

The Length of the Airway to the Bifurcation of the Trachea

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Anatomical measurements were made to determine the length of the airway to the bifurcation of the trachea. These were correlated with an easily obtained external body measurement—the distance between the upper border of the cricoid cartilage and the tip of the xiphoid process; the relation was found to be statistically significant. Two suggestions are given for selecting endotracheal tubes of maximum safe length in adults: Nasotracheal tube—use the distance measured along the body surface between the upper border of the cricoid cartilage and the tip of the xiphoid process. Orotracheal tube—subtract 2 cm. from this distance.

THE MEDICAL literature contains few statements on the length of the curved pathway followed by an endotracheal catheter from the teeth through mouth and pharynx, and into the trachea. Ignorance of the distance from the upper anterior teeth to the carina in a particular patient may lead to the selection of too long an endotracheal tube, with the result that inadvertent endobronchial intubation may occur.

Jackson reported the straight-line distance from the upper anterior teeth to the carina, measured along a bronchoscope, to be 27 cm. in men, 23 cm. in women.¹ Hewer reports the pathway of inspired gas from the anterior teeth to the carina to be 26 cm. in length.² Gillespie warns against the dangers of accidental intubation of a bronchus, and states that when a catheter of proper length is placed for inspection alongside the patient's neck, its

tip should not extend beyond the angle of Louis, the anatomical landmark for the bifurcation of the trachea.³ Leigh and Belton suggest a method, based on the distance from the tip of the nose to the lobe of the ear, for estimating catheter length in children.⁴

This study was carried out to determine the distance (measured along an endotracheal catheter) from the base of the nose to the carina, and from the upper anterior incisor teeth to the carina. We also attempted to establish a relation between tracheal length and an easily obtained external body measurement which would facilitate the selection of an endotracheal tube of proper length for any given patient.

Method

Data were gathered from subjects at autopsy. The group studied consisted of 50 adults, ages 23 to 98, and 7 infants and children ranging in age from stillborn to 6 years. All measurements were made with the subject lying supine on the autopsy table with the head in the neutral position.

The following external measurements were made:

- (1) *Total Body Length.* The distance from crown to heel.
- (2) *Trunk Length.* The straight-line distance from the suprasternal notch to the superior border of the symphysis pubis, measured with a specially constructed caliper.
- (3) *Superior Border of Cricoid Cartilage to Tip of Xiphoid Process.* This distance was measured along the body surface between the two points, using a measuring tape.

The anterior chest wall was exposed through a Y-shaped incision of skin and soft tissue, and the sternum and cartilagenous portion of the

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TABLE 1. Summary of Data for Adult Subjects
(Mean values and range in centimeters, unless otherwise indicated)

	Men			Women		
	No. of Measurements	Mean	Range	No. of Measurements	Mean	Range
Age	26	68 years	35-98 years	24	65 years	23-89 years
Total body length	24	168.5 (5'7")	156.5-179.0 (5'3"-6'0")	24	154.9 (5'2")	140.0-166.0 (4'8"-5'6")
Trunk length	26	51.3	43.0-61.0	24	49.0	43.0-54.5
Upper border of cricoid to tip of xiphoid	26	27.2	24.0-30.5	24	24.2	21.0-27.5
Upper incisor teeth or gum to carina	26	28.5	25.0-31.5	23	25.2	23.0-30.0
Base of nose to carina	21	31.9	28.0-35.0	20	28.4	26.0-33.0

ribs were removed *en bloc* for access to the thoracic cavity. The lungs were left in place to avoid distortion or shortening of the trachea. The heart was removed from the mediastinum, tissues overlying the bifurcation of the trachea were dissected away, and an incision was made at the bifurcation to expose the carina. The following internal measurements were then obtained, using an uncut 10 mm. Portex tube in adults and a 6 mm. Portex tube in children:

(1) *Base of Nose to Carina.* A blind nasotracheal intubation was performed, and the tube was inserted until the tip was in contact with the carina. The catheter was then marked at the nares, withdrawn and measured. In some cases blind intubation could

not be accomplished. If, due to rigor, the catheter could not be manipulated into the trachea by inserting the fingers into the posterior pharynx, this measurement was not obtained.

(2) *Upper Incisor Teeth to Carina.* The tube was passed retrograde from the carina through the trachea and into the mouth until its tip came in contact with the upper incisor teeth or (in edentulous subjects) the gum. It was then marked at the carina, withdrawn and measured.

Results and Discussion

Measurements for adults are summarized in table 1. The data for children are presented separately in table 2.

TABLE 2. Data for 7 Infants and Children
(All distances are in centimeters)

Sex	Age	Total Body Length	Upper Border of Cricoid to Tip of Xiphoid	Upper Teeth or Gum to Carina	Base of Nose to Carina
F	Stillborn 1,610 g.	39.0	8.0	9.0	*
F	Stillborn 1,975 g.	42.0	8.0	9.0	11.0
M	Stillborn 2,495 g.	46.0	8.0	10.5	11.5
M	2 Days	46.0	8.5	10.8	12.1
M	2 Months	53.0	9.0	11.5	12.0
F	5.5 Months	62.0	11.0	13.5	15.5
M	6 Years	118.0	18.0	18.0	*

* Could not be measured.

To determine whether a reliable correlation existed between the distance from the upper incisor teeth or gum to the carina (oral-carinal distance) and the three external body measurements described above, the correlation coefficient relating oral-carinal distances in adults to the set of data for each of the three external measurements was calculated according to the equation.*

$$r_{xy} = \frac{\Sigma[(x - \bar{x})(y - \bar{y})]}{\sqrt{\Sigma(x - \bar{x})^2 \Sigma(y - \bar{y})^2}}$$

A highly significant correlation was found when the oral-carinal distance was compared with the distance from the upper border of the cricoid cartilage to the tip of the xiphoid process ($r = +0.78$).

The measurement of the distance from the upper border of the cricoid cartilage to the tip of the xiphoid process, together with the oral-carinal distance for each adult studied, are plotted on the scattergram shown in figure 1. The equation for the regression line relating these two measurements was calculated according to the formula $y = bx + a$, where $a = \bar{y} - b\bar{x}$, and

$$b = \frac{n\Sigma xy - (\Sigma x)(\Sigma y)}{n\Sigma x^2 - (\Sigma x)^2}$$

The resulting equation (superimposed on the scattergram) is $y = 0.8x + 5.7$, where x is the measured distance in centimeters from the upper border of the cricoid cartilage to the tip of the xiphoid process, and y is the distance from the upper incisor teeth or gum to the carina.

The majority of the adults studied were over 50 years of age, and many of the elderly subjects exhibited a marked degree of dorsal kyphosis. To determine what effect advanced age might have on the observed difference between the distance from the upper border

* Explanation of formula symbols for the correlation coefficient (r_{xy}) calculated:

- Σ = arithmetic sum.
- x = distance in centimeters from the upper border of the cricoid cartilage to the tip of the xiphoid process.
- \bar{x} = mean value of x for all subjects measured.
- y = distance in centimeters from the upper incisor teeth or gum to the carina.
- \bar{y} = mean value of y for all subjects measured.

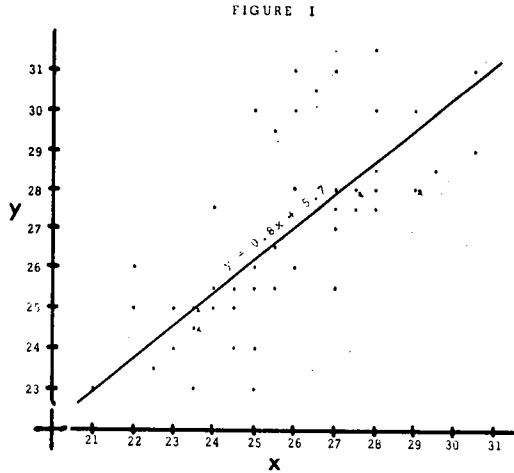


FIG. 1. Scattergram showing the relationship between the oral-carinal distance (y) and the distance from the upper border of the cricoid cartilage to the tip of the xiphoid process (x) in each adult subject. Distances are in centimeters.

of the cricoid cartilage to the tip of the xiphoid process and the distance from the upper incisor teeth or gum to the carina, data from subjects aged 50 and below were compared with data from those 51 and over. Student's "t" test was used. No significant difference was found ($P > 0.50$).

Inspection of the data for adults revealed that the distance from the upper border of the cricoid cartilage to the tip of the xiphoid process was less than the distance from the base of the nose to the carina. Therefore, as a *rule of thumb*, this distance along the body surface (obtained with a measuring tape) would have served as an estimate of the *maximum safe length* for a nasotracheal catheter in all measured subjects.

The distance from the upper border of the cricoid cartilage to the tip of the xiphoid process was *usually* less than the internal distance from the upper incisor teeth or gum to the carina. The mean difference was 1.5 cm. in males, and 1.1 cm. in females. There were ten exceptions to this rule, but in no case was the external distance greater than the internal distance by more than 2 cm. Therefore, as a *rule of thumb*, subtracting two centimeters from the measured distance from the superior border of the cricoid cartilage to the tip of the xiphoid process would have resulted

in an estimate of the *maximum safe length* for an orotracheal tube in all measured subjects.

Although the group of children studied was small, it was noted that in no case was the distance from the upper border of the cricoid cartilage to the tip of the xiphoid process longer than the distance from the upper incisor teeth or gum to the carina. However, rules for the selection of endotracheal tubes of proper length for infants and children have been presented by others.^{4, 6}

Summary and Conclusions

Anatomical measurements were made at autopsy in a group of 50 adults and 7 infants and children to determine the length of the airway to the bifurcation of the trachea. Three external body measurements were also made. A highly significant statistical correlation was found in the subjects studied for the relation between the external measurement along the body surface from the upper border of the cricoid cartilage to the tip of the xiphoid process, and the internal distance from the upper teeth or gum to the carina.

Two rules of thumb are suggested as an aid in predicting the *maximum safe length* for endotracheal catheters in adults: Nasotracheal Tube: Use the distance measured along the

body surface between the upper border of the cricoid cartilage and the tip of the xiphoid process. Orotacheal Tube: Subtract two centimeters from the distance measured along the body surface between the upper border of the cricoid cartilage and the tip of the xiphoid process.

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ACUTE TUBULAR NECROSIS Kidneys of dogs have been exposed, isolated and subjected to ischemia by blood letting. Vasoconstriction was present in the kidneys removed from hypovolemic dogs. Vasoconstriction was maintained even after isolation of the kidney. When hypovolemia was prevented by the administration of dextran, such vasoconstriction did not occur. Once vasoconstriction had occurred, it was impossible to restore renal blood flow even though blood volume and blood pressure were brought back to normal. (Barkin, M., and Kerr, W. K.: *An Aspect of the Vascular Role in the Etiology of Acute Tubular Necrosis, Surg. Gynec. Obstet.* 116: 673 (June) 1963.)