

## Tracheo-bronchial Angles in Infants and Children

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In 1954, Adriani and Griggs<sup>1</sup> reported that both right and left main stem bronchi diverge from the trachea at angles of approximately 110° in children up to 3 yr of age (fig. 1A). In 1959, Smith<sup>2</sup> quoted Adriani and Griggs and confirmed that both the right and left bronchi diverge from the trachea at equal angles of 55° for a total of 110° in children under the age of 3 yr (fig. 1B). Since then, these measurements have in general been accepted. Recently, Brown and Fish<sup>3</sup> observed that the left bronchial angle is greater than the right in neonates.

If Adriani and Griggs' measurements are correct, both endotracheal tubes and straight suction catheters should enter the right and left main bronchi with comparable frequency. We have observed, however, that the endotracheal tube or the suction catheter more commonly enters the right main bronchus in infants and children, just as in the adult. We observed that bronchial sounds over the right lung field are louder than the left when respiration is assisted during tracheal intubation. In a study using a straight suction catheter, Bush<sup>4</sup> observed a probable difference in the angles of the right and left bronchi. Placzek and Silverman<sup>5</sup> also observed that the left main bronchus subtended a more acute angle with the trachea than did the right in a study of suction catheters.

Consequently, we have measured right and left bronchial angles in anesthetized infants and children by means of supine chest x-ray films and, simultaneously, defined the location of the tip of an orotracheal tube inserted beyond the carina.

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## MATERIALS AND METHODS

Three hundred and ninety infants and children of either sex between the ages of 1 month and 13 yr were studied.†† Age distribution is shown in tables 1 and 2. These patients had no history or radiologic evidence of lung, heart, or mediastinal disease. Chest x-ray films were taken with the subjects in the supine position. Measurement of the angles between the axis of the trachea and each main stem bronchus was obtained from the films. Right and left bronchial angles were calculated by drawing a line on the longitudinal axis of the supracarinal position of the trachea and measuring the angles formed by lines extended onto inferior straight margins of the right and left main bronchi (fig. 2). The subjects were divided into a nonanesthetized, nonintubation group (131) and an intubation group (259). In the latter, following induction of general anesthesia and oxygenation, tracheal intubation was accomplished followed by blind bronchial intubation using appropriate sizes of Portex<sup>®</sup> tubes, with or without a cuff. After the location of the tube had been verified as right or left by listening for presence of breath sounds, the tube was withdrawn into the trachea.

## RESULTS

1. *Nonintubation group:* The right bronchial angle ranged from 27 ± 6° (SD) to 33 ± 3°, and the left angle ranged from 45 ± 5° to 49 ± 4°. The overall means of the right and left bronchial angles were 31 ± 5° and 46 ± 5°, respectively (table 1).

2. *Intubation group:* The right bronchial angle ranged from 30 ± 1° to 36 ± 5° and the left angle from 46 ± 7° to 53 ± 8°. The overall right and left means were 32 ± 5° and 51 ± 7°, respectively (table 2).

The overall means of the right and left bronchial angles in both groups were 31 ± 5° and 49 ± 7°, respectively (fig. 2). The angle of the tracheal bifurcation (A + B) totalled approximately 80°.

The endotracheal tube easily entered the right bronchus in all 259 cases.

†† Permission to perform this study was obtained from the parents of the children involved. We do not have a hospital human experimentation committee as in the United States. This work was done at Osaka Kohseinenkin Hospital.

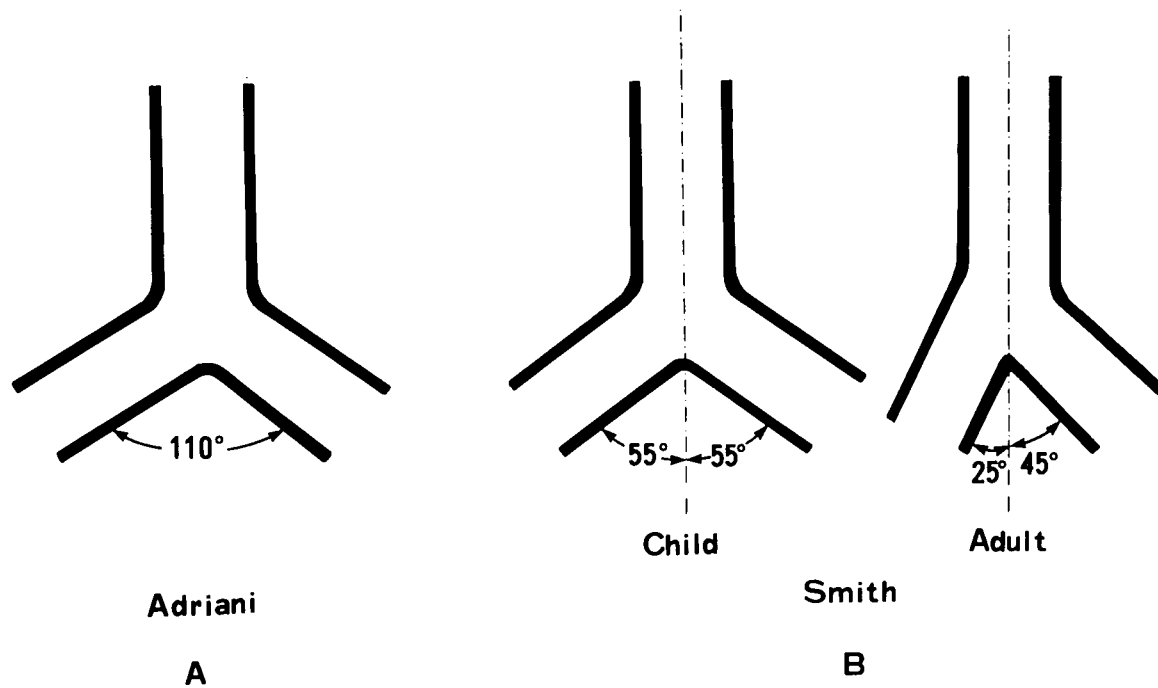


FIG. 1. (A). The tracheobronchial angle of children under 3 yr of age (after Adriani J, Griggs TS: An improved endotracheal tube for pediatric use. ANESTHESIOLOGY 15:466-470, 1954). (B). Angulation of the bronchi in infants contrasted to that of older children and adults (after Smith RM: Anesthesia for infants and children. St. Louis, CV Mosby, 1959, p 29).

DISCUSSION

In reviewing the literature on bronchial angles obtained at autopsy prior to 1937, Miller<sup>6</sup> cited Kobler and Von Hovarka's work (1893) stating that the angle of divergence of the bronchi averaged about 70°. Novack<sup>7</sup> noted that in the newborn infant, the right bronchial angle ranged from 10° to 30° with the left angle greater, ranging from 38° to 45°.

In 1968, Meschan<sup>8</sup> reported on a radiographic study in neonates that showed the right bronchial angle with the long axis of the trachea ranged from 10° to 35°, and the left bronchial angle with the long axis of the trachea ranged from 30° to 65°. In 1970, Alavi *et al.*<sup>9</sup> reported that in living children, the angle of the tracheal bifurcation

ranged from 52° to 78°. In 1979, Brown and Fish<sup>3</sup> reported that the right bronchial angle averaged 30° and the left 47° in a series of 40 neonates, thus, similar to the angle in adults. Little difference exists between the measurements of Brown and Fish and those of our present study. Brown and Fish also observed that the right main bronchus was usually intubated because of more direct continuity with the trachea and because the bevel of the

TABLE 1. Right and Left Bronchial Angles (means ± SD) of Infants and Children (nonintubated group, n = 131)

Age (yr.)	Cases (no.)	Right Bronchial Angle (degrees)	Left Bronchial Angle (degrees)
0-1	68	27 ± 6	45 ± 5
1-2	19	32 ± 5	46 ± 6
2-3	22	31 ± 6	48 ± 3
3-4	16	33 ± 3	46 ± 5
4-5	6	31 ± 4	49 ± 4
Overall mean	131	31 ± 5	46 ± 5

TABLE 2. Right and Left Bronchial Angles (means ± SD) of Infants and Children (intubated group, n = 259)

Age (yr.)	Cases (no.)	Right Bronchial Angle (degrees)	Left Bronchial Angle (degrees)
0-1	29	30 ± 5	51 ± 9
1-2	19	33 ± 6	53 ± 8
2-3	22	31 ± 6	51 ± 8
3-4	15	33 ± 3	53 ± 6
4-5	33	31 ± 3	49 ± 7
5-6	35	31 ± 5	49 ± 6
6-7	34	30 ± 5	48 ± 7
7-8	25	33 ± 4	49 ± 9
8-9	25	31 ± 4	51 ± 6
9-10	6	31 ± 4	48 ± 2
10-11	6	35 ± 6	46 ± 7
11-12	5	36 ± 5	50 ± 3
12-13	5	30 ± 1	52 ± 9
Overall mean	259	32 ± 5	51 ± 7

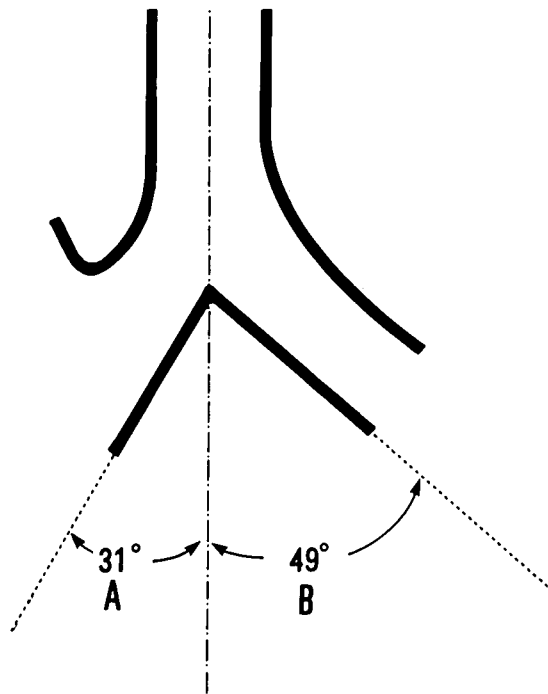


FIG. 2. Diagram demonstrating the method of measurement of right and left bronchial angles and their overall means.

endotracheal tube usually lies to the right on insertion. Cleveland<sup>10</sup> stated that the mean of the right bronchial angle was  $26.42^\circ$  and the mean of the left bronchial angle was  $33.02^\circ$  from birth to 18 yr of age.

In these reports, the angles of tracheal bifurcation were far less than those reported by Adriani and Griggs.<sup>1</sup> Moreover, left bronchial angles were greater than the right in four of the six reports. The measurements reported here are in general conformity with these findings. In addition, an orotracheal tube advanced beyond the carina entered the right bronchus in all cases.

The discrepancy between these findings and those of Adriani and Griggs cannot be resolved readily. As an in-

crease in the angle of tracheal bifurcation is frequently mentioned as a sign of pathologic changes in lung, heart, or mediastinum, perhaps Adriani and Griggs' infants and children had cardiopulmonary disease.

These accumulated findings suggest the following clinical applications: 1) the normal variation in the angulation subtended by bronchi at the carina serves as a norm against which radiologists may detect displacement of the main bronchi owing to the presence of cardiopulmonary disease, and 2) in as much as the angle subtended by the right main bronchus strongly favors inadvertent intubation of that bronchus in infants as well as in adults, this needs to be appreciated by anesthesiologists, neonatologists, and other health-care professionals who care for infants who require tracheal intubation.

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#### REFERENCES

1. Adriani J, Griggs TS: An improved endotracheal tube for pediatric use. *ANESTHESIOLOGY* 15:466-470, 1954
2. Smith RM: *Anesthesia for Infants and Children*. St. Louis, CV Mosby, 1959, p 28
3. Brown TCK, Fish GC: *Anaesthesia for Children*. Edition 1. Melbourne, Blackwell Scientific Publication, 1979, p 3
4. Bush GH: Tracheobronchial suction in infants and children. *Br J Anaesth* 35:322-326, 1963
5. Placzek M, Silverman M: Selective placement of bronchial suction catheter in intubated neonates. *Arch Dis Child* 58:829-831, 1983
6. Miller WS: *The Lung*. Springfield, CC Thomas, 1937, p 21
7. Novack GJ: The developmental topography of the larynx, trachea and lungs in fetus, newborn, infant and children. *Am J Dis Child* 36:515-533, 1923
8. Meschan I: *An Atlas of Normal Radiographic Anatomy*. Philadelphia, WB Saunders, 1968, p 450
9. Alavi SM, Keats TE, O'Brien WM: The angle of tracheal bifurcation: Its normal mensuration. *AJR* 108:546-549, 1970
10. Cleveland RH: Symmetry of bronchial angles in children. *Radiology* 133:89-93, 1979