



Pulmonary Clearance

This learning module is intended as a review of foundational knowledge for practitioners in the community working with children and their family who require pulmonary clearance support. In order for the associated workshop to be effective it is recommended this module be completed prior to the session.

Contents

Learning Outcomes
The Paediatric Respiratory System
Airway Clearance Techniques

Learning Outcomes

- ✓ Identify the indications and contraindications for pulmonary clearance support
- ✓ Review chest physiotherapy, suctioning, mechanical in-exsufflation, and lung volume recruitment

Additional Resources

Cardiopulmonary physiotherapy treatment in a baby:

<https://www.aboutkidshealth.ca/Article?contentid=3876&language=English>

Cardiopulmonary physiotherapy treatment for children:

<https://www.aboutkidshealth.ca/Article?contentid=3877&language=English>

Cough Assist: <https://www.aboutkidshealth.ca/Article?contentid=2447&language=English>

Connected Care Learning Hub – Pulmonary Clearance: <https://www.aboutkidshealth.ca/connectedcare>

Trach/Vent Caregiver Manual <http://www.aboutkidshealth.ca/trachvent>

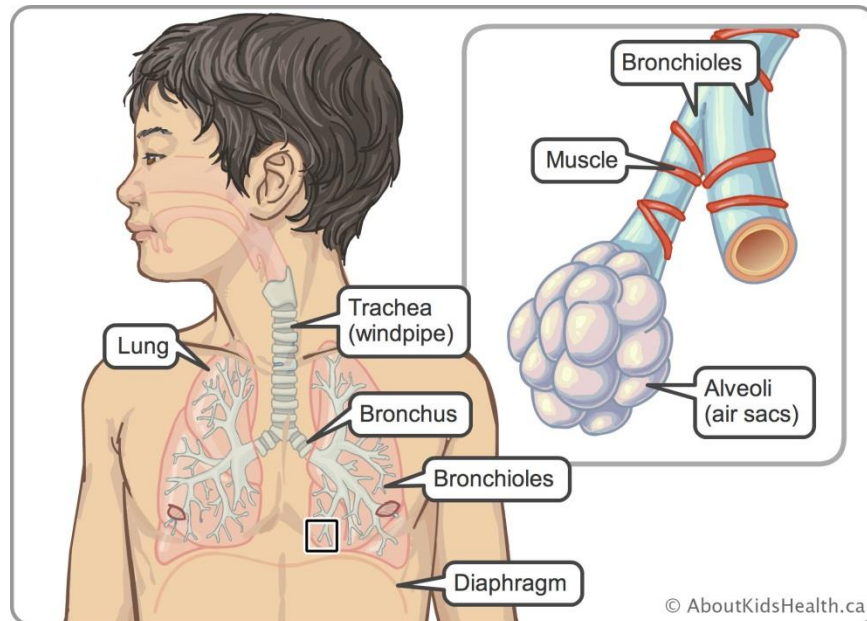
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The Paediatric Respiratory System

Understanding how a child breathes is an important part of learning how to care for a child's respiratory needs.

A child's respiratory system can be broken down into the:

- upper respiratory tract
- lower respiratory tract



Anatomy

Upper respiratory tract

Nasal cavity

Air is warmed, moisturized and cleaned. Tiny hairs called **cilia** line the inside of the nose and filter the air.

Oral cavity

Air is warmed and moisturized however, there are no cilia in the oral cavity, so the air is **not** filtered.

Pharynx

The **pharynx** is a muscular tube between the nose and the mouth.

Larynx (voice box)

The larynx (voice box) is between the pharynx and the trachea. It contains the vocal cords. When air is breathed in and out, voice sounds are created here. *The vocal cords* can be closed to build up pressure in the lungs and create a strong cough.

Epiglottis

The epiglottis is a flap that hangs over the larynx. When you swallow, this flap covers the larynx so food and/or drink will go into the esophagus and not into the trachea and lungs.

Esophagus

The esophagus is the feeding tube that connects the pharynx and the stomach.

Lower Respiratory Tract

Lungs

The lungs are the two organs used for breathing in the body. The lungs take in oxygen from the air and release carbon dioxide. The lobes of the lungs are divided into smaller sections called segments.

Trachea

The trachea is the breathing tube that connects the larynx to the lungs. This is where a tracheostomy tube is inserted.

Bronchi and bronchioles

The trachea divides into two hollow tubes called bronchi, which supply air to each lung. The bronchi divide into smaller and smaller hollow tubes called bronchioles. These are the smallest air tubes in the lungs.

Alveoli

The alveoli are tiny sac-like structures at the tip of the bronchioles. They allow oxygen and carbon dioxide to move in and out of the lungs.

Pleura

The *pleura* are membranes that surround the lungs. The *parietal pleura* is the outside membrane. The *visceral pleura* is the inside membrane, attached to the lungs.

Capillaries

The capillaries are blood vessels in the walls of the *alveoli*. Blood flows through the capillaries, removing carbon dioxide and picking up oxygen.

Respiratory Muscles

Diaphragm

The diaphragm is a large, sheet-like muscle. The diaphragm is the main muscle involved in breathing. It is always active.

Neck muscles

If a child is having difficulty breathing, the muscles of the neck can help.

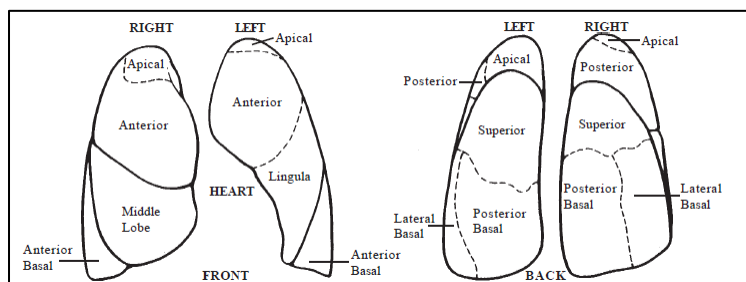
Intercostal muscles

The intercostal muscles are the muscles between the ribs.

Abdominal muscles

The abdominal muscles help move air in and out of the lungs. They also help to create a good strong cough.

Lung Segments



Cystic Fibrosis Foundation, 2012

Respiratory Distress in Children

When a child is having difficulty breathing (respiratory distress), you may see one or more of the following signs.

Early signs of respiratory distress

- Coughing
- Abnormal breathing sounds such as wheezing
- Anxiety or restlessness in your child that cannot be calmed with normal comforting
- Faster heart rate or breathing than normal
- Fever

If the child has an increased heart rate or breathing, try to calm them down and see if their heart rate and breathing rate return to normal.

Late signs of respiratory distress

- ✓ “Rattling” in the child’s chest or back
- ✓ Obvious distress or agitation
- ✓ Retractions
- ✓ Nasal flaring
- ✓ Tripod position (sitting or standing while leaning forward and supporting the upper body with hands on the knees or on another surface)
- ✓ Cyanosis
- ✓ Sleepiness or unresponsiveness

If there is a “rattling” sound when the child breathes, encourage them to try to cough up the mucus to clear their lungs. Cyanosis indicates that the child is not getting enough oxygen. Unresponsiveness indicates that the child has a high level of carbon dioxide in their lungs.

Pulmonary Clearance

A strong cough is important to remove *mucous* from the lungs.

There are two considerations for a strong cough:

- ✓ The child's ability to take a big breath in to completely fill lungs with air
- ✓ The child's ability to breathe out forcefully

In order for the child to have a strong cough, the following needs to be present:

- An inhalation (i.e. taking a big breath in)
- A forced exhalation (i.e. breathing out forcefully) with the glottis closed. The glottis is in the area where the vocal cords are located; it is the middle part of the larynx. Muscles are used to close the glottis.
- An explosive release of air when the glottis opens.

If the child's breathing muscles are weak, the cough will be weak too. There are exercises and devices that can be used to help strengthen the child's cough to help clear the mucous from their lungs.

What is Pulmonary Clearance?

Pulmonary Clearance techniques are exercises and devices that can be used to help the child cough.

If these exercises are used daily, the child will be able to move the *mucous* up from the airway into their tracheostomy, throat or mouth, where it can be suctioned out.

What are the benefits of Pulmonary Clearance Techniques?

- ✓ Allow the lungs to provide oxygen for healthy body growth, function and for active participation in daily activities
- ✓ Prevent unnecessary use of medications for infections
- ✓ Prevent lung disease from increasing in severity and to prevent permanent damage
- ✓ Prevent respiratory failure

Postural Drainage and Percussions

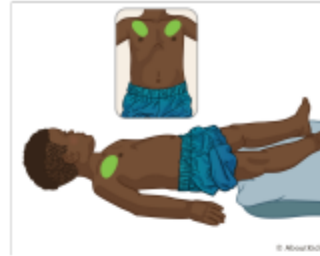
The lungs have three lobes on the right and two lobes on the left which have several segments that can be cleared using proper positioning with percussions, vibrations and coughing. Postural drainage and percussions involve these steps:

1. Positioning
2. Percussion – tapping or clapping the chest over the lung segment with a cupped hand
3. Vibration – rapidly vibrating the chest while the child breaths out
4. Huffing – forced expiration
5. Coughing

Positions of Postural Drainage and Percussions

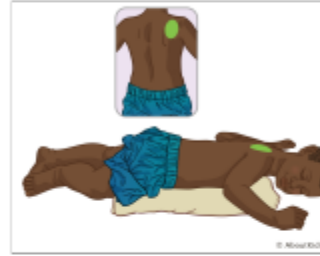
Upper lobe – anterior segments

Position your child flat on their back and treat between their collarbone and nipple. Avoid treatment over breastbone in the centre.



Upper lobe – right posterior segment

With your child positioned flat on their stomach, place a pillow or rolled blanket under the right side of their chest to elevate it slightly. Treat over their right shoulder blade. Avoid treating over the spine.



Upper lobe – left posterior segment

With your child positioned flat on their stomach place 1-2 pillows under the left side of their chest in order to elevate it 45 degrees. Treat over their left shoulder blade. Avoid treatment over the spine.



Right middle lobe

Position your child on their left side at a ¾ turn toward their back. Place a pillow or rolled blanket behind your child for them to lean back against. You can also place a blanket or pillow between their legs for added comfort. Treat close to the right armpit over nipple line.



Lingula (middle of left lung)

Position your child on their right side at a ¾ turn toward their back. Place a pillow or rolled blanket behind your child for them to lean against. You can also place a blanket or pillow between their legs to stop them from rolling completely onto their back. Treat close to the left armpit over nipple line.



Lower lobe – anterior segments

Position your child flat on their back, with a pillow under their legs. Treat over their ribs, about two fingers above the lower edge of the ribcage. Avoid treating over the stomach and very lowest ribs.



Lower lobe – lateral segments

Position your child on their right side, using a rolled blanket or pillow to support them. Treat over their left side, about two fingers above the lower edge of their ribcage. To treat the right side, position your child on their left side.



Lower lobe – posterior segments

Have your child lie flat on their stomach with a pillow under their lower legs. Treat over their ribs, about two fingers above the lower edge of their ribcage. Avoid treating over the spine.



Lower lobe – posterior segments (alternative option)

Depending on their condition, some children are not able to lie flat on their stomachs. For these children, have them lie as far over onto their stomach as possible, with a blanket rolled up under their left side and a pillow between their legs to stop them from lying completely flat.



When should you stop CPT?

If your child develops increased work of breathing, stop routine CPT and seek assistance from your health-care provider. CPT could make these symptoms worse, and an assessment from a physician, nurse practitioner or trained health-care professional is needed to determine if this treatment is indicated.

Figures taken from AboutKidsHealth. (2020). Cardiopulmonary physiotherapy for children older than 1 year old. Retrieved from <https://www.aboutkidshealth.ca/Article?contentid=3877&language=English#>

Suctioning

Suctioning helps to keep the airway clear. The following signs may indicate that suctioning is required:

- Not able to cough up mucous
- Breathing sounds harsh or the child is having difficulty breathing
- Mucous is visible in the nose, mouth or tracheostomy tube
- Difficulty maintaining oxygen saturation

Depending on the child, there are different ways to suction the airway:

- nasal suction (suctioning the nose)
- oral suction (suctioning the mouth)
- tracheostomy tube: tip, tube, deep suctioning

Nasal suctioning

With nasal suctioning, a catheter is passed through the nose to the back of the throat.

Oral suctioning

For oral suctioning, a large, plastic suction catheter called a Yankauer is used to suction secretions in the mouth.

It is useful when the child is:

- unable to remove secretions by coughing (for example, they have a weak cough)
- drooling because they cannot swallow.

Tracheostomy Tip suctioning

Tip suctioning involves using a catheter to suction mucus from just the opening of the tracheostomy tube.

Tracheostomy Tube suctioning

Tube suctioning involves removing mucus from the full length of the tracheostomy tube, including just past the far end of the tube. The depth for suctioning can be obtained by inserting the catheter into the spare tube to the distal end. One easy method is to record the correct measurement on a piece of tape and attach it to the child's bed for quick reference.

Except when necessary, tube suctioning should not be done within 1 ½ hours after meals to prevent inducing vomiting. The suction catheter should not be greater than half the diameter of the tracheostomy tube.

Tracheostomy Deep suctioning

Deep suctioning removes mucus from the child's airway between the end of the tube and the carina (the part where the trachea splits into the bronchi, the tubes that go into the lungs). Deep suctioning has a greater tendency to cause tissue damage in the bronchi, therefore, should only be performed when prescribed by an MD/NP.

Suction machines

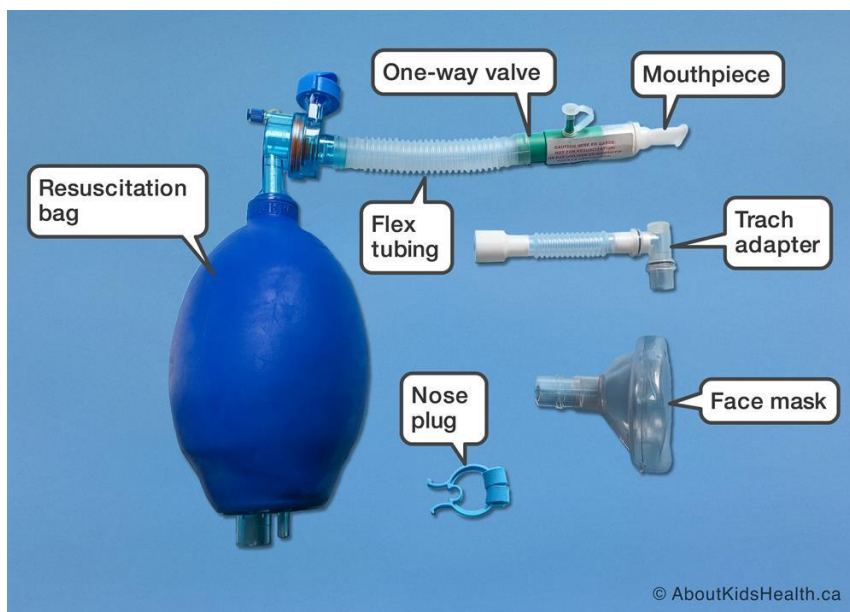
No matter what type of suctioning is performed, a suction machine will be required.

There are portable suction machines and stationary suction machines. At least two suction machines should be available in the home, in case one machine breaks down. At least one of these suction machines should be portable.

Lung Volume Recruitment (LVR)

LVR uses a special bag to help increase the amount of air that the child can breathe into their lungs with a voluntary breath. The LVR bag is squeezed during inhalation (breathing in) for a series of a few breaths to increase the total amount of air in the lungs. After the lungs are filled with air, the child breathes out. Filling the lungs with more air allows the child to clear secretions more effectively. After several cycles of LVR, the child will find that breathing becomes easier and their voice becomes stronger.

For some children, it is recommended to do LVR twice a day and do any further sessions as needed. Frequency may need to be increased when the child is unwell.



Precautions:

- The LVR bag cannot be used for resuscitation
- Although an LVR bag looks similar to a manual resuscitation bag, there are important differences. The LVR bag has a one-way valve
- Clearly label both your LVR bag and your manual resuscitation bag to make sure you do not use the wrong one
- If the child experiences dizziness, chest discomfort or pain, stop and have them rest

Introduction to Mechanical In-Exsufflation

Mechanical in-exsufflation (e.g. Cough Assist) helps children have a stronger cough to assist with clearing secretions from the lungs. This machine delivers pressurized air when the child breathes in. It is then followed by a rapid switch to a negative pressure to suck the air out of the lungs which causes the child to cough.

Indications for this type of therapy include:

- ✓ Children with a weak cough who are unable to perform lung volume recruitment
- ✓ Children who have difficulty with secretion clearance
- ✓ Children who have lung collapse caused by mucous plugging

Contraindications for this type of therapy include:

- ✓ A history of bullous emphysema
- ✓ Susceptibility to pneumothorax or pneumo-mediastinum
- ✓ Any recent barotrauma
- ✓ Untreated tension pneumothorax
- ✓ Active bleeding in the lungs
- ✓ Suspected or confirmed head and/or c-spine injury
- ✓ Unrepaired tracheoesophageal fistula
- ✓ Certain heart conditions (e.g. Fontan)
- ✓ Burns, open wound, infection or skin grafts on the thorax
- ✓ Recently placed transvenous pacemaker or subcutaneous pacemaker
- ✓ Suspected pulmonary tuberculosis
- ✓ Select airway anomalies such as tracheobronchomalacia
- ✓ Recent lobectomy/pneumonectomy
- ✓ Severe obstructive lung disease (e.g. severe asthma)

References

- AboutKidsHealth. (2020). Cardiopulmonary physiotherapy for children older than 1 year old. Retrieved from <https://www.aboutkidshealth.ca/Article?contentid=3877&language=English#>
- AboutKidsHealth. (n.d). *Tracheostomy and ventilation manual for family caregivers*. Retrieved from <https://www.aboutkidshealth.ca/trachvent>
- ALS Society of Canada. (2012). *A Manual for People Living with ALS. 7th ed.* Retrieved from <https://www.als.ca/about-als/resources/living-with-als/>
- Cystic Fibrosis Foundation. (2012). *Introduction to Postural Drainage and Percussion*. Retrieved from <https://www.cff.org/PDF-Archive/Introduction-to-Postural-Drainage-and-Pecussion/>
- Hornick, D. (2007). Mechanical Insufflation-Exsufflation for Airway Mucus Clearance. *Respiratory Care*, 52 (10), 1296-1307
- Muscular Dystrophy Canada. (2013). *Guide to Respiratory Care for Neuromuscular Disorders*. Retrieved from <http://muscle.ca/wp-content/uploads/2012/11/RC13guide-E.pdf>
- Ramsey, A., Tsai, W., Nelson, V. (Eds). (2006). *Growing and Thriving with Respiratory Support: A Family Education Manual*. University of Michigan Hospitals.