Predicting Optimal Insertion Depth of a Left-sided Double-Lumen Endobronchial Tube

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Objective: Appropriate placement of the double-lumen endobronchial tube (DLT) is essential for one-lung ventilation. Several formulae based on body height (BH) have been used for estimating the optimal insertion depth of a left-sided DLT. In this study, the authors examined the following 5 formulae for accuracy of prediction: 0.11 × BH + 10.53 (cm) from Brodsky et al[1]; 0.15 × BH + 3.96 (cm) from Bahk and Oh[2]; 0.148 × BH + 3.8 (cm) from Chow et al;[3] 0.1 × BH + 12.5 (cm) from Takita et al[4]; and 0.1977 × BH – 4.2423 (cm) (authors' formula).

Design: Single-center, retrospective, observational study.

Setting: University hospital.

Participants: Anesthetic records of patients older than 20 years who received one-lung ventilation using a left-sided DLT were included.

Interventions: The patients' sex, age, body weight, BH, and the final correct insertion depth of the left-sided DLT after fiberscope verification were recorded. Linear regression and correlation were used to analyze the data.

Measurements and Main Results: One hundred seventy anesthetic records were analyzed. The insertion depth was distributed normally in 4 groups with different BH intervals. The correlations between the correct insertion depth and all the lengths calculated using each formula were significant ($p < 0.001$), with a similar high coefficient of determination ($r = 0.809$). The regression line derived from the authors' formula—0.1977 × BH – 4.2423 (cm)—showed the most accuracy in predicting the correct insertion depth.

Conclusions: The height-based formula of 170 – 29.5 – 5 – 1 (the insertion depth is 29.5 cm for patients who are 170 cm tall, and the insertion length is increased or decreased by 1 cm for every 5 cm increase or decrease in BH) modified by the equation of 0.1977 × BH – 4.2423 is a useful tool to predict the optimal insertion depth in initially blind left-sided DLT insertion.

KEY WORDS: double-lumen endobronchial tube, insertion depth, one lung ventilation, thoracic anaesthesia

A DOUBLE-LUMEN endobronchial tube (DLT) is used when patients undergo thoracic surgery with one-lung ventilation. A left-sided DLT commonly is used. Optimal placement of the DLT is essential for undergoing anesthesia and surgery. The time taken for DLT intubation can be prolonged because careful adjustment of the DLT to an optimal position is required. Although the final correct position of the DLT should be checked using a bronchoscope, a useful predictive method still is significant when performing the initial blind insertion of the DLT because it can reduce the intubation time. Several studies[1-4] have demonstrated a statistically significant correlation between body height (BH) and the optimal insertion depth of a left-sided DLT. Each of the 4 studies provided a formula based on BH to predict the optimal insertion depth. The authors also developed their own formula —0.1977 × BH – 4.2423 (cm)—which was derived from the authors' previous study.[5] In this study, the authors retrospectively collected data from patients whose tracheas were intubated correctly with left-sided DLTs via bronchoscopic confirmation and examined the 5 aforementioned formulae for an accurate estimation of the optimal insertion depth.

METHODS

Institutional review board approval was obtained. The authors retrospectively collected the anesthetic records of patients who underwent thoracic surgery with one-lung ventilation from May 2012 to April 2014. The study included patients who were older than 20 years and whose procedure included placement of a left-sided DLT (Mallinckrodt Endobronchial Tube; Medtronics, Minneapolis, MN). The optimal position of the left-sided DLT was confirmed using fiberoptic bronchoscopy and defined when the inflated endobronchial blue cuff in the left bronchus was just below the carina. The authors recorded the patient's sex, age, body weight, BH, and the final correct insertion depth of the left-sided DLT after verification via a bronchoscope.

The following 5 formulae were compared: 0.11 × BH + 10.53 (cm) by Brodsky et al[1]; 0.15 × BH + 3.96 (cm) by Bahk and Oh[2]; 0.148 × BH + 3.8 (cm) by Chow et al[3]; 0.1 × BH + 12.5 (cm) by Takita et al[4]; and 0.1977 × BH – 4.2423 (cm) by the authors of this study.

Linear regression and correlation using SigmaPlot version 13.0 for Windows (Systat Software Inc, San Jose, CA) were used to analyze the relationships between the correct depths and the lengths calculated using each formula. The distribution of the insertion depth for groups with different intervals of height (145-154 cm, 155-164 cm, 165-174 cm, and 174-185 cm) also was determined.

RESULTS

One hundred ninety-five anesthetic records were collected. Nineteen patients who underwent right-sided DLT placement and 6 patients ages younger than 20 years were excluded. Thus, 170 patients older than 20 years who underwent left-sided DLT placement were included for further analysis. Of the 170 patients (108 men and 62 women), the mean age ± standard deviation was 54.4 ± 16.5 years; weight, 62.7 ± 11.2 kg; and height, 164.1 ± 8.5 cm. Fig 1 shows the distribution of the insertion depth for 4 groups with different intervals of BH. The distribution of the insertion depth was normally distributed in all 4 groups. The correlations between the correct insertion

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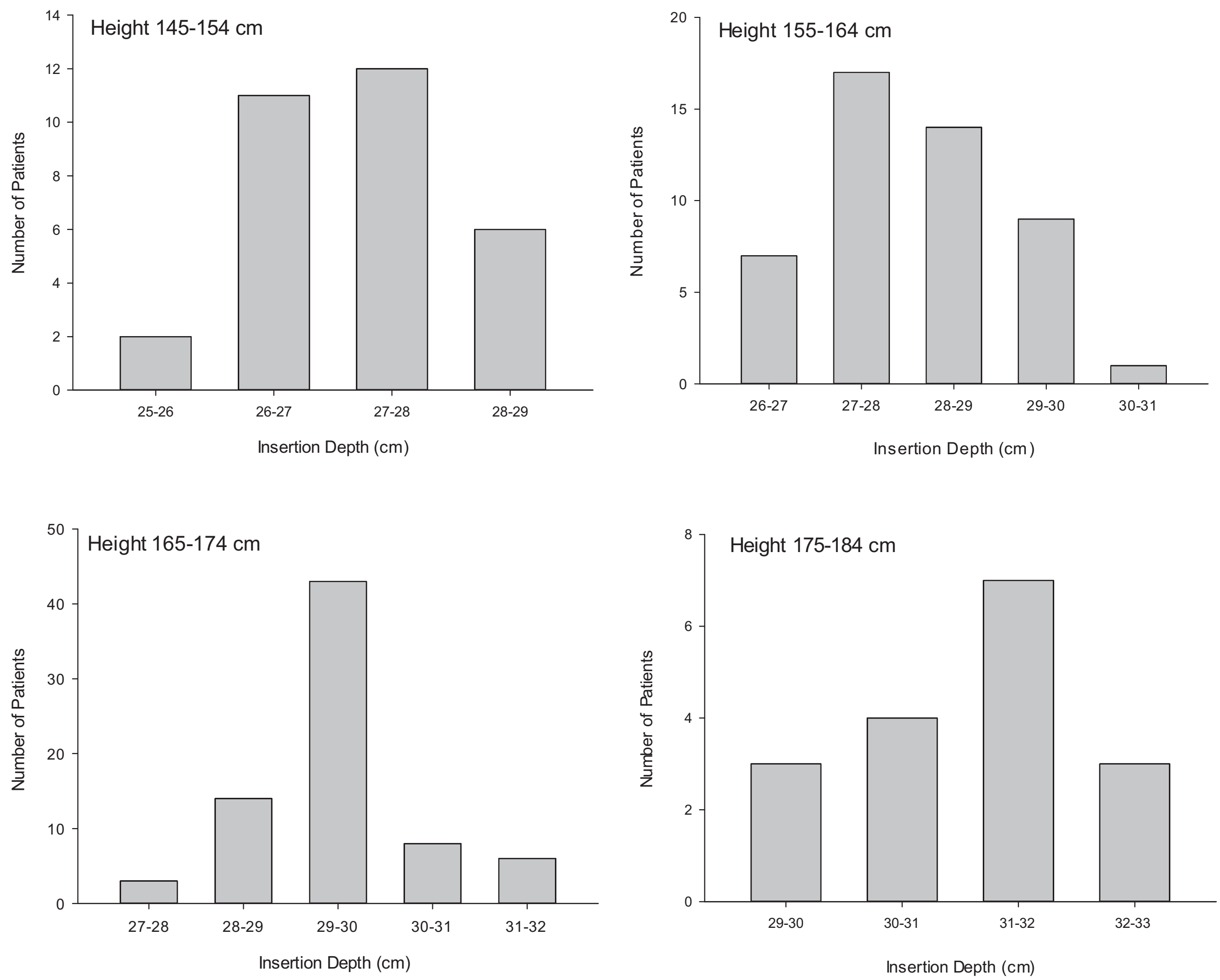

Fig 1. The insertion depth of left-sided double-lumen endobronchial tubes in 4 groups with different intervals of patient body height. The distribution of the insertion depth is normally distributed in all grouped intervals. LDLT, left-sided double-lumen endobronchial tube.

depth and all the lengths calculated using each formula were significant ($p < 0.001$) and had a similar high coefficient of determination ($r = 0.809$). The regression lines of each formula are shown in Figs 2 to 6. The regression line derived from the formula by the authors of this study was the most approximate to the equality line of the scatter chart for correct versus estimated insertion depth. Other formulae showed large deviations in both taller and shorter patients, meaning that the insertion of a left-sided DLT was inadequate in taller patients and too advanced in shorter patients.

DISCUSSION

In this study, 5 formulae were examined for the optimal insertion depth of a left-sided DLT. The results showed that the authors' formula—0.1977 × BH – 4.2423—provided the best predictability. This formula was derived from the authors' previous study.[5] In that study, a formula of 0.1977 × BH – 12.7423 for predicting the optimal insertion depth regarding orotracheal intubation was obtained. The length derived from the formula represented the distance from the corner of the mouth to 5 cm above the carina. The value used in this study, 4.2423 cm, was obtained by subtracting 8.5 cm from 12.7423 cm. The value, 8.5 cm, was calculated by adding 5 cm (5 cm above the carina) to 3.5 cm (the length from the tip of the DLT to the upper edge of the inflated bronchial cuff).

The main difference between the formula developed by the authors of this study and the other formulae was the slope of the regression lines. In the authors' formula, a 1-cm advance or withdrawal of the DLT was determined on every 5-cm increase or decrease of BH. In contrast, the formulae by Brodsky et al[1] and Takita et al[4] were determined on every 10 cm of BH change, and the formulae by Bahk and Oh[2] and Chow et al[3] were determined on every 7.5 cm of BH change. The larger intervals of BH for adjusting the insertion depth in those 4 formulae resulted in an inaccurate estimation in tall and short patients.

However, the authors' formula was too difficult to memorize and calculate. Therefore, the authors simplified the equation and addressed a sequential number of 170 – 29.5 – 5 – 1 for easy recall. It means that the insertion depth is 29.5