

Table 23-2 • Factors Affecting Alveolar–Capillary Gas Exchange

Factors Affecting Gas Exchange	Examples
Surface area available for diffusion	Removal of a lung or diseases such as emphysema and chronic bronchitis, which destroy lung tissue or cause mismatching of ventilation and perfusion
Thickness of the alveolar–capillary membrane	Conditions such as pneumonia, interstitial lung disease, and pulmonary edema, which increase membrane thickness
Partial pressure of alveolar gas	Decreasing the partial pressure of a gas in the inspired air (e.g., ascent to high altitudes) decreases the gradient for diffusion; increasing the partial pressure of a gas in the inspired air (e.g., oxygen therapy) increases the gradient for diffusion
Solubility and molecular weight of the gas	Carbon dioxide, which is more soluble in the cell membranes, diffuses across the alveolar–capillary membrane more rapidly than oxygen

From Porth CM: Pathophysiology: Concepts of Altered Health States, 6th ed. Philadelphia, Lippincott Williams & Wilkins, 2002, p 594.

mechanism of this response, called *hypoxic vasoconstriction*, is not known.⁹ Hypoxic vasoconstriction has the effect of directing blood flow away from hypoxic areas of the lung. By diverting blood flow from these areas, the deleterious effects on gas exchange are reduced.

RELATIONSHIP OF VENTILATION TO PERFUSION

Distribution of Ventilation

Not all areas of the lung have the same ventilation. Body position affects distribution of ventilation. In a seated or standing position, lower regions of the lung ventilate better than upper zones. In a supine position, the apex and base of the lung ventilate about the same; however, ventilation in the lowermost (posterior) lung is greater than that of the uppermost (anterior) lung. In a lateral position, the dependent lung is best ventilated.³

Distribution of Perfusion

As with ventilation, the distribution of pulmonary blood flow is affected by body position and gravity. In the upright position, blood flow is better at the base of the lungs than the apex of the lungs. In the supine position, the blood flow from apex to base is almost uniform, but blood flow in the posterior (dependent) regions of the lung exceeds that of the anterior regions. In the prone position, the same holds true: blood flow in the dependent region (now the anterior chest) exceeds that of the posterior chest.

Considerable inequality of blood flow exists within the human lung (Fig. 23-15). The uneven distribution of blood flow can be explained by the hydrostatic pressure differences in the blood vessels. In zone 1, alveolar pressures exceed pulmonary arterial and pulmonary venous pressures. The capillaries are basically squashed flat by the pressure in the alveoli, and there is no blood flow. In zone 2, pulmonary arterial pres-

ures are greater than alveolar pressures, so some blood flow occurs. Blood flow here is determined by the differences in arterial and alveolar pressures. In zone 3, there is minimal alveolar pressure influence on the pulmonary vasculature, and blood flow is determined in the usual way by the arteriovenous pressure difference.

Matching of Ventilation to Perfusion

Effective pulmonary gas exchange depends on a balance, or matching of ventilation to perfusion (Fig. 23-16A). Two factors may interfere with the matching of ventilation to perfusion: dead space and shunt. As previously described in this chapter, dead

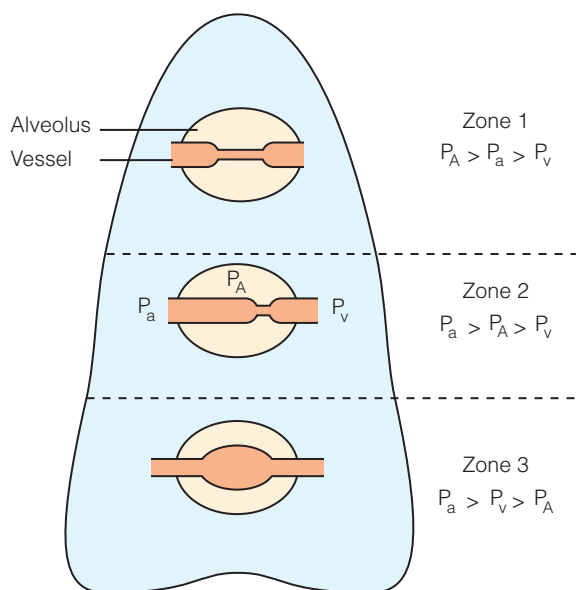


Figure 23-15 • Explanation of the uneven distribution of blood flow in the lung, based on the pressures affecting the capillaries. P_A , alveolar pressure; P_a , arterial pressure; P_v , venous pressure. (From West JB: Respiratory Physiology: The Essentials, 7th ed. Philadelphia, Lippincott Williams & Wilkins, 2005, p 44.)