

# Percutaneous Tracheostomy — A Review

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## HISTORY

“A senseless, frivolous invention of Asceplades” and “A suitable punishment for a sinner in the depths of the inferno” are two of the ways a surgical tracheostomy has been described.<sup>1</sup> This ancient procedure was practiced in India and Egypt around 3000 BC. By the Renaissance, the technique had been refined and its reputation had improved. In the 17th century, Fabricius commented, “This operation redounds to the honour of the physician and places him on a footing with the gods”.<sup>1</sup> The modern surgical technique was described by Chevalier Jackson in 1909 and has undergone very few modifications since.<sup>2</sup>

Tracheostomy was the prerogative of surgeons and usually performed in the operating room, until recently, but the introduction of “percutaneous dilatational tracheostomy” has moved it into the realms of anaesthetists and intensivists. This concept was first introduced by Sheldon in 1955<sup>3</sup> and stimulated by Toye and Weinstein in 1969.<sup>4</sup> Their techniques created a passage using instruments combining dilatation and incision of tissues. Although effective, the procedure fell into disrepute following early complications, notably perforation of the posterior tracheal wall. The introduction by Ciaglia in 1985<sup>5</sup> of the technique using multiple dilators made it possible for anaesthetists and intensivists to perform the procedure in the intensive care unit.

In 1990, Schachner<sup>6</sup> described a technique using a device which slid into the trachea over a metal guide wire. When opened, the device resulted in dilatation of the intercartilaginous space allowing placement of a tracheostomy cannula. In the same year, Griggs modified a Howard Kelly forceps, allowing it to be passed over a guide wire and to be used as a blunt dilator to create a tracheostomy stoma.<sup>7</sup> Fantoni, building on his experience in dilatation of tracheal stenosis in children, fashioned a unique tracheostomy tube with an integral dilator, the basis of the translaryngeal tracheostomy technique<sup>8</sup> introduced in 1997. A modified version of the Ciaglia multiple dilator technique was introduced in 1999, the “Ciaglia Blue Rhino”. This allows one-step dilation by means of a curved dilator with a hydrophilic coating.

## TECHNIQUES

At the time of writing, there are four commercially available tracheostomy kits: Ciaglia multiple dilators (Cook), Blue Rhino (Cook), Griggs forceps (Portex, Boots) and Fantoni’s translaryngeal technique (Tyco Healthcare).

All percutaneous dilatational tracheostomies are performed on anaesthetised, paralysed and ventilated patients after adequate preoxygenation. The thyroid cartilage, cricoid cartilage and suprasternal notch are identified and the tracheostomy is introduced between the first and second, or second and third tracheal rings.

### **Ciaglia and Griggs techniques**

The initial steps of these techniques are similar and will be described together. The intended site of the stoma is prepared and draped and lignocaine and adrenaline injected locally. The existing endotracheal tube is withdrawn so that the cuff is positioned above the vocal cords and a seal achieved by hyperinflation. An assistant should hold the endotracheal tube in this position.

#### *Cook multiple dilator*

The Cook kit consists of a short 11F dilator, an 8F guiding catheter, and six dilators from 12F to 36F.<sup>5</sup> After skin incision and initial dilatation with the 11F short dilator, the guiding catheter is introduced over the wire, maintaining a ridge on the catheter at skin level, thus making a double guide system. Progressively larger dilators (12F to 36F) are passed over this double guide, to dilate the soft tissues and trachea. A tracheostomy tube mounted over an appropriate sized dilator, is then inserted over the guiding catheter, through the stoma and secured.

#### *Cook "Blue Rhino"*

This kit consists of the 11F short dilator, the 8F guiding catheter, and a single dilator ("Blue Rhino") to dilate up to 38F. This is coated with a hydrophilic coating, which greatly facilitates the introduction of the instrument. Three introducers are also provided to insert an appropriately sized tracheostomy tube. The procedure is the same as with the other Cook kit, with the "Blue Rhino" inserted over the double guide system. It is advanced until the 38F mark is at the skin. Once removed, a tracheostomy tube mounted over an appropriate sized introducer is inserted over the guiding catheter, through the stoma and secured.

#### *Griggs*

The Portex kit consists of a short 14F dilator, guidewire dilating forceps (modified Howard Kelly clamps) and tracheostomy tube mounted on an obturator.<sup>7</sup> After initial dilatation with the 14F short dilator, the closed dilating forceps are introduced over the guidewire into the subcutaneous tissues, opened and removed. The procedure is repeated until the anterior tracheal wall is reached. The closed forceps are then advanced into the trachea, indicated by a loss of resistance. The handles are raised to align the jaws in the long axis of the trachea, the forceps opened to dilate the anterior tracheal wall and then removed. The tracheostomy tube assembly is then introduced over the guide wire into the trachea. With the guidewire and obturator removed, the tracheostomy tube is secured.

With these three procedures, the routine use of an end-tidal CO<sub>2</sub> monitor and intra-procedural bronchoscopy to confirm proper placement of the tracheostomy tube are recommended.<sup>9</sup>

### **Fantoni technique**

For this technique, airway control and ventilation are maintained using a small bore ventilation tube with its cuff inflated between the proposed stoma site and the carina.

A curved needle is introduced into the trachea, under bronchoscopic control, and a guide wire is advanced cranially into the oropharynx. A special tracheostomy tube with an integral dilator is then attached to the oral end of the guide wire and traction applied at the neck end. As it is drawn down and out, this tube pierces and dilates the anterior tracheal wall and paratracheal tissues in a retrograde manner. A 2-3 mm incision is necessary to assist it to perforate the skin. The integral dilator is cut off from the rest of the tracheostomy tube, which can then be straightened, rotated and passed caudally to its final position using a special obturator. The tube is secured in place and its position verified with a bronchoscope.

## PERCUTANEOUS v SURGICAL TRACHEOSTOMY

**Table 1**  
Reasons for developing percutaneous tracheostomy

Complications with surgical technique
Avoid transportation of critically ill patients within the hospital
Quicker to organise and perform
Cost

There have been a number of reasons for the development of the percutaneous techniques (Table 1), but the benefits of percutaneous over surgical tracheostomy, have not been conclusively proven. To date, there have been nine studies<sup>10-18</sup> and three meta-analyses<sup>19-21</sup> comparing the two techniques. The studies are summarized in Table 2 and the meta-analyses in Table 3. It should be borne in mind that most of the studies

**Table 2**  
Studies comparing percutaneous and surgical tracheostomy

Author	Technique	Procedures (no.)	Operative complications (%)	Bleeding (%)	Post op complications (%)	Infection
Melloni <sup>11</sup> 2002	Ciaglia	25	8	8	4	0
	Surgical	25	0	0	36	28
Westphal <sup>18</sup> 1999	Ciaglia	40	12.5	2.5	2.5	0
	Fantoni	40	0	0	0	0
	Surgical	40	12.5	2.5	35	35
Porter <sup>16</sup> 1999	Ciaglia	12	42	0	0	0
	Surgical	12	8	0	0	0
Holdgaard <sup>15</sup> 1998	Ciaglia	30	63	20	23	10
	Surgical	30	87	87	100	63
Graham <sup>17</sup> 1996	Ciaglia	31	na	na	61	na
	Surgical	29	na	na	58	na
Friedman <sup>14</sup> 1996	Ciaglia	26	35	13	12	0
	Surgical	27	41	11	41	15
Crofts <sup>13</sup> 1995	Ciaglia	25	na	na	25	0
	Surgical	28	na	na	36	4
Griggs <sup>12</sup> 1991	Griggs	153	na	na	3.9	na
	Surgical	74	na	na	18.9	na
Hazard <sup>10</sup> 1991	Ciaglia	22	na	na	12	4
	Surgical	25	na	na	36	28

**Table 3**  
Meta-analyses of studies comparing percutaneous and surgical tracheostomy

Author	Studies (no.)	Patients (no.)		Duration (mean mins)		Peri op complications		Post op complications		Superiority percutaneous
		PDT	SCT	PDT	SCT	PDT	SCT	PDT	SCT	
Dulguerov <sup>19</sup>	48	1817	3512	11.7	26.9	56	8.8	38	27	Inconclusive
Freeman <sup>20</sup>	5	115	121	9.85	22	46.6	45.3	18	55.7	Some advantages
Cheng <sup>21</sup>	4	103	109	8	20.9	48.2	63.1	14	60	Safer procedure

looking at percutaneous tracheostomy excluded patients with distorted anatomy, neck trauma, morbid obesity, difficult airway, or marked coagulopathy. These are accepted as relative contraindications to percutaneous tracheostomy. Surgical tracheostomy is the procedure of choice for these patients.

There is considerable variation in definitions and reporting of complications during the procedure that may partly be responsible for ambiguous results. Quantifying the severity of bleeding also varies amongst the studies. However, percutaneous tracheostomy appears to have a higher incidence of perioperative complications, especially cardiorespiratory events,<sup>9</sup> but postoperative bleeding and stomal infections are less common.<sup>19,20</sup>

There are few comparative studies of long term complications, including tracheal stenosis. Melloni et al<sup>11</sup> followed up a subgroup of 28 patients for six months with clinical evaluation and videobronchoscopy study at the end of that period. There were no late tracheal complications in the surgical tracheostomy group. Two patients in the percutaneous dilational (PDT) group (n=15) developed long term problems. Tracheomalacia with airway collapse on expiration was observed in a patient who had dyspnea only on exertion. No surgical correction was needed. The second patient failed a trial of decannulation and was shown to have a >50% tracheal stenosis. These authors proposed a classification of endoscopy findings to distinguish between granulomatous and fibrous stenosis, as the treatment of these are different. On the other hand Hazard et al<sup>10</sup> identified seven patients with tracheal stenosis, using a radiological follow up. Five of these had a surgical procedure (n=8), while two had undergone a percutaneous procedure (n=11). With such findings it is unclear whether either technique results in fewer long term complications.

Thus it appears that the speed and ease with which percutaneous tracheostomy can be organised and performed in the ICU, and the elimination of the need to transport critically ill patients out of the ICU environment appear the main reasons for the increasing use and popularity of the non-surgical approach amongst ICU physicians.

### WHICH PERCUTANEOUS TRACHEOSTOMY?

There have been very few studies comparing the various techniques of performing PT. The Ciaglia and Griggs techniques are the most commonly used and have been most frequently compared in the literature. Unfortunately, not all are randomized studies and it is very difficult to have such studies blinded. Bronchoscopy was not a standard in all studies. More importantly, none of the studies was of adequate power

to show a difference in any of the complications, given their relatively low incidence.

Van Heerden et al<sup>2</sup> compared the Ciaglia and Griggs techniques in a serial manner in 54 patients. They used bronchoscopic guidance in the first 15 patients and then only in patients with difficult landmarks. There was no statistically significant difference in the complication rates in the two groups (6/29 for Ciaglia method and 6/25 for Griggs). The first tube change was more difficult in the Ciaglia group. Another study comparing the Griggs and Ciaglia techniques<sup>23</sup> in 80 patients did not show any major complications with either. In a prospective, randomized trial with one hundred patients, Nates et al<sup>24</sup> reported a higher rate of perioperative haemorrhage with the Griggs rather than the Ciaglia technique (25% vs 2%). Anon et al<sup>25</sup> prospectively studied the Ciaglia technique in 25 and the Griggs technique in 38 patients. Neither intraoperative (12% Ciaglia group and 13% in the Griggs group) nor postoperative complications (12% vs 10%) were statistically different. Thus it seems from the limited data that there is little difference in the complication rates of these methods.

A study by Leinhardt et al<sup>26</sup> compared the Rapitrac kit (a kit based on the Schachner system,<sup>6</sup> and no longer available), the Ciaglia method and conventional surgical tracheostomy. This showed an unacceptably high complication rate in the Rapitrac group (4/5 cases) as compared to Ciaglia (3/20 cases) and conventional surgical tracheostomy (2/16 cases). There were three cases of cuff leak in the Rapitrac group, necessitating an immediate tube change, two episodes of paratracheal insertion of the tube, and one of tube blockage and bilateral pneumothorax. Apart from three cases of minor skin edge bleeding, there were no major complications in the PT group. In the 16 patients who had a conventional tracheostomy, there was one episode of tube occlusion and misplacement and two cases of wound infection.

The Fantoni trans laryngeal technique (TLT) has theoretical advantages in patients with difficult or abnormal anatomy, and coagulopathies.<sup>27</sup> Walz et al<sup>28</sup> presented the first prospective randomized trial comparing it with the Ciaglia method. They found both techniques to be fast and safe in performance. Although there was a rise in the  $P_aCO_2$  during the TLT method, it must be emphasized that they used the apnea method rather than ventilating through the microlaryngeal tube provided. Despite this, there were no episodes of hypoxia in either group. Another study compared the Ciaglia, Fantoni and surgical techniques in 120 post cardiac surgical patients.<sup>18</sup> The perioperative complication rate was 12.5% for the Ciaglia and surgical techniques, but there were no complications in the TLT group. A 35% infection rate was noted in the surgical group, with none in the other two groups. In a prospective comparison by Westphal et al, apart from reporting a few technical difficulties, the Fantoni technique was found to be as safe as the Ciaglia and maintained a higher  $P_aO_2/FiO_2$  ratio during the procedure.<sup>29</sup>

The “Blue Rhino” is a recent addition to the kits available on the market. A prospective randomized trial of 25 patients in each arm compared the Blue Rhino with the Ciaglia multiple dilator set.<sup>30</sup> The Blue Rhino was quicker to perform (3 v 7 min). There were 11 (44%) complications with it as compared to 7 (28%) with the multiple dilator method. Three complications associated with the latter technique were life threatening (two posterior wall injuries, one pneumothorax).

Neither the Blue Rhino nor the Fantoni methods have been studied as extensively as the Ciaglia. More comparative studies need to be published before any recommendations can be made. A summary of the advantages and limitations of the commonly available techniques is shown in Table 4.

**Table 4**  
Advantages and limitations of commonly used techniques for percutaneous tracheostomy

Technique	Advantages	Limitations
Ciaglia (Multiple Dilators)	<ul style="list-style-type: none"> <li>• Seldinger technique</li> <li>• Repetitive steps</li> <li>• Widely practised and taught</li> <li>• Serially larger dilators help tamponade bleeding</li> </ul>	<ul style="list-style-type: none"> <li>• Risk of damage to posterior tracheal wall exists with passage of each dilator</li> <li>• Technique necessitates overdilatation and insertion of a smaller trache tube</li> <li>• Risk of aspiration of blood from stoma site</li> </ul>
Blue Rhino	<ul style="list-style-type: none"> <li>• Single step dilation</li> <li>• Risk of posterior wall damage is reduced</li> </ul>	<ul style="list-style-type: none"> <li>• Technique necessitates overdilatation and insertion of a smaller trache tube</li> <li>• A high incidence of tracheal ring fracture has been noted in the literature</li> </ul>
Griggs	<ul style="list-style-type: none"> <li>• Single dilator</li> <li>• Exact dilatation to the size of the trache tube</li> <li>• Mandatory bronchoscopy control</li> <li>• Less chances of damage to the tracheal rings due to pulling out of the dilator</li> </ul>	<ul style="list-style-type: none"> <li>• Multiple steps</li> <li>• Looks complicated</li> <li>• Requires reintubation with a microlaryngeal tube</li> <li>• Tube and dilator unable to be reused if trache tube pulled out inadvertently during the procedure</li> </ul>

As experience has accumulated, the complication rate with percutaneous techniques has decreased compared to surgical techniques. However, to show a statistically significant difference in the complication rates for any two different types of percutaneous techniques would require a larger study sample than has been reported so far in the literature. A meta-analysis is needed. A review<sup>31</sup> evaluating 40 series discussing complications in 1684 percutaneous tracheostomy patients looked at four different techniques. The overall complication rates were: Rapitrac 22.9%, Toye (an early technique combining dilatation and incision of tissues) 10.9%, Ciaglia 7.6% and Griggs 1.2%.

The Ciaglia method was the one reported most commonly. A total of 1074 procedures were analyzed. The overall complication rate was 5.5% with the most common complication being peri- and postoperative bleeding (2.1%). A 1% rate of long term tracheal stenosis was reported. There were 248 Griggs procedures reviewed, with the original investigators providing most of the data. There were very few complications reported. A 2% incidence of bleeding was seen, which is similar to the Ciaglia method.

## ADJUNCTS

### Bronchoscopy

During percutaneous dilatational tracheostomy (PDT), bronchoscopy has only been used as a teaching aid during the early part of the learning curve in many recent series,<sup>32</sup> or not at all.<sup>14, 33-37</sup> However, the accuracy of blind percutaneous puncture of the trachea has been doubted<sup>38</sup> and routine bronchoscopy during the procedure would allow precise placement of the stoma, demonstrate perforation of the posterior

tracheal wall and prevent dilatation or tearing of the posterior wall. It would also allow easy reintubation in case of a complication or loss of airway. There is growing evidence to support routine bronchoscopic control while performing dilatational tracheostomy.<sup>19, 39-42</sup>

### LMA

The laryngeal mask airway has been used during these procedures. It does not protect against aspiration, the struts need to be cut off to allow introduction of a bronchoscope, and ventilating patients with poorly compliant lungs may pose a problem. There are varied reports of its usefulness in the literature<sup>43, 44</sup> and, at present, use of an LMA in preference to an endotracheal tube cannot be recommended.

### Ultrasound

Ultrasound imaging of the neck has been used to delineate the anatomy of the thyroid isthmus and delineate aberrant vessels, identify a potential stoma site and estimate the distance from the surface of the skin to the trachea.<sup>45</sup> In a prospective study of trauma patients, the intended stoma site was changed in 24% following an ultrasound study.<sup>46</sup> It does appear to be a useful adjunct to these procedure, but needs further investigation to prove any potential benefits.

## LONG TERM COMPLICATIONS

Table 5 lists some of the persistent symptoms found during three years follow up of patients who have undergone a percutaneous tracheostomy in a teaching hospital.

**Table 5**  
Complications post-decannulation over 3 years

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Noisy breathing
Difficulty in breathing
Change in voice quality
Persistent cough
Swallowing problems
Unsightly scar

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Clinically significant tracheal stenosis remains the most dreaded long-term complication. The risk of this is higher with fracture of the cricoid cartilage or tracheal rings, or posterior displacement of the anterior tracheal wall.<sup>11, 47</sup> These injuries can result from sub-cricoid puncture, oblique puncture of the trachea and poor fit of the tracheostomy tube over the appropriate dilator, requiring more force to push the combination into the tracheal lumen. Some of these problems can be avoided if the procedure is done under bronchoscopy guidance.

Tracheal stenosis usually occurs 2-3 months after removal of the device.<sup>48</sup> It may be asymptomatic until the tracheal lumen is reduced by 75%.<sup>49</sup> Stridor does not occur until tracheal diameter is 5 mm or less.<sup>50</sup> A combination of symptoms (stridor, hoarse voice, difficulty breathing) and either evidence of inspiratory flow limitation or anatomical evidence of tracheal narrowing are necessary to diagnose clinically significant tracheal stenosis. Unfortunately spirometry has not been very useful in the diagnosis. Law and colleagues could find no correlation between symptoms and spirometry evidence of fixed airway obstruction.<sup>49</sup> A number of patients could not

perform spirometry. There is no documented correlation between symptoms and flow limitation on spirometry,<sup>34, 49, 51-54</sup> in any study of tracheal stenosis.

The incidence of tracheal stenosis following percutaneous tracheostomy is stated as 0-5%, depending on the diagnostic modality used and the degree of narrowing considered as stenosis. The possibility that tracheal injury may have been caused by trans-laryngeal intubation is a confounding factor.<sup>55</sup> The number of patients available for long term follow up is limited by mortality and morbidity following discharge from ICU. Hill and colleagues<sup>34</sup> reviewed eight patients who developed airway obstruction following removal of a tracheostomy tube. Four had stenosis at the level of the stoma site, one had stenosis at the level of the cricoid cartilage, one had excessive granulation at the stoma site and another had a subglottic web. Law et al<sup>49</sup> studied 41 patients who had a percutaneous tracheostomy and were decannulated. They considered >10% narrowing of the tracheal lumen as significant and four patients fell into this category, but there was no correlation between symptoms and tracheal narrowing.

There really are no established criteria for the diagnosis of clinically significant tracheal stenosis and all the present diagnostic evaluations aim at a structural definition. However, the diagnosis should be clinical and only those who are clinically symptomatic should be investigated further.

### **EARLY TRACHEOSTOMY**

Recently, there has been a trend to performing tracheostomy early (<6 days) in the ICU stay. A number of studies have shown benefits from this, by reduction in pulmonary septic complications<sup>56</sup> and rapid weaning from ventilatory support.<sup>57</sup> There is also a demonstrable reduction in use of resources with shorter length of stay and lower hospital costs, without an increase in morbidity or mortality in particular patient groups.<sup>58, 59</sup> Given the ease with which the procedure can be done in the ICU, such evidence will encourage an increase in the number of percutaneous tracheostomies being performed.

### **ANAESTHETIC IMPLICATIONS**

Managing the airway during a percutaneous tracheostomy is a very important and often difficult task.<sup>60</sup> The standard teaching is to position an endotracheal tube with the cuff just below the vocal cords. There is a high incidence of cuff rupture with this approach. There have also been reports of attempts at dilatation of a Murphy's eye. The alternative is to position the cuff above the cords, which is then hyperinflated to achieve a seal against the aryepiglottic folds and the interarytenoid fissure. This presents a risk of aspiration and an assistant is needed to stabilize the tube, especially if the anaesthetist is also guiding the procedure using a bronchoscope. Obviously, the risk of cuff rupture or cannulation of the Murphy's eye is much reduced. The use of a microlaryngeal tube with its cuff inflated beyond the stoma site to protect the airway and maintain ventilation is an integral part of the Fantoni technique.<sup>8</sup> This method of airway control has been reported with other dilatational techniques and seems to work well.<sup>61, 62</sup>

### **COST**

Percutaneous tracheostomy has been proven repeatedly to be cheaper than surgical tracheostomy performed in the operating theatre.<sup>18, 34, 36, 63, 64</sup> However, if the surgical

tracheostomy is performed in the ICU, then it may offer greater savings than a percutaneous technique.<sup>65</sup>

## SUMMARY

There is a definite trend towards performing more percutaneous dilatational tracheostomies in the ICU. These have been shown to be quicker to organise and perform, as well as cheaper than surgical tracheostomy. However, it is still uncertain if they are safer and have fewer complications than surgical tracheostomy. Amongst the commercially available techniques, the Ciaglia is the one used most commonly, but more comparative studies are needed to prove the superiority of any one system. The use of a bronchoscope to guide the procedure should be a standard of care.

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