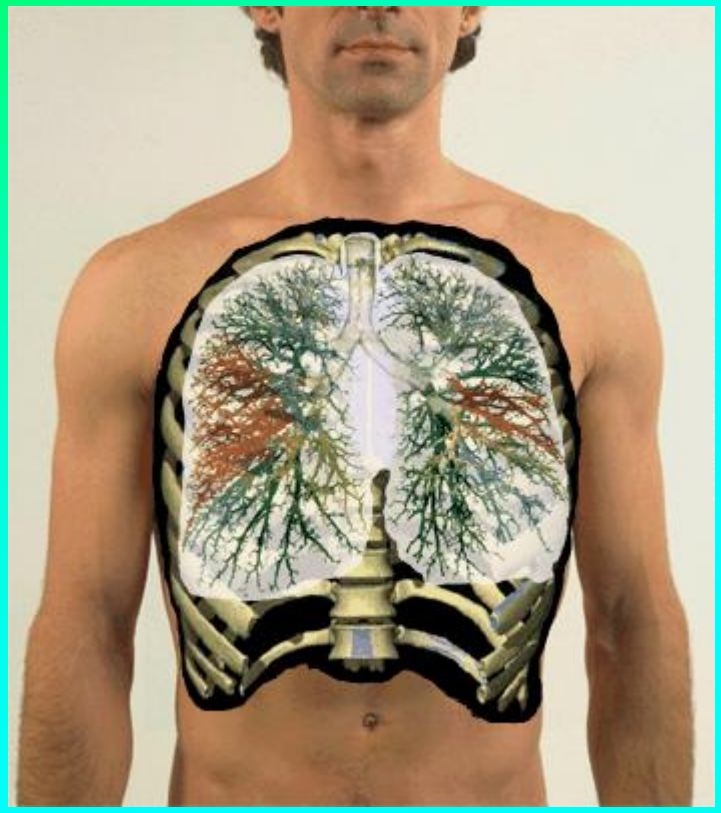

# Restrictive Pattern

- Always reduced VC

Confirmed by

- Always reduced TLC

# Obstructive Pattern

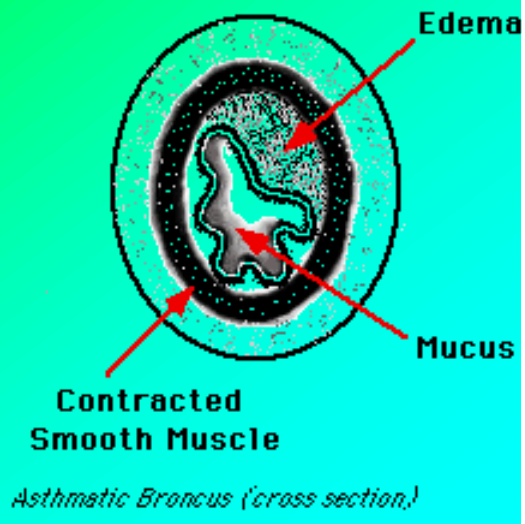


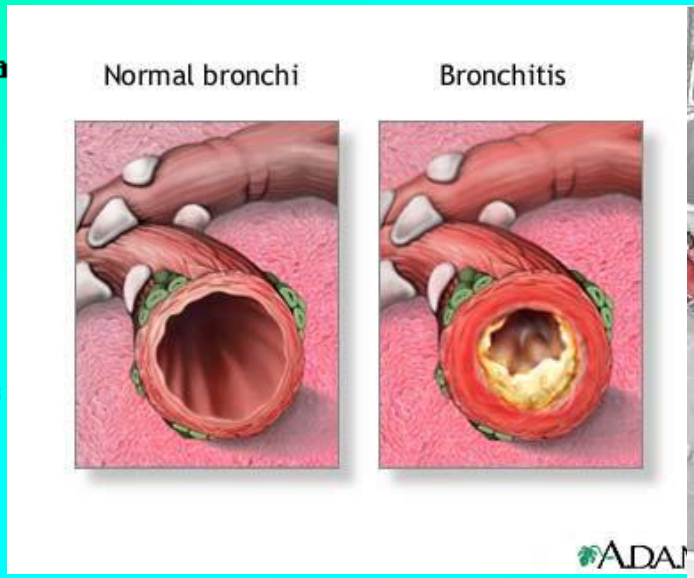
Narrowing of lumen of the airways

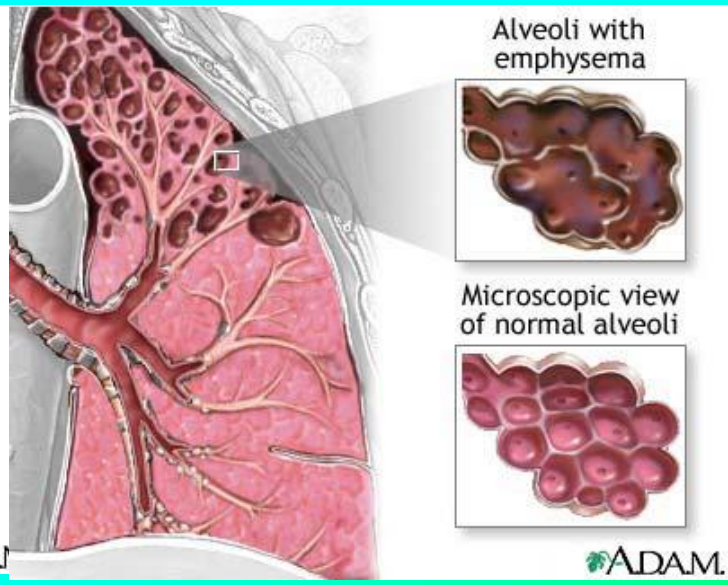
- *↑airway resistance*
- *↓flow rate*

# Obstructive Pattern

- ***↑ airway resistance***
- ***↓ rate at which air can move through the lungs***




**Asthma** **Chronic bronchitis** **Emphysema**

**COPD**

***(Obstruction of lower airways)***


# COPD

## CHRONIC AIRFLOW LIMITATION

"EMPHYSEMA AND CHRONIC BRONCHITIS"

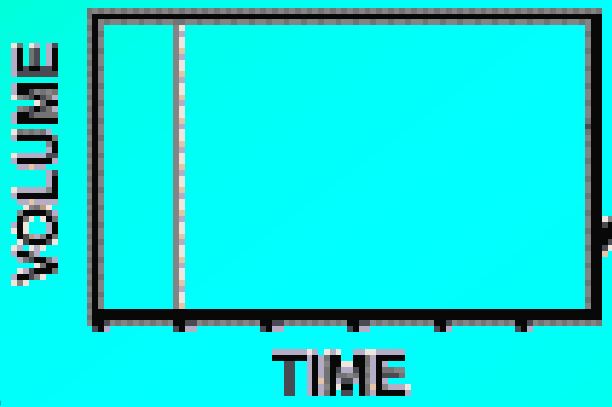
- Easily Fatigued
- Frequent Respiratory Infections
- Use of Accessory Muscles to Breathe
- Orthopneic
- Wheezing
- Pursed-Lip Breathing
- Chronic Cough
- Barrel Chest
- Dyspnea
- Prolonged Expiratory Time
- Bronchitis - Increased Sputum
- Digital Clubbing
- Cor Pulmonale (Late in Disease)
- Thin in Appearance

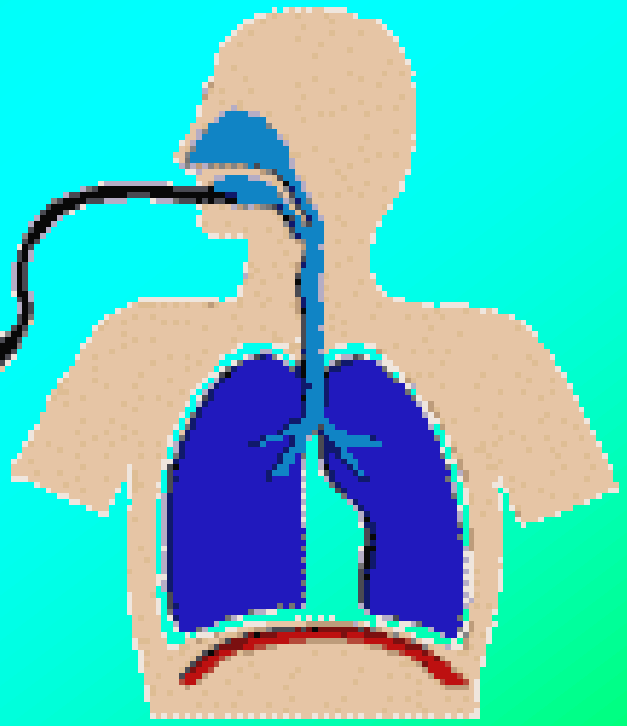


*Rapid and forced breathing accentuates the airway narrowing !*

# FORCED (Expiratory) VITAL CAPACITY TEST

***determines airway resistance, detects airway obstruction***



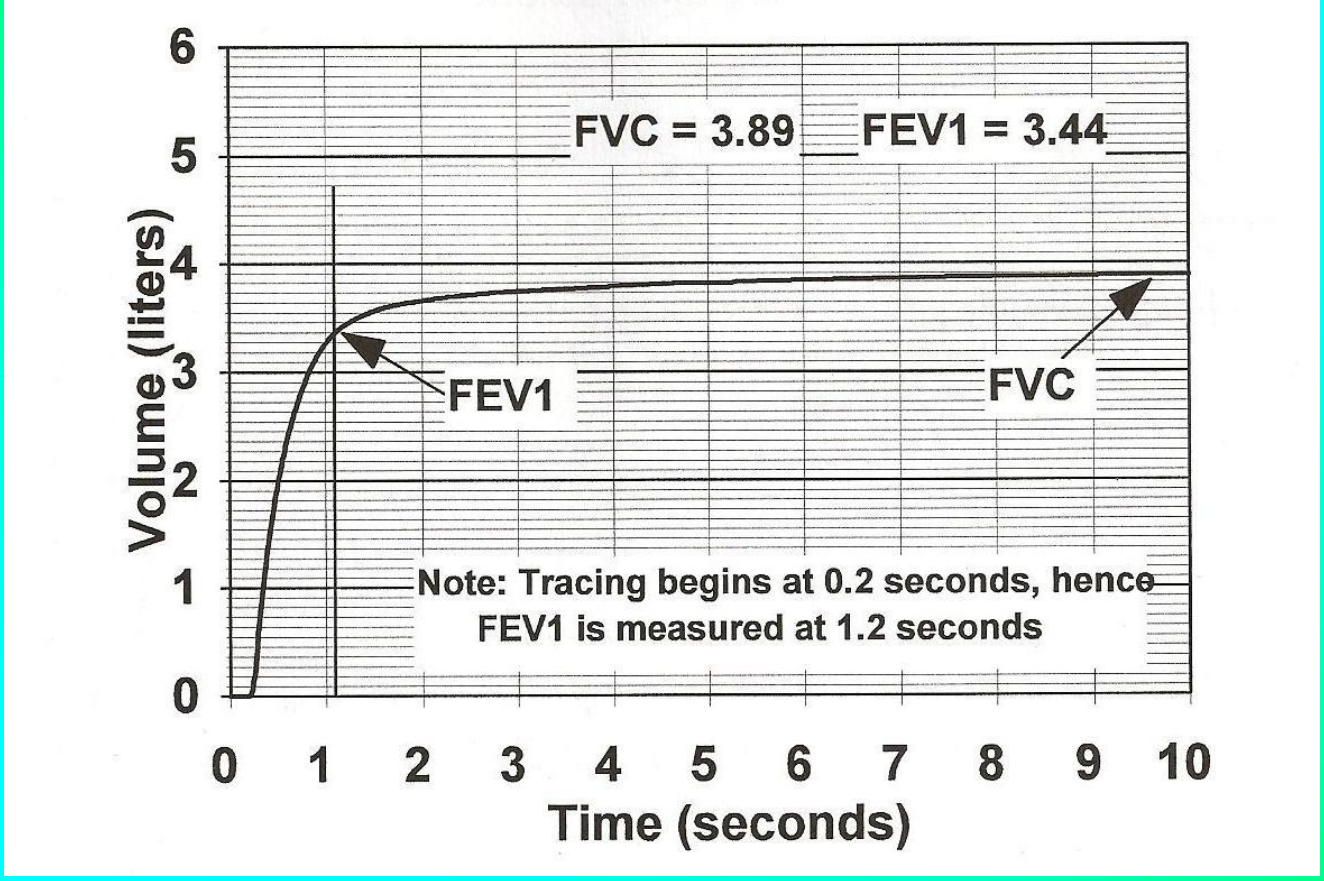
**A VOLUME /TIME CURVE**

- **A fast rise**
- **A plateau at the end**

**Expiration (which follows the maximum inspiration)**

**as forced, fast, and deep as possible**

# A NORMAL VOLUME/TIME CURVE



**Parameters below the Lower Limits of Normal (LLN)**

**indicate a possible lung disease**

Fixed value for the lower limit of normal

**FEV1, (F)VC ≥ 80% of predicted - Normal**

- Tiffeneau Ratio - $FEV_1$ / VC

**≥ 0.7 (70%)**
**NORMAL**

- PseudoTiffeneau Ratio - $FEV_1$ / FVC

**Parameters below the Lower Limits of Normal (LLN)**

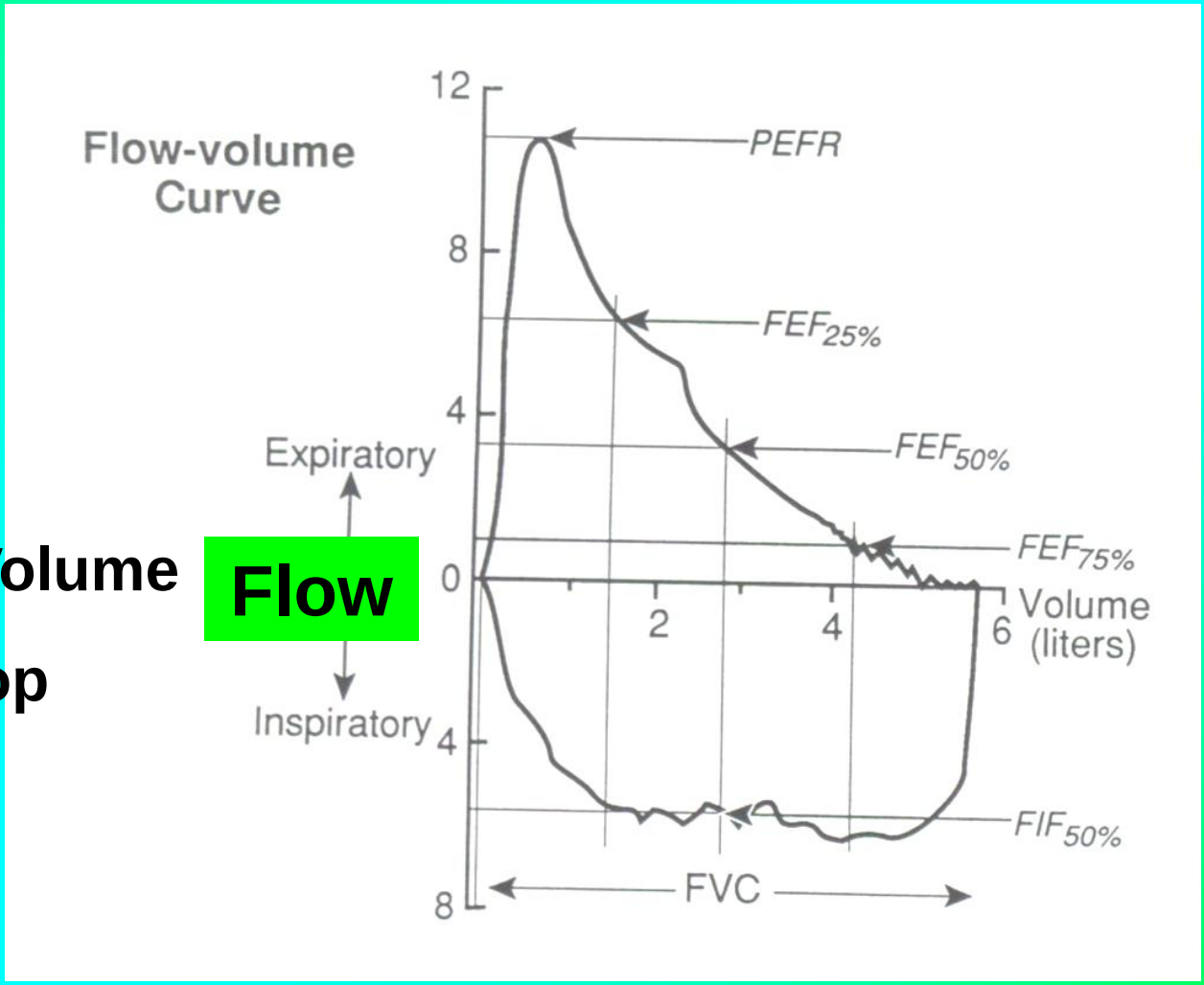
**indicate a possible lung disease**

FEV1, (F)VC ≥ 80% of predicted

FEV1/(F)VC ≥ 0.7 (70%)

# FORCED (EXPIRATORY) VITAL CAPACITY TEST

**Flow - Volume Loop**

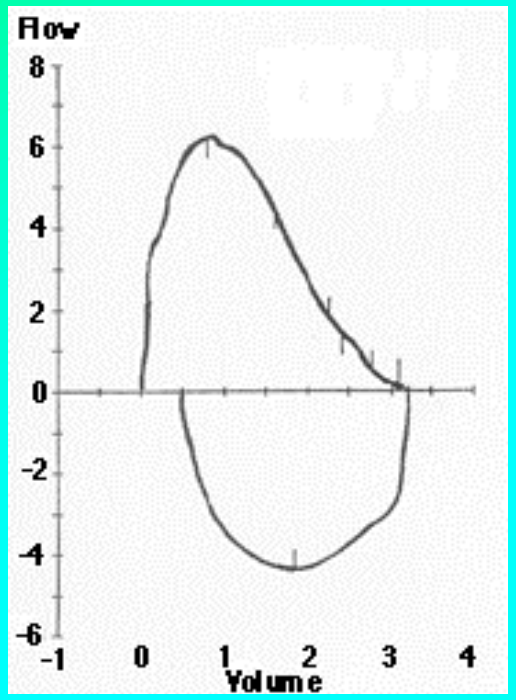


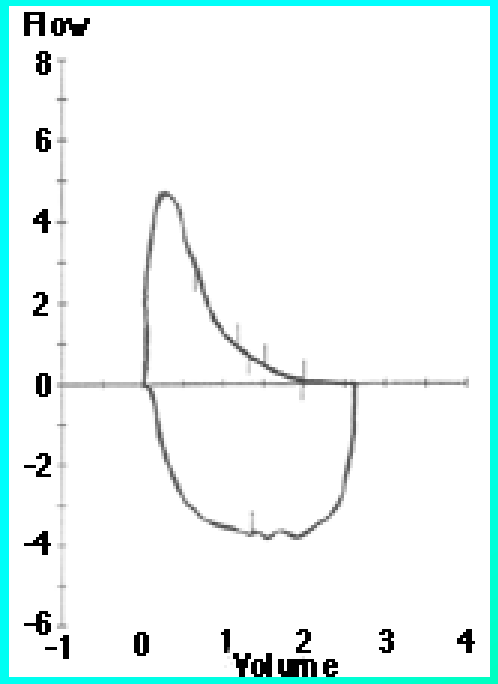
# FVC Test - Obstructive Pattern

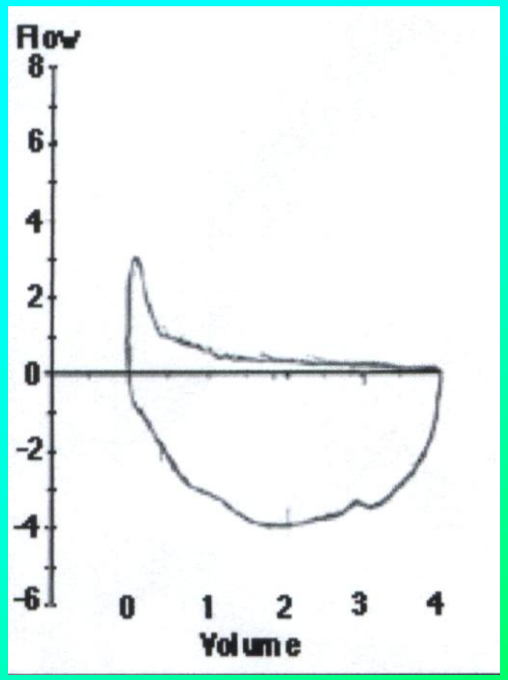
- Flow rate?

Normal

**Obstruction of lower airways**




Flow-volume loop

# Obstructive Pattern

FEV1 ?

Reduced

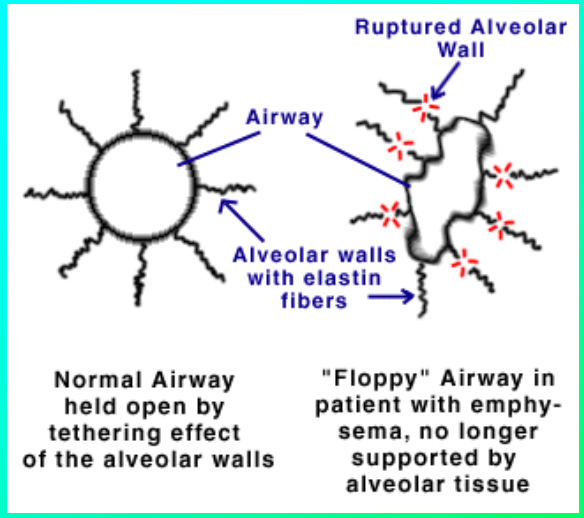
# OBSTRUCTION

**VC?**

**FVC?**

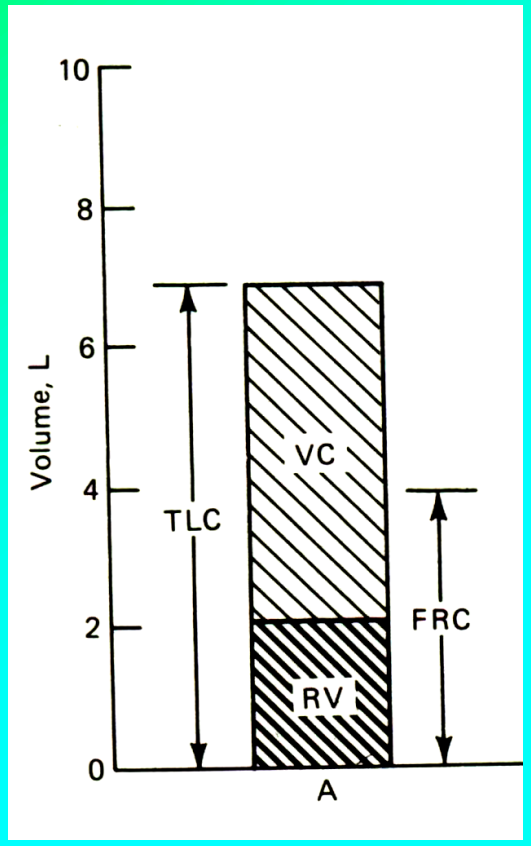
Normal

Air trapping - pseudorestriction

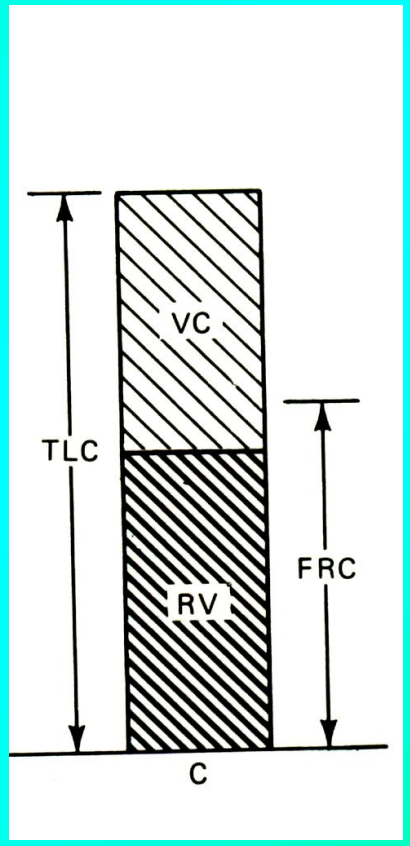



(F)VC reduced

# Obstruction - Other Volumes and Capacities




**NORMAL**




**- Air trapping:**

**↑ RV, ↑FRC, ↓ VC**

**- Hyperinflation:**

**↑ TLC**

# Obstructive Pattern

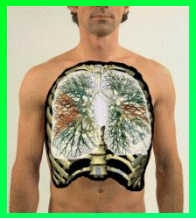
FEV1/(F)VC ?

Reduced

# FVC Test - Obstruction

- $FEV_1$ [L] - Reduced
- F(VC) [L] - Normal or Reduced

- **$FEV_1$ to (F)VC ratio – Reduced !!!**



# Forced Vital Capacity Test

# Obstructive Pattern

FIGURE 2-8. FLOW VOLUME CURVES

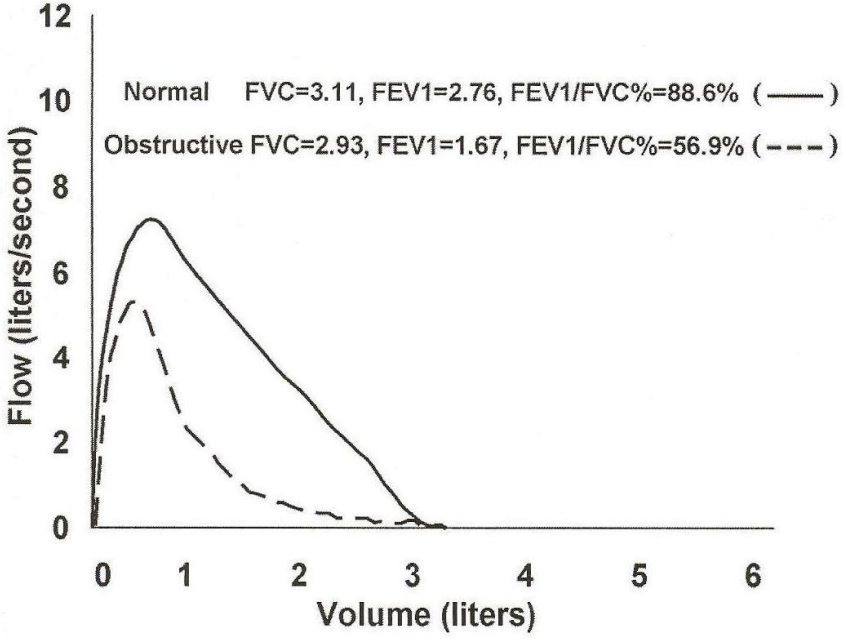
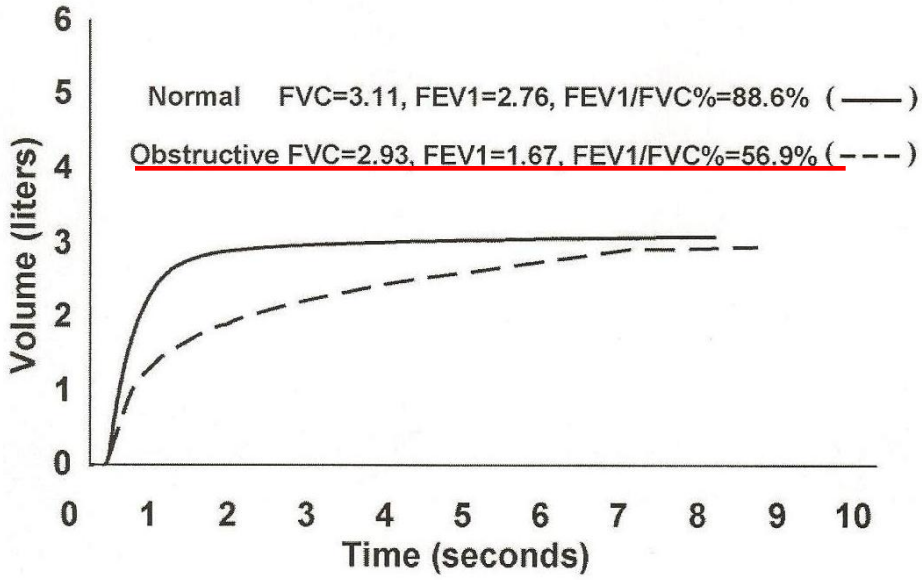
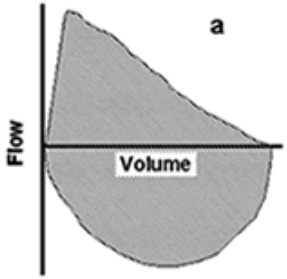



FIGURE 2-7. NORMAL AND OBSTRUCTIVE PATTERNS
VOLUME TIME CURVES

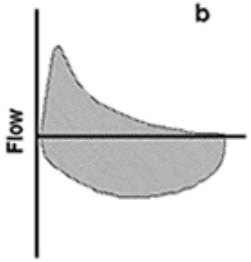



| | Pred | Actual | %Act/Pred | |
|---|---|---|---|---|
| FVC [l] | 3.11 | 2.93 | 94% | (Normal) |
| $FEV_1$ [l] | 2.76 | 1.67 | 61% | (Reduced) |
| FEV1/FVC | 0.87 | 0.57 | 64% | |
| | | | | (Reduced) |

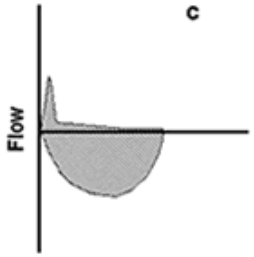
Maximum expiratory and inspiratory flow volume curves with examples of how respiratory disease can alter its shape:



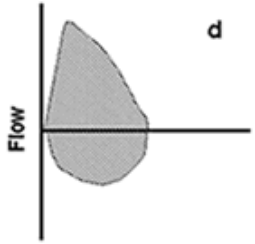

a) normal subject



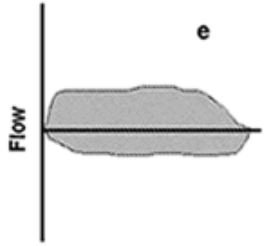

b) obstructive airway disease (e.g. asthma);




c) severe obstructive disease (e.g. emphysema)

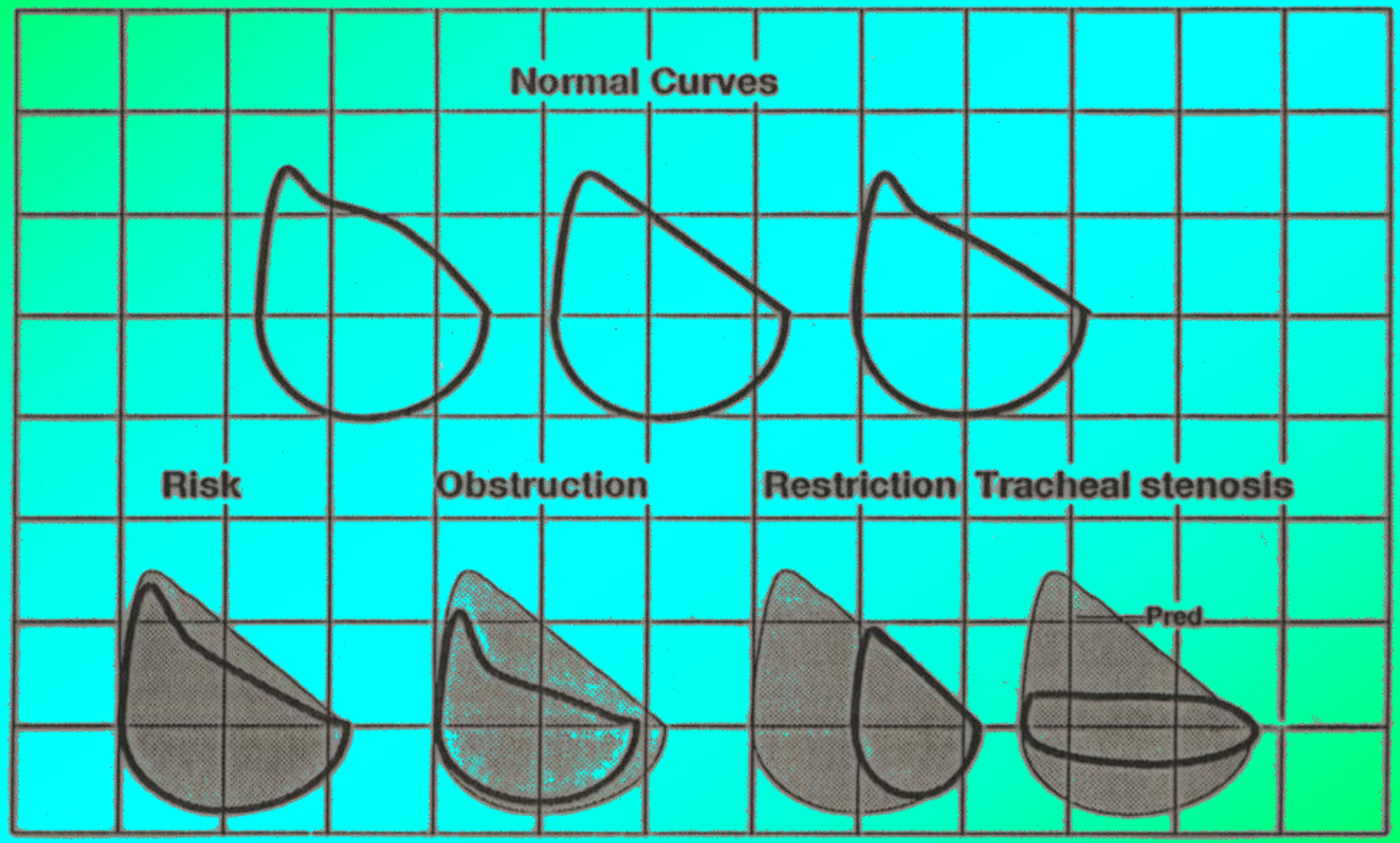



d) restrictive lung disease (e.g. pulmonary fibrosis)




e) fixed major airway obstruction (e.g. carcinoma of the trachea).

## Typical Flow-Volume Curves



# Obstruction Of Upper Airway, Trachea, Large Bronchi -

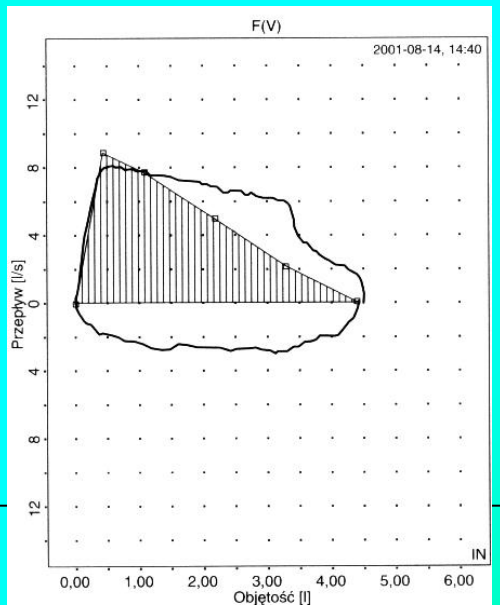
## less common , can be suggested by spirometry

## ***Variable***

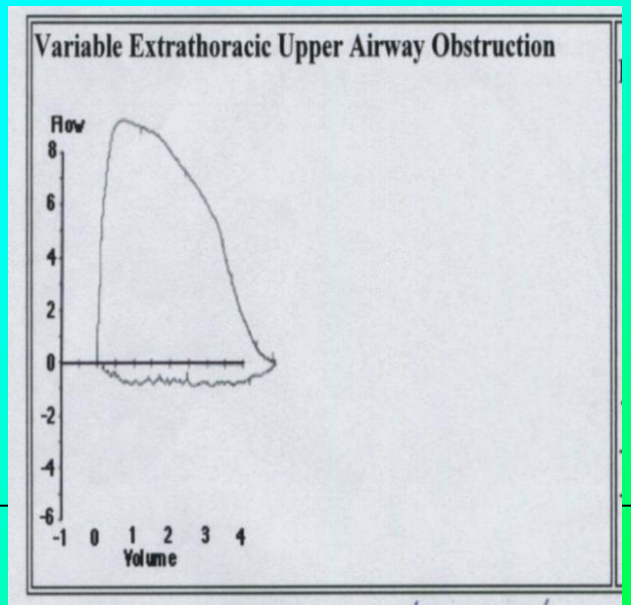
**(airflow is compromised by dynamic changes in airway diameter)**

| | ***Intrathoracic*** | ***Extrathoracic*** |
|---|---|---|
| ***Reasons*** | ***Tracheomalacia Neoplasm*** | ***Vocal cords paralysis, Thyromegaly Tracheomalacia Neoplasm*** |

## ***Flat expiration***




## **Flat inspiration**



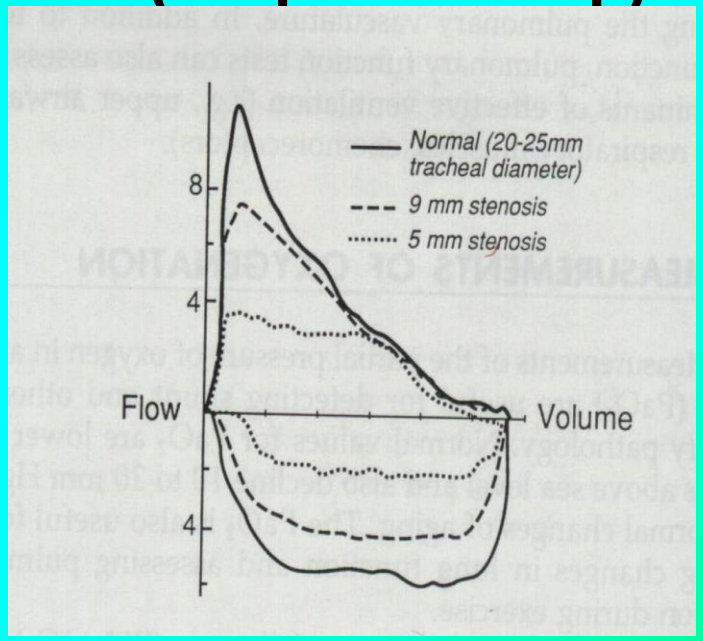
## Obstruction Of Upper Airway, Trachea, Large Bronchi -

## less common , can be suggested by spirometry

# ***Fixed***

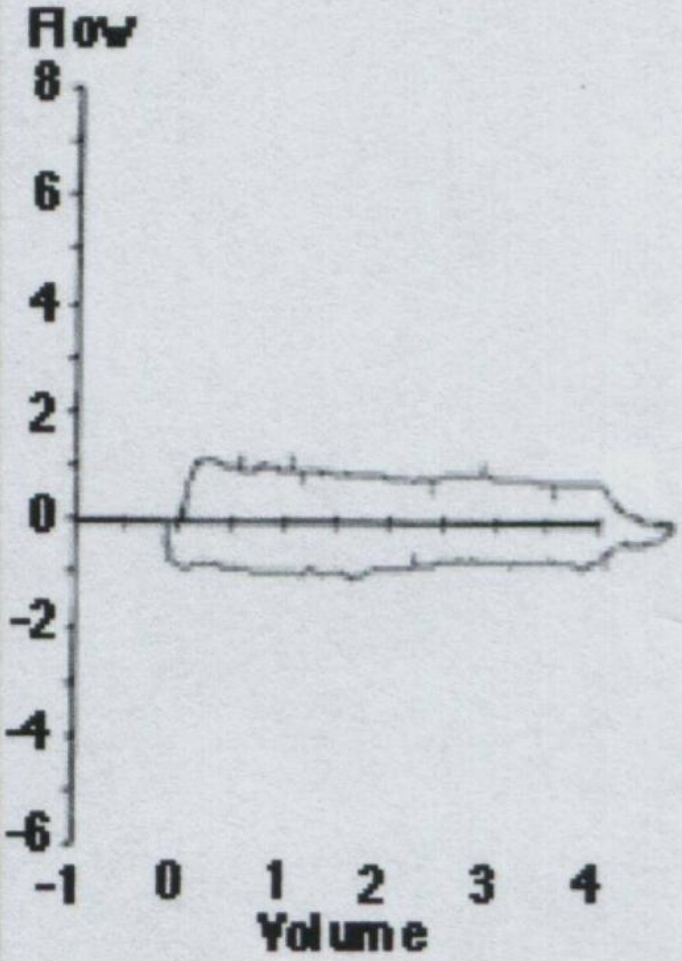
| | ***Intrathoracic*** | ***Extrathoracic*** |
|---|---|---|
| ***Reasons*** | ***Tracheal stenosis*** | ***Foreign body Neoplasm*** |

## Flow/Volume Curve is flat for inspiration and expiration (a squared loop)




***A specific, but not sensitive sign***

# Fixed Upper Airway Obstruction



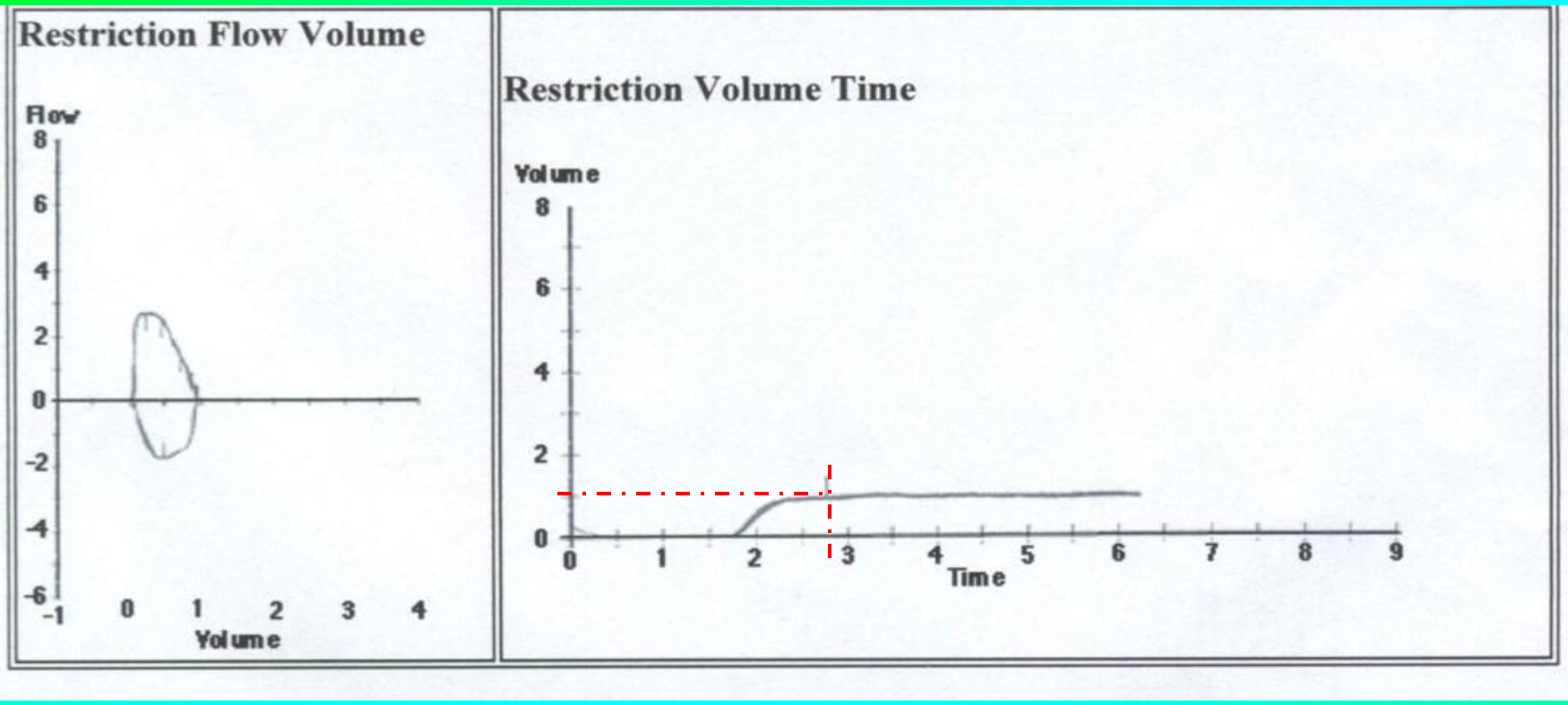
# FVC Test – Restriction

- **$FEV_1$** [L] **- Reduced**
- **F(VC)** [L] **- Reduced**

$FEV_1$ reduced less than F(VC)

**$FEV_1$ to (F)VC ratio - NORMAL or INCREASED**

**PRESERVED**



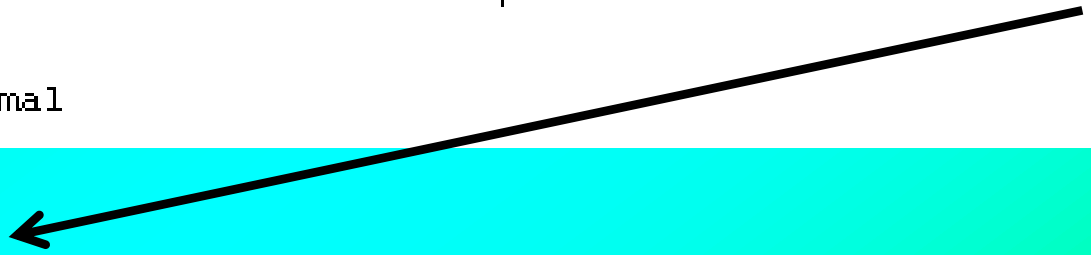

**Flow - volume curve:**

- **shape - relatively unaffected**
- **overall size - appears ↓ when compared to normal on the same curve**

| | | Pred | Actual | %Act/Pred |
|---|---|---|---|---|
| **$FEV_1$** | **[l]** | **1,90** | **0,94** | **49** |
| **FEV1/FVC** | | **0.7** | **0.98** | **140** |
| **FVC** | **[l]** | **2,75** | **0,96** | **35** |
| **PEF** | **[l/s]** | **5,40** | **2,98** | **55** |
| **$FEF_{25-75}$** | **[l/s]** | **2,11** | **2,25** | **107** |

| | OBSTRUCTIVE | RESTRICTIVE | MIXED ? |
|---|---|---|---|
| FEV1 | ↓ | ↓ or N | ↓ |
| FEVC | ↓ or N | ↓ | ↓ |
| FEV1/FVC | ↓ | N or ↑ | ↓ |

*N = Normal



Obstructive changes with reduced VC (additional concurrent restriction?)

# Spirometry requires forced maximal expiration which increases chest pressure

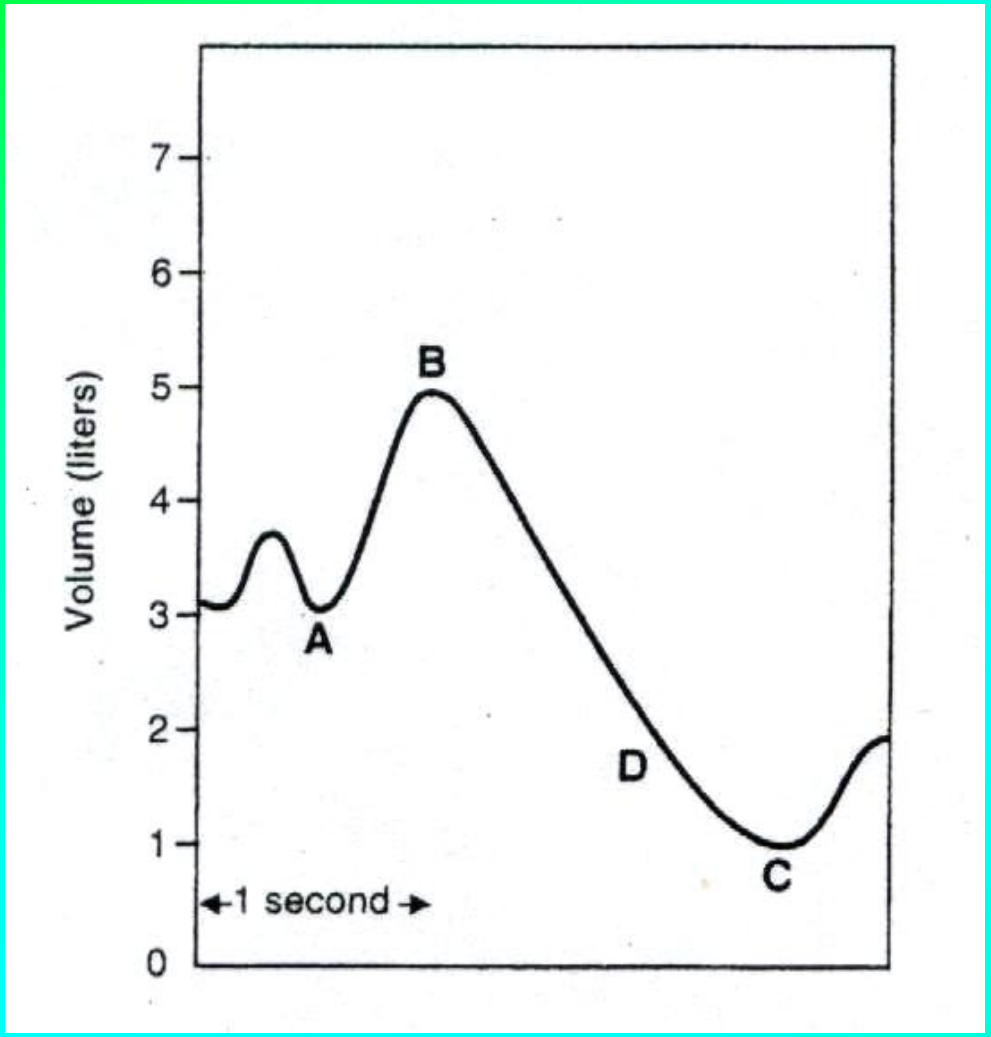
## Absolute Contraindications For Spirometry Testing:

- Recent MI (1 month)
- Recent stroke, eye surgery, thoracic/abdominal surgery
- Hemoptysis
- Known thoracic, aortic or cerebral aneurysm
- Recent pneumothorax
- Uncontrolled hypertension
- Pulmonary embolism

## Relative Contraindications:

- Chest or abdominal pain of any cause
- Oral or facial pain exacerbated by a mouthpiece
- Stress incontinence
- Dementia or confusional state

The following spirogram was obtained from a 23-year-old woman, who was asked to inspire maximally (A to B) and then to expire maximally (from B to C).




1. The forced vital capacity (FVC) is

A. 500 ml

B. 2000 ml

C. 4000 ml

D. 5500 ml

E. Cannot be determined

2. The forced expiratory volume ($FEV_1$) in 1 second is

A. 500 ml

B. 2200 ml

C. 3000 ml

D. 5500 ml

E. Cannot be determined

3. The residual volume (RV) is

A. 1000 ml

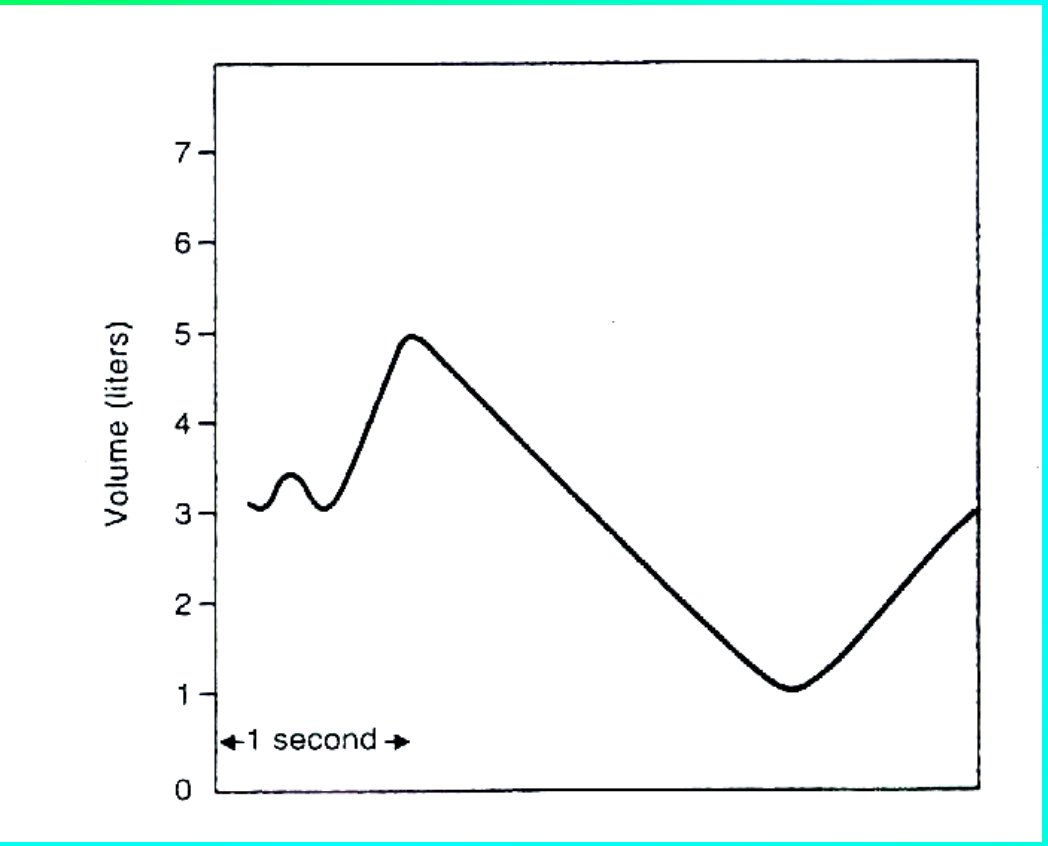
B. 1500 ml

C. 1200 ml

D. One half the functional residual capacity

E. Cannot be determined

**The spirogram of the forced vital capacity (FVC) was obtained from a male patient weighting 70 kg.**




4. The forced expiratory volume in 1 second ($FEV_1$) to FVC ratio is
A.50%
B.75%
C.80%
D.100%
E.Not able to be determined

5. The $FEV_1$ to FVC ratio is typical of
A.healthy individuals
B.a restrictive pattern of pulmonary disease
C.an obstructive pattern of pulmonary disease
D.patients with interstitial pulmonary fibrosis
E.pulmonary edema

6. Which of the following statements about this patient is true?
A. Had the FRC been measured, it would have been less than predicted
B. Had the TLC been measured, it would have been less than predicted
C. Had the RV been measured, it would have been less than predicted
D. The expiratory flow rate (liters/s) is greater than predicted
E. None of them

7. Which one of the following would increase in obstructive, but not in restrictive, lung disease?

A. $FEV_1$

B. $FEV_1/FVC$

C. Vital capacity

D. Functional residual capacity

E. Breathing frequency

8. Which of the following conditions is most likely to produce the change from the normal maximum flow-volume curve illustrated below?

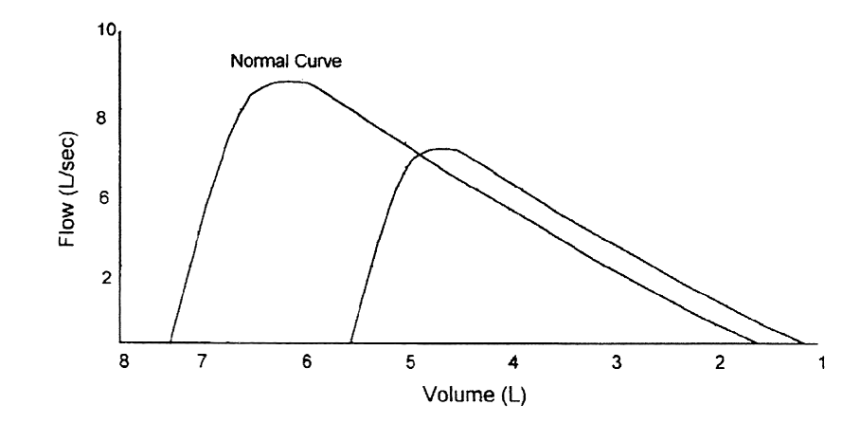
A. Asthma

B. Emphysema

C. Bronchiolitis

D. Fibrosis

E. Fatigue




9.Which one of the followings will be closest to normal in a patient with restrictive lung disease?

A. RV

B. VC

C. FVC

D. $FEV_1/FVC$

E. TLC

**Questions 10-12.** The information which follows was obtained from a 23-year-old patient during a complete work-up (direct spirometry; closed circuit helium method) in a pulmonary function laboratory:

| | |
|---|---|
| Total lung capacity | 7.0 L |
| Inspiratory capacity | 4.0 L |
| Inspiratory reserve volume | 3.5 L |
| Expiratory reserve volume | 1.5 L |

10. The tidal volume (TV) is
A. 100 ml
B. 350 ml
C. 500 ml
D. 1000 ml
E. cannot be determined given the above data

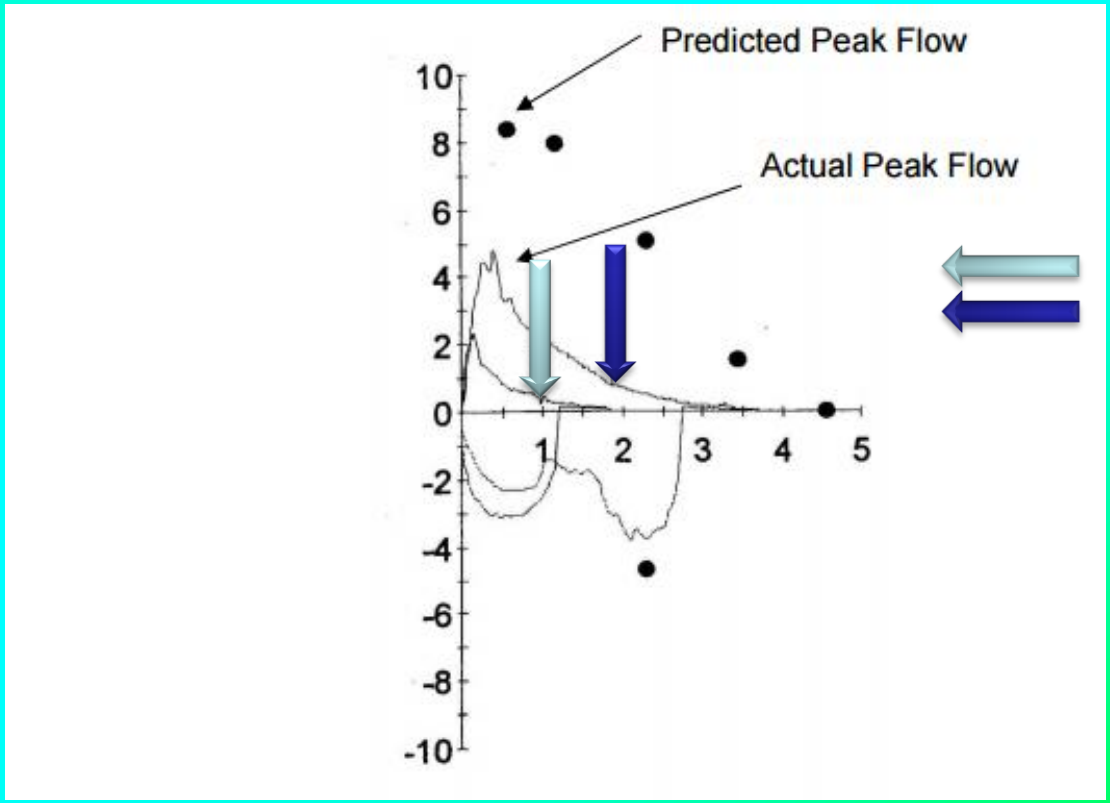
11. The vital capacity (VC) is
A. 3.0 L
B. 5.0 L
C. 5.5 L
D. 6.0 L
E. 7.0 L

12. The functional residual capacity (FRC) is
A. 0.5 L
B. 3.0 L
C. 3.5 L
D. 4.0 L
E. not measurable given the above data

## Case 8

A 54 year-old man presents to his primary care provider with dyspnea and a cough. He is a non-smoker with no relevant occupational exposures.

| | Pre-Bronchodilator (BD) | | | Post- BD | |
|---|---|---|---|---|---|
| **Test** | **Actual** | **Predicted** | **% Predicted** | **Actual** | **% Change** |
| FVC (L) | 3.19 | 4.22 | 76 | 4.00 | 25 |
| $FEV_1$ (L) | 2.18 | 3.39 | 64 | 2.83 | 30 |
| $FEV_1/FVC$ (%) | 68 | 80 | | 71 | 4 |




Darkened circles - Predicted values

FEV1 Pre
FEV1 Post

## Case 8

## Interpretation and Comment

The FVC and FEV1 are both below the lower limit of normal (defined as 80% of the predicted value for the patient). In addition, the FEV1/FVC ratio is only 0.68, less than the lower limit (0,7 or 70%).

A low FEV1 and FVC with a decreased FEV1/FVC ratio is consistent with an initial diagnosis of air-flow **obstruction with reduced VC** which may indicate concurrent restriction.

With an FEV1 of 64% predicted this would be classified as “moderate” airflow obstruction.

In addition, the FVC improves by 0.81 L (25% increase) and the FEV1 improves by 0.65L (30% increase) following administration of a bronchodilator so this patient would qualify as having a bronchodilator response (defined as a 12% and 200 increase in either the FEV1 or FVC).

The flow volume loop also shows several abnormalities consistent with obstructive lung disease. The peak expiratory flow rate is lower than the predicted peak expiratory flow and the curve has the characteristic scooped out appearance typically seen in airflow obstruction.

*Thank you*