Patient Information

Series 1

How do we normally breathe and why we fail to breath?

In these series of patient information, we will discuss multiple topics. These topics will cover questions on how we breathe, why we fail to breathe, how we treat failure to breathe, what are ventilators and other respiratory machines do, how they work, and what are the dangers of using those machines.

In the first series, we will discuss how humans breathe (physiology) and why we sometimes fail to breathe (pathology).

One of the most important roles our lungs play among other things is that it takes air including oxygen from the atmosphere and delivers it to our blood cells to be carried out to all our organs.

The respiratory system is mainly divided into conduction airways (pipes that conduct air in and out of the lungs); which includes our nose, mouth, trachea, bronchi that keep branching into smaller airways and further terminate into air sacs (alveoli). We have about 600 million alveoli in our lungs with a surface area equivalent to a tennis court. Those alveoli are surrounded with a network of blood vessels (arteries, veins, and capillaries) that conduct our blood around those alveoli for carbon dioxide (our waste product), to move from the blood to our lungs out to the atmosphere and for oxygen to move from the alveoli into the veins back to the heart then to our organs. (Figure 1)

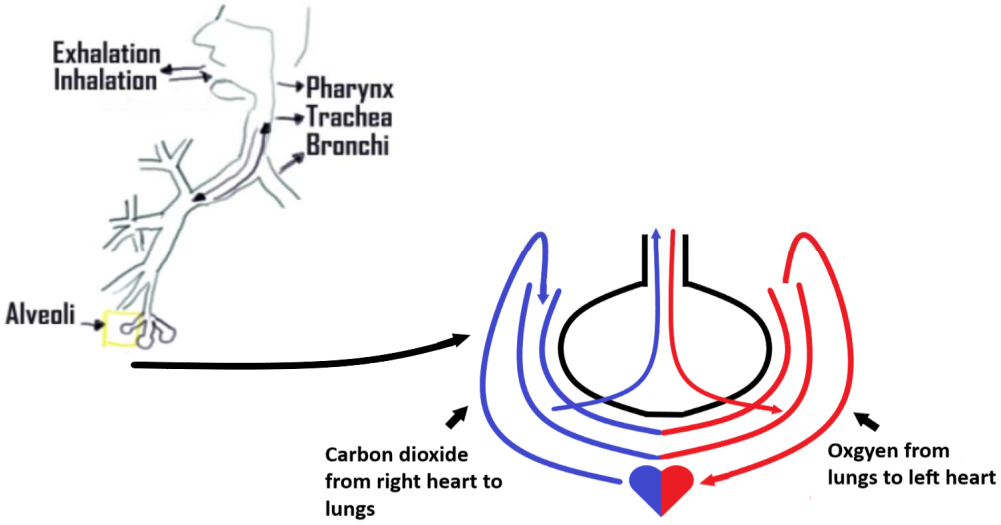

Figure 1

Each breath we take has two phases; inspiration or inhalation which is air going in from the outside rich in oxygen, and expiration or exhalation which is air going out from our lungs rich in carbon dioxide. The inspiration phase is an active phase; it needs energy or work to happen, while the second phase is usually passive phase which requires no energy or work.

Our bodies at the sea level are exposed to atmospheric pressure or barometric pressure of 760 mmHg (millimeter of mercury) or 14.696 Psi (pound per square inch). For the air to go inside our lungs, it has to go through a pressure gradient, meaning from higher pressure outside the lungs to less pressure inside our lungs. This process is called negative pressure breathing (a normal physiologic process).

During active inhalation, our main respiratory muscle which is the diaphragm (the muscle that separates our chest from our abdomen) must contract downwards towards our abdomen. It creates a negative pressure relative to the atmospheric pressure, which leads to air rushing inside our lungs until it inflates, and the pressure equalizes. Depending on how forceful this contraction, it dictates how much air goes into our lungs.
During exhalation, our diaphragm simply relaxes back to its normal position upwards by pushing the air outside the lung again until the pressure equalizes. (Figure 2)

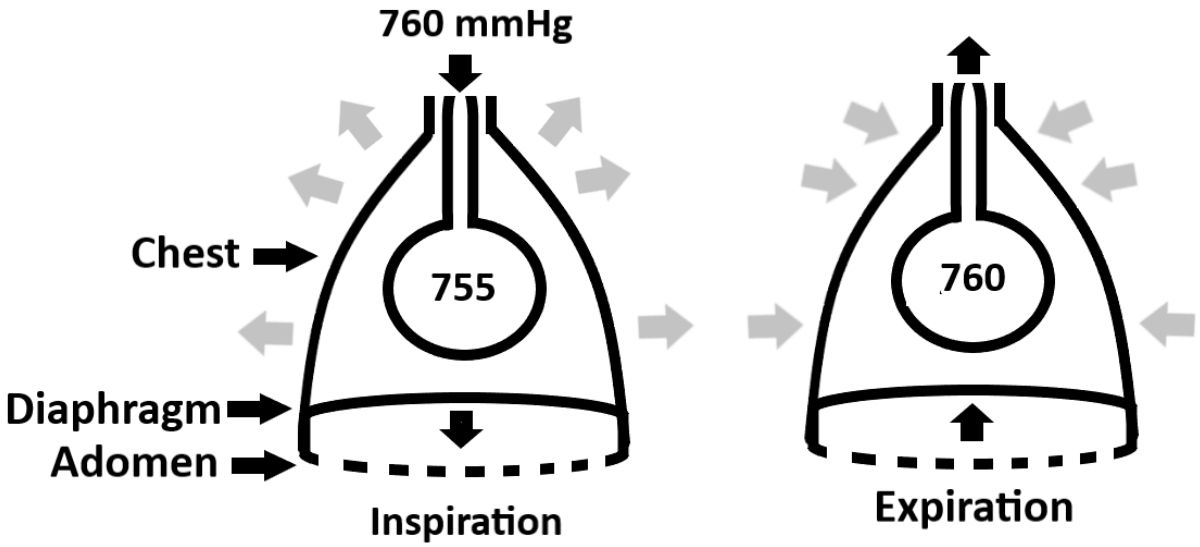

Figure 2

To be noted, breathing is a natural involuntary process and our brain dictates how many times we breathe, and how deep we breathe depends on our needs. For example, during sleep we take fewer, shallower breaths; versus during exercise, stress, and disease conditions, we may take much faster and deeper breaths. Humans have a limited temporary ability to control our breathing rate and depths like holding our breath or slowing or accelerating our breaths. We cannot sustain it for a very long period and as our brain will eventually take control.

So why this amazing respiratory system fails leading to what is called respiratory failure which requires hospitalization, using different oxygen devices or more advanced machines to support our respiratory system?

The answer to this question is rather complicated and there are literally thousands of diseases or conditions that can cause respiratory failure. We can divide it broadly into lack of oxygen (oxygenation problems), or higher levels of carbon dioxide (ventilation problems). Those broad diseases can each cause one of those problems, but they mostly overlap.

We can then subdivide those diseases into five large subcategories:

1. Low levels of oxygen pressure in the air (high altitudes) e.g. high mountains
2. Decreased breathing (hypoventilation) e.g. brain strokes, hemorrhages, trauma, drugs, heart arrest
3. Blood with low oxygen bypassing the lungs (shunting) e.g. pneumonia, aspiration, drowning, heart failure
4. Misdistribution between blood and air in the lungs (ventilation-Perfusion mismatch) e.g. asthma, COPD, blood clots in the lungs
5. Oxygen cannot move from lungs to blood (diffusion) e.g. pulmonary fibrosis, rheumatoid arthritis

The most common conditions fall under number 3 and 4. Usually number 3 (shunting) causes the most severe form of respiratory failure that may require higher levels of support.