Gravity and Physiological Function

Gravity creates gradients in the lungs that influence both ventilation and perfusion. In an upright lung, gravity causes more blood flow (perfusion) at the lung bases compared to the apex due to hydrostatic pressure.

Ventilation also increases from apex to base but less steeply than perfusion. Thus, the ventilation-perfusion ratio (VA/Q) is higher at the apex (more ventilation relative to perfusion) and lower at the base (more perfusion relative to ventilation).

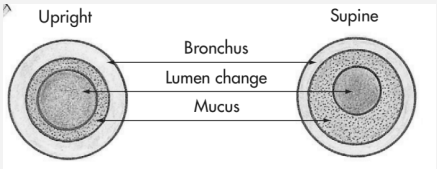
This uneven distribution of VA and Q affects gas exchange efficiency and arterial blood gases: PaO2 tends to be slightly lower at the base of the lungs due to lower VA/Q ratios, while PaCO2 is correspondingly higher.

Oxygen (O2) content and carbon dioxide (CO2) content of the blood depend on both the amount of gas exchange occurring and the matching of ventilation and perfusion, both influenced by gravitational effects on lung zones.

pH can be affected as CO2 retention in poorly ventilated areas leads to respiratory acidosis, while well-ventilated regions support normal pH.

The flow of oxygen into the lungs and CO2 out of the lungs depends on adequate ventilation and perfusion matching influenced by body position and gravity.

Effect on positioning on bronchiolar lumen



Physiological effects

Aspect	Effect of Body Positioning
Lung Expansion & Ventilation	Upright increases lung volumes and functional residual capacity (FRC); supine decreases lung expansion due to abdominal pressure on diaphragm.
Ventilation-Perfusion Matching	Upright and side-lying positions optimize matching; supine may impair and cause uneven gas exchange
Oxygenation	Best in upright; side-lying improves oxygenation in unilateral lung disease; prone can benefit severe respiratory distress.
Blood Flow & Perfusion	Gravity favors blood flow to lung bases in upright; altered flow in supine and other positions.
Cardiac Output	Upright favors venous return and cardiac output; supine or head-down can alter preload and may impact heart function.
Work of Breathing	Increased in supine due to diaphragm limitation; reduced in upright positions.
Risk of Complications	Prolonged immobility or poor positioning increases risk of atelectasis, pneumonia, and impaired oxygen delivery.

Physical therapy implications

Gravity is the principal contributor to inhomogeneity of physiological function down the lungs.

Body positioning significantly affects cardiovascular and pulmonary function by influencing oxygen transport, blood flow, lung expansion, and ventilation-perfusion matching.

Gravity influences blood flow distribution and lung ventilation depending on body posture.

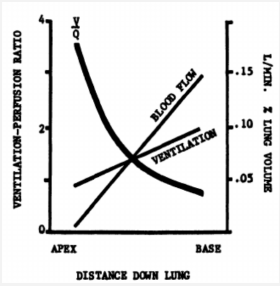
Upright and moving positions promote optimal lung expansion and oxygenation by facilitating better ventilation and perfusion matching.

The upright position can be more energetically demanding than supine positions, which are more demanding than lateral positions. Compression forces also affect the heart and cardiac output.

Indications

Cardiopulmonary Indications	• Shift distribution of alveolar volume • Shift distribution of ventilation • Shift distribution of perfusion • Shift distribution of diffusion • Shift distribution of ventilation to perfusion matching • Shift intraabdominal pressure
Cardiovascular Indications	• Shift gravitational, mechanical, and compression forces on the myocardium, great vessels, mediastinal structures, and lymphatic system • Stimulate fluid volume shifts particularly to the dependent limbs
Other Systemic Indications	• Alter arousal state • Promote relaxation • Promote comfort • Control pain • Prevent skin breakdown, risk for infection, and resulting positioning limitations

Figure 1

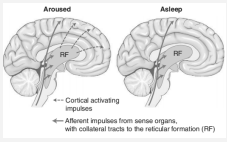


The effect of gravity on ventilation and perfusion from the apex to the base of the lung. The net effect on the ventilation-perfusion ratio is shown by the curve

Effects of Positions on Lung Function

Position	Effect on Lung Function	Clinical Use / Notes
Upright/Sitting	Maximal lung expansion, increased functional residual capacity (FRC), improved ventilation-perfusion (V/Q) matching.	Reference position; best for coughing, breathing, and oxygenation.
Standing	Highest lung volumes and maximal expiratory pressures; gravity pulls diaphragm down, enabling larger thoracic volume.	Ideal for active mobilization and exercise.
Supine	Reduced lung volumes and FRC due to abdominal pressure on diaphragm; increased lung and heart compression.	May impair oxygenation, especially in heart/lung disease.
Side-Lying	Improves ventilation to dependent lung, enhances oxygenation; FRC between upright and supine values.	Used for unilateral lung disease; "good lung down" principle.
Prone	Improves alveolar recruitment and oxygenation; redistributes lung perfusion.	Beneficial in severe ARDS or respiratory distress.
Head-Down (Trendelenburg)	Shifts abdominal contents upward, can improve diaphragm efficiency but may increase respiratory effort in some.	Use cautiously; not routine in respiratory compromise.

Effect of arousal on cerebral activity



The more upright the patient, the greater the neurological arousal and the greater the stimulus to breathe. Commensurate with an increase in arousal, the patient is stimulated to take deeper breaths and, hence, to increase VA . When body positioning is coupled with mobilization, vasodilation and recruitment of the pulmonary capillaries are stimulated, and this, inturn, improves the homogeneity of the distributions of VA and Q, hence augmenting V/Q matching.

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Monitor Responses to Position Changes

ABG Parameters

Subjectively, the patient’s facial expression, respiratory distress, dyspnea, anxiety, peripheral edema, discomfort, and pain are assessed.

Objectively, heart rate, blood pressure, respiratory rate, SaO2, flow rates, and bedside spirometry can be readily assessed.