CHAPTER 1: THE LUNGS AND RESPIRATORY SYSTEM

INTRODUCTION

Lung cancer affects a life-sustaining system of the body, the respiratory system. The respiratory system is responsible for one of the essential functions of life, breathing. Breathing enables us to take in oxygen and expel carbon dioxide. Every cell in the body depends on oxygen to function. If the supply of oxygen is impaired in any way, the entire body is affected.

An understanding of how the lungs and respiratory system work will help you understand how lung cancer affects the body. It may also be helpful as you talk with your health care providers, gather information about your illness, and communicate with your family and friends.

THE RESPIRATORY SYSTEM

Breathing

The respiratory system has one vital function, breathing. When you breathe in or inhale, your body receives oxygen. Oxygen is a gas in the air that is needed to sustain life. The human body cannot survive without oxygen for more than a few minutes. When you breathe out or exhale, you rid the body of carbon dioxide, a gas produced by normal body functions. Getting rid of carbon dioxide is necessary because excessive amounts of carbon dioxide are toxic. The lungs are the place in the body where essential oxygen is taken in, and toxic carbon dioxide is released. When the lungs have difficulty doing their job, other organs in the body have difficulty doing their jobs. Therefore, the health of the lungs has direct and immediate effects on the overall health of the body.
The respiratory system is made up of those body parts that help us take in air and expel carbon dioxide. Take a breath in and you will quickly become aware of some of the body parts of the respiratory system. Air comes in through either the nose or the mouth. It passes to the throat (pharynx), and is pulled into the windpipe (trachea). The trachea splits in two between the lungs sending one branch to each lung (see Figure 1). These branches are called the right and left main bronchus. Before we discuss the path of air once it enters the lungs, let us first consider how we manage the act of breathing.

Air moves in and out of the body by the action of muscles. The diaphragm is a large muscle that sits below the lungs. It separates the lungs and other organs in the chest from the organs of the abdomen. When the diaphragm contracts or tenses, it moves down causing the lungs to expand and pull in air. When the diaphragm relaxes, it moves up, pushing against the lungs and causing them to expel air. There are also muscles between the ribs that help in this cycle of expanding and contracting the lungs, forcing air in and out. Put your hands on your chest and take a breath in. You will feel your chest expand. As you breathe out, you will feel your chest move inward. This movement is the result of the diaphragm and other muscles of the chest automatically contracting and relaxing with each breath in and out.
The lungs take up most of the space in the chest cavity, which extends from the collarbones to the diaphragm (see Figure 2). The organs of the chest are protected by the ribs. The area between the lungs in the middle of the chest is called the mediastinum. It contains the heart, windpipe (trachea), food pipe (esophagus), blood vessels, and many lymph nodes. Examination of the lymph nodes in the mediastinum is an important part of the lung cancer staging process and is discussed in Chapter 4: Lung Cancer Diagnosis and Staging.

**The Lungs**

You have two lungs, one on each side of the chest. The top, cone shaped part of the lung that fits under the collarbone is called the apex. The broad, bottom part of the lung that rests on the diaphragm is called the base.

Unlike some other paired organs in the body, the two lungs are not identical (see Figure 2). The right lung is normally larger than the left. It is divided into three sections or lobes, the upper (also called superior), middle, and lower (also called inferior). The left lung has two lobes, the upper and lower. The left lung has an indentation called the cardiac notch to make room for the heart. Each lung lobe is divided into segments. Health care providers often use the names of lung segments to describe specific locations in the lungs.

The lungs contain elastic fibers that allow the lungs to expand and contract. Healthy lungs have a smooth, shiny surface because they are encased in a thin, moist covering called the visceral pleura. There is also a pleural covering called the parietal pleura that lines the inner surface of the chest cavity. The visceral and parietal pleura are normally slippery and glide easily against each other as you breathe.

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*Figure 2: Organs of the Chest*
The right and left main bronchi carry air in and out of the lungs. They are the beginning of a system of airways called the *bronchial tree*. The point at which the main bronchus enters the lung is called the *hilum*. The bronchial airway system is called a ‘tree’ for a very practical reason. The airways branch approximately 20 times in the lungs. At each branch point, the airways become smaller and more numerous much like the branches of trees (see Figure 3). The main bronchi branch into *lobar bronchi*, one for each lobe of the lung. From here, the airways divide into *segmental bronchi*, one for each lung segment. Segmental bronchi branch several times into smaller airways called *bronchioles*. The final branches of the bronchial tree are called *atria*. The atria end in tiny, microscopic air sacs called *alveoli*. Alveoli resemble clusters of grapes under the microscope. Each lung contains about 300 million alveoli. The walls of the alveoli are extremely thin, which makes them fragile and susceptible to damage. Damage to the alveoli is irreversible.

Alveoli are surrounded by tiny blood vessels called *capillaries*. There are about one billion capillaries in the lungs, more than three for each air sac. The blood in the capillaries is separated from the air in the alveoli only by the extremely thin alveolar and capillary walls. This close proximity allows gases to be exchanged between the blood and the lungs in a process called *respiration*. Inhaled oxygen enters the blood from the alveoli. Carbon dioxide leaves the blood and enters the alveoli to be exhaled. The close relationship between the circulatory and respiratory systems will be discussed in the following section, *The Link Between the Respiratory and Circulatory Systems.*

*Figure 3: The Bronchial Tree*
The lungs are traversed by another important system of vessels called the lymphatics. Each lung contains a network of lymphatic vessels that carry a mixture of fluid and proteins called lymph. Lymph is carried from the lung tissues through a series of lymph nodes to filter the fluid before it is returned to the bloodstream. This network of lymph vessels and lymph nodes are an important part of the body’s immune system. The work of the immune system and its role in lung cancer is discussed in Chapter 2: Understanding Cancer.

THE LINK BETWEEN THE RESPIRATORY AND CIRCULATORY SYSTEMS

The Respiratory Cycle

The respiratory and circulatory systems have closely related jobs. The work of these two systems is sometimes referred to together as the cardiorespiratory system. The respiratory system is responsible for taking in oxygen and expelling carbon dioxide. However, it is dependent on the circulatory system to distribute the oxygen that has been taken in by the lungs to the body tissues. Similarly, the circulatory system picks up carbon dioxide from the tissues and delivers it to the lungs where it is exhaled. Every cell of the body requires oxygen to perform its jobs. Carbon dioxide is released as these jobs are performed and must be eliminated to prevent excess amounts from accumulating in the tissues. Continuous removal of carbon dioxide from the body is just as important for health as is a constant supply of oxygen.

In the respiratory cycle, oxygen is picked up by the capillaries surrounding the alveoli (see Figure 4). The oxygen-rich blood is carried to the heart, which pumps the blood into arteries that carry it to the tissues of the body. In the tissues, capillaries release oxygen and pick up carbon dioxide. This carbon dioxide-rich blood is carried by veins back to the heart, which

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pumps it to the lungs. Carbon dioxide is released from the blood into the alveoli and new oxygen is picked up, beginning the cycle again. A more detailed discussion of the circulatory system is presented in the next section, *The Circulatory System*.

The success of the respiratory cycle is dependent on the very thin walls of the alveoli. These walls normally allow for a quick and easy exchange of oxygen and carbon dioxide. Lung diseases like emphysema and cancer can damage the delicate alveoli and interfere with the vital exchange of gases resulting in abnormal levels of oxygen and carbon dioxide in the blood.

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**Figure 5: Chambers of the Heart**
Arrows show the direction of blood flow through the heart.

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**The Circulatory System**

Similar to the bronchial tree, the circulatory system is a branching network of blood vessels. The heart is at the center of the circulatory system. Its pumping action moves blood through the body. The heart has four compartments called chambers, two on the right and two on the left. The two chambers on the right work together as do the two chambers on the left. The top chambers of the heart are called the right atrium and left atrium. The bottom chambers are called the right ventricle and left ventricle (see Figure 5).

Carbon dioxide-rich, oxygen-poor blood is delivered from the tissues of the body by the veins to the right atrium of the heart. Blood flows from the right atrium to the right ventricle, and then leaves the heart through the pulmonary artery (PA). Before reaching the lungs, the PA divides into a right and left branch, one for each lung. Once in the lungs, the PA branches several times into smaller blood vessels called arterioles. These arterioles run in the walls of the airway system’s bronchioles. The arterioles continue to branch and become
progressively smaller until they reach the level of the alveoli. At the alveoli, the blood vessels have become the tiny, microscopic capillaries that are capable of gas exchange.

Blood passes through the alveolar capillaries releasing carbon dioxide and picking up oxygen. The oxygen-rich blood is delivered to the left atrium by the pulmonary veins (see Figure 6). Blood passes from the left atrium into the left ventricle, and is pumped out through the aorta to be distributed by a branching system of arteries, arterioles, and capillaries throughout the body.

Lung diseases, including lung cancers, can affect the function of the right side of the heart since blood is pumped from the right side of the heart to the lungs. Although right heart abnormalities are not a common complication of lung cancer, they can occur. The left side of the heart is usually not affected by diseases of the lung. However, if the blood pressure in the lungs becomes very high, the left side of the heart can be affected.

**RESPIRATION AND MAINTAINING CHEMICAL BALANCE**

Respiration is one of the body’s stabilizing or *homeostatic mechanisms*. The respiratory system helps maintain a constant internal environment that keeps all of the body cells functioning effectively. It does this by supplying adequate oxygen and removing excess carbon dioxide. Slight changes in the oxygen and/or carbon dioxide levels in the blood trigger processes that
attempt to bring these levels back to normal. For example, if you exert yourself by running or climbing stairs, your heart rate and breathing will automatically increase. This is your body’s response to an increased need for oxygen and an excess of carbon dioxide that must be eliminated. The harder your muscles work, the more oxygen they need and the more carbon dioxide they produce. By breathing faster, you increase your intake of oxygen and expel more carbon dioxide. A faster heart rate increases the speed of delivery of oxygen and the clearance of carbon dioxide. In other words, when you exert yourself, you breathe more quickly and your heart beats faster because the body is attempting to bring your oxygen and carbon dioxide levels back to normal.

Survival depends on the body’s ability to respond to continuous changes in its environment. The body’s ability to respond to changes in its internal and external environments requires constant communication and interaction between the various organ systems of the body. Changes in the body trigger complex responses. Various body systems often work together to return the internal environment to a normal state.

The kidneys help maintain normal levels of many substances in the body. In the preceding example, we discussed how a short-term increase in carbon dioxide from exercising causes rapid increases in heart and breathing rates. However, if the carbon dioxide level is increased over a longer period and the increased efforts of the cardiac and respiratory systems are unable to clear it quickly enough, the accumulation of carbon dioxide can cause the internal body environment to become more acidic (the blood pH decreases). The pH of the blood is an indicator of the acidity or alkalinity of the body. The kidneys respond to a drop in blood pH. They attempt to assist the cardiac and respiratory systems by ridding the body of its excess acid through the urine. This demonstrates how different organ systems work together to try to keep the body in normal balance.

In addition to responding to the pH of the body, the kidneys also respond to prolonged decreases in body oxygen levels by increasing production of a hormone called erythropoietin. Increased erythropoietin leads to an increase in the production of red blood cells, the cells of the blood that carry oxygen. In this way, the kidneys try to help the body meet its oxygen needs by increasing the oxygen-carrying capability of the blood. Anemia is the condition of
having an abnormally low number of red blood cells. There are many causes of anemia, and cancer is one of these causes. Anemia is also a common side effect of some forms of cancer therapy. The symptoms of anemia include feeling abnormally tired, shortness of breath, dizziness, and becoming easily fatigued (tiring quickly). Anemia associated with cancer or its treatment can overwhelm the body’s homeostatic mechanisms. Therefore, if you have the symptoms of anemia, be sure to discuss them with your health care provider. He or she may be able to give you medications or treatments that will correct the problem and eliminate the symptoms.

Damage to lung tissues can reduce the respiratory system’s ability to respond adequately to changes in oxygen and carbon dioxide levels in the body. This impaired capacity can lead to shortness of breath, dyspnea (uncomfortably difficult breathing), fatigue, dizziness, and other symptoms. Although these symptoms have other possible causes, they are common problems for people living with lung cancer. Breathing methods that are designed to help maximize the ability of the lungs to carry out the effective exchange of oxygen and carbon dioxide are described in Chapter 10: Supportive Care for Symptoms of Lung Cancer and Its Treatment.

SUMMARY

The lungs are vital organs; they are necessary to sustain life. The lungs take in needed oxygen and rid the body of excess carbon dioxide. The respiratory and circulatory systems work together to maintain normal oxygen and carbon dioxide levels in all the tissues of the body. When lung tissue is damaged or removed, the lungs become less effective at the vital exchange of these gases. The effects of this decreased function can be experienced throughout the body and cause a variety of symptoms.