Johns Hopkins University
Engineering for Professionals
EN 585.405
Physiology for Applied Biomedical Engineering

- Module 11
  - Respiratory Mechanics
- Video 4
  - Mechanical Properties of the Lung and Chest Wall

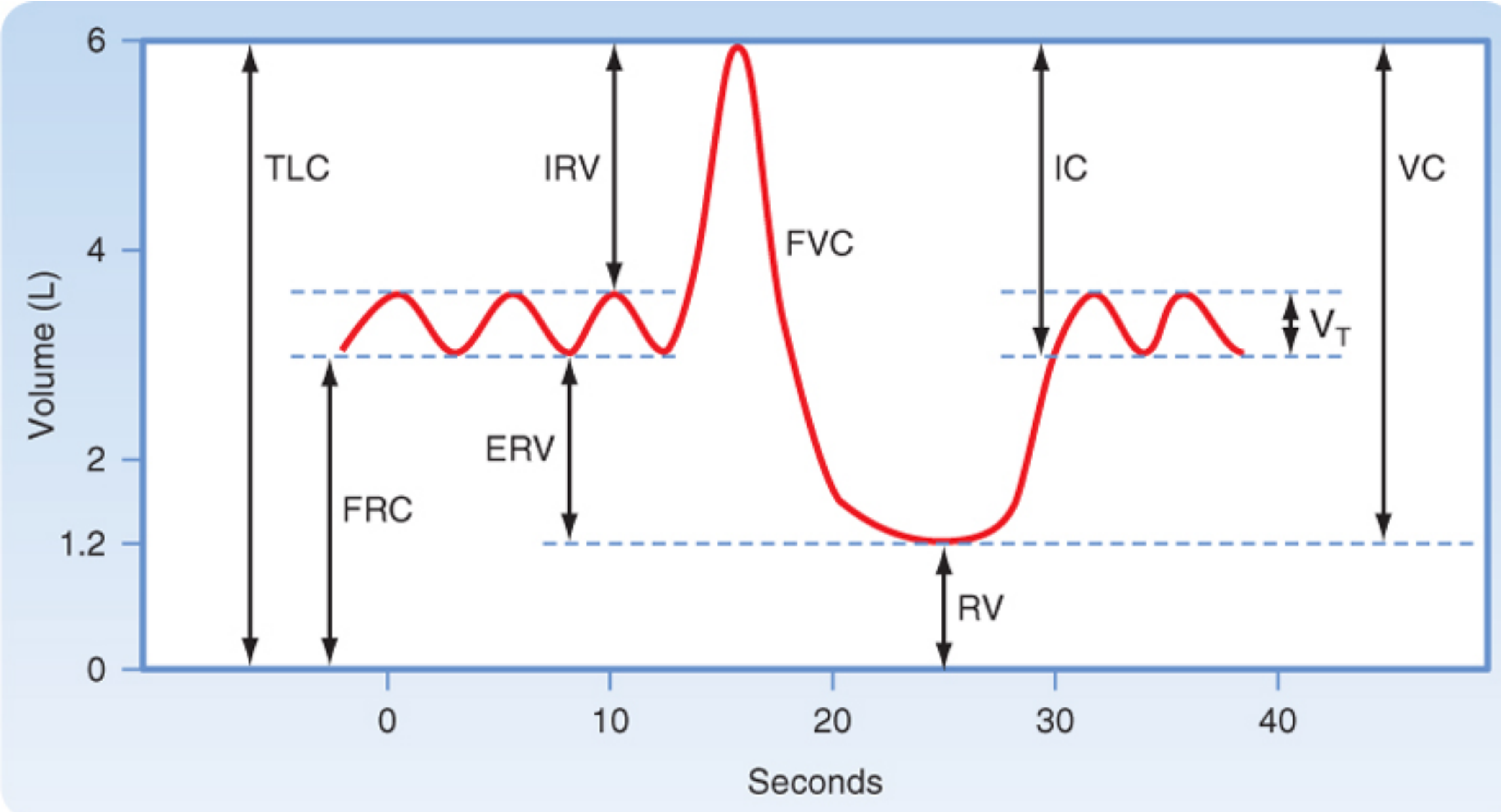
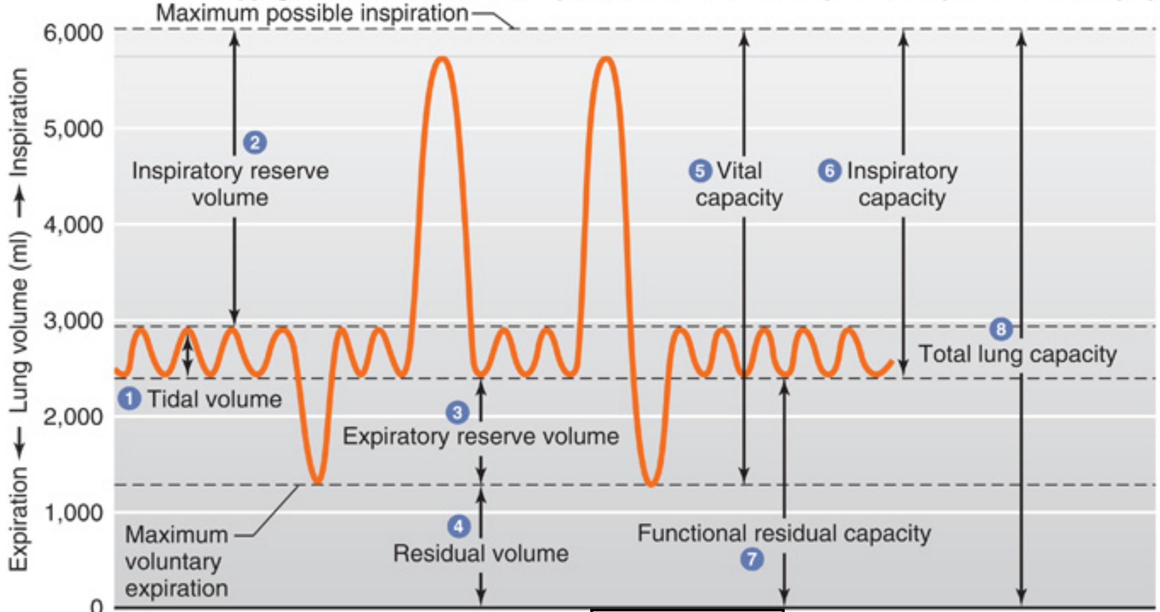
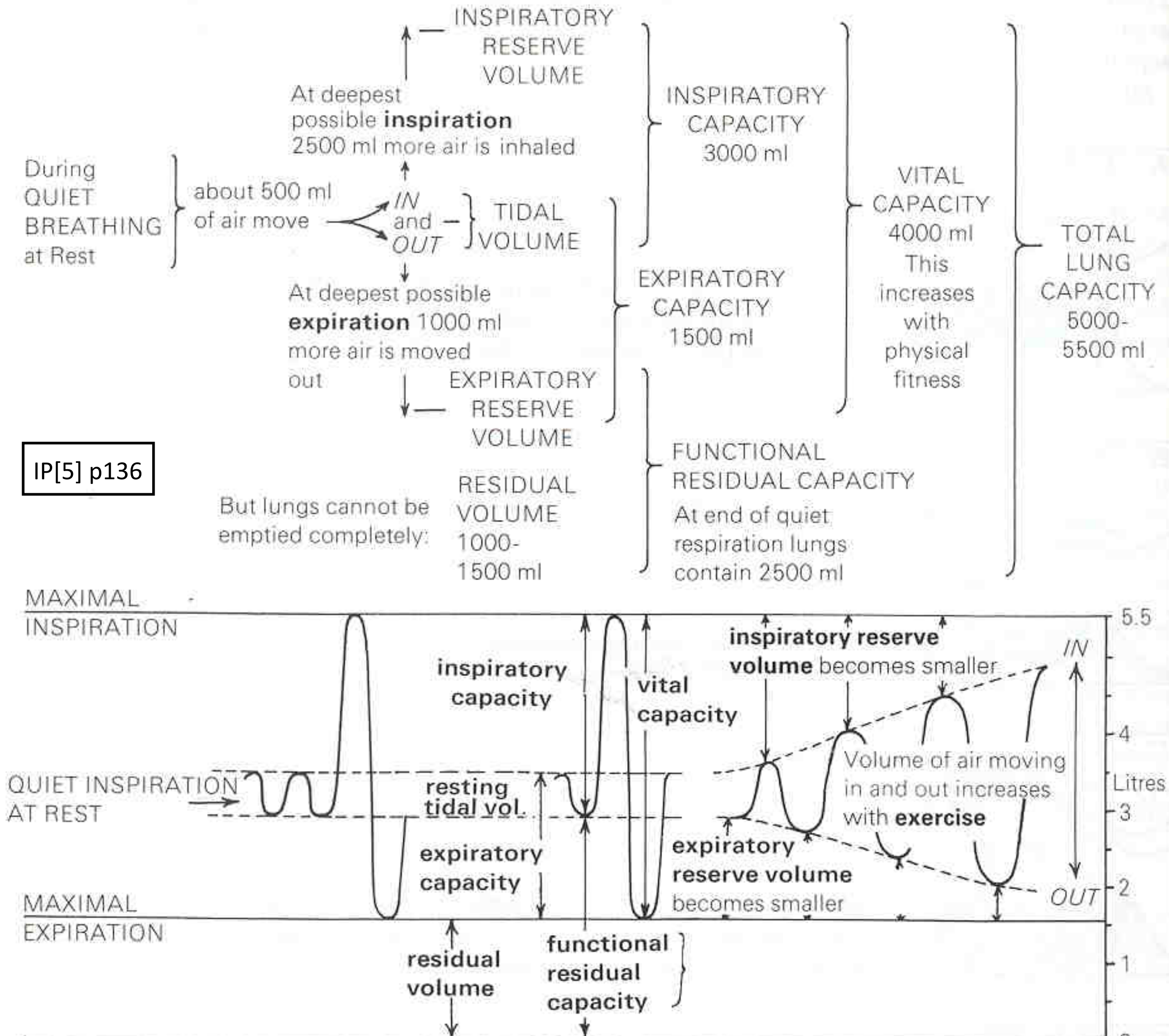


Figure 21-1 The various lung volumes and capacities. ERV, expiratory reserve volume; FRC, functional residual capacity; FVC, forced vital capacity; IC, inspiratory capacity; IRV, inspiratory reserve volume; RV, residual volume; TLC, total lung capacity; VC, vital capacity; VT, tidal volume.



VSL[10] 13-19

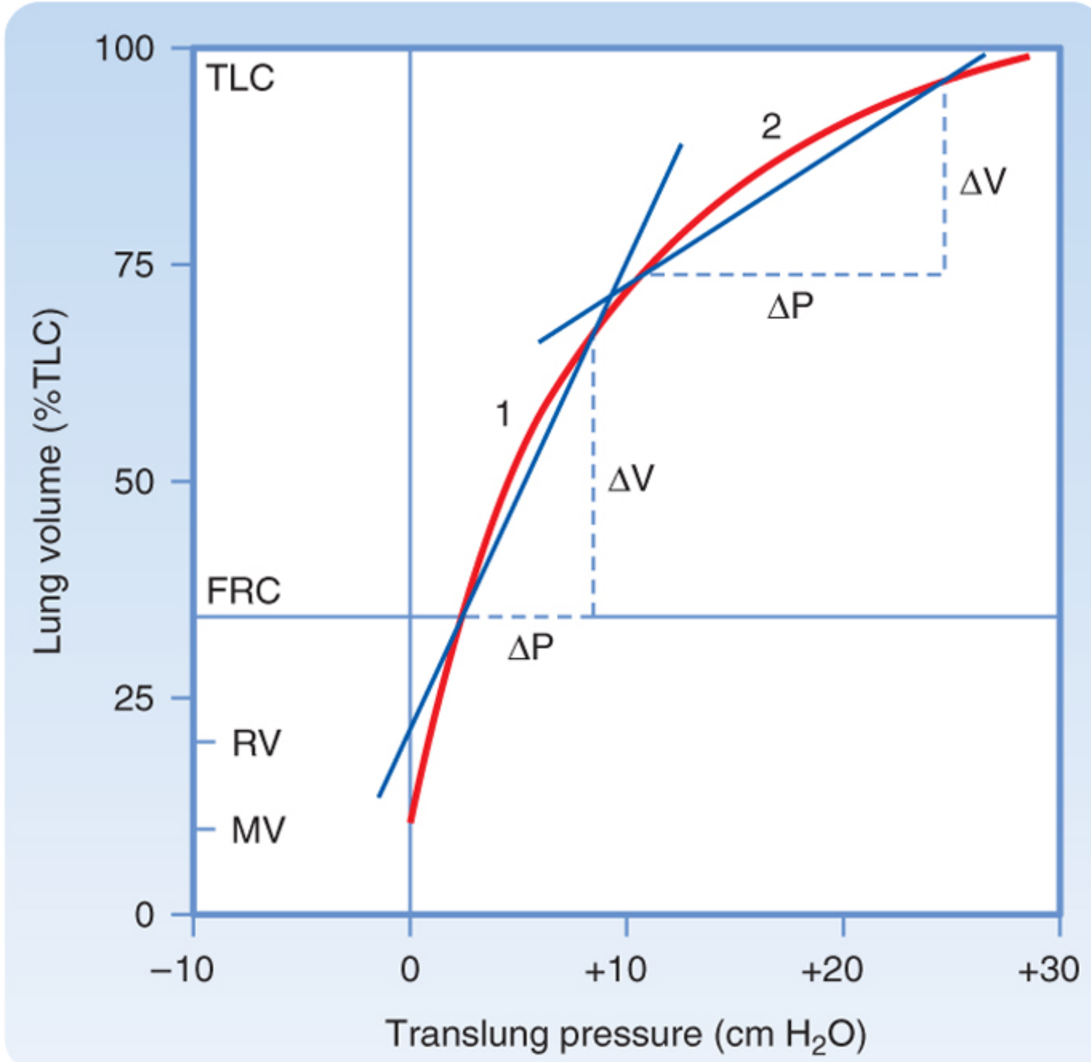
Respiratory Volumes and Capacities for an Average Young Adult Male		
Measurement	Typical Value	Definition
Respiratory Volumes		
1 Tidal volume (TV)	500 ml	Amount of air inhaled or exhaled in one breath during relaxed, quiet breathing
2 Inspiratory reserve volume (IRV)	3,000 ml	Amount of air in excess of tidal inspiration that can be inhaled with maximum effort
3 Expiratory reserve volume (ERV)	1,200 ml	Amount of air in excess of tidal expiration that can be exhaled with maximum effort
4 Residual volume (RV)	1,200 ml	Amount of air remaining in the lungs after maximum expiration; keeps alveoli inflated between breaths and mixes with fresh air on next inspiration
Respiratory Capacities		
5 Vital capacity (VC)	4,700 ml	Amount of air that can be exhaled with maximum effort after maximum inspiration (ERV + TV + IRV); used to assess strength of thoracic muscles as well as pulmonary function
6 Inspiratory capacity (IC)	3,500 ml	Maximum amount of air that can be inhaled after a normal tidal expiration (TV + IRV)
7 Functional residual capacity (FRC)	2,400 ml	Amount of air remaining in the lungs after a normal tidal expiration (RV + ERV)
8 Total lung capacity (TLC)	5,900 ml	Maximum amount of air the lungs can contain (RV + VC)



(after Pappenheimer, J.R., et al (1950) Fed. Proc., **9**,602)

At rest a normal male adult breathes in and out about 12 times per minute. The amount of air breathed in per minute is therefore 500 ml × 12 i.e. 6000 ml or 6 litres – this is the **respiratory minute volume** or **pulmonary ventilation**. In exercise it may go up to as much as 200 litres. These values are about 25% lower in women.

In deep breathing the volume of **atmospheric air inspired** with each inspiration and the amount which reaches the **alveoli** increase.



Koeppen & Stanton: Berne and Levy Physiology, 6th Edition.

Figure 21-4 Deflation pressure-volume (PV) curve. Because of hysteresis caused by surfactant, the deflation PV curve is used for measurements. Compliance at any point along this curve is the change in volume per change in pressure. From the curve it can be seen that lung compliance varies with lung volume. Compare the compliance at 1 versus 2. By convention, lung compliance is the change in pressure in going from FRC to FRC +1 L.

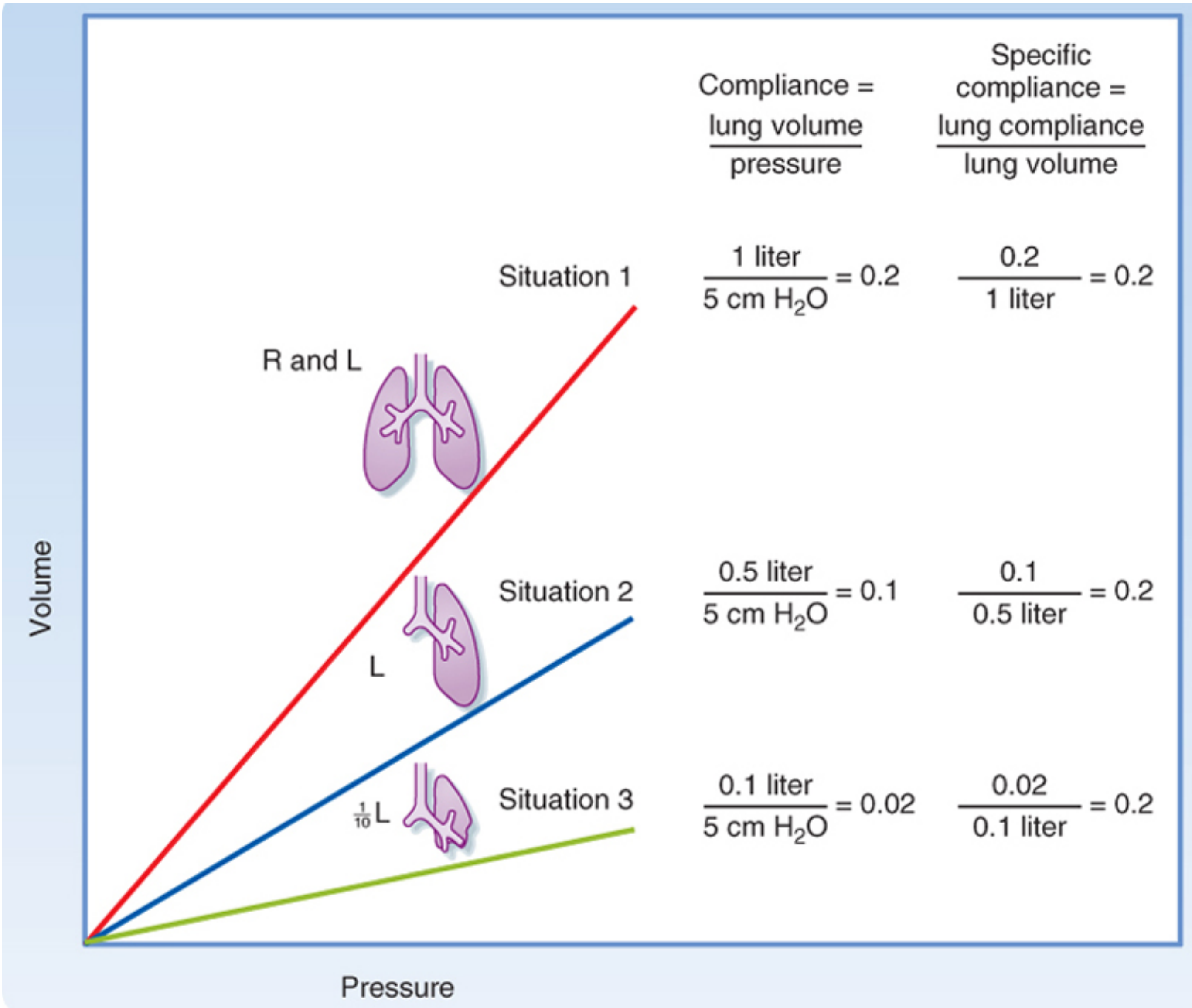


Figure 21-5 Relationship between compliance and lung volume. Imagine a lung in which a 5-cm H_2O change in pressure results in a 1-L change in volume. If half of the lung is removed, the compliance will decrease, but when corrected for volume of the lung, there is no change (specific compliance). Even when the lung is reduced by 90%, the specific compliance is unchanged.

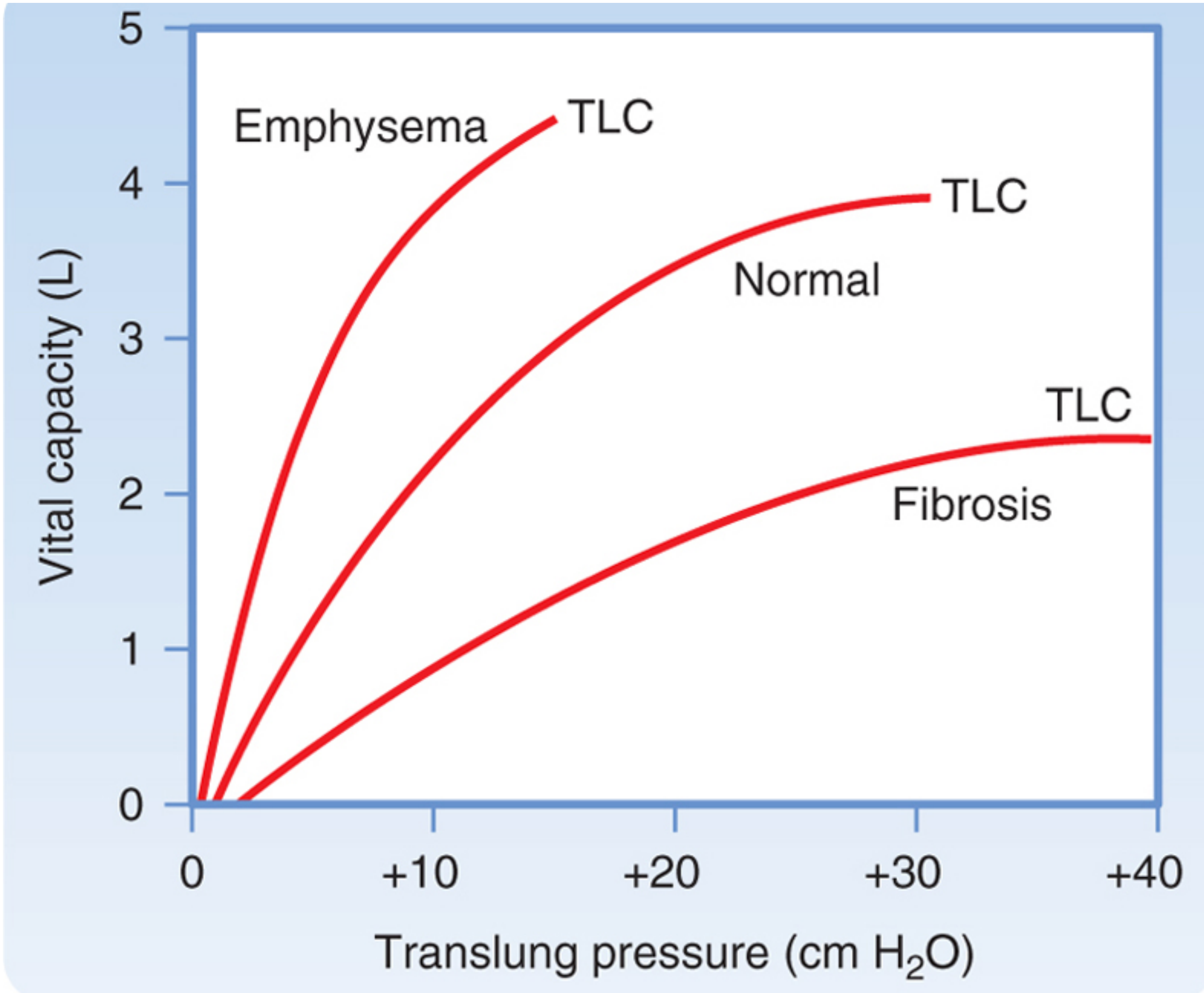
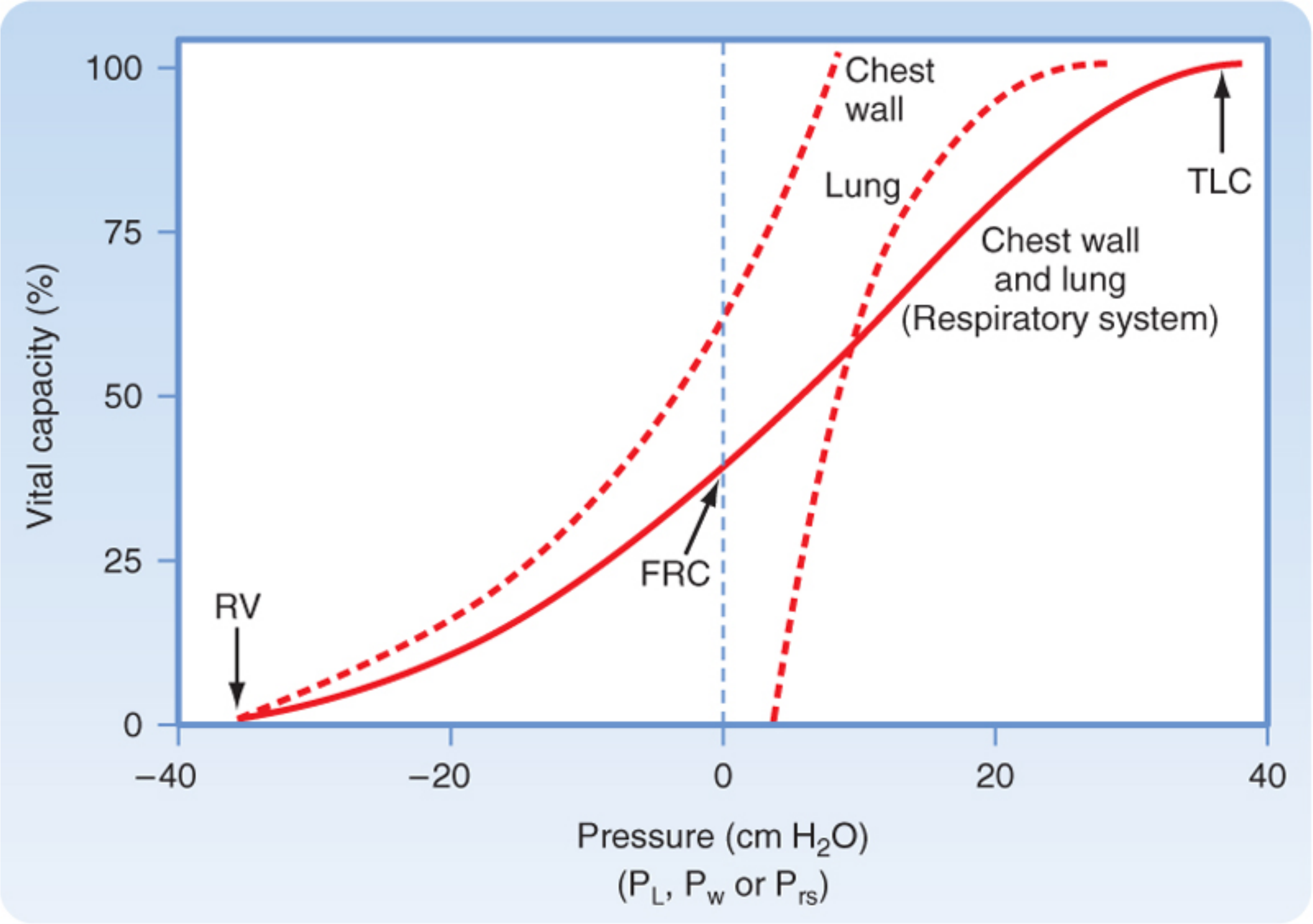
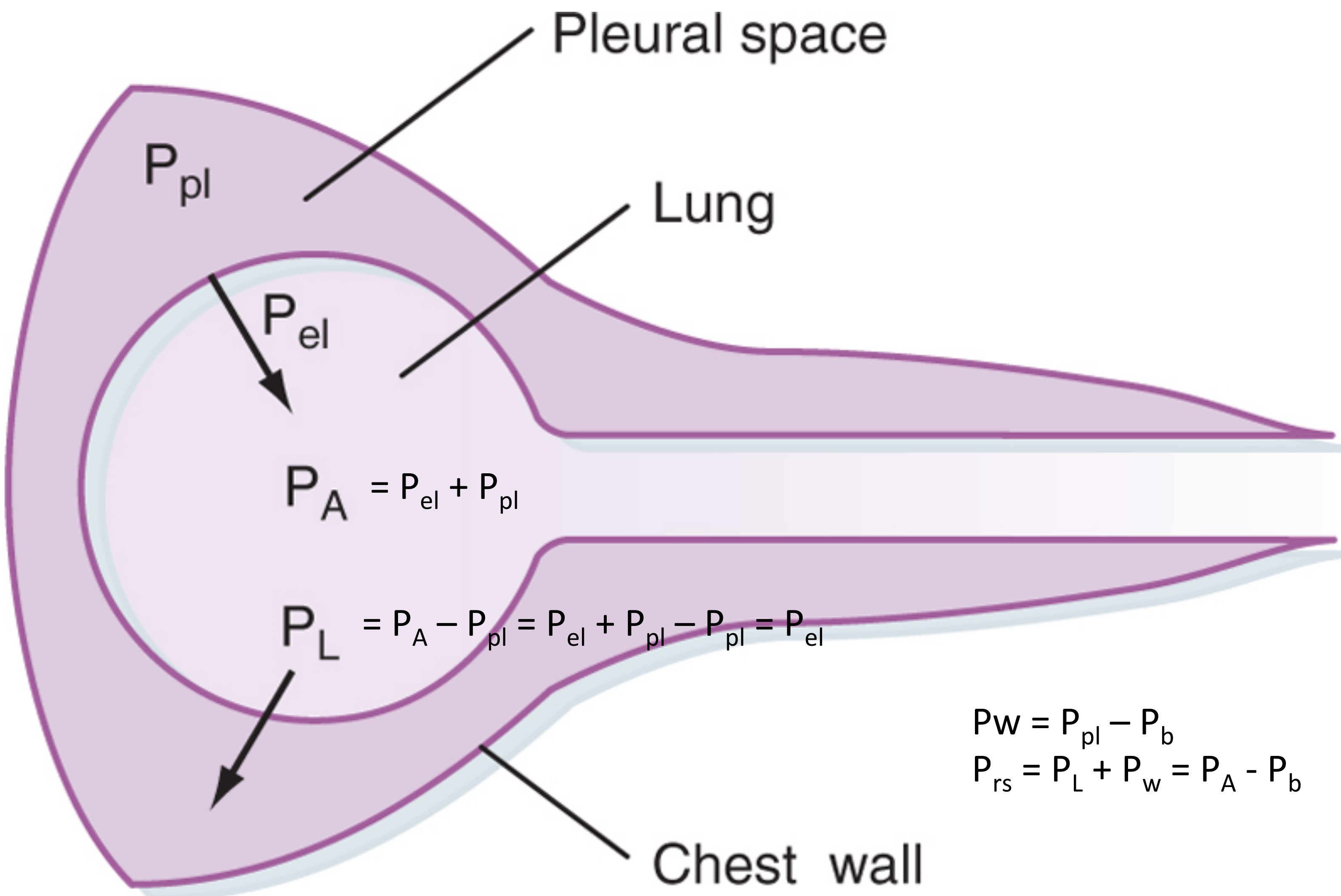


Figure 21-6 Fibrosis/emphysema pressure-volume curve.



Koeppen & Stanton: Berne and Levy Physiology, 6th Edition.

Figure 21-7 Relaxation pressure-volume curve of the lung, chest wall, and respiratory system. The curve for the respiratory system is the sum of the individual curves. The curve for the lung is the same as in Figure 21-6.



$Pw = P_{pl} - P_b$

$P_{rs} = P_L + P_w = P_A - P_b$

Figure 21-8 Relationship between transpulmonary pressure (P_L) and the pleural (P_{pl}), alveolar (P_A), and elastic recoil (P_{el}) pressures of the lung. Alveolar pressure is the sum of pleural pressure and elastic recoil pressure. Transpulmonary pressure is the difference between pleural pressure and alveolar pressure.

END

Video 4, Module 11