TRACHEOSTOMY

Surgical Specialty:	Otolaryngology
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Background:

- General Information
  - Tracheostomy is most commonly performed for patients requiring prolonged mechanical ventilation of the lungs with failure to extubate.
  - It is also indicated to improve tracheo-pulmonary toilet, which eventually helps weaning from mechanical ventilation and discharge to a rehabilitation facility or home.[1,2]
  - Another common reason is to relieve upper airway obstruction. This is often elective, but may be performed as an urgent procedure.
  - It might be performed to provide surgical access for difficult airway situation.
  - Patients undergoing laryngeal surgeries for supraglottic pathology might undergo an elective tracheostomy to provide a stable airway.

- Patient Considerations
  - Patients often have severe pulmonary disease, with very little reserve.
    - Neonates with severe bronchopulmonary dysplasia (BPD) and chronic lung disease (CLD) are a common population.
  - Pulmonary hypertension (HTN) is possible in patients with long-standing pulmonary disease or persistent in newborns and associated cardiac defects.
  - Patients may have progressive neuromuscular disease or injury.
  - Patients may have severe/ refractory obstructive sleep apnea.
  - Patients with craniofacial syndromes (especially those with mandibular hypoplasia) with previous / anticipated difficult airway may undergo elective tracheostomy to avoid emergent intubations.
  - Patients might have supraglottic pathology like laryngomalacia, vascular mass, or vocal cord paralysis.

- Disease Specific Considerations
  - Patients with severe pulmonary disease have poor reserve.
  - High Fraction of Inspired Oxygen (FiO_2) requirements may make brief disconnections of the circuit challenging.
  - Patients with high Positive End Expiratory Pressure (PEEP), above ~8cmH_2O, may have rapid desaturations upon disconnection. It can be difficult to recruit the alveoli when PEEP is lost.

  - Patients with pulmonary HTN frequently do not tolerate low FiO_2 and interruptions in ventilation.
  - Syndromic patients may have difficult airways.

- Associated Comorbidities/Syndromes
  - Preterm infants and those with prolonged NICU stays are more likely to have higher pulmonary pressures, severe BPD, and poor reserve.
  - Neurologic disorders and neuromuscular disorders. There may be poor muscle tone, myopathies, oropharyngeal dysphagia, and increased risk of aspiration. Moreover, some myopathies are associated with Malignant Hyperthermia (MH) or anesthesia-induced rhabdomyolysis (AIR): these may require special preparation of the OR and the use of Total Intravenous Anesthesia (TIVA).
  - Difficult airway in patients with craniofacial syndromes such as Pierre-Robin, Treacher-Collins, Crouzons, Aperts, Goldenhar, or Beckwith-Wiedemann[1,2]
  - Cranio-facial syndromes may also have associated cardiac defects.

Anesthetic Planning:

- Pre-Anesthetic Evaluation
  - Thorough pre-anesthetic evaluation and optimization of comorbid conditions.
  - Discuss the risks/benefits/alternatives with parents, surgeon, and ICU team.
  - Airway history: Evaluate and review the information regarding the current airway – patients are most likely intubated and on ventilator support.
    - Previous intubation attempts, devices used, and exposure.
    - Size of the Endotracheal Tube (ETT)- cuffed/uncuffed and whether an air leak is present or absent
    - Discuss with the Respiratory Therapist (RT)– Ventilator parameters, PEEP requirements, respiratory events, secretions, and when the last time ETT was suctioned.
  - For neonates, review the history of any apnea, bradycardia, and desaturation events
  - Medications given/due including bronchodilators and pulmonary vasodilators (there are many pulmonary vasodilators so either name more or don't name any?)

- Additional labs/tests indicated during work-up
  - Review blood gas results and blood count (e.g. knowledge of baseline $PaCO_2$ can guide ventilation settings).
  - Review of Chest X-ray to confirm the position of the ETT (especially important if the patient has been recently intubated or if the position has been changed), sequelae such as pneumothorax, and the extent of lung disease.
  - Echocardiography- Useful in craniofacial patients with associated cardiac defects; Mandatory to evaluate the severity of pulmonary hypertension, RV, and LV dysfunction in at-risk patients and in children with myopathy.

- Discussions to have with surgeon/ family.
    - Critical airway status- Discuss all backup plans and who would be performing the procedure.
    - Type of tracheostomy tube planned (e.g., Bivona or Tracoe, cuffed or uncuffed, neonatal or pediatric size)
    - Code Status
    - ECMO Candidate

- Specific or Unique Room Set-up Requirements
  - Airway
    - Patients most frequently present with an existing ETT
    - Patients presenting for semi-elective (such as craniofacial syndromes) or urgent procedures (such as trauma, difficult airway, or upper airway obstruction) may not be intubated.
    - Have appropriate size ETTs and intubation equipment which may be needed in case of accidental extubation or difficult tracheostomy placement.
    - Have difficult airway cart and supplies available if anticipated or if history of difficult airway.
    - Have an accordion/ flexible connector extension to connect the circuit to the tracheostomy tube once placed. Some surgeons might prefer to use a sterile one on the field.
    - If using an Anesthesia workstation ventilator, consider having the PEEP and Peak Inspiratory Pressures (PIP) settings programmed before transport of the patient to the OR
    - Consider transporting with an ICU Vent with RT to help transport patients with high PEEP or FiO_2.

  - Drugs/Infusions
    - Emergency medications
      - Epinephrine – low dose 1mcg/kg for treating bronchospasm and 10 mcg/kg dose for a code event.
    - Muscle relaxant
      - Rocuronium
        - May be appropriate to administer prior to transport from the ICU
          - Decreases the chance of the ETT being dislodged due to patient movement
          - Improves compliance to ventilation
            - Especially important in critical airways.
      - Discuss with the surgeon to see if they plan to do an airway evaluation with direct laryngoscopy/bronchoscopy that may require the patient to be spontaneously breathing.
    - Narcotics
      - Fentanyl- 1-2 mcg/kg titrated for analgesia and attenuate hemodynamic stress response
    - Benzodiazepine
      - Midazolam – Administer for transport prior to rocuronium
      - 0.03 -0.1 mg/kg bolus dose
    - Steroids
      - Dexamethasone (0.5 mg/kg)- max 10-20 mg per institutional preference- Decreases airway edema and also decreases PONV.

    - Maintenance – varying options per institutional preference. The goal is to maintain adequate depth and relaxation
      - Volatile agents – Sevoflurane or soflurane
      - Propofol – Infusion at 100-300 mcg/kg/min titrated to effect

        - A useful option when leaving the ICU vent connected in patients with high PEEP.
        - Upon completion, most ICUs will discontinue propofol and switch to alternate agents due to the risk of propofol infusion syndrome.
    - Dexmedetomidine – Infusion at 0.3-2 mcg/kg/hr in addition to a narcotic or inhalational agent. Preferred option for sedation after tracheostomy to take the patient back to the ICU
    - Ketamine- 0.5 -1 mg/kg bolus doses- additional bronchodilator effect

- Monitors
    - Standard American Society of Anesthesiologists (ASA) monitors
    - $ETCO_2$ – vital monitor, necessary to confirm $ETCO_2$ after trach placement.

- Blood Availability (if indicated)
    - Usually not indicated if starting hematocrit is normal
    - Consider if coagulopathy is present.

- ICU Bed Availability
    - Patients from the ICU will return to ICU sedated, paralyzed, and ventilated after tracheostomy
    - Strongly consider ICU for immediate post-op for early close monitoring and recognition of complications and trach care.

- Other Indicated Resources (ex. ECMO standby)
    - ECMO is rarely necessary. Consider if the ENT surgeon feels it could be very difficult anatomy and critical airway when no other means of ventilation would work.

Intraoperative Considerations:

- General
    - Transport
        - ***One of the most critical steps in the care of these patients***
        - Consider transport with ICU Vent in patients with high PEEP and FiO_2 requirements.
        - Have an extra person to help with transport. Respiratory therapists if transporting with ICU Vent (institutional practice might vary)
        - Administer a dose of benzodiazepine and paralytic agent prior to transport
    - Careful attention to ETT when surgeons position for trach. They typically use shoulder rolls. (see below)
    - Positioning and exposure of the neck anatomy can be challenging in neonates and small infants.
    - FiO_2 constraints
        - FiO_2 should be limited as tolerated to avoid airway fire. Keep FiO_2 as low as safely possible at the time of incision of the trachea.
        - Might be difficult to wean FiO_2 if critically ill. Discuss with the surgeon.
        - Increase FiO_2 to 100% just before insertion of tracheostomy (institutional practice might vary)

    - Removal of ETT

        - The surgeon will ask to deflate the cuff and pull back the ETT slightly when entering the trachea.
        - If a significant leak is present, $ETCO_2$ may be briefly absent
        - Withdraw the ETT slightly, keeping the tip below the vocal cords
            - This may be challenging in neonates and infants.
        - It might be necessary to re-advance ETT if the tracheostomy is not successful.
        - ***Remove the ETT, only after the confirmation of $ETCO_2$*** after connecting the circuit to the trach[1] and confirming with the surgeon.
        - Some might prefer to leave the ETT in the glottis until transport to the ICU
        - The surgeon may perform a flexible bronchoscopy from above to confirm the position of the trach.
    - Constant communication between the teams to confirm good $ETCO_2$ and adequate tidal volumes.

- Induction
    - Benzodiapine/Ketamine/Propofol + paralytic agent
    - Prior to transport for patients already intubated in the ICU
    - Modified induction might be necessary in a non-intubated patient with an anticipated difficult airway (spontaneous ventilation + Video laryngoscope/ Fiberoptic Bronchoscope)
    - Rarely, tracheostomy is done with supraglottic airway or deep sedation with spontaneous ventilation[5].

- Positioning
    - Supine with shoulder roll
    - Head placed on a gel/foam head support
    - The surgeon might tape the head in place to maintain extension
    - The face is usually covered with drapes in a small infant; have access to the airway under the drapes (to loosen the securing device, deflate the cuff, and withdraw the ETT).

- Maintenance
    - Medications as discussed above
    - Adequate paralysis

- Hemodynamic/Physiologic goals
    - Minimal FiO_2 to maintain adequate SpO_2.
    - Avoid hypoxia/hypercarbia as they can worsen Pulmonary HTN
    - Minimal interruption to ventilation to prevent loss of PEEP.

- Surgical Considerations (such as neuromonitoring, muscle relaxation, anticipated blood loss)
    - Exposure and access to the airway can be challenging in small infants and syndromic patients
    - Maintain adequate depth to prevent patient movement, cough, or bronchospasm.
    - Stay-sutures are placed on the trachea to prevent loss of airway. They should be labeled as right and left. The sutures are left in place and taped to help identify the airway in case of accidental decannulation.[1]

  - Chest X-ray might be done before leaving the OR to confirm position and rule out pneumothorax or pneumomediastinum (institution-specific preference)
  - A fiberoptic evaluation might be performed by the surgeon to confirm tracheostomy tube position (Institution-specific preference).

- Emergence/Disposition
  - Keep patients sedated and paralyzed
  - Transport back to ICU – Same precautions as above

- Post-op Care
  - Continue sedation in the ICU
  - IV narcotics for analgesia; IV acetaminophen as adjuvant
  - Have a spare trach at the bedside, one of the same size and another 1 size smaller.
  - Have reintubation equipment at the bedside if necessary to intubate from above.
  - Gentle trach care to avoid dislodgement.
  - The first trach change is usually done after 5-7 days under deep sedation or anesthesia.

Case-Specific Complications/Pitfalls

- Hypoxia
  - Interruptions in ventilation might not be tolerated well in patients with poor pulmonary reserve
  - Although the lowest FiO_2 is preferred, higher oxygen levels might be necessary for some patients
  - Prevent the loss of PEEP by minimizing interruption of ventilation.

- Bronchospasm
  - Likely with airway manipulation in a lighter plane of anesthesia
  - Paralysis with adequate depth decreases the incidence
  - Low threshold to treat with 1mcg/kg Epinephrine bolus.

- Dislodgement
  - ETT can be dislodged during transport
  - The tracheostomy tube can be dislodged any time after placement including during transport
  - A false tract may be opened when attempting to replace a dislodged fresh tracheostomy.[1-3]
  - Call ENT for help and reintubate from above if help is not available[7].
  - Institution-specific bedside charts and algorithms can be used to respond to tracheostomy emergencies[7].

- Pulmonary HTN crisis
  - Hypoxia and hypercarbia can worsen the pulmonary HTN
  - Minimize interruptions in ventilation
  - Nitric oxide and right heart inotropic support may be necessary.

- Airway obstruction
  - Mucus plugs can occlude the small airways of infants. Careful suctioning may be needed.
  - The size of the trach may cause problems.

        - Longer tracheostomy tubes may migrate endobronchially or may impinge against the anterior wall, and cause higher airway pressures.

- Pneumothorax/Pneumomediastinum
    - Higher risk in smaller children due to more cranial position of the pleura than in adults.[2,3]
- Bleeding
- Subcutaneous emphysema
    - Small collections may resolve spontaneously.
    - Might be necessary to verify the placement.
- Airway fire
- Granuloma formation is long-term issue.[3]
- Tracheal stenosis is also a long-term issue.[3]
- Tracheo-innominate fistula[6] and airway bleeding
- Fracture of cannula[8]

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