

Chapter 15

Perioperative Respiratory Care and Complications

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ABSTRACT

Clinicians caring for patients with cardio-pulmonary disease invariably must manage the respiratory system. Doing so requires a basic understanding of physiology and the interaction of the heart and lung. The present chapter begins with rudimentary concepts of respiratory physiology, focusing on, gas exchange, pulmonary mechanics, and cardio-pulmonary interactions. These are used to develop an approach to mechanical ventilation and routine perioperative respiratory care of the patient having undergone a cardio-pulmonary procedure. The final section of this chapter addresses specific respiratory challenges encountered in caring for the critically ill cardiothoracic patient in addition to contemporary management strategies.

INTRODUCTION

The present chapter provides the reader with a systematic approach to the respiratory care of patients with cardio-pulmonary disease. The initial section focuses on physiology, specifically, gas exchange, respiratory mechanics, and cardio-pulmonary interactions. Basic understanding of these fundamentals creates a foundation for understanding respiratory pathophysiology.

A problem-oriented approach is provided in later sections of the chapter with a focus on routine mechanical ventilation and ventilator liberation following surgery. The final section of this chapter outlines specific management strategies for commonly encountered respiratory problems in the critical care unit.

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Key words: Gas exchange, respiratory mechanics, cardio-pulmonary interaction, work of breathing, respiratory failure, mechanical ventilation, ventilator liberation, pulmonary edema, chronic obstructive pulmonary disease, pneumothorax, pleural effusion, acute respiratory distress syndrome.

BACKGROUND

The respiratory system's primary function is to exchange oxygen and carbon dioxide in support of metabolism. This is achieved by approximating blood and air over a large surface area. The heart and lungs move blood and air, permitting exchange of gas between alveoli, pulmonary capillaries, tissue, and eventually cells.

The respiratory system is made of two components, the lung and chest wall. Airways smaller than respiratory bronchioles contain alveoli that function as gas exchanging units. The chest wall includes the rib cage, abdomen, and diaphragm. Parietal and visceral pleura separate the chest wall from the lung with a potential pleural space between.

Respiratory Physiology and Pathophysiology

Gas Exchange

The most basic and essential action of the lung is the efficient exchange of gases between the blood and the external environment via the alveolus-blood interface. The movement of gases across this membrane is governed by passive diffusion, a process described by Fick's law of diffusion.

$$\dot{V}_{gas} \propto \frac{A}{T} \cdot D \cdot (P_1 - P_2) \quad D \propto \frac{Sol}{\sqrt{MW}}$$

This law states that the rate of gas migration through a membrane is directly proportional to both the area of the membrane (A), and the difference in partial pressure of the gas on both sides of the membrane ($P_1 - P_2$), and is inversely proportional to the thickness of the membrane (T). Given this relationship, the lung is structurally well suited for gas exchange with its large surface area (50-100 m²) and thin alveolar walls (approximately 0.3 µm)(West, 2012). The transfer rate is also directly dependent on a diffusion constant (D) that is related to both the blood solubility (Sol) of the gas and its molecular weight (MW). The physiologic impact of the diffusion constant is illustrated by the fact that while CO₂ and O₂ have similar molecular weights and partial pressure differences, the relative solubility of CO₂ is much higher, allowing CO₂ transport to occur at 20-fold higher rates than O₂ transport.

Given the specific characteristics of a gas, its rate of transport can be classified as either diffusion limited or perfusion limited. Diffusion limitation occurs with gases that are very soluble in blood (e.g. – carbon monoxide), and therefore the partial pressure difference between the alveolus and blood is maintained throughout capillary transit, continually driving transport. In this situation, a large amount of gas can be absorbed into a relatively small volume of blood, and the amount of gas crossing the membrane is dependent on the rate of diffusion, not the volume of blood that traverses the capillary. Perfusion limitation is seen with gases that are less soluble in blood (e.g. – nitrous oxide), leading to partial pressure

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