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Biopac Student Lab® Lesson 8

RESPIRATORY CYCLE I

Introduction

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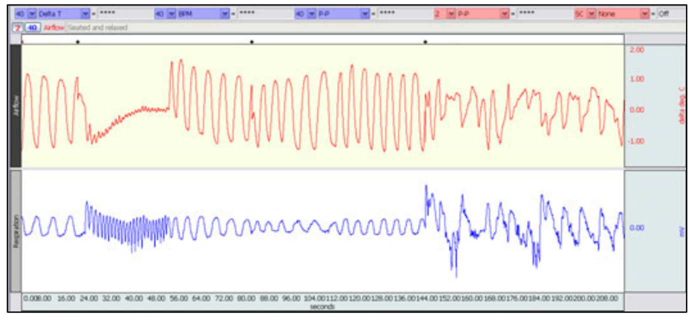

I. INTRODUCTION

Three primary functions of the respiratory system are to provide oxygen for the body's energy needs, provide an outlet for CO_2, and help maintain the pH of the blood plasma. The respiratory cycle serves these multiple purposes in conjunction with the circulatory system.

The mechanics of the respiratory cycle consists of alternating processes of **inspiration** and **expiration**. During inspiration, skeletal muscles (such as the diaphragm and external intercostals) contract, thereby increasing volume within the thoracic cavity and lungs. The increased volume creates less pressure within the lungs than the atmosphere, so air rushes into the lungs. During resting expiration, the inspiratory muscles relax, causing the volume of the thoracic cavity and the lungs to be reduced. This reduction forces gas back into the atmosphere. Normally, unlabored expiration at rest is a passive event determined by relaxation of inspiratory muscles. During exercise or during forced exhalation, e.g., coughing, expiration becomes an active event dependent upon contraction of expiratory muscles that pull down the rib cage and compress the lungs.

During inspiration, oxygen drawn into the lungs diffuses to the pulmonary capillaries and is transported to cells via erythrocytes (red blood cells). The cells use oxygen to supply energy for metabolic processes. When producing energy, these cells then release carbon dioxide as a waste product. Some of the carbon dioxide reacts with water in the body to form carbonic acid, which then dissociates to H^+ and bicarbonate. The erythrocytes transport CO_2 and H^+ back to the lungs. Once in the lungs, the H^+ and HCO_3^- recombine to form water and CO_2 (Fig. 8.1).

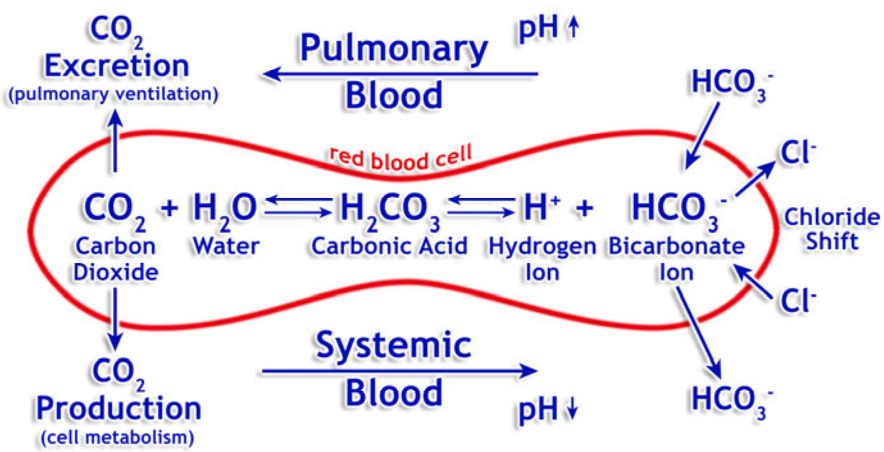

Fig. 8.1

Many factors are involved in the regulation of **ventilation**, the rate and depth of breathing. The basic **rhythm** of breathing is established by **inspiratory** and **expiratory** respiratory centers in the medulla.

- The inspiratory center initiates inspiration via activation of the inspiratory muscles. During normal, quiet breathing at rest (**eupnea**,) the average respiratory rate (RR) is 12-14 cycles/minute. The inspiratory center always acts to produce an active inspiration.
- In contrast, the expiratory center acts to limit and then inhibit the inspiratory center, thereby producing a passive expiration.

This basic breath pattern is affected by:

a) Higher centers in the brain.

b) Feedback from peripheral and central **chemoreceptors** in the arterial system and medulla, respectively.

c) Stretch receptors in the lungs.

d) Other sensory receptors in the body.

For example, cerebral control of the medullary respiratory centers is observed when a subject attempts to thread a needle. The cycle temporarily ceases in order to minimize body movement so that the needle may be threaded more easily. Cerebral control is also evident during speech, which requires expiratory air to pass over the vocal cords.

The separate chemoreceptors sense O_2, CO_2 and H^+ levels in the blood and in the cerebrospinal fluid of the medulla. In ***hyper*****ventilation** (excess ventilation,) the breathing rate and depth is increased so that the lungs rid the body of carbon dioxide faster than it is being produced. Hydrogen ions are removed from body fluids and the pH becomes elevated. This tends to depress ventilation until normal carbon dioxide and hydrogen ion levels are restored. The temporary cessation of breathing after voluntary hyperventilation is known as *apnea vera*.

In ***hypo*****ventilation** (insufficient ventilation - shallow and/or slow breathing) the lungs gain carbon dioxide in body fluids (*hypercapnia*) since the lungs fail to remove carbon dioxide as rapidly as it is being formed. The increased formation of carbonic acid results in a net gain of hydrogen ions, lowering pH in body fluids. The chemoreceptor feedback causes ventilation to increase until carbon dioxide levels and extracellular fluid pH return to normal.

In this lesson, you will measure ventilation by recording the rate and depth of the breathing cycle using a **pneumograph transducer**. This transducer converts changes in chest expansion and contraction to changes in voltage, which will appear as a waveform. One respiratory cycle will then be recorded as an increasing voltage (ascending segment) during inspiration and a decreasing voltage (descending segment) during expiration.

You will also use a temperature transducer to indirectly measure airflow from one nostril. Each inhale brings cooler air across the transducer, and each exhale blows warmer air across the transducer. The temperature of the air passing by the temperature probe is inversely related to the expansion or contraction of the Subject's chest. This indirect method is efficient when rate and relative amplitude measurements are all that's required; a direct airflow measurement requires more complicated equipment and data processing.