Determination of the True Inclination Angle of the Main Bronchi Relative to the Median Sagittal Plane for Placement of a Left-Sided Double-Lumen Tube

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Objectives: **This study aimed to determine the true inclination angle of the main bronchi relative to the median sagittal plane, using CT imaging to help increase accuracy of double-lumen tube (DLT) placement.**

Design: **In this retrospective study, 2 investigators independently measured normal chest CT scans from 50 male and 50 female patients. To determine the true AP axis, a mid-sagittal plane reference line (MSPRL) was drawn, intersecting the midsternum and the vertebral spinous process at the level of mid-carina. Lines were drawn through the center of each main bronchus to determine the inclination angle with regard to the MSPRL.**

Setting: **Research was conducted at a single institution, the Los Angeles County and University of Southern California Medical Center.**

Participants: **Normal chest CT images from 50 women and 50 men.**

Main Results: **The mean true inclination angle between the main bronchi and trachea in the mid-sagittal plane was 108.4° on the left compared with 96.2° on the right ($p < 0.0001$).**

Interventions: **No specific interventions were done because this was a retrospective study and CT scan analysis.**

Conclusion: **The data suggested that the trachea does not merely branch in the horizontal plane but branches posteriorly as well, with a true mean anatomic angle between the left main bronchus and trachea of 108.4°. This finding concurred with the authors' suggestion that the DLT be rotated to 110° counterclockwise instead of the routine practice of 90°. The authors suggest clinicians rotate the DLT an additional 20° counterclockwise and direct the top of the DLT to the 11 o'clock position.**

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KEY WORDS: double-lumen tube, success rate, rotation, left-sided, intubation, bronchial, tracheal, fiberoptic, angle, posterior, bifurcation, bronchus, counterclockwise, thoracic, lung, anesthesia, head turn, rotate, carina, divide, vocal cords, lumen, endobronchial

A DOUBLE-LUMEN ENDOTRACHEAL tube (DLT) often is used during thoracic surgery to provide one-lung ventilation or one-lung isolation. There has been a wide range of operator preference in the placement of a DLT. Left-sided DLTs are versatile, used not only for left-sided surgeries, but for right-sided thoracic surgeries as well; exceptions include tumors involving the lumen of the left main bronchus, and left sleeve pneumonectomies. Right-sided DLTs are not preferred by anesthesiologists because the right superior lobar bronchus branches more proximal to the carina relative to the left-sided upper lobe bronchus and can, therefore, be more readily occluded by the bronchial cuff of the DLT. It must be noted that the distance from the right superior lobar bronchus to the carina varies among different populations.[1] Once in the bronchus, proper positioning of the DLT should be verified clinically by sequentially clamping and unclamping the bronchial and tracheal lumens while inflating and deflating their respective cuffs. However, the DLTs believed to be appropriately positioned by the clamping and auscultation method are, in fact, suboptimally positioned.

The degree to which the proper placement of a left-side DLT occurs is somewhat variable within studies. Anecdotally, the principal investigators have noticed a higher success rate when rotating the DLT 110° to the left (counterclockwise) instead of the traditionally recommended 90° rotation, which is the current clinical practice. Given these observations, this retrospective study proposed to determine the true inclination angle of the main bronchi relative to the median sagittal plane. The hypothesis was that the trachea does not divide into right and left bronchi in the same plane, but rather the left bronchus divides from the trachea at an increased angle of posterior inclination, branching out not merely horizontally, but posteriorly as well, in the third dimension. As such, to increase the initial success rate when inserting a DLT toward the left main bronchus, the DLT should be rotated counterclockwise further than the traditionally recommended 90° after passage through the vocal cords, to meet the previously unaccounted for 3-dimensional anatomic branching of the left main bronchus.

METHODS

The radiology database of LAC+USC Medical Center was queried retrospectively from January 2005 to December 2011. Institutional Review Board approval was obtained and the requirement for written informed consent was waived. Images of these computerized tomograms (CT) were examined for the inclusion criteria, which included age 18 or older, BMI of 20 to 30, and a radiology reading of "normal" or "unremarkable CT scans of the chest." CT scans commonly were ordered for, but not limited to, the following indications: evaluation of abnormality seen on plain radiographs such as a pulmonary nodule; evaluation for pulmonary embolism; respiratory/thoracic complaints such as chest pain/pressure, dyspnea, cough, and

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Conflicts of interest: None.

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hemoptysis; autoimmune disease or hematologic abnormalities; and evaluation of intrathoracic pathology. Exclusion criteria included scans demonstrating patient anatomy that potentially could be compromised secondary to pathologic processes, including scoliosis and cardiopulmonary pathology such as consolidation; atelectasis; metastasis; pleural effusion; and chest wall, diaphragmatic, and esophageal abnormalities. Patients with significant anatomic intrathoracic abnormalities, which could affect the position of the tracheobronchial tree, also were excluded. Although the CT scans were performed for a variety of indications, the most common indication was to evaluate for metastatic disease in patients with a known primary source of cancer. For the purpose of this study, only CT scans with the absence of such disease, as indicated by the radiology reading of "unremarkable CT scans of the chest" were selected.

The CT scans were performed on 2 different scanners, the Toshiba Aquilion and the Siemens Somatom 10. The studies were retrieved on 2 separate workstations (GE Advantage 4.3, GE Medical Systems, Milwaukee, WI and Vitrea 2.0 Imaging software, Vital Images, Inc, Minnetonka, MN) for measurements. The data then were charted anonymously by removing all identifiable patient information. Figures 1 to 4 and Figure 6 came from study patient F22 and visually represent the study methodology.

Three-dimensional surface-shaded volumetric reconstruction images of the central tracheobronchial tree were made on the Vitrea work station for illustration (Fig 1). The figure shows the tracheobronchial tree as seen from the feet in study patient F22. To determine the posterior angles of inclination of the right and left main bronchi, investigators observed the angles formed by the inclination axes, using the median sagittal plane as the baseline reference meridian. Thus, the right and the left main bronchus inclination angles (RMBIA and LMBIA) are formed between the median sagittal plane reference line (MSPRL) and the right and left main bronchus inclination axis (RMBIAxis and LMBIAxis), respectively.

To account for any patient rotation within the CT scanner and to determine the true anterior-posterior axis, the first measurement obtained was the MSPRL. This was performed by drawing a line anteroposteriorly, intersecting the median

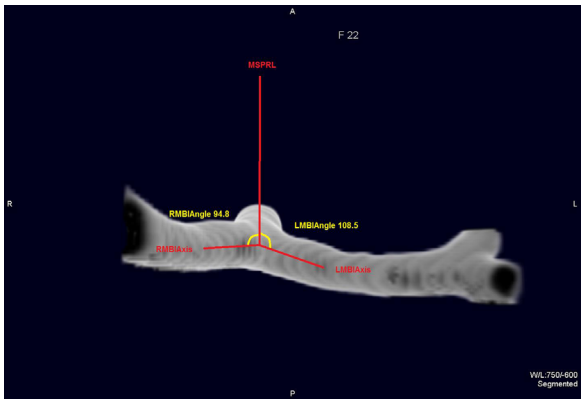

Fig 1. Three-dimensional, surface-shaded volumetric reconstruction of the central tracheobroncial tree as seen from the feet in study patient F22.

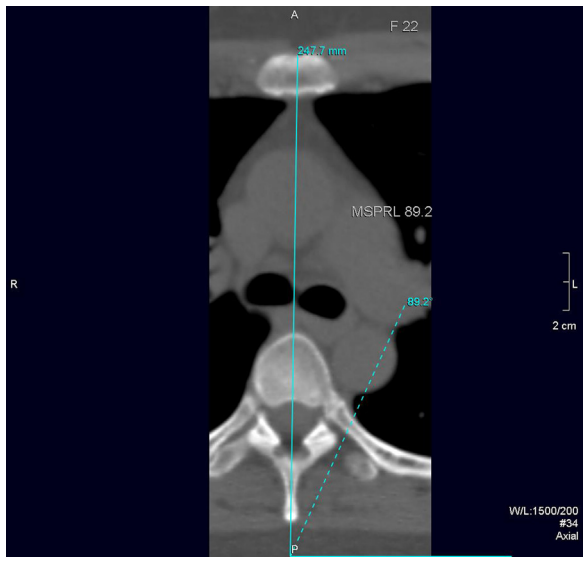

Fig 2. Median sagittal plane reference line (MSPRL) between sternum and vertebral body.

sternum and the median vertebral body at the level of the carina or the proximal portion of the bronchi (Fig 2). The MSPRL represents the true anterior-posterior line of reference from which the left and right main bronchus inclination angles are determined. This line has been reproduced on all subsequent images. To verify that the lines drawn through the centers of the main bronchi actually transected the bronchi, lines were drawn perpendicular to the central line at multiple levels to form the RMBIAxis and LMBIAxis. These right and left main bronchus inclination axes were reproduced on all images. For both proximal and distal level measurements, the median point

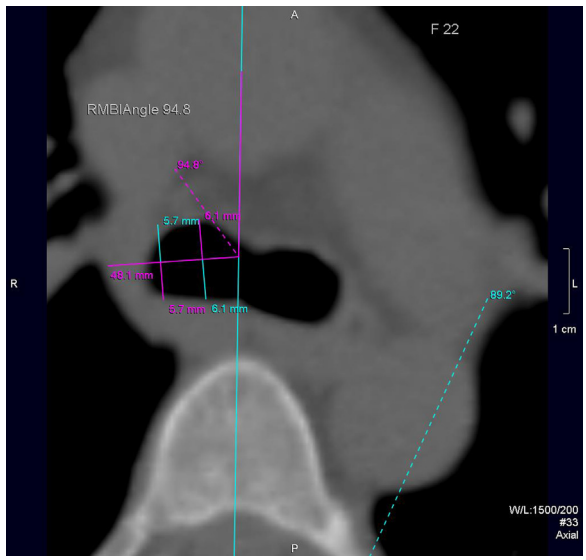

Fig 3. Right main proximal section of bronchus measuring the inclination angle in patient F 22 (RMBIAngle 94.8). The MSPRL from image 1 was transposed to this image. Note the perpendicular transecting lines drawn down the center of the right mainstem bronchus.