Starship
Child Health

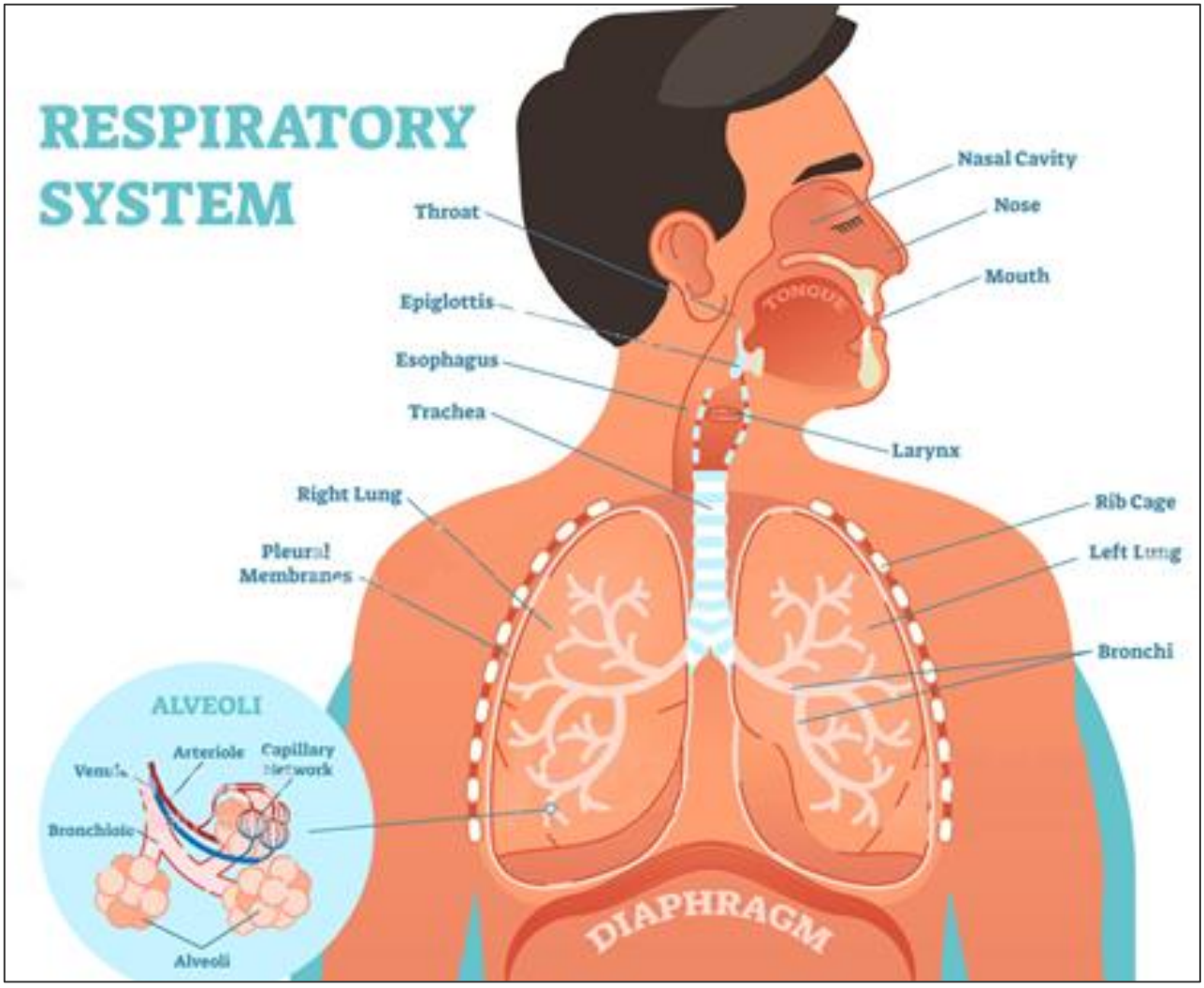
Breathing and Ventilation

How Do We Breathe?

Breathing draws air into the lungs where the oxygen passes into the blood and is then transported around the body. Just like a fire, our bodies need oxygen to make energy. Very little oxygen is stored in the body and we are constantly bringing in new oxygen from the air around us.

Carbon dioxide (CO_2) is a waste gas from the body. It is carried back to the lungs in the blood and breathed out. If CO_2 levels get too high the body becomes acidic and this causes health problems. High CO_2 may also make you feel breathless and give you a headache.

The exchange of gases in the lungs is called 'ventilation' and you may hear your health team talking about oxygen and CO_2 levels when adjusting your child's ventilation.



How Do We Breathe?

There are many things that affect our breathing. The four most important are the airways, the lungs, muscles (the pump), and the brain (control).

1. **Airways**

   These are the passages or pipes that air travels up and down to get between the outside world and the air sacs (alveoli) in the lungs. They include the nose, mouth, voice box (larynx), windpipe (trachea) and airways within the lungs (bronchi). For the airways to work at their best, the air travelling in the airways should be warm and moist; it is usually the nose's job to achieve this humidification.

2. **Lungs**

   This is where the gases (oxygen and carbon dioxide) pass back and forth between the air we breathe and the blood circulating in the body. This happens in tiny air sacs (alveoli). In an adult, the combined surface area of the alveoli is about the size of a tennis court.

3. **Muscles**

   Air is drawn into the lungs by muscles around and below the lungs. The biggest muscle involved is the diaphragm, which is below the lungs, but muscles in the chest wall (intercostal muscles) and neck are also important.

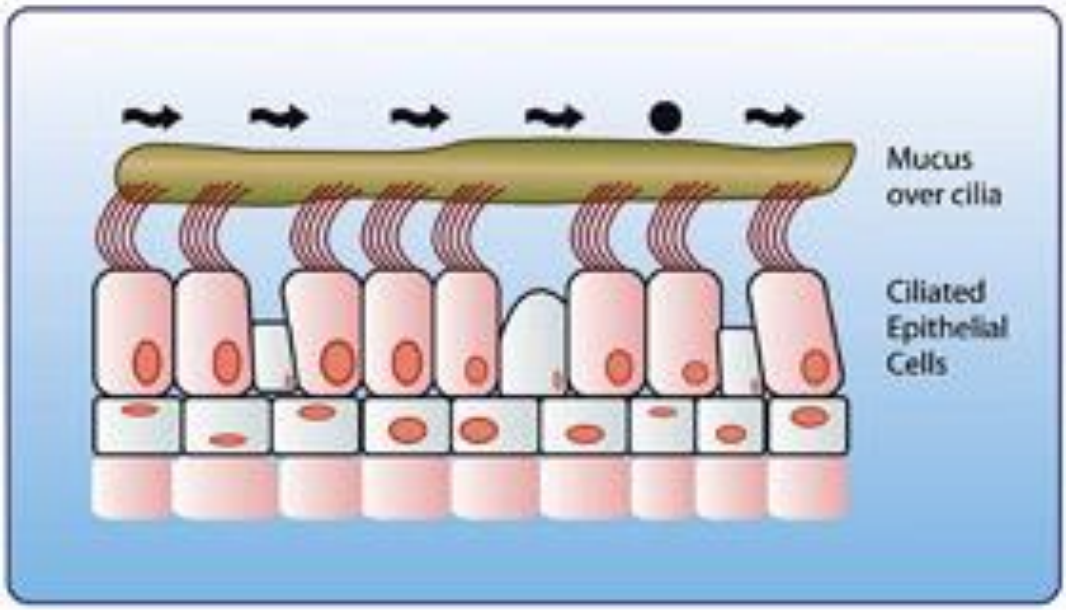
4. **Brain**

   Breathing is controlled by the brain. It automatically responds to the body's oxygen and carbon dioxide sensors but also responds to commands (e.g. breath-holding). These instructions are passed to the muscles via the spinal cord and then nerves.

Lung Health – Infections and Mucus

Breathing brings air from the outside into our body and down into our lungs. Because viruses can be present in the air, the lungs are a common place for infections.

The body has many defenses – some physical and some to do with the immune system. One very important defense is mucus. Mucus lines the airways and is pushed out of the lungs by tiny oars in the airway skin (mucosa) called cilia. We don't usually notice the small amount of mucus in our airways and we usually swallow it without any thought. But if your child has a tracheostomy, you will need to learn how to get rid of this mucus by suctioning it.



Mucus gives some idea of your child's lung health

- If the amount increases, thickens or changes colour, this can be a sign of lung inflammation or infection.

- To work well, the mucus needs to be kept warm and moist. A back-up to this is coughing, which forcefully pushes air and mucus out of the lungs. To cough, you need strong respiratory muscles and good control of your voice box.

Your health team can explain how this affects your child and how best to help. They may emphasise the ways of keeping the air warm and moist (humidification) and how to clear the airways of excessive mucus (suction and physiotherapy).

What Does Ventilation Mean?

Ventilation refers to the amount of air travelling in and out of the lungs. This determines how much oxygen the lungs can take in and how much CO_2 they can get out.

Ventilation requires healthy airways, healthy lungs and sufficient 'airflow'. Airflow through the lungs can be changed by the size and frequency of breaths we take. We usually do this without thinking – when we exercise and need to increase ventilation, we breathe harder and faster.

It is normal for the breathing (size and frequency of breaths) to change during the day and for the body to be in varying positions, predominantly upright. This may be important to help prevent atelectasis (deflation) of parts of the lungs.

What Is A Ventilator?

A ventilator is a mechanical device that helps your child with ventilation – the flow of air in and out of the lungs.

There are lots of different kinds of ventilators and many have more than one way of helping.

Ventilators help with any or all of the four main parts of breathing outlined above, including:

- Keeping the airways open so that air can travel in and out
- Helping to use ('recruit') areas of lung that would otherwise not be involved in breathing
- Helping the breathing muscles to pump air into the lungs
- Initiating breaths if the brain or nerves aren't functioning properly.

Your health team can explain how your child's ventilator helps them to breathe and why they require that specific type of support.

What Do All Those Ventilator Words Mean?

There are various different words that describe the type of ventilation support your child is receiving. You may have heard the medical team talking about these:

Modes: Ventilators use three main 'modes', although there are lots of variations.

1. **Flow – High Flow Therapy:** The simplest ventilator mode delivers a high flow of air through the nose and/or mouth. This reduces the effort of breathing and helps keep the airways open.

2. **Single Pressure ('CPAP'):** This stands for Continuous Positive Airway Pressure. The ventilator delivers a single fixed air pressure that helps keep airways open and 'recruits' more lung to help ventilation.

3. **Two level pressure ('bi-level', 'BPAP,' 'VPAP', 'PS', 'PC', 'P-SIMV'):** There are lots of variations on this and you may have heard some of these words mentioned if your child is on this type of ventilation. These all help ventilation by using two different levels of pressure:
    - A background pressure during expiration (breathing out) that helps keep the airways open and recruit lung **(often called the PEEP or EPAP pressure)**
    - A higher pressure during inspiration (breathing in) that helps your child to take a bigger breath **(variously called IPAP, PS, PC or PIP pressure).**

    Bi-level (expiration and inspiration) may be used to support your child's own breathing or to create breaths all by itself.

Pressure: This is the force exerted by air. Air in a balloon or car tyre is under pressure. Air will flow from high to low pressure, and air pressure is what determines flow through the lungs. This is often described as a number of 'centimetres of water' (usually between 4 and 30, e.g. 6cm of water). Your health team may talk about increasing or decreasing this number depending on your child's needs.

Resp Rate (RR): This stands for respiratory rate, which is the number of breaths your child takes per minute. In 'bi-level' support (mentioned above) this is often a mixture of spontaneous breaths started by your child and mandatory or back-up breaths started by the ventilator. You can count the respiratory rate by watching your child for one minute and counting their breaths.

Alarms: Ventilators often have a lot of alarms that can be set to warn you of potential problems. This is a balance between ensuring an alarm will sound in an emergency, versus having too many nuisance alarms. These can often be set at certain limits and your team will discuss this with you.

Extras For Experts!

There are a lot of technical terms used with ventilators. Don't feel like you need to remember them all! But you may like to know a bit more about what the medical team may be looking at with the ventilator…

Trigger: This is a control on how sensitive the ventilator is at detecting that your child is starting a breath. Often the ventilator breaths will be triggered to be in time with your child's own efforts. If it is too sensitive, it may falsely trigger when the child isn't trying to breathe (often due to 'leak'). This causes uncomfortable 'auto-cycling'. If a trigger is too insensitive, it won't detect a child's breath. These can be adjusted by the medical team as needed.

Leak: This refers to air that escapes from the system between the child and ventilator (in either direction). A leak may be via the circuit (machine and tubing), nose, mouth or tracheostomy (if your child has one). It may occur during inspiration (air from the ventilator that never gets to the child's lungs) or expiration (air from the lungs that doesn't get back to the ventilator). Some leak is expected, and often good. However, if a leak is excessive the ventilator may struggle to be in time with the child's breathing and/or not achieve its target pressures. This means the ventilator isn't working quite as well as we want it to for your child. A leak can often be fixed by simple things such as adjusting the child's mask. The team will go over these tips and ways to troubleshoot with you.

VT: 'Tidal Volume' – the size of a breath in mls (millilitres). It may be measured during inspiration (VTi) or expiration (VTe). When there is a leak, the ventilator doesn't always get this right.

Mv: 'Minute Ventilation' – the amount of airflow pumped through the lungs per minute in litres.

iTime: This is how long it takes to breathe in (seconds). There are a variety of ways the ventilator can be set to adjust or control this.

How Does A Ventilator Connect To My Child?

The ventilator 'circuit' carries the air between the ventilator and your child. The tubing needs a way to connect to your child's airways and this point is called the 'interface'.

There are lots of different options and your health team will help work out what is best for your child – this can depend on your child's size and what they can manage.

Some types of interface are called 'non-invasive' because they stay outside the body and include different kinds of nasal prongs, cushions or masks. A tracheostomy interface is called 'invasive' because it involves surgically placing a small plastic pipe directly into the windpipe (trachea) just below the voice box that the breathing circuit can then connect to.

Your health team will advise you what is best for your child. A child may start with one form of interface and move to another one over time.

What Is Humidification?

Humidification refers to making the air delivered by the ventilator warm and moist. The nose usually makes this happen when we breathe in room air, but extra humidification is often needed for ventilation, especially if a child has a tracheostomy. This helps keeps the airways and lungs healthy and stops mucus getting too thick and dry. Your health team will talk to you about what humidification is appropriate for your child and how this will be achieved.

8. What is 'infection prevention'?

Infection prevention includes all sorts of ways of reducing the chance of your child getting infections. Hand washing is by far the most important. Children needing ventilation are more vulnerable to an infection, so **infection prevention is a very important part of their care.** In addition to cleaning, you can reduce the risk of infections by making sure the environment is as healthy as possible and that your child has appropriate immunisations. Your health team will talk to you about all the infection prevention habits you will need to develop.

What Do Pneumonia, Bronchitis And Atelectasis Mean?

Your health team may use lots of different words to describe problems that could occur in your child's lungs. Here are some of the infections or issues your child may get if they are unwell:

Viral upper respiratory infection: This may be a cold, the flu, or a URTI (upper respiratory tract infection).

- These are common viral illnesses that anyone can get. If your child has one of these viruses they may have a high temperature, feel unwell, develop increased nasal and airway secretions/mucus, and need to cough.
- These are usually not a big problem, but when your child is on a ventilator, a viral infection can affect them more than other children because the increased secretions can make ventilation harder.

Bronchitis: This is an infection of the lower airways (below the voice box).

- This causes the airways to become inflamed – they swell, make much more mucus, and may become obstructed. Viral infections are the most common cause but bacteria may also be involved.
- Your child may have a high temperature, feel unwell, have increased secretions (larger volume, darker colour, stickier) and be having more difficulty breathing. Excessive secretions can block airways, causing coughing and may make breathing/ventilation a lot harder.

Normal airway:

Bronchitis:

What Do Pneumonia, Bronchitis And Atelectasis Mean?

Pneumonia: This is an infection of the small breathing sacs (alveoli) in the lungs.

- The alveoli are important for ventilation because they are where oxygen and CO_2 move between the lungs and bloodstream. With pneumonia, your child would typically have all the signs of bronchitis above but be more unwell and more sleepy than usual. They may find it even harder to breathe properly.

Normal alveoli:

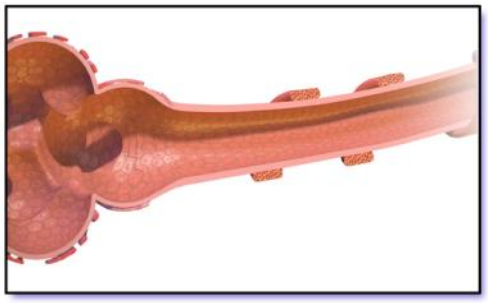
Pneumonia:

:

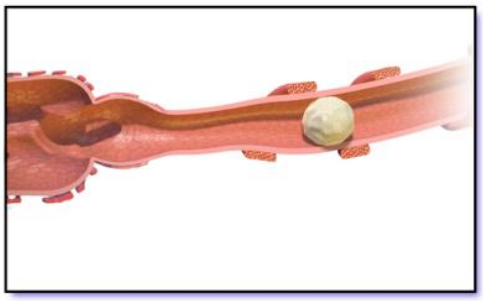
Atelectasis:

Atelectasis is where areas of the lung deflate like an empty balloon. Atelectasis may affect small patches of lung, whole lobes, or entire lungs. These areas cannot function while they are collapsed, but your health team can advise ways to reduce the risk of atelectasis and to recover from it when it occurs.

Normal:



Atelectasis and blocked with secretions:



Child-Friendly Language

There are lots of different words you and your child might hear while in hospital. Sometimes these words can be confusing and scary for your child. Here are ways to explain some common terms that a child or teenager might hear in the hospital environment:

Observations (or 'obs'): This is when the nurses or doctors listen to your heart, watch your chest to see how many times you breathe in one minute, take your temperature, and take your blood pressure. These are done regularly to assess how your body is working. They are also called vital signs. Sometimes a machine is used to measure the heart rate, pulse oximeter, and blood pressure.

Blood pressure: This measures the pressure and force that is occurring to move blood through the body. When the heart beats, it pumps blood around the body; the force of this pushing is your blood pressure.

Blood pressure cuff: This is used to measure blood pressure. It can be used on an arm or leg and feels like a firm hug.

ECG Leads: Stickers are put on the chest most of the time. Sometimes the stickers might be put on your arms and legs. When the stickers are in the right place, they are joined up to a machine that measures how the heart is beating.

G-Tube: This is a tube that goes into the tummy to give you medicines or food. It can also be called a Mic-key button, gastrostomy or GT.

IV line (luer): This is a straw in the hand or arm that helps the body get drinks or medicine quickly in to a vein.

NG-Tube: This tube goes in the nose and then into the tummy. It can be used to give you medicines or food.

Pulse oximeter (oximeter or pulse ox) also called saturations (sats): This machine tells us how much oxygen you have in your body. A strip of tape that looks like a Band-Aid is put on one finger or toe. It contains a small light that joins to a portable machine – this gives us numbers, which are your heart rate and oxygen saturations (e.g. 98 heart rate, 97% saturations).

Stoma: An opening where a tube goes. A tracheostomy is a stoma in the neck. There is a stoma on the stomach where a G-tube goes. Children that have a colostomy have a stoma in their abdomen into the intestine.

Suction: This is a tiny tube to help get secretions/mucus and spit out of the throat and lungs.

Tracheostomy (or trache): A special tube in the neck that helps a child to breathe. This can be permanent or temporary.

Ventilator (or 'vent'): This machine helps put air in and out of the lungs.