Chapter 32
Interpretation of Pulmonary Function Tests

Scott Hagan and Tyler Albert

Learning Objectives
1. Define the key components of pulmonary function testing (PFT).
2. Use flow-volume loops to aid in the interpretation of PFTs.
3. Recognize common patterns of pulmonary disease seen on PFTs.

Clinical Vignette: A 50-year-old woman with a 20-pack-a-year smoking history presents to clinic with chronic dyspnea.

A. **As part of a basic evaluation you decide to order pulmonary function tests (PFTs). What are the main components of pulmonary function tests? What are their normal values?**

Create the spirometry, lung volume, and DLCO table. Label the first column "normal" and leave the second and third columns blank. Fill in the normal values for each measurement.

Teaching points
- Spirometry, lung volumes, and DLCO are the three main parts of PFTs.
- Spirometry: assesses for airflow obstruction by measuring FEV1 (forced expiratory volume in 1 s), FVC (forced vital capacity), and the FEV1/FVC ratio. This can be performed in clinic and can assess for reversibility of obstruction through bronchodilator responsiveness.

S. Hagan (✉) · T. Albert
VA Puget Sound Health Care System, Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA
e-mail: Scott.Hagan1@va.gov

S. Mookherjee et al. (eds.), *Chalk Talks in Internal Medicine*,
https://doi.org/10.1007/978-3-030-34814-4_32

- Lung volumes: usually performed using a plethysmograph, measures TLC (total volume at full inhalation), RV (residual volume after full exhalation), VC (vital capacity, often greater than FVC in patients with obstructive lung disease), and FRC (functional residual capacity, volume remaining at the end of tidal exhalation).
- DLCO (diffusion capacity for carbon dioxide): measurement of gas crossing the alveolar–capillary barrier, a marker of surface area for gas exchange, however, can also be decreased with pulmonary vascular diseases; should be corrected for anemia.

B. **How is spirometry represented on a flow-volume loop?**

Draw and label the axes. Depending on the audience, consider asking a learner to draw a representative flow volume loop for a normal patient; redraw or correct it if necessary.

Teaching points

- Flow-volume loops represent the appropriateness of airflow for given lung volumes, and have characteristic shapes for each disease processes.
- A common point of confusion is that the inspiratory flow curve begins descending from the far-right side of the *x*-axis.
- Remember that FEV1 is not represented on a flow-volume loop as time is not represented on the curve.

C. **You order spirometry for our patient. What do you notice is different about this patient's flow loop? What would the corresponding values be for their spirometry and lung volumes?**

Draw out the patient's flow-volume loop, labeled C on Fig. 32.1. *Ask learners to fill in the FEV1, FVC, and FEV1/FVC ratio loop in comparison to normal loop as increased (↑), decreased (↓), or unchanged (−).*

Teaching points

- The "scooped out" expiratory curve indicates airflow obstruction, which is confirmed by the reduced FEV1/FVC ratio.
- Additionally, the curve is shifted to the left, suggesting hyperinflation (increased TLC) and air trapping (increased RV).

D. **Which diseases cause airflow obstruction and how might you distinguish them with PFTs?**

Write asthma and COPD as the main diagnoses, provide the negative bronchodilator response, and make the point that this does not reliably differentiate between the two.

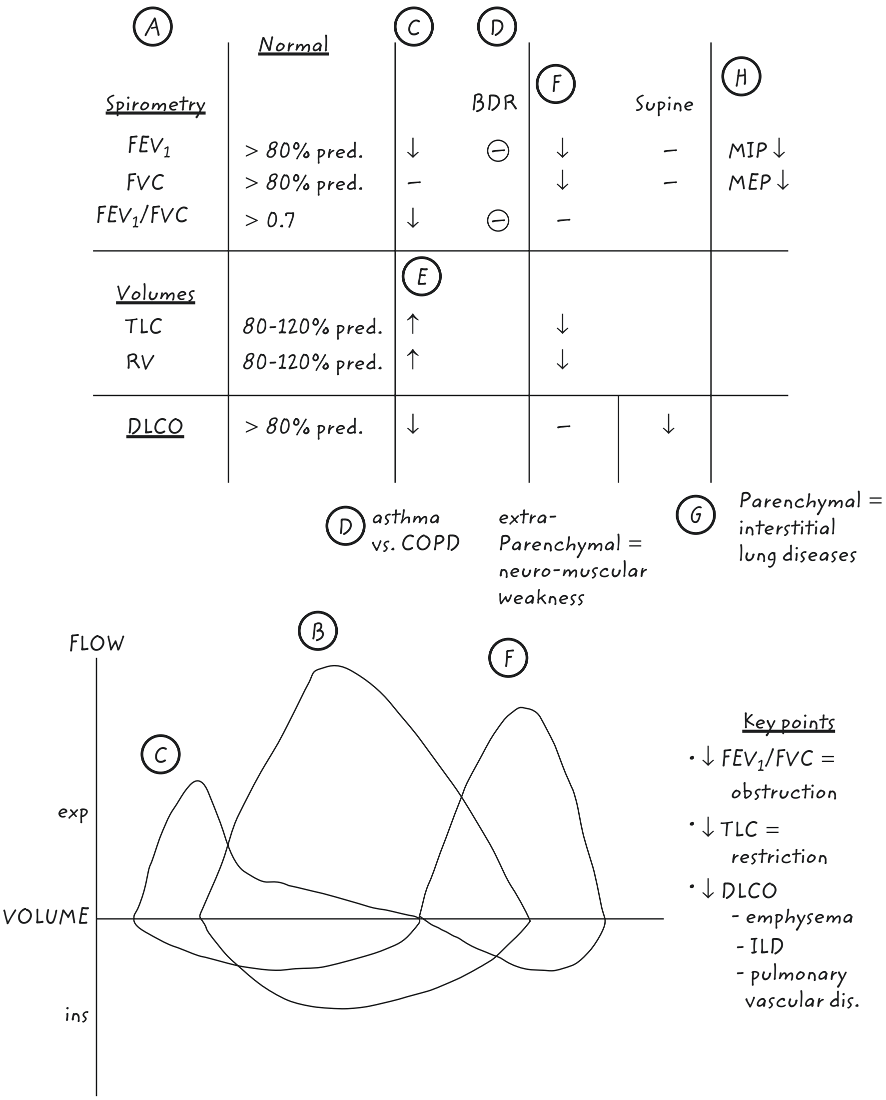

Fig. 32.1 Interpretation of pulmonary function tests, A–H

Teaching points

- Asthma and COPD (a syndrome resulting from chronic bronchitis and emphysema) are the two main obstructive lung diseases.
- Bronchodilator responsiveness (BDR, an increase of 12% *and* 200 cc of FVC *or* FEV1) measures the reversibility of airflow obstruction; however, this does NOT reliably distinguish asthma from COPD.
- The most important distinguishing feature of asthma versus COPD is clinical history: age of onset, smoking history, family history, and related diagnosis (e.g., other atopic diseases), productive cough, etc.

E. **You obtain lung volumes and a DLCO on our patient. How does this help?**

Write in the increased TLC and RV and reduced DLCO for our patient, underline COPD as the more likely diagnosis in this patient.

Teaching points

- An increased total lung capacity (hyperinflation) and/or residual volume (air trapping) are both more common with emphysema, and COPD, however, can be seen with severe, chronic asthma.
- A reduced DLCO (a decrease in the surface area for gas exchange) is suggestive of emphysema as opposed to asthma.
- Our patient developed dyspnea later in life, with a reduced DLCO, an elevated RV, and a negative BDR. She likely has emphysema, which is diagnosed anatomically (histology or radiographically).

F. **Imagine a different flow-volume loop for this patient. What do you notice has changed?**

Draw out the final flow-volume loop, labeled F on Fig. 32.1. *Fill in the third column of the chart as learners identify a reduced TLC, RV, and FVC. Give them the rest of the values (low FEV1, normal FEV1/FVC, normal DLCO).*

Teaching points

- We notice that her flow rates are preserved, and her FEV1/FVC is preserved, ruling out obstruction.
- All of her volumes have declined, indicating restriction.

G. **The patient's DLCO is preserved. What does this tell us about the differential for her restrictive lung disease (RLD)?**

Write out the key considerations for reduced and unchanged DLCO as shown in Fig. 32.1.

Teaching points

- DLCO helps to distinguish parenchymal (low DLCO, e.g., interstitial lung diseases) from extra-parenchymal (normal DLCO) RLD.
- Differential for extra-parenchymal RLD: diaphragmatic paralysis, pleural diseases (scarring, effusions), neuromuscular weakness (myasthenia gravis, amyo-

trophic lateral sclerosis (ALS), multiple sclerosis (MS)), chest wall disorders (obesity, scoliosis), extrathoracic disorders (ascites).

H. **What further pulmonary function tests could help distinguish the cause of the patient's extra-parenchymal RLD?**

Write out the supine spirometry, maximum inspiratory pressure (*MIP*)*, and* maximum expiratory pressure (*MEP*) *findings as shown in* Fig. 32.1.

Teaching points

- Supine spirometry: A decline in FVC below 20% is suggestive of diaphragmatic weakness, as a weakened diaphragm is unable to move abdominal contents without the help of gravity.
- Maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP): A reduced MIP and/or MEP can be suggestive of neuromuscular weakness and can help delineate between inspiratory and expiratory muscle involvement.
- *Write her supine spirometry, MIP, and MEP values in the chart*. The patient's supine spirometry was unchanged, while MIPs and MEPs were reduced, indicating neuromuscular disease. The patient ultimately was diagnosed with amyotrophic lateral sclerosis.

Return to objectives and key points

1. Key PFTs to focus on for interpretation: FEV1/FVC (airflow obstruction), TLC (restriction), and DLCO (emphysema, interstitial lung disease (ILD), pulmonary vascular disease).
2. Flow-loop patterns are helpful adjunct to PFT values. A "scooped out" curve suggests airflow obstruction, while a small and narrow curve suggests RLD.
3. Extra tests to order: For reduced FEV1/FVC, order BDR; for reduced TLC with normal DLCO, order supine spirometry and MIP/MEP.

Resources

1. Pellegrino R, Viegi G, et al. Series "ATS/ERS task force: standardisation of lung function testing": interpretative strategies for lung function tests. Eur Resp J. 2005;26:948–68.
2. Benditt JO. A primer on reading pulmonary function tests. Accessible at: https://courses.washington.edu/med610/pft/pft_primer.html.
3. Bays AM, Luks AM. A tutorial in pulmonary function test interpretation. Accessible at: https://depts.washington.edu/uwmedres/Library/eLearning/Pulmonary/.