Feasibility of MDCT for Predicting Left Double Lumen Endotracheal Tube Displacement during Supine to Lateral Repositioning of Patients

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Abstract

Multidetector-row computed tomography (MDCT) allows visualization and measurement of anatomical structures. Because we seek a reliable method by which we can predict displacement of the double lumen endotracheal tube (DLT) in patients when supine to lateral repositioning is required during surgery, we performed MDCT preoperatively for 84 patients scheduled for elective respiratory surgery with a left DLT. We obtained 3D MDCT reconstruction images of each patient’s bronchus and then measured the distance between the vocal cords and the bifurcation of the left upper lobe bronchus. We defined this distance as the MDCT-derived appropriate depth of placement (ADP). We used two other methods to determine ADP: the standard measurement method based on the patient’s height and the chest X-ray method based on the distance from the superior border of the sixth cervical vertebra to the tracheal bifurcation. During surgery, we evaluated the actual change in ADP when the patient was moved from the supine to the lateral position. We then compared the actual ADP with the MDCT-derived ADP to assess whether the MDCT-derived ADP predicts DLT displacement during the patient repositioning.

We found that during surgery, the DLT had slipped out of position in 31 (44%) patients, had moved too deeply in 6 (7%), and had not changed in 41 (49%). Multiple logistic regression analysis showed that the MDCT-derived ADP was significantly associated with DLT displacement upon patient repositioning (odds ratio, 2.9; 95% CI, 1.5–5.6; p=0.002), whereas standard ADP and chest X-ray-derived ADP were not associated with DLT displacement. We postulate that various factors, such as extension or flexion of the neck and size of the DLT, may contribute the DLT displacement during patient repositioning.

We believe, on the basis of our study data, that ADP derived from pre-operative MDCT will be useful for predicting DLT displacement when patients are moved from the supine to lateral position during surgery.

Key Words

Double lumen tube displacement, MDCT, repositioning

Abbreviations

ADP: appropriate depth of placement; CXR: chest X-ray; DLT: double lumen endotracheal tube; FOB: fiberoptic bronchoscopy; IQR: interquartile range; MDCT: multidetector-row computed tomography; ROC: receiver operating characteristic; VBL: ADP in the lateral position; VBMD: distance between the vocal cords and left upper lobe bifurcation; VBS: ADP in the supine position; 3DCT: three-dimensional computed tomography

Introduction

A double lumen endotracheal tube (DLT) is often used during respiratory and esophageal surgeries to facilitate differential lung ventilation¹. Because the DLT has two lumens, the outer diameter of the DLT...
is larger than that of a single-lumen endotracheal tube. Thus, intubation with a DLT is difficult and requires a special technique.

The difficulty is added to by common anatomical factors in patients undergoing respiratory surgery. Furthermore, any presurgical anatomical change in the upper airway, such as a change resulting from pharyngeal cancer or an upper airway procedure, or any neck extension disorder resulting from radiation therapy can cause difficult intubation for patients undergoing respiratory surgery. Utmost skill is necessary to overcome the difficulties associated with DLT intubation; otherwise, serious complications can ensue.

Intubation difficulties can lead to critical hypoxemia. Such hypoxemia occurs when apneic time is prolonged during numerous insertion attempts or an extended insertion time or during inappropriate placement of the DLT during intubation and anesthesia. Also, the DLT can slip out of its proper place when the patient is repositioned during surgery or by surgical manipulation. Ventilatory impairment can result. Several reports have shown that hypoxemia is a frequent complication of improper placement or displacement of the DLT. We believe that accurate preoperative determination of the appropriate depth of placement (ADP) will issue in proper intubation and smooth induction of anesthesia. It may also decrease the incidence of serious surgical complications.

Conventionally, the ADP is calculated on the basis of the patient’s height or on a preoperative chest X-ray (CXR) film. Benumof et al. described the most acceptable distal position of a left-sided DLT as the position in which the tip of the left lumen can be seen at the proximal edge of the left upper lobe bronchial orifice under fiberoptic bronchoscopy (FOB). Thus, the ADP for a left-sided DLT equals the distance from the tip of the DLT to the incisors.

Multidetector-row computed tomography (MDCT) allows visualization and measurement of anatomical structures. It has become possible to create 3DCT images by automated analysis of high-resolution slice data obtained from MDCT. Okuda et al. demonstrated 3DCT reconstruction of the trachea and bronchus and its usefulness in selecting the appropriate bronchial tube. Previously, we created 3DCT images of the trachea and bronchus, and we examined correlation between ADP of the left DLT under FOB and reported that the MDCT-based ADP correlated strongly with the actual ADP established under FOB. We also reported that all preoperatively calculated ADPs were underestimated for the lateral position but not the supine position. Because the ADP of the DLT changes with neck extension and flexion or deviation of the trachea when the patient’s position is changed, it becomes still more difficult to predict ADP in the lateral position.

Conventionally, the actual ADP is evaluated under FOB. We identified the position of the DLT in relation to the vocal cords using a McGRATH MAC® video laryngoscope (Aircraft Medical Ltd, Edinburgh, UK). With the McGRATH MAC® laryngoscope and FOB, we are able to accurately measure the distance from the DLT tip to the vocal cords. We conducted the study described herein to determine whether MDCT-determined ADP can predict actual displacement of the DLT when patients are moved from the supine to lateral position during surgery.

Patients and Methods

The study was approved by the St. Marianna University Ethics Committee (No. 2646) and registered in the UMIN Clinical Trials Registry, Japan (ID012758).

Patients

Eighty-four patients were enrolled in the study. All 84 patients were to undergo elective respiratory surgery that would involve a left DLT. The study was conducted between July 2014 and March 2015. Written informed consent was obtained from all patients before their enrollment. No patient with a history of tracheal or pharyngeal surgery, who was pregnant, or who was under 20 years of age was included.

Determining the ADP

For all patients included in the study, the ADP was determined by three different methods: the standard height-based method, the CXR-based method, and our MDCT-based method.

Height-based ADP was calculated as height (cm) × 0.11 + 10.5. The resulting height-based ADP was assumed to equal the distance from the patients’ incisors to the DLT tip.

CXR-based ADP was determined on an X-ray film acquired preoperatively with the patient in the standing position and in full inspiration. The distance from the superior border of the sixth cervical vertebra (level of the vocal cords) to the tracheal bifurcation was measured, and the ADP was calculated as 0.53 × the distance from the superior border of the sixth cer-
Figure 1. MDCT and 3DCT images.

Right: Multi detector-row computed tomography image. Left: Three-dimensional computed tomography image.

A: Vocal cord; B: Tracheal carina; C: Left upper bifurcation

Anesthesia

All patients received epidural anesthesia before surgery. An epidural catheter was inserted in the vertebral interspace via either Th7/8 or Th8/9. Electrocardiography, pulse oximetry, and noninvasive blood pressure monitoring were performed continuously. General anesthesia was induced with propofol 1–2 mg/kg and remifentanil 0.5 mcg/kg/min. Tracheal intubation was facilitated with rocuronium 0.9 mg/kg. Anesthesia was maintained with propofol and remifentanil (total intravenous anesthesia). Levobupivacaine 0.125% or 0.25% was administered via epidural catheter during and after surgery for perioperative analgesia. After anesthesia induction, the radial artery was cannulated for invasive blood pressure monitoring. All patients underwent controlled mechanical ventilation with oxygen and air. After conversion to one-lung ventilation with a peak inspiratory pressure of <30 cm H$_2$O, the respiratory rate was adjusted to 12 breaths/min to maintain SpO$_2$ >90% and carbon dioxide within the physiological range at FiO$_2$ 0.46–1.0.

Measurement of actual ADP

During surgery and with the patient in the su-
pine position, the position of the DLT was adjusted under FOB and McGrath MAC® laryngoscope observation, and the distance from the distal tip of the tube to the vocal cords was determined and confirmed and marked on the DLT. We defined this distance as the ADP in the supine position (VBS). After the patient was moved from the supine to the lateral position, we again measured the distance. We defined this as the ADP in the lateral position (VBL). All calculations were done after extubation. Displacement due to the positional change was calculated as the difference between the actual ADP in the supine position and actual ADP in the lateral position.

For each patient, we compared actual ADP in the supine position and actual ADP in the lateral position to the height-based ADP, CXR-based ADP, and MDCT-based ADP. In addition, actual ADP in the supine position and actual ADP in the lateral position were measured when the anesthesia was stopped.

Statistical Analyses

Data are shown as median values and interquartile ranges (IQR). Data were subjected to simple linear regression analysis, Kruskal-Wallis test, chi square test, and/or multiple logistic regression analysis and receiver operating characteristic (ROC) curve analysis, as appropriate. Multiple logistic regression analysis was used to identify risk factors for DLT displacement. ROC curve analysis was used to determine the ADP cutoff value predictive of DLT displacement after repositioning. Significance was accepted at p<0.05.

Results

The overall incidence of DLT displacement during repositioning of patients from the supine to lateral position was 51%.

1. Patient characteristics are shown on Table 1. The DLT moved distally (deep into a peripheral bronchus) in 6 patients (7%, Group A) and proximally (toward the mouth and actually slipping out of the bronchus in 37 patients (44%, Group B). There was no displacement upon repositioning of the remaining 41 patients (49%, Group C) (ADP was the same in the supine and lateral positions). Both VBMD and VBL were significantly longer in Group B than in Group A or C (p=0.016, p=0.001, respectively).

The percentage of male patients was significantly greater in Group B (p=0.045) than in Group A or C. However, no significant between-group difference was found in patient height, use of the left lateral or right lateral position, DLT size, or operative procedure.

2. Results of correlation analysis are shown in Fig. 2. Strong correlation was found between height-based ADP and VBMD (r=0.70; p=0.0001), but weak correlation was found between CXR-based ADP and VBMD (r=0.39, p=0.0001).

3. Results of correlation analysis between VBS and VBMD and between VBL and VBMD are shown in Fig. 3. Significant correlation was found both VBS and VBL and VBMD (r=0.45 and r=0.57, respectively; p=0.001).

4. The displacement after positional change is shown on Table 1, and correlations between the amount of displacement and height and VBMD are shown on Fig. 4. Weak correlation was found between the amount of displacement and both height and MDCT-based ADP (r=0.22 and r=0.22, respectively; p=0.04). The amount of displacement after positional change tended to increase with increases in patient height.

5. Multiple regression analysis showed VBMD to be a predictor of DLT displacement during patient repositioning in Group B (odds ratio: 2.9, 95% CI: 1.5–5.6; p=0.002, Table 2). In addition, ROC analysis showed the cutoff value of VBMD to be 20.7 cm, with an area under the ROC curve of 0.69, sensitivity 0.67, and specificity 0.62 (p=0.004, Table 3).

Discussion

We found a 51% overall incidence of endotracheal tube displacement during respiratory surgery performed with a DLT. The overall incidence was accounted for by a 7% incidence of distal displacement and 44% incidence of proximal displacement. Klein et al. reported distal displacement in 8% of cases and proximal displacement in 30% of cases upon patient repositioning (13). Our incidences of shallow and deep displacement were similar to theirs. Furthermore, they reported that the DLT is easily moved more deeply after intubation and easily moved in the opposite direction during patient repositioning. However, they measured only the change in positon of the DLT tip observed under FOB. Further, they did not measure actual ADP; they simply estimated the change in the position of the tip upon patient repositioning. We compared actual ADP in the supine position with actual ADP in the lateral position. This is a distinct feature of our study.

The median DLT displacement was 0.8 cm in our Group A (DLT position was too deep) and 2.0 cm
<table>
<thead>
<tr>
<th></th>
<th>Group A (n=6)</th>
<th>Group B (n=37)</th>
<th>Group C (n=41)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex ratio; M/F</td>
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<td>28/9</td>
<td>20/21</td>
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<td>Age; years</td>
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<td>72 (56–76)</td>
<td>67 (63–72)</td>
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<tr>
<td>Height; cm</td>
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<td>164 (158–170)</td>
<td>162 (153–167)</td>
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<td>Body weight; kg</td>
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<td>58 (54–63)</td>
<td>58 (53–66)</td>
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<td>22 (20–24)</td>
<td>23 (21–25)</td>
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<tr>
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<td>13/24</td>
<td>17/24</td>
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<tr>
<td>DLT size</td>
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<td>32 Fr</td>
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<td>13</td>
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<td>19</td>
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</tr>
<tr>
<td>39 Fr</td>
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<td>6</td>
<td>1</td>
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<td>19</td>
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<td>4</td>
<td>4</td>
<td></td>
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<tr>
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<td>2</td>
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<td>9</td>
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<tr>
<td>Bulla resection</td>
<td>0</td>
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<td>5</td>
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<tr>
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<tr>
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<td>4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>35</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>Height-based ADP; cm</td>
<td>26.5 (25.1–27.8)</td>
<td>27.2 (24.8–29.0)</td>
<td>27.0 (24.4–28.9)</td>
<td>0.082</td>
</tr>
<tr>
<td>CXR-based ADP; cm</td>
<td>26.5 (25.8–27.4)</td>
<td>26.8 (25.4–28.8)</td>
<td>26.5 (24.9–28.6)</td>
<td>0.242</td>
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<td>VBMD; cm</td>
<td>17.2 (16.7–17.6)</td>
<td>18.4 (17.7–19.3)</td>
<td>17.5 (16.8–18.8)</td>
<td>0.016</td>
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<tr>
<td>VBS; cm</td>
<td>17.1 (16.4–18.2)</td>
<td>16.7 (16.2–17.8)</td>
<td>17.4 (16.5–18.5)</td>
<td>0.246</td>
</tr>
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<td>VBL; cm</td>
<td>16.4 (15.6–17.6)</td>
<td>19.1 (17.8–19.8)</td>
<td>17.4 (16.5–18.5)</td>
<td>0.001</td>
</tr>
<tr>
<td>VBL–VBS; cm</td>
<td>−0.8 (−1.1–0.3)</td>
<td>2.0 (0.1–5.7)</td>
<td>0.0 (0.0)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Number of patients or median (IQR) values are shown unless otherwise indicated.

Group A: patients in whom the double lumen endotracheal tube (DLT) moved distally; Group B: patients in whom the DLT moved proximally; Group C: patients in whom the DLT was not displaced.

M: male; F: female; BMI: body mass index; L: left; R: right; ASA PS: American Society of Anesthesiologists physical status.

CXR: chest X-ray

VBMD: distance between the vocal cords and the left upper lobe bronchus measured on the 3DCT image; VBS: insertion length in the supine position; VBL: insertion length in the lateral position.
in our Group B (DLT position was too shallow). The displacement was slightly more than 4 cm in 5 patients in our Group B. However, the deep displacement was not more than 1.1 cm in our Group A. The wall of the distal bronchus blocks the DLT tip; we cannot insert it deeply. Both Klein et al.\textsuperscript{13}) and Brodsky et al.\textsuperscript{14}) reported the incidence of displacement with patient repositioning, but neither group calculated the amount of displacement. Although Yoon et al.\textsuperscript{15}) reported the amount of displacement, they determined this under FOB and did not compare the ADP between the supine and lateral positions. Overall, our data support the reported change in ADP in nearly 40% of patients during repositioning and the importance of observing the position of DLT tip by FOB after repositioning.

McGRATH MAC\textsuperscript{®} laryngoscopy is similar to conventional laryngoscopy in endotracheal intubation. We can intubate the patient while confirming the vocal cords on an LCD screen\textsuperscript{1}). Moreover, the McGRATH MAC\textsuperscript{®} laryngoscope offers several advantages over conventional laryngoscopes\textsuperscript{1}). Because it is difficult to identify the location of the DLT in the lateral position when using a standard laryngoscope, we used a McGRATH MAC\textsuperscript{®} laryngoscope to confirm the precise location. In previous studies, the ADP was assumed to be the distance from the position of the bronchial tube tip to the oral commissure or an incisor, and the tube was positioning with use of FOB. However, the ADP, when determined by this method, is somewhat arbitrary because the skin at the corners of the mouth is loose and does not lend itself to precise measurement, especially in the elderly. The McGRATH MAC\textsuperscript{®} laryngoscope provides superior visibility, even in the lateral position, and positional identification of the vocal cords is more objective.

We found significant correlation between VBMD and both VBS and VBL. Chang et al.\textsuperscript{16}) reported significant association between ADP and height ($y = \text{height} \times 0.12 + 10.5$, $r=0.47$) and also significant association between DLT insertion depth and the distance between the cranial side of the sixth cervical vertebrae and the tracheal carina calculated on a CXR film. Our results are in agreement with theirs.

Physiologically, the trachea is thought to increase in length with increases in height. Generally,
for tall patients with a long trachea, a large-size DLT is necessary. However, a large DLT easily slips out of position. In small patients with a short trachea, a small-size DLT is required. Conversely, a small DLT is easily inserted too deeply.

Multiple logistic regression analysis showed VBMD to be a predictor of displacement only in Group B; height-based ADP and CXR-based ADP were not shown to be predictors. Furthermore, a VBMD value of ≥20.7 cm was shown to predict DLT displacement after repositioning. These results indicate that VBMD has value in predicting the change in ADP with patient repositioning, but the weak correlation we found indicates that it is difficult to predict the amount of displacement. This means that several factors, such as cervical extension and flexion, DLT size, tracheal deviation, lung collapse during differential ventilation, carinal displacement, and arcuation, may cause DLT displacement when the patient is moved from the supine to lateral position. Both neck extension and flexion cause movement of the DLT\(^1\). In our study, the VBS was measured under FOB and with a McGrath MAC\(^\circ\) video laryngoscope with the patient in the supine position and neck extended over a pillow after intubation. We also measured VBL by FOB and with a McGrath
Figure 4. Scatter-plots showing correlation between displacement of the DLT upon patient repositioning and VBMD (upper) and between displacement of DLT and height (lower).

DLT: double lumen tube; ADP: appropriate depth of placement of DLT.

VBMD: distance from vocal cords to bifurcation of the left upper lobe bronchus on 3DCT image.

MAC® video laryngoscope with the patient in the lateral position and neck flexed with a pillow. The cervical extension or cervical flexion may cause displacement of the DLT when the patient is moved from the supine to lateral position. Sato et al showed that the DLT can become inserted too deeply under cervical flexion and that the insertion can become too shallow under cervical extension.21) Further, Brodsky et al.9) demonstrated that a pillow causes extension of the neck and that the depth of insertion is easy to change with a pillow. These studies showed that the use of a pillow and either cervical extension or cervical flexion are strongly associated with the difference in ADP between the supine and lateral position.

The vocal cords are attached to the backside of the thyroid cartilage at the level between the fifth cervical vertebra and sixth cervical vertebra. Because the distance between the vocal cords and the left upper lobe bifurcation reflects the neck measurement, we thought that the ADP varied with cervical extension or flexion in our study. The distance from the incisors to the vocal cords is approximately 12 cm in adults.22) Generally, an appropriate DLT insertion length is the distance from the incisors to the tracheal tube tip.

Previously, we calculated the predictive ADP from MDCT and suggested image making from an incisor to the vocal cord was not created because the image processing of trachea based on a CT level of the air and the measurement of the distance from an incisor to DLT tip by MDCT might cause an error.8) Therefore, we speculated that MDCT would be particularly useful for reconstruction images and then measurement of the distance between the bifurcation of the left superior lobar bronchus and the vocal cords to determine the ADP preoperatively.

DLT size appears to be implicated in DLT displacement during patient repositioning. With increa-
Table 2. Results of Multiple Logistic Regression Analysis of Potential Independent Factors for Predictive of Displacement of the Left Double Lumen Endotracheal Tube During Patient Repositioning

<table>
<thead>
<tr>
<th></th>
<th>odds ratio</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>displacement</td>
<td></td>
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<tr>
<td>MDCT based ADP</td>
<td>2.88</td>
<td>1.48-5.63</td>
<td>0.002</td>
</tr>
<tr>
<td>CXR based ADP</td>
<td>1.16</td>
<td>0.28-4.87</td>
<td>0.840</td>
</tr>
<tr>
<td>Height based ADP</td>
<td>0.74</td>
<td>0.21-2.60</td>
<td>0.645</td>
</tr>
<tr>
<td>No displacement</td>
<td></td>
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</tr>
<tr>
<td>MDCT based ADP</td>
<td>1.56</td>
<td>0.89-2.73</td>
<td>0.124</td>
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<tr>
<td>CXR based ADP</td>
<td>1.15</td>
<td>0.29-4.57</td>
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<tr>
<td>Height based ADP</td>
<td>0.90</td>
<td>0.30-2.75</td>
<td>0.855</td>
</tr>
</tbody>
</table>

95%CI: 95% confidence interval; MDCT: multidetector-row computed tomography
ADP: appropriate depth of placement; CXR: chest X-ray

Table 3. Results of receiver operating characteristics (ROC) analysis for predicting ADP

<table>
<thead>
<tr>
<th>Predicted ADP</th>
<th>Cutoff value (cm)</th>
<th>AUC</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>p Value</th>
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</thead>
<tbody>
<tr>
<td>MDCT-based</td>
<td>20.7</td>
<td>0.69</td>
<td>0.67</td>
<td>0.62</td>
<td>0.004</td>
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<td>CXR-based</td>
<td>26.2</td>
<td>0.57</td>
<td>0.79</td>
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<td>0.29</td>
</tr>
<tr>
<td>Height-based</td>
<td>27.2</td>
<td>0.61</td>
<td>0.58</td>
<td>0.64</td>
<td>0.09</td>
</tr>
</tbody>
</table>

ADP: appropriate of placement; MDCT: multidetector-row computed tomography
CXR: chest X-ray

ses in the size of the DLT come increases in the degree of DLT displacement. This is thought to be associated with the increases in depth of DLT insertion that correspond to increases in patient height\(^{19,23,24}\). Brodsky et al. reported significant association between the appropriate depth of DLT insertion and height\(^{10}\). They also reported that the depth of DLT insertion increased or decreased by 1 cm when patients’ heights increased or decreased by 10 cm.

We found correlation between height-based ADP and the distance between the vocal cords and left upper lobe bifurcation. However, we did not choose the DLT size on the basis of patient height. Rather, we measured the bronchus diameter preoperatively on CT images and chose the DLT based on the inner diameter of the left main bronchus. This difference in the method of selecting the DLT size may account, at least in part, for the difference between the Broadsky et al.\(^{14}\) results and ours.

Additional factors that may be related to displacement of the DLT during patient repositioning include carina displacement and the side on which the thoracotomy is performed. We did not find a significant difference in DLT displacement between right and left thoracotomy, so we deem the side on which the thoracotomy is performed to be of little consequence in terms of DLT displacement.

Yamase et al. studied the size of the divergence angle between the left bronchus and tracheal axis from with the right and left lateral decubitus position\(^{25}\). They showed that the angle that the bronchus with left and right lateral position was differed with supine position. With patients in the lateral position, the bronchus moves toward the diaphragm causing displacement of the DLT. In addition, thoracotomy-induced lung collapse can result in a change in the anatomical position of the bronchus in the dependent lung. They also suggested that the trachea and the bronchus move with respiration and heartbeats, so the DLT displacement occurs regardless of surgical manipulation.

Yoon et al. reported the gravity does not have a major influence on the position of DLT and that the DLT insertion depth is often increased by repositioning the patient from the supine position to either the right or left lateral decubitus position\(^{15}\). In contrast, Desiderio et al. reported that the tracheal bifurcation is displaced downward under the influence of gravity in the lateral decubitus position, and they concluded that the gravitational pull causes cranial displacement of the DLT in the lateral decubitus position\(^{26}\). It remains unclear, however, whether gravity affects the position of the DLT in the lateral position.

We did not examine which factor or factors were involved in displacement of DLT with the change in patient position. However, our results suggest that
cervical extension or flexion is a major factor in the DLT displacement that occurs during patient repositioning.

The degree to which our study results might have been influenced by our study limitations is unknown. After identifying the position of the DLT in relation to the vocal cords with a McGRATH MAC® video laryngoscope, we measured the length of DLT insertion with a ruler upon extubation. However, the measurement is only as precise as the marks on the endotracheal tube, which are 0.5 cm apart. In contrast, MDCT-based ADP is measured in millimeters. The difference in accuracy of the measurements might have weakened correlation between VBS (ADP in the supine position) or VBL (ADP in the lateral position) and VBMD (MDCT-based ADP). However, we showed strong association between the MDCT-based ADP and the actual ADP by improving the measurement method.

In our study, actual ADP measurement was performed in every case, and the MDCT-based ADP was performed at random by one anesthesiologist. However, because the MDCT-based ADP and actual ADP were measured at different times, we believe investigator bias was avoided.

We conclude, despite our study limitations, that MDCT-based ADP is useful in predicting DLT displacement when patients are moved from the supine to lateral position. However, further study is needed to investigate whether use of MDCT-based ADP reduces perioperative complications, such as hypoxemia, in patients undergoing respiratory surgery.

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