

# Estimating the Diameter of the Left Main Bronchus

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## SUMMARY

Two hundred and six standard PA chest X-rays were measured. The mean diameter of the left main bronchus (LMB) was  $12.6 \pm 1.9$  mm. The mean diameter of the 92 male LMB was  $13.0 \pm 2.6$ , and for females  $11.8 \pm 1.6$ . These data correspond closely to that reported by others. The correlation between the diameter of the LMB and that of the trachea was 0.74 but was not precise enough to be useful as an estimate for clinical use. Similarly there was good correlation between the diameter of the right main bronchus and that of the left ( $r=0.75$ ) but not precise enough to be clinically useful.

In contrast to previous claims, only direct measurement of the left main bronchus has sufficient precision to define the appropriate size of left double-lumen tube to be selected for lung separation.

Keywords: BRONCHUS: left main, chest X-ray, trachea, measurement

Although selection of the appropriate size of a double-lumen tube for one-lung anaesthesia has been based on the sex or height of the patient<sup>1</sup>, the most accurate selection depends on identifying the diameter of the bronchus in which the bronchial segment of the tube is to be inserted. Usually the bronchial segment of interest will be the left, as the length of the left main bronchus is about twice that of the right<sup>2</sup>. The diameter of the bronchial arm of a double-lumen tube should be just less than the diameter of the left main bronchus. This gives an optimal fit and ensures that minimal bronchial cuff inflation will achieve an effective seal. The largest diameter also optimizes gas flow during ventilation. Obviously, if a tube is selected with a bronchial segment diameter larger than the left main bronchial diameter, the tube will fail to enter the bronchus.

A study of over 200 standard postero-anterior (PA) chest X-rays identified the left main bronchus in 142. The diameter of the left main bronchus varied from 9 to 15.5 mm. Although the mean diameter of the bronchi of females was less than that of males, the bronchial diameter was not accurately predicted from the patient's weight or sex<sup>3</sup>. Only in males was

bronchial diameter moderately predicted by age and height ( $r^2=0.23$ ).

A post mortem study of 36 females in 1957 suggested that the mean ratio of the diameter of the left main bronchus and the trachea was 0.68 with a range from 0.50 to 0.93<sup>4</sup>. No regression line for the relationship was calculated. These limited data have been used to derive a formula for predicting left main bronchial diameter<sup>5</sup>. This was then clinically applied, with selection of an undersized tube for the predicted diameter for all but the smallest tube. In 70 patients, no tube was found to be too large<sup>5</sup>. This study did not actually size the left main bronchus and may have used smaller tubes than necessary in some patients.

A precise estimate of bronchial size should allow the largest possible double-lumen tube to be used and this would give the best conditions for fiberoptic bronchoscopy through the tube and suctioning. We studied a series of postero-anterior chest X-rays to ascertain if measurements other than direct measurement of the left main bronchus could be clinically useful in determining the appropriate size of double-lumen tube.

## METHODS

Consecutive standard PA chest X-rays taken for clinical purposes in the two periods from April 14 to May 9 and from November 5 to 10, 1998 and stored in digital format were used. Two hundred and six erect standard PA chest X-rays of adults were examined. Measurement was made by the air shadow of the diameter of the left and right main bronchi approximately 1 cm distal from the carina.

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Measurement of the tracheal diameter was made 1 cm below the line joining the inferior edge of the clavicles.

Measurement was made on a digital system (Agfa) calibrated for standard films. For each film a measurement was made of the diameter of the right and left main bronchi and the trachea. If any measurement was not possible because of an inadequate air shadow, this was noted. As this study examined the interrelationship, no correction was made for the shadow enlargement caused by the airways being some distance from the plate.

Statistical analysis was by Instat 2.0 and Statview 5 programs (Macintosh).

Ethical approval for this study was given by the Research Ethics Committee of the Royal Adelaide Hospital.

## RESULTS

Two hundred and six PA chest X-rays of adults (76 females and 130 males) were examined. In 179 patients the trachea was measured. The mean  $\pm$ SD diameter of the trachea was  $17.5 \pm 2.6$  mm. In males the trachea was slightly larger, mean  $17.9 \pm 2.8$  mm, range 12.0 to 24.5 mm. In females it was slightly smaller, mean  $17.0 \pm 2.2$  mm, range 12.6 to 21.4 mm.

In 142 the left main bronchus was measured. The mean diameter was  $12.6 \pm 1.9$  mm. Males had a slightly greater diameter, mean  $13.0 \pm 1.9$  mm, range 9.4 to 17.7 mm. Females had a slightly smaller diameter, mean  $11.8 \pm 1.6$  mm, range 8.4 to 15.2 mm.

In 97 films, the right main bronchus could be measured. The mean diameter was  $14.6 \pm 2.6$  and again males tended to have a larger bronchus, mean  $15.0 \pm 2.6$  mm, range 9.4 to 21.3 mm and females had a slightly smaller diameter, mean  $13.8 \pm 2.4$  mm, range 9.2 to 19.9 mm.

In 131 patients both the left main bronchus and the trachea were measured. The line of best fit was

$$\text{LMB} = 0.514 T + 3.58$$

where LMB is the diameter of the left main bronchus and T is the tracheal diameter in mm.  $r = 0.740$   $P < 0.0001$  (Figure 1).

However, the 95% confidence limits for the slope are 0.43 to 0.60 and for the intercept are 2.16 to 5.01. Thus a measurement of a trachea of 20 mm has a 95% confidence band for the left main bronchus from 10.8 to 16.9 mm.

In 81 patients both the left and right main bronchus were measured. The line of best fit was

$$\text{LMB} = 0.554 R + 4.59$$

where LMB is the diameter of the left main bronchus

and R is right main bronchus in mm.  $r = 0.754$   $P < 0.0001$  (Figure 2).

However, the 95% confidence limits for the slope are 0.446 to 0.662 and for the intercept are 2.992 to 6.181. Thus a measurement of the right main bronchus of 15 mm has a 95% confidence band for the left main bronchus from 9.7 to 16.1 mm

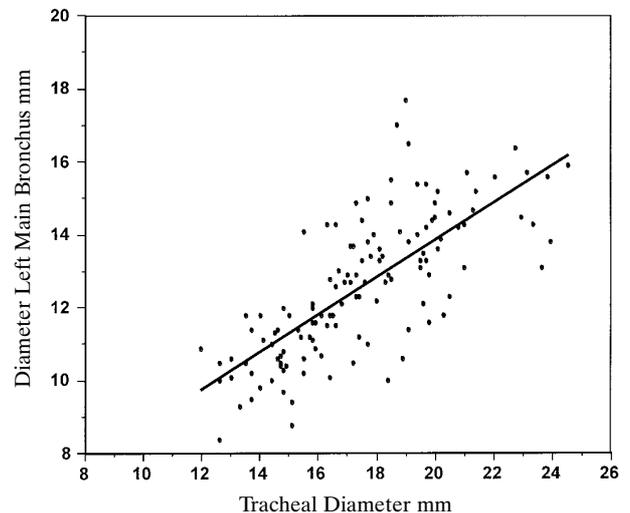


FIGURE 1: Relationship between tracheal diameter (T) and diameter of the left main bronchus measured 1 cm beyond the carina.  $\text{LMB} = 0.514 T + 3.58$ ,  $r = 0.740$ .

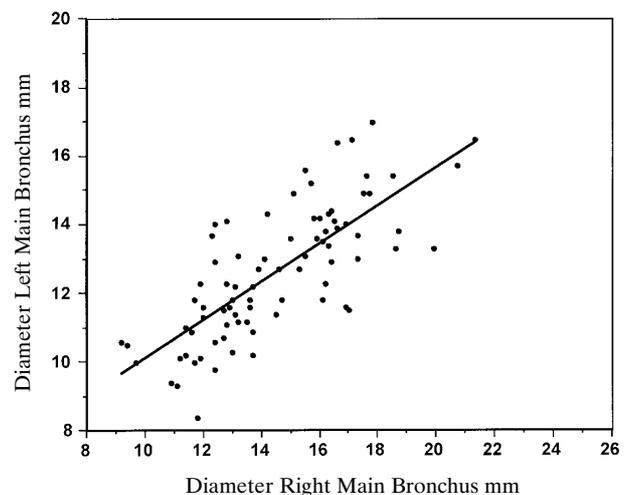


FIGURE 2: Relationship between the diameter of the right main bronchus (R) and diameter of the left main bronchus, measured 1 cm beyond the carina.  $\text{LMB} = 0.554 R + 4.59$ ,  $r = 0.754$ .

## DISCUSSION

Two hundred and six PA chest X-rays were examined. In 142 the left main bronchus was measured giving a success rate of 69% (95%CI: 62 to

75%). This is significantly more than the proportion of X-rays successfully measured by Hannallah et al which was approximately 50% (95% CI 43 to 57%)<sup>3</sup>. This difference may reflect the more powerful viewing technique used in this study as the images were viewed on a filmless digital system where both contrast and penetration of the image were adjustable. These adjustments can improve the visibility of the air bronchogram and help measurement. The mean diameter of the left main bronchi was similar in this study to that previously published<sup>3</sup>, if an 8% magnification factor is allowed. For males, adjusting for magnification, this was 12.0 mm (95% CI 11.6 to 12.4 mm) versus 12.4 mm (95% CI 12.1 to 12.7)<sup>3</sup>, and for females this was 10.8 mm (95% CI 10.4 to 11.2) versus 10.7 (95% CI 10.5 to 10.9 mm).

Where both the left main bronchus and the trachea were measured, the line of best fit was not a simple ratio and the line of best fit deviates markedly from the simple ratio proposed by Jesseph et al<sup>4</sup> and adopted by Brodsky and his co-workers<sup>5</sup>. In addition, the 95% confidence limits for the slope and the intercept are so wide that they are not clinically useful. Similarly in the 81 patients where both the left and right main bronchus were measured, the 95% confidence limits for the slope and the intercept are too

wide to be able to derive useful estimates of left main bronchial diameter.

As a precision within one millimetre is needed to select the optimal size of double-lumen tube, it would appear that direct radiological measurement is the only reliable method for determining the size of the left main bronchus. Hannallah et al found the correction required for magnification caused by the depth of the structures in the chest varied from 8 to 10%<sup>3</sup>. Thus, a clinically useful estimate of the diameter of the left main bronchus is 90% of the diameter measured directly on the chest X-ray.

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