Perspectives
Recovery Strategies from the OR to Home

ABSTRACT

While there is a relative consensus as to whether mechanical ventilation should be initiated, the management of babies during recovery from respiratory failure remains largely subjective and is predominantly determined by institutional or individual practices or preferences. This can lead to babies either being left on the ventilator too long, or extubated too hastily, thus requiring repeated re-intubation. The current scientific literature fails to provide a uniform view of the most appropriate way to wean babies from mechanical ventilation. In her article, Ms. Larson discusses the strategies for the weaning phase that can promote a successful extubation of the neonate.

Tracheostomy is more hazardous in children than in adults, and carries special risks in the very young. The past 20 years have seen a large shift in the age distribution of tracheostomy. Whereas formerly the operation was done largely for management of epiglottitis and laryngotracheobronchitis, today the prime indication is subglottic stenosis in infants consequent upon intubation for respiratory distress syndrome and prematurity. Ms. Bissell, a nurse, shares her experience and knowledge she gained in caring for her premature son's trachesotomy.

Weaning Neonates from Mechanical Ventilation: *Is there a right way?*

CONTINUING EDUCATION FOR NURSING

By Stephanie Carlisle Larsen, BS, RRT

Respiratory distress is a common cause of morbidity in the preterm infant population. The March of Dimes reported in 2007 that premature birth rates have decreased, yet the decline is minor.[1] Nationally, premature birth rates are currently at 12.7%, an overall 36% increase from the 1980s.[1] Regardless, the preterm population requiring intubation is substantial. Some infants are intubated for a short period of time and others are intubated at length, depending on gestational age, lung maturity, and severity of disease. Consequently, many avenues of weaning are explored in this population to limit exposure. Even in the best-case scenario of a neonate who experiences a successful short-term extubation, reintubation or continuous positive airway pressure (CPAP) may be required because of apnea or respiratory distress. These complications could result in additional ventilator-induced lung injury (VILI). The ideal situation would be to maintain the infant on the ventilator for exactly the right amount of time to halt the progression of disease before VILI can be induced, followed by a successful transition to unassisted breathing. Although there are various issues to be explored in neonatal mechanical ventilation, the weaning phase is the aspect that will be dissected in this article.

When to begin the weaning process: concerns and considerations

The introduction raised the most debatable question in the discussion of weaning: Some prefer to act on instinct, or when they feel the infant is "ready." The problem with these assumptions is that there is no concrete number or condition that is consistent across patients. To establish uniformity, weaning should be trialed when the patient presents hemodynamic stability along with acceptable gas exchange (typically pH > 7.25). The goal for any ventilated patient is to assist alveolar gas exchange and to attain physiologic function.[2] Spontaneous patient effort, along with clinical assessment, should be closely observed during the weaning phase. If any abnormality is noted and found to be of significance for disease state, discontinuation of the weaning process should be discussed with the team of care providers. Abnormalities include, but are not limited to, increased respiratory rate, desaturations, apnea, any changes of significance in vital signs, and decreased tidal volumes. Weaning failure is likely when one or more imbalances exist between ventilatory needs and respiratory capacity. In some cases, weaning failure occurs because of problems such as airway secretions, bronchospasms, muscle weakness, central nervous system abnormali-

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Care of the Child with Long-term Tracheostomy

By Cynthia Bissell, RN

A tracheotomy is a surgical procedure that is usually performed in the operating room with the patient under general anesthesia. A tracheotomy is an incision into the trachea that forms a temporary or permanent opening called a tracheostomy. Sometimes the terms "tracheotomy" and "tracheostomy" are used interchangeably. The opening or hole is called a stoma. The incision is usually vertical in children and runs from the second to the fourth tracheal ring. A tube is inserted through the opening to allow for the passage of air and removal of secretions. Instead of breathing through the nose and mouth, the child will now breathe through the tracheostomy tube.

The tracheotomy is one of the oldest surgical procedures in the world. Amazingly, a tracheotomy was portrayed on Egyptian tablets dating back to 3600 bc. Asclepiades of Persia is credited as the first person to perform a tracheotomy in 100 B.C.

The term "tracheotomy" was coined by Lorenz Heister in 1718. Tracheotomies were originally used for emergency treatment of upper airway obstruction, with little success. Upper airway obstruction in children was first discussed as a clinical entity in 1765. It was suggested that a tracheotomy be performed as an emergency treatment to prevent children from suffocating due to throat inflammation. Tracheotomies were used in the early 1800s to treat airway inflammation in children caused by diphtheria. In 1965, the use of intubation and respiratory support for neonatal patients was described by McDonald and Stocks. This revolutionized neonatal care, but at the same time, it has led to many more children surviving with tracheostomies due to subglottic stenosis.

The tracheotomy surgery takes approximately one hour. After a tracheotomy procedure, the child usually stays in the hospital for about 5 days, unless there is a complicating condition. It takes about 2 weeks to recover fully from the surgery.

As recently as the 1960s, children with tracheostomies were forced to live in the hospital. Some hospitals had "bronchoscopic clinic wards" specially established for children with tracheostomies. Today, the goal for most children with long-term tracheostomies is to live at home with their families. Once a child is discharged from the hospital, most of the routine daily care is performed by the caretakers, usually the parents.

The challenges of pediatric home care are different than hospital care. Parents are usually the main caretakers in pediatric home care. Most children with tracheostomies will qualify for some home nursing hours. As a general rule, children with tracheostomies will qualify for about 8 hours of skilled nursing care per day. However, these hours vary depending on the individual child's needs. It is often difficult to receive approval for home nursing hours from insurance companies, and it can also be difficult to fill the hours. Limited coverage for equipment can also be a challenge in the home setting. For these reasons, accepted standards of care for children at home can be a bit different from hospital care.

Types of Tracheostomy Tubes

A tracheostomy (also abbreviated as trach, trache, or trachy) tube is a curved tube that is inserted into a tracheotomy stoma. There are several different types and brands of tracheostomy tubes. Tracheostomy tubes can be made of metal, plastic, or silicone. Plastic and silicone tubes are increasingly popular because they are lightweight and there is less crusting of secretions.

For infants and small children, the trach tube is usually a single cannula plastic tube that generally is not cuffed (even if mechanical ventilation is required). The tube size and type is determined by the doctor depending on the reason for the trach tube as well as the size, age, and medical needs of the child. The proper diameter, length, and curve of the tube help to minimize complications related to damage to the tracheal wall.

Reasons for Insertion of a Tracheostomy

There are many reasons why a child might require a tracheostomy. Most reasons fall into 2 categories: Either there is a problem with the airway itself or a problem with the lungs. Below is a list of some of the most common reasons for a tracheostomy

Airway Problems That May Require a Tracheostomy

- Subglottic stenosis
- Vocal cord paralysis
- Tracheomalacia
- Subglottic web
- Large tongue or small jaw that blocks the airway
- Treacher Collins and Pierre Robin syndromes
- Congenital abnormalities of the airway
- Obstructive sleep apnea
- Infection, such as epiglottitis or croup
- Laryngectomy
- Tumors, such as cystic hygroma
- Laryngeal injury or spasms
- Severe neck or mouth injuries
- Airway burns from inhalation of corrosive material, smoke, or steam
- Foreign body obstruction

Lung Problems That May Require a Tracheostomy

- Need for prolonged respiratory support, such as bronchopulmonary dysplasia
- Chronic pulmonary disease to reduce anatomic dead space
- Chest wall injury
- Diaphragm dysfunction

Other Reasons for a Tracheostomy

Figure 1. Shiley Pediatric Tracheostomy Tube with obturator
Source: reprinted by permission of Covidien Patient Monitoring and Respiratory Solutions

- Neuromuscular diseases paralyzing or weakening chest muscles and diaphragm
- Aspiration related to muscle or sensory problems in the throat
- Fracture of cervical vertebrae with spinal cord injury
- Long-term unconsciousness or coma
- Disorders of respiratory control, such as congenital central hypoventilation or central apnea
- Facial surgery and facial burns

Precautions with a Tracheostomy

A child with a tracheostomy can do most things that other children do. Parents should try to treat their child as normally as possible. It is important not to be overly protective. However, children with trachs must be watched very closely, as they may not be able to verbally indicate discomfort.

There must be a trained person with the child at all times. At minimum, this person must be trained in cardiopulmonary resusitation (CPR) and know how to perform CPR on a child with a tracheostomy. They must be able to suction and change a tracheostomy tube. For school-aged children, there should be a trained person (preferably an RN or LPN) with the child at school and on the bus to and from school. Children with trachs are often on some type of monitoring device, such as a cardiac/apnea monitor or pulse oximeter, when not directly supervised (such as during naps and at bedtime). These monitors alert caregivers in the event of a problem such as accidental decannulation or a mucus plug.

Water represents a particularly serious threat, as drowning can easily occur if the tube is submerged in water. Extreme caution must be used with baths and when washing the child's hair.

Other suggested precautions

- No showering or swimming
- When holding a child with a trach, be sure that the chin is up and the tube opening is unobstructed
- Check with the doctor before applying any salves or ointments near the trach
- Avoid powder, talc, chlorine bleach, ammonia, aerosol sprays, or perfumes near a child with a trach
- Prevent foreign objects from entering the trach tube, such as water, sand, dust, small toy pieces, etc
- Avoid sandboxes and beaches

Children with trachs must be watched very closely, as they may not be able to verbally indicate discomfort.

- Avoid chalk dust
- Watch play with other children so that toys, fingers, and food are not put into the trach tube and that other children do not pull on the trach
- Avoid clothing that blocks the trach tube, such as crewnecks, turtlenecks, and shirts that button in the back
- No plastic bibs
- No necklaces
- No fuzzy or fur clothing, bedding, or stuffed toys
- Avoid animals with fine hair or that shed excessively
- Do not allow anyone to smoke near the child
- Keep the child's environment as free from dust, lint, and mold as possible
- Limit the use of wood stoves and fireplaces, which dry the air
- During cold weather, avoid allowing the child to breathe freezing cold air directly into the trach
- Use a heat moisture exchanger (HME), gauze bandage, loose cotton scarf, or surgical mask to protect the tracheostomy on dusty, smoggy, or windy days
- Avoid exposure to people with colds or other contagious illnesses
- Be sure the child is up-to-date on all immunizations
- Have child receive early flu shots if recommended by the child's pediatrician
- Some types of HMEs are small enough or have filters that could be swallowed by young children
- No latex balloons; these are dangerous for all children. Latex over any airway will block breathing
- No contact sports

Infection Control

- Hand washing is the single most important way to stop the spread of infection. Have antibacterial soap at every sink, as well as hand sanitizers where water is not available
- Screen all visitors for colds, limit visit time, and avoid crowds; be defensive, not paranoid
- Use masks for family members with colds
- Humidify the air with cool mist, but remember to clean the humidifier each day with soap and water
- Daycare is a leading risk factor for upper respiratory infections. It is not always possible for parents to be at home with their children, but this is helpful when possible. Also, a smaller daycare center poses less risk of infection than a larger one
- Parental smoking (secondhand smoke) is a risk factor for respiratory infections.
- Remember, cold viruses can survive for several hours on objects such as toys, doorknobs, remote controls, and telephones. Disinfect these objects properly. The dishwasher is useful for disinfecting many washable items
- A cold is contagious for 2 to 4 days after symptoms appear
- Keep tissues in every room of the house and dispose of them promptly and properly after use, and do not use handkerchiefs

Tracheostomy Complications

Respiratory Distress and Tube Obstruction

Tube obstructions from mucus plugs are the most common cause of respiratory distress for children with tracheostomies. Symptoms of a mucus plug include resistance when trying to suction or bag and/or symptoms of respiratory distress.

Symptoms of Respiratory Distress

- Difficulty breathing
- Increased respiratory rate
- Increased heart rate
- Grunting, noisy breathing
- Stridor
- Whistling noise when breathing
- Cyanosis
- Restlessness
- Sweaty, clammy skin
- Retractions
- Anxiety, frightened look
- Flared nostrils
- Infants may have trouble sucking

- Difficulty eating or refusing to eat
- Reduced airflow through the tube
- Low O_2 saturations for children on pulse oximetry

Suction the trach or change trach tube if needed for respiratory distress. The tube may have become blocked with dried secretions, blood, or a mucus plug. If symptoms do not clear with suction or trach change, activate emergency medical services.

Bleeding

A very small amount of bleeding (pink- or red-streaked mucus) often occurs as a result of routine suctioning. This bleeding can be managed with close observation and by modifying the care that may have caused the problem.

Possible Causes of Minor Bleeding

- Irritation to the fragile tissue around the stoma
- Insufficient humidity in the airway
- Too frequent, deep, or vigorous suctioning
- Suction pressure that is too high
- Infection
- Trauma or manipulation of the trach tube
- Foreign object in the airway
- Excessive coughing

Call the doctor or emergency services for a significant amount of bright-red bleeding from the tracheostomy.

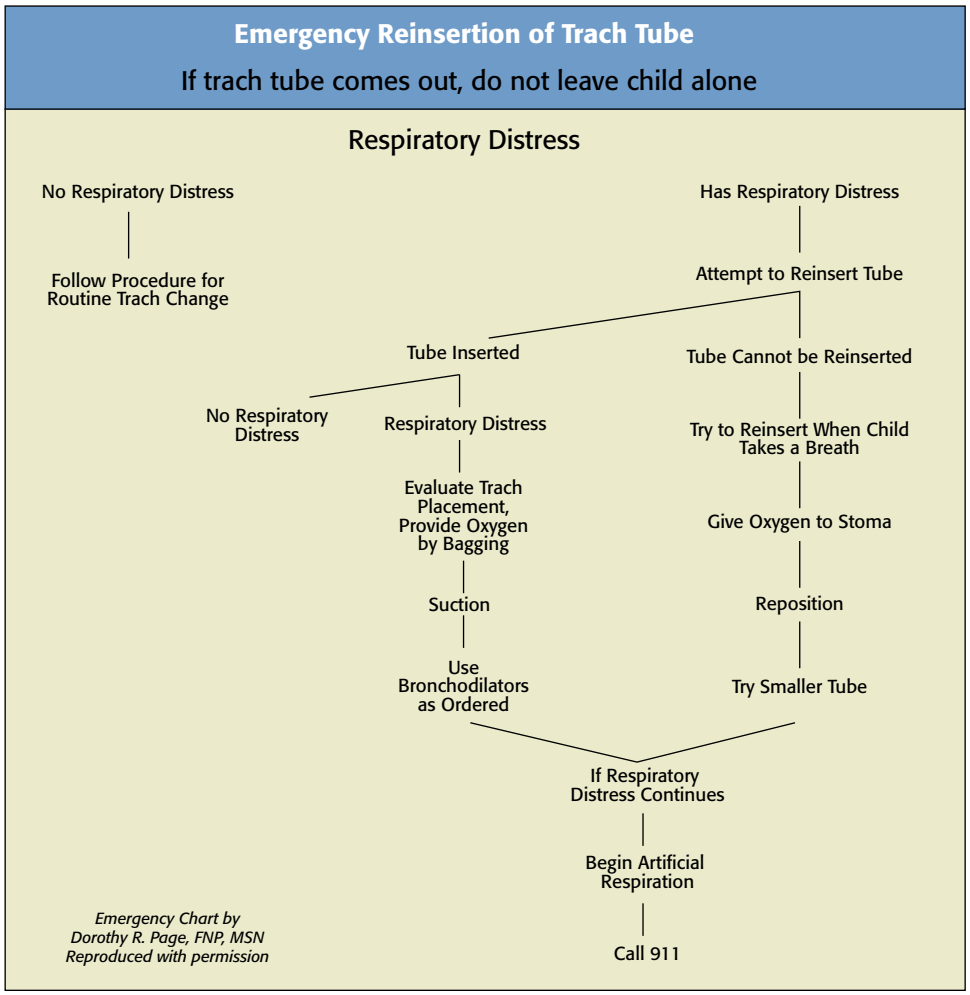

Figure 2. Emergency reinsertion of a trach tube.
Source: Emergency Chart by Dorothy R. Page, FNP, MSN. Reproduced with permission.

Infection

Children with tracheostomies are at high risk for respiratory infections, such as colds, pneumonia, tracheitis, and bronchitis, because the trach tube bypasses the natural defenses (nasal hair and mucus membranes) of the upper airway that filter out dust and bacteria. The skin around the stoma must also be monitored closely for signs of infection.

Symptoms of Infection

- Yellow or green secretions (may be pink/blood tinged)
- Thicker mucus
- Increased amount of mucus
- Redness, rash, and/or inflammation at the stoma site
- Bleeding at the stoma site
- Foul odor
- Fever
- Congested lung sounds
- Increased respiratory effort or change in respiratory rate
- Listlessness
- Discomfort with trach care, tenderness at the stoma site

Other Complications

Granuloma (common)

A growth of inflammatory tissue that is caused by the irritation of the airway by the tracheostomy tube.

Suprastomal Tracheomalacia (common)

Collapse of the trachea into the airway above the trach tube caused by the tube pushing on the trachea above the stoma. Covering the tube with the chin in order to vocalize may also contribute to suprastomal collapse.

Tracheal Stenosis

Scar tissue at the site of the tracheostomy tube, often from excessive trach cuff pressure.

Tracheoesophageal Fistula

An abnormal connection between the trachea and the esophagus resulting from erosion of the back wall of the trachea.

Pressure Necrosis

Infants with short, fat necks or children on mechanical ventilation may develop infections or pressure sores of the skin and soft tissue around the trach site.

Tracheoinnominate Fistula (rare)

An erosion of the tube into a large artery that runs in front of the trachea. Catastrophic hemorrhage could lead to death.

Tracheostomy Care

Rubbing of the trach tube and secretions can irritate the skin around the stoma. Daily care of the trach site is needed to prevent infection and skin breakdown under the tracheostomy tube and ties. Care should be administered at least once per day and more often if needed. Children with new trachs or children on ventilators may need trach care more often. Tracheostomy dressings are used if there is drainage from the tracheostomy

site or irritation from the tube rubbing on the skin.

Procedure for Tracheostomy Care

- Wash your hands
- Explain the procedure in a way appropriate for the child's age and understanding
- Lay the child in a comfortable position on his/her back with a small blanket or towel roll under his/her shoulders to extend the neck and allow for easier visualization and trach care
- Open sterile cotton swabs, trach gauze, and regular gauze
- Pour half- strength hydrogen peroxide into a sterile cup or clean disposable paper cup and pour sterile water into another cup
- Clean the skin around the trach tube with cotton swabs soaked in half-strength hydrogen peroxide. Using a rolling motion, work from the center outward using 4 swabs, one for each quarter around the stoma and under the flange of the tube. Do not allow any liquid to get into the trach tube or stoma area under the tube. Note: Some doctors recommend cleaning with just soap and water in home care, using hydrogen peroxide only to remove encrusted secretions. This is because daily use of hydrogen peroxide may irritate the skin of some children
- Rinse the area with cotton swabs soaked in sterile water
- Pat dry with gauze pad or dry cotton swabs
- Check the skin under the trach ties
- Tuck precut trach gauze around and under the trach tube flush to skin. Do not cut the gauze or use gauze containing cotton because the child may inhale small particles. Use precut tracheostomy gauze or unfilled gauze opened full length and folded into a "U" shape or use 2 gauze pads, one placed under each wing of the tube. Be sure the trach dressing does not fold over and cover the trach tube opening. Change the dressing when moist to prevent skin irritation. Tracheostomy dressings may not be needed for older tracheostomies when the skin is in good condition and the stoma is completely healed and free from rash or redness

Daily care of the trach site is needed to prevent infection and skin breakdown under the tracheostomy tube and ties.

- Wash your hands after trach care

Suctioning a Tracheostomy

The upper airway warms, cleans, and moistens the air we breathe. The trach tube bypasses these mechanisms so that the air entering via the tube is cooler, dryer, and not as clean. In response to these changes, the body produces more mucus. The trach tube is suctioned to remove mucus from the tube and trachea, which allows for easier breathing. Generally, a child with a trach should be suctioned every 4 to 6 hours and as needed. Avoid unnecessary suctioning, as this can irritate the airway. There may be large amounts of mucus with a new tracheostomy. This is a normal reaction to an irritant (the tube) in the airway. These heavy secretions should decrease in a few weeks. Frequency of suctioning will vary from child to child and will increase with respiratory tract infections. While a child is in the hospital, suctioning is done using sterile technique; however, a clean technique is usually sufficient for most children at home.

The size of the suction catheter depends on the size of the tracheostomy tube. Size 6, 8, or 10 French are typical sizes for neonatal and pediatric trach tubes.

Suction Depths

- Shallow suctioning: Suction secretions at the opening of the trach tube that the child has coughed up
- Premeasured suctioning: This technique is best for routine suctioning. Suction the length of the trach tube; suction depth varies depending on the size of the trach tube. The obturator can be used as a measuring guide. Premarked suction catheters are helpful with this technique
- Deep suctioning: Insert the catheter until resistance is felt, then withdraw the catheter slightly before suctioning. Deep suctioning is usually not necessary. Be careful to avoid vigorous suctioning, as this may injure the lining of the airway

Procedure for suctioning a tracheostomy

- Wash your hands
- Explain the procedure in a way appropriate for the child's age and understanding
- Set up equipment and connect suction catheter to suction machine tubing
- Pour normal saline into a sterile or clean cup
- Put on gloves (optional for home care; if used, use powder-free gloves)
- Turn on the suction machine (suction machine pressure for infants, 60 to 80 mm Hg; for children and adolescents, 80 to 120 mm Hg)
- Place the tip of the catheter into the saline cup to moisten, lubricate, and test to see that suction is working
- Instill sterile normal saline with plastic squeeze ampule into the trach tube if needed for thick or dry secretions. Excessive use of saline is not recommended. Use saline only if the mucus is very thick, hard to cough up, or difficult to suction. Recommended amount per instillation is approximately 1 to 3 cc
- Some children need extra breaths with a manual resuscitator. The purposes of bagging: hyperoxygenation, hyperinflation, and hyperventilation of the lungs. Manual resuscitation is usually not needed for stable children with no additional respiratory problems. If bagging is needed, be sure to suction any visible secretions first, and then give 3 to 5 breaths if needed
- Preoxygenate if ordered (extra oxygen may be given before and after suctioning to prevent hypoxia)
- Gently insert the catheter into the trach tube without applying suction. Note: Some research has shown that there is less hypoxia suctioning while going in and out. This is not as

important as the amount of time it takes to suction
- Put your thumb over the opening in the catheter's "chimney opening" to create suction and use a circular motion (twirl the catheter between your thumb and index finger) while withdrawing the catheter so that the mucus is removed well from all areas. Suction only the length of trach tube—premeasured suctioning (deeper insertion may be needed if the child has an ineffective cough). Avoid suctioning for more than 5 seconds because of oxygen loss and risk of atelectasis (collapse of part or all of a lung)
- Clear the catheter by drawing saline from the cup through the catheter
- Let the child rest and breathe, then repeat suctioning if needed until clear. Allow at least 30 seconds between suctioning
- The child's mouth or nose may also be suctioned if needed after suctioning the trach. Then dispose of that catheter (do not put the same catheter back into trach)
- In home care, catheters may sometimes be used more than once before disposal or cleaning if the child needs frequent suctioning or if supplies are limited. Keep the tip of the catheter clean, and store it in the original package. Some catheters have a protective sleeve to help keep it clean
- Wash hands after suctioning

In addition to a stationary suction machine, small, portable, battery-operated suction machines are available for travel. The batteries are rechargeable, or the machine can be plugged into a car cigarette lighter. A suction trap (e.g., ARGYLE™ DeLee Mucus Traps, Covidien) is a small plastic suction device that may also be used as a backup.

Changing a Tracheostomy Tube

There are different opinions among professionals regarding how often the tracheostomy tube should be changed. However, the typical recommendation is every 1 to 2 weeks for cleanliness and to decrease the formation of granulomas. This recommendation may vary depending on the particular child and doctor. Always change the trach tube with 2 people present (unless this is not possible in an emergency). Change the trach tube before a feeding or at least 2 hours after a feeding. Suction the trach tube if needed before changing the tube.

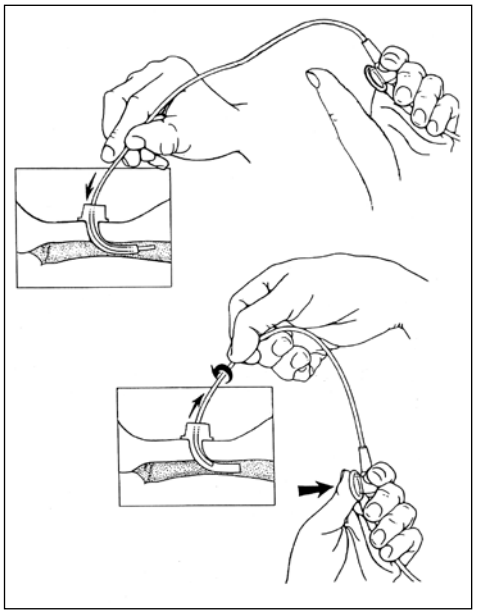

Figure 3. Suctioning a trach tube
Source: Courtesy of the Department of Otolaryngology, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio.
Reprinted with permission.

Procedure for changing a tracheostomy tube
- Wash your hands
- Explain the procedure in a way appropriate for a child's age and understanding. Use a calm, gentle approach. If you are anxious, the child may sense your anxiety
- Cut trach ties ("twill tape") to the appropriate length, cutting the ends of the tape at an angle to make it easier to thread through the hole in the trach wing (flange) and to prevent fraying or wrap a piece of tape around the end of the tie, similar to the end of a shoe lace, to make it easier to thread
- Inspect all tubes for cracks, tears, or decreased flexibility before use, especially if the tubes are reused
- Bring the trach tie through one end of new trach tube. Avoid touching the part of the tube that is inserted into the trachea. Try to keep it sterile
- Insert the obturator into the new tube; be sure it slides in and out easily. The obturator helps to guide the tube, and the rounded tip adds protection to the stoma during insertion
- Place a small amount of sterile, water-soluble lubricant (Surgilube® or K-Y® Jelly) on the end of the new trach tube and place the tube in the sterile tray or clean surface until ready to insert. Never use petroleum jelly as a lubricant. Note: some doctors do not recommend using lubricants at all, because of the danger of aspiration. If you do use a lubricant, use it sparingly
- Have a suction machine and oxygen handy if needed
- Place the child on his/her back with a small blanket or towel roll under his/her shoulders to help hyperextend the neck. It might be helpful to wrap the child in a blanket mummy-style if he/she is not cooperative. The child may also sit up for the trach tube change
- Administer oxygen if ordered
- Cut the old trach ties while holding onto the trach tube. Always hold the tube when ties are not secure; a cough can dislodge the tube
- Gently remove the old trach tube (follow the angle of the tube, an upward and outward arc)
- Insert the new tube in a smooth curving motion, directing the tip of the tube toward the back of the neck in a downward and inward arc (like inserting a suction catheter)
- Do not force the tube! Always have a smaller-sized trach tube with obturator handy if for some reason you are unable to reinsert the tube
- Remove the obturator immediately while holding the tube securely with the other hand. Remember that the child cannot breathe with the obturator in place
- Changing the trach tube will cause the child to cough; do not let go of the tube
- Thread the trach tie through the other end of the tube and tie them, allowing one finger between the neck and the ties. Tweezers or hemostats may be helpful to thread the ties through the hole in the neck plate of the tracheostomy tube. Once the ties are properly adjusted, secure the ties with a double or triple square knot and cut off the excess tape (Never tie in a bow)
- Inspect the old tube for color, mucus plugs, or odor, then discard. Most plastic pediatric trach tubes are disposable
- When changing the trach tube,

Figure 4. Dale Tracheostomy Holder, Dale Medical Products Inc.

observe the skin for irritation, breakdown, and signs of infection
- Remember to praise the child; a trach change can be emotionally difficult for some children
- Wash your hands after the trach change

Changing Tracheostomy Ties

Tracheostomy ties will need to be changed more often than the tube. Some specialists recommend changing the trach ties daily. This is usually not necessary in home care; however infants with short fat necks, overweight children, and children on high humidification will probably need daily tie changes. Change the ties if they become soiled, wet, loose or cause pressure on the child's skin. Trach tie changes should be done with two people. You should be able to slip one finger under the ties. Tight trach ties could decrease the blood flow to the child's head and cause pressure to the skin around the neck.

Ways to secure the tracheostomy tube
- Twill tape
- Velcro® tracheostomy tube holders (See Figure 4. Dale Trachesotomy Holder, Dale Medical Products)
- Cotton shoe laces
- Umbilical cord tape
- Metal (chain) trach holders

Tracheostomy Humidification

The nose and mouth provide warmth, moisture, and filtering for the air we breathe. A tracheostomy tube bypasses these mechanisms. Humidification must be provided to keep secretions thin and to avoid mucus plugs. Children with tracheostomies do best in a high-humidity environment.

Humidity should be delivered to the child while he/she is sleeping and as needed during waking hours when mucus is dry, thick, or blood tinged. Attach a mist collar (trach mask) with aerosol tubing over the trach with the other end of the tubing attached to the nebulizer bottle and air compressor. Sterile water goes into the nebulizer bottle. Oxygen can also be delivered via the mist collar if needed.

Moisture that accumulates in the aerosol tubing must be removed frequently to prevent occlusion of the tubing and/or accidental aspiration. Disconnect the tubing at the child's end and empty the liquid into a container and discard. Do not drain fluid into the humidifying unit. Fluid traps (or drainage bags) are helpful in preventing occlusion and aspiration. These collection devices also need to be emptied frequently. Position the air compressor and tubing lower than the child to help prevent aspiration from moisture in the tubing.

During the day, a heat moisture exchanger (HME) can be worn on the trach tube. An HME is a humidifying filter that fits onto the end of the trach tube and comes in several shapes and sizes. All styles fit over the standard 15-mm trach tube connector. HMEs also help prevent small particles from entering the trach tube. Change the HME daily and as needed if soiled or wet.

Sterile saline drops can be instilled into the trach tube if secretions become thick and difficult to suction. The amount of saline instilled into the tube can vary from 1 to 3 cc depending on the child's age and size. A saline nebulizer treatment is also helpful to loosen secretions if the child has a nebulizer machine (aerosolized medication delivery system) at home. Additional fluid intake can also help to keep secretions thinner.

Both heating a home in winter and air conditioning in the summer tend to dry the air. Room humidifiers are helpful, but it is vital that these machines be cleaned regularly to prevent bacterial growth. Warm mist humidifiers are especially prone to bacterial growth. Bacteria, mold, and mildew grow best in warm, wet environments.

Cleaning Equipment

Keeping respiratory equipment clean is essential for preventing respiratory infections. Many of the supplies used for tracheostomy care are intended to be disposable. However, sometimes in home care, supplies must be washed and reused for economic reasons (to control cost). Although this is not always recommended, sometimes it is unavoidable. There are several different solutions, techniques, and frequencies for cleaning equipment. Check with the manufacturer, equipment supplier, or respiratory therapist for specific cleaning instructions.

Conclusion

Learning that your child needs a tracheostomy can be devastating for parents. Families are usually frightened and apprehensive about their child having a tracheostomy, and they may question their ability to care for a child who is technology dependent. Parents need to be comfortable with all aspects of tracheostomy care before taking their child home. Nursing services should also be arranged before discharge from the hospital to ensure that the families have enough at-home support to manage their child's care safely. Management of children with tracheostomies is a complex process that requires careful coordination and consistent follow-up.

Cynthia Bissell RN has been in nursing for over 20 years, however her expertise comes from her own experience. In July 1993, Ms. Bissell gave birth to identical twin sons were born 3½ months too soon. Both boys had many of the problems common among premature infants. Eric's most significant problem is spastic quadriplegic cerebral palsy. Aaron's problems are mostly respiratory: bronchopulmonary dysplasia and acquired subglottic stenosis. Aaron's airway was damaged from the ventilator tube when he was in the neonatal intensive care unit. The ventilator saved Aaron's life, but no medical procedure is done without the possibility of complications. Aaron had a tracheotomy surgery at one month of age because of acquired subglottic stenosis. His condition was complicated by BPD, and he was oxygen dependent for several years.

Unable to find much information, Ms. Bissell decided to publish pertinent tracheostomy information on the Internet and dedicated this site to Aaron named "Aaron's Tracheostomy Page." www.tracheostomy.com is now the internet's leading tracheostomy resource and is recommended by otolaryngologists around the country and around the world.

Weaning Neonates from Mechanical Ventilation: Is there a right way? — Continued

ties, unresolved lung disease, and edema. These problems can be avoided by frequent pulmonary toilet and correct use of bronchodilators. Each infant should have a regimen of care that is discussed and implemented by the team to ensure aggressive yet effective treatment. Although mechanical ventilation saves lives, it should be discontinued at the earliest possible time to prevent further lung injury and morbidity.[3]

Another concern during the weaning phase is sedation. If there is decreased drive (central apnea), muscle weakness, or impaired neuromuscular transmission, such as sedation issues, the patient may not tolerate ventilator weans.[2] Sedation can interfere with the infant obtaining adequate tidal volumes, providing the lungs with the opportunity to collapse. In most neonatal cases, target tidal volumes should be in the 4 mL/kg range. Parameters to keep in mind when considering extubation include a FiO_2 of 40% or less, peak inspiratory pressure (PIP) less than or equal to 20, positive end-expiratory pressure (PEEP) of 3 to 5 cm H_2O, and a mandatory rate of 20 or less.4 In cases of extremely low birth weight (ELBW) infants (infants weighing less than 600 g) who meet the criteria for extubation, another consideration is which device to have on standby in case of extubation failure. Some physicians and care teams would often divert extubation because of the lack of equipment available to comfortably and safely ventilate an ELBW infant. Most CPAP devices that are often used as a medium between extubation and low flow oxygen are available only in certain sizes that accommodate the majority of the neonatal population, making some infants a difficult fit. Breakdown of the nares and forehead is very common in these ELBW infants because of improper size and the length of time on the device. The benefits and drawbacks of CPAP as a weaning medium will be discussed later in this article.

If an infant's journey begins or crosses paths with high frequency oscillatory ventilation (HFOV), the decision of whether of not to wean should be made according to the same parameters used with conventional ventilation. Why do we tend to prolong extubation with HFOV when typically we can wean and extubate directly from this mode? Many neonates can be extubated from HFOV to nasal directional positive airway pressure (NCPAP) devices and forgo conventional ventilation altogether. HFOV is not above conventional ventilation. However, other patients may require a slower transition. If extubation from HFOV is not the goal, the infant can be trialed to transition to conventional at a MAP (mean airway pressure) of 15 or less. In some cases, such as patients with an air leak syndrome, transition to conventional ventilation may not take place when settings reach the acquired goal. Because oscillation is an effective mode of ventilation in patients with air leaks, settings can be weaned low to accommodate the desired pH.5

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Once the patient shows stability, the general concept is to wean according to the parameter that is potentially causing the most harm. For example, if the PIP is greater than 25 with tidal volumes of 4 mL/kg or greater and FiO_2 is stable, keeping saturations at 83% to 93%,[6] the ideal wean would be PIP on conventional ventilation. If this were a patient on HFOV, the choice wean would be FiO_2 until it was less than 60%, and then the MAP would be the parameter of choice. When working with neonates, the most common weaning route is to manipulate one parameter at a time. By working in this way, the therapist and team will have a clear understanding of how the patient responded to that particular change.

Effective Methods of Weaning Protocols

The use of preresearched protocols seems to be a popular method in justifying weaning and, eventually, extubation. Extubation readiness testing has been used in various facilities among the pediatric population but is still in the early stages of development in the neonatal intensive-care unit (NICU) world. The benefit of having objective criteria to justify extubation in infants is absent. An extubation readiness study in VLBW infants was performed using a 3-minute spontaneous breathing trial (SBT) while providing endotracheal CPAP. The test yielded a high negative predictive value, highlighting those infants who were most likely to fail extubation.[7] The entry criteria required that the infants were trialed to have a set ventilator rate of less than or equal to 45 bpm in the volume guarantee mode. Oxygen requirements were to be 45% or less, with tidal volumes of 4.5 mL/kg or greater. The infants were placed on the SBT every morning, and the results were recorded as successful if extubation criteria were met. Likewise, if the trial proved unsuccessful, the SBT would be discontinued and the infants would be trialed again the next morning. Those with successful results would be extubated. Overall, the trial did prove to be an effective measurement of readiness to extubate 83% of the time. The overall duration of mechanical ventilation and the duration of all forms of ventilatory support, such as CPAP, were not changed dramatically. The conclusion of this study suggested that placing VLBW infants on an SBT was not harmful, and the outcomes proved to be adequate to clinical judgment alone.[7] The purpose of an extubation readiness test is to assess in a timely manner the infant's ability to breathe spontaneously with adequate volumes by an evidence-based guideline and to optimize the amount of time an infant is supported by mechanical ventilation. Extubation readiness testing is another tool that can be used to evaluate the infant's ability to extubate successfully and validate the decisions of physicians and the care team.

Modes that make a difference

The weaning phase begins when the severity of the respiratory disease decreases enough to allow the clinician to wean settings; therefore, the infant then contributes greater effort in his overall respiratory drive. Studies have shown that some ventilator modes have a positive influence on the weaning and extubation phases of ventilation. There are a few modes to consider

when the weaning phase is initiated.

Some agree that volume-targeted ventilation allows for instant weaning of peak airway pressure while maintaining a consistent tidal volume. Others argue that pressure support ventilation keeps the patient comfortable and in control of his own minute ventilation requirements. Is there a correct method? Does the outcome depend on the mode of ventilation used? Outcomes vary dramatically from patient to patient and rely on key factors such as where the infant was born, medications used, and therapies administered before and after extubation. Regardless of which mode of ventilation you choose to wean from, be consistent and understand the pros and cons of that mode so that it will allow you to make better decisions.

Volume guarantee ventilation in the weaning phase of premature infants is being widely discussed and studied. The use of volume guarantee ventilation in the NICU can sometimes be problematic. For example, if there is a leak around the infant's endotracheal tube, the ventilator will try to achieve the volume set in the volume guarantee mode, therefore increasing peak pressures. Because most neonates are intubated with uncuffed endotracheal tubes, the likelihood of a leak is probable. In addition, this is a negative feedback system. That is, if the infant's metabolic demand rises (such as with necrotizing enterocolitis [NEC]), the ventilator will lower the PIP, creating more work for the infant to overcome in order to normalize the pH.

Pressure support ventilation is also used as a weaning tool. The idea of pressure support is to administer adequate pressure, allowing the infant to overcome the resistance of the endotracheal tube and ventilator circuit. By doing so, pressure support is used to assist respiratory muscles in an effort to lessen the work of breathing caused by the added resistance of being intubated. Pressure support ventilation can be used alone or in adjunct with synchronous intermittent mandatory ventilation (SIMV). Pressure support ventilation allows the respiratory drive to be controlled more by the patient than by the machine. The infant has the ability to set his own inspiratory time, rate, and minute ventilation. In straight SIMV mode, the weaning process will consist of weaning the rate and PIP to an acceptable range until the infant is ready to be extubated. Gas exchange and tidal volumes can be used to assess when the infant should be extubated. Because a premature infant has a respiratory rate of between 30 and 60 bpm under normal circumstances, it is not necessary to wean the mandatory rate completely off in order to extubate. If a neonate has stable vitals and adequate gas exchange on a set rate of 20 bpm on conventional ventilation, the rate should not halt extubation trials.

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Newer modes of ventilation are being trialed in NICUs. Neurally adjusted ventilator assist (NAVA) is considered mechanical ventilation that detects the electrical activity of the diaphragm during contraction to make the patient and ventilator more synchronous. NAVA uses the Edi signal as a tool that allows clinicians to interpret the disorganized breathing pattern that is seen so often in infants. This interpretation allows information to be processed according to informed decisions, therefore better ventilating the tiny lungs. Another newer technique found effective is INSURE. This method of intubation, with surfactant administration and rapid extubation, aims to couple CPAP with a short-term intubation to improve oxygenation and defer long-term intubation in infants suffering from hyaline membrane disease.[8]

Adjuncts to promote a successful extubation

There is no sure method to predicting a successful extubation 100% of the time. There are, however, a few additional therapies that provide a better chance of successful extubation with minimal postextubation problems. The common concerns after extubation include stridor, apnea, bradycardia, respiratory acidosis, and need for reintubation. Medications along with noninvasive support act as a bridge for infants to be successfully extubated.

Caffeine, Theophylline, and Decadron

By the time an infant is ready to be weaned on ventilator settings, he has most likely had several medications enter his system. The two we will discuss that are important in the weaning/extubation phase are decadron and caffeine. Methylxanthines, such as caffeine and theophylline, have a history of success in promoting respiratory drive and muscle function.[9] Caffeine is used for the treatment of apnea because of prematurity in neonates. Decadron is another adjunct drug used to decrease airway edema in the preextubation period. The significance of having decadron on board is to decrease the potential of postextubation stridor caused by the airway inflammation.

Methylxanthines have been used to facilitate extubation in NICUs for many years, yet no studies are conclusive regarding adequate dosing in infants.[10] Methylxanthines have proven to be effective in decreasing apneic episodes among the neonatal population. The two most commonly used, as listed above, are caffeine and theophylline. Caffeine has been chosen as the successor of theophylline because of its longer half-life and less toxic nature. The standard dosage of caffeine is a 20-mg/kg loading dose in addition to a 5-mg/kg daily dose. Even with the prescribed doses of caffeine, about one-third of preterm infants still fail extubation. Some recent studies have considered the use of higher doses of caffeine in preterm infants, resulting in a higher extubation passing rate and less apnea observed by the infant's nursing team.[10] Even though most clinical experts would agree that using caffeine periextubation yields a higher success rate, there are very few studies supporting this observation and providing guidelines for the correct dosage in the neonate population.

Nasal Continuous Positive Airway Pressure

CPAP is intended to provide positive pressure to improve the function of the lungs and reduce the instance of apnea. CPAP has been evaluated in various settings of extubation and as a treatment for apnea in the premature infant. Although the results varied from trial to trial, the collective data reveal that the neonates weighing less than 1500g who were extubated directly to nasal CPAP had lower needs for

reintubation, a reduction in the frequency of postextubation problems (such as apnea and bradycardia), and a decrease in the requirement for additional ventilation strategies. The use of CPAP in this population appears to have a role in facilitating extubation. Even though nasal CPAP is not tolerated in all patients because of nasal breakdown or discomfort, it is still a tool that can inhibit successful exctubation.[11]

High Flow Nasal Cannula

Another device that is being seen in NICUs more frequently is the high flow nasal cannula (HFNC). This device has a high humidity capacity, and flows up to 7 L/m can be initiated on premature infants. The same outcomes are being seen with nasal CPAP and HFNC used as an intermediate mode of support postextubation.[12] The device of choice depends solely on patient demands. Some practitioners find that nasal CPAP is a disadvantage because of the moderate to severe breakdown that may occur in a short period of time. The HFNC system is that of a regular nasal cannula interface, allowing more comfort and less opportunity for breakdown when used properly. The system also provides high humidity, which averts mucosal drying that leads to airway obstruction. Despite the lack of clinical trials of this system in NICUs, the HFNC is being used as an alternative to nasal CPAP. High flow cannula use seems to be well tolerated by most patients and has become a safe tool to discourage reintubation.[11]

Why weaning failed/succeeded and actions taken

Inability to tolerate weaning can result from a variety of factors. The main issues usually involve pain, weakened respiratory muscles, and decreased respiratory drive. Extubation attempts that fail repeatedly often cause a setback in the healing process and can account for an onset of new problems. The management of infants who fail extubation readiness and extubation requires identification and timely correction of the problems that could impede the recovery process. Triggering the ventilator may pose problems in the actual weaning phase. Many neonates have trouble triggering breaths from the machine, causing fatigue. A simple flow trigger adjustment may be the answer to what appear to be chronic problems. Clinicians must evaluate all potential areas of failure to pinpoint a solution or establish a different plan of care for the infant.

If the infant has airway abnormalities caused by chronic ventilation, such as tracheal stenosis or tracheal malasia, the next step in correcting the problem could very well be a tracheostomy.

Sedation is another conflict that can make it seem that weaning attempts are failing. The infant must be spontaneously breathing in order to test his respiratory effort and drive. However, if the infant is in discomfort or pain, fighting the ventilator, or has an increasing respiratory rate leading to a decrease in tidal volumes, sedation may be at fault. An infant can be ready to wean and extubate but seem below the standard protocol if sedation is not managed properly. Normal signs of extubation failure, such as an increased respiratory rate or heart rate or decreased tidal volumes during an extubation readiness test, may in turn suggest sedation problems that need to be addressed by pain management before the next trial.

Some infants have such a severe lung disease that they may require chronic ventilation and/or a tracheostomy. There is not much information available that provides concrete answers regarding when to trach. However, if the infant has airway abnormalities caused by chronic ventilation, such as tracheal stenosis or tracheal malasia, the next step in correcting the problem could very well be a tracheostomy. Many parents seem to shy away from making this decision in a timely manner. Most families feel that a trach is forever and will completely debilitate their child. To most people's surprise, a tracheostomy is sometimes the exact opposite of those expectations. A tracheostomy can actually make the airway patent enough for the infant to be able to sprint off the ventilator, allowing for more freedom, and eventually the trach could be removed and the abnormality dissolved.

Tracheostomy Role in Weaning the Ventilated Infant

There is little available information about when to progress to a tracheostomy after prolonged ventilation. There are professional opinions that include, but are not limited to, projected trajectory, social situation, and developmental needs. There are some families with children who have taken the next step in communicating their trials, successes, and long-term goals. The indications and outcomes after tracheostomy in young patients have started to evolve during recent years. In recent studies, it has been shown that tracheostomies in a high percentage of young patients are merely a bridge to the next step. Most neonates with tracheostomies will develop and outgrow the need for an artificial airway.[12] However, tracheostomies are also used for an extended period of time in infants with long-term problems such as chronic lung disease.[12] The question is not "Why?" when discussing tracheostomy, but "When?"

There is little information available regarding when to trach a neonate. Most professionals have their own opinion that varies from patient to patient. Parents also play an important role in making this decision. Some parents feel that the tracheostomy is a permanent handicap for their child. Others realize the immediate need for the procedure and revisit the long-term possibilities when necessary. In the Middle Ages, tracheostomies were viewed as "a lifesaving intervention in cases of respiratory distress." Tracheostomies and the procedures it entails have made quite a few advancements since the Middle Ages; however, the statement still rings true.[13]

Using a tracheostomy for a patient with chronic lung disease has many advantages.[12] In my experience, you can see immediate progress in children who are struggling to overcome airway obstruction after they have a tracheostomy. The child almost immediately looks more comfortable in his breathing pattern, allowing for growth and progress. On many occasions, minor developmental delays that once seemed like they would require vigorous therapy seem

to begin to correct themselves. The patient is more in touch with his surroundings after the stress brought on by airway obstruction is relieved. Sedation issues that once seemed unbearable seem to diminish after the placement of a tracheostomy tube. The child seems more at ease and comfortable. There are still issues that a simple tracheostomy cannot solve. However, if it meets one of the above advantages for the child, a tracheostomy is necessary in the quality of life.

Tracheostomy remains a necessary procedure for specific circumstances.[13] Decisions should be made with all of the advantages and complications presented to the family during a discussion with the team or providers responsible for the patient's care. In the end, the infant relies on his care providers to present his case to the parents, allowing all parties involved to be a part of the decision process. If any alternatives are available and a tracheostomy can be avoided, it is always better to be less invasive.[1] The best outcomes for infants with tracheostomies come from centers with knowledgeable and proficient personnel who can deliver proper treatment and facilitate parents to receive appropriate training for home care.

Conclusion

Predicting successful extubation is an art, but it is not an exact science. Premature infants all respond differently to the weaning phase of ventilation. Some tolerate more generous weans, whereas other infants prefer a slower approach. Modes of ventilation, adjunct therapies, and noninvasive devices have made the process a bit smoother. As technological advances and more studies on the subject matter are performed, we as clinicians should have a better perspective on the ventilatory needs of the premature infant. For now, we must use the resources available along with our clinical knowledge to use mechanical ventilation as a life-saving mechanism without prolonging intubation and causing further harm.

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1. List at least three nursing interventions when caring for a child with a tracheostomy
2. Describe the precautions that need to be taken for a child with a tracheostomy
3. Describe different methods of weaning the neonatal population from mechanical ventilation.

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1. **What is the most common reason for a child to receive a tracheostomy?**
   a. sleep apnea
   b. subglottic stenosis
   c. tracheomalacia
   d. neuromuscular disease

2. **What is the most common type of pediatric tracheostomy tube?**
   a. a metal tracheostomy tube
   b. a double cannular tube
   c. a single cannular tube
   d. a cuffed tube

3. **Which of the following presents the most serious danger for children with tracheostomies?**
   a. dust
   b. contact sports
   c. water
   d. smoke

4. **The best way to prevent the spread of infection is to**
   a. avoid crowds
   b. screen all visitors for symptoms of infection
   c. wash hands frequently
   d. have the child wear an HME filter

5. **Symptoms of respiratory distress include**
   a. increased heart rate
   b. stridor
   c. restlessness
   d. all of the above

6. **Which of the following is a life-threatening complication?**
   a. tracheoinnominate fistula
   b. suprastomal Tracheomalacia
   c. granuloma
   d. infection

7. **The accepted standard technique for suctioning a tracheostomy in the home setting is:**
   a. sterile technique
   b. modified sterile technique
   c. clean technique
   d. dirty technique

8. **Deep suctioning should be done**
   a. every 4 to 6 hours
   b. routinely
   c. only if absolutely necessary
   d. never

9. **Most doctors agree that the tracheostomy tube should be changed**
   a. once a week
   b. once a month
   c. every 3 months
   d. every 6 months

10. **To secure the tracheostomy tube which of the following can be used?**
    a. twill tape
    b. velcro holder
    c. chain
    d. all of the above

11. **With CPAP, a concern with ELBW infants is breakdown of the nares and forehead due to improper sized interfaces and length of time the infant remains supported by the device.**
    a. True
    b. False

12. **A new technique being used/trialed in NICUs is INSURE, which uses the Edi signal of the diaphragm as a tool to allow clinicians to interpret the disorganized breathing pattern this is often seen in infants.**
    a. True
    b. False

13. **Decadron is often the drug of choice used to treat apnea due to prematurity.**
    a. True
    b. False

14. **Sedation has no effect on the outcome of an extubation.**
    a, True
    b. False

Mark your answers with an X in the box next to the correct answer

	A	B	C	D
1	☐	☐	☐	☐
2	☐	☐	☐	☐
3	☐	☐	☐	☐
4	☐	☐	☐	☐
5	☐	☐	☐	☐
6	☐	☐	☐	☐
7	☐	☐	☐	☐
8	☐	☐	☐	☐
9	☐	☐	☐	☐
10	☐	☐	☐	☐
11	☐	☐		
12	☐	☐		
13	☐	☐		
14	☐	☐		
15	☐	☐	☐	☐
16	☐	☐	☐	☐

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1. List at least three nursing interventions when caring for a child with a tracheostomy	1	2	3	4	5	6
2. Describe the precautions that need to be taken for a child with a tracheostomy	1	2	3	4	5	6
3. Describe different methods of weaning the neonatal population from mechanical ventilation.	1	2	3	4	5	6

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