RESPIRATION AND THE AIRWAY

Comparison of techniques for double-lumen endobronchial intubation: 90° or 180° rotation during advancement through the glottis

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Editor’s key points
- Rotation of a double-lumen endobronchial tube (DLT) through 180° during insertion aligns both tracheal and bronchial lumens along the sagittal plane.
- This single operator study compared initial rotation of a DLT through 90° or 180° after advancement through the glottis into the trachea.
- Initial rotation through 180° was associated with less resistance and a lower incidence of sore throat and glottic trauma.
- This technique appears advantageous, but further studies are required.

Background. During endobronchial intubation with a double-lumen endobronchial tube (DLT), the DLT is conventionally rotated through 90° when the bronchial tip is just past the vocal cords. This study was performed to investigate if rotation of the DLT through 180° decreases postoperative hoarseness, sore throat, or vocal cord injuries.

Methods. Patients (n = 164) undergoing thoracic surgery were randomized into two groups. Just after the bronchial tip passed the glottis, left-sided DLTs were rotated 90° (Group 90, n = 84) or 180° (Group 180, n = 80) counterclockwise and advanced. In the Group 180, DLTs were re-rotated 90° clockwise after the tracheal tip passed the glottis. Resistance during the advance of DLTs was assessed. Hoarseness and sore throat were evaluated for three postoperative days. Vocal cords were examined on the first postoperative day.

Results. In nine patients allocated to Group 90, the DLT could not be advanced past the glottis because of severe resistance. There was less resistance to advancement of the DLT in Group 180 compared with Group 90 (P < 0.001). The incidence of hoarseness was comparable between the two groups. Sore throat and vocal cord injuries occurred less frequently in Group 180 compared with Group 90 (20 vs 40%, P = 0.008; 19 vs 47%, P = 0.032).

Conclusions. Rotation of a DLT through 180° facilitated its passage through the glottis and reduced the incidence of postoperative sore throat and vocal cord injuries.

ClinicalTrials.gov registration number. NCT01441362.

Keywords: airway management; anatomy; anesthesia, general; intratracheal, intubation

Accepted for publication: 20 March 2013

Hoarseness, sore throat and vocal cord injuries are common after tracheal intubation. These complications impair patients’ satisfaction and activities immediately after surgery and even after discharge from the hospital. 1–5 These problems occur more frequently after using double-lumen endobronchial tubes (DLTs) compared with using single-lumen tubes with endobronchial blockers for one-lung ventilation during thoracic surgery. 5, 6 DLTs are elliptical on cross-section and have a larger external diameter on the lateral aspects (compared with single-lumen tubes), increasing the potential risk for traumatic injuries to the airway. 5

For intubation using a left-sided DLT the tube is conventionally rotated 90° counterclockwise after the bronchial tip has passed the vocal cords to align the bronchial lumen with the left mainstem bronchus. However, when using this method, the tip of the tracheal lumen may work as an obstacle during passage through the glottis, increasing resistance with the potential for glottic trauma. If a DLT is inserted with the tracheal lumen facing anteriorly via rotating 180° instead of 90° during passing the glottis, the bronchial and tracheal lumens are aligned on the sagittal plane, which may decrease the resistance during advancement through the glottis and potential traumatic airway injuries.

Therefore, we hypothesized that 180° rotation of DLTs during passing the glottis would be effective in reducing postoperative hoarseness, sore throat, and vocal cord injuries compared with 90° rotation. The purpose of this study was to determine whether hoarseness, sore throat, or vocal cord injuries were decreased when DLTs were advanced through the glottis with the tracheal lumen faced anteriorly.
Methods
The study protocol was approved by Seoul National University Hospital Institutional Review Board (Ref. H-1007-182-325) and was registered at ClinicalTrials.gov site (NCT01441362). After obtaining written informed consents, the patients with ASA physical status I or II, aged 20-75 yr and undergoing elective thoracic surgery requiring the placement of a left-sided DLT, were enrolled into the study between January and December 2011. Any patients with preexisting hoarseness, sore throat, or cervical spine diseases were not included in the study. We also excluded patients suspected to have difficulties with airway management such as Mallampati score of 3 or 4, thyromental distance <6.0 cm, and neck range of motion <90°. Using an internet-based computer program (http://www.randomizer.org), patients were randomly assigned to one of the two groups depending on the 90° (Group 90) or 180° (Group 180) counterclockwise rotation of DLTs during passing the glottis.

Anaesthetic management
The DLT size was selected according to the gender and the height of patients.7,9 We used a 39 Fr DLT for men taller than 178 cm; a 37 Fr DLT for men 160-178 cm tall and for women taller than 165 cm; a 35 Fr DLT for men shorter than 160 cm and for women 153-165 cm tall; and a 32 Fr DLT for women shorter than 153 cm.

On arrival in the operating room, standard monitoring was established, including non-invasive arterial pressure, ECG, and pulse oximetry. General anaesthesia was induced with fentanyl 1.5 µg kg⁻¹, propofol 2.0 mg kg⁻¹, and rocuronium 0.8 mg kg⁻¹. After ~3 min, tracheal intubation was performed with a disposable polyvinyl chloride left-sided DLT (Broncho-Cath®, Mallinckrodt Medical Ltd, Athlone, Ireland) by an experienced anaesthesiologist (J.-H.S.). In both groups, the DLTs were initially inserted into the glottis with the bronchial tip directing anteriorly under direct laryngoscopy using either a Macintosh 3 or 4 laryngoscope blade. In Group 90, after the bronchial tip had passed the vocal cords, the stylet was removed, the DLT was rotated 90° counterclockwise directing the bronchial lumen to the left side and then advanced until predetermined designated depth of insertion.9 In Group 180, after the bronchial tip was inserted into the glottis, the stylet was removed, the DLT was rotated 180° counterclockwise to direct the tracheal lumen anteriorly and then advanced until the tip of the tracheal lumen passed just beyond the vocal cords. Afterwards, the DLT was re-rotated 90° clockwise to align the bronchial lumen with the left mainstem bronchus and then advanced. If the DLT could not pass the glottis because of severe resistance in both groups, advance of DLTs through the glottis would have been reattempted under the protocol of the other group as follows: in Group 90, the DLT was further rotated 90° counterclockwise to direct the tracheal lumen anteriorly as in Group 180, and vice versa.

The DLT position was correctly adjusted under direct vision of a fiberoptic bronchoscope (LF-DP or LF-GP, Olympus Optical Co., Tokyo, Japan) after removal of the headrest during intubation.8 Subsequent anaesthetic management was performed by the anaesthesiologists who were unaware of the group assignment and not involved in the study. The patients were placed in the lateral decubitus position and the operating table was flexed under the patient’s iliac crest. To prevent movement of DLTs during lateral positioning, the DLT was held at the level of the incisors with one hand while keeping the head immobile with the other hand. The head and neck were aligned with the thoracic vertebral column to prevent the neck from flexing laterally. After completing positional change, the DLT position was reassessed by fiberoptic bronchoscopy. Mechanical ventilation was performed with tidal volumes of 6–8 ml kg⁻¹ and positive end-expiratory pressure of 5–8 cm H2O. Respiratory rate and inspired oxygen fraction were adjusted to obtain the arterial tensions of carbon dioxide 5.3–6 kPa and oxygen >12 kPa, respectively. Anaesthesia was maintained with inhaled sevoflurane 2–2.5%. Rocuronium was administered at intervals of 30–40 min to maintain neuromuscular block, but it was not given within 1 h of the end of surgery.

At the end of surgery, pyridostigmine 0.3 mg kg⁻¹, and glycopyrrolate 0.01 mg kg⁻¹ were administered to reverse neuromuscular block. After gentle suctioning of oral secretions and manual ventilation with 100% oxygen, DLTs were carefully extubated after the patients were returned to the supine position.

Postoperative pain was managed using i.v. patient-controlled analgesia (PCA) or patient-controlled epidural analgesia (PCEA). The i.v. PCA consisted of fentanyl 10–20 µg ml⁻¹ and morphine 0.4–0.7 mg ml⁻¹ with total volume 100 ml at a continuous infusion rate of 0.5 ml h⁻¹ and a bolus 1 ml with a lockout interval 10 min. The PCEA consisted of 0.12% levobupivacaine and fentanyl 2 µg ml⁻¹ with total volume 500 ml at a continuous infusion rate of 6 ml h⁻¹ and a bolus 0.5 ml with a lockout interval 20 min.10 The PCA was maintained until the third postoperative day.

Measurements
During laryngoscopy, glottic exposure was assessed using Cormack and Lehane’s grading.11 Resistance during the advance of DLTs through the glottis was subjectively evaluated as none, mild, moderate, or severe. Severe resistance was defined as the inability to advance DLTs without fear of damage on the glottis. In such cases, intubation was not performed according to the intention-to-treat. Thus, these data were only used to compare the difference in resistance during the advance of DLTs, and were excluded from the subsequent analyses.

The primary outcomes of this study were the incidence and the severity of postoperative hoarseness and sore throat. Hoarseness was defined as an acoustic quality that was different from the previous voice quality of the patient12 and sore throat as continuous throat pain.4 On the first, second and third postoperative days, an investigator unaware of the group assignment asked the patients about hoarseness. Hoarseness was graded as follows:12 none, no hoarseness;
mild, noticed by patient; moderate, obvious to observer; severe, aphonia. The investigator also asked the patients about sore throat, which was graded as follows: none, no sore throat; mild, pain with deglutition; moderate, pain present constantly and increasing with deglutition; severe, pain interfering with eating and requiring analgesic medication. In the patients who had consented to undergo the flexible laryngoscopic examination, as a secondary outcome, the vocal cords were examined with regard to the presence of haemorrhage, oedema, haematoma or any other vocal cord lesions on the first postoperative day by an experienced otorhinolaryngologist (T.-K.K.) blinded to the group allocation.

Statistical analysis
In Knoll and colleagues’ study, 44% of patients complained of sore throat 1 day after DLT intubation. We considered a 50% decrease in the incidence of sore throat to be clinically significant. Assuming a Type-I error protection of 0.05 and a power of 0.80, 70 patients were needed in each group.

All reported P-values were two-sided and P < 0.05 was considered statistically significant.

Results
A total of 179 patients were eligible for this study, and 15 patients were excluded (Fig. 1). There were no significant differences between the two groups with respect to patient characteristics and intraoperative variables (Table 1). There were no patients with unintentional right endobronchial intubation in both groups.

There was less resistance to advancement of a DLT through the glottis in Group 180 than in Group 90 (P < 0.001; Fig. 2). In nine patients allocated to Group 90, the DLTs could not be advanced past the glottis because of severe resistance. However, after further rotation up to 180° as in Group 180, all the DLTs were smoothly passed through the glottis without severe resistance: no resistance in two, mild resistance in five, and moderate resistance in two patients. There were no severe hoarseness, sore throat, and vocal cord injuries in these nine patients: hoarseness in two patients, sore throat in four, and vocal cord hyperaemia in two.

There were no patients with newly developed hoarseness or sore throat on the second and third postoperative days, and none of the patients complained of severe hoarseness or sore throat during the entire study period (Fig. 3). There were no differences in the incidence and the severity of hoarseness between the two groups (Fig. 3a). However, sore throat occurred more frequently in Group 90 rather than in Group 180 on the first postoperative day (30/75 vs 16/80, P = 0.008; Fig. 3b).

Vocal cords were examined in the 64 patients who had consented to undergo the flexible laryngoscopy. All the vocal cord lesions only consisted of haemorrhage or oedema. Vocal cord injuries occurred more frequently in Group 90 compared with Group 180 (P = 0.032, Table 2).

Discussion
During intubation using a left-sided DLT, rotating the DLT 180° counterclockwise just after the bronchial tip had passed the vocal cords facilitated passage of DLTs through the glottis, compared with the conventional technique (90° counterclockwise rotation). In a previous study, when intubation was performed using a Carlens tube with a carinal hook, the tube was rotated 180° counterclockwise followed by rotating 90° clockwise after passing the hook beyond the vocal cords to prevent impingement on the vocal cords or cartilaginous tissues in the posterior portion of the glottis. For intubation of the commonly used modern DLTs without a carinal hook, we used to pass the DLT through the glottis with rotating it only 90° counterclockwise. However, when DLTs are rotated 180°, the tracheal and bronchial tips of the DLT are located anteroposteriorly on the sagittal plane, which facilitated passage of DLTs through the glottis without severe resistance.

Even though the tracheal and bronchial diameters of a patient are larger than the external diameter of a DLT, intubation may fail only because the DLT cannot pass the glottis as shown in our study. In such cases, intubation may be tried with a one-size smaller DLT or a single-lumen tube with bronchial blocker. However, such multiple intubation attempts may accompany inherent risks such as airway trauma, hypoxaemia, or hypercapnia in addition to wasting expensive DLTs.

Many factors such as sex, smoking history, duration or type of surgery, and tracheal tube size are the risk factors for postoperative hoarseness and sore throat, which may frequently occur because of physical damage caused by the manipulation of tracheal tube. A number of strategies to reduce postoperative hoarseness or sore throat have been investigated, but most published studies focused only on using drugs to prevent such complications. Our study demonstrated that the intubation technique to facilitate DLT advance through the glottis could effectively decrease postoperative sore throat and vocal cord injuries.

In this study, sore throat occurred more frequently in Group 90 than in Group 180, whereas the incidence of hoarseness was similar between the two groups. In a previous study, hoarseness after tracheal intubation was directly related to the duration and not to the act of intubation. In our study, there was no significant difference in the duration of surgery and anaesthesia between the two groups, which might explain the comparable incidence of hoarseness in both groups.

Tracheal intubation can damage any portion of airway such as the pharynx, larynx, and trachea. During advancement of a DLT through the glottis, physical contact between the DLT and the glottis is remarkably intense, which can cause trauma to the vocal cords. The incidence of vocal cord injury was 47% in
Group 90 but all the injuries were minor lesions such as hyperaemia and oedema, which was consistent with the findings of previous studies.\(^5\)\(^6\) We examined the vocal cord lesions only in the patients who had consented to undergo flexible laryngoscopy. Although the vocal cord examination could not be performed according to randomized group assignment, there was a significant difference in the incidence of vocal cord lesions between the two groups, which might support the main findings of our study.

Airway injuries may not occur during intubation, but may also be the result of some intraoperative factors such as movement of the tube.\(^1\)\(^2\)\(^4\) Although it was impossible to blind the intubation technique in our study, the use of neuromuscular blocking agents was standardized in both groups and all the procedures after intubation, including anaesthetic management, tracheal extubation, postoperative analgesia, interview **

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**Fig 1** CONSORT diagram. DLT, double-lumen endobronchial tube.

**Table 1** Patient characteristics and intraoperative variables. Values are expressed as the mean (range or SD) or number of patients. There were no significant differences between the groups. DLT, double-lumen endobronchial tube; VATS, video-assisted thoracoscopic surgery; PCA, patient-controlled analgesia.

<table>
<thead>
<tr>
<th></th>
<th>Group 90 (n=75)</th>
<th>Group 180 (n=80)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>55 (20–73)</td>
<td>56 (21–74)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>64 (10)</td>
<td>62 (9)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>165 (8)</td>
<td>164 (7)</td>
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<tr>
<td>Body mass index (kg m(^{-2}))</td>
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<tr>
<td>Sex (male/female)</td>
<td>45/30</td>
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<tr>
<td>Smoking history (yes/no)</td>
<td>20/55</td>
<td>26/54</td>
</tr>
<tr>
<td>Laryngoscopic grade (1/2/3)</td>
<td>58/14/3</td>
<td>57/18/5</td>
</tr>
<tr>
<td>DLT size (32/35/37/39 Fr)</td>
<td>4/30/35/6</td>
<td>4/29/40/7</td>
</tr>
<tr>
<td>Type of surgery (VATS/thoracotomy)</td>
<td>64/11</td>
<td>61/19</td>
</tr>
<tr>
<td>Surgical side (left/right)</td>
<td>28/47</td>
<td>33/47</td>
</tr>
<tr>
<td>Duration of surgery (min)</td>
<td>139 (67)</td>
<td>146 (67)</td>
</tr>
<tr>
<td>Duration of anaesthesia (min)</td>
<td>198 (67)</td>
<td>206 (69)</td>
</tr>
<tr>
<td>PCA (i.v./epidural/none)</td>
<td>61/11/3</td>
<td>59/19/2</td>
</tr>
</tbody>
</table>

**Fig 2** Resistance during the advance of double-lumen tubes through the glottis. Values are expressed as the number of patients. There were no patients with severe resistance in Group 180. *\(P<0.001\) between groups.

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regarding postoperative adverse symptoms, and vocal cord examination, were performed by blinded manner.

The 180° rotating technique requires an additional manipulation of the DLT compared with the conventional technique. Moreover, if the DLT is not sufficiently re-rotated 90° clockwise after passing the glottis and is thereby advanced with the bronchial tip facing posteriorly, it might cause trauma to the trachea especially on the posterior membranous wall. Therefore, this intubation technique should be performed carefully by experienced anaesthetists.

In conclusion, compared with the conventional intubation technique for left-sided DLTs with 90° counterclockwise rotation just before passing the glottis, 180° rotation of DLTs to direct the tracheal lumen anteriorly facilitated passage of DLTs through the glottis. Thereby, it appeared to be effective for reducing postoperative sore throat, and vocal cord injuries.

**Declaration of interest**

None declared.

**Funding**

This work was supported by the Department of Anaesthesiology and Pain Medicine, Seoul National University Hospital.

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Handling editor: J. P. Thompson