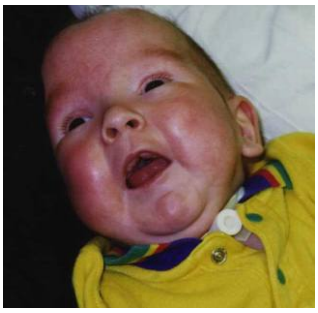
"The How and Why of Tracheostomies"

Rebecca Tribby et al. modified for CE by C. Mattera



INTRODUCTION

Children may need a tracheostomy due to host of conditions/disorders.

The reason for a tracheostomy can affect the care that is needed by the child and will determine how long the tracheostomy is required. Children who are very dependent on a tracheostomy due to an inadequate airway or ventilator dependence are at much higher risk for life threatening events.

All tracheostomy tubes have similar parts, but there are a variety of brands that may be used for children. The tube must fit in the growing, changing airway of the child and meet the child's functional needs. Some of the more common brands, sizes and types of tubes will be presented.

Children may receive or have a tracheostomy at any age from infancy to adolescence. There are unique issues at every age and developmental stage. Therefore, a brief review of the different developmental stages is presented.

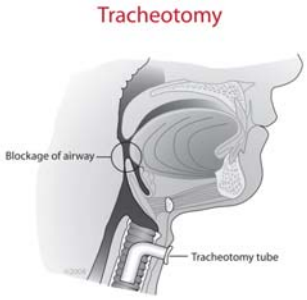
Objectives

Upon completion of the class, independent study materials and post-test question bank, each participant will independently do the following with a degree of accuracy that meets or exceeds the standards established for their scope of practice:

- Discuss causes of airway obstruction that necessitate a tracheostomy.
- Describe the variety of tracheostomy tubes that may be used by children
- Consider how the child's age and developmental status will affect the care that is needed.
- Predict the types of unexpected emergencies that can occur with a child with a tracheostomy or who is ventilator dependent.
- Prepare for unexpected emergencies when caring for a child with a tracheostomy.
- Describe how EMS should respond in the event of an unexpected emergency such as tracheostomy tube obstruction, accidental decannulation, or inability to replace a tracheostomy tube, including CPR technique.

Tracheostomy

Definition: A tracheostomy is a vertical or horizontal surgical opening into the trachea that is usually done in the OR under general anesthesia. It forms a temporary or permanent opening that bypasses the nose and mouth for ventilation. The terms tracheotomy and tracheostomy are interchangeable.



Stoma is the opening of the tracheostomy. The tract is usually established and healed in about 5 days. The stoma is kept open with a tracheostomy tube.

A tracheostomy is performed in children for several reasons:

- To bypass an upper airway obstruction
- Manage chronic aspiration
- Allow for long term ventilation

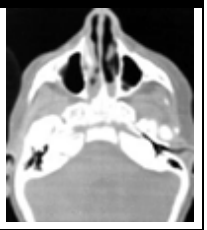
An anatomical or functional blockage of the airway can lead to significant respiratory distress requiring a tracheostomy. This obstruction may be isolated or part of a syndrome or multi-system disorder; it may be congenital or acquired.

Indications for a Tracheostomy -

Abnormalities of midface area

- Abnormalities in the growth of the skull and facial bones
- Choanal (nasal) atresia or stenosis; infants are obligate nose breathers
- Narrow nasopharyngeal channels
- Relative small mandible (lower jaw)
- Relatively large tongue

Retrieved from http://www.uhrad.com



Congenital Craniofacial Syndromes

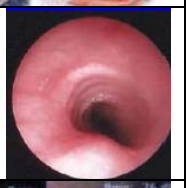
- Pierre Robin sequence
- Treacher Collins; Goldenhar; Nage
- Down Syndrome – upper airway obstruction
- CHARGE syndrome - choanal stenosis

Blockage from polyps, tumors, hemangiomas(benign vascular tumor), cystic hygromas (benign lymphatic lesions)
Localized lymphangioma is typically multicystic and/or multinodular
Retrieved from/http://www.tcconnection.org/

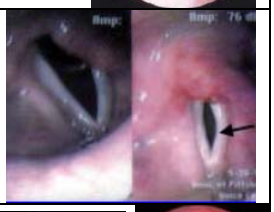
Congenital malacia

- Malacia of larynx, trachea, or bronchi
- Softening of the cartilage resulting in collapse of the airway

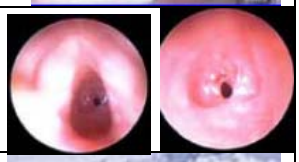
Retrieved from http://www.emedicine.com/med/topic2976.htm



Upper Airway Obstruction
Acquired causes - Vocal cord paralysis
Unilateral vocal cord paralysis.
(On left: Larynx in abduction - normal)
(On right: Larynx in adduction, showing paralyzed vocal cord - arrow)
Retrieved from http://www.aafp.org/afp/980600ap/rosen.html



Subglottic stenosis from intubation



Injuries head/neck that cause airway swelling

- Thermal – burns
- Chemical – caustic ingestion
- Blunt trauma: MVC; snowmobile/ ATV; direct blow to neck

Tend to be school aged boys

Chronic aspiration due to muscle or sensory problems in throat

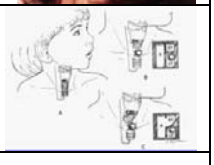
- Recurrent pneumonia
- Inadequate ability to swallow oral secretions
- Impaired nasopharyngeal control
- Associated with developmental delay, CP, and seizure disorder

Retrieved from http://www.tracheostomy.com/trachkids/kids20/zachery_wayne.htm

Laryngotracheal separation

- Surgical separation between the larynx and trachea
- Tracheostomy stoma is the only airway

Retrieved from http://www.tracheostomy.com/surgery/diversion.htm



Narrow or obstructed airways, bronchopulmonary dysplasia (chronic lung disease seen in premature babies)

Neuromuscular diseases, paralysis or weakening chest muscles and diaphragm as in brain damage or muscular dystrophy
Congenital central hypoventilation or central apnea

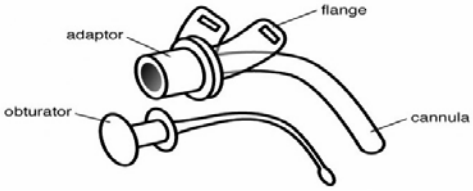
Obstructive abnormalities may be at a specific site of the upper airway
Nose/nasopharynx - Choanal stenosis or atresia; injury to the nasopharyngeal area; or poor muscle control of the nasopharyngeal area **Oral/oropharynx:** Blockage by the tongue and small jaw as in Pierre Robin syndrome, Down syndrome, or cranial facial syndromes; or collapse of pharyngeal muscles: laryngomalacia or hypotonia from brain injury **Glottis:** Bilateral vocal cord paralysis usually involves the laryngeal abductors. May be caused by CNS abnormality, neuromuscular disorder, injury/trauma, or idiopathic changes **Subglottis:** Stenosis or narrowing of the smallest part of the airway usually due to long term intubation **Trachea** • Tracheomalacia or softening of the tissue causing collapse of the trachea • Stenosis or narrowing of the trachea

The type and site of the obstruction can affect the care the child needs

Children who are very dependent on a tracheostomy due to an inadequate airway are at much higher risk for life threatening events. Some children may be able to have the trach site sealed as they get older and others will continue to need the tracheostomy for life

Tracheostomy tubes

Definition*:* A tracheostomy (trach) tube is a curved tube that is inserted into a tracheostomy stoma. All tracheostomy tubes have similar parts:



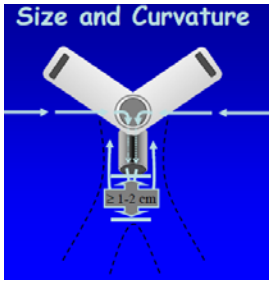
Adaptor: Portion of the trach tube seen on the outside of the patient's neck between the flanges; universal size to allow connection of respiratory equipment

Flange: Place to connect the ties

Tube or cannula: part that goes in the stoma

Obturator: Guide used during trach tube change

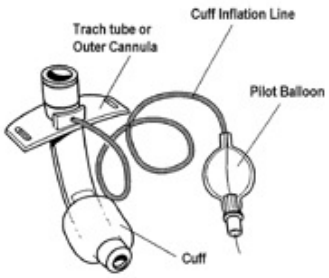
Trach tubes come in different sizes and types:



- Internal diameter ranges from 3.0 to 6.5 mm for pediatric single cannula tubes
- May be a single tube or have an inner cannula that can be removed and cleaned. External diameter is larger with a double cannula tube.
- Length increases with size: neonatal, pediatric, adult
- Curvature of the tube varies by brand and size. Goal: Avoid touching the posterior tracheal wall
- Trach tubes may or may be have a cuff: Infants and young children generally have uncuffed tubes. Children > 8 years generally have cuffed tubes.
- Fenestrated tubes have a hole in the stem that allows breathing through the vocal colds to permit talking or weaning off of the trach
- Tube selection is dependent on the size of the airway and the child's needs

Cuffed Tracheostomy Tube

Definition: A cuffed tracheostomy tube has a balloon around the distal end of the cannula that forms a seal between the tracheostomy tube and the trachea when the cuff is inflated.

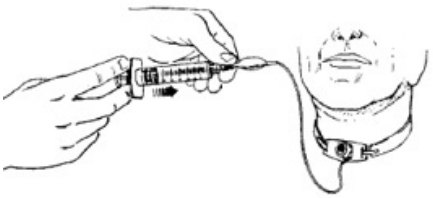


Used to:

- Prevent an air leak around the trach tube when the child is connected to high positive pressure ventilation (at night)
- Reduce aspiration of secretions

All cuffed tracheostomy tubes have similar parts:

- Cuffed-soft **balloon** around the outside of the lower end of the cannula
- **Cuff inflation line -** Tubing that connects the cuff internally and pilot balloon externally to provide a way to inflate/deflate the tube cuff
- **Pilot balloon** –External balloon that shows if cuff is inflated or deflated
  - Does not show how much air is in the cuff
  - Do not squeeze balloon as that will increase pressure on the airway
- **Valve** – Spring loaded one way valve used to put air into or pull air out of the cuff using a syringe
  - Push the syringe straight in and out
  - Twisting the syringe into the valve will break it



Air cuffed tube - high volume, low pressure

Cylinder shaped plastic softens at body temperature

- Inflates with air
- Molds to walls of the trachea
- Distributes the pressure on the trachea more evenly
- Volume of air expands the trach cuff which exerts a lower pressure on the airway

Cuff increases the diameter of the tracheostomy tube

- Can seal airway with minimal inflation. DO NOT use minimal leak techniques; maintain cuff pressure < 20 cm H_2O
- Extra bulk can cause irritation to the stoma when changing the tube and can make it more difficult to change the trach tube, as the tube may fit more tightly in the airway
- May interfere with the ability of the child to speak even when the trach cuff is deflated

Tight-to shaft tube - high pressure, low volume

Air permeable plastic

- Inflates with sterile water
- Small increase in volume puts higher pressure on trachea; do not inflate to occlusion; optimal inflation is less than minimal diameter of the trachea
- Unable to determine transtracheal pressure
- Increased pressure may cause stenosis
- Usually used for children requiring ventilation during sleep only, to limit the high pressure contact between the trach cuff and the airway

Retracts very close to the tube when deflated

- No increase in tube diameter when deflated; usually easier to change than a standard cuffed trach tube
- Facilitates better phonation

Foam cuffed tube - high volume, low pressure

Cuff filled with sponge-like foam

- Fome-Cuf® tubes are a unique problem-solver used to address extremely difficult airway management problems; ideal when long-term ventilator support is indicated
- Remove air before insertion; pilot balloon kept open to manage
- Self inflates - equalizes cuff pressure with atmospheric pressure
- Conforms to the contour of the trachea - helpful for tracheal malacia

Cuff remains inflated at all times, but exerts less pressure on the trachea

- May be more difficult to deflate the cuff
- May be more difficult to change the trach tube

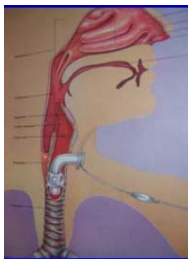
S&S of cuff leak

- Frothy and thinner secretions or signs of recently eaten food
- Increased vocalization
- Low pressure alarm or airway pressure readings decreased on vent
- Pilot balloon is flat or air can't be withdrawn from cuff

Intervention

- Withdraw any air or fluid from the cuff; then instill the prescribed volume.
- Change trach if any of the above signs reoccur

Complications resulting from excessive cuff pressure on the tracheal wall:



- Tracheal perfusion compromise leading to ischemic necrosis and tracheal stenosis
- Ulceration and softening of the cartilage leading to tracheomalacia and dilation
- Tracheal rupture, perforation, scarring or fistula
- With the cuff inflated, the only route of effective air exchange is through the tracheostomy tube because air will not be able to flow freely past the exterior wall of the trach tube

Note: A speaking valve cannot be used with an inflated cuffed tracheostomy tube

Brands of Tracheostomy Tubes

Three common brands vary by rigidity

Jackson Tracheostomy Tubes

- Least commonly used
- Made of metal: very durable; most rigid; may cause trauma to airway due to stiffness of the trach tube
- Has inner cannula that can be removed and cleaned
- Needs special adaptor to connect to a ventilator or BVM
- Can be sterilized & reused by several patients

Shiley® Tracheostomy Tubes

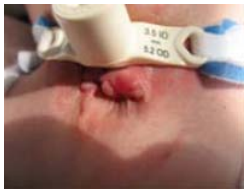
- Most common
- Made of polyvinyl chloride (PVC) plastic; more flexible than metal tube
- Single cannula for neonatal and pediatric sizes
- Inner cannula available for larger "adult" sizes
- Universal adapter for attachment of BVM
- Single patient use; can be recleaned
- Secretions more likely to stick along the inside

Portex™ Bivona® Tracheostomy tubes

- Made of silicone plastic with an internal wire coil
- Softer and most flexible
- Shape adapts to the angle of the airway
- Swivel connector
- Need to be replaced prior to an MRI test due to the internal wire coil

Tracheostomy Care

Objectives



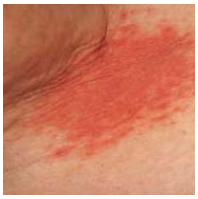
Upon completion of the class, independent study materials and post-test question bank, each participant will independently do the following with a degree of accuracy that meets or exceeds the standards established for their scope of practice:

- Asses the stoma of a child with a tracheostomy.
- Describe and recognize common stoma skin conditions and their treatments.

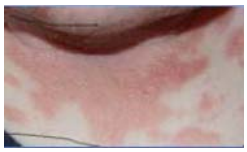
Stoma assessment

Assess the stoma and skin for the presence of *granulation tissues*, drainage, swelling, or color change. Granulation tissue occurs as result of surgery, infection, or irritation. It is red in color and bleeds easily. It does not contain nerves, so is not painful. It can grow in size and occlude the stoma.

It is important to check under the tracheostomy ties, near the flanges of the trach tube, for skin breakdown or rashes. Document observations, notify OLMC of any problems.



- **Yeast infections** can grow in warm, moist areas like under the flange. Personal physician often orders Nystatin® cream to area; if on neck will order Nystatin® powder.
- **Contact dermatitis:** Inflammation resulting from secretions or moisture around the stoma such as caused by trach collars with humidity



  Treatment: Keep the area dry; avoid gauze dressings that hold moisture
  – Lyofoam® or Mepilex® dressings keep the area dry
  – Caregivers may use steroid cream to reduce inflammation
  – If infected; they will apply antibiotic cream

Supplemental O_2 may be required to treat low oxygen levels in children who have tracheostomies. There are various delivery systems for home oxygen such as heated humidity systems, ventilator systems, nebulizer treatments, or a sleeve for an artificial nose. The type of oxygen system used is based on the child's needs including: liter flow, portability and hours per day of use.

Types of oxygen systems available for home care use

- Oxygen concentrator –an electric device that filters oxygen from room air.
- Liquid oxygen – gaseous oxygen cooled until it becomes liquid oxygen.
- Oxygen cylinders – gaseous oxygen forced by pressure into metal containers.

Each system functions similarly, and delivers a set amount of oxygen. Each system has its own distinct advantages and disadvantages and its own storage, transport and safety issues.

Emergency care of a child with a tracheostomy and/or ventilator

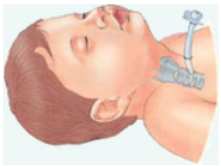
Anyone caring for a child with a tracheostomy must be prepared to recognize and respond to a life threatening tracheostomy emergency. Prevention and preparation for emergencies will help to eliminate them or result in positive outcomes.

Listen to caregivers – they know the child best

Critical HISTORY: History of present illness – *what is different today*?; interventions taken prior to EMS arrival; child's baseline abilities; why the child has a trach (syndromes/diseases), status of the upper airway; reason for a ventilator; if the child can breathe on their own; baseline vital signs; amount and route for home oxygen; suctioning frequency and what their normal secretions are like; devices and medications; medical information forms.

Look for MedicAlert® jewelry or health forms is usual caregiver is not available.

Assess for DOPE and infection (tracheal or pulmonary); reassess pulse, RR frequently



Displaced- total or partial removal of tube
Obstructed – mucus plug, blood, foreign body, or moved against soft tissues
Pulmonary problems – pneumothorax, pneumonia, reactive airway, aspiration
Equipment – ventilator malfunction, oxygen depletion, tubing kinked

Check breath sounds while ventilating. If not clear or if gurgling – suction (see below)
If breathing is adequate but low pulse ox: apply infant mask directly over stoma – or as tolerated by child.

Assess circulation/perfusion.
ECG monitor: Consider bradycardia as secondary to ventilatory/oxygen problem until proven otherwise.

Accidental Decannulation

Cause	Prevention
Child moving during trach tie changes	Use two people during trach tie changes Swaddle child during trach tie changes
Loose trach ties	Check ties to ensure you can get only one finger between the ties and the child's neck
Short length of trach tube (usually neonatal tubes)	Caregiver should consult with physician to determine if a longer trach tube can be used
Respiratory equipment pulling on trach tube	Secure respiratory equipment to child with a chest strap or secure to child's clothing before moving child
Child removes tracheostomy tube	Monitor child closely

Signs & Symptoms: The trach tube may be partially or completely out of the stoma

- Increased work of breathing- retractions or nasal flaring
- Increased heart rate; change in skin color – pale or cyanotic; decreased SpO_2
- Level of consciousness – restlessness to unconscious
- Alarms of cardio respiratory monitor – high heart rate, low heart rate, apnea
- Low pressure alarm if volume ventilated
- Trach tube partially or totally out of the stoma

Interventions for accidental decannulation

- Assess child's status and hyperextend the child's neck to gain access to the trach site
- Establish a patent airway – always first priority
- If partially out, immediately put tube back in stoma and tighten ties even if conditions not ideal
- If completely out, insert the spare trach tube. There should always be 2 spare trach tubes with the child at all times – the child's size and one size smaller. If the regular size doesn't fit, use the smaller one to keep the airway patent. If no spare trach tube is available, replace one that came out. It can be replaced with a clean one later.
- If you cannot reinsert the tube, observe child to see if they can breathe through the stoma alone. This may be possible if the stoma is well healed and fairly large. Child may be able to breathe through nose and mouth if there is no severe obstruction above the trach site. If distress persists – see change out cannula (below). Provide manual ventilation as necessary

Tracheostomy Tube Obstruction

Normal airway clearance: The upper airways warm, filter and humidify inhaled air. The body keeps the airways free of obstruction with the mucociliary system and coughing. Mucus is secreted in the respiratory system to protect the lungs from foreign particles. Cilia move the mucus up to the central airways. An effective cough clears the mucus from the body. Adequate airway clearance helps to avoid airway obstruction, increased work of breathing, respiratory inflammation, infection and irreversible lung damage. The trach tube bypasses these mechanisms, so the air inhaled via the tube is cooler, dryer, and not as clean.

Ineffective or impaired airway clearance: In response, the body makes more mucus that can accumulate due to the tracheostomy or a weak or ineffective cough. .A child with a tracheostomy is at higher risk to have ineffective clearance of the airways. Children may wear a Heat Moisture Exchange (HME) or artificial nose 3-4 hours a day at least twice a day to help keep secretions moist.

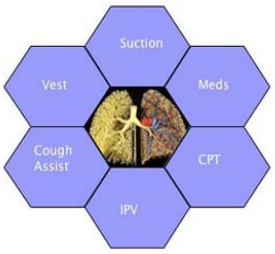
Objectives

Upon completion of the class, independent study materials and post-test question bank, each participant will independently do the following with a degree of accuracy that meets or exceeds the standards established for their scope of practice:

- Describe the different methods of airway clearance and when they are needed.
- Recognize importance of correct technique when clearing airway to prevent complications.

- Determine when a child needs to be suctioned.
- Use recommended suctioning technique including use of normal saline and manual ventilation.
- Assess tracheal secretions for characteristics such as color, consistency, odor, and amount.
- Explain how medications can assist with facilitation of airway clearance.

Tube obstruction definition: A trach that is partially or totally occluded and compromises the integrity of the child's airway. Mucus plugs are the most common cause for respiratory distress in children with tracheostomies.



AIRWAY CLEARANCE

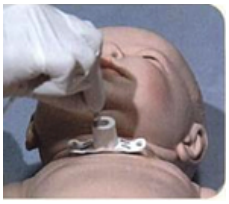
There are several ways to facilitate airway clearance in the child with a tracheostomy including suctioning, airway clearance medications and bronchial hygiene modalities such as chest physiotherapy, Intrapulmonary Percussive Ventilation (IPV), Cough Assist device (Mechanical Insufflator-Exsufflator), and High-Frequency Chest Wall Oscillation (HFCWO) Vest – but these are not done by EMS.

Assess secretions	
Color • Normal color clear or white • Yellow tinged in the morning (normal) • Yellow or green or brown may indicate viral or bacterial infection • Blood tinged may be from suctioning too deep, a granuloma, pneumonia or trach tube change	**Consistency** • Ranges from thin to thick • Thicker secretions may be due to inadequate humidification, infection or dehydration.
Amount • Ranges from scant to copious • Amount will increase with an infection	**Odor** • Pseudomonas bacteria smells like dirty socks • Odor around trach tube can be caused by colonized bacteria

Suctioning is the most common procedure done for a child with a trach. Suctioning maintains a patent airway by removing secretions that the child is unable to cough out of the trach tube. Proper suctioning technique reduces potential complications resulting from improper technique. Assessing secretions enables EMS to recognize signs of concern, such as infection, dehydration, or potential complications.

Questions to ask

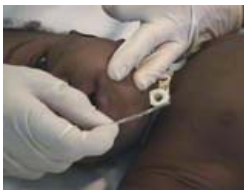
- Reason for the tracheotomy
- What signs indicate a need for suctioning?
- What is the child's oxygen requirement?
- What size is the tracheostomy tube? What size suction catheter is generally used?
- What is the usual frequency of suctioning? What depth to suction?
- What is pressure setting on the suction machine?
- Does the child need manual resuscitation?



Signs & Symptoms of Tube Obstruction/need to Suction
• Visible secretions (bubbles of mucus in trach opening); rattling mucus sounds, dry raspy breathing or a whistling noise from the trach • Respiratory distress, cough, increased RR/work of breathing, increased use of accessory muscles; retractions, flared nostrils; increased inhalation or exhalation time (capnography) • Reduced airflow through the tube; decreased/absent air entry/chest rise; decreased/absent or coarse breath sounds • Vital sign changes: Tachycardia, change in respiratory rate • Restlessness; child asks to be suctioned; child-specific signs that suctioning is needed • Change in color/cyanosis; diaphoresis, decreased oxygen saturation; hypercarbia • Inability and /or difficulty in passing suction catheter; resistance when trying to suction or ventilate • Difficulty or refusing to eat • Alarms: High pressure alarm on ventilator; cardio-respiratory monitor alarms

Equipment needed for suctioning

- Suction machine with collection bottle, pressure gauge and connecting tubing
- **Appropriate size suction catheter** – depends on size of the trach tube: Use largest catheter that fits the trach tube size. **To estimate the size** of the suction catheter, double the internal diameter of the trach tube size. Ex: ID 3.5 trach tube X 2 = 7. Would lake a size 6 suction catheter. Sizes 8 and 10 Fr are most commonly used for children.



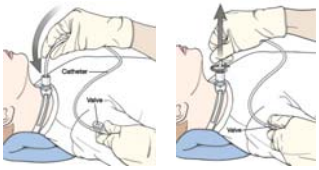
- **Appropriate catheter length: Pre-measure** so that distal side holes are just past tip of the trach tube; suction only to end of trach tube. The obturator can be used as a measuring guide.
- Sterile suctioning: single catheter use, sterile gloves
- Clean suctioning: reuse catheter, clean gloves
- Clean container to hold sterile water or saline
- Sterile water or saline to rinse suction catheter
- Manual resuscitation device (BVM) and mask

Suction technique

- Deliver O_2 (15 L/min) by placing oxygen mask directly over trach opening or via BVM. If unable to ventilate, change trach tube (see below)
- **Ensure that suction unit is set at the correct recommended pressure in mmHg**

Infants	60 - 80
Children	80 -100
Teen/Adults	80 -120

  If portable suction unit: set to 100 mmHg or less.
- Shallow suctioning: Remove secretions at opening of trach tube that child has coughed up.
- Insert catheter no more than 2 to 3 inches into the trach tube (based on premeasured length). **DO NOT use force.** Apply suction on insertion and withdrawal; twirl the catheter when inserting and withdrawing to effectively suction the tube wall. Apply suction for less than 5 seconds (some old sources say 10 sec – but that has been reduced to 5 sec); allow child to rest for 10 seconds after each suctioning pass.



- Use BVM to give breaths after the first suctioning pass for children on ventilators or on oxygen
- The routine instillation of normal saline is not recommended. If secretions are very thick, insert no more than 2-3 mL of sterile saline, then suction.
- If the child has a double cannula trach tube; remove and suction or clean the inner cannula. If removal of the inner cannula fails to clear the airway, change the trach tube (ALS).

Remember 6 words: *WHEN IN DOUBT, CHANGE IT OUT*

If manual ventilation continues to be difficult: remove the old tube and insert a new trach tube or ET tube of the same approximate size. This procedure requires 2 people. Get help of a knowledgeable caregiver when available.

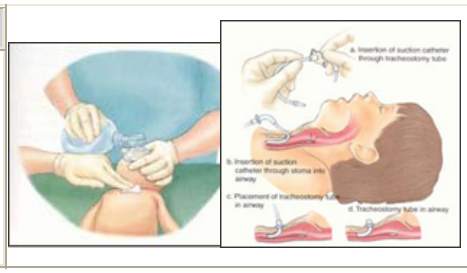
- Ask for a replacement trach tube.
- If child has a cuffed trach tube: deflate the balloon by connecting a syringe to the valve on the pilot balloon. Aspirate air until the pilot balloon collapses. DO NOT cut the pilot balloon or the attached tubing – as this will NOT deflate the cuff.
- Cut the cloth or Velcro ties that hold the trach tube in place.
- Remove the trach tube using a slow, outward and downward movement.
- Gently insert a new same size trach tube with the obturator in place, in a smooth, curving motion directing the tip of the tube towards the back of the neck in a downward arc. **DO NOT force the tube.** May lubricate tube with NS.
- If successfully inserted, confirm proper placement via capnography/breath sounds and secure tube with trach ties. If an ETT was placed and correct position is confirmed, secure tube with a commercial tube immobilizer or with tape if tube is too small for commercial immobilizer. **DO NOT CUT THE ETT TO MAKE IT SHORTER!**

Difficult Tracheostomy Tube Insertion

Cause	Prevention
Granulation tissue	Avoid trauma to stoma; physician will need to remove granulation tissue
Poor positioning	Position child in prone position Use roll under shoulders to hyperextend neck Swaddle child or have second person help restrain child
Tube dry and not sliding in	Lubricate tube w/ NS
Partially closed stoma	Pull down on stoma, calm child, wait for child to inhale

Signs & Symptoms

- Unable to find opening
- Trach tube does not go into stoma
- Increased heart rate
- Change in skin color – pale or cyanotic
- Increased work of breathing- retractions or nasal flaring
- Level of consciousness – altered



Intervention

- If the trach tube cannot be inserted easily, withdraw and attempt to pass a next smaller size trach tube.
- If unable to insert this trach tube, thread a suction catheter through the smaller sized trach tube. Use the catheter tip to probe the opening; slide the tube over the catheter into the opening and then remove the catheter. Attempt to ventilate and check breath sounds.
- Option: Select an ETT with an ID equal to or smaller than the ID of the last trach tube attempted. Aim the tip of the ETT downward to prevent tissue damage after passing it through the stoma. If he ETT has a cuff, inflate the cuff after checking proper placement (capnography, 5 pt auscultation). Make sure the outer diameter of the ETT is smaller than the outer diameter of the trach tube most recently attempted.
- If unable to place any tube, and child is in respiratory distress and needs ventilation, cover stoma and place mask over nose and mouth, ventilate with BVM as long as there is no obstruction of the upper airway.
- If ventilations fail through the mouth and nose or stoma, insert a suction catheter approximately 2 inches into the stoma. Connect oxygen and transport immediately.

Suction complications (can be significant)

- **Microatelectasis** (collapse of the small alveoli) – Prevent by limiting suction application time and ventilating/giving oxygen during and at end of suctioning
- **Hypoxia** – Prevent by limiting suction application time to 5 seconds or less; allow time for recovery; oxygenate between suction passes and at the end of suctioning
- **Granuloma** (mass or nodule of chronically inflamed tissue) - prevent by pre-measuring the suction catheter
- **Bleeding from the trachea -** Prevent by pre-measuring the suction catheter and avoid suctioning the mucosa

Airway clearance medications: Children with tracheostomies may be on one or all of these medications, especially with a respiratory infection or reactive airway disease

Bronchodilators: Relax the smooth muscle of the airways and help the cilia move the secretions by increasing the beat frequency. Ex: Albuterol and Atrovent (ipratropium)

Inhaled steroids (not given by EMS): Reduce the inflammation in the airways to improve the ability of secretions to move up the airway. Ex: Pulmicort and Flovent

Mucolytics (not given by EMS): Improve airflow and airway clearance by thinning thick secretions. Ex: Pulmozyme and Mucomyst

CPR for child with a trach

If child is unresponsive and is not breathing or is gasping: Suction to attempt to clear the airway
If no response, attempt to ventilate with peds BVM to trach
Quickly assess pulse; begin chest compressions if no pulse
Prepare to change tube if not done already

Safe Transport

Ask caregiver for the best way to move the child, particularly if the child is very prone to fractures, such as in *osteogenesis imperfecta* (brittle bone disease). Leave braces or splints on and immobilize around it.

Patients with Down Syndrome may have upper c-spine instability and may be more prone to spine injury. Spine motion restriction is important in any mechanism of injury in which there has been movement of the neck.

Patients with cardiac conditions may have absent pulses in the extremities, may be chronically hypoxic (clubbing of the fingernails), or have hypoxic episodes. Confirm baseline with caregivers.

Contact OLMC; initiate transport to the nearest *appropriate* facility (EDAP).

Transport considerations
Gather all equipment and supplies needed to keep child safe and to be ready for an emergency. ▪ The "Go Bag" – fully stocked plus suction ▪ Electrical equipment with portable battery power ▪ Bring necessary specialized equipment (ventilator, apnea monitor, G-tube) or medications to hospital whenever possible (do not delay treatment or transport) ▪ Try to use gel-cel or dry-cell batteries for ventilator
Plan for humidification for the duration of transport ▪ Battery powered nebulizer can give nebulized normal saline ▪ Supply of HME or artificial noses; Normal saline
Secure all equipment and supplies ▪ Avoid having equipment becoming a projectile if there is a sudden stop ▪ Secure O2 appropriately (Upright for liquid oxygen)
Restrain child with a properly installed child restraint system ▪ Do not modify the child restraint system ▪ Do not use a child restraint system with a harness-tray/shield combination or an armrest - Child can fall forward with a sudden impact causing the tracheostomy to contact the shield or arm rest, possibly resulting in injury or a blocked airway. ▪ Use a three-point harness with a rear facing car safety seat or a five-point harness ▪ If transporting in a wheelchair, secure with four-point tie down device and remove lapboards or trays
Reassess child at least every 3-5 minutes; more frequently as necessary and possible

Tracheostomy "Go Bag": A "Go Bag" is any container that has the equipment and supplies needed to care for the tracheostomy including suctioning and emergency trach tube change.

Things that should be in the "Go Bag"

- BVM with an appropriate sized mask
- Same size and size smaller trach tubes; trach ties
- Suction machine, suction catheters; DeLee suction catheters
- Normal saline; water soluble lubricant; scissors; tape
- Medical information

The Go Bag should be checked by caregiver on a routine basis; this equipment should not be used except for an emergency.

VENTILATOR CARE

Caring for a child with a ventilator can be very challenging. The terms and acronyms used with mechanical ventilation can be very confusing. There are many alterations of the pulmonary system that can lead to chronic respiratory failure requiring long term ventilation. Knowing the pathophysiology of respiratory failure helps one understand the various conditions that require long term ventilation and helps you to anticipate the child's care needs.

Some children are totally vent dependent and can't breathe without support. They don't do well "off the vent". They would need immediate action if something happened to the ventilator. Some children are able to breathe on their own and use the ventilator for supplemental support. They can be "off the vent' for short periods of time – giving EMS more time to figure out what's wrong and to try to fix it.

A child with chronic lung disease may require frequent hospitalizations when young, but gradually improve and wean from the ventilator. In contrast, a child with neuro-muscular disease will have a life long need for ventilatory support.

There are a variety of mechanical ventilators used in the home or extended care settings. While this presentation cannot provide detailed information about each type, there are basic principles related to mechanical ventilation, such as volume control ventilation or pressure control ventilation that apply to all ventilators.. The various modes will be discussed briefly.

There are a multitude of things that can lead to potentially life threatening problems for a child on a ventilator. All ventilators have alarm systems to alert you to the possible problems. Causes and responses to these alarms will be discussed.

Objectives

Upon completion of the class, independent study materials and post-test question bank, each participant will independently do the following with a degree of accuracy that meets or exceeds the standards established for their scope of practice:

- Describe causes of chronic ventilatory failure
- Discuss the conditions that require long term mechanical ventilation
- Identify the different modes of ventilation
- Know how to safely troubleshoot a home ventilator to respond to alarms

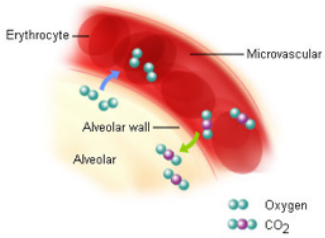
There are a variety of types of ventilators. They are classified in a number of ways:

How a breath is delivered	
Positive pressure: Positive pressure ventilators consist of a compressible air reservoir that pushes air through a set of tubes and valves (patient circuit) to the patient at higher than atmospheric pressure	
Negative pressure: The iron lung was a negative pressure ventilator. It applied pressure around the chest that is lower than atmospheric pressure and helped to pull air into the lungs.	

Setting of ventilator use

- **Hospital or critical care**: Sophisticated computerized devices able to provide multiple modes of ventilation, patient monitoring and central alarms
- **Transport devices** : Designed to be portable and withstand excessive shock or vibration that can occur in ambulances
- **Home or portable ventilator**: Do not have all of the specialized features of the hospital ventilators. They are smaller and lighter to allow for portability.

Chronic Respiratory Failure



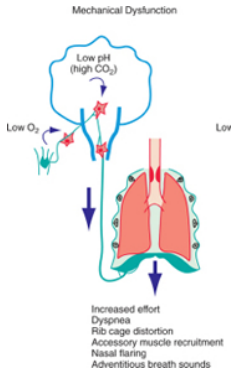
Definition - Respiratory failure caused by:

- An increase in CO_2 levels (pCO_2 greater than 50 mm Hg)
- A decrease in O_2 levels (pO_2 less than 60 mm Hg)
- Both

Lack of recovery from acute respiratory failure or an insidious onset of respiratory distress leading to failure can occur over weeks, months or years.

There are three pathophysiologic categories of respiratory failure:

Increased respiratory load from chronic cardiopulmonary disease



Physiology: Normal matching of ventilation and perfusion is disrupted causing hypoxia and eventual muscle fatigue due to increased work of breathing

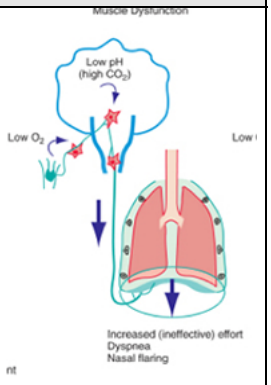
Clinical conditions

- Chronic lung disease: bronchopulmonary dysplasia (BPD), lung hypoplasia
- Congenital heart disease
- Skeletal deformities: kyphoscoliosis or thoracic wall deformities

Clinical signs

- Decreased inspiratory breath sounds
- Increased retractions and use of accessory muscles
- Cyanosis when breathing room air
- Decreased level of function/activity; poor weight gain

Ventilatory muscle weakness



Physiology: Inability to inhale an adequate volume of air & exhale CO_2

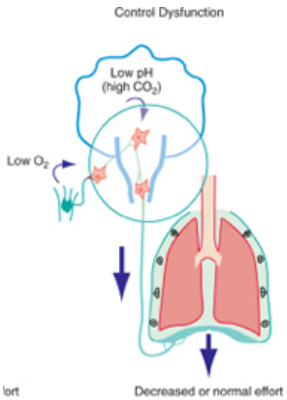
Clinical conditions

- Neuromuscular disorders: spinal muscular atrophy (SMA), muscular dystrophies or myopathies
- Phrenic nerve paralysis
- Spinal cord injury above C-3

Clinical signs

- Weak cough; retained airway secretions
- Increased use of accessory muscles
- Incompetent swallowing; weak or absent gag reflex
- Decreased level of normal activity/function

Decreased Central Nervous System (CNS) control



Physiology: Absence of adequate autonomic control of respiration results in decreased respiratory drive.

Clinical conditions

- Congenital central hypoventilation syndrome (CCHS)
- Injury to the brain
  - Arnold Chiari type II malformation of the brain
  - Incompetent swallowing
  - Incompetent swallowing
  - Weak or absent gag reflex

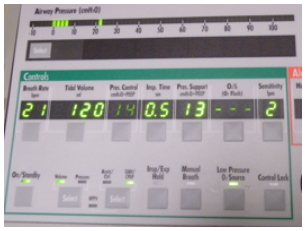
Clinical signs

- Weak cough; retained airway secretions
- Increased use of accessory muscles
- Incompetent swallowing; weak or absent gag reflex
- Decreased level of normal activity/function

Diagrams from Kliegman (2007), Nelson Textbook of Pediatrics (18th ed). Chapter 370.5.

- Children less than 2 years of age are more likely to develop respiratory failure due to an inability to compensate for lung and airway dysfunction.
- The immature respiratory system also has a great potential for improvement due to growth of the airways and increase in number of alveoli in the first 8 to 10 years of age. This may allow for eventual weaning from mechanical ventilation.
- The pO_2 decreases approximately the same amount as the pCO_2 increases with hypoventilation. This may cause a minimal decrease in the oxygen saturation with a significant amount of CO_2 retention. Therefore, pulse oximetry is not a sensitive indicator of adequate ventilation – use capnography.

Volume Control Ventilation



Definition: Volume control ventilation provides a set volume of gas for the inspiratory phase with passive exhalation by the patient. The amount of pressure needed to deliver the breath will vary.

Tidal volume (V_T) is the volume of air that is inhaled in one breath. The typical amount of V_T for a child without lung disease is 4-8 mL/kg. This is less if the child has lung disease.

Volume is delivered by

- Assist control (AC) – each triggered breath gets a set V_T Most frequently used type of ventilation that can be used for all kinds of respiratory failure.
- Synchronized intermittent mandatory ventilation (SIMV) – breaths are synchronized with the patient's breathing efforts. Breaths above the set rate do not get the set V_T .
- High and low pressure alarms can be set to alert the caretaker to an obstruction or leak in the system.

Advantage: Guaranteed amount of gas delivered regardless of lung compliance.

Disadvantage: Increased risk of barotrauma due to increased pressure needed to deliver a preset volume.

Pressure Control Ventilation

Definition: Pressure control ventilation provides a set inspiratory pressure to deliver the gas in the inspiratory phase and passive exhalation. The amount of volume needed to deliver the breath will vary.

Pressure terms

- **Peak inspiratory pressure** (PIP) is the highest pressure at the end of inspiration. It should be limited to 40 cm H_2O in a healthy lung to avoid epithelial-alveolar damage.
- **Positive end expiratory pressure** (PEEP) retains positive pressure in the lungs during the exhalation phase of a mechanically started breath. This increases the functional residual capacity of the lungs by increasing the surface area of the alveoli to enhance oxygenation.

  Traditionally, PEEP is started at 5 cm H_2O and is increased as needed.
- **Continuous positive airway pressure** (CPAP) maintains a positive pressure through the breathing cycle. There is no cycling of pressures, it stays the same with inspiration and expiration, and the child initiates all breaths.

  Used to support oxygenation and work of breathing by keeping airways open.
- **Pressure is delivered by**
  - Pressure control ventilation - similar to A/C; each triggered breath gets a set PIP and PEEP.
  - Pressure support - amount of pressure applied to the airway during spontaneous inspiration by the patient. Pressure support can be used to support the patient initiated breaths during SIMV.

ALARMS

Alarms may be triggered for a variety of reasons. ALWAYS CHECK THE CHILD.

Press Silence/Reset button.

After the intervention, press Silence/Reset button again to reset the alarm.

LTV 950 and HT 50 alarms:

- DISC/Sense: Tubing disconnected; check the trach tube and check all tubing to and from the vent; reconnect; check for kinks or occlusions
- Bat EMPTY or BAT LOW: Internal battery low or empty; plug into AC outlet ASAP
- HIGH PRES: Occurs when circuit pressure is > high pressure alarm; check for kinks and occlusions
- LOW PRES: Occurs when circuit pressure is < low pressure alarm; check for disconnect
- POWER LOST or POWER LOW: External power and voltage drops to low level or is operating on external power and the voltage drops below a useable level and switches to the internal battery. Unplug from current outlet and replug in somewhere else (Wright, 2012).

Volume alarms are needed to alert the caregiver to changes in the amount of air inspired or exhaled by the child. The volume alarm reading is affected by trach tube or circuit leaks, as well as how the ventilator measures the volume. These are not as reliable as pressure alarms.

Advantage: Use as a mode for weaning vent support. It may be more comfortable for a child who can breathe spontaneously.

Disadvantage: Lack of reliable alarm systems. Changes in compliance or resistance of the lungs can potentially lead to hypoventilation.

Developmental Stages

Definition: Refers to the changes (physical, social, emotional, intellectual or behavioral) in a child with age. Most children become able to do more complex things as they get older. **Assess and communicate directly with the child based on their developmental age, not chronological age**. DO NOT make assumptions about their level of understanding based on their appearance.

Stages of development are often classified into age specific groups such as:

Newborn

Normal milestones: Smiling; crying

- Parents need to grieve the loss of the "Gerber Baby"
- May be first child for parents
- May delay normal development
- Child unable to cooperate

Infant

- Sitting
- Crawling
- Walking

Toddler

- Normal milestones: Increasing mobility; talking; jumping
- Desire for independence
- Need to explore; environmental concerns
- Educational system

Preschool

- Drawing
- Following basic commands
- Completing simple chores

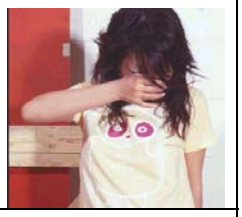
School age

- Forming friendships
- More responsibility
- Body image important
- Communication
- Integration into school

joshuas.50megs.com/images/joshcorydad4-21-01.jpg

Adolescent

- Puberty
- Increasing independence
- Self-care
- Body image
- Transition to adult

Social and emotional development as classified by Erickson's eight stages of development:
Basic trust vs. basic mistrust (1 to 2 years)  
Autonomy vs. shame (2 to 3 years) 
Initiative vs. guilt (3 to 5 years) 
Industry vs. inferiority (5 to 13 years)
Identity vs. identity diffusion (13 or 14 to about 20 years) 
Intimacy vs. isolation (young adult)
Concern for the next generation vs. Self-absorption (adulthood)
Integrity vs. despair (mature adult)

Cognitive development as classified by Piaget
Sensory Motor Period (0 - 24 months) 
Preoperational period (2-7 years)
Period of concrete operations (7-11 years) 
Period of formal operations (11-15 years)

- Children with a tracheostomy may need specialized therapies such as speech, occupational (OT), and physical (PT) to promote their developmental skills
- Children with developmental delay may progress more slowly or may not progress through the expected developmental stages
- It is important to work with the child at his own pace and developmental level

REFERENCES

American Thoracic Society (2000) Care of the child with a chronic tracheostomy. American Journal Respiratory Critical Care Medicine, 161, 297-308.

Available on line by going to the American Thoracic Society website http://www.thoracic.org/index.php and search using the word tracheostomy.

Becker, C., Allaire, K., Meszaros, M., Tribby, R. (2004) Caring for Your Child's Tracheostomy. University of Wisconsin Hospitals and Clinics.

Butnaru, C. S. (2006). Tracheotomy in children: Evolution in indications. Interantional Journal of Pediatric Otorhinolaryngology, 70, 115-119.

Hess, D. R. (2005). Tracheostomy tubes and related appliances. Respiratory Care, 50(4), 497-510.

Illinois EMSC. (2007). Children with Special Healthcare Needs reference card. www.luhs.org/EMSC

Ireton, J (2007). Tracheostomy suction: a protocol for practice (Review) Paediatric Nursing, 19(10), 14-18.

Lewis, C. W. (2003). Tracheostomy in Pediatric Patients A National Perspective. Archives Otolaryngology Head and Neck Surgery (129), 523-529.

Tweedie, D. J., Skilbeck, C. J., Cochrane, L.A., Cooke, J., Wyatt, M. E. (2008). Choosing a paediatric tracheostomy tube: an update on current practice. The Journal of Laryngology & Otology, 122, 161-169.

Takamizawa, S. (2003). Laryngotracheal separation for intractable aspiration pneumonia in neurologically impaired children: Experience with 11 cases. Journal of Pediatric Surgery, 38(6), 975-977.

Wegner C., Leiser, L., and Egan, R. (2009). Caring for Kids with Tracheostomies Care Notebook. Milwaukee: MaxiShare.

Wilkins, R., Stoller, J. ,& Kacmarek, R. (2009). Egan's Fundamentals of Respiratory Care (9th ed), St. Louis: Mosby Elsevier

Wootten, C. T. (2006). Tracheostomy in the first year of life: Outcomes in term infants, the Vanderbilt Experience. Otolaryngology - Head and Neck Surgery, 365-369.

Verger J.T.,& Lebet R.M (Eds.) (2008). AACN Procedure Manual for Pediatric Acute and Critical Care. St Louis: Saunders Elsevier.

CREDITS FOR MUCH OF THE CONTENT AND VISUAL IMAGES

Program Content developed by:

Rebecca Tribby, MSN, RN
Clinical Nurse Specialist/Case Manager, American Family Children's Hospital
Nursing Education Director, University of Wisconsin Pediatric Pulmonary Center
Clinical Instructor, University of Wisconsin-Madison School of Nursing
Madison, WI

Candace Dreier, RRT
Core Faculty Respiratory Care-Home Care, University of Wisconsin Pediatric Pulmonary Center
American Family Children's Hospital
Respiratory Home Care Specialist-Senior, University of Wisconsin Health Home Care Services
Madison, WI

Carole Wegner MSN, RN
Clinical Nurse Specialist/Program Coordinator, Tracheostomy/Home Ventilator Program
Children's Hospital of Wisconsin, Milwaukee, WI

Lori A Leiser, CRT
RCS Resource Specialist-Home Care, Tracheostomy/Home Ventilator Program
Children's Hospital of Wisconsin, Milwaukee, WI

In addition, the following individuals worked on this project:

Suzanne Nelson, MS, RN
Graduate Student
Center for Children with Special Health Care Needs, University of Minnesota School of Nursing
Nursing trainee, University of Wisconsin-Madison Pediatric Pulmonary Center

Jeniele Luebke, MS, RN
Graduate Student
University of Wisconsin-Madison School of Nursing
Nursing trainee
University of Wisconsin-Madison Pediatric Pulmonary Center

Instructional Design & Programming by:

Cid Freitag, MA Sr Instructional Design Consultant
University of Wisconsin –Madison Division of Information Technology- Academic Technology Group
Michelle Glenetski, Graphic Designer, Web & Flash Developer
University of Wisconsin - Madison Division of Information Technology - Academic Technology Group
Madison WI

Funding for this project was provided by:

University of Wisconsin Pediatric Pulmonary Center, Project T72MC90008, Maternal and Child Health Bureau (Title V, Social Security Act), Health Resources and Services Administration, United States Department of Health and Human Services.
Children's Hospital of Wisconsin,
Respiratory Care Services Department
Milwaukee, WI

A special thanks to:
the families who provided their pictures, expertise and insight in the development of this program.