ENDOBRONCHIAL ANESTHESIA BY MEANS OF AN IMPROVED ENDOBRONCHIAL AIRWAY * †

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INTRODUCTION

INTRATHORACIC surgery for lobectomies, pneumonectomies and operations for lung abscesses on so-called "wet" cases have created a special problem in addition to the usual demands upon the anesthesiologist by thoracic surgery. Two dangers are always present, namely, drowning of the patient by excessive fluids and contamination of the healthy lung. We are presenting an improved endobronchial airway that is serving us well toward the elimination of the danger of excessive secretions and the reduction or elimination of the spread of secretions, pus, blood, or tissue debris from the pathologic lobe to the healthy lung.

HISTORY

An endotracheal tube will establish an airway or a channel through which secretions can be aspirated and thus combat one of the cited dangers of intrathoracic surgery, but it will not prevent contamination of the contralateral lung which frequently leads to a fulminating spread of infection (1).

Endobronchial anesthesia can eliminate the second danger by "sealing off" the main bronchus of the sound side by means of an inflated cuff placed around the endobronchial airway in the bronchus. This technic of "closed endobronchial anesthesia" was suggested by Gale and Waters in 1932 (2, 3).

Franz Kuhn, at the turn of the century, suggested an endotracheal tube made of a coil of flat metal. The tube was 12 to 15 cm. in length and was inserted with a curved introducer by the sense of touch alone. Because of the trauma produced, metal tubes fell into disuse. In 1921–1922 Coburn (4) initiated the use of a spiral tube which was covered by thin rubber tubing. This spiral tube was employed for pharyngeal insufflation. Flagg, in 1929 (5, 6), revived the use of this type of tube which has a central section of flexible metal hose. Flagg's original tubes were constructed after discussion with Jackson and

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Flagg's tube is really a flexible modification of the Jackson type bronchoscope. A covering of Penrose rubber tubing was added to minimize trauma and to make the coils airtight. Woodbridge (7) modified the original Flagg tube in 1934 by shortening the solid metal tip so that almost the entire tube consisted of flexible coiled wire. In 1932 Coryllos and McKesson (8, 9) designed a metal tube for use during thoracic operations; it was similar to the other metal tubes but was provided with distal illumination like a bronchoscope. Likewise, Magill (10) devised an instrument which consists of a flexible metal tube resembling a bronchoscope, mounted on the outside of an illuminated stilet, and provided with an inflatable cuff. More recently Magill and Nosworthy have performed endobronchial anesthesia by placing a bronchoscope of suitable size inside a long Magill tube carrying an inflatable cuff. When intubation has been performed the tube is held firmly in position while the bronchoscope is withdrawn (11).

In 1941 McCuskey (4) initiated a Woodbridge type tube, 38 cm. long and 7 mm. in diameter with a rigid, semicircular light carrier to fit within it, in order to insert the tube into the desired bronchus under direct vision. Caine, in 1943 (4), using the McCuskey tube, recognized that the stilet-light carrier was too bulky to permit passage of the essential suction tube.

DESCRIPTION OF ENDOBRONCHIAL AIRWAY

Utilizing these previous contributions, two of us (C. P. B.*—H. S. R.) have designed an endobronchial airway (figs. 1 and 2) which combines direct vision placement and a noncollapsible tube of coiled

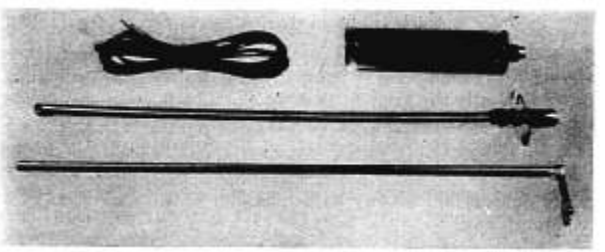

FIGURE 1.

wire into one instrument, with several additional advantages. It is essentially an elongated Woodbridge endotracheal tube in which the obturator is a special bronchoscope. The obturator contains an

* Charles P. Bailey, M.D., F.A.C.S., whose interest and helpful suggestions from the surgical and other aspects are hereby acknowledged with appreciation.

auxiliary canal for the light carrier as well as an oxygen tract. The oxygen tract permits the administration of oxygen, with or without carrying an anesthetic agent, at a rate up to 3 liters a minute. The tube itself is encased in a rubber sheath with an inflatable cuff fitted on the end to be inserted into the bronchus. The proximal end of the air-

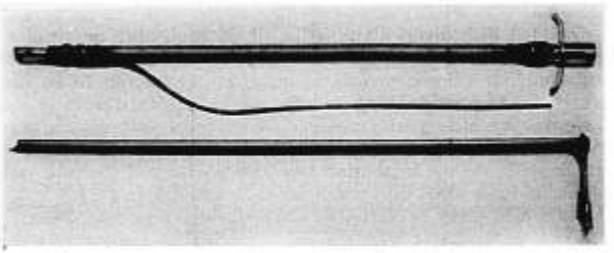

FIGURE 2.

way fits the standard adapters used for direct connection of a Woodbridge tube to any of the carbon dioxide absorption anesthesia machines. The tube is now available † in three sizes—small, medium and large. The medium size is comparable to a 40 cm. by 7 mm. bronchoscope.

The authors believe that a tube of coiled piano wire impregnated in latex would be of more durable construction and this improvement may soon be made available.

TECHNIC OF INSERTION OF TUBE

Since this endobronchial airway is essentially an endotracheal tube containing a bronchoscope it naturally follows that the technic of insertion is basically the same as that for the introduction of an ordinary bronchoscope (10).

The equipment required consists of the following and is best used from a table maintained for this purpose alone.

1. Endobronchial airway with inflatable cuff.
2. Mouth gag.
3. Battery, cords and connections.
4. Aspirating tube with mechanical aspirator.
5. Laryngoscope.
6. Bronchoscopic sponges.
7. Bronchoscopic grasping forceps.
8. Foot rest for assistant.
9. Negus glass disk.

† Foregger Company, Inc., New York City, N. Y.

10. Source of oxygen.
11. Dry 10 cc. syringe with blunt wide gauge needle.
12. Hemostat.

The mouth gag, battery, cords and connections, aspirating tube and bronchoscopic grasping forceps are standard bronchoscopic equipment. The laryngoscope may be either the standard "U" type used by bronchoscopists or the "L" type more commonly used by anesthesiologists.

The source of oxygen may be either the gas machine or a portable oxygen tank with flowmeter. A section of rubber tubing is attached from the outlet of the source to the oxygen tract on the bronchoscope within the endobronchial airway. During the period of placement of the tube, especially if any time is required for thorough aspiration, the anesthetic agent is added to maintain anesthesia. The flow of oxygen or anesthetic mixture is maintained at the capacity of the oxygen tract.

The personnel required is the same as for ordinary bronchoscopy—operator, assistant who holds the head and an instrument assistant. If the anesthesiologist is familiar with bronchoscopic procedures, he inserts the tube. If not, since thoracic surgeons are, of necessity and training, bronchoscopists as well, it is expedient for the surgeon to act as operator. In the latter instance, the assistant to hold the head is advantageously the anesthesiologist because he can maintain an airway and anesthesia while he is holding the head. The instrument assistant may conveniently be one of the instrument nurses for subsequent surgery.

Intubation is performed usually after the patient has been deeply anesthetized, but may also be done following topical anesthesia. This means that the procedure is done on an ordinary operating room table rather than a bronchoscopic table. In order to have the head extend beyond the end of the table for optimum maneuvering, the patient must be lifted into this position which is an inconvenience and may well cause dislodgement of the "cut down" needle which should be in place before anesthesia is started. It has been found, however, that with the relaxation afforded by the anesthesia the procedure can be carried out by extending the patient's head without moving the patient.

Asepsis should be maintained during the placement of the tube. The patient is relatively immune to the infection he himself harbors but careless implantation of other types may well result in an additional infection. Protection for the operating team is important because coughing frequently ensues during introduction of the tube and the use of a Negus glass disk and mask by the operator is advantageous.

ANATOMY

At the level of the second costal cartilage in adults and at the level of the third costal cartliage in children, the trachea bifurcates into the right and left main bronchi. This corresponds posteriorly to the fourth or fifth thoracic vertebra.

The septum between the right and left main bronchi, the "carina," is situated to the left of the midtracheal line. It is recognized, endoscopically, as a short, shining ridge running sagittally or vertically in the recumbent position. On either side are the openings of the right and left main bronchi. The lower border of the carina is on a level with the upper portion of the right superior lobe bronchus.

The right main bronchus is shorter, wider and more nearly vertical than its fellow on the opposite side, and is practically the continuation of the trachea. The deviation of the right main bronchus is about 25 degrees and its length unbranched in the adult is practically nothing; the proximal margin of its orifice is on a level with the carina. The deviation of the left main bronchus is about 75 degrees and its adult length is about 5 cm.

DIMENSIONS OF THE TRACHEA AND BRONCHI (CADAVERIC DIMENSIONS)
(After Jackson and Jackson (10))

	Adult Male	Female	Child	Infant
Diameter of trachea	14×20	12×16	8×10	6×7
Length of trachea, centimeters	12.0	10.0	6.0	4.0
Length right bronchus, centimeters	2.5	2.5	2.0	1.5
Length left bronchus, centimeters	5.0	5.0	3.0	2.5
Length upper teeth to trachea, centimeters	15.0	13.0	10.0	9.0
Length total to secondary bronchus, centimeters	32.0	28.0	19.0	15.0

In life muscle tonus causes the lumen to vary and on the whole renders it smaller (11).

Of greatest practical importance, based on the anatomy of the tracheobronchial tree, is the short right main stem bronchus. When the endobronchial tube with the inflatable cuff is inserted into the right main stem bronchus it may obstruct the opening of the upper lobe. This difficulty is not so likely to arise when the left main stem bronchus is intubated because of its greater length. Prevention of blockage of the right upper lobe bronchus is not entirely dependent on the operator's skill in placing the tube—the anatomical relationships frequently determine this. If the lower and middle lobes on the right side are normal, the trained anesthesiologist will have little difficulty in maintaining adequate minute volume respiration even with the upper lobe bronchus obstructed. In cases of right lower lobe disease it might be impossible to maintain adequate aeration. It follows then, anatomically, that endobronchial intubation is much more applicable for surgery in the right pulmonary area.

FURTHER COMMENT ON TECHNIC

After the endobronchial airway has been inserted to its proper depth within the main stem bronchus the cuff is inflated and the bronchoscope (which serves as a stilet for the flexible tube) is carefully

removed. The tube is connected with the gas machine by means of necessary adapters for continuation of anesthesia and the patient is placed in position for the surgical procedure.

The inflatable cuff is virtually the only means of ensuring a gas-tight connection. At the same time it constitutes a potential source of danger. Proper inflation of the cuff is a requisite because under-inflation may lead both to leakage and to displacement. Over-distention may cause the cuff to bulge in front of the tube and obstruct respiration, or it may produce trauma to the mucosa, and it may produce a condition resembling a bronchiolar spasm with fixation of the chest and subsequent cyanosis.

The quantity of air injected into the cuff is an unreliable guide to proper inflation. A good practical procedure in our hands consists of filling a 10 cc. syringe with air and attaching it to the inflating tube with a blunt wide gauge needle. The breathing bag is then held in one hand and the inflating syringe in the other. The cuff is then inflated until it just prevents leakage of gases at the manual pressure on the bag required to cause expansion of the patient's chest.

After the cuff is inflated the movements of the chest are noted. Restriction of thoracic movement should be seen over the lung whose bronchus has *not* been intubated. For stated anatomical reasons, the upper half of the chest on the sound side should be closely watched, to be certain that it moves on respiration. Inflation of the lungs from the bag will often help to confirm this. The cuff, when inflated, occludes the lumen of the trachea and the opposite bronchus, and the diseased lung collapses.

ADVANTAGES

The use of an endobronchial airway provides the advantages offered by the use of an endotracheal tube. These are classified under three headings by Gillespie (1), namely, freedom of airway, control of intrapulmonic pressure, and artificial ventilation. In addition, other important advantages peculiar to this technic are afforded because the healthy lung is "sealed off" from the diseased lung.

1. It prevents drowning of the patient in his own secretions. This danger is ever present when a sudden large volume of material may be emptied into the tracheobronchial tree, as sudden rupturing of an abscess into a bronchus or a profuse hemorrhage into a bronchus. Aspiration, as practiced with an ordinary endotracheal airway, may be unsuccessful in removing such fluid fast enough.

2. It prevents contamination of the healthy lung with infection from the diseased lung. This is always a serious danger, and any procedure which will decrease the incidence of this complication has merit. Contamination of the healthy lung is particularly prone to follow intrathoracic surgery in the lateral position in which the diseased lung

is uppermost. At the same time that liquid material is prevented from reaching the "sealed off" lung, fragments of tissues of various kinds, blood, and other debris are also prevented from contaminating the healthy lung.

3. Endobronchial intubation decreases the need for preoperative bronchoscopy, as the tracheobronchial tree is aspirated in the usual bronchoscopic manner during its insertion.

4. This procedure usually will allow operations to be performed on a completely collapsed lung, at times quite desirable.

5. In unusual cases it may be advantageous to pack the bronchus of the diseased lung prior to operation. The bronchus on the involved side in some instances was packed tightly with narrow gauze, using the endobronchial airway as a bronchoscope for this procedure. The tube was then placed in the opposite bronchus for surgery. A strand of fine wire suture attached to the gauze pack and extending beyond the mouth provides a means of quick removal of the pack, should this be found necessary.

6. An endobronchial airway eliminates the possibility of loss of anesthetic gases if a bronchopleural fistula is present or if any openings in the main stem bronchus or its subdivisions occur during the surgical procedure.

7. It reduces the incidence of contralateral atelectasis.

8. The intubation is done under direct vision so that it is possible to know the exact location of the distal portion of the tube.

9. It decreases the number of aspirations during surgery as the functioning lung does not become "wet." This permits administration of smoother anesthesia.

10. The surgeon can aspirate the main stem of the bronchus at the time it is opened, so that secretions, pus, blood and tissue debris are removed before extubation. This further minimizes contralateral contamination and infection.

DISADVANTAGES

1. Slightly deeper anesthesia is necessary when an endobronchial airway is used than with the endotracheal technic.

2. Training is required in bronchoscopic technic.

3. It may produce trauma to the bronchus from the presence of the tube alone, overdistention of the cuff or undue traction on the tube after the cuff has been inflated.

4. The eparterial bronchus may be occluded on the intubated side. The tube is more efficacious in right pneumonectomies because the left main stem bronchus is longer than the right and provides fewer opportunities for occlusion of the upper lobe bronchus.

5. The tube may become displaced during the operation. This may occur without notice to the anesthesiologist, and when it does occur not only are the advantages of the technic lost but the cuff may remain

partially inflated and prevent passage of secretions around the tube. The cuff must be deflated when positive pressure is made to observe whether the bronchus is airtight following its ligation and severance. From this point until reinflation of the cuff, the distal portion of the airway may become displaced.

COMMENT

The tube, as described, has been employed by the authors in over 50 intrathoracic operations. To the best of our knowledge, no contralateral spread during surgery has occurred following its use.

SUMMARY

A modified and improved endobronchial airway has been presented to combat the two special dangers which are always present in intrathoracic surgery—drowning of the patient by excessive fluids and contamination of the healthy lung.

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