Lobarspirometry*

I. Description of the Catheter and the Technique of Intubation

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Introduction

The ability to measure the function in anatomical divisions of the lung has not kept pace with the surgeon's competence in resecting smaller and smaller units. Knowledge concerning the relative function of small divisions has been derived from pre- and postoperative bronchspirometric measurements, since techniques for direct measurement have not been available until recently.¹⁻³

In 1951, a spirometric catheter for the direct measurement of lobar function was designed in this laboratory. The first model was tested in 1953, and was improved upon as a result of subsequent experience. The purpose of this paper is to describe this catheter, to discuss the technique of intubation, and to indicate situations in which use of this catheter may be of particular value.

The Catheter

The catheter (Fig. 1A) is a three-lumen, soft latex-rubber tube 40 cm. long and from 1.1 cm. to 1.5 cm. in outside diameter. One channel extends the entire length of the catheter, and forms the airway to the lower lobe. A second channel parallels the first until, near the tip of the catheter, it turns away at 90° and forms the airway to the upper lobe. Each of the airways to the upper and lower lobes has an internal diameter of approximately 5.3 mm. The third channel, considerably shorter than the other two, is the airway to the contralateral lung, and has an internal diameter of approximately 6.5 mm.

The most distal balloon, when inflated, occludes the main stem and upper lobe bronchus, thereby functionally separating the lower and the upper lobe. The detail of this balloon is shown in Figure 1B. The proximal balloon occludes the trachea, and acting together with the distal balloon, isolates the contralateral lung.

Figure 1C illustrates the body of the catheter in cross-sectional diameter, and shows the relationship of the five lumina to one another and the means of assuring only minimal wastage of space. At the lower and upper ends of the catheter these triangular divisions become rounded, and continue as a tube.

At the tips of the upper- and lower lobe channels, two parallel lead-foil strips are embedded in the rubber to provide fluoroscopic identifica-

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tion of the channels during intubation. Since the left main bronchus is considerably longer than the right, it is seldom feasible to use the same catheter for studies on both sides, and we have therefore built right- and left-handed models. In the right lung, anatomical considerations require that the middle lobe be measured with the lower lobe.

**Intubation**

With pre-medication and under topical anesthesia, intubation is carried out as for routine bronchospipometry. A spring-steel, wire guide is inserted into the lower lobe channel, and bent to the proper angle to guide the catheter into the trachea. The configuration of the upper lobe channel at the distal end of the catheter may make introduction of the tip through the glottis troublesome. This aspect of intubation may be simplified by bending the laterally projecting, upper-lobe channel parallel with the lower-lobe channel, and then exhausting the residual air in the distal balloon. The vacuum in this balloon holds the two channels parallel until they have entered the trachea. The wire guide is then removed.

Under fluoroscopic control, the catheter is then placed in the appropriate main stem bronchus. The vacuum in the distal balloon is released and the catheter is rotated and moved up and down until the upper lobe channel suddenly moves laterally and engages in the upper lobe bronchial orifice. The distal balloon is then inflated until traction on the catheter meets with resistance, and does not dislodge the channel from its position within the upper lobe bronchial orifice. Care must be taken not to inflate this balloon more than is necessary to stop leakage, since with

![Diagram of lobar spirometry catheter and cross section](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21313/)

**FIGURE 1**: Lobarspirometry catheter, arrangement of the three airways and isolation balloons is shown in A, the detail of the tip in B, and the cross section in C.
over-inflation, the coryna may be pushed aside and compromise the bronchus to the contralateral lung.

When the catheter is firmly in place, the subject lies supine, and recording spirometers are attached to each of the three airways. The proximal balloon is inflated, and simultaneous recordings are made from the upper lobe, the lower lobe, and the contralateral lung. If the functional isolation of each unit is complete, no spirometer will record a loss of volume. Weighting of one spirometer bell will not cause either of the others to rise if the seal in the balloons is adequate. A vital capacity maneuver must not reveal any obstruction. As an additional check, we have routinely used the nitrogen meter to sample one unit while 100 per cent oxygen is ventilating the others. When the check for the adequacy of the functional isolation is complete, the usual recordings of oxygen uptake and ventilation may be made.

To determine the flow characteristics of the lobar spirometric and two commonly used bronchospirometric catheters (Zavod and Carlens), an E. Greiner flow meter was mounted in series with the catheters. The connector had a lateral arm leading to a water manometer. The catheters selected for testing had similar outside diameters (14mm.). The resistance to air flow through the combined upper- and lower-lobe lumina of the lobar catheter is almost identical to that in the left lumen of the Carlens bronchospirometric catheter (Fig. 2). The flow resistance in the Zavod catheter is markedly greater than those in the other two. Individually determined, the flow resistances of the upper- and lower-lobe lumina are almost equal.

![Flow characteristics of the lobar spirometric catheter and left side lumen of two standard catheters (Zavod and Carlens). Upper- and lower-lobe lumina combined on the lobar spirometric catheter.](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21313/)
Similar comparison of tracheal lumina of the three catheters results in a plot of flow resistance similar to that in Figure 2. The same general relationship among the three catheters in the same ranges of value is also found when flow and pressure in the short lumina are measured.

Possible Uses for Lobarspirometry

This lobarspirometric catheter was originally designed for specific research purposes, and the experience gathered during its use in 25 right-sided and 5 left-sided lobar studies confirms its usefulness in such areas as the investigation of pressure volume gradients, the mechanics of lung motion, and the study of perfusion differences accompanying changes in body position.

However, our experience also indicates that this catheter may be used to provide data available in no other way. Thus, in those patients whose pulmonary function is severely reduced, data obtained by use of this catheter may allow salvage by pulmonary resection. Also, this catheter can often be used when abnormalities of the tracheobronchial tree prohibit the use of the standard bronchospirometric procedures.

SUMMARY

We have described a new three-lumen catheter designed to allow oxygen uptake and ventilatory studies to be simultaneously performed on the upper and the lower lobe of one lung and on the entire contralateral lung. Some general areas where this catheter may be very useful have been indicated.

RESUMEN

Hemos descrito un catéter de tres luces ideado para permitir el ingreso de oxígeno y hacer estudios ventilatorios simultáneamente en los lóbulos inferior y superior de un pulmón y en el contralateral completo. Se señalan algunas indicaciones útiles para este catéter.

RESUME

Les auteurs ont décrit un nouveau cathéter à trois lumières établi pour permettre l'arrivée d’oxygène et des études ventilatoires portant simultanément sur le lobe supérieur et inférieur d’un poumon et sur la totalité de l’autre poumon. Les auteurs ont donné quelques indications générales pour lesquelles cette sonde pouvait être de grande utilité.

ZUSAMMENFASSUNG

Wir haben einen neuen Katheter mit drei lumina beschrieben, der die Aufgabe hat, die Sauerstoffaufnahme zu gestatten und ventilatorische Studien gleichzeitig vom oberen und unteren Lappen einer Lunge und der ganzen kontralateralen Lunge zu ermöglichen. Es wurden einige allgemeine Anwendungsgebiete aufgezeigt, bei denen dieser Katheter eine nützliche Verwendung finden kann.

REFERENCES