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Dimensions of Double-Lumen Tracheobronchial Tubes

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SUMMARY

The diameter of the left main bronchus is the determining dimension when selecting the size of a left tracheobronchial (double-lumen) tube for lung separation. However, this information is not given by any manufacturer, either on the tube or in the package insert.

This paper describes the lengths and diameters of the deflated bronchial cuff segment of left tracheobronchial tubes in common use. One hundred and seventy-one left tracheobronchial tubes ranging in size from 28 to 41 nominal French gauge from four manufacturers were measured. There was wide variation between tubes of the same nominal size from the same manufacturer. For tubes of the same size from the same manufacturer, the diameter of the segment with the deflated bronchial cuff varied by more than 1 mm in diameter in some instances.The diameter of the bronchial cuff segment did not consistently decrease as the nominal size decreased even for the same manufacturer. There was major overlap in diameters of the bronchial segments between Fr 41, Fr 39, and Fr 37 tubes from most manufacturers, so that some of the Fr 39 tubes have a bronchial cuff segment diameter as much as 0.5 mm larger than the Fr 41 tube.

It is concluded that the current French gauge markings on left tracheobronchial tubes are of very limited value in determining the appropriate size to be selected for a patient.

More accurate and consistent dimensions of tracheobronchial tubes are required to improve clinical selection.

Key Words: TRACHEOBRONCHIAL TUBES: measurement, double-lumen, sizing

Choosing an appropriate tracheobronchial (double-lumen) tube has been referred to as one of the "dark arts" of anaesthetic practice[1]. Selection and insertion of a double-lumen tube is not always straightforward and is done infrequently by most anaesthetists. The left main bronchus is intubated wherever possible because it is longer than the right and therefore provides a greater "margin of safety" for correct placement of the cuff[2]. However, determining the appropriate tube size[4] is difficult, as the internal diameter of the left main bronchus does not correlate closely with sex, age, height or weight[3,4]. Indeed it is only moderately correlated with the size of the trachea[5]. The only sure method of sizing is direct measurement on a standard postero-posterior (PA) chest X-ray[1]. Once this is done, the true bronchial diameter is about 10% smaller than measured[3].

The difficulty of tube selection is compounded by the fact that the nominal sizing of the tubes in French gauge (circumference in mm) gives only a poor guide to the diameter of the bronchial segment of the tube. Manufacturers do not indicate on the tube or in the accompanying leaflet, the external diameter of the bronchial segment of their tube. In addition, if the tube is inserted by a plugging method such as the technique described by Russell, accurate knowledge of the length of the bronchial cuff is important in determining the further distance the tube should be inserted once the carina is identified[6,7].

Some authors have quoted dimensions for the external diameter of the bronchial segment of various sizes of double-lumen tube based on information given to them by the manufacturer[2,3,8]. We are not aware of any study which has independently assessed the dimensions of the various double-lumen tubes.

This study was conducted with left double-lumen tubes to establish whether there was a consistent relationship between the nominal French gauges and the tubes' dimensions. Although the lengths of all cuffs and diameters of bronchial and tracheal segments were measured, the bronchial cuff length and the bronchial segment diameters are the most clinically important and therefore are the measurements reported in this study.

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METHODS

Double-lumen tubes (which had been used) were washed and then measured. Linear measurements on the bronchial cuff lengths were made with callipers with the cuffs inflated firmly. The beginning of each cuff was defined as the point at which the fully inflated cuff began to lift off the tube.

In contrast, the diameter of the bronchial cuff was measured at the centre of the cuff with the cuff fully deflated (bronchial diameter). The measurement was made by closely winding a spiral of strong inelastic linen thread five or more times firmly around the tube. The thread turns were marked with a line along the axis of the tube on at least five turns. Then the thread was unwound and the length of five marked segments were measured. The average circumference was calculated as one-fifth of the total length. To correspond with the nominal diameter of the tube, the circumferences were converted by dividing by π (3.1416).

Twenty tubes were measured independently by each author to ascertain the error of each measurement. Length measurement of the bronchial cuffs and diameter measurement of the deflated cuffs were made. The difference between the measurements of the two authors was then calculated as a percentage of the average of the two measurements. The average and the standard deviation of these percentage differences was calculated for the 20 pairs. The remaining tubes were measured only once.

RESULTS

The results of the independent measurements made on the twenty tubes by both authors are given in Table 1. Length measurements were least reproducible as the beginning of the bronchial cuffs rising from the tube was not easy to define. The average difference in length measurement varied by 6.95% for the bronchial cuff. In contrast, the diameter measurements had a much better reproducibility with the difference being only 1.81% for the bronchial segment diameter.

A total of 171 left tracheobronchial tubes from four manufacturers were measured. All manufacturers had nominal 41, 39, 37, and 35 French gauges. Two manufacturers had nominal 28 Fr gauges and one manufacture had a nominal 32 Fr gauge. The manufacturers, the sizes measured and the number of tubes obtained from each manufacturer are shown in Table 2.

TABLE 1

Measurement Site	Difference Average	Difference SD
Bronchial cuff length	6.95%	5.14%
Bronchial cuff diameter	1.81%	1.70%

TABLE 2

Size of Tube	Manufacturer			
	Sheridan	Mallinckrodt	Portex	Rüsch
41	17	8	4	2
39	26	11	6	3
37	30	10	11	3
35	13	5	10	2
32	nm	2	nm	nm
28	5	3	nm	nm

nm=not manufactured.

The average lengths of the bronchial cuffs are shown in Table 3. It can been seen that most manufacturers do not substantially alter the length of the bronchial cuff with different tube sizes. In addition, with most manufacturers, the variation in cuff length for a given size tube is wide. Overall the length variation for a given manufacturer varied from 1 mm (Rüsch 37) to 12 mm (Rüsch and Portex 41). Similarly, for the same nominal tube size, the average length of bronchial cuffs varies widely between manufacturers. The maximum difference was seen in nominal 39 Fr tubes from a bronchial cuff average length of 17 mm (Rüsch) to 27.5 mm (Portex).

The diameters of the bronchial cuff segment of the tubes are shown in Figure 1. The figure shows that even from the same manufacturer, there is a substantial overlap between sizes so that, for example, a 41 Fr tube with the smallest bronchial segment diameter may be smaller in diameter than a 37 or

TABLE 3

Manufacturer	Size	Bronchial Cuff mm			
		Length Average	Length SD	Length Maximum	Length Minimum
Sheridan	41	22.82	2.51	27.0	17.0
	39	22.77	1.45	25.0	20.0
	37	23.27	1.46	25.0	20.0
	35	22.38	2.10	26.0	18.0
	28	22.90	0.74	24.0	22.0
Mallinckrodt	41	20.88	1.36	22.0	18.0
	39	19.09	1.87	22.0	16.0
	37	19.70	1.16	21.0	18.0
	35	19.30	1.64	22.0	17.5
	32	11.50	2.12	13.0	10.0
	28	12.67	2.31	14.0	10.0
Portex	41	24.50	5.74	28.0	16.0
	39	27.50	0.84	29.0	27.0
	37	23.09	1.14	24.0	21.0
	35	22.70	1.42	25.0	21.0
Rüsch	41	21.00	8.49	27.0	15.0
	39	17.00	1.73	18.0	15.0
	37	15.33	0.58	16.0	15.0
	35	14.00	2.83	16.0	12.0

39 Fr tube of a large diameter. For some tubes of a given nominal size of 35 Fr, 37 Fr and 41 Fr, the variation in diameter for the same nominal size is 1 mm or more. Furthermore the tubes do not correspond with their stated French gauge at the bronchial segment level either, all being much smaller than the nominal size.

DISCUSSION

A total of 171 left tracheobronchial tubes were measured from four manufacturers. It is evident that there are major variations between manufacturers in the dimensions of tubes with the same nominal size. Of even more concern is the variations of the bronchial segment diameter of tubes of the same nominal size from the same manufacturer.

It is very improbable that the differences between manufacturers and between sizes are caused by shrinkage in the polyvinyl chloride plastic as the tube ages or during washing as these changes are not consistent. A consistent reduction would be expected if aging or shrinkage were occurring.

There does not appear to be any consistency between the manufacturers except that all manufacturers decrease some of the tube dimensions as the nominal size decreases. However, even this is not completely true as the range of diameters overlaps for some manufacturers with single size steps (Figure 1). None of the tubes meet their nominal French gauge at the bronchial cuff segment; the bronchial circumference is always smaller that the French gauge. This situation would not be so extreme if the true dimensions were known for any tube, but at present no manufacturer gives the dimensions of bronchial or tracheal cuff segment diameters or length either on the tube, the packaging or in the inserted leaflet.

Table 4 gives a guide, in 1 mm steps, to the relationship between the diameter of the left main

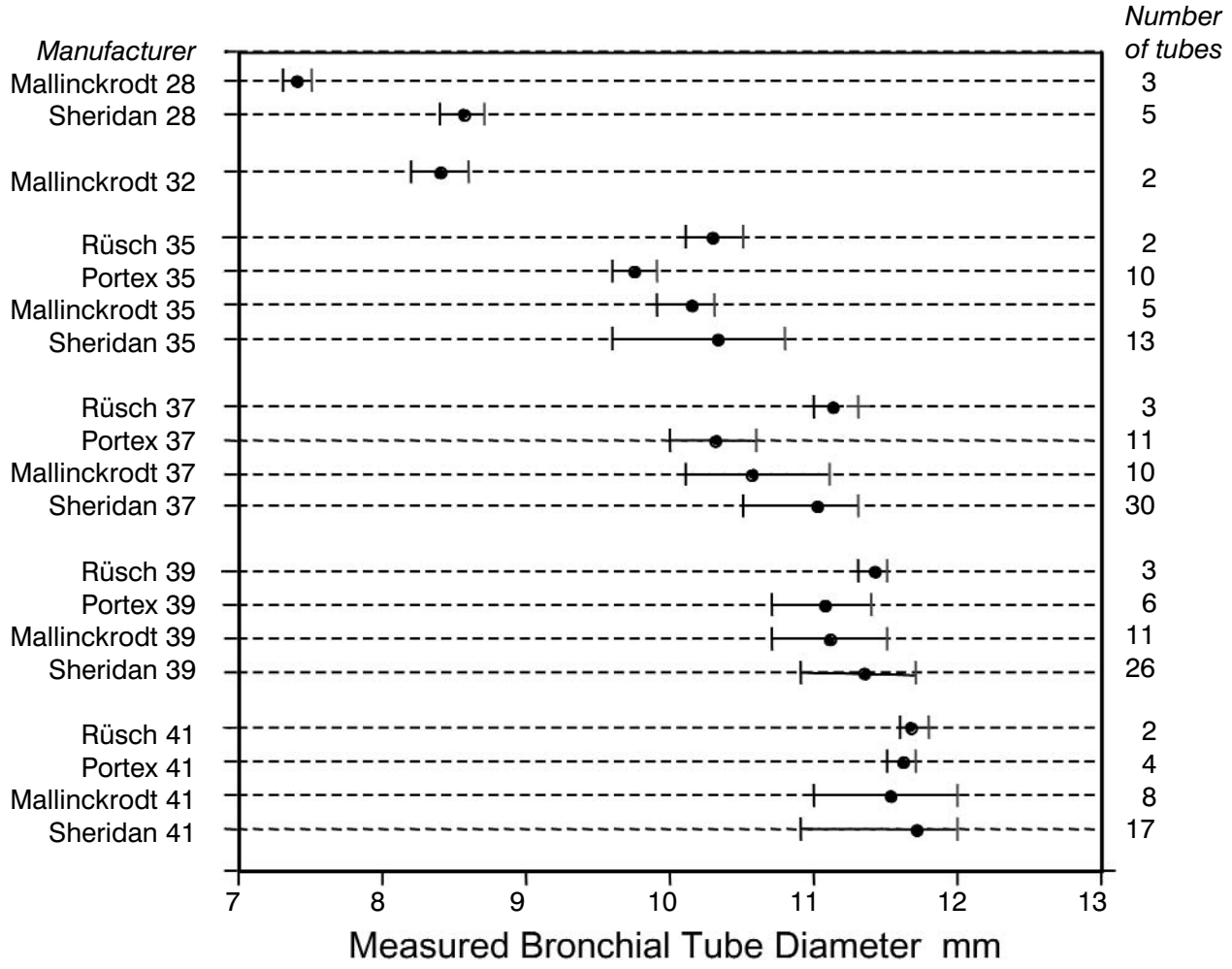

FIGURE 1: Measurement of the bronchial diameter measured over the deflated bronchial cuff for the four manufacturers and various nominal size French gauge tubes. For each tube type, the mean bronchial diameter is shown (dot) with the minimum and maximum diameters about the mean as a barred line. The number of tubes measured for each set of values is given to the right of the line.

TABLE 4
Relationship between bronchial measurement and tracheobronchial tube selection

	Measured Diameter of Left Main Bronchus on P-A Chest X-ray					
CXR Measured (Actual) Diameter mm	9 (8.1)	10 (9.0)	11 (9.9)	12 (10.8)	13 (11.7)	≥14 (12.6)
Sheridan	NA	28		35	37/39	41
Mallinckrodt	28	32		35	37/39	41
Portex	NA	NA	35	37	39/41	
Rüsch	NA	NA	NA	35	37/39	41

NA=no tube from this manufacturer appropriate.

bronchus as measured on a standard P-A erect chest X-ray and the largest appropriate sized tube, allowing that the actual size of the bronchus is approximately 90% of the measured size because of radiological magnification[3]. The table is derived from Figure 1, using the maximum measured diameter of the nominal size tube. It can be seen that a 10 mm measured diameter left main bronchus could accept either a 28 Fr Sheridan or a 32 Fr Mallinckrodt tube. Similarly, a 13 mm measured diameter bronchus could accept either a 37 Fr or a 39 Fr Rüsch tube or a 39 Fr or 41 Fr Portex tube. For a given manufacturer, the appropriate left tracheobronchial tube can be selected, but because of the variation in any designated tube size, the actual size selected may be smaller than intended. From these relationships, it is apparent that not only is there an inconsistency between manufacturers, but also the steps in size appear to be poorly placed.

These variations in external diameter suggest that there may be similar variations in the internal diameter of the same nominal size tracheobronchial tube. A substantial variation could have important implications for the insertion of a fibre-optic bronchoscope to check the tube position.

Tracheal tubes have accurate designations of their length and internal diameter with a small tolerance in accordance with the International Standard ISO5361. It seems anomalous that this is not the case for tracheobronchial tubes. Even if there are significant variations in manufacture which make consistency difficult, the precise dimensions should be available to help the clinician and at the least these should be printed in the package insert. The present situation of great variation and inconsistency between manufacturers makes the clinical task of fitting the appropriate tube to the patient difficult. It also increases the likelihood that one or more inappropriate tubes will be tried and discarded, an action which increases cost to the hospital and may risk damaging the patient.

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