

The Margin of Safety of a Left Double-Lumen Tracheobronchial Tube Depends on the Length of the Bronchial Cuff and Tip

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SUMMARY

The left tracheobronchial double-lumen tube is the commonest device to separate the left and right lungs for differential ventilation. With the appropriate tube, the left bronchial cuff is positioned in the bronchus so that the cuff is beyond the carina but the tip of the tube does not occlude the aperture of the left upper lobe bronchus. The difference between the length of the left main bronchus and the length of the cuff and tip of the bronchial segment of the tube has been termed "the margin of safety" by Benumof. If the length of the cuff plus the tip exceeds that of the left main bronchus, there will be occlusion of the left upper lobe bronchus.

The bronchial cuff and bronchial tip lengths were measured on two hundred and twenty left tracheobronchial (double-lumen) tubes from four manufacturers. The largest cuff-tip length was 40 mm with a Portex 41Fr tube but some 41Fr tubes from all manufacturers had cuff-tip lengths of 33 mm or greater which exceed the length of the shortest left main bronchus measured by Benumof. There was also a marked variation in cuff-tip lengths of the same size tube from the same manufacturer. The largest variation was 18 mm for the Portex 41 but substantial variation of 8 mm or more was found in at least one French size of all manufacturers.

Users must be aware that significant cuff-tip length variation occurs and match the selected tube to the patient to ensure an adequate margin of safety.

Key Words: double-lumen tube, lung isolation, equipment, margin of safety

In 1987, Benumof wrote of the need to position the bronchial segment of a left double-lumen tracheobronchial tube so that it did not obstruct either the carina nor the left upper lobe bronchus origin¹. He measured patients, cadavers and cadaveric casts of the bronchi to find the length of the left main bronchus between the carina and the origin of the left upper lobe bronchus. The dimensions from all three groups were similar with a mean of about 48 mm and a standard deviation of 8 mm. Overall the shortest left main bronchus was 27 mm and the longest was 68 mm with little difference between the male and female groups. From these dimensions, he developed the concept of a "margin of safety" assuming that

the length of the tip and of the cuff of the tube were uniform¹. His tube information was obtained from three manufacturers. Benumof and his colleagues did not make any measurements of the tubes.

On the left side, the margin of safety for the position is the length of the left main bronchus (LMB) over which a left sided tracheobronchial (double-lumen) tube can be moved in the bronchus without obstructing the airway. It equates to the length of the LMB minus the distance between the proximal end of the bronchial cuff to the distal end of the bronchial tip and is thus dependent not only on the anatomy of the patient but also the dimensions of the tube (Figure 1). Choosing a tracheobronchial tube with best margin of safety for a particular patient (based on the measurement of their LMB by X-ray) is important, as a patient with a short left main bronchus may be better managed with a slightly smaller diameter tube or a selection from several tracheobronchial tubes of the appropriate diameter so that the tube selected has the shortest cuff-tip length and thus the best margin

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of safety to avoid occlusion at the carina or of the left upper lobe bronchus. Although manufacturer's data have been quoted, there are no previous independent data on the dimensions of the various sizes from various manufacturers of the tracheobronchial tubes.

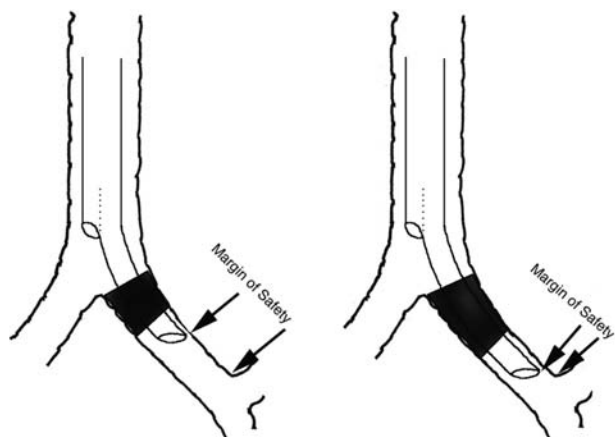


FIGURE 1: Illustration of the margins of safety in the same left main bronchus with the tube positioned so the upper edge of the bronchial cuff is at the carina with a tube with a short cuff and tip and with a tube with a long cuff and tip. The tube with the short cuff and tip has a much greater margin of safety for its position.

This study measured the actual lengths of the cuff and tip on the common sizes of left tracheobronchial tube provided by the four major manufacturers to give the tube dimension of the margin of safety.

METHODS

Left-sided tracheobronchial tubes were collected after they had been used. They were decontaminated and then measured. The bronchial cuff was measured fully inflated so to provide a clearly defined proximal and distal margin of the cuff. This cuff length was then measured with a pair of calipers. The length of the bronchial tip was measured from the end of the cuff to the longest point on the tip. These figures were then added together, to provide the cuff-tip measurement.

The technique of these measurements is similar to that by Russell and Strong for the diameter of the bronchial segments of tracheobronchial tubes².

RESULTS

Two hundred and twenty left-sided double-lumen tracheobronchial tubes were measured. The mean, standard deviation and range of tip lengths and of cuff lengths for each size for each manufacturer are given in Table 1. The mean and range of lengths for the combined cuff and tip for each size for each manufacturer are shown in Figure 2.

Contrary to claims made by the manufacturers

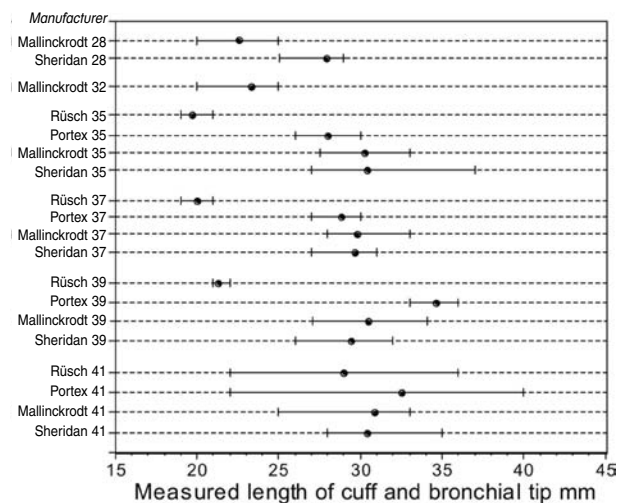


FIGURE 2: Plot of the mean, minimum and maximum lengths of the cuff-tip of the left bronchial segments for each of the tube sizes from each of the four manufacturers. The line indicates the minimum and maximum length measured in mm for each size of each manufacturer. The dot on the line indicates the mean length. (The value from the 2 Ruesch 26 tubes has not been charted as they were both 16.0 mm.)

Mallinckrodt, Sheridan and Ruesch of a 2 mm variation¹, there is in fact a wide range of cuff-tip lengths. These are wide 1) across nominal sizes for the same manufacturer, 2) for the same size and different manufacturer and 3) possibly most alarmingly, in the samples of the same size from the same manufacturer. This variation of the tubes in length from the proximal edge of the bronchial cuff to the tip of the bronchial tube is caused both by variation in cuff length and variation in tip length for the same size tube from even the same manufacturer (Table 1). When one takes into account the wide range in left main bronchial lengths (27-68 mm) then the margin of safety ranges from -13 to +49 mm for our samples of French 32 to French 41 tubes and highlights the need for a careful individual selection of a left tracheobronchial tube for the patient.

DISCUSSION

Using the concept of the margin of safety when choosing a tracheobronchial (double-lumen) tube may help with efficient and efficacious placement of the tube. Patient size and gender indicators can be misleading, and it is important to determine the actual dimensions of the patient's LMB, giving one an estimate of the likely margin of safety. However we cannot rely on the consistency of tracheobronchial dimensions to simplify the calculation of a margin of safety; if a small LMB is encountered, actual measurements of the cuff-tip lengths of the available tubes of appropriate diameter are essential to provide

TABLE 1
 Dimensions of left tracheobronchial bronchial segments (cuffs and tips) in mm

Make	Size	N	Cuff				Tip			
			Mean	SD	Min	Max	Mean	SD	Min	Max
Mallinckrodt	41	14	20.86	1.70	18	24	10.00	1.71	7.0	13.0
	39	27	19.63	1.74	16	23	10.74	1.53	8.0	13.0
	37	17	19.35	1.37	17	21	10.41	1.42	8.0	13.0
	35	9	20.06	1.55	17.5	22	10.22	1.12	8.5	11.5
	32	7	14.71	2.56	10	18	8.57	1.51	6.0	10.0
	28	4	12.75	1.89	10	14	10.50	0.58	10.0	11.0
Sheridan	41	20	23.10	2.43	17	27	7.30	3.51	4.0	18.0
	39	26	22.77	1.45	20	25	6.67	1.22	5.0	10.0
	37	30	23.27	1.46	20	25	6.37	0.90	5.0	8.0
	35	14	22.64	2.24	18	26	7.75	4.20	5.0	18.0
	32		Not avail							
	28	6	22.25	1.72	19	24	5.58	0.92	4.0	6.5
Portex	41	4	24.50	5.74	16	28	8.00	2.83	6.0	12.0
	39	7	27.57	0.79	27	29	7.00	0.82	6.0	8.0
	37	11	23.09	1.14	21	24	5.73	0.47	5.0	6.0
	35	10	22.70	1.42	21	25	5.30	0.48	5.0	6.0
	32		Not avail							
Rüsch	41	2	21.00	8.49	15	27	8.00	1.41	7.0	9.0
	39	3	17.00	1.73	15	18	4.33	1.53	3.0	6.0
	37	4	15.25	0.50	15	16	4.75	1.26	3.0	6.0
	35	3	14.67	2.31	12	16	5.00	2.00	3.0	7.0
	32		Not avail							
	26	2	11.00	1.41	10	12	5.00	1.41	4.0	6.0

the best (shortest) tube with the widest margin of safety. Without a margin of safety, flexion of the neck could move the bronchial segment of the tube in 8 mm or more and cause an obstruction³.

At present, if the anaesthetist is aware of a possible length problem in the left main bronchus of the patient, the approximate length of a tracheobronchial tube cuff-tip can be measured through the transparent wrapping and an appropriate tube selected. It would however, be ideal if this information was available on the tube or on the packaging.

The best solution to the problem could be that manufacturers supply a more rigorous quality control, enabling the practitioner to work on the basis that the cuff-tip length is standardized and thus the cuff-tip length is a known quantity and there is a precise figure to work with.

If a situation occurs where either because of a long cuff-tip length on the selected tube or because the patient has a very short left main bronchus, the margin of safety is less than 10 mm, this is a strong argument for inspection of the final position of the bronchial segment of double-lumen tube with a fiberoptic bronchoscope even if this is not the anaesthetist's routine practice.

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