

A Comparison of Tracheal Tube Tip Designs on the Passage of an Endotracheal Tube during Oral Fiberoptic Intubation

J. Ruari Greer, F.R.C.A.,* Sharon P. Smith, F.R.C.A.,* Tim Strang, F.R.C.A.†

Background: The design of an endotracheal tube has been shown to influence the passage of the tube through the glottis during fiberoptic intubation. Difficulty in passing the endotracheal tube can occur if the aryepiglottic folds obstruct the passage of the bevel. The relevant aspects of endotracheal tube design include the shape of the bevel, the material used by the manufacturer, and the ability of the tube to conform to the shape of the fiberoptic. The aim of the current study was to compare the ease of passage through the glottis of two different tubes. One tube was a wire reinforced polyvinyl chloride tube with a standard bevel and the other was a newly designed tube with a bevel of different shape and made of silicone rubber. The new design is for use with the a commercial intubating laryngeal mask.

Methods: The authors studied a population of 30 patients who received a standard anesthetic. In all cases, oral fiberoptic intubation was attempted. Anesthetic was administered to each patient using both tubes, and before the study the order of the tubes was randomized. The difficulty in passing the tube was assessed by a blinded observer and graded using a three-point scale (grade 1: no difficulty passing the tube; grade 2: obstruction to passing the tube relieved by withdrawal and a 90° anticlockwise rotation; grade 3: obstruction necessitating more than one manipulation or external laryngeal manipulation).

Results: In 27 patients, no difficulty was shown by use of the silicone-tipped tube. In only three patients was there difficulty that necessitated a 90° anticlockwise twist. With the wire-reinforced tube, no difficulty was experienced on 14 occasions. Grade 1 difficulty was experienced eight times and difficulty necessitating more than one maneuver, head movement, or external laryngeal manipulation was seen on eight occasions. Statistical significance was achieved at $P = 0.0002$ (Wilcoxon signed rank test).

Conclusions: The authors conclude that the use of the silicone-tipped tube with the new bevel design may provide an advantage in the clinical situation of fiberoptic intubation.

THE technique of fiberoptic intubation was first de-

scribed by Murphy in 1967.¹ It is now a well-established technique in anesthesia in which difficult intubation is anticipated or encountered unexpectedly.

Obstruction to passing the tube over the fiberoptic and into the trachea may be encountered at the laryngeal inlet. It has been suggested that various aspects of tube design may influence the passage of the tube through the glottis. The Intubating Laryngeal Mask Airway (Intavent, Maidenhead, Berkshire, United Kingdom) is supplied with its own tube.² The bevel of this tube is made from silicone rubber and is softer than the standard polyvinyl chloride design and the bevel is hemispherical, with the leading edge in the midline; the tube itself is also less rigid than the standard design (fig. 1). The aim of the current study was to compare the ease of passage through the glottis of a wire-reinforced tube with a standard bevel with that of a silicone-tipped (ILMA) tube.

Methods

The study was approved by the local ethics committee and we received fully informed written consent from the patients. We studied 30 adult patients who were classified as American Society of Anesthesiologists physical status I or II and who were undergoing elective surgery. Patients were excluded from the study if they were had difficult airway. We anesthetized the patients in a standard manner using 2 to 3 mg/kg propofol and 1 to 2 µg/kg fentanyl followed by 0.6 mg/kg atracurium. We performed manual ventilation for 3 min to allow full muscle relaxation to develop; this was considered to be adequate if the patient did not cough after the passage of the fiberoptic through the vocal cords. In all cases, oral fiberoptic intubation was attempted. Each patient was to undergo intubation using both tubes and, before the study, the patients were randomized to undergo intubation with either the wire-reinforced tube or the silicone-tipped tube in the first instance. We compared a size 7.0-mm ID wire-reinforced tube (10.6 mm OD; Mallinckrodt Medical, Athlone, Ireland) with a size 7.0-mm ID silicone-tipped tube (10.0 mm OD). In all cases, we used the Olympus LF1 intubating laryngoscope (4 mm OD; Keymed Ltd, Stock Road, Southend on Sea, Essex, England).

A 10-cm William airway was placed in the patient's mouth, and jaw thrust was applied to hold the oral airway in place. The first tube was passed over the

This article is featured in "This Month in Anesthesiology." Please see this issue of ANESTHESIOLOGY, page 5A.

* Specialist Registrar in Anaesthetics, † Consultant Anaesthetist.

Received from the Department of Anaesthesia, Manchester Royal Infirmary, Oxford Road, Manchester, United Kingdom. Submitted for publication June 5, 2000. Accepted for publication October 4, 2000. Supported was provided solely from institutional and/or departmental sources. Presented in part at the meeting of the Anaesthetic Research Society, Edinburgh, United Kingdom, November 11-12, 1999, and at the annual meeting of the Difficult Airway Society, Edinburgh, United Kingdom, November 26, 1999.

Address correspondence to Dr. Greer: 23 Harry Rowley Close, Wythenshawe, Manchester, M22 1HY, United Kingdom. Address electronic mail to: jonessmith13@compuserve.com. Reprints will not be available from the authors. Individual article reprints may be purchased through the Journal Web site, www.anesthesiology.org.



Fig. 1. The bevel design of the two tubes compared in the study. (Left) The standard wire-reinforced tube. (Right) The silicone-tipped bevel of the Intubation Laryngeal Mask Airway tube.

fiberscope. The fiberscope was advanced through the glottis. At this stage, the fiberscope was in the trachea; however, the tip of the tube was above the vocal cords. The fiberscope, the tube, and patient's face were covered with a green towel. An investigator blind to the study then entered the room and passed the tube into the trachea. The observer wore a pair of gloves and passed the tube covered with the green towel into the trachea. The investigator then left the room, and the tube and the fiberscope were removed. The patient underwent manual ventilation for a brief period to ensure that adequate oxygenation was maintained and the maneuver was repeated using the second tube. The tube was oriented on the fiberscope such that for each tube the bevel faced to the left. The observer graded the intubation using a three-point scale (table 1). We analyzed the results on the three-point scale using the Wilcoxon signed rank test.

Results

We studied 30 patients. We graded the difficulty of intubation as grade 0, grade 1, or grade 2. The silicone-tipped tube was passed without difficulty in 27 patients and only necessitated a 90° anticlockwise rotation in 3. Using the wire-reinforced tube, no difficulty was encountered in 14 patients, in 8 patients the passage of the tube necessitated a 90° anticlockwise rotation, and in another 8 patients there was difficulty intubating, necessitating

Table 1. Grading of Difficulty of Passage of the Tube

Grade	Difficulty
Grade 1	No difficulty passing the tube
Grade 2	Difficulty observed on initial attempt relieved by withdrawal and a 90° anticlockwise rotation
Grade 3	Difficulty necessitating more than one manipulation or head movement or external laryngeal manipulation

more than one maneuver, external laryngeal manipulation, or movement of the head.

We analyzed our data using the Wilcoxon signed rank test and demonstrated statistical significance ($P = 0.0002$). We did not demonstrate carry-over effect (table 2).

Discussion

It has been shown that the passage of an endotracheal tube over a fiberscope and into the trachea may be difficult.³ The incidence of this difficulty has been described as between 23%⁴ and 46%.³ The factors implicated in causing difficulty in passing the tube into the glottis include the diameter of the fiberscope and the design of the tube and the tube tip.

Hakala and Randell⁴ compared the effect of differing fiberscope diameters on the ease of passage of an endotracheal tube. A fiberscope with a thicker insertion cord promoted greater ease of passage through the glottis. It was thought that the excess free distance between the inside of the tube and the insertion cord may lead to snagging on the laryngeal inlet. The use of a pediatric tube will decrease the incidence of difficult fiberoptic intubation by decreasing the distance between the fiberscope and the tube.⁵

Other aspects of tube design may affect its progression. It has been suggested that a wire-reinforced tube may be easier to pass than a preformed polyvinyl chloride tube.⁶ This tube has a less natural curve and may cause less displacement of the fiberscope if rotation of the tube is necessary. It may also follow the bronchoscope better and, being soft, may cause less damage to the soft tissues of the airway.

The influence of endotracheal tube tip design has previously been described as having an effect on the passage of a tube through the vocal cords. A tube was designed and described in 1983 by Dr. P. Moore.⁷ This tube has no bevel and tapers in a conical fashion. When this tube is positioned on the fiberscope, the gap between the inside of the tube and the fiberscope is minimized. It was shown that this design caused less obstruction during passage through the vocal cords. This tube was only described as a prototype.

The ILMA was described in 1997 as an adjunct to difficult intubation. The ILMA is supplied with its own tube. The design of this tube is such that it facilitates

Table 2. Results of the Difficulty of Passage of the Tube through the Glottis

	ILMA (Silicone Tube)	Flexometallic Tube
Grade 1	27	14
Grade 2	3	8
Grade 3	0	8

ILMA = Intubating Laryngeal Mask Airway (Intavent, Maidenhead, Berkshire, United Kingdom).

passage through the intubating laryngeal mask and into the trachea. The bevel is made of silicone rubber and is softer than the standard polyvinyl chloride bevel. The bevel is hemispherical and has a leading edge in the midline (fig. 1). The ILMA tube is relatively less stiff than the wire-reinforced tube, which conforms better to the fiberoptic scope and may allow easier passage. The ILMA tube is reusable.

In our study we compared a size 7.0 flexometallic tube to a size 7.0 ILMA tube. This is the smallest size of ILMA tube available and we thought this decision afforded the best comparison available. We chose to use the wire-reinforced tube because it is the one commonly used in our hospital practice (fig. 1).

External manipulation of the tube or larynx can affect passage. During fiberoptic intubation, the tip of the tube will catch most frequently on the right aryepiglottic fold or the arytenoid cartilage. This has also been described with the passage of an endotracheal tube over a gum elastic bougie. The passage of the tube was found to be easier after a 90° anticlockwise rotation was applied to the tube.^{8,9} The effect of this maneuver was to rotate the tube into a position in which the tip lies anterior to the bougie and is impeded by nothing.

We have demonstrated that the use of the silicone-tipped tube (ILMA) is advantageous during fiberoptic intubation. We believe that the passage of the tube is made easier primarily by the bevel design. This bevel design has previously been shown to be advantageous in the passage of this same tube through the glottis. A study by Murashima *et al.*¹⁰ compared a tube with a wedge-shaped end with the tube we used in our study when passing the tube through the ILMA. This article states that the midline bevel guided the tube away from the arytenoids and toward the center of the glottis.

Improved flexibility of the tube may be a factor in the ease of fiberoptic intubation. A study by Brull *et al.*¹¹ suggested that a more flexible tube can change direction more easily and thereby lead to easier fiberoptic intubation. The silicone-tipped tube has been shown to be

more flexible than the polyvinyl chloride wire-reinforced tube *in vitro*.¹²

Fiberoptic intubation can be difficult, requiring considerable operator skill, and the consequences of failure are great. Repeated attempts at passage of the tube through the glottis may lead to laryngeal trauma or bleeding in the airway, and this may confound further attempts at airway control. We propose that the ease of passage of an ILMA tube with a hemispherical bevel with the leading edge in the midline in comparison with a more rigid flexometallic tube of standard bevel design confers a clinical advantage during fiberoptic intubation. This tube may be considered as a first choice for fiberoptic intubation or may be considered as an adjunct to fiberoptic intubation when a polyvinyl chloride tube proves to be difficult to pass on the first attempt.

The authors thank Sally Hollis, Department of Medical Statistics, Lancaster University, Lancaster, United Kingdom.

References

1. Murphy P: A fiberoptic scope used for nasal intubation. *Anaesthesia* 1967; 22:489-91
2. Brain AJJ, Varghese C: The intubating laryngeal mask airway. Instruction manual, 1st edition. 1998.
3. Coe PA, King TA, Towey RM: Teaching guided fiberoptic nasotracheal intubation. An assessment of an anaesthetic technique to aid training. *Anaesthesia* 1988; 43:410-3
4. Hakala P, Randell T: Comparison between two fibrescopes with different diameter insertion cords for fiberoptic intubation. *Anaesthesia* 1995; 50:735-7
5. Marsh NJ: Easier Fiberoptic intubations. *ANESTHESIOLOGY* 1992; 76:860-1
6. Calder I: When the endotracheal tube will not pass over the flexible fiberoptic bronchoscope (letter). *ANESTHESIOLOGY* 1992; 77:398
7. Jones HE, Pearce AC, Moore P: Fiberoptic intubation. Influence of tracheal tube tip design. *Anaesthesia* 1993; 48:672-4
8. Cossham PS: Difficult intubation. *Br J Anaesth* 1985; 55:187-8
9. Dogra S, Falconer R, Latto IP: Successful difficult intubation. Tracheal tube placement over a gum-elastic bougie. *Anaesthesia* 1990; 45:774-6
10. Murashima K, Fukutome T, Brimaombe J: A comparison of two silicone-reinforced tracheal tubes with different bevels for use with the intubating laryngeal mask. *Anaesthesia* 1999; 54:1198-200
11. Brull SJ, Wiklund R, Ferris C, Connelly NR, Ehrenwerth J, Silvermann DG: Facilitation of fiberoptic oral intubation with a flexible tracheal tube. *Anaesth Analg* 1994; 78:746-8
12. Brain AJJ, Varghese C, Addy EV, Kapila A: The intubating laryngeal mask: I. Development of a new device for intubation of the trachea. *Br J Anaesth* 1997; 79:699-703