# Double-lumen endotracheal tube for one-lung ventilation through a fresh tracheostomy stoma: A case report

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***For one-lung ventilation in many surgical cases, double-lumen endotracheal tubes are the first-line choice for airway management. For most cases, double-lumen endotracheal tubes are faster, easier to place, cheaper, and less prone to malposition than today's bronchial blocker devices.***

***This report describes an elective tracheostomy and the use of a double-lumen endotracheal tube directly through the fresh stoma site for a 55-year-old man with a known difficult airway who had undergone a left-sided radical neck dissection and postoperative radiation 10 years earlier. The 11-hour operation, in supine and lateral positions, occurred uneventfully. This report documents one-lung ventilation of a 4-hour duration using a double-lumen endotracheal tube directly through a fresh tracheostomy site without supplemental continuous positive airway pressure to maintain an oxyhemoglobin saturation of more than 97% as measured by pulse oximetry.***

***During the past decade, unique modifications of the use of bronchial blockers and their use with tracheostomies have been reported. Complications have been reported with double-lumen endotracheal tubes and with more recent classic and modified uses of the bronchial blockers. This article discusses appropriate preoperative patient selection and intraoperative airway management plans for the modified use of one-lung anesthesia airway devices with an emphasis on use with tracheostomies.***

***Key words:*** **Arndt, bronchial blocker, double-lumen endotracheal tube, one-lung ventilation, tracheostomy, Univent.**

This report involves a unique case of successful one-lung ventilation of a 4-hour duration using a conventional double-lumen endotracheal tube (DL-ETT) electively placed directly through a fresh stoma site in a patient with abnormal upper airway anatomy. This type of airway management is unusual, and there is limited information in the anesthesia literature to support its use. Other alternative airways for patients with a known difficult intubation and the requirement of one-lung ventilation for maximum surgical exposure are described. The Univent (Vitaid, Ltd, Toronto, Ontario, Canada) and Arndt blockers (Cook Medical Inc, Bloomington, Indiana) have been used in patients with existing tracheostomies who require one-lung ventilation. These bronchial blockers will be explored as potential options for optimal airway management as related to this particular case.

## Case summary

A 55-year-old man, ASA physical status III, with a known history of difficult airway management was admitted for elective esophagogastrectomy and jejunostomy. The patient's height was 185 cm, and he weighed 73 kg. Significant medical history included hypertension, 35 pack-year history of smoking, chronic obstructive pulmonary disease, dysphagia, and gastroesophageal reflux in the distant past. A preoperative chest radiograph showed lung hyperinflation and left lung scarring. Pulmonary function tests showed mild obstructive disease that was partially reversible. Pulse oximetry revealed a preoperative oxyhemoglobin saturation ($Spo_2$) of 97% while breathing room air. A Mallampati airway classification II was observed. The electrocardiogram demonstrated sinus rhythm at 80 beats per minute; the blood pressure was 102/75 mm Hg preoperatively; and a recent stress test had revealed no cardiac ischemia. The results of all preoperative laboratory work were within normal limits.

Ten years before admission, the patient had a left-sided radical neck dissection for pharyngeal cancer and subsequent postoperative radiation. Two weeks before the current proposed procedure, the patient had a bronchoscopy and esophagoscopy for evaluation of recurrent dysphagia, and biopsies confirmed squamous cell carcinoma of the distal esophagus. After induction for the bronchoscopy with easy mask ventilation, the anesthesiologist noted a "frozen larynx" with a grade 3 visualization using a MacIntosh 3 blade. Then a difficult intubation with a 6.5-mm ETT was performed using a Miller 3 blade. According to the surgeon's operative report, the jaw opening was compromised and the larynx was "fibrotic and

swollen." With some difficulty due to the distorted anatomy, the esophagoscopy was performed with the assistance of an otorhinolaryngologic surgeon. Follow-up computed tomography and magnetic resonance imaging revealed no metastasis. The following case report documents the successful use of an elective tracheostomy followed by the immediate use of a DL-ETT directly through the fresh stoma site.

On the day of surgery, the patient was fasting except for taking amlodipine besylate and valsartan that morning with a sip of water. In the preoperative holding area, the patient was medicated with 4 mg of intravenous midazolam before the placement of an arterial line and epidural catheter. The operating room had been prepared with difficult airway supplies, and the anesthesia team selected a normal-sequence intravenous induction similar to the one a few weeks earlier (propofol, 160 mg; rocuronium, 50 mg; lidocaine, 80 mg; and fentanyl, 50 µg). The same anesthesiologist successfully orally intubated the patient with a 6.5-mm ETT using a Miller 3 blade.

Next, the elective tracheostomy was preformed by the surgeons. Through this fresh stoma site, a disposable 39 left DL-ETT (Hudson RCI, Temecula, California) was inserted, and proper positioning was confirmed by fiberoptic bronchoscopy. The DL-ETT was secured at the 19-cm marking. A baseline arterial blood gas measurement with two-lung anesthesia showed a pH of 7.34, $Paco_2$ of 43, and $Pao_2$ of 236 (fraction of inspired oxygen [$Fio_2$], 0.99). A nasogastric tube was placed by the surgeon on the second attempt and maintained to low wall suction during the case.

During the one-lung ventilation portion of the case, which lasted more than 4 hours, the $Spo_2$ was maintained at more than 97% as measured by pulse oximetry without use of a continuous positive airway pressure (CPAP) device. An arterial blood gas sampling during the one-lung portion of the case revealed a pH of 7.32, $Paco_2$ of 43, and $Pao_2$ of 90 ($Fio_2$, 0.99). Intraoperative intravenous medications of note were 2 doses of the combined 2 g of ampicillin sodium and 1 g of sulbactam sodium; morphine, 15 mg; fentanyl, 1,000 µg; midazolam, 4 mg; metoprolol, 4 mg; and a phenylephrine infusion for short-term hypotension after induction and before the surgical incision.

Maintenance anesthesia for the case was inhalation with isoflurane and oxygen, opioids, rocuronium, and epidural analgesia with an 8-mL/h infusion (1 mg/mL of bupivacaine and 2.5 µg/mL of fentanyl solution). Total intravenous fluids for the case were 3,700 mL of normal saline. The procedure of an esophagogastrectomy and jejunostomy was completed with an estimated blood loss of 250 mL and a 500-mL urine output.

At the end of the case, the DL-ETT was removed from the stoma site and replaced with an 8.0-mm cuffed Shiley tracheostomy tube. The surgeon then performed a bronchoscopy through this tracheostomy tube. Copious amounts of purulent sputum were suctioned through the Shiley tube, and the patient was transferred to the intensive care unit. On postoperative day (POD) 1, the patient was weaned to a 40% oxygen tracheostomy mask and had an $Spo_2$ of 100% as measured by pulse oximetry. By POD 3, the oxyhemoglobin saturations by pulse oximetry fell to the low 90% range, and atelectasis was confirmed by chest radiograph. Subsequently, a very complicated postoperative intensive care unit course followed, with methicillin-resistant *Staphylococcus aureus* pneumonia documented on POD 13 and *Klebsiella* species pneumonia documented on POD 20. The patient was discharged with home oxygen therapy, antibiotics, and a feeding tube on POD 24.

## Discussion

Indications for separation of the 2 lungs and/or one-lung ventilation are *absolute* or *relative* (Table 1).[1] Esophageal resection is listed as a surgical item in the medium (lower) priority to aid surgical exposure and avoid the need for surgical retraction of the lung. The patient described in this case report had a known distorted upper airway with a normal tracheobronchial tree as confirmed by the bronchoscopy performed 2 weeks earlier. Surgeon's preference, previous difficult airway management, and planned postoperative ventilation led to the anesthesia and surgical teams' decision to place an elective tracheostomy at the beginning of this surgery.

In the present case, the contingency airway plan was the use of a bronchial blocker tube through the tracheostomy site with immediate confirmation by fiberoptic bronchoscopy. There are 2 types of endobronchial blockers: wire-guided (Arndt) and enclosed (Univent). The wire-guided endobronchial blocker (also known as Arndt blocker or WEB) was originally developed for oral placement through a minimum ETT of 7.5 mm; in the present case, it was not an option for oral use because a 6.5-mm ETT (internal diameter, 6.5 mm; outer diameter, 8.9 mm) was thought by the anesthesiologist to be the maximum size that could be placed through the vocal cords. In addition, an orally placed Univent tube, with its oval design, would have been too large in diameter because the retractable bronchial blocker channel increases the anterior-posterior diameter of the tube. A Univent

**Table. Indications for separation of the two lungs (double-lumen tube intubation) and/or one-lung ventilation***

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| I. Absolute |
| 1. Isolation of one lung from the other to avoid spillage or contamination |
| A. Infection |
| B. Massive hemorrhage |
| 2. Control of the distribution of ventilation |
| A. Bronchopleural fistula |
| B. Bronchopleural cutaneous fistula |
| C. Surgical opening of a major conducting airway |
| D. Giant unilateral lung cyst or bulla |
| E. Tracheobronchial-tree disruption |
| F. Life-threatening hypoxemia due to unilateral lung disease |
| 3. Unilateral bronchopulmonary lavage |
| A. Pulmonary alveolar proteinosis |
| II. Relative |
| 1. Surgical exposure-high priority |
| A. Thoracic aortic aneurysm |
| B. Pneumonectomy |
| C. Thoracoscopy |
| D. Upper lobectomy |
| E. Mediastinal exposure |
| 2. Surgical exposure-medium (lower) priority |
| A. Middle and lower lobectomies and subsegmental resections |
| B. Esophageal resection |
| C. Procedures on the thoracic spine |
| 3. Postcardiopulmonary bypass pulmonary edema/hemorrhage after removal of totally occluding unilateral chronic pulmonary emboli |
| 4. Severe hypoxemia due to unilateral lung disease |

(Reprinted from Benumof JL, ed. *Airway Management Principles and Practice*, Boston, MA: Mosby; 1996:413, with permission from Elsevier.)

tube with a 6.5-mm internal diameter corresponds to an outer diameter of 10.2 mm/12 mm due to its unique oval design. Although not applicable in the present case, the Univent blocker has been used successfully in difficult oral intubation cases by advancing the blocker distally (like a stylet) through the subglottic opening.[2] At the time of the present case, a Univent tube was available on site as a backup to be used through the new stoma site with immediate verification of tube placement by fiberoptic bronchoscopy. Another 100% silicone-based product is the SilBroncho DL-ETT (Vitaid, Ltd) that, by use of a flexible material, may reduce trauma to the insertion site, although its nonconventional use through a tracheostomy stoma is uncertain.

Robertshaw tubes have been used through tracheostomies,[3,4] but these tubes are rarely available because disposable DL-ETTs and bronchial blockers have become commonplace. Modified uses of the Arndt and Univent bronchial blockers with confirmation by flexible fiberoptic bronchoscopy have been successful through existing stoma sites and would have been another option. Disposable DL-ETTs, the Univent, and the Arndt bronchial blockers on the market today are latex-free.

The Univent blocker was introduced by Inoue in 1982. A few case studies have been published in which the Univent blocker was used through a fresh stoma site. One case report describes a 48-year-old patient who had a fresh tracheostomy for a difficult mask ventilation–cannot intubate scenario. Then, 5 days posttracheostomy, the patient returned to the operating room and had a left upper lobectomy with one-lung ventilation in which the bronchial blocker was dissected out of the Univent and positioned in the bronchus alongside the tracheostomy tube.[5] A Japanese journal article documents use of the bronchial blocker, also taken out of the Univent system, used in a 60-year-old patient with pharyngeal cancer who had a tracheostomy placed 2 months before the current surgery. In that case, intraoperative airway obstruction occurred with "severe hypoxia and resultant bradycardia and hypotension…probably because of not only malposition of blocker but also atelectasis in the upper lobe of the dependent lung by secretion."[6] Bellver et al[7] documented multiple cases of easy, successful, planned use of the complete Univent system through existing tracheostomies in patients who had undergone laryngectomy in the past and now required an operation needing one-lung anesthesia. The Arndt blocker has also been documented for use in a patient with a tracheostomy postpharyngectomy. Liu et al[8] documented a case report of a 67-year-old man with a history of stoma stenosis in whom a reinforced cuffed tracheal tube was used along with the WEB providing a unique successful method of one-lung ventilation. They have repeated this procedure successfully in other similar patients with existing tracheostomies.

All one-lung airway devices require tube placement confirmation by the immediate use of fiberoptic bronchoscopy in the supine and lateral positions. It is imperative that preoperative alternative airway plans be carefully considered with bronchial blocker devices available on site at institutions that perform one-lung anesthesia cases. Planned use of these bronchial blockers might be considered for patients who previously have had extensive neck surgery,

pneumonectomy, or postoperative neck radiation; for patients with suspected difficult intubation; and for patients with existing tracheostomies who now require surgery involving one-lung anesthesia. These bronchial blockers also could be used in cases of unanticipated difficult direct laryngoscopy on the initial attempt to place the DL-ETT. Complications of intraoperative obstruction or intraoperative malfunction of the first airway tube selected might lead to the immediate use of another airway device.

Like the DL-ETT, the Arndt blocker and the Univent permit use of CPAP to reverse hypoxemia during the one-lung portion of the case. During general anesthesia, 90% of patients develop atelectasis in the dependent portions of the lung.[9] In addition, a higher $F_{IO_2}$ causes the oxygen to move at a faster rate from the alveolus into the capillary. Consequently, if the net flow of gas into the blood exceeds the inspired flow of gas, the alveolar lung unit may collapse, a condition referred to as *absorption atelectasis*. Intraoperative considerations for the use of CPAP to the nondependent lung during one-lung anesthesia may include limiting absorption atelectasis, reversal of hypoxemia, and improving postoperative pulmonary function.

New trends in anesthesia support the intraoperative use of CPAP for major surgeries in general. A recent randomized study of patients undergoing major abdominal surgery showed a reduced need for reintubation, less postoperative pneumonia, and less sepsis in the group electively treated with postoperative CPAP.[10] CPAP is applied to the Arndt blocker by using the inner channel of the blocker connected to the adapter now included in the packaged set. The 9 Fr blocker guide loop in the Arndt set is replaceable once removed and can be used again should malposition occur (Sally Hooper, district manager, Cook Medical, oral communication).[11] Also, a smaller 7.0 Fr blocker is now available that can be used through a 6.0 ETT.[11] CPAP is applied to the Univent tube by joining a standard CPAP device to the open end of the suction port of the enclosed bronchial blocker via a 4.5-mm connector of a single-lumen ETT.[12] High-frequency jet ventilation has also been successfully used through this adaptation of the Univent blocker shaft.

At our institution, thoracic surgeons prefer the DL-ETT as the standard choice for most cases requiring one-lung anesthesia. A study by skilled thoracic anesthesiologists has shown that placement of the DL-ETT usually is faster (2.08 minutes) than placement of the Univent (2.38 minutes) or the Arndt blocker (3.34 minutes).[13] In addition, aspiration of secretions from the collapsed lung by the blockers is very difficult, but possible, and it should be done with intermittent short periods of low-pressure suctioning intraoperatively. The inner channel of an Arndt blocker is even narrower than the Univent blocker, leading to increased time for the lung to collapse and similar difficulty with suctioning. Continuous suctioning of the nondependent lung via a bronchial blocker is not recommended because negative pressure pulmonary edema potentially could result. Many surgeons prefer placement of the DL-ETT over the Univent bronchial blocker for left-sided one-lung ventilation because Campos et al[14] report malpositions with the Univent tube occurred more frequently than with the left-sided DL-ETT. The Arndt blockers are newer, introduced in 1999, and dislodgment and complications also limit its use.

Dislodgment, obstruction, and trauma to lung tissue are some complications that can occur regardless of whether DL-ETT or bronchial blockers are used. A common time of intraoperative malposition or dislodgment of the Univent tube is while turning the patient from the supine to the lateral position, and some advocate that once optimal supine position of the Univent is achieved, deflation of the Univent bronchial blocker should occur before turning the patient to the lateral positon.[15] Because the Arndt blocker is shown to have more malpositions than the Univent system, it is recommended that if the Arndt blocker is used, it should be deflated and advanced 1 cm before lateral positioning to avoid dislodgement.[13] Reconfirmation of tube placement by fiberoptic bronchoscopy after any patient position change is prudent. Regardless of the one-lung airway device used, immediate use of a fiberoptic bronchoscope is required for confirmation of placement of all types of tubes.

Anesthetists must be aware of which types of surgery are absolute and relative indications for one-lung anesthesia. Interestingly, a new study documents that faculty and senior residents with limited thoracic anesthesia experience (those with some knowledge of the DL-ETT and Univent and Arndt devices, but not having performed more than 2 cases of lung isolation in the previous month) who were given a tutorial on the use of the 3 devices had no significant difference in failure rates for placing these 3 devices the following day (38%).[16] The high failure rate noted in this study might suggest that anesthesia personnel who occasionally perform one-lung isolation cases could benefit from increasing their insertion skills of all of these airway devices. Median insertion times for completed placement of these devices was the following: DL-ETT, 6.1 minutes; Univent tube, 6.7 minutes; and Arndt blocker,

8.6 minutes.[16] The DL-ETTs are always the first-line choice in airway management for cases of absolute lung separation, ie, unilateral bronchopulmonary lavage or contamination from the other lung with massive bleeding or to avoid infection from one lung to the other. Information from Vitaid airway management (Univent) lists "pulmonary lavage" as the only relative contraindication of the use of the Univent.[17]

Bronchial blockers are advantageous because they do not require reintubation at the end of surgery for postoperative ventilation as does the DL-ETT. The DL-ETTs are cheaper, faster to position, and less likely to be malpositioned or become dislodged, and their use has been well documented over the years. Case studies have documented successful use of the bronchial blockers through tracheostomy sites. Most of the cases cited in the literature regarding tracheostomies and the use of bronchial blockers are patients with an existing mature tracheostomy site. The present case documents use of a DL-ETT immediately through a fresh stoma site providing one-lung anesthesia of a 4-hour duration with an intraoperative $Spo_2$ of more than 97% as measured by pulse oximetry. Regardless of the one-lung airway technique used, an experienced anesthesia team, immediate availability of a fiberoptic bronchoscope to verify tube placement in supine and lateral positions, and backup airway plans and supplies in case of intraoperative airway dislodgment or obstruction are essential. On occasion, the use of bronchial blockers is an acceptable alternative and may be advantageous for unique airway management cases. The design of bronchial blockers makes them especially worthy of consideration for cases requiring one-lung anesthesia in patients with preexisting tracheostomies or abnormal tracheobronchial tree anatomy.

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