Percutaneous and surgical tracheostomy

E Lams, A Ravalia

Percutaneous techniques for elective tracheostomy have provided a quick and relatively simple method that can be performed in the intensive care unit. Evidence-based studies comparing surgical and percutaneous tracheostomies suggest similar complication rates in trained operators of both techniques.

Tracheostomy is one of the most commonly performed procedures in critically ill patients. Tracheostomy allows for greater patient comfort, ease of weaning, effective pulmonary cleansing and increased airway security. Traditionally, tracheostomy has been performed in theatre using the basic surgical technique described by Chevalier Jackson in 1909. Ciaglia et al (1985) described a percutaneous tracheostomy technique based on Seldinger's principle involving serial dilatation of the trachea through a superficial incision.

Immediate advantages of the Ciaglia technique over surgical tracheostomy include a procedure that is relatively quick, simple, and cheap to execute, and can be performed at the bedside without logistical problems and hazards of transporting critically ill patients to theatre. There is great controversy, however, over immediate and long-term complication rates of the percutaneous technique compared to the surgical one. As Susanto (2002) notes, lack of large prospective multicentre trials has fuelled this debate. An online search of Ovid and Medline from 1995–2002 has been performed to assess immediate and long-term complications of different tracheostomy techniques.

Dr E Lams is Specialist Registrar in Anaesthetics and **Dr A Ravalia** is Consultant Anaesthetist in the Department of Anaesthesia, Kingston Hospital, Surrey KT2 7QB

Correspondence to: Dr E Lams

TABLE 1.
Complications of tracheostomy

Early complications	Haemorrhage (anterior jugular veins/thyroid isthmus)
	Hypoxia or cardiovascular compromise
	False passage or tube displacement
	Posterior tracheal wall perforation
	Subcutaneous emphysema
	Pneumothorax
Late complications	Infection of wound, trachea or chest
	Tracheal erosion into oesophagus or innominate vessels
	Tracheal stenosis
	Hoarseness
	Dysphagia

SURGICAL TRACHEOSTOMY

Elective surgical tracheostomy is performed under general anaesthesia with endotracheal intubation. A horizontal skin incision is made midway between the cricoid and suprasternal notch. The pretracheal muscles are separated, the thyroid isthmus is divided between clamps and the cut ends oversewn. Any bleeding vessels, e.g. transverse branches of anterior jugular veins, are stopped to ensure a bloodless field. The wound edges are retracted. A cricoid hook may be used to secure the trachea as a vertical incision, a slit or circular opening, is made in the second, third and fourth tracheal rings. Ventilation with 100% oxygen precedes withdrawal of the tube to the level of cricoid cartilage. The tracheostomy tube is inserted and secured. The skin is closed.

PERCUTANEOUS *VS* SURGICAL TRACHEOSTOMY

Both surgical and percutaneous tracheostomy techniques have the potential for complications (*Table 1*). Many studies have been performed to compare complication rates of the two techniques. The current literature consists of meta-analyses, small retrospective and prospective studies, and case series. These studies suffer from inadequate powering and lack of subgroup heterogeneity, but are important in showing general trends in complication rates between the two techniques.

META-ANALYSES

Dulguerov et al (1999) published a meta-analysis reviewing the two types of tracheostomy between 1985–1996. The surgical group comprised 3512 patients from 21 studies and the percutaneous group 1817 patients from 27 studies. The perioperative rate of death and cardiac arrest

was almost ten times higher in the percutaneous group than in the surgical group (77 *vs* 9 per 10 000 procedures). Perioperative complications such as hypotension or desaturation, posterior tracheal wall lesion, difficult tube placement and false passage were all significantly higher in the percutaneous tracheostomy group compared with surgical tracheostomy (507 *vs* 46 per 10 000 procedures respectively).

The high perioperative mortality rate in the percutaneous tracheostomy group was found to decrease during the first year of performing tracheostomy, suggesting that a learning curve was present. There was a degree of heterogeneity between the two groups, with a greater percentage of percutaneous tracheostomies occurring in intensive care unit (ICU) patients and therefore having inherently higher complication rates. There was also significant variation between studies in the two groups in terms of study design, patient population and intervention technique.

A meta-analysis by Freeman et al (2000) looked at 236 ICU patients from five prospective studies. They found that percutaneous tracheostomy took 10 minutes less to perform than surgical tracheostomy, had a lower operative and postoperative bleeding rate and fewer stomal infections. Mortality rates did not differ between surgical and percutaneous tracheostomy. Although the studies were adequately matched for patient age and mortality, the individual studies involved small numbers of patients and were not adequately powered for clinical end points.

PROSPECTIVE RANDOMIZED TRIALS

Freeman et al (2001) published their own prospective, randomized trial comparing Ciaglia dilatational endoscopically-guided percutaneous *vs* surgical tracheostomy in 80 critically ill patients. There was no significant difference in tracheostomy-associated mortality in either group. Percutaneous tracheostomies were performed more quickly than surgical ones (mean 20.1 *vs* 41.7 minutes), and percutaneous tracheostomy cost much less.

Another prospective randomized trial was performed by Massick et al (2001) in critically ill patients. The percutaneous tracheostomy was performed with bronchoscopic guidance using Ciaglia technique in 50 patients. A surgical tracheostomy technique was performed at the bedside in another 50 patients. There were no perioperative deaths. Two patients in the percutaneous tracheostomy group had bleeding requiring conversion to surgical tracheostomy. One surgical tracheostomy patient required cardiovascular and respiratory support. Four patients with percutaneous tracheostomy experienced postoperative displacement of tracheostomy which resulted in one death.

Both studies showed no perioperative mortality and a low perioperative complication rate of 3–8%. Both these studies, however, had exclusion criteria. Massick et al excluded patients with distorted neck anatomy, coagulopathy, previous difficult intubation, and positive end expiratory pressure requirements of <5–10 cmH_2O. They had an additional 64 patients who failed selection criteria and underwent surgical tracheostomy in theatre with a perioperative complication rate of rate of 20%. There were no deaths. Freeman et al had similar exclusion criteria but in addition excluded patients with vasopressor support, inspired oxygen concentration >40%, and white cell count 710 x 10^9/litre.

A prospective randomized trial by Gysin et al (1999) compared surgical and percutaneous tracheostomy in 70 patients. The size of incision was smaller with percutaneous tracheostomy, but otherwise serious and intermediate complications were low in both groups.

Hill et al (1996) from the University of Kentucky prospectively collected data on a series of 356 critically ill patients undergoing percutaneous tracheostomy without endoscopic guidance. The procedure-related mortality was 0.3%. The perioperative complication rate was 8%. This study did not specify any exclusion criteria. In contrast to other studies, the authors with increasing experience came to consider percutaneous tracheostomy the method of choice in patients with difficult anatomy, such as those with goitre or with short, thick necks.

TECHNIQUES OF PERCUTANEOUS TRACHEOSTOMY

There are many different techniques of percutaneous tracheostomy (*Table 2*).

Toye and Weinstein (1986) described a single tapered dilator with a recessed cutting blade that

TABLE 2.
Tracheostomy techniques

Originator/name	Type	Introduced	Special points
Toye and Weinstein	Single tapered dilator	1969	Recessed cutting blade
Ciaglia	Serial dilator over wire	1985	Seldinger technique
Rapitrac	Forceps with guide wire	1989	Cutting bevelled conus
Guide wire dilating forceps (Griggs)	Forceps with guide wire	1990	Lack of cutting edge
Fantoni	Translaryngeal	1997	Retrograde positioning
Blue Rhino (Ciaglia)	Single tapered dilator	1999	Hydrophilic coating
Percu Twist	Threaded screw device	2001	Single twisting action

was advanced over a guide wire into the trachea. Ciaglia et al (1985) developed a sequentially dilating technique with serial dilators advancing over a guide wire. In 1989 Schachner et al described the Rapitrac (Fresenius, Runcorn, Cheshire, UK). This is a forceps device with a bevelled conus tip advanced over a guide wire into the trachea and forcibly dilating it. The guide wire dilating forceps was developed in 1990 by Griggs. These forceps are similar to the Rapitrac but lack a cutting edge on the tip of the instrument.

In 1999, Ciaglia developed with Cooke Critical Care the Blue Rhino (Bloomington, USA): a single tapered dilator with a hydrophilic coating which sequentially dilates up the trachea. Most recently developed is the Percu Twist by Rusch (Kernen, Germany). It consists of a single tapered screw-like device that advances over a guide wire and in a twisting action dilates up the tract in one continuous motion.

In 1997 Fantoni and Ripamonti described a translaryngeal method of percutaneous tracheostomy. This technique involves passing a guide wire retrogradely through a skin incision at the level of the second and third tracheal cartilages into the oropharynx. Using the guide wire, the tracheostomy tube is pulled into position. An overall complication rate of 5.5% was reported by Fantoni and Ripamonti. Literature describing complications of different methods of percutaneous tracheostomy have been published (*Table 3*).

Toye and Weinstein (1986) described 100 patients with their technique. Their perioperative mortality was 1%, peritracheal insertion 6%, pneumothorax 1% and infection 1%. No late complications were reported.

Powell et al (1998) reviewed 39 studies of percutaneous tracheostomy. Three studies involving 248 patients examined the guide wire dilating forceps technique. Three perioperative and five postoperative haemorrhages were reported. No deaths or late complications were reported. Nine series of studies involving 262 patients using the Rapitrac method were identified. The mortality rate was 1.53%. Complicating factors in these deaths were peritracheal insertion, loss of airway and bronchospasm. In three of the nine series the Rapitrac method was abandoned because of high complication rates. The overall perioperative complication rate was 22.9%. The sharp tip of the Rapitrac can lacerate adjacent structures and mechanical pressure generated can cause uncontrolled tissue disruption and over dilation.

Twenty seven series involving 1074 cases using the Ciaglia dilatational technique were identified. The mortality rate was 0.56%. Four perioperative deaths were reported secondary to arrhythmia and hypoxia. Two postoperative deaths were the result of tracheo-innominate fistula exsanguinations. In this series approximately 30% were performed with endoscopic guidance, the remaining were performed 'blind'. The perioperative and postoperative complication rates were similar in the two groups (endoscopic: 7.2% and 3.9%; blind: 8.2% and 6.1%).

Dulguerov et al found in their meta-analysis that perioperative and postoperative complications in percutaneous tracheostomy were lowest with progressive dilation technique under endoscopic control. In a prospective study, Imami et al (1995) compared endoscopically guided with blind percutaneous tracheostomy. They found a 59% reduction in the minute volume in the endoscopic group but a reduced perioperative complication rate of 4.3% *vs* 47.1%.

A preliminary study by Frova and Quintel (2002) with the Percu Twist included fifty consecutive patients in an open observational trial. The Percu Twist method of tracheostomy was performed under endoscopic control successfully in all cases. Bleeding classed as 'II (medium)' on a scale of I–III was present in 4% and tracheal ring fracture in 8% of cases. There were no reports of posterior tracheal wall injury.

Comparing complication rates between different methods of percutaneous tracheostomy is difficult because of variability in study design and operator experience. The progressive dilator technique and Rapitrac method have been extensively used. Experience would suggest that the Rapitrac method has a high perioperative complication rate and that the progressive dilator technique under endoscopic control is as safe as surgical tracheostomy in specific group of patients. Large prospective trials are needed for further evaluation, particularly with the newer Percu Twist kit.

TABLE 3.
Complications of percutaneous techniques

Type	Number of studies performed	Patients	Mortality	Peri-/postoperative complications
Toye dilator	1	100	1%	1–6%
Ciaglia dilator	27	1074	0.56%	7.2%/3.9%
Rapitrac	9	262	1.53%	22.9%
Guide wire dilating forceps	3	248	0%	3.2%
Blue Rhino	4	105	0	4%
Percu Twist	1	50	0%	4–8%

TRACHEAL STENOSIS IN PERCUTANEOUS TRACHEOSTOMY

The incidence of tracheal stenosis in critically ill patients is difficult to determine as many patients die or go home with tracheostomy in situ and so are lost to follow up. If tracheal stenosis is present it is difficult to determine if stenosis is caused by pre-existing endotracheal intubation.

Ciaglia and Graniero (1992) followed up 30 patients who had percutaneous tracheostomy over an 8-year period. They found one patient with stomal erosion, and one patient with minimal voice changes only. Law et al (1997), in a series of 41 decannulated percutaneous tracheostomy patients, found 17% with minor voice changes only. On flexible laryngoscopy, 7% had 10–30% stenosis and 2% had >40% stenosis. None of these patients had dyspnoea or stridor.

Norwood et al (2000) reviewed 48 decannulated critically ill patients at 30 months after percutaneous tracheostomy with computed tomography. The scan revealed 31% of patients with greater than 10% stenosis of which 6% were symptomatic. Van Heurn et al (1996), in a study of 66 decannulated patients following percutaneous tracheostomy, showed voice changes in 21% of patients, and 26% of patients had asymptomatic tracheal narrowing of at least 10%. One patient had 75% stenosis.

As Stauffer et al (1981) have shown the incidence of tracheal stenosis for surgical tracheostomy has a range of 0–11% for symptomatic stenosis and up to 65% for stenosis seen on computed tomography.

CONCLUSION

A large multicentre prospective randomized trial comparing surgical and percutaneous tracheostomy in critically ill patients has yet to be conducted. Existing meta-analyses are limited by heterogeneity between sub groups and inadequate powering of individual studies. Comparison between individual studies is limited by operator experience and differences in patient populations. The evidence might suggest that percutaneous tracheostomy is faster, involves fewer logistical problems and is cheaper to perform than surgical tracheostomy in theatre. Percutaneous tracheostomy, however, should not be undertaken lightly as inexperience may be associated with significant mortality and morbidity. With experienced operators, endoscopic control and in a specific population of patients, complications are probably no different from surgical tracheostomy.

Many different types of percutaneous tracheostomy kits are available. The Ciaglia progressive dilational method has been used extensively and has a low complication rate in experienced hands. The Rapitrac method has shown a high perioperative complication rate in some studies, and probably is not the method of first choice. HM

Conflict of interest: none.

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KEY POINTS

- Percutaneous techniques provide a quick and relatively simple bedside method of tracheostomy for critically ill patients.
- A large multicentre prospective randomized trial comparing surgical to percutaneous tracheostomy has yet to be conducted.
- Available evidence suggests similar complication rates between surgical and percutaneous methods in trained operators.
- Incidence of tracheal stenosis after surgical and percutaneous tracheostomy appears to be significantly higher than the symptomatic rate would suggest.