

Failure to provide adequate one-lung ventilation with a conventional endotracheal tube using a transbronchial approach: a case report

[Ventilation unilatérale inadéquate avec un tube endotrachéal traditionnel et l'utilisation d'une approche transbronchique : une étude de cas]

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Purpose: To report a case where failure to provide adequate one-lung ventilation during transbronchial intubation resulted in a potentially fatal mishap.

Clinical features: A 61-yr-old male was scheduled for right lung lobectomy. Induction of general anesthesia was smooth, and subsequent resection of the right middle lobe was uneventful. Difficult ventilation with high airway pressure and poor right lung re-expansion prompted repositioning of the double-lumen tube after the resection. The removal of the right middle bronchial clamp and associated right mainstem manipulation caused flooding of blood into the double-lumen tube.

Mindful of the risk of fatal desaturation, the surgeon immediately opened the right mainstem bronchus and cleared the airway. Confirmation of a displaced double-lumen tube prompted the surgeon to insert an endotracheal tube (internal diameter 5.5 mm) from the opened right mainstem bronchus to the left main bronchus to maintain oxygenation. Although bronchoscopic examination confirmed proper location of the reinserted tube, oxygen saturation was not sufficiently (60%) improved. Another 5.5-mm endotracheal tube was inserted, with its tip inside the right upper bronchiole, for further ventilatory support. Finally, a rise in SpO₂ to around 95% allowed completion of surgery.

Conclusions: Displacement of the double-lumen endobronchial tube and flooding with clotted blood will result in potentially fatal ventilation difficulties. Repositioning and cleaning of the tube must be prompt to reduce the risk of hypoxemia. Where emergency single-lung ventilation is required, we suggest the utilization of a modified single-lumen endotracheal tube with a shortened cuff-tip length to ensure an adequate margin of safety for mainstem bronchus intubation.

Objectif : Présenter un cas de ventilation unilatérale inadéquate, pendant l'intubation transbronchique, qui a provoqué un incident potentiellement fatal.

Éléments cliniques : Un homme de 61 ans devait subir un lobectomie pulmonaire droite. L'induction de l'anesthésie générale a été facile et la résection subséquente du lobe moyen droit sans incident. Des difficultés de ventilation avec une pression élevée dans les voies aériennes et une ré-expansion pulmonaire droite plutôt difficile ont commandé la réinsertion rapide du tube à double lumière après la résection. Le retrait du clamp de la bronche moyenne droite et la manipulation associée de la bronche souche droite ont provoqué un afflux de sang dans le tube à double lumière. Conscient du risque de désaturation fatale, le chirurgien a immédiatement ouvert la bronche souche droite et libéré les voies aériennes. La confirmation du déplacement du tube à double lumière a rapidement mené le chirurgien à l'insertion d'un tube endotrachéal (diamètre interne de 5,5 mm) par la bronche souche droite ouverte vers la bronche souche gauche afin de maintenir l'oxygénation. L'examen bronchoscopique a confirmé la bonne position du nouveau tube, mais la saturation en oxygène demeurait inadéquate (60 %). Un autre tube endotrachéal de 5,5 mm a été introduit, dont la pointe était à l'intérieur de la bronche intermédiaire supérieure droite, pour une assistance ventilatoire supplémentaire. Une hausse de la SpO₂ à environ 95 % a finalement permis de terminer l'intervention chirurgicale.

Conclusion : Le déplacement du tube endobronchique à double lumière et l'arrivée de caillots sanguins peuvent provoquer des difficultés de ventilation potentiellement fatales. La remise en place et le nettoyage du tube doivent se faire rapidement pour réduire le risque d'hypoxémie. Lorsqu'une ventilation d'urgence à un seul poumon est nécessaire, nous suggérons d'utiliser un tube endotrachéal unilumière modifié, la distance entre le ballonnet et le bout distal du tube étant réduite, afin de ménager une marge de sécurité suffisante à l'intubation de la bronche souche.

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ACCIDENTAL displacement of a double-lumen tube with resultant ventilation difficulties, high airway pressures and flooding of blood inside the tube can be a major hazard to the patient. Problems need to be solved within a few minutes to avoid any hypoxia and save a life. Because of the small lumen diameters that limit suctioning and airway clearance, direct opening of the trachea or bronchus, although traumatic, can provide an efficient method to maintain the airway. Transbronchial intubation can provide a method to secure one-lung ventilation, but the conventional endotracheal tube (ETT) may require special modification due to its relative long cuff-tip-length (CTL) when compared with the mainstem bronchus.

Case report

A 61-yr-old male was scheduled for right middle lobectomy for a tumour in the right lung. Induction of general anesthesia was accomplished using atracurium besylate, fentanyl and sodium thiopental, and subsequently maintained with isoflurane in oxygen, fentanyl and vecuronium. A 35-French left-sided double-lumen tube [DLT; Kendall, Sher-I-Bronch® The Kendall Co. (U.K.) Ltd., Basingstoke, England] was inserted in the trachea. Direct fiberoptic bronchoscopy confirmed proper positioning, with the cephalad surface of the left endobronchial cuff just below the tracheal carina. The patient was then placed in the left lateral position. Arterial blood-gas analysis of left-lung ventilation with the patient on 100% oxygen (FiO_2 1.0) confirmed acceptable readings for pH (7.464), PaCO_2 (51.0 mmHg), and PaO_2 (73.5 mmHg). Resection of the right middle lobe was uneventful. The surgeon then requested re-expansion of the right lung to check for leakage. He then suggested repositioning of the double-lumen tube 1 cm outward from the mouth because of poor lung expansion and high airway resistance. However, no improvement was noted. After removal of the right middle bronchial clamp and associated manipulation of the right mainstem bronchus, ventilation difficulties and high airway pressures became more pronounced. Blood clots were suctioned out from both lumens but ventilation difficulties persisted. Pulse oximetry revealed progressive worsening of saturation, which fell to around 21% within minutes. Given the urgency of the situation, a bronchoscopic examination was performed to check proper positioning of the DLT, however, this proved to be in vain due to massive hemorrhage, which obscured the field. The surgeon immediately opened the right mainstem bronchus to check for ruptured blood vessels and removed the

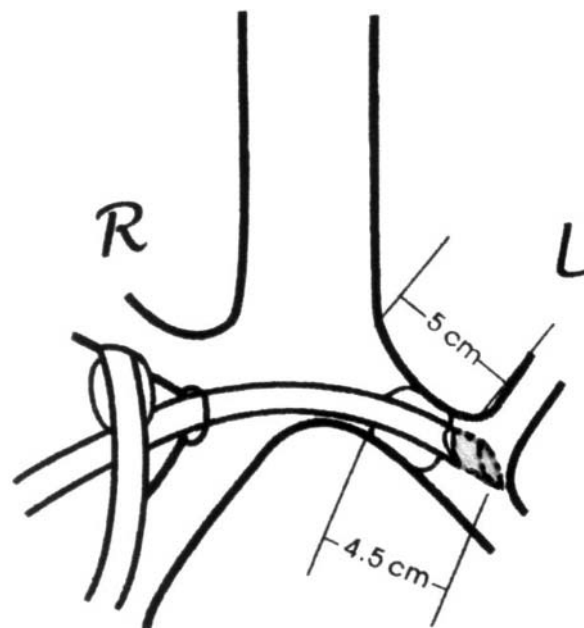


FIGURE 1 shows the actual position of the two internal diameter 5.5-mm single-lumen endotracheal tubes (ETTs) placed by the surgeon. The left endobronchial tube bypassed the orifice of the left upper lobe. Another cuffed ETT was inserted inside the right upper bronchiole. Dotted line, shade area illustrates cutting of the beveled tip of a modified ETT with ideal positioning to provide adequate one lung ventilation using a transbronchial approach.

clotted blood using suction. The position of the left side endobronchial aperture of the DLT was also checked by palpation. As displacement of the DLT was confirmed, the surgeon subsequently inserted a cuffed ETT (internal diameter 5.5 mm; Kendall Curity®) via the opened right mainstem bronchus through the carina to the left mainstem bronchus to ensure left lung ventilation. The DLT was simultaneously moved out and fixed at the 25-cm mark. After thorough cleaning and suctioning of the DLT, a fiberoptic examination was conducted through the DLT to check the proper placement of the 5.5-mm single-lumen ETT relative to the left mainstem bronchus. Positioning was correct, but SpO_2 was still not adequate, increasing to only 60%. The anesthesiologist was not able to confirm breathing sounds in the left apex area of the lung on auscultation. Simultaneously, another cuffed 5.5-mm ETT was inserted, with its tip inside the right upper bronchiole, for further ventilatory support (Figure 1). Finally, elevation of SpO_2 to around 95% permitted surgical repair of the right

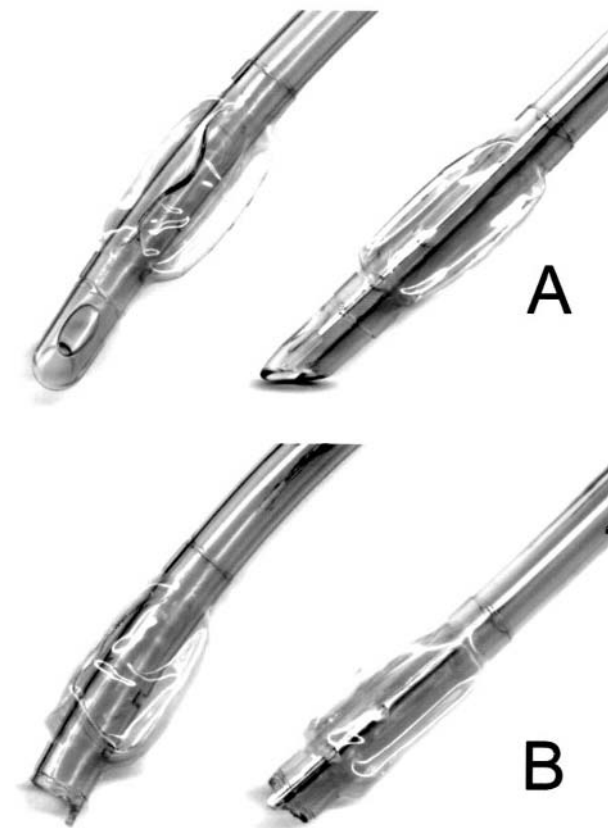


FIGURE 2 A shows the original design of the single-lumen endotracheal tube in anterior and lateral view. B shows the cutting of the beveled tip into a bird's mouth shape (same views) to avoid sectioning the inflating lumen.

mainstem bronchus. Continuous positive-pressure ventilation in the double-lumen tube after thorough cleaning of the airway producing acceptable arterial blood gas readings. Fortunately, vital signs remained stable throughout anesthesia, even during the period when SpO_2 had dropped dramatically. Following completion of surgery and exchange of the DLT for a standard size ETT (internal diameter 7.5 mm), the patient was transferred to the intensive care unit. Mechanical ventilator support was carefully withdrawn after five hours and no neurological sequelae were noted.

Discussion

Accidental displacement of a DLT can occur during thoracic surgery. The resultant ventilation difficulties and flooding of clotted blood inside the DLT will be a hazard, with the potential consequences of the

resulting hypoxia.¹ For our patient, the course of anesthesia had been smooth. The main reason that the surgeon asked for the withdrawal of the DLT was that high airway pressures were noted during re-expansion of the right lung after the right middle lobectomy. At that critical juncture, the surgeon came to the conclusion that the high airway pressures and occlusion of the right lung ventilation were the result of the accidental inward displacement of the DLT occurring during or after surgical manipulations.

Despite the dramatic consequences of replacing the DLT it seems prudent to suggest, that the emergency management of the dislodged left-sided DLT and the associated flooding with blood should be evaluated carefully, within the surgical context. In our case, single-lung ventilation with direct transbronchial endotracheal intubation did not provide sufficient oxygenation, despite cleaning of the airway. There are several possible explanations for this failure. Firstly, flooding of the surgical field with fresh blood may obstruct the upper orifice of the left mainstem bronchus of the dependent lung in the left lateral position after the DLT was dislodged. However, a postoperative chest roentgenogram clearly ruled out this possibility in this patient.

Secondly, the cuff-tip length (CTL) of the left-sided double-lumen endobronchial tube (3 cm; Kendall, Sher-I-Bronch®) is 1.5 cm shorter than that of the 5.5-mm ETT (4.5 cm; Kendall Curity®). If the endobronchial cuff of the DLT is positioned just below the carina, we estimate that, on average, this will provide a safety margin of 2 cm.² Using the 5.5-mm ETT (Kendall Curity®) for transbronchial intubation, a CTL of 4.5 cm may cause obstruction or bypass of the left upper lobe orifice. As the length of the left mainstem bronchus in oriental patients is below average, it is reasonable to assume that these patients are at elevated risk for this complication.³ Moreover, the Murphy-eye on the right side of the ETT will tend to lie opposite to the orifice of the left upper bronchiole, thus hindering ventilation. The absence of breathing sounds at the left apex provided further confirmation of this complication. As the left lower lobe typically constitutes just 20–25% of total lung volume, ventilation of this segment alone will be associated with a large shunt fraction and inadequate ventilation^{1,2,4} and oxygenation. Ventilating the left lower lobe increased SpO_2 to only 60%. Additional ventilation of the right upper lobe was necessary to produce satisfactory oxygen saturation (up to 95%).

Thus, the design of the single-lumen ETT restricted its effectiveness to provide adequate single-lung ventilation, even though the position of the cuff just past the carina was confirmed by direct fiberoptic bronchoscopy.

When no suitable short-cuff ETT is available in an emergency situation, cutting the bevelled tip of the ETT will reduce CTL, reducing the risk of left upper lobe obstruction during transbronchial intubation.⁴⁻⁶ Modification of the endotracheal tip needs to take into account its original design, however.⁷ The distal inflating lumen of the conventional single-lumen ETT can be protected by fashioning a small 'bird's mouth' aperture (Figure 2) as opposed to the parallel cutting recommended by other workers.^{4,5} The modified 3-cm CTL will ensure an adequate safety margin for left upper lobe ventilation, especially in oriental patients³ (Figure 1). Additionally, it seems reasonable to suggest that such a modification of the ETT may be of value for mainstem bronchial intubation, as a second approach to single-lung isolation in tracheal resection instead of using a Foley catheter⁸ when high-frequency positive-pressure jet ventilation is not available.^{6,8,9} Additionally, the shortened CTL decreases the risk of herniation of the cuff over the tracheal carina during outward movement of the ETT to ensure upper lobe ventilation.

In conclusion, displacement of the double-lumen endobronchial tube and flooding with clotted blood will result in potentially fatal ventilation difficulties. Repositioning and cleaning of the tube must be prompt to reduce the risk of hypoxemia. Where emergency single-lung ventilation is required, we suggest the utilization of a modified single-lumen endotracheal tube with a shortened cuff-tip length to ensure an adequate margin of safety for mainstem bronchus intubation.

References

- 1 *Dodge TL, Mahaffey JE, Thomas JD.* The anesthetic management of a patient with an obstructing intratracheal mass: a case report. *Anesth Analg* 1977; 56: 295-8.
- 2 *Benumof JL, Partridge BL, Salvatierra C, Keating J.* Margin of safety in positioning modern double-lumen endotracheal tubes. *Anesthesiology* 1987; 67: 729-38.
- 3 *Chang PJ, Sung YH, Wang LK, Tsai YC.* Estimation of the depth of left-side double-lumen endobronchial tube placement using preoperative chest radiographs. *Acta Anaesthesiol Sin* 2002; 40: 25-9.
- 4 *Theman TE, Kerr JH, Nelems JM, Pearson FG.* Carinal resection. A report of two cases and a description of the anesthetic technique. *J Thorac Cardiovasc Surg* 1976; 71: 314-20.
- 5 *Lippmann M, Mok MS.* Tracheal cylindroma: anesthetic management. *Br J Anaesth* 1977; 49: 383-6.
- 6 *Abou-Madi MN, Cuadrado L, Domb B, Barnes J, Trop D.* Anesthesia for tracheal resection: a new way to manage the airway. *Can Anaesth Soc J* 1979; 26: 26-8.
- 7 *Campos JH.* Effects on oxygenation during selective lobar versus total lung collapse with or without continuous positive airway pressure. *Anesth Analg* 1997; 85: 583-6.
- 8 *Macnaughton FI.* Catheter inflation ventilation in tracheal stenosis. *Br J Anaesth* 1975; 47: 1225-7.
- 9 *Baraka A.* Oxygen-jet ventilation during tracheal reconstruction in patients with tracheal stenosis. *Anesth Analg* 1977; 56: 429-32.