

Selection of an Appropriate Left-sided Double-lumen Tube Size for One-lung Ventilation among Asians

Abstract

Context: Selecting an appropriate size double-lumen tube (DLT) for one-lung ventilation has always been a challenge as most choose it based on experience or using the existing guidelines based on gender and height. **Aims:** The aim of this study was to determine if the appropriate choice of this tube could be based on the patients' height, weight, tracheal diameter (TD), or the left main stem bronchus diameter (LMBD) and also to determine the relationship between height and depth of insertion among Asians. **Subjects and Methods:** This was a retrospective review of 179 patients who were intubated with a left-sided DLT and also had a posterior-anterior view of a digital chest radiograph for tracheal and left main bronchus diameter measurements. Additional data collected included patients' demographics and DLT size used. **Results:** There were 123 (68.7%) males and 56 (31.3%) females with an overall mean age of 33.3 ± 16.3 years. Majority of the males (48.8%) used a size 39 Fr while females (46.4%) used a 35 Fr. There were weak correlations between DLT size with height (male: $R^2 = 0.222$; female: $R^2 = 0.193$), DLT size with weight (male: $R^2 = 0.109$; female: $R^2 = 0.211$), DLT size with TD (male: $R^2 = 0.027$; female: $R^2 = 0.016$), and DLT size with LMBD (male: $R^2 = 0.222$; female: $R^2 = 0.193$). There was a good correlation between depth of DLT inserted with patient's height for both genders. **Conclusion:** The appropriate size of the left-sided DLT could not be predicted based on patients' height, weight, tracheal or left main bronchus diameter alone in Asians; however, the depth of insertion of the tube was dependent on the height in both genders.

Keywords: Chest radiograph, double-lumen tube size, left main bronchus diameter, tracheal diameter

Introduction

Double-lumen tubes (DLTs) are commonly used to provide one-lung ventilation (OLV) in patients undergoing thoracic surgery. However, the biggest challenge among anesthesiologists lies in selecting the most appropriate size to provide optimum ventilation with minimal trauma.^[1,2] The conventional recommendation is to insert the largest possible DLT according to patient's height and gender.^[3] With the lack of proper guidelines, especially for Asians, we would like to determine if the appropriate size of the DLT could be based on height, weight, tracheal or left main bronchus diameter and also to determine the relationship between height and depth of insertion among male and female patients in this region.

Subjects and Methods

This was a retrospective study conducted on patients who were intubated with a

left-sided DLT for OLV from the year 2005 to 2015 in our center. Approval was obtained from the Dissertation Committee of the Department of Anesthesiology and Intensive Care and by the Medical Research and Ethics Committee (Project code: FF-2015-385). From the records, we included only patients who were managed by one single anesthesiologist, patients whose trachea were intubated with a left-sided Mallinckrodt DLT (Mallinckrodt™ (Covidien, Tullamore, Ireland)) with a posterior-anterior view of a digital chest radiograph (Medweb Telemedicine Intranet Software version 7.0.9, 2014, San Francisco, CA) taken in our center. Patients who had a distorted trachea-bronchial tree on the chest radiograph were excluded.

From the patients' records, data collected included patients' age, gender, height, weight, American Society of Anesthesiologists (ASA), type of surgery,

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size of the left-DLT used, and the level anchored at the incisors. Using the preoperative digital chest radiograph retrieved from the system, measurements of the tracheal diameter (TD) taken at the level between the two clavicle heads and the left main bronchus diameter (LMBD) at one cm below the carina were then performed by a single operator to reduce bias and error. These measurements were done using a digital ruler from the Medweb software as mentioned above whereby calibration has been done, pixel by pixel and zooming the images during measurements would not result in error.

Statistical analysis was performed using SPSS v. 21 software (SPSS, Inc., Chicago, IL, USA). Descriptive statistics (mean and standard deviation and percentage) were used to summarize the data. Pearson regression analysis was used to determine the association between the variables.

Results

A total of 179 records of patients who underwent OLV requiring DLT intubation with a posterior-anterior view of a digital chest radiograph done in our center over the study period were retrieved. There were 123 (68.7%) males and 56 (31.3%) females. The mean age for all patients was 33.3 ± 16.3 years. 116 (64.8%) patients were classified as ASA I, 54 (30.2%) patients in ASA II while the remaining 9 (5%) in ASA III. Majority of the cases (45%) performed were for bilateral sympathectomy for hyperhidrosis through video-assisted thoracoscopic surgery (VATS), 16.2% for VATS bullectomy, 10% for decortication for empyema, and 9.5% for resection of malignant lung tumors. Only 3.4% of patients

required a thoracotomy for tuberculosis. The remaining cases were for esophagectomy, spine tumor, scoliosis surgery, and others. All the 179 chest radiographs reviewed had a visible tracheal air column, and only 176 (98.3%) had a clearly visible left main bronchial air column which could be measured. Demographic characteristics and airway dimensions of the patients are shown in Table 1.

Majority (48.8%) of the male patients were intubated with DLT size 39 Fr with an average height of 169.7 ± 7.1 cm, while 46.4% of female patients with a mean height of 155.4 ± 5.7 cm used a 35 Fr DLT. Further analysis showed a weak correlation between DLT size and height (male: $R^2 = 0.222$, $R = 0.47$; female: $R^2 = 0.193$, $R = 0.44$) as well as weight (male: $R^2 = 0.109$, $R = 0.33$; female: $R^2 = 0.211$, $R = 0.46$) as shown in Figure 1.

We further categorized the patients' height into three different height ranges for all patients to compare with

Table 1: Demographic and airway dimensions

	Male (n=123)	Female (n=56)
Age (years)	33.6±16.2	32.2±17.3
Height (cm)	169.2±7.3	157.3±6.1
Weight (kg)	61.8±12.3	57.0±12.5
BMI (kg/m ²)	21.6±4.4	23.0±4.5
TD (mm)	17.2±2.2	15.1±2.0
LMBD (mm)	11.8±1.8 (n=120)	10.6±1.6

Results are expressed in mean±SD. TD: Tracheal diameter, LMBD: Left main bronchus diameter, BMI: Body mass index, SD: Standard deviation

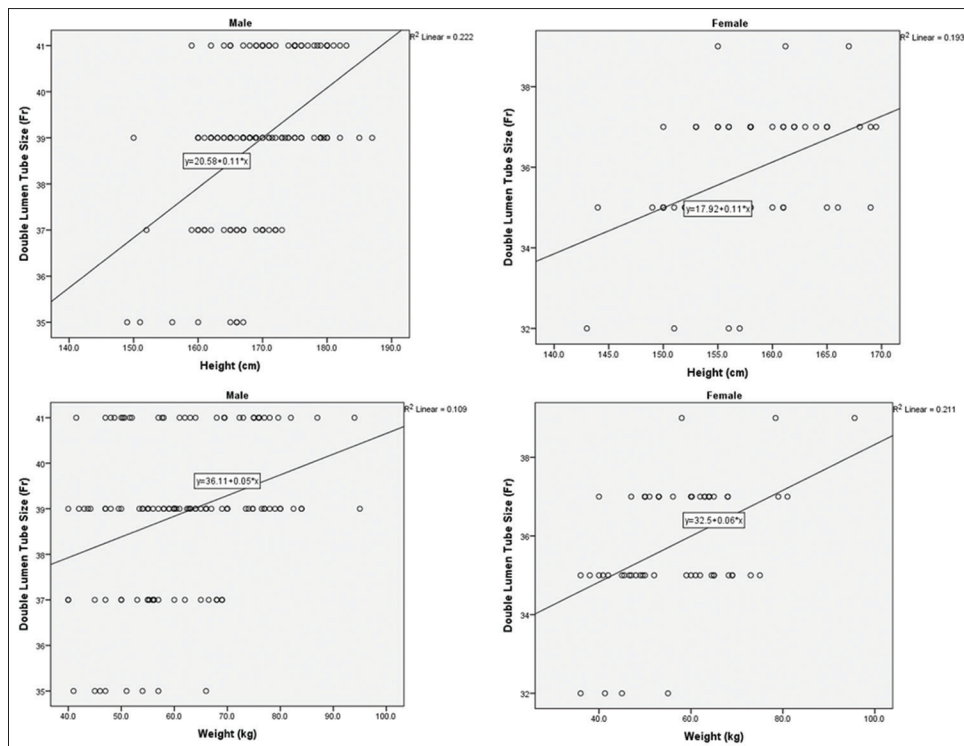


Figure 1: Relationship between double-lumen tube size with height and weight for both genders

the conventional recommendation (based on gender and height range).^[3] For the males, 59 (48%) were from the height range of 160–170 cm and only 33 (55.9%) of these patients were suitable for a 39 Fr DLT as recommended [Figure 2]. As for those measuring >170 cm in height, only 23 (41.8%) out of 55 patients in this category received the recommended size of 41 Fr DLT. Majority of these patients ($n = 25$, 45.4%) used a size 39 Fr instead. For females with height ranges of 150–160 cm and >160 cm, 30 out of a total of 53 (56.7%) patients were intubated with the recommended size of DLT according to height range [Figure 3].

TD was successfully measured on all 179 chest radiographs. The average TD for 123 males was 17.2 ± 2.2 mm (range: 10–24 mm) and 15.1 ± 2.0 mm for 56 females (range: 10–20 mm) as shown in Table 1. The LMBD could not be measured from the chest radiograph in three patients who were all males. We found a positive correlation between TD with LMBD for males ($R^2 = 0.142$, $R = 0.38$) and females ($R^2 = 0.375$, $R = 0.612$), and therefore, unknown values of LMBD can be calculated based on the equation as shown in Figure 4. When comparison was made between DLT size with TD and LMBD, there was weak correlation between DLT size with TD (male: $R^2 = 0.027$, $R = 0.163$; female: $R^2 = 0.016$, $R = 0.128$) and DLT with LMBD (male: $R^2 = 0.222$, $R = 0.174$; female: $R^2 = 0.193$, $R = 0.215$).

Pearson regression analysis showed that the depth of DLT was positively correlated to patient’s height (male: $R^2 = 0.220$, $R = 0.47$; female: $R^2 = 0.114$, $R = 0.34$) as shown in Figure 5. The regression lines for both male and

female were almost identical and were $y = 13.95 + 0.09x$ and $y = 14.92 + 0.08x$, respectively. We found that the average depth of DLT insertion in male patients <160 cm in height was 28.1 ± 1.4 cm, between 160 and 170 cm was 28.6 ± 1.3 cm, and for patients >170 cm was 29.8 ± 1.2 cm. For female patients of height <150 cm, the average depth was 26.0 ± 1.7 cm, between 150 and 160 cm was 27.1 ± 1.4 cm, and >160 cm was 27.8 ± 1.3 cm.

Discussion

In general, one of the difficulties encountered by most anesthesiologists performing OLV is the selection of an optimal size DLT which would best fit the patient. In our center, this selection has always been based on the patients’ height and gender as recommended by Slinger which was calculated approximately based on the median values.^[3] However, this recommendation may not be appropriate for all patients, especially Asians who are generally smaller. Mackey *et al.* found that the average tracheal widths for Asians and non-Asians were 19 ± 2 mm (men), 16 ± 2 mm (women) and 21 ± 2 mm (men), 17 ± 3 mm (women), respectively.^[4] This was consistent with our findings among Asians whereby the mean TD was 17.2 ± 2.2 mm for males and 15.1 ± 2.0 mm for females.

In our study, we found that most of our male population were from the height range of 160–170 cm but only 34 (56.6%) of these patients were suitable for a 39 Fr DLT and those >170 cm in height, a 41 Fr DLT could only fit 41.8% patients as recommended. Fifty (43.5%) of these two categories of patients required a downsizing of the DLT [Figure 2]. In the female category, only about half of the patients in the category of 150–160 cm and >160 cm used a DLT size based on the recommendation [Figure 3]. This was not surprising as the TDs in Asians are generally

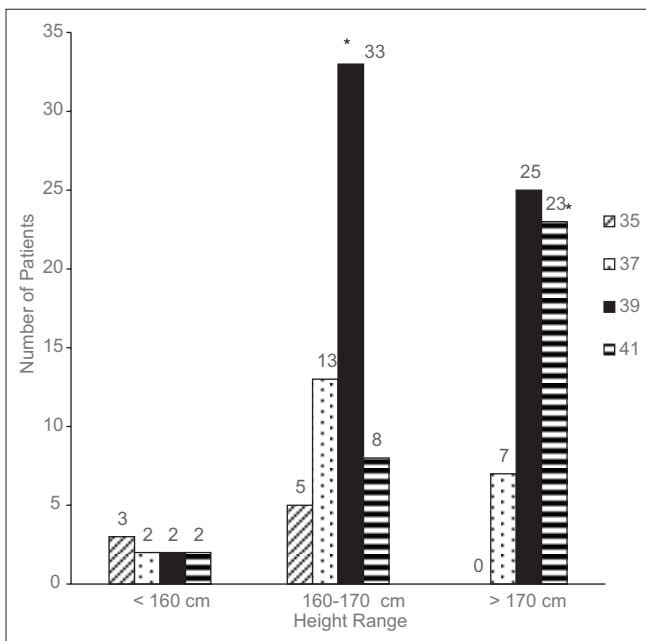


Figure 2: Distribution of double-lumen tube size (Fr) used according to height range in males. *The recommended size double-lumen tube based on height and gender guidelines

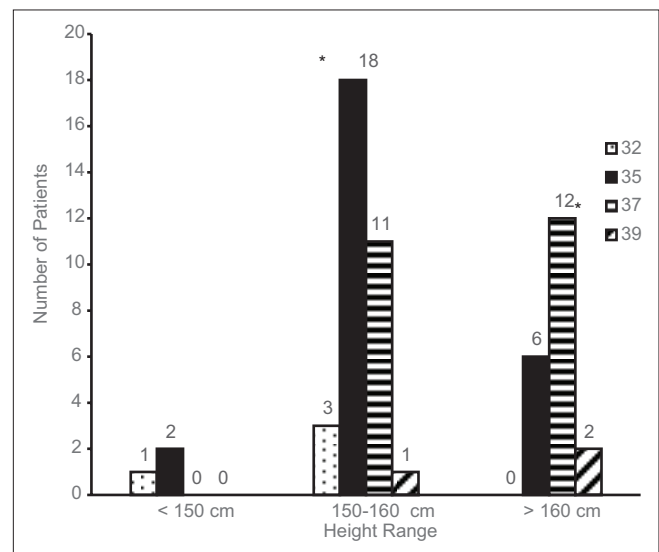


Figure 3: Distribution of double-lumen tube size (Fr) according to height range in females. *The recommended size double-lumen tube based on height and gender guidelines

smaller and that the recommendation based on height range may not be suitable.

Other methods have been proposed to determine the appropriate size of the DLT which included measurement of TD and LMBD. Brodsky *et al.* found that direct measurements from the posterior-anterior chest radiograph of the tracheal width at the interclavicular plane can be used as a guide. In their study, the mean tracheal width for men was 20.90 ± 0.32 mm and 16.90 ± 0.25 mm for women and that majority of the men used a 41 Fr DLT regardless of their height or weight with the tracheal width being a better predictor for the selection of the appropriate size DLT.^[5] From our study, we found that only 33 (26.8%) of all our male patients used a size 41 Fr DLT. The mean TD in this group of patients was 17.9 ± 2.2 mm which corresponded to the recommended size of DLT based on TD measured from the preoperative chest radiograph. Majority of the other patients with similar TD measurements used smaller size DLTs. For the female category, we found that only 41.1% of them used the recommended DLT size 37 Fr with a mean TD of 15.3 ± 2.0 mm. A larger proportion of them (46.6%) with similar TD were intubated with a smaller DLT size 35 Fr. DLT size and TD were found to be poorly correlated for both genders (male: $R = 0.163$; female: $R = 0.128$).

Knowledge of the patient's LMBD could also provide a useful guide to choose the appropriate DLT size.^[6-9] Therefore, if the LMBD is measured from either a chest radiograph or a CT scan and also measurements of the external diameter of the bronchial tip of the DLT are performed, we could then select a DLT with a bronchial lumen which has a slightly smaller diameter. Unfortunately, the anatomy of left main bronchus is not always visible in a chest radiograph. Hannallah *et al.* could only visualize and directly measure the width of the left main stem bronchus in half of their patients^[7] and up to 69% by Hampton *et al.*^[10] Interestingly, we were able to measure the LMBD in 98.3% (95% confidence interval: 93%–97%) of our patients. This may be due to the more effective filmless digital system in our center where the contrast of the image

is adjustable which improved the left air bronchogram visibility to help with measurement.

In adults, the left bronchial width is directly proportional to the tracheal width, and the ratio between LMBD and TD was found to be 0.69 in men and 0.68 in women at autopsy.^[11] Based on the relationship between TD and LMBD, the LMBD could then be calculated by multiplying the TD measured at the level of the clavicles by 0.68.^[5] In our study, we found that the ratio between the mean LMBD and TD was 0.69 ± 0.11 in males and 0.70 ± 0.09 in females which was consistent with the autopsy findings. We would also be able to calculate the LMBD values from the measured TD on the chest radiograph using the following equations: $LMBD_{\text{mm}} = 6.58 + 0.3 (TD_{\text{mm}})$ for males and $LMBD_{\text{mm}} = 3.13 + 0.49 (TD_{\text{mm}})$ for females obtained from the Pearson regression analysis as shown in Figure 4.

In our study, the mean LMBD for males was 11.8 ± 1.8 mm and females was 10.6 ± 1.6 mm. Chow *et al.* measured the LMBD using CT scan on Asian-born adults and found that the mean bronchial diameter was 11.6 ± 1.4 mm and 9.6 ± 1.0 mm in male and female patients, respectively, which were very similar to our findings. They selected the size of the left-sided DLTs based on the LMBD measurements and found that they could predict the sizes of the DLT fairly accurately, especially the smaller DLTs.^[12] We, however, could not find a strong correlation between the DLT size and LMBD in our patients (male: $R = 0.174$; female: $R = 0.215$).

The gold standard for the final accurate placement of the DLT with the blue endobronchial cuff just visible below the carina can only be achieved using a fiberoptic bronchoscope. The correct depth of this placement has been reported to be correlated with the patient's height and is taken at the level of the upper incisors or gingival margin. Brodsky *et al.* found a significant correlation between depth of insertion with patients' height in both genders. As the height increases, the optimal depth of DLT insertion increases. The average depth

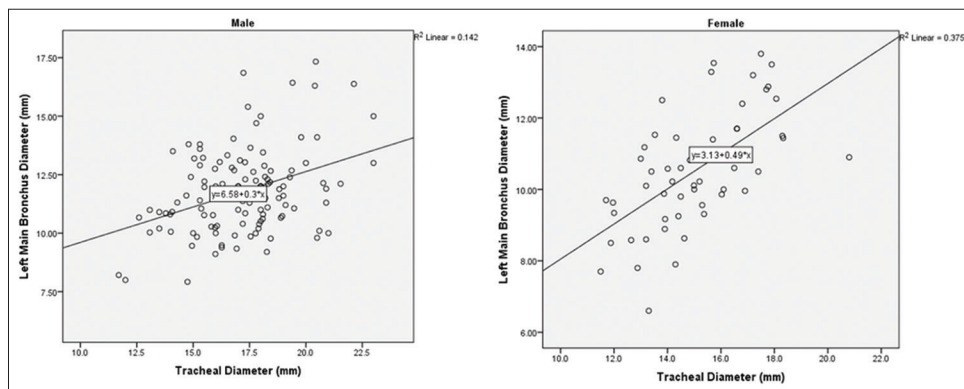


Figure 4: Relationship between tracheal diameter and left main bronchus diameter according to genders

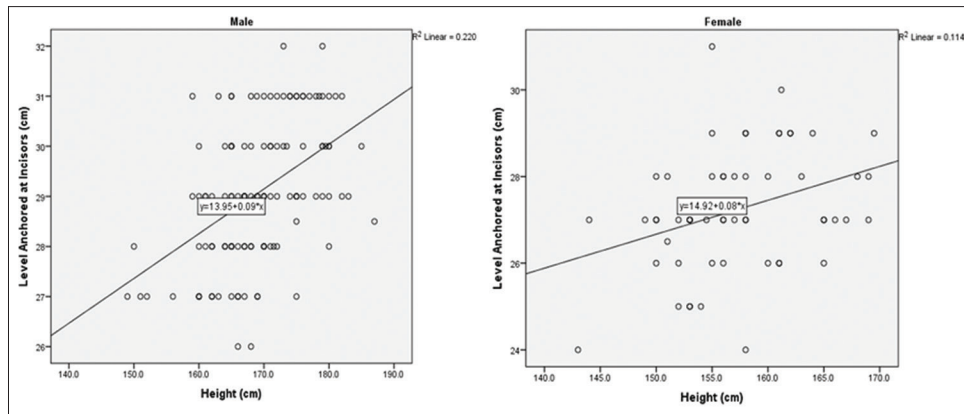


Figure 5: Relationship between depth of double-lumen tube insertion with height of patients for both genders

of insertion was 29 cm for patients 170 cm tall, and for each 10 cm increase or decrease in height, average placement depth was increased or decreased by 1 cm.^[13] This corresponded closely to our findings as we found a significant correlation between the depth of insertion with height for both male and female patients [Figure 5]. The regression slope of 0.09 (for males) and 0.08 (for females) showed that a 10 cm change in height predicts a 9.0 mm and 8.0 mm change in the depth of insertion, respectively.

Conclusion

We found that there was a poor correlation between DLT size with height, weight, TD, or LMBD for both genders. Only about half the patients for both genders used a DLT size predicted according to height range. Most of the remaining patients required a downsizing. All patients had good lung isolation which enabled the surgery to be performed successfully. The depth of insertion was, however, dependent on height.

This was a retrospective study, and to ensure that the technique of insertion of the DLT was standardized, we confined our data from cases conducted by one anesthesiologist. One of the main limitations of this study was that the measurements of the TD and LMBD from the digital chest radiograph must not be taken as the absolute values as the images were magnified. Magnification of chest radiograph is based on triangular mathematics, depending on the distance between X-ray source to object and X-ray source to image. Our X-ray source to object was 180 cm and the distance between the plate and the bronchus was about 15 cm. From here, we were able to calculate the magnification percentage which was estimated to be 8.0%. The type of DLT studied was the left-sided Mallinckrodt DLT (Mallinckrodt™ (Covidien, Tullamore, Ireland)); therefore, the findings may not be applicable to the DLTs by other manufacturers.

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Conflicts of interest

There are no conflicts of interest.

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