



**The Chinese University of Hong Kong**  
**Non-confidential Abstract of Technology Disclosure**

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**Title:**

**An Endotracheal Tube with a Built-in Endobronchial Blocker for One-lung Anesthesia/lung Isolation in Children**

**CUHK Ref. No.:**

07/MED/264

**Inventor(s):**

Professor Anthony HO, Department of Anaesthesia and Intensive Care

**Patent Status:** US Patent Pending

**Non-confidential abstract:**

Isolation of one lung from ventilation is sometimes required in clinical practice. In surgery involving the chest (lungs, esophagus, thoracic spine, etc.), non-ventilation of one lung is the norm. Isolation of one lung from ventilation in children under the age of 6-8 years is challenging because of the lack of special tubes, which are available only for larger patients. These special tubes come in sizes for children only as young as 6-8 years probably because of the difficulties in making such relatively complex tubes with large enough lumens suitable for ventilation in small children. For lung isolation in small children, one technique is the use of a small blocker that is passed, either through or outside of the lumen of the endotracheal tube, into the main stem bronchus of the lung to be blocked from ventilation.

One serious problem with this technique is that the bronchial blocker often pops back into the trachea, causing not only loss of lung isolation, but also complete airway obstruction. Occasionally, it is also difficult to maneuver the blocker into the main stem bronchus to be blocked.

We have invented an endotracheal tube that could prevent the problem of retrograde migration of the bronchial blocker. It incorporates a bronchial blocker that can effectively isolate one lung to provide the surgeon with an optimum surgical field. Placement of the blocker into the desired main stem bronchus should also be easier.

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## Background

There are currently 2 popular tubes for one-lung isolation on the market. Fig. 1 is the double lumen tube (DLT). Fig. 2 is the Univent tube. The DLT is by far the more popular one. They both have multiple channels. One would have thought, why not make them smaller to fit smaller children? The problem is that the channels would get too small and the resistance to airflow too great to be of any use. Certainly passing suction catheters and a pediatric fiberoptic bronchoscope (needed for positioning of tube and balloon blocker) would also be out of the question. That is why the smallest DLT only fits a child of 8-10 years of age and the smallest Univent tube only fits a child of 6-8 years. Smaller children will have to use a regular single lumen endotracheal tube with a separate endobronchial blocker either through the lumen of the endotracheal tube or outside the lumen, depending on the size the tube, which, of course, is dictated by the size of the child.

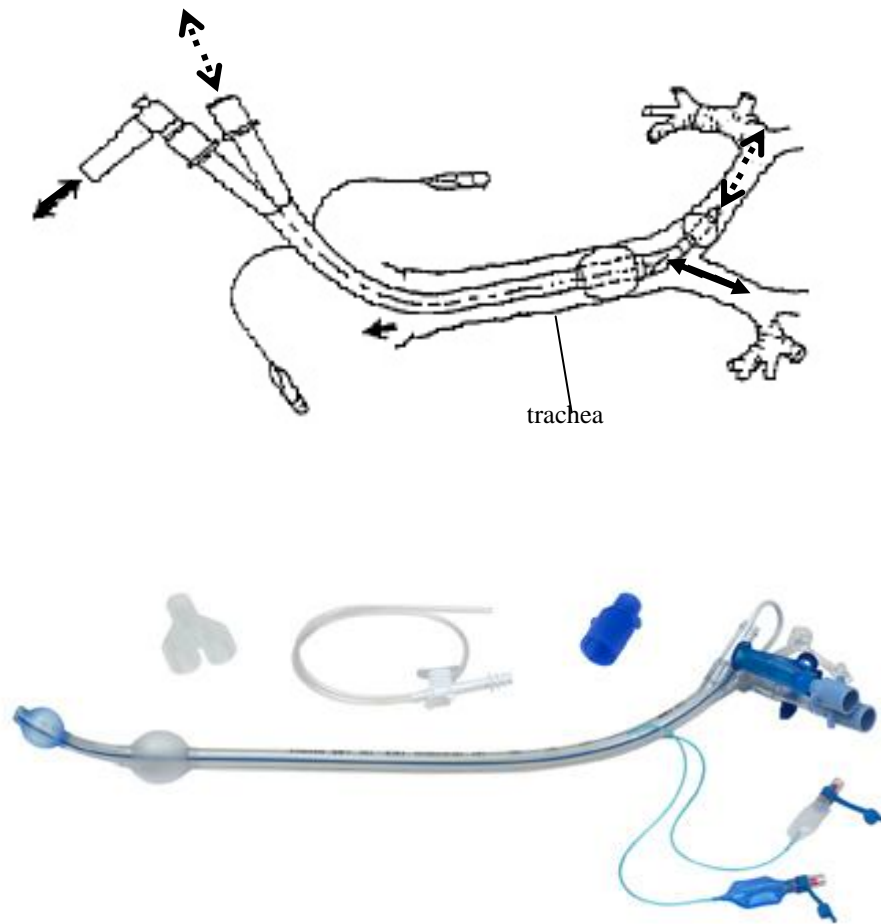


Figure 1. Double lumen tube for isolating one lung. Arrows point to directions of ventilating gas. Solid arrows for right lung, dashed arrows for left lung.

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Figure 2. The Univent tube. It has a built-in endobronchial blocker

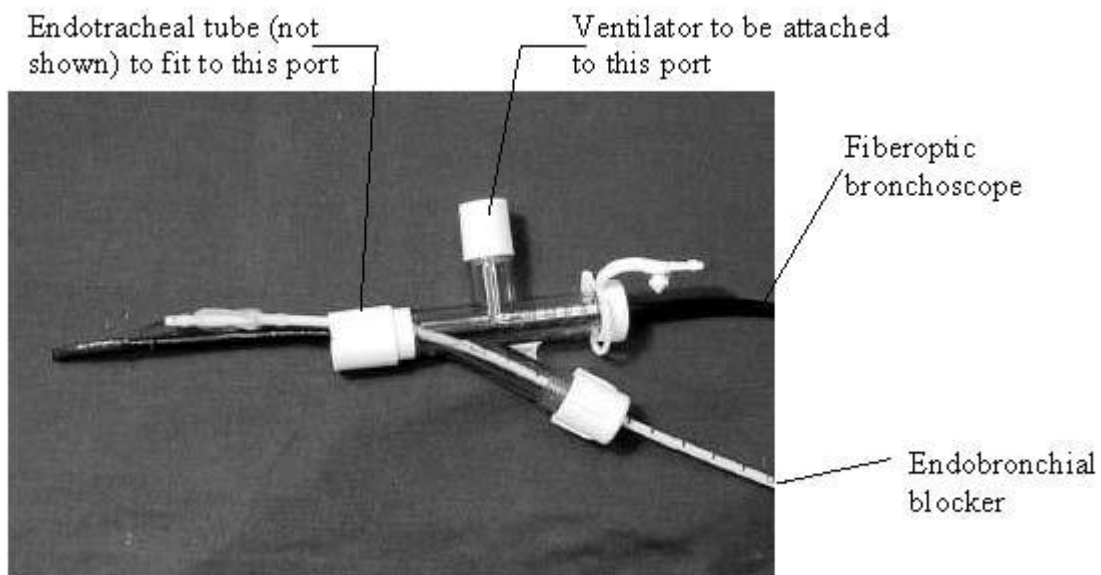
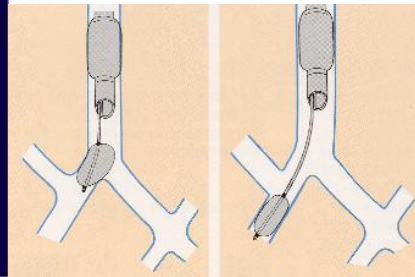


Figure 3. The Arndt endobronchial blocker and multiport adapter.

Fig. 3 shows the popular Arndt multiport adapter with an endobronchial blocker and a fiberoptic bronchoscope. The adapter allows simultaneous ventilation, fiberoptic bronchoscopy, and passage of the endobronchial blocker. To be able to do all that simultaneously, the endotracheal tube must be at least 4.5-5 mm in internal diameter.

One-lung anesthesia is required in an increasing variety of pediatric surgeries involving structures in the thorax, especially if minimally invasive techniques are being employed.<sup>1-4</sup> It remains a challenge to provide consistent non-ventilation of one lung with relative ease and reliability in small children, in part, because the choices of lung isolating devices are limited. As mentioned above, the

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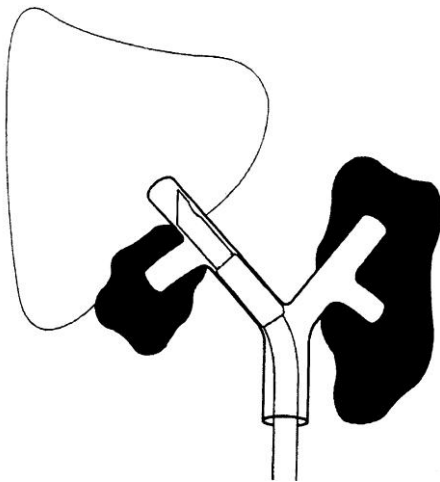
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smallest double-lumen tube (DLT) (26Fr) and Univent® tube (3.5 mm ID) designed for lung isolation in larger patients fit only children older than the ages of 8-10 and 6-8 years, respectively. These relatively complicated tubes, if made any smaller, may result in lumens that are too small for ventilation.

For smaller children, there are basically two techniques that could be used for one-lung ventilation. I will first discuss the less desirable and less popular of the two so we could concentrate on the preferred technique in more details later.

An easy way to ventilate only one lung is to deliberately pass the endotracheal tube (ET) distally into the mainstem bronchus of the side to be ventilated. The biggest problem is that an ET that fits the trachea appropriately may be too big for either of the mainstem bronchi (see Table 1 for diameters of trachea and mainstem bronchi). A small enough tube that fits the mainstem bronchus may have too much leak once the ET is withdrawn back into the trachea for bilateral ventilation. Sometimes an ET may be too small for the mainstem bronchus, leading to excessive leak and partial ventilation of the opposite supposedly collapsed lung.

What about a cuffed ET? It would solve the problem of leak around the tube. Fig. 4 illustrates the problem of the cuffed ET in the left mainstem bronchus. Since the right mainstem bronchus is even closer to the carina, non-ventilation of the right upper lobe is even a bigger problem than that of the left upper lobe.



**Figure 4.** Illustration of how a cuffed endotracheal tube could miss the upper lobe of the lung. The margin of safety is worse with right lung ventilation because the right mainstem bronchus is shorter.

*From:* Hammer G, Hall S, Davis PJ. Anesthesia for general abdominal, thoracic, urologic, and bariatric surgery. In: Smith's Anesthesia for Infants and Children, 7<sup>th</sup> ed. Ed. Motoyama EK, Davis PJ, Mosby 2006, Philadelphia. 685-722

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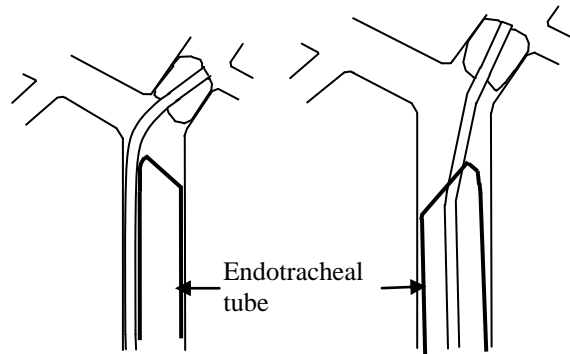
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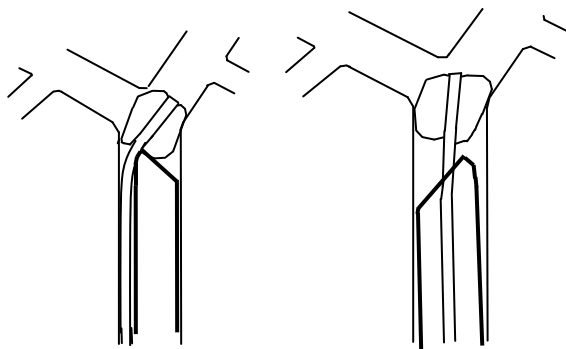
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A much preferred and popular technique for one-lung isolation in small children is the use of endobronchial blockers (EBs).<sup>1-4</sup> (Fig 5). Depending on the size of the patient [and thus the endotracheal tube (ET)], the EB may be placed either intra- or extra-luminal of the ET. For example, a child <10 months of age will likely need an ET with internal diameter  $\leq 4$  mm; an Arndt 5F pediatric endobronchial blocker would need to be extra-luminal of the ET (left panel).

When a balloon-tipped catheter is used to block a mainstem bronchus of a lung, a common problem the anesthesiologist and surgeon face is the tendency of the bronchial balloon to retrograde-dislodge into the trachea<sup>1-3,5,6</sup> causing loss of lung isolation and leading to partial to total tracheal obstruction (Fig 6).



**Figure 5.** Conventional technique for lung isolation in small children (<6-8 years of age).



**Figure 6.** Retrograde dislodgement of endobronchial blocker causing loss of lung isolation and airway obstruction.

If not immediately recognized, hypoxia and even cardiac arrest<sup>6</sup> could result. At the very least, this leads to loss of lung isolation, interruption of surgery, increased surgical manipulation of the lung, and necessitates the anesthesiologist to reposition the EB, which is always a challenge in the middle of surgery. If the problem persists, the surgeon may have to abandon the minimally invasive approach and convert to an open thoracotomy, thus subjecting the patient to more postoperative pain and a big scar, and the risk of such late complications<sup>7</sup> as “winged” scapula (24%), marked asymmetry of the thoracic wall (20%), fusion of the ribs (10%), severe scoliosis (8%), and breast maldevelopment (3.3%). Because of their short mainstem bronchi, small children may be particularly susceptible to this problem of dislodgement of the EB.

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**Table 1.** Airway Dimensions in Children

Age (yr)	Trachea <sup>a</sup> (mm)	Expected right bronchial diameter (mm)	Expected left bronchial diameter (mm)	Trachea <sup>b</sup> (mm)	Expected right bronchial diameter (mm)	Expected left bronchial diameter (mm)
0.5–1	5.6	4.8	3.7	N/A	N/A	N/A
1–2	6.5	5.6	4.3	5.3	4.6	3.5
2–4	7.6	6.5	5.0	7.4	6.4	4.9
4–6	8.0	6.7	5.3	8.0	6.7	5.3
6–8	9.2	7.9	6.1	9.2	7.9	6.1
8–10	9.0	7.7	6.0	10.5	9.0	6.9
10–12	9.8	8.4	6.5	11.6	10.0	7.0
12–14	10.3	8.6	6.8	13.0	11.2	8.6
14–16	12.7	10.9	8.4	13.9	12.0	9.2
16–18	NA	NA	NA	13.7	14.6	9.0
18–20	NA	NA	NA	13.9	12.0	9.2

The average mean tracheal AP (sagittal) diameters are given, as this dimension determines the “limiting diameter” (i.e., largest size tube admissible). The bronchial diameters are calculated from measured bronchial:tracheal ratios of 0.86 (right bronchus) and 0.66 (left bronchus) in children (1).

NA = not applicable.

<sup>a</sup> See Reference 1.

<sup>b</sup> See Reference 2.

**Table 1.** Airway Dimensions in Children. The average mean tracheal AP (sagittal) diameters are given, as this dimension determines the “limiting diameter” (i.e., largest size tube admissible). The bronchial diameters are calculated from measured bronchial:tracheal ratios of 0.86 (right bronchus) and 0.66 (left bronchus) in children. NA = not applicable. <sup>a</sup>Respiration and circulation (biological handbooks). Bethesda, MD: Federation of American Societies for Experimental Biology, 1971:105–8. <sup>b</sup>Griscom NT, Wohl MEB. Dimensions of the growing trachea related to age and gender. *AJR Am J Roentgenol* 1986; 146: 233–7.

*Table From:* Hammer GB, et al: *Anesth Analg* 1999; 89(6):1426-9

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