PERCUTANEOUS DILATIONAL TRACHEOSTOMY: A CONCISE CLINICAL REVIEW

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ABSTRACT
Percutaneous dilational tracheostomy (PDT) is a commonly performed procedure in any intensive care unit. We hope to provide a concise review of the basic anatomy, technique, indications, contraindications, and complications of PDT. PDT is now a long established procedure for most physicians caring for intensive care unit patients. Not all clinicians will be able to perform the procedure but everyone caring for these patients should be familiar with the technique, indications, and potential adverse effects.

BACKGROUND
Tracheostomy is a long established tool for physicians treating patients with respiratory failure. It is one of the oldest surgical procedures. Chevalier Jackson published his techniques of surgical tracheostomy in 1909. Prior to Jackson’s technique, mortality from the procedure was considered acceptable if 25% of patients survived. Open surgical tracheostomy (OST) was the dominant mode of tracheostomy in the 20th century till Ciaglia described the initial percutaneous technique in 1985. Percutaneous dilatational tracheostomy (PDT) provides a means for a less invasive technique to access the patient’s trachea. While the debate over timing to tracheostomy, patient selection, and technique continues, few will argue that a designated team of nurses, well trained physicians, and support staff are needed for a successful, safe, and efficient procedure to occur.

Anatomy
It is essential for all physicians performing tracheostomy to understand the basic anatomy of the neck. As the proceduralist approaches the patient’s neck the important anatomic features include the thyroid cartilage, cricoid cartilage, cricothyroid membrane, manubrium, sternal notch, internal carotid artery, and internal jugular vein, see Figure I. The tracheal length is approximately 10 to 13 cm with an anterior-posterior diameter of 1.8 cm. It begins approximately 1.5 cm below the vocal cords. However, variation in anatomy is common and several factors may alter the usual landmarks. For example, goiter, tracheal deviation, kyphoscoliosis, or obesity can alter the procedural approach. External visual cues and bronchoscopic recognition of important landmarks must be understood by both the proceduralist and bronchoscopist. As the bronchoscopist enters the endotracheal tube with the bronchoscope the carina, anterior trachea, subglottic shelf, cricoid cartilage should be identified. A coordinated step by step approach should be taken by both proceduralist and bronchoscopist in order to confirm proper positioning of the tracheostomy tube, avoid damage to equipment, and loss of control of the patient’s airway.

Patient Selection, Indications, and Timing
Patient selection criteria are similar for both approaches, PDT or OST. Patients with large goiter or tumor may be better served with a surgical tracheostomy given the difficulty identifying palpable landmarks.

Several different techniques have been developed using the percutaneous approach. A recent meta-analysis by Cabrini et al. compared different techniques for PDT. They evaluated whether multiple dilators, rotational dilation, retrograde tracheostomy, single step dilatation, or balloon dilation techniques was superior to one another. In their review the single step dilatation technique seemed to have fewer failures and mild complications compared to rotational dilatation, balloon dilatation, and guide wire dilating forceps.
General indications for tracheostomy include the need for prolonged ventilator weaning, management of respiratory secretions, failed extubation, enhanced patient comfort to facilitate weaning, and upper airway obstruction. Indications and contraindications are indicated in Table I and II. Contraindications can be divided into relative and absolute categories. Kornblith et al. recently reported a single center experience with bedside percutaneous tracheostomy. They retrospectively reviewed 1000 percutaneous tracheostomy within their surgical intensive care unit and found an average complication rate of 1.2% percent in normal risk patients and 1.7% in high risk patients. Their most common reported complication was misplacement of the tracheal tube and bleeding. Their study reported no deaths attributed to percutaneous tracheostomy. They concluded that PDT should be the new gold standard of care for patients being considered for tracheostomy.

Timing of tracheostomy has been a highly debated topic within the medical literature. Tracheostomy should be performed when endotracheal intubation is projected to be prolonged. A recent trial in the U.K. and U.S. (TracMan, http://www.tracman.org.uk) attempted to answer if there are any differences in patients receiving early or late tracheostomy. Patients were screened at 72 hours of intubation and if the clinician believed they would require mechanical ventilation beyond 14 days they were asked to participate in the study. Patients were randomized to an “early” vs. “late” tracheostomy group, with approximately 900 patients were enrolled in the study. The early group received a tracheostomy immediately, whereas the late group were delayed for at least 10 days. They found patient demographics to be similar in both groups. They concluded that the early tracheostomy group had fewer days of sedation, however, over half of the patients in the late tracheostomy group were either weaned and successfully extubated or died prior to 14 days. A major inadvertent finding of the study is that clinicians are poor predictors of who will require prolonged ventilation and intubation. A recent randomized controlled trial conducted in Italy compared two groups of ICU (intensive care unit) patients. They enrolled 600 adult ICU patients without lung infection after 24 hours of ventilation. Patients who had worsening respiratory condition, unchanged sequential organ failure assessment score, and no pneumonia at 48 hours were randomized into early (between 6 to 8 days of laryngeal intubation) and late (between 13 to 15 days of laryngeal intubation). Ventilator associated pneumonia and survival was no different between both groups. This study has led many clinicians to acknowledge that early tracheotomy likely will not lead to reduced ventilator associated pneumonia, shorter hospital stay, or lower mortality. Therefore, based on these two large randomized controlled trials our practice has been to only consider tracheostomy in medical ICU patients likely to fail extubation after at least 10 days of laryngeal intubation. At this time early tracheostomy can only be advocated for trauma patients based on class II data and recent guidelines published by the Eastern Association for the Surgery of Trauma. This Level II recommendation states that fewer days of mechanical ventilation will be needed and ICU stay will be shorter with early tracheostomy (within 5 days of injury).

Technique of PDT
Tracheostomy can be done with several different techniques. We will only discuss the percutaneous single dilator technique, which is the most common and widely accepted technique. A pre-procedure checklist with a trained procedural team is ideal as indicated in Table III. After informed consent is obtained and the procedure team is assembled, the patient is positioned with a towel roll between the scapula. The head and neck should be maintained in a midline position throughout the procedure to prevent inadvertent malposition of the tracheostomy. In the United States, standard universal protocol is mandatory to assure all necessary staff and personnel are present and agree. In most of these patients the technique assumes mechanical ventilation with a preexisting endotracheal tube. A laryngeal mask airway can be safely used in selected patients (i.e. patients with progressive neuromuscular disease requiring long term airway management). The patient should be evaluated for coagulation disorders and presence of uremia. If uremia is present we typically give a dose of intravenous 1-desamino-8-arginine vasopressin at 0.3 µg/kg one hour prior to start of procedure. PDT can be performed if the prothrombin time/international normalized ratio (INR) is <1.6 times control and the platelet count is >50,000.

The proceduralist identifies the appropriate landmarks. The patient is prepped and draped in sterile fashion. Topical anesthetic with 1% lidocaine with epinephrine is given within the subcutaneous tissue and pretracheal fascia. The
patient is premedicated with an intravenous narcotic and benzodiazipine or propofol. A paralytic agent may be
given to prevent coughing, unless otherwise contraindicated. The patient is preoxygenated with 100% oxygen and
the ventilator is placed on a set rate using either pressure or volume mode. Bronchoscopy is used for optimal
placement of the guide wire and immediate confirmation of tracheostomy placement into the airway. Recently,
ultrasound has been used as a possible means for guidance of PDT. Rajajee et. Al recently conducted a feasibility
study on 13 neurosurgical patients using ultrasound guidance as means for successful guide wire placement. They
subsequently confirmed guidewire placement using bronchoscopy and found ultrasound feasible, safely avoids
vital vascular structure with no cases of tube misplacement, pneumothorax, posterior wall injury, or significant
bleeding.

Optimal position of the tracheostomy should be between 10 o’clock and 2 o’clock between the 1st and 2nd or 2nd
and 3rd tracheal ring as indicated in Figure II. Bronchoscopy should be limited to confirm placement of guide wire
and tracheostomy, since bronchoscopy is thought to cause progressive hypercapnea and hypoxemia due to
transient obstruction of the endotracheal tube. Bronchoscopy is best utilized during the initial entry, for confirming
that the direction of the guidewire is distal in the trachea, and there is no inadvertent false tract entry. Lastly, it
allows suctioning of any peri-procedural bleeding or clots, and confirms final position of tracheostomy.

The most widely used technique is the single dilator method, which is described below. After proper patient
positioning, sterile prep and drape, topical anesthetic, intravenous sedation with analgesia, and a muscle relaxant,
a 1-1.5 cm incision is made guided by identified landmarks. The incision can be made horizontally or vertically at
the level between the 1st and 4th tracheal cartilaginous rings. A blunt dissection clamp can be used to gently spread
the pretracheal planes and palpate the tracheal rings. This clamp can also be used to apply pressure to the anterior
tracheal wall to confirm anticipated point of entry. First, the introducer needle is passed through the incision and
between the tracheal rings. The needle is attached to a saline or lidocaine filled syringe so that air bubbles can
be aspirated once inside the trachea. The bronchoscopist then confirms the point of entry. A guide wire is passed
into the trachea via the introducer needle. The introducer needle is then removed. A punch dilator is passed over
the guidewire creating the initial tract. A small catheter is then placed over the guidewire to prevent kinking of the
guidewire as the large dilator is inserted into the trachea. The tracheostomy tube is then preloaded onto a
dilator/loader and passed over the guidewire and catheter into the newly established tract. The endotracheal tube
is then removed followed by bronchoscopic intubation of the tracheostomy for final confirmation of positioning
within the trachea.

COMPLICATIONS OF PDT
The complications of PDT are similar to those of ST. We will highlight those complications, which are specific to
PDT. Complications most commonly reported are bleeding, infection, malposition, and stenosis. Death is rare from
tracheostomy and has been reported in 0 to 1.6% of cases. Complications should be categorized as early
or late. Often early is defined as within 48 hours of procedure, whereas late and long term complications are seen
within weeks of the procedure. Many early complications are self limited and require little or no intervention. Well
established surgical back up is important for any non-surgical proceduralist to insure patient safety and timely
intervention. Complications of PDT are highlighted in Table IV.

CONCLUSION
PDT is a safe and efficient procedure when performed by an adequately trained team of physicians, nurses,
respiratory therapist, and necessary assistants. Published guidelines from the American College of Chest Physicians
and the American Thoracic Society/European Respiratory Society have recommended a minimum of 20 supervised
procedures to be performed. The timing of tracheostomy will remain a challenge until we can better define
particular characteristics of those ICU patients who will require prolonged mechanical ventilation at the onset of
their initial respiratory failure.

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### Table I. INDICATIONS FOR PDT

- Prolonged mechanical ventilation: anticipated > 10 days
- Improved management of respiratory secretions
- Upper airway obstruction
- Enhance patient comfort and allow for weaning with reduction of sedation
- Failed extubation
- Reduction of extubation risk in a known difficult airway

### Table II. CONTRAINDICATIONS FOR PDT

#### Relative Contraindications
- Unstable cervical spine
- Prior neck surgery or radiation
- Extensive burns to the neck
- Morbid obesity (BMI > 40)
- FIO2 >60
- PEEP > 15
- Surgical wounds near planned site
- Large thyroid goiter or local malignancy at planned site
- Anatomic variations (severe tracheal deviation and superficial vasculature at planned site)
- Severe trachomalacia

#### Absolute Contraindications
- Infants
- Clinical instability
- Uncorrectable coagulopathy
- Significant infection at anticipated site
- Emergency airway access
- Patient unlikely to survive > 48 hours
- Unable to define and/or palpate tracheal anatomy after proper patient positioning
- Absence of informed consent
- Lack of operator training

### Table III. PROCEDURE TEAM AND PRE-PROCEDURE CHECKLIST

#### TEAM MEMBERS

- **Proceduralist**: Guides steps of procedure and assures safety of patient
- **Bronchoscopist**: Inspects airway, maintains control of airway, and familiar of necessary bronchoscopic landmarks
- **Bronchoscopy technician**: Provides all necessary bronchoscopic equipment
- **Bronchoscopy nurse**: assists bronchoscopist in management of endotracheal tube repositioning
- **Respiratory Therapist**: confirms patient ventilator settings and oxygenation
- **ICU Nurse**: provides continuous assessment of patient and provides necessary sedation, analgesia, and paralytics as needed

#### PREPROCEDURE CHECKLIST

- Consent signed
- Labs reviewed and medications reviewed
- Coagulopathies corrected
- Patient positioning
- Anticipates difficult airway
- Verifies ventilator settings