

output, especially in combination with a small functional residual capacity, might be endangered by the rapid rise in alveolar halothane concentration that occurs with the rapid inhalation inductions. Heavy premedication may also compromise these inductions because of respiratory depression and sedation.⁶ One of the advantages of the rapid techniques is that they do not require venous access, and our healthy volunteers were managed safely without it. However, in a patient with airway abnormalities, it would obviously be prudent to establish an intravenous infusion prior to induction regardless of what induction technique is to be used.

In theory, induction could be accomplished in one circulation time from lung to brain if the inhaled drug was sufficiently potent, insoluble in blood, and non-irritating to breathe. In fact, the available nonexplosive inhalation drugs are potent but relatively soluble. Halothane is not very irritating to breathe, but is more soluble than enflurane and isoflurane, which are irritating. We anticipate that adding nitrous oxide to the halothane would further speed the triple-breath induction without causing hypoxemia or hypotension. Wilton and Thomas² data support this hypothesis as their average induction time using single-breath halothane, nitrous oxide, and oxygen was 83 s, compared to the 112 s for a single-breath induction in our current study. Use of this method with isoflurane or enflurane is an attractive idea, because these have lower blood solubilities than halothane. Airway irritation and the pungent odor may

limit the concentrations that are tolerated during rapid inductions with these drugs. Indeed, Loper *et al.*⁷ have reported on a series of patients who had a rapid inhalation induction with either isoflurane or halothane. Although they found that the induction time was significantly shorter in the isoflurane group as compared to the halothane group, they found it necessary to use fentanyl in a dose of 5 $\mu\text{g}/\text{kg}$ to inhibit coughing in their patients. Therefore, for a "pure" inhalation induction, halothane appears to be more satisfactory.

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Selective Blind Endobronchial Intubation in Children and Adults

HIROSHI KUBOTA, M.D.,* YUKIO KUBOTA, M.D.,† YOSHIRO TOYODA, M.D.,‡ HIROYUKI ISHIDA, M.D.,§
AKIRA ASADA, M.D., PH.D.,¶ HIDEO MATSUURA, D.D.S., PH.D.**

Double-lumen endobronchial tubes are widely used in thoracic anesthesia, and in emergency situations, such as pulmonary bleeding in adults. However, a dou-

ble-lumen endobronchial tube for infants and children is not commercially available. Therefore, a bronchial blocker or ordinary endotracheal tube, with or without

* Staff Anesthesiologist, Department of Anesthesia, Osaka Kohseinenkin Hospital.

† Chief, Department of Anesthesia, Osaka Kohseinenkin Hospital.

‡ Associate Chief, Department of Anesthesia, Osaka Kohseinenkin Hospital.

§ Postdoctoral Fellow, Department of Anesthesiology, Kyoto University.

¶ Associate Professor, Department of Anesthesiology, Osaka City University.

** Professor, Department of Dental Anesthesiology, Osaka University.

Received from the Department of Anesthesia, Osaka Kohseinenkin Hospital, Osaka, Japan; the Department of Anesthesiology, Kyoto

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Address reprint requests to Dr. Y. Kubota: Department of Anesthesia, Osaka Kohseinenkin Hospital, 4-2-78, Fukushima, Fukushima-Ku, Osaka 553, Japan.

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TABLE 1. Rate of Successful Blind Left Endobronchial Intubation

	Child		Adult	
	Percent	N*	Percent	N*
1. Head mid position No rotation of the tube	0	0/59	1	3/300
2. Head mid position Tube rotated 90° counter-clockwise	59	35/59	72	215/300
3. Head mid position Tube rotated 180°	44	26/59	61	182/300
4. Head turned to the right Tube rotated 180°	92†	54/59	92†	275/300

* Entering into left bronchus/attempts of endobronchial intubation.

† $P < 0.01$ compared with other techniques.

stylet, has been used.¹⁻⁹ Even in adults, endobronchial intubation with a double-lumen tube using a fiberoptic bronchoscope is difficult to perform rapidly in an emergency, such as massive pulmonary bleeding. Also, and especially in pediatrics, selective endobronchial intubation may be necessary for the treatment of interstitial pulmonary emphysema.³ Therefore, instantaneous unilateral endobronchial intubation using a single-lumen endotracheal tube may be a life-saving measure, not only in infants and children, but in adults as well. Owing to the anatomic structure of the tracheo-bronchial tree,¹⁰ left endobronchial intubation is not easily accomplished.^{11,12} Therefore, several techniques for blind left endobronchial intubation have been evaluated.^{1-4,7-10} The comparative efficacy of these techniques for left endobronchial intubation has not been determined in a large number of patients. The present study was undertaken, therefore, to discover a simple, quick, and reliable technique for selective left bronchial intubation in both children and adults.

MATERIALS AND METHODS

Fifty-nine infants and children (age 1 month to 12 yr) and 300 adults (age 18-65 yr) were studied. These patients had no history or radiologic evidence of lung, heart, or mediastinal disease. Following induction of anesthesia, tracheal intubation was accomplished using the appropriately sized ordinary Portex® (Hythe, England) endotracheal tube (left-sided bevel) with or without cuff. Blind endobronchial intubation was attempted by one of the authors under the following conditions: 1) head in mid position, no rotation of the tube; 2) head in mid position, tube rotated 90° counter-clockwise; 3) head in mid position, tube rotated 180°; and 4) head turned to the right, tube rotated 180°. Two authors

confirmed the location of the tip of the endotracheal tube by auscultation of the chest, bilaterally, for presence of breath sounds. We compared the data by chi-square analysis, and $P < 0.01$ was considered significant. Permission to perform this study was obtained from the parents of the children involved and patients when feasible.

RESULTS

The results are summarized in table 1. The most successful technique involved turning the head to the right and rotating the tube 180° in both children and adults. There was no difference in the results of auscultation among the two authors.

DISCUSSION

One-lung anesthesia with the aid of a double-lumen tube is a widely practiced technique in adults undergoing pneumonectomy or lobar resection for tumor. The major advantage of unilateral ventilation lies in preventing of spread of purulent secretions or blood into the dependent intubated lung. However, use of a double-lumen tube is not appropriate for pediatric patients because of size limitations imposed by the airway. Thus, in the infant or child, several instances of one-lung ventilation using a single-lumen tube have been described.¹⁻⁹ Even in the adult, in an emergency such as massive pulmonary hemorrhage, unilateral rapid intubation with a cuffed single-lumen tube might be life-saving. A single-lumen endotracheal tube usually tends to enter the right mainstem bronchus, and many factors can influence the rate of success for left or right endobronchial intubation: the size of endotracheal tube in relation to tracheal diameter; the tip of the tracheo-bronchial angle lies to the left of the midline; the right main stem bronchus is larger in diameter than the left; the right tracheo-bronchial angle is more acute than the left; and the tip of an ordinary endotracheal tube tends to the right of the midline of the trachea. For these reasons, selective blind left endobronchial intubation is more difficult to perform than the right.

Two main techniques have been utilized to isolate a dependent portion of the lung or an entire lung by using either a single-lumen endotracheal tube or a bronchial blocker. In this study, we sought a quick and reliable technique for blind left endobronchial intubation, using an ordinary single-lumen tube without a bronchial blocker, since use of a bronchial blocker is more time-consuming.

In 1950, Bonica *et al.*¹³ first described the technique for blind endobronchial intubation, in which they used a single-lumen endotracheal tube with left-sided bevel for right endobronchial intubation and right-sided

bevel for intubation of the left bronchus. They noted that left endobronchial intubation could be accomplished blindly by rotating the endotracheal tube 90° counter-clockwise, thus causing the tube to slide along the left wall of the trachea to enter the left mainstem bronchus. Cullum *et al.*¹ reported a technique for endobronchial intubation in infants, but the success rate was not given.

We thought that use of a right-sided bevel might be useful in left endobronchial intubation. But the ordinary endotracheal tube has a left-sided bevel, so we rotated the endotracheal tube 180°. Bloch¹⁴ has also made this suggestion, but, utilizing this technique, we achieved success rates of only 44% (in children) and 61% (in adults). To modify this method, we also turned the head to the right with the same degree and direction of tube rotation. This method proved to be the most reliable for selective left endobronchial intubation, in a plastic tracheo-bronchial model. Surprisingly, the success rate in pediatric and adult patients improved to 92%. We presume that the resilience of the endotracheal tube caused its tip to enter the left bronchus more easily. In our study, right endobronchial intubation was achieved within 2–3 s after tracheal intubation, and left endobronchial intubation was also accomplished within 4–5 s.

In summary, our findings indicate that right endobronchial intubation is easily accomplished merely by advancing the endotracheal tube after tracheal intubation. The most reliable technique for selective left endobronchial intubation involves rotation of the endotracheal tube 180°, with the head turned to the right.

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