The LoTrach™ system: its role in the prevention of ventilator-associated pneumonia

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ABSTRACT

Objectives: To discuss the development of the LoTrach™ system in light of current evidence around the prevention of ventilator-associated pneumonia (VAP) and its practical application in the intensive care setting.

Background: VAP causes substantial morbidity and mortality in ventilated patients in the Intensive Care Unit (ICU), increases length of stay in ICU and is extremely costly. Strategies are needed to reduce the risk of VAP.

Method: We examine the need for an endotracheal tube (ETT) specifically designed for the critically-ill patient, the development of the LoTrach system from conception to production, and the role of the various components of the system in preventing VAP. Early issues in implementing this revolutionary equipment into ICU are explored and three case studies highlight advantages of this system.

Conclusion: The LoTrach system has been designed to facilitate the provision of a number of evidence-based interventions that have been shown to reduce VAP. Pulmonary aspiration is ubiquitous with conventional cuffs but prevented by the cuff of the LoTrach system when held at a constant and safe pressure against the tracheal wall with a cuff pressure controller. Other aspects incorporated in the ETT are aimed at clearing the secretions from the subglottic space, preventing tube occlusion and accidental extubation, and avoiding damage to the airway. In this way the LoTrach system employs a multifactorial approach to the prevention of VAP and the cost savings from LoTrach rather than a standard ETT will be considerable because of an average 3 day reduction in ICU length of stay related to this. It thus has the potential to be a very useful tool in the ICU setting in the prevention of VAP.

Key words: Evidence-based practice • Intensive care • LoTrach™ • Practice innovation • Ventilator-associated pneumonia

BACKGROUND

Ventilator-associated pneumonia (VAP) is the leading nosocomial cause of mortality in the intensive care unit (ICU). It also has substantial cost implications, extending ICU length of stay by at least 6 days and costs by up to £12 000 per patient episode (Safdar et al., 2005; Anderson et al., 2007). Aspiration of oropharyngeal secretions is an independent risk factor for VAP (Metheny et al., 2006) and is recognized as being a major cause of the acquisition of nosocomial infection in the ICU (d’Escrivan and Guery, 2005; Craven, 2006). Indeed, there is clear evidence for a link between microbial colonization of the oral cavity and colonization of the lungs in critically ill patients who develop VAP in the ICU setting (Brennan et al., 2004). In the ICU, regurgitation and aspiration occurs in most patients with conventional endotracheal tubes (ETTs) in place (Metheny et al., 2006). Even patients intubated with a correctly inflated ETT cuff are not fully protected from aspiration. Secretions that accumulate above conventional ETT cuffs trickle down the space between folds present in the cuff material (Seegobin and van Hasselt, 1986), particularly if relatively thick cuff material is used (Young et al., 2006). Furthermore, removal of these secretions is challenging, and even the most diligent of critical care nurses cannot effectively extend care of the oral cavity to reach the posterior pharynx, larynx and subglottic space above the ETT cuff with conventional suction equipment. Accordingly, efforts to reduce the risk of aspiration and VAP have been directed towards developing ETTs that provide effective airway seals at low mucosal pressures and that allow secretion drainage from, and irrigation of, the subglottic space just above the tube cuff.

To date, even the most recently developed ETT designs have failed to fully prevent aspiration of subglottic secretions, and some have not reached full
commercial production. Perhaps the most studied of these recent ETT designs is the Hi-Lo Evac\textsuperscript{®} tube (Mallinckrodt\textsuperscript{®}; Nellcor Puritan Bennett, Boulder, CA, USA). While it is without doubt that the design of this ETT reduces VAP (Dezfulian et al., 2005; Lorente et al., 2007), there are major disadvantages associated with its use, including failure to completely eliminate aspiration and problems with airway mucosal injury (Young et al., 1997; Berra et al., 2004; Dragoumanis et al., 2007). There is also the cuff of the Microcuff\textsuperscript{®} ETT (Kimberley Clark, San Antonio, TX, USA) that is made of a very thin material and so the folds within the cuff are of narrow calibre. This reduces the rate of, but does not eliminate, trans-cuff leakage of pooled subglottic secretions. An alternative gilled cuff described by Reali-Forster et al. (1996) has been shown to effectively stop aspiration in a sheep model but has not yet been marketed.

The LoTrach\textsuperscript{™} ETT (Figure 1) has recently become available commercially and has been designed specifically to reduce the risk of critically ill patients acquiring VAP. It combines the following features:

- provides continuous effective airway seals at low mucosal pressures (Young et al., 2006);
- allows secretion drainage from the subglottic space;
- allows subglottic and upper airway cleansing by saline irrigation;
- provides protection against unplanned extubation and protects the airway against trauma by means of improved flexibility of the tube shaft and tip (Young, 2007).

A LoTrach tracheostomy tube, which incorporates all the advantageous features of the ETT, is also available for use in patients requiring long-term ventilatory support or who are undergoing ventilatory weaning.

**CURRENT ISSUES WITH CONVENTIONAL ETTS**

The use of high-volume, low-pressure (HVLP) cuffed ETTs became widespread during the 1970s following the recognition that the use of the preceding low-volume, high-pressure cuffs for long-term ventilation was associated with a high incidence of tracheal wall injury. However, while HVLP cuffs reduced the damage from high pressures exerted on the tracheal mucosa, it soon became clear that even a correctly inflated HVLP cuff did not guarantee prevention of pulmonary aspiration of secretions (Pavlin et al., 1975). In addition, concerns have been raised by Mol et al. (2004) that cuff pressure monitoring is poorly performed in many ICUs, with both underinflation and overinflation being common. Seegobin and van Hasselt (1986) observed directly by means of bronchoscopy the leakage of coloured dye passed HVLP cuffs in situ in the tracheas of anaesthetized patients. These investigators showed that, even when the HVLP cuffs were correctly positioned and inflated to the recommended working pressures (30 cmH\textsubscript{2}O), dye instilled into the subglottic space above the cuffs would always leak down longitudinal channels formed by folds in the cuff material to reach the trachea below. This mechanism of leakage of subglottic secretions into the trachea has subsequently been confirmed in bench-top tests of a broad range of conventional HVLP-cuffed ETTs (Young et al., 1997). A recent study examined tracheal aspirates from a cohort of 360 mechanically ventilated, tube-fed patients and showed that, even when managed to the highest standards of oropharyngeal care, 320 of the participants (89%) aspirated stomach contents passed their ETT cuffs into the trachea at least once during their stay in ICU (Metheny et al., 2006). Manufacturers’ attempts to reduce this trans-cuff leakage by reducing the thickness of cuff material, and thereby reducing the calibre of the folds within the cuff wall, have failed to eliminate the problem, at least in the bench-top model (Young, 2007).

Most conventional HVLP-cuffed ETTs in use today do not have drainage ports to allow subglottic secretion drainage. Those ETTs that do have subglottic ports have been shown unequivocally to reduce VAP.

![Figure 1](image-url)
The LoTrach™ system

by at least 50\% (Dezfulian et al., 2005; Lorente et al., 2007). One must ask why then are these tubes so infrequently used in most ICUs given that the Centers for Disease Control and Prevention in the USA recommends their use (Tablan et al., 2004)? The answer is probably fourfold as follows:

1. Continuous suctioning using these ETTs has been associated with posterior tracheal wall suction injury (Berra et al., 2004).
2. The tubes have a large external diameter to accommodate the suction port and are very stiff, the relative inflexibility of the tubes increasing the risk of upper airway damage both during insertion and over the period of mechanical ventilation. In fact, there is even a case report of a fatal tracheo-innominate vein fistula developing when an ETT tip eroded through the anterior tracheal wall over time (Siobal et al., 2001).
3. The incidence of late VAP was not improved in the early studies. However, a more recent study has shown a convincing reduction in early and late VAP (Lorente et al., 2007).
4. The standard single posterior port is prone to failure as suctioning often draws mucosa into the subglottic port opening, thereby blocking the flow of secretions. In addition, because continuous subglottic drainage is contraindicated with these tubes (Berra et al., 2004), the risk of pulmonary aspiration can, at best, only partially be reduced with intermittent drainage because of the leaky nature of HVLP cuffs.

It is clear that a better design of ETT is required for patients undergoing prolonged ventilation.

DESIGN AND DEVELOPMENT OF THE LOTRACH ETT

The development of the LoTrach ETT began with the repeated observation by nursing staff that enteral feed was commonly retrieved from the tracheobronchial tree despite diligent care of the ETT cuff pressure. The mechanism of leakage was clear from the existing literature and from the subsequent bench-top models (Young et al., 1998; Young and Young, 2003). A simple solution was to design a cuff without the HVLP cuff’s defective folds but specially calibrated to ensure an accurate and acceptable tracheal wall pressure. It was hypothesized that if the cuff is automatically maintained at the correct inflation pressure, then aspiration should be completely prevented while protecting the tracheal wall at all times. This was the basis for the development of the LoTrach system. In addition to preventing pulmonary aspiration, the LoTrach system has been designed to reduce a number of other risk factors for VAP while minimizing the mechanical forces on the airway and providing an effective airway seal at a low mucosal pressure (Young et al., 2006; Young, 2007). Advantages of this design of ETT for patient care are summarized later and in Table 1.

Effective airway seal while applying low mucosal pressure

This new ETT design has a low-volume, low-pressure (LVLP) cuff which when inflated to the working intracuff pressure of 80 cmH₂O exerts a tracheal wall pressure within the desirable range of 22–30 cmH₂O (Seegobin and van Hasselt, 1984). Furthermore, unlike conventional HVLP-cuffed ETTs, there are no folds or seams within the cuff wall, eliminating the risk of channels forming that allow the passage of subglottic secretions into the trachea. The effectiveness of the LVLP cuff in preventing leakage was originally shown in bench-top model tracheas (Young et al., 1998; Young and Young, 2003). At equivalent tracheal wall pressures of 30 cmH₂O, in the steady state, a standard HVLP-cuffed ETT held no fluid above its cuff, whereas the LVLP cuff of the LoTrach ETT held a fluid column as high as 30 cm above it. This exceeds the height of any column of fluid that could form in the human pharynx (Young, 2007). The effectiveness of the LVLP cuff has subsequently been confirmed in vitro in excised pig and human tracheas and in vivo in anaesthetized and critically ill patients (Young et al., 1999, 2000, 2006). The design of the LVLP cuff, together with the concomitant use of a constant pressure cuff inflation device to maintain optimal cuff pressure, avoids too high a wall pressure, which causes tracheal injury (Nordin, 1977), or too low a wall pressure, which risks aspiration and VAP (Rello et al., 1996). This combination has been shown clinically to eliminate trans-cuff leakage and pulmonary aspiration when the LVLP cuff is correctly inflated in the trachea using

Table 1 Advantages of the LoTrach endotracheal tube (ETT) for patient care in the intensive care unit

| Effective airway seal while applying low mucosal pressures with the low-volume, low-pressure cuff |
| Facility for subglottic secretion drainage from above the ETT cuff |
| Facility for retrograde upper airway irrigation for cleansing of subglottic and oropharyngeal spaces |
| Integral bite block and securing flange to prevent accidental extubation and ETT occlusion |
| Improved lubricity of the inner lumen for instrumentation and potentially reduced adhesion of biological material to the ETT lumen |
| Increased tube flexibility to reduce airway trauma |
| Designed for use with constant pressure inflation device to maintain optimal cuff pressure |

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a continuous cuff pressure controller (CPC) (Young et al., 2006). The CPC (Figure 2) has an inflation line leading from the machine to the cuff inflation valve on the ETT. The machine calculates the pressure exerted by the cuff on the tracheal wall and can be adjusted for patients with high airway pressures and when executing lung recruitment manoeuvres.

**Subglottic secretion drainage and irrigation**
The LoTrach ETT has three subglottic drainage/irrigation ports that open at different levels immediately above the cuff. These three suction channels join to form one tube opening at the proximal end of the ETT to allow intermittent suctioning of secretions with a standard syringe. There is good evidence that intermittent suctioning of secretions from the subglottic space above an ETT cuff is effective at reducing the incidence of VAP by 50% even when conventional HVLP cuffs are used (Dezfulian et al., 2005). Continuous suction techniques are no longer recommended as sustained suction on the tracheal wall causes injury (Berra et al., 2004). With the leak-resistant LVLP cuff of the LoTrach ETT, intermittent subglottic drainage is particularly effective because, unlike HVLP-cuffed ETTs, there is full protection against aspiration of accumulating secretions from episodes of suctioning (Evans and Young, 2005). The presence of three drainage port openings at different sites around the circumference of the tube provides maximal clearance of subglottic secretions independent of the positioning of the tube within the trachea. Furthermore, if one drainage channel becomes occluded by being closely apposed to the tracheal mucosa, there are always two other drainage channels through which fluid flow can occur. Theoretically, this should reduce failure of subglottic drainage, which has been a problem in about 50% of patients managed with the Hi-Lo Evac tube (Dragoumanis et al., 2007).

The triple subglottic drainage ports of the LoTrach ETT, together with the reliable LVLP cuff seal, also permit safe retrograde cleansing of the entire upper airway with normal saline. The difficulty in accessing the subglottic space with conventional ETTs contributes to colonization of the upper airway, increasing the risk of VAP (Kollef, 2004). In addition, bathing of the upper airway structures in refluxed gastric contents exacerbates tracheal injury and delays healing (Leverment and Pearson, 1977). It is becoming increasingly recognized that any preventative strategies aimed at reducing aerodigestive tract contamination and colonization by pathogenic organisms are crucial in preventing aspiration and VAP (Shaw, 2005). Because the LVLP cuff eliminates leakage in the LoTrach ETT, normal saline at room temperature can be injected using a standard Luer syringe into the subglottic space through the drainage ports. The saline washes up through the laryngeal inlet and into the oral and/or nasal cavities carrying secretions with it. The effluent can then be easily removed by use of a conventional suction catheter in the oral cavity and/or nares. Any remaining fluid can be removed from above the cuff by aspirating the subglottic port. Based on the experience of both critical care units represented by the authors of this study, it was noted, through a 4-month audit (detailed later in this study), that typically 50–200 mL of normal saline is required to fully remove secretions and irrigations are normally performed twice daily or more frequently as appropriate. Although a minimum of once-daily subglottic irrigation is recommended, this is not evidence based and it is believed that nursing staff on every shift would prefer to ensure for themselves that the subglottic space is clear. A study is currently underway to provide evidence in this area. A protocol for performing subglottic irrigation with the LoTrach system is shown in Table 2.

**Preventing unplanned extubation**
The LoTrach ETT features an integral, flanged bite block (Figure 3). The bite block inhibits tube occlusion by preventing the patient from biting on the ETT. This has been effectively demonstrated in two patients in different ICUs in early 2008. Both patients were inadequately sedated and unexpectedly woke and bit on the bite-block section of the ETT. In each case, there was no tube occlusion, and oxygenation was unaffected. These incidences were observed by one of the authors of this study. The flange provides a securing system designed to reduce the incidence of accidental extubation. The necessity for this is illustrated by
Table 2 Recommended procedure for subglottic irrigation using the LoTrach endotracheal tube

This is a two-person procedure and should be performed by either a doctor or a registered nurse deemed competent. It is recommended this procedure is carried out every 12 h or more frequently if appropriate.

**Equipment**
- Normal saline at room temperature
- 50 mL Luer syringe
- 10 mL syringe
- Suction unit with either Yankauer or soft suction catheter attached
- Towel (to protect patient from spillage)

**Procedure**

First person
- Attach a 50-mL syringe of normal saline to subglottic port
- Slowly and gently instil the saline, watching monitoring display throughout
- Note that if injection pressure exceeds 30 cmH₂O (occurs rarely), the injected saline may leak past the cuff

Second person
- Use Yankauer or soft suction catheter to remove accumulating fluid from mouth and/or nose

First person
- Remove any remaining fluid from above the cuff by aspirating subglottic port using 10-mL syringe and applying suction for 10–15 s

Repeat whole procedure if secretions do not run clear
- Normally, 50–200 mL of normal saline is required to completely cleanse the upper airway

Special precaution: Self-terminating bradycardic episodes can occur occasionally during this procedure because of vagal stimulation especially if the injected saline is cold. Should this be problematic, then stop irrigation and aspirate residual fluid from above cuff with 10-mL syringe attached to the subglottic port

The tube can be fixed with the flange positioned either horizontally or vertically and the orientation can be changed as required to minimize the risk of pressure sores around the lips (Figure 4).

**Non-stick inner lumen**

The inner lumen of the LoTrach ETT is coated with a non-stick lining to inhibit the adhesion of biological material. This is designed to facilitate the passage of suction catheters and bronchoscopes but may also reduce the accumulation of secretions sticking to the tube lumen and hence improve tube blockage rates. This potential advantage has not been formally evaluated. Jaber et al. (2004) showed that tube patency in conventional ETTs is progressively reduced after 5 days of mechanical ventilation if utilizing heat moisture exchangers (HME) as opposed to a heated, humidified circuit. It is therefore recommended that hot water humidification rather than HME be used with the LoTrach ETT.
Reducing airway trauma
ETTs used in the critical care setting should minimize the mechanical forces that cause injury to the airway. Injury is common with the prolonged placement of a fix curved, relatively rigid polyvinyl chloride tube. These ETTs tend to exert pressure on the anterior wall of the trachea by the tip of the tube and on the posterior arytenoids where the midshaft of the ETT bows forwards. The LoTrach ETT has been designed to be more flexible than conventional ETTs and tends to conform to the patient’s airway rather than forcing the airway to conform to the tube. This is intended to reduce these localized pressure points where the tube lies against the airway mucosa.

COST IMPLICATIONS
The LoTrach ETT is significantly more expensive than current tubes utilized in ICUs. However, as stated earlier, the severe detriment to the patient of increased mortality/morbidity should they acquire VAP coupled with significantly increased hospital costs because of extended number of ventilator days far outweighs the cost of the equipment. When a clinician needs to justify quality improvements to hospital administrators, cost-effectiveness is often paramount. Fortunately, the price of the LoTrach tube is equivalent to only 1–2 h of ICU stay. This is highly cost-effective as the evidence for just one of the components of the LoTrach care bundle, namely subglottic secretion drainage, shows on meta-analysis that the length of ICU stay is reduced by 3 days (Dezfulian et al., 2005).

The CPC cannot be purchased and is issued on a loan basis, thus avoiding a large initial outlay. It is anticipated that once the use of the system becomes widespread, then purchasing costs will be reduced.

THE LOTRACH SYSTEM IN CLINICAL PRACTICE
Indications for use of the LoTrach ETT
The LoTrach ETT is indicated in any adult patient expected to require intubation for more than 24 h. There are no specific contraindications to its use.

Placement of the LoTrach ETT
The LoTrach ETT can be placed as a primary airway or as a replacement for a conventional ETT when intubation for more than 24 h is expected. If a replacement of a conventional ETT is required, this is normally performed over a bougie or a tube exchange catheter.

Initial feedback
As described by Ruffell and Adamcova (2008, p. 49), an audit was completed in 2007 in one of the units initially working with LoTrach ‘not with the intention at present of proving whether it reduces VAP but initially to analyse the suitability and ease of use of the varying components’.

The audit was carried out over a period from 14 December 2006 to 4 April 2007. Thirteen patients with the LoTrach system were audited. It is appreciated that this cohort is extremely small but the unit was limited in the number of ETTs made available through this evaluation phase.

Intubation
The majority of intubations (9/13; 69.2%) were carried out by senior house officers each of whom found the procedure as easy as, or easier than, inserting conventional HVLP ETTs. Intubations with LoTrach were not considered to be a more specialized procedure than intubations with conventional ETTs. In light of the challenges detailed in the next section, it is interesting to note that only in one case was the ETT initially inserted insufficiently far into the patient’s airway.

ETT retention
Nurses generally preferred the flange of the ETT to be fixed vertically as they found it easier to perform mouth care and it appeared to be very secure. Such retention was not always possible because of the anatomical shape of the patient’s head/jaw.

Subglottic irrigation
This was always carried out by nursing staff and there was no instance of a nurse being unsure of the procedure after demonstration and initial attempt. Their understanding of the rationale for this system in preventing VAP was enhanced as they observed first-hand the composition of the secretions they were aspirating during such a procedure.

Extubation
On only one occasion was a patient extubated electively. The other patients either had tracheostomies performed or died. In the case of the elective extubation, it was noted that there were minimal secretions at the distal end of the ETT as the tube was removed. The likely reason for this was that the subglottic space was clear and so no secretions were lying above the cuff prior to deflation.
Challenges during implementation into clinical practice

Both the CPC and the LoTrach ETT have comprehensive instructions for use but, as the system is unique and intubation is often an emergency procedure in the ICU setting, there is often little time to study such manuals. Thus, one of the authors of this study worked for 6 months training nursing, medical and physiotherapy staff in units around the UK who were considering using, or had already acquired, the LoTrach system. A guideline for subglottic irrigation was produced (Table 2), and photographs of the recommended fixation methods (Figure 4) were distributed with the ETTs. As the inflation line from the CPC is attached to the ETT continuously, there is no issue with a practitioner inserting fluid into the wrong port. A short PowerPoint presentation discussing VAP and the role of LoTrach has been made available as a teaching package for the staff to access from their work computers to emphasize the rationale and benefits of using the system.

Currently, two main challenges remain in the clinical implementation of the LoTrach system. First, there is a tendency for new users to fail to insert the ETT sufficiently far into the trachea during their initial attempts at intubation. This error results from a failure to appreciate that the LoTrach ETT is designed to prevent trauma by conforming to the patient’s airway to a much greater degree than a conventional ETT. As a result of this, the LoTrach ETT takes a 2–3 cm longer path through a patient’s oropharynx compared with a much less malleable conventional ETT, which forces the patient’s airway to conform to its relatively fixed curvature. Consequently, for the tip of a LoTrach ETT to be positioned at an equivalent level in a patient’s trachea, it needs to be inserted so that the ETT insertion depth measured at the incisors reads 2–3 cm more than that of a conventional ETT. Accordingly, it has been noted that when the LoTrach ETT is introduced to new users, for the first few attempts at intubation, it is inserted insufficiently far in over 80% of cases. This manifests itself as an apparent cuff leak as the cuff inflates partially in the laryngeal inlet.

Second, there has been initial reluctance by some nursing staff to perform subglottic irrigation. This has resulted from lack of confidence that irrigation fluid would not track passed the cuff into the lower airways. In the majority of cases, once nursing staff have carried out their first irrigation and observed the safe and successful extraction of, often offensive, fluid from the subglottic space, this initial reluctance has rapidly dissipated. It is anticipated that as the use of the LoTrach system becomes more widespread, these issues will be resolved.

Case studies

The following case studies provide examples from our recent clinical practice where the use of the LoTrach system was advantageous to patient care.

Case 1

A 60-year-old male was admitted to the ICU following an elective maxillofacial procedure to close an oroantral fistula (an abnormal tract formed between the oral cavity and the maxillary sinus). Immediately following the procedure, he bled heavily into his oral cavity and developed laryngeal oedema. He required reintubation, which proved to be very difficult (Grade IV laryngoscopy), and a standard HVLP-cuffed ETT was initially inserted using a bougie. In the ICU, he continued to haemorrhage and there was evidence of aspiration on his chest X-ray film. The upper airway became filled with purulent material from the antral fistula. The HVLP-cuffed ETT was exchanged for a size 8/0 LoTrach ETT with relative ease over a bougie that had been reintroduced into the trachea through the previous ETT. The LVLP cuff was inflated to 80 cmH2O (wall pressure of 30 cmH2O), and pressure was maintained using the LoTrach CPC. Daily subglottic irrigation was performed, and copious purulent secretions and blood were successfully and safely evacuated from the subglottic space above the ETT cuff. The volume of upper airway secretions was substantially reduced by day 13 from admission. The patient underwent a surgical tracheostomy on day 20, was awoken and was successfully decannulated on day 36 from admission.

Case 2

A 32-year-old female was admitted to the ICU having developed septic shock originating from septic arthritis of the knee. She had a LoTrach ETT in situ for 16 days until a tracheostomy was performed. She was intermittently ventilated in the prone position during the course of her critical illness. The flexibility of the LoTrach ETT, coupled with the security of the flanged bite block in preventing accidental extubation, ensured that the process of proning and returning supine were smooth and safe procedures. The ability to perform subglottic irrigation throughout the period of proning ensured minimal leakage of nasal/oral contents onto the pad below the patient’s face. The patient made a full recovery.
Case 3
A 72-year-old man required an emergency laparotomy for bowel perforation. A LoTrach ETT was inserted immediately prior to the operation. The ETT was in situ for 8 days. It was noted that there was minimal lung consolidation, and twice-daily subglottic irrigation removed debris from above the cuff on each occasion. The patient initially did not absorb his nasogastric feed, and at one stage, fluid resembling feed was noted in aspirates from the subglottic space during irrigation. There was no feed suctioned from his lungs, indicating that the fluid had not migrated down passed his ETT cuff. The ETT was tied vertically with two tracheostomy tapes (one positioned above and the other below the ear) and remained firmly in place during turning procedures.

CONCLUSIONS
Given that each case of VAP is associated with a direct cost of up to £12,000, it is recognized that even marginally beneficial preventative interventions in the fight against VAP are likely to yield significant net savings (Shorr and Wunderink, 2003). The LoTrach ETT has been designed to have substantial advantages over conventional HVLP-cuffed tubes in the prevention of VAP. It employs a five-pronged approach to prevention of VAP. This comprises reduced cuff leakage, cuff pressure maintenance (using the LoTrach CPC), convenient drainage and irrigation of subglottic secretions, prevention of tube movement and accidental extubation and potential inhibition of biofilm formation in the tube lumen. The LoTrach ETT has the potential to be a very useful tool in the fight against VAP in the ICU setting (Ruffell and Adamcova, 2008).

WHAT IS KNOWN ABOUT THIS TOPIC
• VAP is a leading cause of mortality in the ICU.
• VAP has significant cost implications.
• The main cause of VAP is the aspiration of secretions passed the cuff of the ETT.

WHAT THIS PAPER ADDS
• A LVLP cuff inflated to achieve a tracheal wall pressure of 22–30 cmH2O prevents all aspirations passed the cuff without causing tracheal mucosal damage.
• The LoTrach ETT is the only ETT in which irrigation of the subglottic space and upper airway is possible. This aids reduction in colonization of the upper airways.
• The LoTrach system facilitates the application of evidence-based VAP preventative measures, thus enabling ICU staff to implement best practice.

REFERENCES
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