

Perforation of the trachea by an endotracheal tube: an autopsy case

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Abstract An 80-year-old woman was intubated with a spiral endotracheal tube via a tracheal stoma during an arytenoidectomy. After being connected to the ventilator, the victim quickly became cyanosed, showed a decrease in blood pressure, and fell into cardiopulmonary arrest. Despite continuous resuscitation, the victim died. Necropsy found a tracheal perforation located 2.0 cm distal from the tracheal stoma that led to the right pleural space through the mediastinal space. We concluded that the tip of spiral endotracheal tube passed through the membranous part of the trachea into the pleural space and caused a hemopneumothorax followed by blood aspiration and death. Tracheal perforation is a rare, but life-threatening complication following a tracheostomal intubation. The inappropriate use of a tracheal tube stylet, guiding catheter, dilating forceps, and oversize tracheal tube have been demonstrated to cause airway injuries. However, fatal incorrect intubation with a spiral endotracheal tube via a tracheal stoma that resulted in death has not been reported previously.

Keywords Spiral endotracheal tube ·
Tracheostomal intubation · Stab · Perforation

Introduction

Tracheal intubation is performed with the patient under general anesthesia for airway management during surgery. Most patients are intubated orally or nasally using an

endotracheal tube. When a tracheal stoma exists in anterior region of the neck that penetrated to the bronchial lumen, the tracheal intubation is usually performed via the stoma. Tracheal perforation is a rare complication following a tracheostomal intubation [1–3]. Using an experimental cadaver model, Fikkers et al. [3] reported that the distance between the dorsal tracheal wall and the pleural cavity was so short that a tracheal perforation could easily enter the pleural space and causes serious complications following tracheostomal intubation. Many reports of tracheal perforation have demonstrated the mechanisms of damage to the tracheal wall. These include excessive pressure applied to the distal tip of a stylet protruding from a tracheal tube against tracheal wall [4], an improper stabilization of a guiding catheter allowing the tracheal tube to move along the posterior tracheal wall [5, 6], a blunt dissection of tracheal wall by dilating forceps [7–9], and forced insertion of an oversize tube [10]. We conducted an autopsy on a case where cause of death was tracheal perforation by the tip of the endotracheal tube that was intubated via a tracheal stoma.

Case report

An 80-year-old woman had a thyroidectomy approximately 1 year before death. Dyspnea appeared immediately after the operation. The inferior laryngeal nerve was found to be damaged and a tracheostomy tube (Table 1) was inserted via a tracheal stoma. One year later, she felt discomfort in the stoma and was scheduled to undergo an arytenoidectomy to reduce the dyspnea and suturing of the stoma.

General anesthesia was induced with 250 mg thiopental sodium followed by an intravenous administration of 1.5 mg vecuronium bromide. For the induction of general anesthesia, a Montandon tube (Fig. 2; Table 1) was

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Table 1 The list of tracheal tubes used to the victim

Name	Shape	Regular usage		This case
		Use	Intubation route	Intubation route
Tracheostomy tube	Quadrantal curved tube of 5.0 to 7.0 cm long	Respiratory failure, upper airway obstruction	Tracheostomal	Tracheostomal
Montandon tube	Shown in Fig. 2	General anesthesia	Tracheostomal	Tracheostomal
Spiral endotracheal tube	Shown in Fig. 3	General anesthesia	Oral or nasal	Tracheostomal
Double-lumen endotracheal tube	Rod tube with two lumens inserted into bilateral lungs	General anesthesia	Oral	Oral

intubated easily via the tracheal stoma and artificial ventilation was performed without complications. Resistance in ventilation occurred several minutes after the intubation. The Montandon tube was extubated and a spiral endotracheal tube (Fig. 3; Table 1) without a tracheal tube stylet was smoothly intubated via the tracheal stoma. The physician confirmed chest movement, connected the tracheal tube to a ventilator, and checked for correct positioning by measuring the expiratory concentration of carbon dioxide (end-tidal CO₂) by capnography. End-tidal CO₂ was undetectable by capnography, and the victim quickly became cyanosed followed by decreased arterial oxygen saturation and blood pressure immediately after the intubation of a spiral endotracheal tube. The spiral endotracheal tube was removed immediately, a tracheostomy tube (Table 1) was re-intubated, and positive pressure ventilation was continued. However, the victim fell into cardiopulmonary arrest approximately 5 min after re-intubation of the tracheostomy tube. A chest radiograph showed a right-sided pneumothorax. Cardiopulmonary resuscitation was started and a drainage tube was inserted to the right pleural space about 20 min after re-intubation. A large quantity of air and hemoserous fluid was drained. The tracheal wall was confirmed to be intact on bronchoscopy 55 min after re-intubation of a tracheostomy tube. The right pleural space was identified on a chest roentgenogram. The physicians suspected the existence of tracheal perforation. The tracheostomy tube was extubated again and a double-lumen endotracheal tube (Table 1) was intubated orally into the bilateral primary bronchus at 85 min after the initial re-intubation of the tracheostomy tube. Despite continuous resuscitation, the victim died approximately 12 h after the primary intubation of the Montandon tube.

Autopsy findings

An oval stoma 1.2×1.0 cm in diameter was present in anterior region of the neck surrounded by subcutaneous bleeding. The stoma passed into the tracheal lumen at the level of the first and second tracheal rings. A tracheal perforation of 1.0×

0.6 cm in diameter was found at 2.0 cm distal from the stoma and penetrated the right pleural space (Fig. 1). Abnormal findings such as stenosis or distortion were not detected in the tracheal lumen. The mediastinal space was shifted to the left and bleeding was present. A purplish red fluid of 600 ml was present in the right pleural cavity. The left lung weighted 445 g and the right lung 460 g, and deep purplish-red regions distinctly corresponding to lobules or segments existed in both lungs. By histological examination, the deep purplish-red regions of the lungs were full with blood extending from the bronchus to the alveoli. We concluded that the victim died from respiratory failure caused by a hemopneumothorax and blood aspiration.

Discussion

In the case of a tracheal stoma, tracheostomal intubation rather than oral intubation is more common for the induction of general anesthesia like this case because it is easier. In this case, a tracheal tube stylet, guiding catheter,

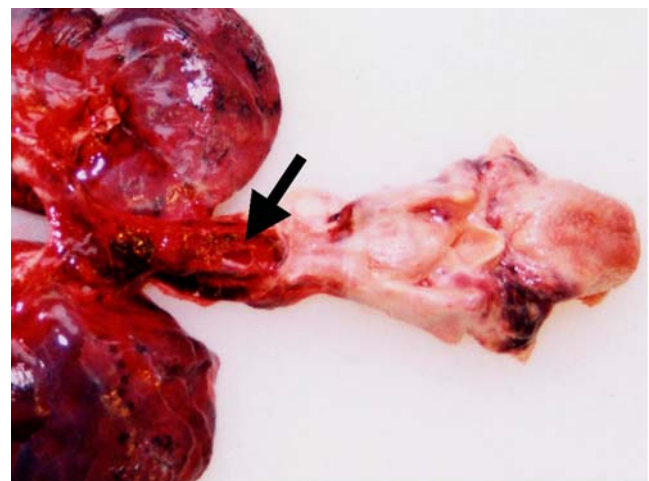


Fig. 1 A perforation 1.0×0.6 cm in diameter (*arrowhead*) is observed in the right membranous part of the posterior trachea 2.0 cm distal to the tracheal stoma. The perforation led into the right pleural space through the mediastinal space. The tracheal stoma is anterior and not shown in this photograph

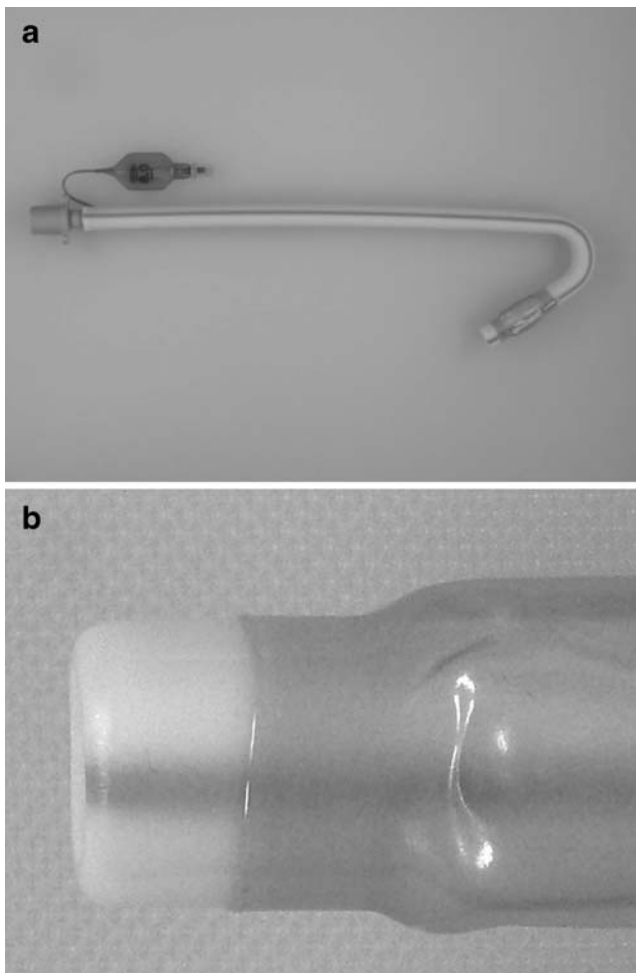


Fig. 2 The tip of the Montandon tube is curved counter to the root similar to the letter *J* (a), which is intubated via a tracheal stoma during operative procedures. The edge of the tip is cut in a horizontal plane and soft (b), which requires excessive force on the tracheostomal intubation to cause the tracheal perforation in this case

and dilating forceps were not used on the tracheostomal intubation. In addition, the size of the Montandon tube and spiral tube was appropriate for the victim because the tubes passed smoothly into the trachea. Therefore, a problem with the Montandon tube or the spiral endotracheal tube must have contributed to the tracheal perforation and respiratory deterioration of the victim during the operation.

The tip of a Montandon tube is soft and flat (Fig. 2), and it would be very difficult to use sufficient force to cause the tracheal perforation in this case. However, if a partial dislodgement occurred in the Montandon tube, the tube would become stenosed and cause an increase in the resistance of ventilation. This phenomenon may account for the increase in respiratory resistance after intubation in this case.

On the other hand, a spiral endotracheal tube is a gently curved rod with an acuminate and hard tip (Fig. 3) and is intubated apically. In addition, it may be possible to add

excessive pressure and cause the tracheal perforation in this case. According to the accompanying manual, the spiral endotracheal tube is suitable for orotracheal or nasotracheal intubation but is not suitable for tracheostomal intubation. With consideration of these findings, we suggest that the tip of the spiral endotracheal tube intubated via the tracheal stoma may stab the membranous part of the trachea and enter the pleural space. This suggestion is consistent with the clinical findings of the disappearance of end-tidal CO_2 and the appearance of acute respiratory failure immediately after the spiral endotracheal tube intubation.

A tracheal stenosis, which is reported to occur in prolonged tracheal intubation at a high frequency of about 60%, may result in tracheal perforation on tracheostomal re-intubation [1, 9]. Smith and Hopkinson reported that tracheal distortion may stretch the membranous part and a

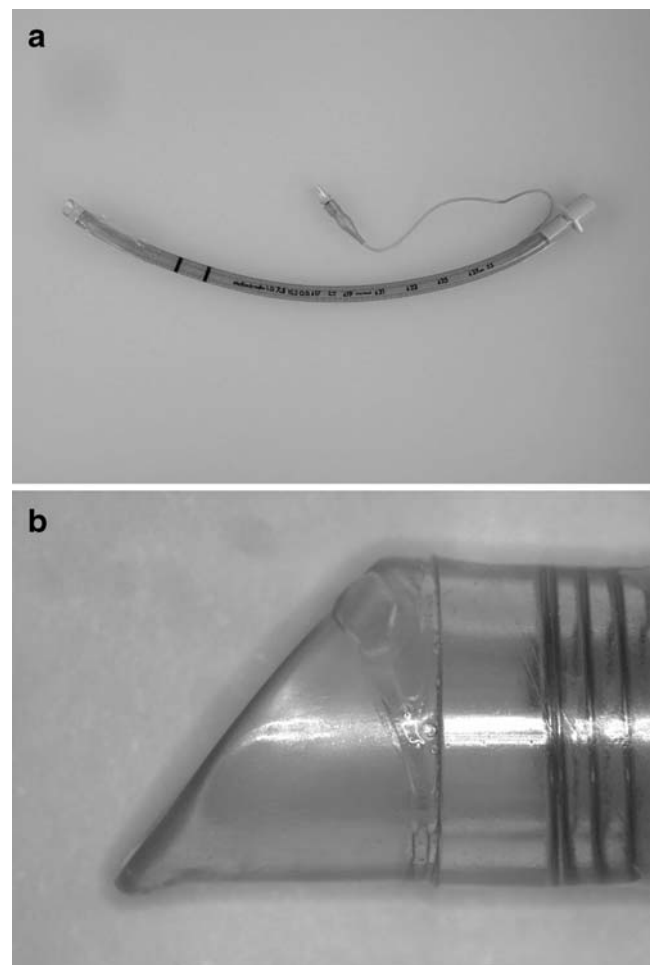


Fig. 3 A spiral endotracheal tube is reinforced with embedded spiral wire in the trunk portion to minimize kinking, maintain shape, and provide stiffness (a). The tip of the tube is acuminate, hard, and made of polyvinylchloride (b). The tip has a 1.02 cm in the external diameter, which could be able to cause the perforation of 1.0×0.6 cm in diameter of the present victim's trachea if excessive pressure is used, even if a tracheal tube stylet is not used

redundant membrane may act as a blind pocket that tends to puncture on tracheal intubation [4]. Although the victim in this case had been intubated with a tracheostomal tube about 1 year before this fatal complication, neither tracheal stenosis nor tracheal distortion was detected at autopsy. Marty-Ané et al. demonstrated that the membranous part of the trachea is very friable and susceptible to injury in elderly patients and in women [11]. The present victim was an 80-year-old woman, so gender and age suggest the possibility of damage to the membranous part of the trachea by the light pressure of the tip of the spiral endotracheal tube.

The potential complications of tracheal perforation are subcutaneous emphysema, pneumothorax, and respiratory failure of which the latter two are life-threatening complications and immediate management such as thoracocentesis should be performed as soon as possible [1, 3]. In the case described, when the respiratory failure occurred, the spiral endotracheal tube was removed and exchange for a tracheostomy tube and positive pressure ventilation was continued. A chest radiograph taken soon after the cardiopulmonary arrest showed a right-sided pneumothorax. The pneumothorax probably deteriorated from the continuous positive pressure ventilation because the ventilation intensified air leakage into the pleural cavity through the tracheal perforation, which was distal to the fenestra of the tracheostomal tube. In addition, respiratory failure would progress from the aspirated blood. We believed that the victim might have survived if appropriate treatment had been administered immediately at the time of loss of end-tidal CO₂.

Conclusion

Many reports have demonstrated that inappropriate use of a tracheal tube stylet, guiding catheter, dilating forceps, or oversize tube may cause airway injury on tracheostomal intubation. This is the first autopsy case report with a fatal

tracheal perforation stabbed with the tip of the endotracheal tube, due to improper use of a spiral endotracheal tube via a tracheal stoma.

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