REVIEW ARTICLE

Percutaneous Dilatational Tracheostomy-An Intensivist's Art

Yatin Mehta, Mayank Vats, Pawan Suri

Introduction

Tracheostomies in the intensive care unit (ICU) are generally elective surgical procedures performed in already intubated patients in whom prolonged mechanical ventilation is expected (1). Various other indications of tracheostomy are tracheo-bronchial toilet, patient's comfort, risk of laryngeal injury and to provide oral feeds /oral hygiene.

Traditionally surgical open tracheostomy (ST)-performed by a surgeon in the operating room has been the procedure of choice. More recently Percutaneous Dilatational Tracheostomy (PDT) technique-a bed side procedure which can be performed by many trained specialists is becoming increasingly popular. PDT consists of percutaneous needle puncture of the trachea, followed by stepwise (Ciaglia technique) or one-stage (Grigg's technique) dilatation and placement of a tracheostomy tube.

Personnel and Equipment

Minimal personnel requirements include an experienced operator and an assistant to handle endotracheal tube and to monitor ventilatory and oxygenation requirements. He may also perform bronchoscopic control. All personnel should be proficient in airway management and to tackle acute airway complications.

Commonly used drugs in ventilated patients usually can achieve sufficient sedation and analgesia.

In most adult patients, ≥8F tracheostomy tube can be used. Tube size may be individualized according to patient. Two types of PDT kits are commercially available for Ciaglia technique-(a) curved dilators (Cook Inc, Bloomington, USA) (b) straight dilators (SIMS, Inc, Keene, USA). With both types of dilator sets, a flexible tracheostomy tube with a conical tip, is preferred (e g. Shiley PERC Mallinckrodt Inc. USA).

A flexible tracheostomy tube with tapered end is provided in the kit for Grigg's technique. (SIMS Portex Ltd. Hythe, UK).

PDT Technique

Patient should be supine, with the head extended (a pillow under the shoulders), properly anaesthetized, sedated and pre oxygenated (FiO_2 =1.0) with vigilant cardiac and oxygenation monitoring. After preparing and draping operative area, identification of the thyroid and cricoid cartilage is done.

The assistant loosens the fixation system of the in-situ endotracheal tube, deflates the cuff and changes ventilator settings as required to compensate for air leak. The endotracheal tube is then slightly withdrawn (under direct visualization via flexible bronchoscope or with direct laryngoscope) until the tip of the deflated cuff is just below the vocal cords. The assistant should hold the tube firmly to prevent inadvertent premature extubation and the cuff is reinflated.

After adequate 2% xylocaine infiltration in skin and subcutaneous tissue by 22-24 G needle, a horizontal incision (1.5-2cm) is made above the 1^{ST} or 2^{ND} tracheal cartilage. With the left hand, operator stabilizes the trachea, a 12- or 15– gauge needle is inserted at the anterior midline, between the 2nd or 3^{rd} tracheal ring preferably under bronchoscopic observation (12'0 clock position) by an assistant, thus avoiding paratracheal needle insertion, injury to the posterior tracheal wall or endotracheal tube and cuff damage. During the procedure, the bronchoscope should be inserted temporarily, to avoid decreased minute ventilation or hypoxia.

Aspiration of free air bubbles in the syringe confirms the intra tracheal location of needle; about 3-5 ml (2%) xylocaine is then injected into the trachea to abolish cough reflexes during rest of the procedure. A flexible, guide wire (0.05J) with its curve facing the distal trachea is introduced through the needle. The intra-tracheal distal orientation of the guide wire is confirmed by the bronchoscope. The needle is then withdrawn, and any of the under described techniques can be followed:-

From The Department of Anesthesiologyy & Critical Care, Escorts Heart Institute and Research Centre, Okhla Road, New Delhi.
Correspondence to: Dr. Yatin Mehta, Director, Department of Anesthesiology & Critical Care, EHIR, Okhla Road, New Delhi-110 025.

Ciaglia (Progressive Dilation) Technique (2)

An 8-Fr guiding catheter is introduced into the trachea over the guide-wire. While using the curved dilators, dilatation is done over this 'double guide' to prevent kinking of dilator resulting in tissue trauma. The straight dilators are introduced at an angle of 90 degree to the skin and advanced with a rotating movement until a band mark is reached. Dilatation is to be started with a 12Fr dilator, positioned accurately according to the guiding marks. The whole assembly is advanced as a single unit to the skin position mark on the dilator.

Dilators of gradually increasing size are then inserted and removed. For a 8mm tracheostomy tube dilatation with 36 Fr dilator is sufficient Slight over-dilation ensures passage of a 6,7, or 8-mm tube.

The tracheostomy tube with its cuff deflated and lubricated is preloaded and positioned on the proper-sized lubricated dilator. The appropriate dilator carrying the tracheostomy tube is threaded over the double guide to the proper position (guiding marks) and the assembly is inserted as a unit into the trachea up to the flange of the tracheostomy tube.

After insertion and bronchoscopic visualization of the tracheostomy tube, the guide wire, dilator and endotracheal tube is removed. Bronchoscopic visualization via the tracheostomy tube confirms the position of the tip of the tracheostomy tube and tracheo-bronchial toilet with suction of blood can be done. The tracheostomy tube is secured with tape, and antiseptic dressing is applied to the stoma. Immediately after tracheostomy, ventilator with 100% Fio2 is connected to the tracheostomy tube.

Whole procedure takes about 5-10 minutes (from needle puncture up to the placement of tracheostomy tube). A chest radiograph after the procedure is mandatory to detect the presence of any barotraumas, aspiration atelectasis (e.g. by blood clots) or any other pulmonary abnormality resulting from the intervention.

Grigg's (Rapid Dilatation) Technique (3)

Grigg's (Rapid Dilatation), PDT Kit (SIMS Portex Ltd,) includes guide wire, dilators and specially designed Grigg's dilating forcep.

The initial steps of Grigg's technique are same as that of Ciaglia's technique. Once the guide-wire is introduced in to trachea the dilating forcep is threaded over the guide-wire and introduced through the anterior tracheal interspace (with bronchoscopic confirmation of intratracheal position) and opened gently after tilting the handle towards the head of the patient, so that the tips lie inside and parallel to the tracheal wall to dilate the tracheostomy site, and sufficiently to accept the tracheostomy tube.

The dilatation is done in two steps. In the first step the dilating forcep dilates only the pre tracheal tissue with the tips of Grigg's forceps remaining at right angle to the anterior tracheal wall. Then the tips are pushed through the anterior tracheal wall. Once the stoma of adequate size is made, the dilating forceps is removed, and the selected tracheostomy tube, fitted on a plastic trocar, is slided over the guide-wire into the trachea with lubricated and deflated cuff, under bronchoscopic control. The trocar and guidewire are removed, the cuff inflated, the endotracheal tube withdrawn and the tracheostomy tube is secured.

Although less commonly used, this technique is equally safe and more rapid as compared to the Ciaglia technique. It is also cheaper and the Grigg's forcep can be sterilized and reused.

We are using an intermediate technique under bronchoscopic supervision of tracheal puncture followed by dilatation with 2-3 sized dilators. A mosquito's forcep is introduced followed by grigg's forcep to dilate the stoma and placement of tracheostomy tube. After placement of tracheostomy tube, confirmation of its position and aspiration of blood done by bronchoscopic visualization, hence enhancing the safety of procedure.

Indications for PDT

- Intubated patients in whom prolonged mechanical ventilation is expected
- Tracheo-bronchial toilet,
- Patient's comfort,
- Risk of laryngeal injury
- Provide oral feeds /oral hygiene.

Contraindications for PDT

Absolute

- Hemodynamic instability
- Infection/cellulites of neck,
- Previous tracheostomy or neck surgery/anatomic distortion, (e.g. thyromegaly, tumor, dislocated course of the trachea),
- Cervical vertebrae injury/fracture

Relative

- Age < 14 years,
- Emergency situations,
- Coagulopathy (quick<40%, PTT>120sec, total platelet counts <10,000 µl
- Difficult neck (extremely obese or extremely long),
- High ventilatory/oxygenation requirements (PEEP>15cm H_2O, FiO_2=1.0).

Complications of PDT

Procedural

- Bleeding
- Paratracheal insertion, Tracheal wall tear / rupture
- Tracheoesophageal fistula,
- Barotrauma,
- Cardiac arrhythmias/ hypotension/ transient O2 desaturation/ hypercarbia
- Loss of airway, Death,

In situ

- Bleeding
- Stomal infection
- Tube displacement/ early decannulation
- Tube obstruction, Cuff leakage
- Tracheal erosion,/Tracheoesophageal fistula,
- Atelectasis
- Death

Post-Decannulation

- Cosmetic deformity,
- Subglottic/Tracheal stenosis,
- Tracheal granuloma, Trachemalacia, Voice change.

Discussion

PDT is a bedside tracheostomy technique that consists of percutaneous needle puncture of the trachea followed by stepwise or one time dilatation of and placement of tracheostomy tube. Modern surgical tracheostomy (ST) was introduced by Jackson in the early 1900 (4).

With the advent of modern ICU's, now a day the chief indication for tracheostomy is for patients requiring prolonged mechanical ventilation. As surgical or conventional tracheostomy carries a high risk of perioperative and postoperative morbidity there has been consistent inclination towards the development of new less invasive technique of tracheostomy.

Since 1950, various per cutaneous tracheostomy techniques have been described with varying results and complications. PDT as originally described by Shelden et al in 1955 involved a blind cannulation of the trachea with a bladed instrument that holds the tracheostomy tube (5). In 1969, Toy and Weinstein proposed another percutaneous approach using Seldinger technique. Their device contained an instrument, similar to Shelden's apparatus (6). Schachner and co-worker used a specially designed tracheal spreader (Respitrach, Sydney, Australia). This spreader is advanced down the wire in to the trachea and enlarges the puncture site to insert a tracheostomy tube (7).

These techniques have failed to achieve wide acceptance because of their inherent risk of false passage and tracheal damage.

Ciaglia (1985) performed extensive work on PDT and developed a new technique of tracheostomy with serial dilators (2). Schachner *et al* (1987) used a dilating forceps over a guide wire in place of serial dilators. Later on Griggs *et al* (1990) advocated the use of a modified Kelly forceps over a guide wire for the facilitation of stomal dilatation (7).

With the new trend towards performing early tracheostomy in patients requiring prolonged mechanical ventilation and considering the risk benefits of conventional tracheostomy there has been increased use of PDT in modern ICU's. Many large scale, randomized, case controlled trials comparing the efficacy, cost, risk and complications have favored the use of PDT in ICU's. However the high rates of complications associated with surgical tracheostomy is biased by the fact that these data deal with mixed population in the study group.

In a large prospective study conducted by Boulus *et al* including 141 cases of PDT (120-bedside, 21-O.T.) the complication rates was 11%(16/141) and most complications were easily recognized and did not preclude the completion of PDT .The postoperative complication rate was 8% (most common being peristomal oozing). They followed patients for an average period of 36±27 weeks and found only 3 cases of clinically symptomatic tracheal stenosis (8).

Hazard *et al* in a comparative randomized trial reported complication in 45.8 % of operative tracheostomy and 12.5% of PDT. Delayed stomal healing, subglottic stenosis and cosmetic deformity were common after ST (88%) than PDT (22%) (9), whereas Crofts et al found no significant difference in the incidence of complication in both groups (10). Leinhardt et al in comparative study did not find any difference in complications rates but noted that PDT could be performed more quickly and did not require patient's transport to O.T (11).

Minimal bleeding during the procedure is almost inevitable. Petros *et al* defined minimal, moderate and severe bleeding as blood loss of <50ml, 50-100ml and >100 ml respectively. Moderate aspiration of blood was defined as occlusion of segmental bronchi with blood or coagula without resultant reduction of SpO2, whereas severe aspiration was defined as major bronchus occlusion resulting in hypoxia. They found that in most cases bleeding stopped by manual compression or by

tracheostomy cannula .Aspiration of blood was cleared by bronchoscpic suction in their study . They found only 3 cases of barotraumas out of 137 cases in whom PDT was performed and in all cases it subsided spontaneously (12).

Peristomal bleeding (2% - 6%) was the most frequent postoperative in-hospital complication in different studies. (2, 8, 9) Holgaard and coworker encountered minor bleeding in PDT (n=6) and ST (n=24) ($p<0.01$), and stomal infections significantly higher in ST group ($p<0.01$) (13).

PDT is superior to ST, as it has a lower overall post procedural complication rates.The absence of wound/ stomal infection and minimal bleeding in PDT is clinically significant. Minimal bleeding is due to minimal tissue disruption and tamponading effect of the tight fit of the dilators and tracheostomy tube. Minimal tissue disruption and consequent decreased exposure of raw skin surface is the likely reason for decreased incidence of infection and it may also be the reason for the clinically significant more rapid and cosmetically better stomal closure.

Recently, with widespread availability of fibreoptic bronchoscope, many complications of PDT, related to para-tracheal insertion, tracheal wall tear, tracheo-esophagial fistula etc. could be prevented. In this method flexible bronchoscope is inserted through endotracheal tube to visualize appropriate site of puncture needle, guide wire, dilator and tracheostomy tube, to identify venous circulation on the site of needle puncture by transillumination (14), to help prevention of injury to posterior tracheal wall and to clean up the blood after tracheostomy either through tracheostomy tube or endotracheal tube.

Marrelli and Paual introduced endoscopic guidance while performing PDT (15). Winkler et al advocated that the use of flexible bronchoscope during PDT is safe to avoid posterior tracheal wall injury (16).

Carlos *et al* concluded that with bronchoscopic guidance, paratracheal tube insertion, risk of barotrauma and posterior tracheal wall injury could be avoided which are more common in PDT as compared to ST. They also concluded that the critical point of procedure (i.e. needle and guide wire insertion) could be easily performed under endoscopic supervision by less experienced surgeon and it can also be used in obese, thick cervical tissue and patient with stiff neck (unable to hyperextend the neck) which otherwise are contraindications of PDT and they recommended PDT under flexible bronchoscopic guidance as a procedure of choice for an ICU patient requiring elective tracheostomy (17).

We, at our center are also exclusively using bronchoscopic guided technique for PDT and have observed no complication pertaining to wrong insertion of tracheostomy, tube and, after tracheostomy we used to clear the airway through tracheostomy tube or endotracheal tube by bronchoscopic suction simultaneously.

Kollig *et al* combined ultrasonography (USG) before procedure to avoid injury to thyroid gland or subcutaneous vessels and bronchoscopic surveillance during the procedure hence enhancing the safety of the procedure and minimizing complications (18).

PDT can be performed more expeditiously as compared to ST. Hazard *et al* reported an average placement time of 4.3 min (9). In other studies average procedure time was 15 minutes (8) and 12.8minutes (12).

The cost of PDT has been reported to be less than ST (29 39, 40), which is important in today's cost containment era. Cobean et al analyzed cost effectiveness of PDT and found savings of $1645 (95% C.I. $ 1492-$ 1798) per tracheostomy done by PDT technique (19). Bowen et al also had same conclusions (cost per PDT - $ 1753, ST - $ 2604). ST requires, more costly logistics in the O.T. since several departments need to cooperate (Anaesthetist/ Surgeon/ operating staff), which can practically be neglected in PDT (20).

PDT is definitely superior to ST, as operation theatre (OT) time needs not to be scheduled. PDT can be performed sooner once the decision to do a tracheostomy is made hence cutting short the time interval between decision making and procedure leading to better results and more secured airway. ICU utilization may be improved (21), the earlier tracheostomy insertion may allow more aggressive and potentially more rapid weaning or earlier transfer of the patient with a more secure airway.

Post cardiac surgery PDT is considered a relative contraindication due to sternotomy but, we in fact find it advantageous as the incision is small and the site is little higher i.e. away from the sternum cf ST and therefore probably less chances of sternal wound infection. Also, doing it bedside in ICU is easier considering the logistics involved in shifting these sick patients with multiple central/ monitoring lines and other equipments.

Because this swift and simplified technique is situated in the 'gray zone' between surgeons and physicians that's why surgeons frequently argue against PDT performed by intensivists, anaesthetists, pulmonologists, although intrinsically logical but this implies that no cardiologist should perform angioplasty, no pulmonologist should perform closed tube thoracostomy and no gastroenterologist should go for endoscopic polypectomy (1). These all are myths and anybody who is perfect in handling the emergent complications associated with PDT can perform it, may it be intensivist, anesthetist, or pulmonologist. PDT does have an operative learning curve and should be performed by physician trained in the technique. As, it is a Seldinger technique, and most intensivists could be trained in this procedure. For all of these reasons, we believe that PDT is the procedure of choice for most patients in the ICU who need a tracheostomy and this can be easily performed by an intensivist.

Conclusion

PDT is a safe bedside ICU procedure in experienced hands, and may – due to its relative simplicity, safety and bedside performance – influence optimal airway management strategies in the future. However, a cautionary note is essential; the simplicity of a procedure should never lead to its misuse. As surgical colleagues say-No surgery is simple, these are only simple-minded surgeons.

References

1. Noppen M. Percutaneous Dilatational Tracheostomy. In: Bollinger CT, Mathur PN (eds) Interventional Bronchoscopy. Prog. Resp Res Basel, Karger 2000; 30, pp 215-25.
2. Ciaglia P, Firsching R, Syniecc. Elective percutaneous tracheostomy: A new simple bedside procedure. Preliminary Report. *Chest* 1985; 87: 715-19.
3. Grigg WM, Worthley LI, Gilligan JE *et al*. A simple percutaneous tracheostomy technique. *Surg Gynaecol Obst* 1990; 170: 543-45.
4. Jackson C. Tracheostomy. *Laryngoscope* 1919; 19: 285-90.
5. Sheldon CH, Pudenz RH, Tichy FH. Percutaneous tracheostomy. *JAMA* 1957; 165: 2068-70.
6. Toy FJ, Weinstein JD. A percutaneous tracheostomy device. *Surgery* 1969; 65: 384-89.
7. Schachner A, Ovil Y,Sidi J *et al*. Percutaneous tracheostomy – A new method. *Crit Care Med* 1989; 17: 1052-57.
8. Boulus T. Thomas NZ, Paul AK. Percutaneous tracheostomy: report of 141 cases. *Ann Th Surg* 1994; 57: 862-867
9. Hazard P, Jones C, Benitone J. Comparative clinical trial of standard operative tracheostomy with percutaneous tracheostomy. *Crit Care Med* 1991; 19: 1018-24.
10. Crofts SL, Alzeer A, McGuire GP *et al*. A comparison of percutaneous and operative tracheostomies in tntensive care patients. *Can J Anaesth* 1995; 42: 775-79.
11. Leinhardt DJ, Mughal M, Bowles B *et al*. Comparision of percutaneous tracheostomy and operative tracheostomy. *Chest* 1996; 110: 480-85.
12. Petros S, Engelman L. Percutaneous tracheostomy in a medical ICU. *Int Care Med* 1997; 23: 630-34.
13. Holgaard HO, Pedersson J, Jenson RH *et al*. Percutaneous tracheostomy vs conventional tracheostomy: A clinical randomized trial. *Act Anaesth Scand* 1998; 42(5): 545-50.
14. Fernando C, Joao LFC, Plinio G. Endoscopic guided percutaneous tracheostomy: Early experience of a prospective trial in critical care. *Chest* 1997(Supp.)112/3/1S
15. Marreli D, Paul A, Manolidis S *et al* –Endoscoic guided percutaneous tracheostomy: Early results of a consecutive trial. *J Trauma* 1990; 30: 433-35
16. Winkler WB, Karnik R, Seel Mann *et al*. Bedside percutaneous tracheostomy with endoscopic guidance: Experience with 71 ICU Patients. *Int Care Med* 1994; 20(7): 476-79.
17. Carlos AB, Peter BA, Donald RK *et al*. Bronschopic guidance makes percutaneous tracheostomy a safe, cost effective and easy to teach procedure. *Surgery* 1995; 118: 879-83.
18. Kollig E, Heydenreich U, Roetman F *et al*. Ultrasonography and bronchoscopic control percutaneous tracheostomy on trauma ICU. *Injury* 2000; 31: 663-68.
19. Cobean R, Beals M, Moss C *et al*. Percutaneous Tracheostomy-A safe, cost effective, bed side procedure. *Arch Surgery* 1996; 131(3): 265-71.
20. Bowen CP, Whitney LR, Trowit JD *et al*. Comparison of safety and cost of percutaneous tracheostomy vs surgical tracheostomy. *Am Surg* 2001; 67(1): 54-60.
21. Rodrignez JL, Stcinberg M, Ivonetti FA. Early tracheostomy for primary airway management in the surgical critical care setting. *Surgery* 1990; 108: 665-69.