Respiratory System – Important Concepts

The Act of Breathing

Breathing starts at the nose and mouth. You inhale air into your nose or mouth, and it travels down the back of your throat and into your windpipe, or trachea. Your trachea then divides into air passages called bronchial tubes.

These airways need to be open during inhalation and exhalation and free from inflammation or swelling and excess or abnormal amounts of mucus.

The Lungs

As the bronchial tubes pass through the lungs, they divide into smaller air passages called bronchioles. The bronchioles end in tiny balloon-like air sacs called alveoli. Your lungs have over 300 million alveoli.

Each alveolus is surrounded by a mesh of tiny blood vessels called capillaries. Here, oxygen from the inhaled air passes through the alveoli walls and into the blood.

After absorbing oxygen, the blood leaves the lungs and is carried to your heart. Your heart then pumps it through your body to provide oxygen to the cells of your organs.

As the cells use the oxygen, carbon dioxide is produced and absorbed into the blood. Your blood then carries the carbon dioxide back to your lungs, where it is removed.

The Diaphragm

Inhalation and exhalation are the processes by which the body brings in oxygen and expels carbon dioxide. The breathing process is aided by a large dome-shaped muscle under the lungs called the diaphragm.

When you breathe in, the diaphragm contracts downward, creating a vacuum that causes a rush of fresh air into the lungs.

The opposite occurs with exhalation, where the diaphragm relaxes upwards, pushing on the lungs, allowing them to deflate.

The air is about 21% oxygen and 78% nitrogen. Just a small amount of 1% is carbon dioxide. However, carbon dioxide levels have a greater effect on breathing than do oxygen levels. When the concentration of carbon dioxide in your blood increases, your breathing rate automatically increases, causing you to expel more carbon dioxide. Then, when the carbon dioxide in your blood decreases your breathing slows down.

A person can't just decide to stop breathing indefinitely. You can hold your breath for awhile, but even if you lose consciousness, your respiratory control center will take over and force your body to breathe.

Clearing the Air

The respiratory system has built-in methods to prevent

harmful substances in the air from entering the lungs.

Small hairs in your nose, called cilia, help filter out large particles. Cilia are also found along your air passages and move in a sweeping motion to keep the air passages clean. But if harmful substances, such as cigarette smoke, are inhaled, the cilia stop functioning properly, causing health problems like bronchitis.

Mucus produced by cells in the trachea and bronchial tubes keeps air passages moist and aids in stopping dust, bacteria and viruses, allergy-causing substances, and other substances from entering the lungs.

Impurities that do reach the deeper parts of the lungs can often be moved up via mucous and coughed out or swallowed.

DISEASES OF THE RESPIRATORY SYSTEM

Lung diseases are some of the most common medical conditions in the world. Tens of millions of people suffer from lung disease in the U.S. Smoking, infections, and genetics are responsible for most lung diseases.

RESPIRATORY DISEASES AFFECTING THE AIRWAYS (trachea and bronchi)

<u>Asthma</u>: The airways are persistently inflamed, and may

occasionally spasm, causing wheezing and shortness of breath. Allergies, infections, or pollution can trigger asthma's symptoms.

Chronic obstructive pulmonary disease (COPD): Lung conditions defined by an inability to exhale normally, which causes difficulty breathing. *Note: Chronic means "persisting over a long period of time".*

Chronic bronchitis: A form of COPD characterized by a chronic productive cough.

Emphysema: Lung damage allows air to be trapped in the lungs in this form of COPD. Difficulty blowing air out is its hallmark.

Acute bronchitis: A sudden infection of the airways, usually by a virus.

Cystic fibrosis: A genetic condition causing poor clearance of mucus from the bronchi. The accumulated mucus results in repeated lung infections.

RESPIRATORY DISEASES AFFECTING THE AIR SACS (Alveoli)

These air sacs make up most of the lung tissue. Lung diseases affecting the alveoli include:

Pneumonia: An infection of the alveoli, usually by bacteria.

Tuberculosis: A slowly progressive pneumonia caused by the bacteria Mycobacterium tuberculosis.

Emphysema results from damage to the fragile connections between alveoli. Smoking is the usual cause. (Emphysema also limits airflow, affecting the airways as well.)

Pulmonary edema: *Note: The word edema means "swelling"* Fluid leaks out of the small blood vessels of the lung into the air sacs and the surrounding area. One form is caused by heart failure and back pressure in the lungs' blood vessels; in another form, direct injury to the lung causes the leak of fluid.

Lung cancer has many forms, and may develop in any part of the lungs. Most often this is in the main part of the lung, in or near the air sacs. The type, location, and spread of lung cancer determines the treatment options.

Acute respiratory distress syndrome (ARDS): Severe, sudden injury to the lungs caused by a serious illness. Life support with mechanical ventilation is usually needed to survive until the lungs recover.

Pneumoconiosis: A category of conditions caused by the inhalation of a substance that injures the lungs. Examples include black lung disease from inhaled coal dust and asbestosis from inhaled asbestos dust.

THE URINARY SYSTEM

The urinary system consists of the kidneys, ureters, urinary bladder, and urethra.

The kidneys filter the blood to remove metabolic wastes and produce urine. The ureters, urinary bladder, and urethra together form the urinary tract, which acts as a plumbing system to drain urine from the kidneys, store it, and then release it during urination.

The kidneys have other important jobs:

- maintaining the correct amount of water, ions, pH, blood pressure, calcium, minerals and other nutrients in the body

The kidneys are a pair of bean-shaped organs found along the posterior wall of the abdominal cavity. Each kidney is the size of a clenched fist. The left kidney is located slightly higher than the right kidney because the right side of the liver is much larger than the left side.

The kidneys, unlike the other organs of the abdominal cavity, are behind peritoneum and touch the muscles of the back. They are surrounded by a layer of adipose tissue that holds them in place and protects them from physical damage.

URETERS

- a pair of tubes, each about 10 inches long that carry

urine from the kidneys to the urinary bladder. Gravity and peristalsis of smooth muscle tissue in the walls of the ureters move urine toward the urinary bladder. The ends of the ureters extend slightly into the urinary bladder and are sealed at the point of entry to the bladder. Valves prevent urine from flowing back towards the kidneys.

URINARY BLADDER

- a sac-like hollow organ used for the storage of urine. The urinary bladder is located along the body's midline at the inferior end of the pelvis. Urine entering the urinary bladder from the ureters slowly fills the hollow space of the bladder and stretches its elastic walls. The walls of the bladder allow it to stretch to hold anywhere from 600 to 800 milliliters of urine.

URETHRA

- the tube through which urine passes from the bladder to the exterior of the body. The female urethra is around 2 inches long and ends between the clitoris and the vaginal opening. In males, the urethra is around 8 to 10 inches long and ends at the tip of the penis. The urethra is also part of the male reproductive system as it carries sperm out of the body through the penis.

Urethral sphincter muscles control the flow of urine out of the body. The opening of this muscle is under voluntary control but opens involuntarily when the bladder reaches a certain set level of distention.
Urinary System Physiology

Maintenance of Homeostasis

The kidneys maintain the homeostasis of several important internal conditions by controlling the excretion of substances out of the body.

Ions. The kidney can control the excretion of potassium, sodium, calcium, magnesium, phosphate, and chloride ions into urine. In cases where these ions reach a higher than normal concentration, the kidneys can increase their excretion out of the body to return them to a normal level.

The kidneys can also conserve these ions when they are present in lower than normal levels by allowing them to be reabsorbed into the blood during filtration.

pH. (amount of acid or base) The kidneys monitor and regulate the levels of hydrogen ions (H+ acid) and bicarbonate ions (base) in the blood to control blood pH.

H+ ions are produced as a natural byproduct of the metabolism of dietary proteins and accumulate in the blood over time. The kidneys excrete excess H+ ions into urine for elimination from the body. The kidneys also conserve bicarbonate ions, which act as important pH buffers in the blood.

Osmolarity. The cells of the body need to grow in an isotonic environment in order to maintain their fluid and electrolyte balance. The kidneys maintain the body's

osmotic balance by controlling the amount of water that is filtered out of the blood and excreted into urine.

When a person consumes a large amount of water, the kidneys reduce their reabsorption of water to allow the excess water to be excreted in urine. This results in the production of dilute, watery urine.

If the body is dehydrated, the kidneys reabsorb as much water as possible back into the blood to produce highly concentrated urine full of excreted ions and wastes. The changes in the amount of water excreted are controlled by antidiuretic hormone (ADH), produced in the hypothalamus and released by the posterior pituitary gland to help the body retain water.

Blood Pressure is also monitored by the kidneys to help maintain homeostasis. When blood pressure is elevated, the kidneys can help to reduce blood pressure by reducing the volume of blood in the body. The kidneys can reduce blood volume by reducing the reabsorption of water into the blood and producing watery, dilute urine.

When blood pressure becomes too low, the kidneys can produce the enzyme renin to constrict blood vessels and produce concentrated urine, which allows more water to remain in the blood.

The NEPHRON is the functional unit of filtration.

- Each kidney has over one million nephrons.

Arterioles (small arteries) in the kidneys deliver blood to a bundle of capillaries surrounded by a capsule called a glomerulus. As blood flows through the glomerulus, much of the blood's plasma flows out of the capillaries and into the capsule, leaving the blood cells and a small amount of plasma to continue flowing through the capillaries.

The plasma in the capsule flows through a series of tubules lined with filtering cells and surrounded by capillaries. The cells surrounding the tubules selectively absorb water and substances from the filtrate in the tubule and return it to the blood in the capillaries.

Waste products present in the blood are secreted into the filtrate, which ends up as urine, containing only water, waste products, and excess ions. Most of the nutrients, and ions needed for functioning are reabsorbed back into the blood.

Storage and Excretion of Wastes

After urine has been produced by the kidneys, it is transported through the ureters to the urinary bladder. The urinary bladder fills with urine and stores it until the body is ready for its excretion.

Hormones

The kidneys produce and interact with several hormones involved in the control of systems outside of the urinary system.

Calcitriol. Calcitriol is the active form of vitamin D in the human body. It is produced by the kidneys from precursor molecules produced by UV radiation striking the skin. Calcitriol works with parathyroid hormone (PTH) to raise the level of calcium ions in the bloodstream. When the level of calcium ions in the blood drops below a threshold level, the parathyroid glands release PTH, which in turn stimulates the kidneys to release calcitriol.

Erythropoietin. Erythropoietin, also known as EPO, is a hormone produced by the kidneys to stimulate the production of red blood cells. The kidneys monitor the condition of the blood that passes through their capillaries, including the oxygen-carrying capacity of the blood.

When they sense that blood is carrying deficient levels of oxygen, kidney cells lining the capillaries begin producing EPO and release it into the bloodstream, through which it reaches the red bone marrow. These cells are stimulated to increase their rate of red blood cell production.

Renin. The kidneys produce this enzyme to increase blood volume and blood pressure when they sense that there is low blood pressure, blood loss or dehydration.

LOSS OF KIDNEY FUNCTION (RENAL FAILURE)

When the kidneys become damaged, waste products and fluid can build up in the body, causing swelling in your ankles, vomiting, weakness, poor sleep, and shortness of breath. If left untreated, diseased kidneys may eventually

stop functioning completely. Loss of kidney function is a serious -- and potentially fatal – condition.

The sudden loss of kidney function is called acute kidney injury, also known as acute renal failure (ARF). ARF can occur following:

- A traumatic injury with blood loss

- The sudden reduction of blood flow to the kidneys

-Damage to the kidneys from shock during a severe infection called sepsis

-Obstruction of urine flow, such as with an enlarged prostate

-Damage from certain drugs or toxins

-Pregnancy complications, such as eclampsia and pre-eclampsia, or related HELLP Syndrome

Marathon runners and other athletes who don't drink enough fluids while competing in long-distance endurance events may suffer acute renal failure due to a sudden breakdown of muscle tissue. This muscle breakdown releases a chemical called myoglobin that can damage the kidneys.

Chronic Kidney Disease – loss of function lasting over three months

- is particularly dangerous because you may not have any symptoms until considerable, often irreparable, kidney damage has occurred. Diabetes (types 1 and 2) and high blood pressure are the most common causes of CKD.

Other causes:

-Immune system conditions such as lupus and chronic viral illnesses such as HIV/AIDS, hepatitis B, and hepatitis C.

-Urinary tract infections within the kidneys themselves, called pyelonephritis, can lead to scarring as the infection heals. Multiple episodes can lead to kidney damage.

-Inflammation in the tiny filters (glomeruli) within the kidneys; can happen after strep infection and other conditions of unknown cause.

- Polycystic kidney disease , in which fluid-filled cysts form in the kidneys over time; inherited disease.

-Congenital defects, present at birth, are often the result of a urinary tract obstruction or malformation that affects the kidneys. One of the most common involves a valve-like mechanism between the bladder and urethra. These defects, sometimes found while a baby is still in the womb, can often be surgically repaired by a urologist.

-Drugs and toxins, including long-term exposure to

some medications and chemicals, such as NSAIDs (nonsteroidal anti-inflammatory drugs), like ibuprofen and naproxen, or “street” drugs.

A person can function with only one kidney. You can live a normal life with 30% kidney function. When function drops to around 20%, there is a problem. Sometimes a relative or friend will donate a kidney to be transplanted.

A person with nonfunctioning kidneys can go through a process called dialysis, in which, about three times per week blood is run through tubules &filtered by a machine.