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OSCE IN MEDICINE

for Postgraduates and DNB

Ashis Kumar Saha

JAYPEE

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CHAPTER 10

Pulmonary Function Tests

There are four possibilities in respect to FEV1, FVC, and FEV1/FVC ratio:

1. *Normal*: When all the values are within normal limit.
2. *Obstructive disease*: It can be defined as—
   a. FEV1—reduced
   b. FVC—relatively spared
   c. FEV1/FVC ratio—reduced
3. *Restrictive disease*:
   a. FEV1—low normal
   b. FVC—reduced
   c. FEV1/FVC—normal or increased
   d. In this case restrictive lung disease can be diagnosed by low total lung capacity which should be low.
4. Combined restrictive and obstructive lung disease can be diagnosed if the FVC is reduced out of proportion of FEV1/FVC ratio, i.e., FEV1/FVC ratio is 65% predicted and FVC is 40% predicted. Restrictive disease can be ruled by normal FVC.

Value of TLC, RV, and RV/TLC in lung disease: All will in the direction of restriction or obstruction. The interpretations are:

1. When all the values are normal—normal.
2. High volumes—indicate obstruction
   a. TLC increased—indicates hyperinflation. It can be more accurately determined if FRC is low.
   b. RV increased—indicates air trapping
   c. Ratio of RV/TLC—increased the degree of air trapping
3. Low volumes—in case of restrictive lung disease
   a. TLC decreased—indicates restrictive lung disease. It can help in the grading of restriction

Size and shape of the flow-volume curve **(Figs. 1A to H)**:

1. Normal size and shape also known as "knee variant" **(Fig. 1A)**
2. Small and concave or scooped—suggestive of obstructive lung disease **(Fig. 1B)**.
3. Small and steep slope with witch's hat shape: It indicates restriction at the parenchymal level **(Fig. 1G)**.
4. Small but parallel slope as compared to predicted curve: It indicates restriction at the chest wall level **(Fig. 1H)**.
5. Small and convex slope: It indicates poor effort of respiration suggestive of neuromuscular disease **(Fig. 1H)**.
6. Small and flat of both expiratory and inspiratory component: Fixed inspiratory and inspiratory obstruction **(Fig. 1D)**
7. Small and flat at expiratory component: It indicates variable intrathoracic obstruction **(Fig. 1F)**.
8. Small but flat inspiratory component: It indicates variable extrathoracic obstruction **(Fig. 1E)**.

Interpretation of lung function test **(Flowchart 1; Tables 1 and 2)**:

Step 1:

- FEV1/FVC is <70%—indicates obstructive pattern (chronic obstructive lung disease and asthma)
- ≥70%—indicates restrictive pattern

Step 2: Severity of obstruction:

- *FEV1:* 80–100% predicted (stage 1)
- *FEV1*: 50–80% predicted (stage 2)
- *FEV1*: 30–<50% predicted (stage 3)
- *FEV1*: <30% predicted (stage 4)
- *FEV1*: <50% with right-sided heart failure (stage 4)

Step 3:

- ≥12% increase and an absolute improvement of at least 200 mL after inhalation of β-agonist
- FEV1 or FVC is considered a significant response.

Step 4: Total lung capacity—normal range is 80–100% predicted.

- *TLC > 120%*: Hyperinflation
- *TLC < 80%*: Restrictive lung disease
- *70–80% predicted*: Mild restrictive lung disease
- *60–70% predicted*: Moderately restrictive lung disease

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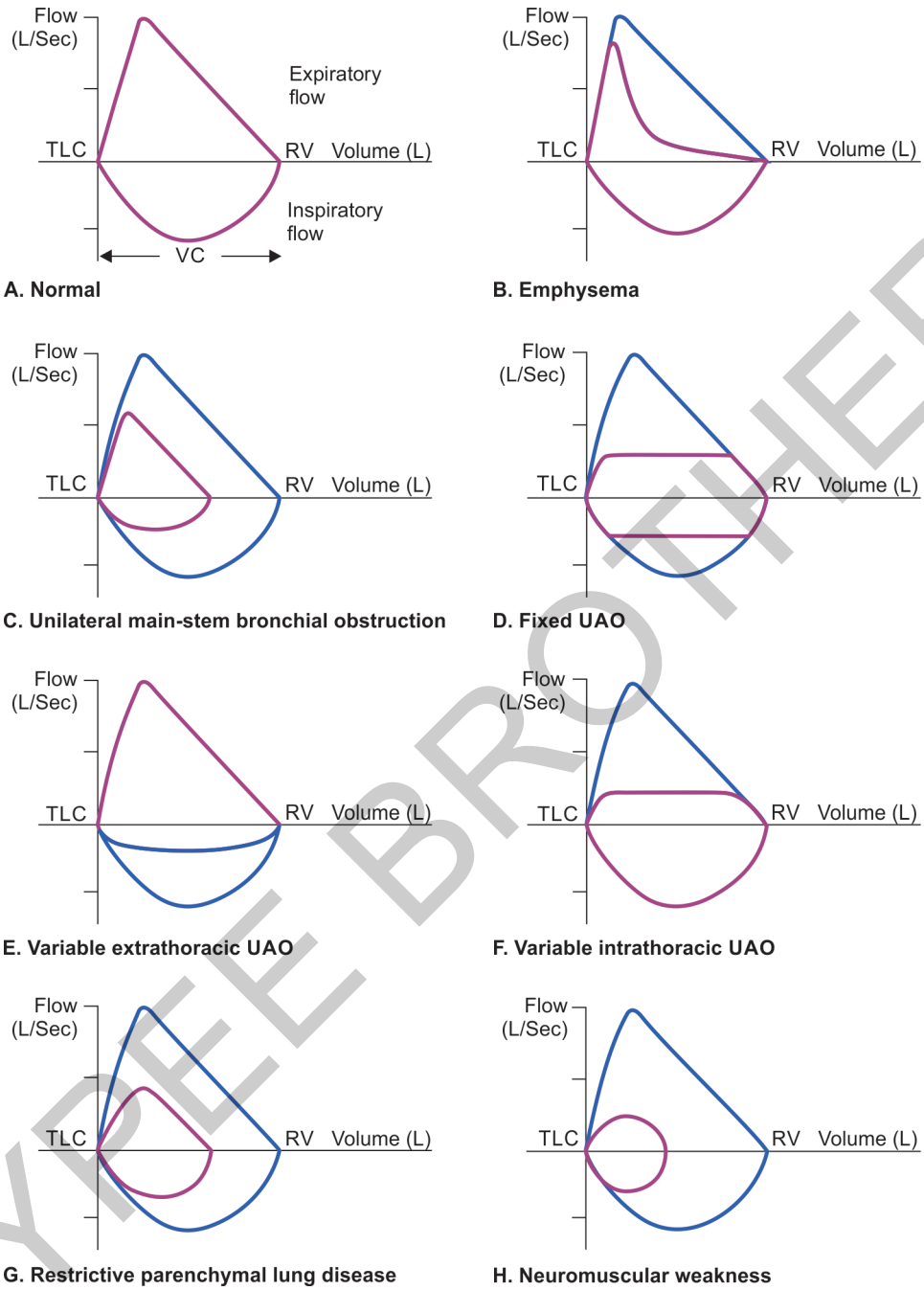

FIGS. 1A TO H: Different size and shape of the flow-volume curves.

- *50–60% predicted*: Moderately severe restrictive lung disease
- *<50% predicted*: Severely restrictive lung disease

Step 5: RV/TLC ratio (normal is 80–120% predicted): RV/TLC ratio > 35% or more than predicted—indicates air trapping

Step 6: DLCO (normal range is 80–100% predicted):

- In obstructive lung disease:
  - Decreased in emphysema
  - Normal in chronic bronchitis
  - Normal in increased in case of asthma
- Restrictive lung disease:
  - Decreased in parenchymal lung disease
  - Normal in nonparenchymal disease

Stepwise approach:

1. Determination of FEV1/FVC ratio
2. Determination of FEV1—whether it is low or normal.
3. Severity of the abnormality should be graded.

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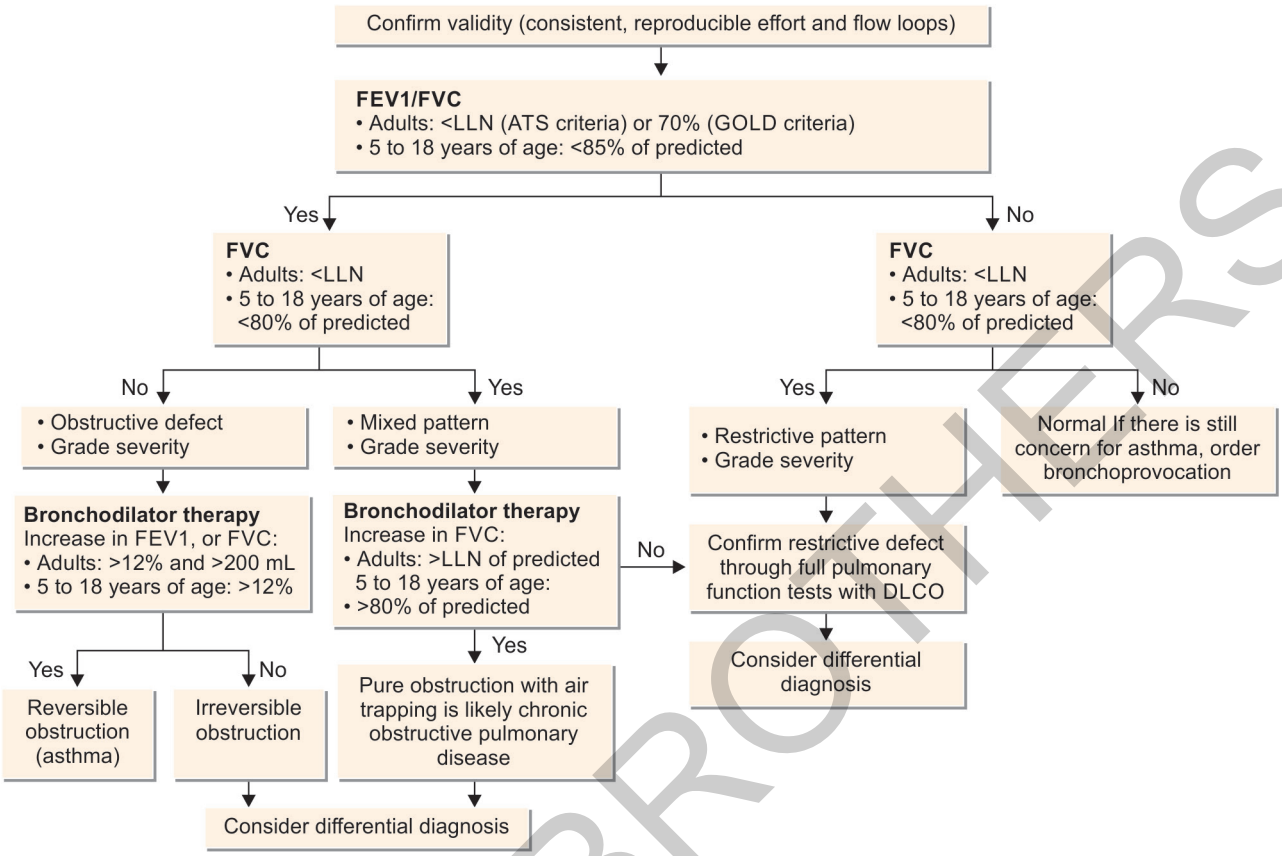

FLOWCHART 1: Interpretation of pulmonary function test.
(ATS: American Thoracic Society; GOLD: Global Initiative for Chronic Obstructive Lung Disease; LLN: lower limit of normal)

TABLE 1: Interpretation of pulmonary function test.

Test results based on age		Suggested diagnosis
FVC	**FEV1/FVC ratio**	
5–18 years: ≥ 80%	5–18 years: ≥ 85%	Normal
Adults: ≥ LLN	Adults: ≥ LLN or ≥ 70%	
5–18 years: ≥ 80%	5–18 years: < 85%	Obstructive defect
Adults: ≥ LLN	Adults: < LLN or < 70%	
5–18 years: < 80%	5–18 years: ≥ 85%	Restrictive pattern
Adults: < LLN	Adults: ≥ LLN or ≥ 70%	
5–18 years: < 80%	5–18 years: < 85%	Mixed pattern
Adults: < LLN	Adults: < LLN or < 70%	

(LLN: lower limit of normal)

TABLE 2: American Thoracic Society grades for severity of pulmonary function test.

Severity	FEV1, percentage of predicted
Mild	>70
Moderate	60–69
Moderately severe	50–59
Severe	35–49
Very severe	<35

4. Reversibility of the obstructive defect
5. Bronchoprovocation

In the tracings of spirometry usually three values are shown:

1. Predicted values which are expected normal values of any person with reference to age, sex, weight as well as height.
2. Measured values which are characterized by the actual values. These are shown by inspiration and expiration maneuvers.
3. Percentage of the predicted value can be calculated and expressed as the percentage of the predicted value, i.e., *(measured value/predicted value) × 100.*

Presence of airway abnormality can be diagnosed by the following measurement:

- *FEV1*: <80% of the predicted value
- *FVC*: <80% of the predicted value
- *FEV1/FVC ratio*: <75%

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In case of obstructive disorder:

- *FEV1*: < 80% of the predicted value
- *FVC*: Reduced to <80% of the predicted value
- *FEV1/FVC ratio*: <75% of the predicted value
- Total lung capacity will be increased.
- Residual volume will be increased.
- RV/TLC will be increased.

In case of restrictive diseases:

- *FEV1*: <80% of the predicted value with proportion to FVC
- *FVC*: Reduced to <80% of the predicted value
- *FEV1/FVC ratio*: Normal or increased to >75% of the predicted value
- Total lung capacity will be reduced.
- Residual volume may or may not be reduced.
- RV/TLC will be normal.

Slow vital capacity: It is similar to FVC. In slow vital capacity, the patient can exhale slowly and completely, but in case of FVC, the patient will exhale forcefully, as a result of high flow through the airways that lead to excessive narrowing of the or closure of the diseased airways resulting in air trapping and the air cannot be exhaled completely **(Fig. 2)**.

Maximum volume ventilation: In this procedure the patient is asked in breathe as fast and as hard as possible for 6–12 seconds. The result will be extrapolated to 60 seconds in liter/minute.

Normal MVV = FEV1 × 30. If MVV is >FEV1 × 40, it suggests test is poorly performed.

Mixed obstructive-restrictive pattern: If the patient demonstrates reduced TLC—suggests restrictive lung disease, if FEV1/FVC ratio is increased—suggests obstructive lung disease. In this case to detect the degree of obstruction, percent reduction of FEV1 is required. Again, FEV1 is reduced due to reduction of TLC in the restricted lung disease. So to correct this, following is required: *Percent of predicted FEV1/Percent predicted TLC*. It may be moderate or moderately severe degree.

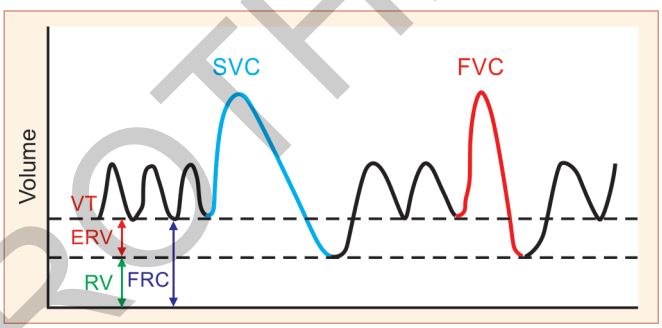

Fig. 2: Slow vital capacity and forced vital capacity.
slow vital capacity (SVC); Forced vital capacity (FVC)

CASE 1

A 50-year-old white smoker female came to respiratory clinic with chronic respiratory distress. Her spirometry done that demonstrated:

Parameters	Predicted	Pre	% predicted	Post
FVC	3.30	1.51	45.75	2.34
FEV1	2.69	0.4	14.86	0.55
FEV1/FVC		26.49		0.23
FEF25-75	2.84	0.12	4.22	

Lung volume:

Parameter	Predicted	Pre	% predicted
Total lung capacity	5.2	7.2	138.46
Residual volume	1.87	5.3	283.42
RV/TLC	35.96	73.61	

Diffusing capacity:

Parameter	Predicted	Pre	% predicted
DLCO	23	4	17.39
VA	5.25	2.25	42.85
DLCO/VA	4.38	1.77	40.41

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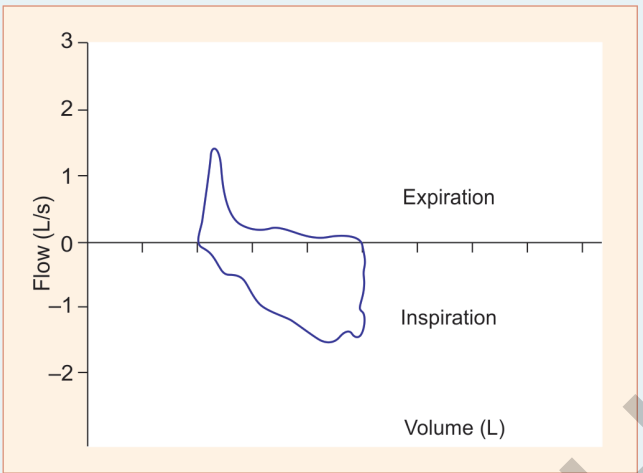

1. **What is shown in the result of spirometry?**
2. **What is the result shown in lung volume changes?**
3. **What are the changes in the flow-volume curve?**
4. **What is the interpretation of diffusion capacity?**
5. **What is your interpretation of the result?**
6. **How can you estimate air trapping?**

Answers

1. *Spirometry demonstrates*:
   a. FEV1 is reduced to very severe degree.
   b. *FVC*: Reduced
   c. *FEV1/FVC*: Reduced
   d. *FEF25-75*: It signifies obstruction
2. Lung volume demonstrates:
   a. Total lung capacity—severely increased
   b. Residual volume—severely increased
   c. RV/TLC—indicates air trapping along with evidence of hyperinflammation
3. Flow-volume curve demonstrates small and scooped out looking like "dog-leg appearance"
4. Diffusion capacity demonstrates that DLCO/VA is very low suggestive of defect in the diffusion.
5. Based on the results of spirometry, lung-volume and flow-volume curves are the diagnosis of obstructive lung disease with hyperinflammation and impaired gas exchanges suggestive of emphysema.
6. Air trapping can be estimated by following two ways:
   a. TLC – VA = 7.2 – 2.25 = 4.95 L
   b. RV (predicted) – RV (measured) = 5.3 – 1.87 = 3.43 L

CASE 2

A 70-year-old female came to respiratory clinic and pulmonary function test was advised:

Spirometry demonstrated:

Parameters	Predicted	Observed	% predicted
FVC	3.3	3.25	101.5
FEV1	2.4	2.6	108.3
FEV1/FVC		80	
FEF25–75	1.9	2.7	142

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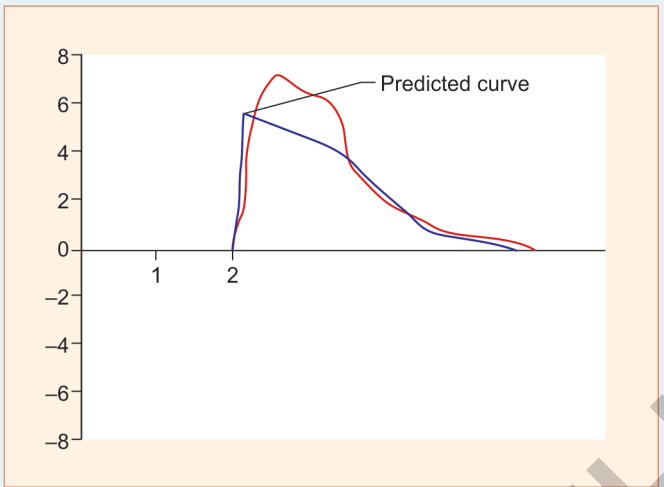


1. **How can you interpret the spirometry?**
2. **What is your diagnosis?**

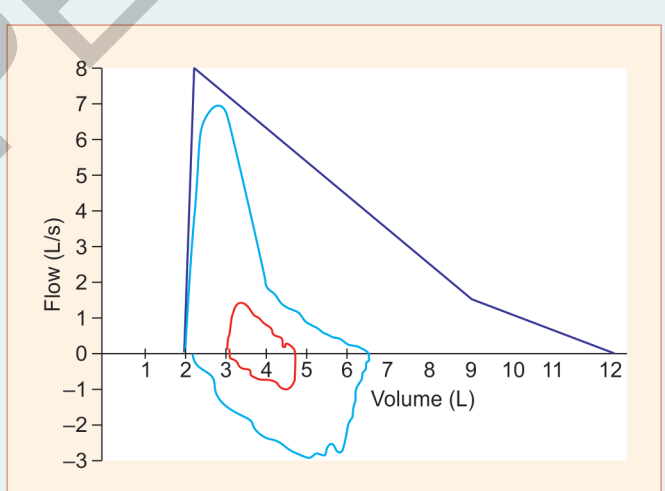
Answers

1. FEV1, FVC, FEV1/FVC, and FEF25–75 are all within normal limit. Flow-volume curve demonstrates as normal with knee. This is normal variant and can be reproducible.
2. The spirometry of patient is normal.

CASE 3

A 60-year-old female came with history of progressively increasing respiratory distress. Her spirometry was performed:

Parameters	Predicted	Observed	% predicted
FVC	4.58	2.4	52.4
FEV1	3.6	1.92	53.3
FEV1/FVC		0.79	
FEF25–75	3.3	1.5	45.45



1. **Interpret the spirometry.**
2. **What is the diagnosis?**
3. **What are the causes of this disease extrinsic to lung?**

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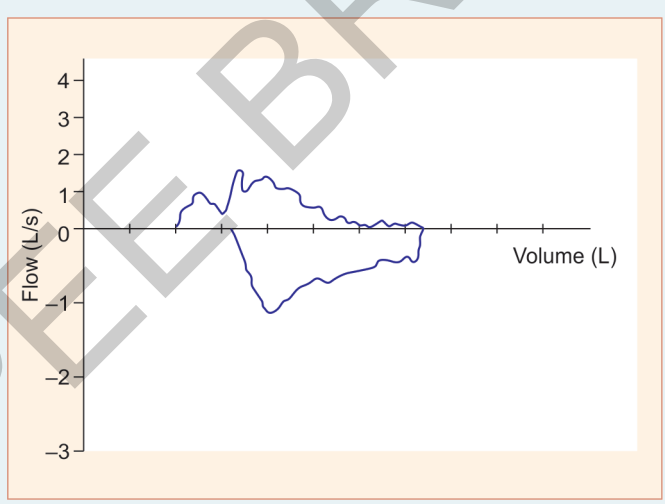
Answers

1. Interpretation of spirometry:
   a. FEV1 is reduced.
   b. FVC is reduced.
   c. FEV1/FVC ratio is in the lower limit of normal.
2. The patient has been suffering from the restrictive lung disease.
3. Following are the causes of restrictive disease extrinsic to lung:
   a. Kyphoscoliosis
   b. Obesity
   c. Pleural causes:
      - Pleural fibrosis
      - Pleural scarring
      - Pleural effusion
      - Asbestosis
   d. Ascites
   e. Neuromuscular disorders:
      - Amyotrophic lateral sclerosis
      - Muscular dystrophy
      - Poliomyelitis
      - Phrenic neuropathies

CASE 4

A 75-year-old Asian male came to respiratory clinic with history of respiratory distress.

Parameters	Predicted	Observed	% predicted
FVC	3.08	1.35	43.83
FEV1	2.4	0.6	25
FEV1/FVC		0.44	
FEF25–75	1.5	0.25	16.66



1. **Interpret the spirometry.**
2. **Describe flow-volume curve.**
3. **Why the shape of the inspiratory part of the flow-volume curve is like this?**
4. **Why the shape of the expiratory part of the flow-volume curve is like this?**
5. **Why both part of the curve are flattened?**
6. **What are the causes of this type of graph?**

Answers

1. Spirometry demonstrates:
   - Both FEV_1 and FVC are low.
   - FEV_1/FVC is low.
2. Flow-volume curve demonstrates the curve is flat in respect both the inspiratory and expiratory components indicating the presence of fixed airway obstruction.

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3. It is flat due to extrathoracic obstruction above the level of sternal notch. Pressure within the larynx, pharynx, and extrathoracic portion of trachea will be negative as compared to pressure outside the airways (atmospheric pressure) during inspiration thereby curve of the inspiratory part of the curve becomes flat.
4. Obstruction intrathoracic part of trachea and main bronchi is compressed during expiratory phase of respiration by increased intrathoracic pressure thereby producing flattening in the expiratory phase flow-volume curve.
5. In case of fixed airway obstruction above or below the level of sternal notch. It will not be related to expiratory or inspiratory phase; hence, this curve does not depend upon the intrathoracic or extrathoracic part of the airways. Hence, both phase of flow-volume curve are flattened.
6. Causes of this type of graph are as follows:
   a. Fibrotic stricture in the upper airways
   b. Nonmovable tumor in the upper or lower airways

CASE 5

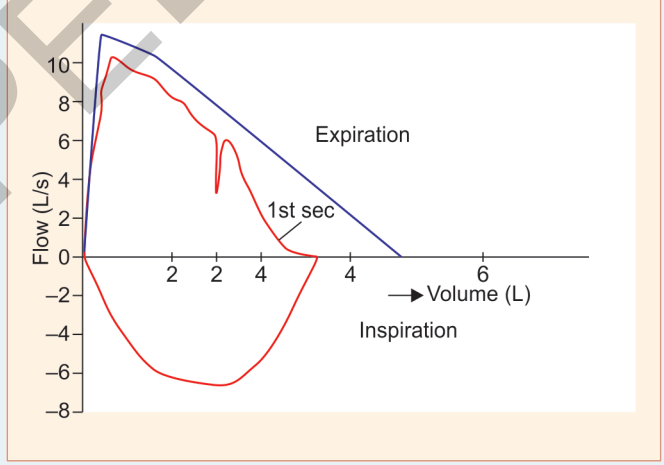
A 52-year-old white male with body mass index (BMI) of 30/m^2 came for routine test required for the service. Spirometry was advised.

Spirometry:

Parameters	Predicted	Observed	% predicted
FVC	5.12	4.72	92
FEV1	4.1	3.6	87.8
FEV1/FVC		0.76	
FEF25–75	1.95	0.98	50

Lung volumes:

Parameters	Predicted	Observed	% predicted
TLC	7.4	7.68	103.7
RV	2.09	2.48	
RV/TLC			



1. **Interpret the results of spirometry.**
2. **Interpret flow-volume loop.**
3. **What is your interpretation?**

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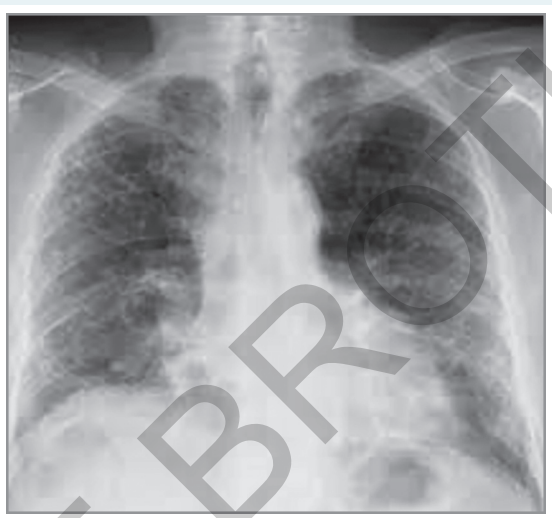
Answers

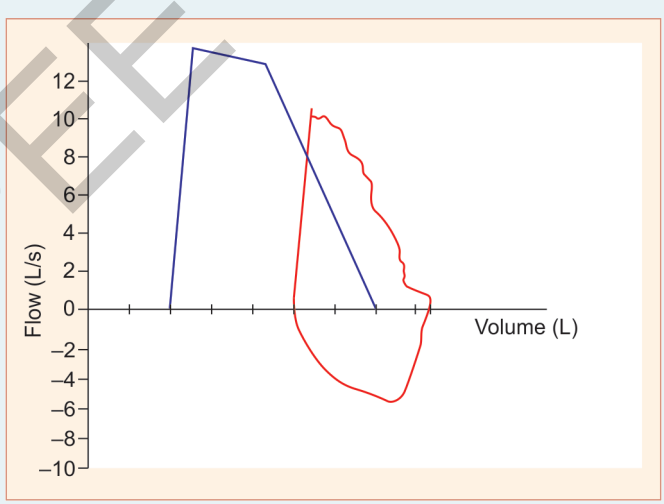
1. Interpretation of spirometry results: All the values are within normal limit except FEF25–75 is low. It indicates obesity.
2. In the flow-volume curve—in the observed value the curve is little smaller as compared to predicted graph. But, the expiratory curve is interrupted by sudden cough in the 1st second.
3. Patient has normal spirometry except mild isolated reduction in FEF25–75 indicating presence of obesity.

CASE 6

A 52-year-old male came to respiratory clinic with respiratory distress. His flow-volume curve demonstrated:

Straight X-ray of chest demonstrated:





1. **Demonstrate flow-volume curve.**
2. **Describe the chest X-ray.**
3. **What is the diagnosis?**

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Answers

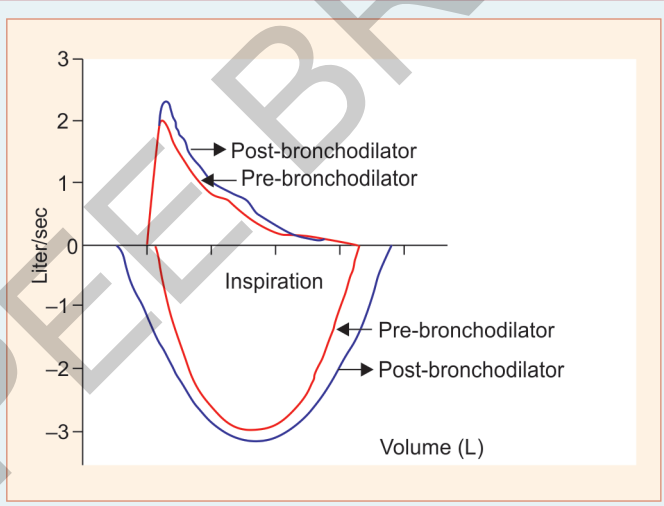
1. Flow-volume curve demonstrates:
   a. Observed flow-volume curve is small but steep like Witch's hat.
   b. The width of the curve is low having normal ratio indicating restrictive lung disease.
   c. Observed curve is shifted to the right as compared to predicted curve indicating decreased total lung capacity and residual volume. This proves restrictive pattern of parenchymal disease like interstitial lung disease.
2. X-ray of chest demonstrates:
   a. Reticular pattern of the interstitial marking in the periphery of the lung bilaterally worst in the lung bases.
   b. There is bisection of the diaphragm by right fifth anterior rib indicating some loss of lung volume loss.
3. This patient has been suffering from interstitial lung disease.

CASE 7

An 80-year-old man admitted in emergency with severe respiratory distress. He was undergone pulmonary function test prior to and after administration of bronchodilator drugs.

Spirometry demonstrated:

Parameters	Predicted	Prebronchodilator	% predicted	Postbronchodilator	% predicted	Change
FVC	2.96	1.88	63	2.08	70.2	9.5%
FEV1	2.1	0.78	37.1	0.9	42.8	15.3
FEV1/FVC		41		44		
FEF25–75	1.46	0.23	15.7			



Flow-volume curve demonstrated:

1. **How can you interpret flow-volume curve?**
2. **How can you interpret spirometry?**
3. **What is your diagnosis?**

Answers

1. Flow-volume curve demonstrates:
   a. Pre- and postbronchodilator curves are small and scalloped.
   b. There is some improvement after administration of bronchodilator.
   c. Curve itself demonstrates either air-leak or poor initial breath in the postbronchodilator study.
2. Spirometry demonstrates:
   a. There is severe reduction in FEV1 and FEV1/FVC ratio—indicates obstructive lung disease.
   b. FEF25–75 is very low—indicating obstruction and air trapping.

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c. There is only 15.3% change after administration of the bronchodilator which is <200 mL—it indicates insignificant bronchodilator response to bronchodilator.

3. Patient has been suffering from severe obstructive pulmonary disease and inadequate response to bronchodilator.

CASE 8

A 55-year-old female has been admitted with respiratory distress. Respiratory and cardiovascular system examinations were normal. So pulmonary function test was performed:

Parameters	Predicted	Observed	% predicted
FVC	2.9	2.5	86.2
FEV1	2.3	2.2	95.6
FEV1/FVC		0.88	
FEF25–75	2.34	2.24	96.5

Lung volume demonstrated:

Parameters	Predicted	Observed	% predicted
TLC	4.8	4.3	89.6
RV	1.95	1.75	89.7
RV/TLC	0.40	40.7	

Diffusion capacity:

Parameters	Predicted	Observed	% predicted
DLCO	20	11	55
DLCO/VA	4.22	2.4	56.8
VA	4.75	4.5	88.4

Picture of the hand in this patient demonstrated:



1. Interpret the above pulmonary function test.
2. What are the causes of the respiratory distress?
3. What is the conclusion correlation with the above picture?

Answers

1. Interpretation of pulmonary function tests:
   a. FEV1, FVC, and FEV1/FVC are within normal limit.
   b. TLC, RV, and RV/TLC are within normal limit.
   c. DLCO/VA is very low. It suggests abnormality in the gas exchange.

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2. Causes of this abnormality are as follows:
   a. Early parenchymal lung disease
   b. Anemia
   c. Pulmonary vascular disease
3. As the respiratory and cardiovascular examination was normal, and the conjunctiva demonstrated anemia, the patient has been suffering from severe anemia leading to respiratory distress.

CASE 9

A 65-year-old female was admitted with severe respiratory distress with cough and expectoration. She was advised spirometry.

Parameters	Predicted	Prebronchodilator	% predicted	Postbronchodilator	Change
FVC	4.5	3.06	68%	3.15	2.9
FEV1	3.75	2.56	68.26	2.9	13.2
FEV1/FVC		0.83			
FEF25–75	4.5	2.5	55.5	3.1	24

Lung volume:

Parameters	Predicted	Observed	% predicted
TLC	5.5	4.2	76
RV	1.1	1.48	134.5
RV/TLC	20%	35.2	

Diffusion capacity:

Parameters	Predicted	Observed	% predicted
DLCO	28	22.1	78.92
DLCO/VA	5.09	5.39	105.9
VA	5.5	4.1	74.5

The chest X-ray of the patient:



1. Interpret the lung function test.
2. What is the most likely conclusion?
3. What is the above chest X-ray demonstrates?
4. What is the most likely diagnosis in this case?

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Salient Features

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- Demonstrates the history-taking in short and comprehensive ways along with the case-based very short answers
- Demonstrates the ethical questions based on the case scenario
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- Also helps in the group study
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- Covers framework for formulating the differential diagnoses as well as management plans
- The questions are set-up in such a way so that these can be written within the speculated time

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