

A Defective Endotracheal Tube

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ABSTRACT

Routine inspection and testing of endotracheal tubes prior to use may fail to detect certain manufacturing defects.

We describe a case of endotracheal tube kinking at the junction where the inflation tube for the pilot balloon is attached to the endotracheal tube.

This case report highlights the importance of maintaining an awareness that airway obstruction or leak due to structural defects can still occur even with high quality, prepacked single use plastic endotracheal tubes. It also emphasises the need to have a systematic approach when dealing with such critical events.

Keywords: AIRWAY: Obstruction; EQUIPMENT: Endotracheal tubes.

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INTRODUCTION

Various manufacturing defects in endotracheal tubes (ETT) have been described. A published analysis of ETT leakage found that when mechanical defects were present, these were most likely to involve the cuff, pilot valve or cuff inflation tube⁽¹⁾. We report a case of partial airway obstruction with a 5.5 mm cuffed ETT, due to a kink at the notch in the tube wall where the cuff inflation tube is attached, during anaesthesia for a change of pacemaker.

CASE REPORT

A nine-year-old boy with congenital heart block, body weight of 23 kg, was scheduled for an elective change of pacemaker and pacemaker leads. He was asymptomatic clinically.

Following establishment of patient monitoring; ECG, pulse oximetry and invasive blood pressure monitoring, the child was induced with thiopentone, fentanyl and pancuronium. Intubation with size 5.5 cuffed PVC ETT (Portex blue-line, single use) was uncomplicated. ETCO₂ was established and bilateral air entry confirmed by auscultation.

The child was then ventilated at inspiratory pressure of 17 mmHg (monitored expired tidal volume of 250 ml) and rate of 16 breaths per minute. Anaesthesia was maintained with oxygen, nitrous oxide and isoflurane. Morphine was given to provide analgesia.

The child was cleaned and draped as for median sternotomy. One hour into surgery, ETCO₂ was noted to have increased gradually from a baseline value of 30 mmHg to 50 mmHg. This was accompanied by a corresponding drop in the expired tidal volume monitored to about 100 ml. SaO₂ remained unchanged at 100% with FiO₂ of 0.40.

Upon noting the rise in ETCO₂ and drop in expired tidal volume, the patient was immediately disconnected from the ventilator and the lungs ventilated manually. No obvious change of lung compliance was detected. The circuit was checked systematically for kinks, obstructions or leaks but none was found. A 10F suction catheter was then passed down the lumen of the ETT to exclude partial obstruction. Though no secretions could be suctioned, the suction catheter would not pass fully down the tube.

ETT marking at the incisor was checked and remained the same at 18 cm. Visual inspection of the ETT did not reveal any cause of airway obstruction. Due to the nature of the operation and surgical draping, it was difficult to auscultate the chest. Two puffs of ventolin was administered for presumed bronchospasm.

Tidal volume subsequently increased to 130 ml transiently but soon decreased to 80 ml at the same ventilatory settings. ETCO₂ rose to 90 mmHg. The child was ventilated manually again, this time requiring increased ventilating pressure of 25-30 mmHg to maintain adequate tidal volume and to keep ETCO₂ at about 60 mmHg. A suction catheter was passed down the ETT but resistance was encountered this time within the oral cavity. A palpating finger inside the oral cavity did not reveal any intraoral kinks of the ETT.

Oxygenation was maintained at 98-100% with FiO₂ of 0.50 and higher ventilatory pressures. There was no episodes of hypotension or arrhythmia.

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After discussion with the surgeon, surgery was expedited and surgical drapes removed immediately once surgery was completed. A direct laryngoscopy was performed. This showed the ETT to be kinked intraorally at a point just beyond the soft palate.

The child was reintubated at once with another size 5.5 cuffed ETT with marked improvement in the ventilatory mechanics.

Examination of the kinked tube revealed that it was softer to palpation at a point where the inflation tube for the pilot balloon was attached to the tube wall (Fig. 1), in comparison to an identical size 5.5 cuffed tube with another batch number (Fig. 2). The defective ETT retained the deformed configuration over the next two months despite attempts to straighten it and storage in a cool environment (Fig. 3).



Fig. 1 Photograph showing kink at the junction where the inflation tube is attached to the wall of the ETT.



Fig. 2 Comparison of the defective ETT (LOT 210870, REF 100/199/055) with a size 5.5 ETT from another batch (LOT 97A15, REF 100/188/055).



Fig. 3 The defective ETT after 2 months storage in a cool environment.

DISCUSSION

Similar cases have been described by Arai et al in 1983⁽²⁾. They observed three cases of ETT (Portex, blue-line, disposable) kinking during neurosurgical anaesthesia in adults in which flexion of the neck was negligible. All the kinkings occurred at the notch in the tube wall where the cuff inflation tube was attached. Factors postulated include:

1. Tube wall is thinner at the level of the notch, about half the original thickness, thus causing it to kink at this point of weakness when it is bent.
2. Location of the notch in the wall is at a distance of 17 cm from the tip of tube (size 9.5 ETT) so that it stays in the oral cavity, in contact with the tongue. This is where the tube bends most, following the anatomic curvature of the airway. That is, the notched part is located at the bottom of the "U" when the tube is bent into a U-shape.
3. When the PVC ETT is softened in the oral cavity at body temperature, the U-shaped bend may gradually change to a sharp V-shaped kink.

In our case, the kink occurred at a distance of 13 cm from the tip of the tube, corresponding to the location of the notch in the wall of a size 5.5 ETT. This point is well within the oral cavity at a point just beyond the soft palate, thus making it difficult to detect even with a palpating finger. The only early warning signs were: decreasing tidal volume on a pressure control mode of ventilation and persistently high ETCO₂ due to hypoventilation. The suction catheter was unable to pass through the tube due to the sharp V-shape kink as the tube softens at body temperature.

Other manufacturing defects in ETT have been described. These include cuff defects leading to herniation and intraluminal tracheal obstruction⁽³⁻⁵⁾, elliptical defects in the tube wall at the level of the notch cut for insertion of the pilot tube causing air leak^(6,7) and intraluminal plastic films and meniscus^(8,9) causing near complete airway obstruction.

The checking of ETT for defects before placement is an integral part of routine checking of anaesthetic equipment. This usually includes examining the tube to ensure patency and inflating the cuff to detect air leakage. In our case, routine check of the ETT failed to pick up the structurally weakened point in the tube wall. Only after "incubation" at body temperature for a period of time and on palpation did the structural defect become obvious.

There has been no further reports of this type of structural defect since 1983. The 5.5 mm cuffed endotracheal tube is the smallest cuffed tube commonly used in our practice. Recently, there has

been a growing interest in the use of even smaller paediatric cuffed tubes, down to size 3.5. Any structural defects in the tube wall of a small sized ETT will result in more significant airway incidents compared to a larger sized ETT.

We feel, therefore, that it is timely to highlight this case in view of the increasing use of paediatric cuffed tubes.

CONCLUSION

In conclusion, although inspection of ETT prior to use is important, clinical assessment by the anaesthetist is still the most crucial factor in confirming tube function. In particular, there are two important learning points to be highlighted in this case. Vigilant monitoring of ventilatory pressure and expired tidal volume is crucial to the early detection of airway obstruction. In cases where no other cause

for inadequate ventilation is found, it is imperative to perform a direct laryngoscopy and replace the ETT if in doubt.

REFERENCES

1. Arai T, Kuzume K. Endotracheal obstruction possibly due to structural fault. *Anesthesiology* 1983 Nov; 59(5):480-1.
2. Kearl RA, Hooper RG. Massive airway leaks: an analysis of the role of endotracheal tubes. *Crit Care Med* 1993; 21:518-21.
3. Henderson MA. Airway obstruction with a cuffed single-use plastic endotracheal tube. *Anaesth Intens Care* 1993; 21:370-2.
4. Dunn HC. A defective endotracheal tube. *NZ Med* 1988 Jul; 101(849).
5. Famewo CE. A not so apparent cause of intraluminal endotracheal tube obstruction. *Anesthesiology* 1983; 58(6):593.
6. Lewer BMF, Karim Z, Henderson RS. Large air leak from an endotracheal tube due to a manufacturing defect. *Anaesth Analg* 1997 Oct; 85(4):944-5.
7. Gettelman TA. Endotracheal tube failure: undetected by routine testing. *Anaesth Analg* 1995; 81:1311-20.
8. Kee WD. An unusual problem with an endotracheal tube. *Anaesth Intens Care* 1993; 21(2):247-8.
9. Barst S, Yossefy Y. An unusual cause of airway obstruction. *Anesthesiology* 1998; 88(2):548.