

A Litigation Primer On The Respiratory System



Samuel D. Hodge, Jr.

is Professor and Chair, Department of Legal Studies, Temple University. Professor Hodge teaches both law and anatomy. He is also a skilled litigator and national lecturer, who has written multiple articles and books on medicine and trauma including *Anatomy For Litigators* (for more information, go to www.ali-aba.org/BK40). Address correspondence to Professor Hodge at Temple University, Department of Legal Studies, 1801 Liacouras Walk, Alter Hall, Room 464, Philadelphia, PA 19122 or via e-mail at temple885@aol.com.

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It's not just a lot of hot air.

FORMER NBC journalist David Bloom provides an example of the fragile nature of the respiratory system. This athletic 39-year-old man was dispatched to Iraq to cover the war. His live dispatches were broadcast daily as the reporter traveled with the troops on their way to Baghdad. After spending long hours in a tank, Bloom started to experience painful cramping in his legs. He consulted with a physician over the phone who suspected that the television personality may be developing deep vein thrombosis because of his prolonged confinement in a compact space. The reporter was told to seek medical attention but he ignored that advice. Instead, Bloom took a few aspirin and kept reporting on the war. A couple of days later, he died from a blood clot that had traveled from his leg to the lungs thereby causing a fatal blockage. This condition, a pulmonary embolism, is a well-known complication involving the respiratory system. *See David Bloom — Respected NBC Reporter Dies in Iraq*, United Justice, [http:// www.unit-edjustice.com/david-bloom.html](http://www.unit-edjustice.com/david-bloom.html).

This tragic story is not that unusual. Medical issues with the respiratory system and thoracic region are commonplace. Those who have had the “wind knocked out of them” or sustained a bruised rib are painfully aware of the consequences of a minor chest injury. Blunt trauma to the thorax area can be life threatening and includes such things as multiple rib fractures that prevent normal

respiration, a broken rib that punctures an internal organ, or a lung that requires the immediate insertion of a chest tube. Diseases that affect the respiratory system can range from an upper respiratory infection to a pulmonary embolism. In fact, lung cancer is the second most diagnosed malignancy and the number one cause of death from a malignancy each year. *Lung Cancer 101*, [LungCancer.org](http://www.lungcancer.org), <http://www.lungcancer.org/reading/about.php>.

This article will examine the respiratory system and the area that surrounds the lungs. The layers of the thoracic region will be reviewed from the chest wall to the tiny balloons inside the lungs in order to ascertain how the body receives its much needed supply of oxygen. This anatomical analysis will be followed by an overview of some of the more common injuries and diseases to this body system.

AN OVERVIEW OF THE RESPIRATORY SYSTEM

• Talk about being overworked. A person inhales about 20,000 times each day and by the time that individual reaches 70 years of age; he or she will have taken over 600 million breaths. *About Lungs and Respiratory System*, http://kidshealth.org/parent/general/body_basics/lungs.html. So, what exactly is this system that provides for respiration? The answer is provided in *City of Tulsa v. Smittle*, 702 P.2d 367 (Okla. 1985), where the court defined the respiratory system as “[t]he tubular and cavernous organs and structures by means of which pulmonary ventilation and gas exchange between blood and ambient air are brought about, also called apparatus.”

This is a rather complex definition so a simpler explanation might be more appropriate. The primary task of the respiratory system is to make sure that the blood is infused with oxygen so that the blood can deliver air to all parts of the body. This is done through breathing which allows a person to inhale oxygen from the atmosphere and to expel carbon dioxide from the blood. *Respiratory System: Oxygen Delivery System*, Body Systems, The Franklin

Institute, <http://www.fi.edu/learn/heart/systems/respiration.html>. Carbon dioxide is a waste product of metabolism whose amount will increase very quickly if breathing stops. *Respiratory System*, Chapter 7, *Advanced Anatomy and Physiology for ICD-10-CM/PCS*, Contexo/Medio, 2010.

Working in tandem with the circulatory system, this gaseous exchange occurs when air enters the body through the nose or mouth and travels down the trachea. Air then enters the bronchial tubes, a series of pipes that resemble an upside down tree, on its journey to the lungs. Once in the lungs, the oxygen is absorbed into millions of tiny balloons which are richly supplied by very small blood vessels. The exchange of carbon dioxide and oxygen takes place in these microscopic balloons. *Respiratory System*, [Answer.com](http://www.answer.com/topic/respiratory-system), <http://www.answer.com/topic/respiratory-system>.

How important is this gas exchange? Without oxygen, the cells could not move, reproduce, or turn food into energy. In fact, the consequence of a prolonged absence of oxygen is death. *Your Respiratory System*, Your Gross and Cool Body, <http://yucky.discovery.com/flash/body/pg000138.html>. That is why the most basic tenet of emergency medicine is to remember the ABC's: airway, breathing, and circulation. This protocol exists to remind individuals providing emergency care of the importance of airway, breathing, and circulation, to maintain a patient's life. These three functions are paramount in any emergency treatment since the loss of one will rapidly lead to the patient's demise. *ABC (Medicine)*, Wikipedia, [http://en.wikipedia.org/wiki/ABC_\(medicine\)](http://en.wikipedia.org/wiki/ABC_(medicine)). In addition to this gas exchange, the respiratory system brings inhaled air to the proper body temperature, moisturizes the air to achieve the proper humidity and protects the body from harmful substances through coughing, sneezing, filtering, or swallowing them. *How Lungs Work*, The Respiratory System, American Lung Association, <http://lungusa.org/your-lungs/how-lungs-work>.

ANATOMY OF THE CHEST • The best way to explain the respiratory system is to start with an examination of the chest since it is that area of the body that houses the majority of the parts to this system. This structure represents that area between the bottom of the neck and top of the abdomen. The chest is comprised of the ribs, sternum, thoracic vertebrae, and fibrous tissues known as costal cartilage. These anatomical parts join together to form a rigid structure that protects a host of important internal organs.

The Ribs

The ribs are made up of 12 pairs of bones that are unequal in length. All of the bones are curved and extend from the spine to the front of the abdomen. The top seven sets of bones are known as “true ribs” and are attached to the breastbone or sternum by costal cartilage. Ribs numbered eight through 10 are “false ribs” and do not contact the breastbone. Rather, they are secured by costal cartilage to the last rib that attaches to the sternum. The bottom two bones, or ribs 11 and 12, are “floating ribs.” While they attach to the spine in the rear, they are not secured together in the front.

The ribs are aligned one below another in a way that creates gaps between the bones. These gaps are known as the intercostal spaces and are determined by the size of the adjacent ribs and their cartilage. For instance, the largest gaps are found in the anterior part of the rib cage. The spaces between the top ribs are also wider than the gaps between the lower ribs. *The Ribs*, Gray’s Anatomy, <http://education.yahoo.com/reference/gray/subjects/subject?id=28>.

The Sternum

The sternum, or breastbone, is located in the middle part of the chest. This flat bone runs longitudinally and connects on the sides to the first seven ribs. The top part of this structure articulates

with the starting points of the left and right collar bones.

The sternum is made up of three portions: the manubrium, body, and xiphoid process. The manubrium is the top and broadest part of the structure. The first rib and collarbone both connect to the manubrium. The body, or middle part, of the sternum constitutes the longest aspect and provides the connecting points for the second through the seventh ribs. The xiphoid process is the lowest portion of the sternum; it can be easily palpated and is shaped like the point of a knife. *See*, Fisher, *Sternum Fractures*, e-Medicine, www.emedicine.com/radio/topics654.htm.

The Thoracic Vertebrae

The posterior portion of the ribcage articulates with the thoracic vertebrae. This area consists of 12 bones that make up the largest part of the spine. Vertebra T2 through T9 provide the attachment sites for the ribs. Because of this attachment, the vertebrae are not very mobile and are less likely to sustain trauma than the cervical or lumbar parts of the spine.

Costal Cartilage

As two pieces of wood must be secured together by nails, the bones in the chest must be anchored together by soft tissues. Costal cartilage is the fibrous band of connective tissue that secures the ribs to the sternum. Costal cartilage varies in size depending upon the length of the rib to which it attaches. For instance, this fibrous tissue increases in length with each descending rib through the first seven. These soft tissue connectors also provide the chest wall with flexibility so it can move during respiration.

Movement Of The Chest During Respiration

Many consider breathing to be the function of the mouth and lungs. Respiration, however, is much more complicated and also involves the diaphragm

and ribs. The diaphragm, a large muscle that separates the abdominal and thoracic cavities, plays a vital role in the breathing process. When the diaphragm contracts, it creates a “vacuum-like” effect in the thoracic cavity. This phenomenon expands the lungs by filling them with air that is inhaled through the windpipe. The diaphragm relaxes when air is expelled causing the lungs to contract. This process is very much like a balloon deflating when air is released. *The Diaphragm, Ribs, and Breathing*, The Respiratory System, www.naturalhealthschool.com/diaphragm_breathing.html.

Breathing requires several simultaneous movements to take place. As the chest expands, air is inhaled causing the ribs to elevate, or move upwards. At the same time, the middle portion of the lower ribs moves laterally. Medical literature notes that this movement mimics the actions of a bucket handle. The metal handle connects to the top of the bucket on each side. As it is lifted, the handle moves laterally and up in a unified fashion very much like the movement of the ribcage during respiration.

When the upper ribs elevate, the front and back diameter of the ribcage increases similar to the movements of a pump handle which moves up and down. *The Thoracic Cage/Respiration and Breathing*, www.courses.vcu.edu/danc291-003/unit_4.htm.

PARTS OF THE RESPIRATORY SYSTEM •

Many people asked to identify the part or parts of the respiratory system would immediately respond “the lungs” but this is only a small part of the picture. The primary organs of the respiratory system are much more encompassing and include the nose, pharynx, larynx, trachea, bronchi, and lungs. One or more of these structures draw in air, exchange gases with the blood, and expel the carbon dioxide. The conducting division of the respiratory system includes the structures that provide for airflow from the nostrils through the bronchioles. In turn, the airway from the nose through the larynx is considered the upper respiratory tract and the area consist-

ing of the trachea through the lungs comprises the lower respiratory tract. Shaham-Albalancy, Amira, *Respiratory System, Anatomy and Physiology*, <http://mysite.verizon.net/res87hyc/id21.html>.

The following is a brief overview of the structures that make up the respiratory system:

The Upper Respiratory Tract

- Nose. This is the entrance to the respiratory tract;
- Pharynx. It is located behind the mouth and is the passage to both the stomach and lungs;
- Larynx. It is situated at the top of trachea and contains the vocal cords;
- Trachea. It is a tube like structure that helps pass air from the larynx to the bronchi.

The Lower Respiratory Tract

- Bronchi. These are the branches of the bronchi that bring air into the lungs;
- Alveoli. These tiny sacs are located in the lungs and allow for the exchange of gas;
- Lungs. The two cone shaped organs are located on opposite sides of the chest.

Respiratory System Functions, *Buzzle.com*, <http://www.buzzle.com/articles/respiratory-system-functions.html>.

The Nose And Nasal Cavity

What is the only external part of the respiratory system? The answer is as clear as the nose on your face. The nose is made up of bone and cartilage and is covered by various thicknesses of skin. The two openings located in the front of the nose, the external nares or nostrils, allow air to enter or exit the body during respiration. In turn, the nostrils contain coarse hairs which serve as a protective barrier to prevent large particles like dust and other debris from entering the airway. *The Respiratory System — Design: Parts of the Respiratory System*, <http://www.faqs>.

org/health/Body-by-Design-V2/The-Respiratory-System-Design-parts-of-the-respiratory-system.html. The nares and nasal passages are separated in the middle by a wall known as the nasal septum. The part of the septum closer to the tip of the nose is made of soft tissue and hyaline cartilage, a flexible material that is firmer than skin or muscle. Deeper inside the nose and closer to the skull, the septum is made up of thin pieces of bone. *Your Nose*, How the Body Works, Kids Health from Nemours, <http://kidshealth.org/kid/htbw/nose.html>.

Behind the nose, the nostrils open into a nasal cavity, a hollow space that connects with the back of the throat. The palate in the roof of the mouth forms the floor of the nasal cavity. Three flat plates, the conchae, project forward towards the nasal septum from the sides of the nasal cavity. These conchae help to retard the passage of air thereby causing it to swirl in the nasal cavity. *Id.*, and *The Respiratory System — Design: Parts of the Respiratory System*, supra. This allows the mucous membranes to moisten and warm the air, trap any bacteria or particles and then sweep them to the throat where they become embedded in the mucous. Any bacteria left over in the swallowed mucous is attacked by the hydrochloric acid in the gastric juices of the stomach. *The Respiratory System — Design: Parts of the Respiratory System*, *Id.* This process is aided by microscopic hairs called cilia that oscillate back and forth in order to advance the mucous from the back of the nose and sinus to a position further down the throat. *Your Nose*, How the Body Works, Kids Health from Nemours, supra.

The paranasal sinuses are the next structure that would be encountered as air continues its journey through the respiratory system. These air-filled spaces contained in the skull surround the nasal cavity and produce the much needed mucous. The paranasal sinuses are classified according to the bones within which the sinuses lie. These include the maxillary sinuses which are under the eyes, the frontal sinuses which are just above the eyes, the

ethmoid sinuses, which are located within the bone between the nose and the eyes, and the sphenoid sinuses, which are just under the pituitary gland. *Paranasal Sinuses*, Wikipedia, http://en.wikipedia.org/wiki/Paranasal_sinuses.

The function of these cavities is to warm and humidify the air as well as giving resonance to the voice. Sinuses also decrease the weight of the skull by providing these open spaces. *What are Paranasal Sinuses*, WiseGeek, <http://www.wisegeek.com/what-are-paranasal-sinuses.htm>.

The Pharynx

The pharynx, or that structure better known as the throat, is a muscular tube about five inches long that extends from the base of the skull to the level of the sixth cervical vertebra where it meets up with the esophagus. The pharynx serves two masters, the respiratory and the digestive systems. For example, it receives air from the nasal cavity and air, food, and water from the mouth. *Pharynx*, The Internet Encyclopedia of Science, <http://www.daviddarling.info/encyclopedia/P/pharynx.html>.

The tonsils and adenoids are located in the pharynx and are part of a ring of glandular tissue, the Waldeyer's ring, which encircles the back of the throat. Chuna, John, *Tonsillitis and Adenoid Infection*, [MedicineNet.com](http://www.medicinenet.com/adenoids_and_tonsils/article.htm), http://www.medicinenet.com/adenoids_and_tonsils/article.htm. The tonsils, which are so famous for causing sore throats in children, are the two masses situated on either side of the back of the throat. They are normally the same size and have the same pink color as the surrounding tissue. Their surfaces contain small indentations, known as crypts, which may appear deep and contain stones or pus pockets. *Id.* The adenoids, however, are situated high in the throat behind the nose and roof of the mouth. Unlike the tonsils, they are not readily visible without the use of special instrumentation. *Id.*

The tonsils and adenoids are strategically positioned near the entrance to the throat in order to

seize incoming infections. This ability can cause tonsils and adenoids to become infected but it also helps create antibodies to those “germs” as part of the immune system’s ability to resist and fight future infections. *Tonsils and Adenoids*, Ear, Nose, & Throat Associates of Corpus Christi, <http://www.entassociates.com/tonsils.htm>.

The Larynx

The larynx or voice box is the next portion of the respiratory system and it contains the vocal cords, which are responsible for the production of sound. This hollow structure is located in the neck between the pharynx and trachea. The larynx is a two-inch-long, tube-shaped organ in the neck. *Definition of Larynx*, [MedicineNet.com](http://www.medicinenet.com/script/main/art.asp?articlekey=6224), <http://www.medicinenet.com/script/main/art.asp?articlekey=6224>.

The voice box is composed of nine cartilages which are linked to each other by ligaments and muscles and are lined with mucous membranes. Movement of these tissues changes the tension of the vocal cords, thereby altering the pitch of the sound produced by the vocal cords. *Larynx*, The Internet Encyclopedia of Science, <http://www.david-darling.info/encyclopedia/L/larynx.html>.

One of the most important functions of the larynx is to prevent choking and this task is accomplished by the epiglottis. This structure is a leaf-shaped flap located just behind the tongue. It is usually upright at rest allowing air to freely pass into the larynx and lungs. When an individual swallows, however, the epiglottis flops down to guard the entrance to the larynx so food does not enter the windpipe. After the task of swallowing is accomplished, the epiglottis returns to its normal resting position. Heller, Jacob, *The Trachea, Epiglottis*, University of Maryland Medical Center, <http://www.umm.edu/imagepages/19595.htm>.

The trachea, nicknamed the windpipe, is located in the front of the neck and can be palpated by touching that area. Its basic function is to allow air to pass into the lungs. This fairly rigid pipe starts

just below the larynx or sixth cervical vertebrae and continues to around the level of the fifth thoracic vertebra where it divides into the right and left bronchi. *Anatomy of the Respiratory System*, http://faculty.ucc.edu/biology-potter/anatomy_of_the_respiratory_system.htm. From a size perspective, the trachea is four to five inches long, and less than one inch in diameter. It consists of 16 to 20 C-shaped cartilage rings connected by ligaments, with a mucus membrane. These rings are incomplete in their posterior aspect so that are closed by smooth muscle. This structure also helps push objects out of the airway should something become trapped. *What is the Trachea*, WiseGeek, <http://www.wisageek.com/what-is-the-trachea.htm>.

The trachea is the primary airway to the lungs and any injury to this area can hinder respiration. Damage to this structure may mandate intubation which procedure requires the insertion of a tube through the nose or mouth which then extends down to the trachea in order to restore the flow of air to the lungs. Alternatively, inflammation or fracture may mandate the performance of a tracheotomy. This life saving procedure requires the making of an incision in the front of the throat around the level of the second and fourth tracheal rings thereby creating an opening in the trachea through which a tube is placed to restore ventilation. *Id. See also*, Moore, Keith, et al, *Neck*, Clinically Oriented Anatomy, Chapter 8, Fourth Edition, Lippincott, Williams & Wilkins, Philadelphia, 1999 at 1048-1049.

The Bronchial Tree

The bronchial tree consists of three parts; the bronchi, bronchioles, and alveoli. *Bronchial Tree*, Innvista, <http://www.innvista.com/health/anatomy/bronchi.htm>. The bronchial tree is so named because it resembles the branches of an upside down tree.

The bronchi are located at bottom of the trachea where it divides into two tubes that enter each

lung at the anatomical point known as the hilus. These two branches of the tree are called the primary bronchi. In turn, each primary bronchus subdivides into secondary bronchi that enter the lobes of the lungs and form smaller tertiary bronchi. Shahan-Albalancy, Amira, *Respiratory System Anatomy and Physiology*, supra and *Bronchial Tree*, Innvista, *Id.* The left bronchus is narrow and located more horizontally than the one on the right because of the position of the heart. The right bronchus is shorter but wider than the opposite side and extends downward in a more vertical fashion. Because of the difference in size between the two bronchi, objects are more easily inhaled into the right bronchus. *Bronchial Tree*, Innvista, *Id.*

The cartilage and mucous membranes of the primary bronchi resemble those in the trachea. As the branching continues downward through the bronchial tree, the degree of hyaline cartilage in the walls decreases until it disappears in the smallest bronchioles. However, as this cartilage thins out, the amount of smooth muscle correspondingly increases. *Bronchus*, Wikipedia, <http://en.wikipedia.org/wiki/Bronchus>.

While the bronchi allow the air to enter the lungs, the bronchioles are smaller airways that propel oxygen on to the inside walls of the lungs where the alveoli permit the oxygen to be absorbed by the blood for transfer throughout the body. *What is the Function of the Bronchi and the Bronchioles?* [Answers.com](http://wiki.answers.com/Q/What_is_the_function_of_the_bronchi_and_the_bronchioles), http://wiki.answers.com/Q/What_is_the_function_of_the_bronchi_and_the_bronchioles.

The alveoli serve as the main gas exchange units of the lungs. The gas-blood barrier between the alveolar space and the pulmonary capillaries that surround these tiny balloons is extremely thin in order to allow for the rapid exchange of gases. *Interactive Respiratory Physiology*, John Hopkins School of Medicine, http://oac.med.jhmi.edu/res_phys/Encyclopedia/Alveoli/Alveoli.HTML. To be more specific, there are about 300 million alveoli in a lung that resemble microscopic balloons or tiny sacs. These tiny

structures are engulfed by a complex of pulmonary capillaries. It is through the walls of both the alveoli and capillaries that the rapid transfer of oxygen and carbon dioxide takes place. This cycle allows the carbon dioxide from the red blood cells to be absorbed into the capillary walls and then into the alveoli. The waste material then leaves the alveoli and is exhaled through the nose or mouth. The reverse process occurs when oxygen is absorbed into the alveoli and then transferred to the small blood vessels for absorption into the red blood cells. *The Alveoli for Medical Assistants*, MA Exam Help, <http://www.maexamhelp.com/id109.htm>.

Lungs

It seems that the oxygen's journey through the respiratory system has taken a long time to reach the lungs but the respiratory system is very complex and consists of many parts that are needed to make it work properly.

The lungs are the largest and best known structure in this bodily system but the reader may be surprised by a number of facts about this spongy tissue. For example, the right and left lungs are not the same size and the lungs are made up of multiple lobes with a different number on the left and right sides. Since the lungs process the air a person breathes, they are also the only internal organs that are regularly exposed to the outside environment. *Lungs*, National Graphics, <http://science.national Geographic.com/science/health-and-human-body/human-body/lungs-article>.

The lungs are located on either side of the chest, and are separated by the heart and other contents of the mediastinum. This organ has a light, spongy appearance and is highly elastic; hence the retracted state of the lungs when they are removed from the chest cavity. Each lung is cone shaped and offers a smooth and shining surface. *The Lungs*, Human Anatomy, http://www.theodora.com/anatomy/the_lungs.html.

The left lung has two lobes, a superior and inferior part separated by a fissure, which extends across the length of the lung. The inferior lobe is the larger of the two lobes. The right lung is divided into three lobes, superior, middle, and inferior. The middle lobe is the smallest lobe of the right lung and is wedge-shaped in appearance. Although the right lung is 2.5 cm. shorter than the left as the result of the diaphragm rising higher on the right side to accommodate the liver, it is broader because of the space occupied by the heart which is nestled next to the left lung. *Id.* The bottom of both lungs rest on the diaphragm and their combined weight is about 2.5 pounds. *The Respiratory System — Design: Parts of the Respiratory System*, supra.

The lungs are covered by a thin layer of tissue known as the pleura which lines the interior wall of the chest cavity. Its purpose is to protect and cushion the lungs. The pleura also secrete a liquid that serves as a lubricant, allowing the lungs to move smoothly in the chest cavity with breathing. *Pleura*, National Cancer Institute, http://www.cancer.gov/Common/PopUps/pop_Definition.aspx?id=45842&version=Patient&language=English.

Breathing And The Autonomic Nervous System

The automatic nervous system controls the flow of air into and out of the lungs and insures the breathing of an unconscious or sleeping person is carried out in a normal pattern and rate. Gogoi, Nilutpal, *Breathing: An Ideal Marriage of the Nervous and Respiratory Systems*, Ezine Articles, <http://ezinearticles.com/?Breathing:-An-Ideal-Marriage-of-the-Nervous-and-Respiratory-Systems&id=283667>. For instance, if a person holds his breath, the body will override that decision and force the individual to breathe again. Freudenrich, Craig, *How Your Lungs Work*, <http://health.howstuffworks.com/human-body/systems/respiratory/lung3.htm>.

The rate of breathing is determined by an area located in the brain stem known as the medulla ob-

longata. The nerve cells in this portion of the brain automatically dispatch signals along the phrenic nerve to the diaphragm and muscles directing them to contract and relax at certain intervals. *Id.* The respiratory center issues 12 to 20 signals every 60 seconds. This means that individuals breathe about 12 to 20 times within a one minute period. In contrast, an infant breathes between 30 to 50 times a minute. Gogoi, Nilutpal, *Breathing: An Ideal Marriage of the Nervous and Respiratory Systems*, supra.

When a person fails to exhale, the carbon dioxide level in the blood dangerously increases causing the blood to become more acidic. Increased acidity conflicts with the activity of the body's enzymes which are specialized proteins that participate in most biochemical reactions within the body. This type of situation is mitigated by special receptors known as chemoreceptors that prevent the blood from becoming too acidic. These receptors, which are located in the blood vessels of the neck and brain stem, monitor the blood. When acid builds up to an unhealthy level, the chemoreceptors trigger signals from the nervous system that override the signals from the cerebral cortex. This forces the individual to exhale and resume breathing normally thereby eliminating carbon dioxide and allowing the blood levels to return to normal. *Id.*

Blood Supply To The Lungs

If the lungs lacked a blood supply, there would be no way for the body to rid itself of carbon dioxide or to acquire oxygen. *Why Do the Lungs Need a Blood Supply*, http://wiki.answers.com/Q/Why_does_the_lungs_need_a_blood_supply. This is such an important task that the lungs have a dual blood supply; the pulmonary arteries for gas exchange with the alveoli and the bronchial arteries that supply the lung tissue itself. The vast majority of blood from the bronchial arteries, however, goes into the left side of the heart through the pulmonary veins and this deoxygenated blood is part of the normal physiological shunt that exits in the body. The oth-

er element of this shunt comes from the thebesian veins, the smallest of the cardiac veins, which drain some coronary blood directly into the chambers of the heart. Roberts, Fred, *Respiratory Physiology*, Royal Devon & Exeter Hospitals, Exeter, UK, http://www.nda.ox.ac.uk/wfsa/html/u12/u1211_01.htm.

RESPIRATORY TRAUMA AND DISORDERS • The chest and respiratory system are susceptible to a variety of injuries and malfunctions, many of which can be life threatening. This portion of the article will focus on chest injuries related to blunt trauma as well as those injuries and diseases involving the respiratory system. Penetrating chest injuries, such as those caused by a gunshot or stab wound, will not be addressed.

Statistically, trauma to the chest area occurs each day to 12 out of one million people and one-third of these victims require hospitalization. One event, however, accounts for 70 to 80 percent of all serious blunt chest injuries: motor vehicle accidents. Sawyer, *Blunt Chest Trauma*, e-Medicine, www.emedicine.com/med/topic3658.htm. Motorcycle operators are also susceptible to major chest trauma with more than 26 percent of bike accidents resulting in this type of injury. Hitosugi, *Analysis of Fatal Injuries to Motorcyclists By Helmet Type*, *The American Journal of Forensic Medicine and Pathology*, 25(2):125-128, June 2004. Presentation of symptoms varies from minor chest discomfort to shock, and the gravity of the injury is largely dependent upon the mechanism of trauma and the body part involved. Sawyer, *Blunt Chest Trauma*, e-Medicine, www.emedicine.com/med/topic3658.htm.

As for the respiratory system, problems include such things as asthma, pneumonia, lung cancer, and asbestosis. Respiratory problems are among the most common and rapidly expanding in prevalence worldwide. The major health issue associated with respiratory illness is the inability to breathe. This problem can last a short time such as with a

common cold or the symptoms can last for years such as with a person who suffers from asthma. *Respiratory and Lung Disease*, Health-cares.net, <http://respiratory-lung.health-cares.net>.

SOFT TISSUE TRAUMA TO THE CHEST •

A direct impact to the thorax area can result in discomfort, swelling, and bruising of the soft tissues. Ecchymosis results from a broken blood vessel that causes a disbursement of blood to the surrounding tissue. This is a common occurrence in rib injuries, but bruising does not interfere with breathing. The elderly are more susceptible to the development of black and blue marks especially since certain medications they take for arthritis and heart problems can interfere with clotting.

Seat Belt Syndrome

Chest wall discomfort is a by-product of minor trauma to the soft tissue structures that make up the thorax. Bruising and discomfort are a frequent complication of the restraining forces caused by a seat belt in an accident. In fact, the term “seat belt syndrome” has been coined to describe this condition. Researchers have determined that minor chest injuries occur in about 30 percent of car crash victims as a result of the restraining loads exerted on a car’s occupant by a seat belt during a crash. Hill, *Chest and Abdominal Injuries Caused by Seat Belt Loading*, *Accid. Anal. Prev.* 1994 Feb; 26(1):11-26.

Intercostal Muscle Sprains

The intercostal muscles occupy the space between the ribs. Their function is to contract and pull the rib cage upwards during breathing. These muscles can be strained by any movement that involves a forceful or extreme twisting of the body or by swinging the arms in a manner that occurs in tennis and golf. *Rib Injuries*, www.betterhealth.vic.gov.au/bhcv2/bhcarticles.nsf/pages/rib_injuries?open_document.

Costochondral Separations

Costal cartilage is the connective tissue that secures the ribs to the sternum. A costochondral separation occurs when this fibrous band is torn away from the attaching ribs or sternum. Precipitating factors include something as simple as a sneeze or cough, as well as CPR, or participation in contact sports. This injury can result in a lump-like deformity at the separation site if the rib moves out of its correct anatomical position. Moore, *Clinically Oriented Anatomy*, 4th Edition, Lippincott, Williams, and Wilkins; 1998 at page 72.

Costochondritis

Costochondritis is a painful chest condition that mimics the symptoms of a heart attack. In reality, it is a harmless condition involving an inflammation of the cartilage of the ribcage. Costochondritis accounts for 10 percent of all chest pain episodes, and 30 percent of the people who visit the emergency room because of chest pain are diagnosed with this problem. Pillinger, *Costochondritis*, www.net-doctor.co.uk/diseases/facts/costochondritis.htm. This condition causes sharp anterior chest pain between the second and fifth ribs. It is easy to diagnose because the pain is replicated by pressing on the openings between the ribs demonstrating that the condition is musculoskeletal, and not cardiac, in nature. Costochondritis occurs primarily in women and has been linked to increased physical activity and trauma. In many cases, however, the cause of the problem is undetermined.

FRACTURES • Any number of bones can fracture in the chest because the area is so large. Fracture sites include the ribs, sternum, and thoracic vertebrae.

Rib Fractures

Rib fractures are the most common result of blunt trauma to the chest. In the United States, this type of fracture represents 10 percent of all trau-

matic injuries and 14 percent of chest wall problems with the middle and lower ribs being the most susceptible to injury. Nadalo, *Rib Fractures*, www.e-Medicine.com/radio/topic609.htm. These facts are not surprising since the ribs are directly under the skin's surface and don't enjoy the same protection as other bones. *The Ribs*, <http://topcondition.com/members/ribs.htm>.

Fractures of the first three ribs are rare and represent a life-threatening emergency because of the potential for injury to the subclavian artery and brachial plexus which run underneath the first rib. Rib fractures in the lower part of the chest wall are dangerous because they can signify internal injuries to several important organs. For instance, a rib fracture on the lower right side can lacerate the liver, and the spleen can sustain trauma when a rib on the lower left side is broken. *Types of Chest Trauma*, www.jcjc.cc.ms.us/faculty/adn/jmcmillan/chest-trauma.html.

Rib fractures caused by motor vehicle collisions are associated with the side of the vehicle in which the occupant was seated. While it seems counter-intuitive, those seated on the left side of the vehicle sustain right-sided rib fractures, and those occupying the passenger seat on the right side sustain left-sided fractures. A simple rib fracture is painful but does not require much treatment. Healing takes about six weeks. Arajarvi, *Chest Injuries Sustained in Severe Traffic Accidents by Seatbelt Wearers* *Journal of Trauma*, 1989 Jan; 29(1):37-41.

Flail Chest

On the other hand, multiple rib fractures can present a very serious problem known as a flail chest. This condition occurs when multiple fractures cause a part of the rib cage to become displaced. A flail chest is diagnosed when two or more adjacent ribs are broken at two or more locations. *Id.* This can cause problems with breathing since the affected ribs cannot expand and contract in synchrony with the rest of the chest. Auerbach, *Medicine for the Out-*

doors: *The Essential Guide to Emergency Medical Procedures and First Aid*, Lyons Press, 1999. When breathing becomes labored, mechanical ventilation may be required to force a steady flow of air into the lungs.

Fractures Of The Sternum

Sternum fractures are also a common complication of motor vehicle accidents especially when the driver's chest forcibly strikes the steering wheel. Most of these fractures occur in the body, or long part, of the sternum and extend from one side to the other. Sternum fractures present a red flag for other problems such as a cardiac contusion or compression fracture of the thoracic vertebrae due to hyperflexion of the back at the time of injury. Fisher *Sternum Fractures*, e-Medicine, www.emedicine.com/radio/topic654.htm.

Medical investigators have uncovered interesting statistics about sternal fractures. In blunt trauma victims admitted to the hospital following a motor vehicle accident, 89 percent had fractures of the breastbone, tended to be over fifty, and female. Surprisingly, 70 percent of this group was wearing seat belts. Hill, *Sternal Fractures: Associated Injuries and Management*, Journal of Trauma, 1993, July; 35(1): 55-60. Another study determined that fractures of the sternum increased at higher deceleration speeds of the car and with age. Statistically, 72 percent of those with sternal fractures also had rib fractures, and 91 percent of the people with rib fractures had sternal fractures. Miltner, *The Influence of Age on Injury Severity of Restrained Front Seat Occupants in Head-On Collisions*, Med. Law., 1995; 14(1-2): 105-116.

Cardiopulmonary resuscitation requires the forceful application of chest compressions in order to restore the flow of oxygen-infused blood to the brain. A common concern among the lay population is whether there is liability if the administration of CPR causes a rib or sternum to fracture. Setting aside issues of immunity and standard of care, sternal fractures from CPR occur in at least one-fifth of

adults and a combination of rib and sternal fractures happen in one-third of the patients receiving conventional CPR. Hoke, *Skeletal Chest Injuries Secondary to Cardiopulmonary Resuscitation*, Resuscitation, Dec; 63(3):327-38.

Fractures Of The Thoracic Vertebrae

The thoracic spine is the largest part of the back and is a fairly stable area. Herniated discs are rare in this region, but fractures can occur when the dynamic forces of trauma exceed the strength of the vertebrae. The most common causes for a fracture in this area are motor vehicle accidents, a fall from a height, and penetrating trauma. Fractured vertebra most often occur in the lower units, such as at T11 or T12, and are less frequent in the upper-and mid-thoracic regions because of the stabilization provided by the ribs. In fact, 60 to 70 percent of fractures in this region occur in the T12, L1, and L2 vertebrae because these rigid structures lack rib attachments making them more mobile. Those in their thirties are most susceptible to this type of injury and trauma can occur to both the spinal cord and cauda equine, or end fibers of the spinal cord. Nadalo, *Thoracic Spine Trauma*, e-Medicine, www.emedicine.com/radio/topic816.htm.

The diameter of the spinal cord also plays a factor in thoracic spine fractures. The spinal canal in the thoracic spine is narrower than it is in the cervical and lumbar areas. This means that the spinal cord in the mid-part of the spine has less room available before cord compression occurs as the result of a thoracic spine fracture. Leahy, *Thoracic Spine Fractures and Dislocations*, e-Medicine, www.emedicine.com/orthoped/topic567.htm.

INTRATHORACIC INJURIES • Blunt trauma to the chest always raises the specter of a sinister injury to the internal organs. Labeled an intrathoracic injury, a significant chest impact can damage the internal organs such as the lungs, liver, and spleen.

Pneumothorax

A pneumothorax, or collapsed lung, is a common intrathoracic injury. This potentially life-threatening condition occurs when air escapes from a lung that has been punctured by a piece of bone or enters through an external hole in the chest which then accumulates between the lungs and chest wall. This process results in a change in lung pressure causing the lungs to compress and eventually collapse. Symptoms include difficulty breathing and pain. If the pneumothorax is left untreated, the person will go from respiratory distress to shock.

On occasion, a pneumothorax can develop spontaneously as the result of a ruptured bleb which is a small air-filled sac in the lung. This condition tends to occur in tall, thin men between the ages of 20 to 40 who have a history of cigarette smoking. Other precipitating factors include lung disease, asthma, and pneumonia. *Types of Chest Trauma*, www.jcjc.ccc.ms.us/faculty/adm/jmcmillian/chesttrauma.html.

A pneumothorax can be diagnosed by the absence of breath sounds or by plain film x-ray which can detect an accumulation of air outside of the lungs. Treatment requires the physician to restore the normal pressure within the chest cavity. This is done by inserting a tube into the chest wall to allow the air to escape. The chest tube will remain in place for several days to make sure the lung has not only correctly re-inflated but stays inflated.

Hemothorax

An hemothorax is very similar to a pneumothorax except it represents an accumulation of blood instead of air within the chest. This condition is usually the result of a broken rib that punctures the lung. Treatment again includes the insertion of a chest tube in order to remove the accumulated blood.

Sucking Chest Wound

A puncture of the chest wall allows air to pass in and out of the chest with each breath. This condition is known as a sucking chest wound or an open pneumothorax and treatment requires the wound to be sealed. Willoughby, *First Aid: Chest Injury*, http://nv.essortment.com/chestinjuryfir_rmkl.htm. This condition can be diagnosed by the sucking sound that is heard when the victim takes a breath of air which enters the chest through the hole in the thorax.

Pericardial Tamponade

The heart is surrounded by a sac known as the pericardium. Pericardial tamponade occurs when blood or fluid collects within the pericardium area. This prevents the heart from expanding properly thereby restricting its pumping action. *Pericardial Tamponade*, e-Cure Me, www.ecureme.com/emy-health/data/pericardial_tamponade.asp.

This condition is most often caused by a penetrating chest injury, but it can be observed in blunt chest trauma resulting in a myocardial rupture or an aortic tear. *Chest Trauma-New Treatments*, www.medical-library.org/journals2a/chest_trauma.htm.

Pulmonary Contusions

A pulmonary contusion is the by-product of trauma to the lung tissue causing blood and fluid to accumulate in the tiny air sacs of the lungs. This condition can cause respiratory difficulties or progress into acute respiratory distress syndrome, or ARDS.

Pulmonary contusions have been discovered in 30 to 70 percent of people who have sustained significant blunt chest trauma. The most common cause of the malady is motor vehicle accidents involving rapid deceleration. Vignish, *Outcome in Patients with Blunt Chest Trauma and Pulmonary Contusions*, *Indian Journal of Critical Care Medicine*, 2004; Vol. 8; Issue 2; 73-77.

Chest x-rays are useful in diagnosing a pulmonary contusion but the test often lags behind the clinical picture. X-rays are most useful 24 to 48 hours following an injury when the true extent of the contusion can be visualized. Also, a CT scan will accurately demonstrate the extent of a lung injury when a pulmonary contusion is present. *Chest Trauma — Pulmonary Contusion*, www.trauma.org/thoracic/chestcontusion.html.

Traumatic Tears Of The Aorta

The aorta is the major artery that carries oxygenated blood from the heart to the other arteries of the body. It originates in the heart's left ventricle and eventually splits into two vessels that supply blood to the lower extremities.

A traumatic tear of the aorta is a rather lethal injury with an 85 percent pre-hospital mortality rate. Philips, *Traumatic Rupture of the Thoracic Aorta: Endoluminal Approach*, The Internet Journal of Thoracic and Cardiovascular Surgery, 2001; Volume 4; Number 1. See also: www.isus.com/ostia/index.php?xmlfilepath=journals/ijc/volini/tar.xml. Up to 15 percent of all car accident deaths result from an injury to the thoracic aorta, and many victims die at the accident location as the result of complete aortic transections. This large artery is most vulnerable to injury from frontal or side impacts. It may also occur as the result of a fall from a height. *Chest Trauma — Traumatic Aortic Injury*, Trauma.org, www.trauma.org/thoracic/chestaorta.html. Other precipitating causes include decelerating forces and blunt chest trauma. *Aortic Rupture — Traumatic Aortic Disruption*, Family Practice Notebook.com, www.fp-notebook.com/cv299.htm.

Blunt trauma or a deceleration force to the aorta primarily results in an injury to the thoracic aorta. A seat belt injury, however, will injure the abdominal aorta. Samett, *Aorta Trauma*, e-medicine, www.emedicine.com/radio/byname/aorta-trauma.htm.

Many people with aortic ruptures will have little visible evidence of serious chest trauma and physi-

cal examination is not of much help in making the diagnosis. A weak pulse in the legs and elevated blood pressure in the arms may suggest an aortic rupture as well as a fracture to the first or second ribs. Argyle, *Chest Trauma*, www.madsci.com/manu/trau_che.htm.

RESPIRATORY PROBLEMS FROM A SPINAL CORD INJURY •

A spinal cord injury can have devastating effects upon the body and the respiratory system may be impaired as the result of paralysis of the chest or diaphragm. The degree of impairment, however, will vary depending upon the level of injury but a few generalizations can be made. *The Respiratory System*, Apparelyzed, <http://www.apparelyzed.com/respiratory.html>.

A spinal cord injury can occur at any level but the more devastating consequences occur with injuries in the cervical region of the spine. The lungs and windpipe are usually not affected by a spinal cord injury. *Understanding and Managing Respiratory Complications after SCI*, Spinal Cord Injury Information Network, <http://www.spinalcord.uab.edu/show.asp?durki=44544>. However, respiratory problems may occur when the signals sent from the brain can no longer flow through the spinal cord to control the respiratory muscles. With spinal cord damage at C4 and higher, all of the muscles which control breathing will be paralyzed. These muscles include the diaphragm, the abdominal muscles and the intracostal muscle. In these cases, breathing can only be accomplished through the use of a ventilator which forces air in and out of the lungs in order to re-oxygenate the blood. Injuries between the C4 and T6 levels may also prevent people from breathing on their own. Coughing may become an issue with quadriplegics who often require assistance with this bodily function. Paraplegics, however, may have enough abdominal movement to generate sufficient pressure to clear their airways. Injuries between T6 and T12 usually do not interfere with breathing but the ability to cough will be limited. It is only with

spinal cord injuries below the T12 level that normal respiration and cough reflexes are maintained. *The Respiratory System*, Apparelyzed, supra.

Those who suffer spinal cord injuries are at an increased risk for developing respiratory complications. For instance, a loss of respiratory muscle control weakens the respiratory system, reduces a person's lung capacity, and increases respiratory congestion. These complications occur regardless of the level of injury. However, the chances for complications are increased for those with an injury across the entire cord and for persons with quadriplegia. *Understanding and Managing Respiratory Complications after SCI*, Spinal Cord Injury Information Network, supra.

Ventilatory failure is a common respiratory complication for quadriplegics with spinal cord damage in the area of C1 to C5. These individuals usually lack the ability to breathe without assistance. Another common problem is atelectasis or the failure of the gas exchange to take place in the alveoli. This occurs when the lungs partially collapse because these structures are not receiving enough oxygen. One other known risk of spinal cord injury is pulmonary embolism. This occurs when a blood clot causes a blockage in the blood vessels of the lungs. A pulmonary embolism is the primary complication of pulmonary circulation and the second leading cause of mortality in individuals with spinal cord injury during the first year after injury. Also, quadriplegics are about 100 times more at risk to die from diseases of pulmonary circulation regardless of when they were injured. On the other hand, paraplegics are about 50 times more likely to be killed by pulmonary embolism. Atelectasis, pulmonary embolism and ventilatory failure are very serious and life-threatening respiratory complications. Nevertheless, pneumonia remains the primary cause of death in those with a spinal cord injury. *Id.*

RESPIRATORY SYNDROMES • As mentioned earlier, **ARDS** stands for Acute Respiratory Distress Syndrome, but few individuals recognize either the initials or the medical problem. ARDS statistics are grim. More than 150,000 people are victims each year and only half of them survive. In fact, more people die annually from ARDS than from breast cancer. *Walk Raises Funds for ARDS*, ARDS Foundation, <http://www.ardsusa.org/ARDS-walk.htm>.

ARDS is an acute condition, which results in a moderate to severe loss of lung function. ARDS is characterized by intense inflammation of the lung tissue, which can result from a variety of factors. This is why it is a syndrome and not a disease. Unfortunately, this lung inflammation results in a loss of function and the alveoli lose their ability to exchange carbon dioxide and oxygen in the blood. This inability is due to the collapse of these tiny air sacs and leakage of fluid into the alveoli. *Acute Respiratory Stress Syndrome*, The ARDS Foundation, <http://www.ardsusa.org/acute-respiratory-distress-syndrome.htm>.

In many cases, the precipitating cause of ARDS is obvious. At other times, such as with a drug overdose, the underlying reason may be difficult to pinpoint. ARDS typically occurs within 12-48 hours after the event, although, in some case, it may take a few days. People who develop ARDS are critically ill and often suffer from multisystem organ failure. This is a life-threatening problem and hospitalization is required for prompt treatment. *Acute Respiratory Distress Syndrome (ARDS)* eMedicine Health, http://www.emedicinehealth.com/acute_respiratory_distress_syndrome/article_em.htm.

A number of risk factors are associated with ARDS including such things as:

- Sepsis which is the presence of various microorganisms, or their toxins in the blood or tissues;
- Severe traumatic injury such as that caused by multiple fractures, severe trauma, and injury to the chest;

- Fracture of the long bones such as the femur;
- Transfusion of large amounts of blood;
- Drug overdose;
- Acute pancreatitis;
- Inhalation of vomit;
- Pneumonia; and
- Inhaling chemicals.

Id.

ARDS manifests itself in a number of ways and its symptoms can vary depending on the cause of the medical emergency and its severity. Warning signs include severe shortness of breath, rapid breathing, hypertension, confusion, extreme tiredness and a cough or fever. *ARDS — Symptoms*, Mayo Clinic, <http://www.mayoclinic.com/health/ards/DS00944/DSECTION=symptoms>.

Treatment for ARDS should be initiated as soon as possible to prevent additional damage to the lungs as well as reducing the risk of death. The primary goal is to keep the patient alive through mechanical ventilation. This is necessary because the diaphragm and other muscles in the chest become fatigued and can stop working in their effort to transfer oxygen into the body. This failure causes the level of oxygen in the blood to drop dangerously low thereby causing injury to the vital organs and body processes. Mechanical ventilation maintains the oxygen in the blood at a life-sustaining level. *Treatment for Acute Respiratory Distress Syndrome (ARDS)*, Healthcumminities.com, <http://www.pulmonologychannel.com/ards/treatment.shtml>.

OTHER RESPIRATORY PROBLEMS • The respiratory system is subject to a number of other medical problems and the following is an explanation of some of the more common issues.

Asthma

Asthma is a chronic lung disease that inflames and narrows the airways causing recurring episode

of wheezing, chest tightness, coughing, and shortness of breath. These incidents of coughing usually occur at night or early in the morning. *What is Asthma*, National Heart and Blood Institute, http://www.nhlbi.nih.gov/health/dci/Diseases/Asthma/Asthma_WhatIs.html.

Asthma most often starts in childhood but it can affect individuals of any age. In the United States, in excess of 22 million people suffer from asthma and nearly 6 million of these people are children. *Id.*

Those with asthma have inflamed airways that are swollen and very sensitive. These airways tend to react strongly to certain substances such as cigarette smoke and other pollutants causing the muscles around them to tighten. In turn, the bronchial tubes narrow and less air is able to enter the lungs. The cells in the airways may also produce more mucus than normal causing breathing passages to further narrow. This chain reaction can trigger an asthma attack. *Id.*

The severity of asthma varies. Some find the symptoms to be a minor annoyance. It can also present as a major problem that interferes with activities of daily living. In fact, severe asthma may be life threatening. This respiratory problem can't be cured, but the symptoms can usually be controlled. Treatment includes the long-term use of medication to prevent flare-ups and by using a bronchodilator to quickly open swollen airways that are limiting breathing. *Asthma — Definition*, [Mayoclinic.com](http://www.mayoclinic.com/health/asthma/DS00021), <http://www.mayoclinic.com/health/asthma/DS00021>. Therapeutic drugs include anti-inflammatories which reduce the amount of swollen cells in the airways and prevent blood vessels from releasing fluids into the airways.

Bronchitis

Bronchitis is an inflammation of the brachial tubes within the lungs that become inflamed because of an infection or other cause. *Bronchitis*, [eMedi](http://www.medic)

http://www.emedicinehealth.com/bronchitis/article_em.htm.

When the tubes swell, they produce mucus causing the sufferer to cough. *Acute Bronchitis — Topic Overview*, WebMD, <http://www.webmd.com/lung/tc/acute-bronchitis-topic-overview>. Bronchitis occurs most often during the winter months and is usually paired with an upper respiratory infection. This medical problem can be caused by a virus, such as influenza A and B, as well as by bacteria, including *Mycoplasma pneumoniae*. It can even occur when a person inhales fumes, dust, chemical solvents, and smoke. *Bronchitis*, [eMedicinehealth.com](http://www.emedicinehealth.com), supra.

The symptoms of bronchitis can be deceptive but generally include such things as a:

- Cough;
- Production of mucus;
- Shortness of breath, made worse by mild exertion;
- Wheezing;
- Fatigue;
- Slight fever and chills; and
- Chest discomfort.

Also, bronchitis sufferers don't always produce sputum and many smokers have to clear their throats after they wake up. If this habit lasts for more than three months, it may indicate chronic bronchitis.

Emphysema

Emphysema is a progressive disease of the lungs that destroys the alveoli and surrounding tissue preventing the body from receiving its much needed supply of oxygen. Emphysema causes shortness of breath because the alveoli over-inflate and lose their normal shape. Emphysema is considered an obstructive lung disease because airflow on exhalation is stopped or slowed since the misshaped alveoli fail to exchange gases, a condition known as hypoxemia. *Bronchitis — Symptoms*, Mayo Clinic,

<http://www.mayoclinic.com/health/bronchitis/DS00031/DSECTION=symptoms>.

Smoking is the primary cause of emphysema but not the only cause. Exposure to air pollution, second-hand smoke, irritating fumes and dusts in the workplace have also been inculcated. In fact, a small number of people with emphysema have a genetic form of the disease known as alpha 1-antitrypsin (AAT) deficiency-related emphysema caused by an inherited lack of the protective protein AAT. *Cause of Emphysema*, Emphysema Foundation, <http://emphysema.org/emphysema-causes.htm>.

There is no magic drug available to modify the rate of decline in lung function for those with emphysema. The available remedies merely help to reduce the symptoms, increase exercise tolerance, lower the number of exacerbations and help improve overall health status. Medications include bronchodilators, glucocorticoids, antibiotics and vaccines. Oxygen therapy can be used during activity or to help shortness of breath.

Pulmonary Vascular Diseases

Pulmonary vascular disease is a catch-all phrase that represents a category of disorders which affect the blood circulation in the lungs. These problems include pulmonary embolism, chronic thromboembolic disease, pulmonary arterial hypertension, pulmonary veno-occlusive disease, arteriovenous malformations and pulmonary edema. *Understanding Pulmonary Vascular Disease*, American Lung Association, <http://www.lungusa.org/lung-disease/pulmonary-vascular-disease/understanding.html>.

A pulmonary embolism occurs when one or more of the arteries in the lungs become blocked by a blood clot. This medical emergency is usually caused by a clot that travels to the lungs from another part of the body such as the legs or arms, a condition known as deep vein thrombosis. While signs and symptoms vary among individuals, they generally include sudden shortness of breath, chest pain and a cough that may bring up blood-tinged

sputum. *Pulmonary Embolism*, Mayo Clinic, <http://www.mayoclinic.com/health/pulmonary-embolism/DS00429>. This variation in symptoms can make the diagnoses illusive.

A pulmonary embolism is dangerous because the blood clot can move through the vessels of the lung on its journey to smaller vessels where it becomes wedged in a structure that is too small to allow it to move any further. This prevents additional blood from reaching that section of the lung causing a pulmonary infarct, meaning that the lung dies because no blood or oxygen is able to reach it. *Pulmonary Embolism*, eMedicineHealth.com, http://www.emedicinehealth.com/pulmonary_embolism/article_em.htm.

Factors that increase the risk for pulmonary emboli include prolonged immobilization, increased clotting potential of the blood and any damage to the walls of the veins. These three causes have been dubbed “Virchow’s Triad.” *Pulmonary Embolism*, Medicine.net.com, http://www.medicinenet.com/pulmonary_embolism/page2.htm.

A pulmonary embolism usually occurs suddenly. Occasionally, however, small emboli can occur over a period time in which case these blood clots may cause a more gradual onset of symptoms. Less-specific symptoms may include anxiety, lightheadedness, fainting, sweating, rapid breathing, and an increased heart rate. *Pulmonary Embolism*, APS Foundation of America, Inc., <http://www.apsfa.org/pesymptoms.htm>.

A pulmonary embolism is a true medical emergency that requires prompt medical intervention. Treatment includes medication and/or surgery. Physicians usually administer anticoagulants such as Heparin or Coumadin to abate the symptoms. While clots generally dissolve on their own, there are medications that can expedite the process. However, these clot-busting drugs can result in a severe blood loss so they are usually limited to life-threatening situations. Surgery includes a clot removal process by using a thin flexible catheter that is

threaded through the blood vessels in order to reach the clot. A catheter may also be utilized to insert a filter into the inferior vena cava thereby blocking the blood clots from being swept into the lungs. *Pulmonary Embolism — Treatment and Drugs*, Mayo Clinic, <http://www.mayoclinic.com/health/pulmonary-embolism/DS00429/DSECTION=treatments-and-drugs>.

Pulmonary hypertension (PH) refers to an increased pressure in the pulmonary arteries that carry the blood from the heart to the lungs in order to pick up oxygen. *What Is Pulmonary Hypertension?* National Heart, Lung and Blood Institute, U.S. Department of Health and Human Services, http://www.nhlbi.nih.gov/health/dci/Diseases/pah/pah_what.html. In other words, a person has high blood pressure in the arteries of the lungs. *Pulmonary Arterial Hypertension*, American Lung Association, <http://www.lungusa.org/lung-disease/pulmonary-arterial-hypertension>. The symptoms of this progressive disorder include shortness of breath during routine activities, feeling tired, chest pain, and a racing heartbeat. All physical activity may be limited as the condition worsens. *What Is Pulmonary Hypertension?* National Heart, Lung and Blood Institute, supra. A variety of conditions can cause high blood pressure in the pulmonary arteries such as congestive heart failure, blood clots in the lungs, HIV, use of illegal drugs, cirrhosis, chronic lung disease and sleep apnea. When no cause for PH can be identified after testing, the condition is referred to as idiopathic pulmonary arterial hypertension. *Pulmonary Hypertension*, WebMD, <http://www.webmd.com/lung/pulmonary-hypertension-1>.

Pneumonia

Pneumonia is an infection of the lungs generally caused by bacteria, viruses, or fungi. Schiffman, George, *Pneumonia*, MedicineNet.com, <http://www.medicinenet.com/pneumonia/article.htm>. This problem can be caused by a variety of factors such as bacteria or viruses contained in the nose, sinuses,

or mouth that spread to the lungs, breathing germs directly into the lungs or inhaling food, liquids, or vomit that lodges in the lungs. Bacteria related pneumonia tends to be the most serious form and it is the most common cause of pneumonia in adults. On the other hand, viruses are a common cause of pneumonia in young children. Blaivas, Allen, *Pneumonia*, MedlinePlus, <http://www.nlm.nih.gov/medlineplus/ency/article/000145.htm>. Pneumonia is frequent complication of a pre-existing condition or illness and is set off when an individual's defense system is weakened, usually by a simple respiratory tract infection or influenza. This illness affects the lungs in different ways. For instance, lobar pneumonia affects a lobe of the lungs, and bronchial pneumonia affects patches throughout both lungs. *Pneumonia Fact Sheet*, American Lung Association, <http://www.lungusa.org/lung-disease/influenza/in-depth-resources/pneumonia-fact-sheet.html>.

Symptoms and signs can develop suddenly with pain in the side of the chest that may make it difficult to breathe and coughing is painful. This discomfort is attributed to the inflammation of the alveoli and a narrowing of the bronchioles caused by the infection. *Pneumonia Symptoms*, <http://www.pneumoniasymptoms.org/pneumonia-symptoms.html>. Other symptoms usually include fever, chills and a cough accompanied with yellow-green phlegm or occasionally blood. As the problem becomes worse, what started out as a dry cough, becomes a productive cough containing phlegm whose color has changed and may be smelly. Usually, pneumonia will improve with treatment and causes no long-term damage to the lungs. *Id.*

Treatment for pneumonia depends on the cause of the condition and the severity of the symptoms. Antibiotics are usually given for bacterial pneumonia. However, these types of drugs are ineffective to treat viral infections so the person may only be given cough syrup. If a fungus is responsible for the pneumonia, antifungal medication may be issued. Severe cases of pneumonia usually require hospitalization

in order to administer oxygen therapy to help the person breathe as well as for the administration of intravenous antibiotics. *Pneumonia Treatment*, [Family-Doctor.org](http://familydoctor.org/online/famdocen/home/common/infections/common/pneumonia/932.html), <http://familydoctor.org/online/famdocen/home/common/infections/common/pneumonia/932.html>.

LUNG CANCER • Lung cancer is the most common cancer related death in the United States and the mortality rate is highest among African-American males followed by Caucasian males. *Incidence and Mortality Rate Trends*, A Snapshot of Lung Cancer, National Cancer Institute, <http://www.cancer.gov/aboutnci/servingpeople/snapshots/lung.pdf>. Not surprisingly smoking is the primary cause of this disease but other risk factors include exposure to radon, asbestos, environmental factors, and secondhand smoke. There are even times when a person contracts lung cancer and the doctor is unable to pinpoint the origins of that malignancy. Hereditary also plays a role in its development. *Lung Cancer 101*, [lungcancer.org](http://www.lungcancer.org/reading/about.php), <http://www.lungcancer.org/reading/about.php>.

Lung cancer is the abnormal growth of cells in one or both lungs. These abnormalities retard the function of the normal cells which then fail to develop into healthy lung tissue. As they become larger, the abnormal cells can form tumors which impede the lung's ability to supply oxygen to the body via the blood. *Id.*

Cancer of the lung may start in any part of this organ but more than 90 percent are believed to originate within the epithelial cells. These are the cells of the respiratory system lining the bronchi and bronchioles. The pleura or tissues surrounding the lungs may also be an originating source of lung cancer and this form malignancy is called mesotheliomas. *Lung Cancer*, [Medicine.Net.com](http://www.medicinenet.com/lung_cancer/article.htm), http://www.medicinenet.com/lung_cancer/article.htm.

The proper medical term for lung cancer is "bronchogenic carcinoma" and there are two major forms: non-small cell lung cancer and small cell

lung cancer. Each type affects different kinds of cells in the lungs, and each enlarges and multiplies in different fashions. *Lung Cancer — An Overview*, Memorial Sloan-Kettering Cancer Center, <http://www.mskcc.org/mskcc/html/12163.cfm>. This classification, however, is based upon the appearance of the tumor cells upon microscopic examination. *Lung Cancer*, [Medicine.Net.com](http://www.Medicine.Net.com), supra. Tumors detected in the lungs may also come from a totally unrelated location such as the stomach, breast, prostate, or skin, a condition called lung metastases. *Lung Cancer — An Overview*, Memorial Sloan-Kettering Cancer Center, supra.

Non-small cell lung carcinoma (NSCLC) includes malignancies such as, adenocarcinoma, squamous cell carcinoma and large cell carcinoma. Large cell carcinoma and adenocarcinoma are most often detected on the outer edges of the lungs. They may consist of solitary nodules, masses, or scar tissue. Squamous cell carcinoma is more centrally located and its symptoms may mimic pneumonia or a collapsed lung. These cells tend to grow slowly and can take some time to transform into an invasive cancer. Adenocarcinoma is much more insidious and has a poorer prognosis than squamous cell cancer. Large cell cancer also has a poor outcome similar to adenocarcinoma. *Types of Lung Cancer*, Health Communities.com, <http://www.oncologychannel.com/lungcancer/types.shtml>.

Small cell lung cancer (SCLC), is a rapidly growing and aggressive malignancy that comes in two forms depending upon the composition of the cancerous cells. They are small cell carcinoma or oat cell cancer, which is the most common form, and combined small cell carcinoma. *General Information About Small Cell Lung Cancer*, National Cancer Institute, <http://www.cancer.gov/cancertopics/pdq/treatment/small-cell-lung/Patient#Keypoint1>. Statistically, small cell lung cancer accounts for about 15 percent of lung cancers and smoking is the primary risk factor. SCLC is the worst form to develop because it is by far the most aggressive. While

the abnormal lesions start in the bronchi and are small at their inception, they soon develop in large tumors that frequently metastasize to other organs. *Lung Cancer — Small Cell*, MedlinePlus, U.S. National Library of Medicine, <http://www.nlm.nih.gov/medlineplus/ency/article/000122.htm>.

About two-thirds of those people who are diagnosed with small cell lung cancer have extensive infiltration at examination. Unfortunately, their prognosis is extremely poor since this form of cancer is usually incurable. Those with extensive small cell lung cancer have a median survival rate of a mere six weeks. Patients who have a localized stage of the illness have an average survival rate of about 12 weeks. The survival rate for those who are treated aggressively with chemotherapy and multimodality therapy generally don't live more than two years but about 20 percent of patients with a limited form of the cancer have lived up to five years. Maghfoor, Irfan, et al., *Lung Cancer, Oat Cell (Small Cell)*, [Emedicine.com](http://www.Emedicine.com), <http://www.emedicine.medscape.com/article/280104-overview>.

A number of symptoms are associated with small cell lung cancer, such as a persistent cough or a change in the quality of a chronic cough, wheezing, blood in sputum, chest pains, and an unintentional weight loss. Fayad, Lisa, *Small Cell Lung Cancer Symptoms*, [About.com:cancer](http://www.About.com:cancer), <http://cancer.about.com/od/smallcelllungcancer/a/SCLCSymptoms.htm>.

Lung cancer is diagnosed by the utilization of a number of diagnostic tools depending upon the presentation of symptoms. In addition to the standard chest x-ray, CT-scan and MRI, the physician may exam the sputum under a microscope. More invasive procedures include the use of a bronchoscope in which a small lighted tube is threaded through the respiratory system in order to make a visual observation of the area and to take a tissue sample if necessary. A needle may also be inserted through the chest so that the fluid surrounding the lungs may be sampled for cancer cells. This procedure is called

a thoracentesis. Finally, a thoracotomy is available whereby the chest is surgically opened and part or all of the offending tissue is removed. *Diagnostic Tests for Lung Cancer*, [WrongDiagnosis.com, http://www.wrongdiagnosis.com/1/lung_cancer/tests.htm](http://www.wrongdiagnosis.com/1/lung_cancer/tests.htm).

CONCLUSION • There are many types of injuries and illnesses that affect the respiratory system and surrounding area and a number of them have life threatening consequences. Motor vehicle acci-

dents account for the vast majority of chest injuries and can include rib fractures, a pneumothorax or a torn aorta. The respiratory system is a complex body structure that extends from the openings in the nose to the tiny air sacs in the lungs that are important for the exchange of oxygen for carbon dioxide. By having a basic understanding of the anatomy of the respiratory system, one can better appreciate the diseases that affect the respiratory system and understand the mechanism of trauma.

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PRACTICE CHECKLIST FOR A Litigation Primer On The Respiratory System

- The primary task of the respiratory system is to make sure that the blood is infused with oxygen so that the blood can deliver air to all parts of the body. This is done through breathing which allows a person to inhale oxygen from the atmosphere and to expel carbon dioxide from the blood.
- The organs of the respiratory system include the nose, pharynx, larynx, trachea, bronchi, and lungs. One or more of these structures draw in air, exchange gases with the blood, and expel the carbon dioxide.
- The airway from the nose through the larynx is considered the upper respiratory tract and the area consisting of the trachea through the lungs comprises the lower respiratory tract. The upper respiratory tract includes the nose, pharynx, larynx and trachea. The lower respiratory tract includes the bronchi, alveoli, and lungs.
- The chest is comprised of the ribs, sternum, thoracic vertebrae, and fibrous tissues known as costal cartilage.
- The ribs are made up of 12 pairs of bones that are unequal in length. All of the bones are curved and extend from the spine to the front of the abdomen.
- The sternum is located in the middle part of the chest. This flat bone runs longitudinally and connects on the sides to the first seven ribs. This structure is made up of three parts: the manubrium, body, and xiphoid process.

- The posterior portion of the ribcage meets up with the thoracic vertebrae. This area consists of twelve bones that make up the largest part of the spine. Vertebra T2 through T9 provide the attachment sites for the ribs.
- Breathing requires several simultaneous movements to take place. As the chest expands, air is inhaled causing the ribs to elevate, or move upwards. At the same time, the middle portion of the lower ribs moves laterally.
- Trauma to the chest is a common event and one-third of these victims require hospitalization. Motor vehicle accidents account for 70 to 80 percent of all serious blunt chest injuries.
- Rib fractures are the most common result of blunt trauma to the chest and it represents 10 percent of all traumatic injuries and 14 percent of chest wall problems with the middle and lower ribs being the most susceptible to trauma.
- A significant chest impact can cause an intrathoracic injury which describes damage to the internal organs such as the lungs, liver, and spleen.
- A pneumothorax occurs when air escapes from a lung that has been punctured by a piece of bone or enters through an external hole in the chest and then accumulates between the lungs and chest wall.
- An hemothorax represents an accumulation of blood within the chest.
- A puncture of the chest wall allows air to pass in and out of the chest with each breath. This sucking chest wound requires the hole to be sealed immediately.
- Pericardial tamponade occurs when the sac surrounding the heart fills with blood or fluid thereby preventing the heart from expanding properly.
- A pulmonary contusion is the by-product of trauma to the lung tissue causing blood and fluid to accumulate in the tiny air sacs of the lungs. This condition can progress into acute respiratory distress syndrome, or ARDS.
- Blunt trauma or a deceleration force to the aorta can result in an injury to the thoracic aorta and a seat belt injury can injure the abdominal aorta.