ENDOBRONCHIAL ANESTHESIA *

VIKING OLOV BJÖRK, M.D., ERIC CARLENS, M.D., AND OLLE FRIBERG, M.D.

Stockholm, Sweden

Received for publication June 27, 1952

EARLY METHODS

THREE different methods have previously been employed to prevent transbronchial spread of disease during lung resections. With the first method the healthy lung was separated from the diseased portion by the use of an endobronchial anesthetic tube with an inflatable rubber cuff (Gale and Waters, 1931 and Magill, 1936) (7). With the second method the main bronchus to the diseased lung was occluded (Crafoord, 1938, Halton, 1943 and Moody, 1947, 1948 and 1949) (5, 8, 9, 10).

Neither of these methods, in which operation is performed with the

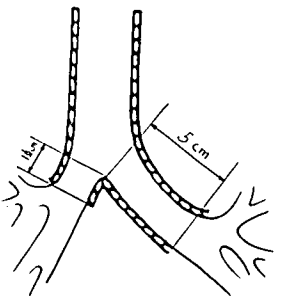


FIG. 1. Diagram of the bronchial anatomy. The left main bronchus is long enough to permit insertion of an endobronchial tube with inflatable cuff without danger of obstructing the upper lobe bronchus. The right main bronchus is too short for this purpose.

patient in the lateral position, was entirely satisfactory. Either it was not possible to aspirate the accumulated secretions or it was difficult to keep the instrument in the proper position during a prolonged operation. With some bronchial occluding methods it is impossible to deflate the lung, making the operation more difficult.

With the third method, advocated by Overholt (11) in which the patient is in the prone position during the operation, the danger of spread has been considerably diminished. This position, however, is

* From the Sabbatsberg Hospital, Stockholm, Sweden.

not advisable for resections of a middle lobe, the lingula or an anterior segment. In many cases alternate dissections from the front and from the back which are possible with the patient in the lateral position will facilitate the operation. Furthermore, the lateral position is preferable from a physiologic point of view, since, with this position, ventilation is increased in the lower portion of the lung. This increased ventilation is the result of the higher position of the diaphragm, which facilitates a deeper expiration.

TECHNIC FOR ENDOBRONCHIAL ANESTHESIA

The double lumen catheter was originally constructed by Carlens (4) for bronchospirometry but has been adopted for endobronchial anesthesia (figs. 1 and 2). Its use has facilitated certain technical steps

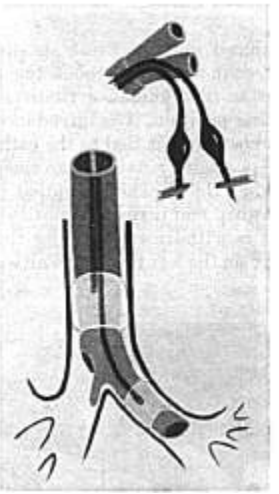


FIG. 2. The double lumen catheter in place. Note the rubber hook engaging the carina.

in lung resections to such a degree that this catheter is now routinely used at the Sabbatsberg Hospital (1, 3).

The double lumen catheter † is made of rubber and is obtainable in two sizes. The lumen of each side of the catheter has a diameter of 7 mm. for men and 6 mm. for women. The total outer diameters are 13 and 11 mm., respectively (fig. 3).

† The catheter described can be obtained from A. B. Stille-Werner, Stockholm 4, Sweden. It is now manufactured in three sizes.

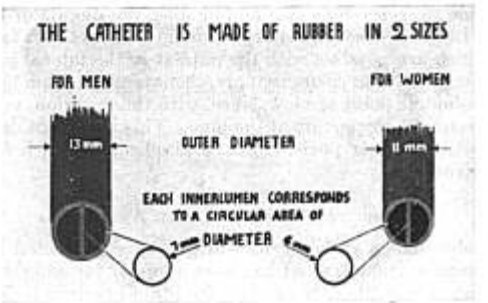


FIG. 3. Diagram of cross sections of the double lumen catheters.

The tube is introduced under topical anesthesia with 2 per cent pontocaine® or 4 per cent cocaine without the aid of fluoroscopy or bronchoscopy. Under mirror guidance (indirect laryngoscopy) with the patient in the sitting position, it is introduced over a curved metal stilet (fig. 4). The rubber hook is tied to the catheter with a moistened silk thread until, with a slight, rotating movement, the tube is passed through the larynx, when the slipknot is untied (fig. 5). The catheter is gently pushed downward and turns automatically to the left, at which time the curved stilet is withdrawn. During the introduction the tip exerts a slight pressure on the left tracheal wall and enters the left main

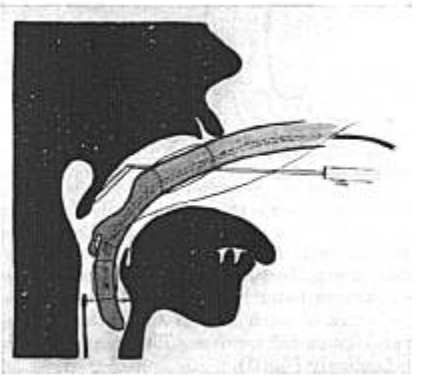


FIG. 4. The double lumen catheter is introduced under mirror guidance over a curved metal stilet. The rubber hook is tied to the catheter.

bronchus. The hook can then be felt engaging the carina. A slight pressure downward is exerted on the catheter and the cuffs are inflated. Anesthesia and suction can then be applied to each lung separately. The catheter is maintained in the correct position by the hook and the two rubber cuffs. Pressure in the cuffs should be just sufficient to prevent leakage from the bronchus and the trachea. The pressure can easily be checked when controlled respiration is started.

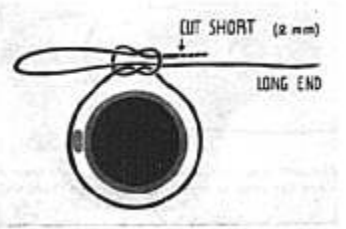


FIG. 5. Diagram of the slipknot.

It is possible, with general or local anesthesia, to introduce the catheter over a straight metal stilet through a laryngoscope and remove the stilet and the silk thread as soon as the hook has passed the larynx. The Macintosh laryngoscope has been found to be the best type for this purpose. Many anesthetists prefer this technic, but for patients who

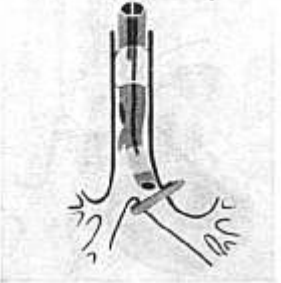


FIG. 6. In cases of left pneumonectomies the catheter is withdrawn and a soft aortic clamp is placed at the origin of the left main bronchus.

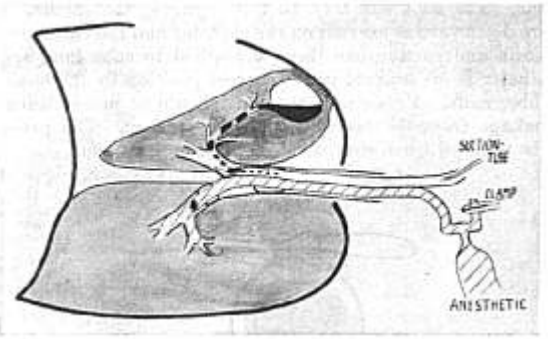


FIG. 7. The diseased lung may be deflated to provide more operating space when the lung is separated from the chest wall.

have short necks and big teeth it may be of value to be familiar with the former procedure as well.

Lobectomies and segmental resections may be performed in the same manner on the right and the left side, but in left pneumonectomies open closure of the bronchus cannot be carried out. When the lung is liberated and the hilar structures are dissected, the cuffs are deflated and the catheter is withdrawn about 5 cm. Immediately beforehand, the bronchial secretion in the left side is aspirated to prevent spread. Afterward, only the proximal cuff is reinflated, both lumina are connected to the anesthetic machine and the catheter is used as a single lumen endotracheal tube. At the moment the catheter is withdrawn, a soft aortic clamp is placed at the origin of the left bronchus (Fig. 6).

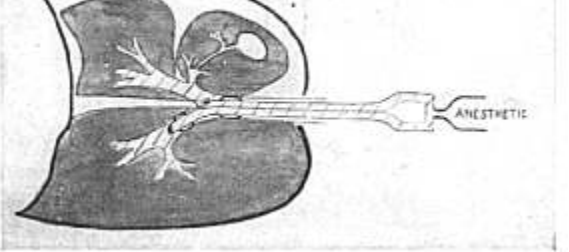


FIG. 8. The lung is inflated when lobar or intersegmental planes are developed.

INDICATIONS FOR ENDOBRONCHIAL ANESTHESIA

Endobronchial anesthesia is indicated to prevent transbronchial spread in many thoracic cases. Although the amount of sputum is diminished by preoperative chemotherapy and antibiotics in combination with postural drainage, manipulation of the lung by the surgeon during the operation will produce a considerable amount of purulent

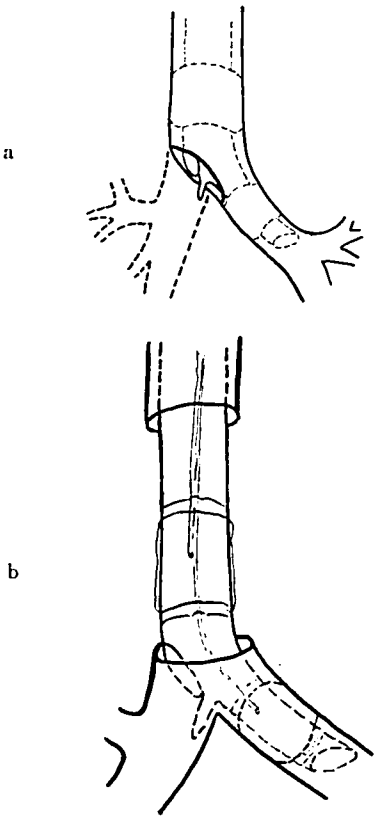


FIG. 9. *a*, Resection of the carina and adjacent parts of the trachea is facilitated by the endobronchial anesthesia technic. *b*, Diagram of tracheal resection.

material. This is true in the following cases: (1) tuberculosis with cavitation or with secondary suppuration behind a bronchial stenosis; (2) long-standing saccular bronchiectasis; (3) chronic lung abscess; (4) secondary suppuration behind a bronchiogenic carcinoma or other bronchial tumors and (5) sudden intrabronchial hemorrhage. The occurrence of the last mentioned indication for endobronchial anesthesia is difficult to predict.

We have saved the life of one patient who had a bronchiogenic carcinoma by our method. In this case a sudden hemorrhage occurred from the tumor before the lung was liberated and it was possible to occlude the bronchus. The anesthetic was administered to the healthy lung and ventilation was maintained while continuous suction was applied to the open part of the tube in the diseased and bleeding lung. The cancer was inoperable, but as the bleeding from the tumor continued, a palliative resection, including the left lung, part of the dia-

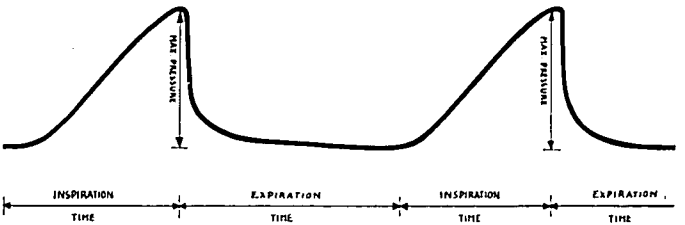


FIG. 10. Pressure curve from the endobronchial tube during controlled respiration with the spiropulsator.

phragm, a portion of the left auricle and a considerable part of the pericardium was carried out. The wound healed by primary intention.

With practice, the double lumen catheter is nearly as easy to use as an ordinary endotracheal tube and it is now preferred in all cases of resections. The only contraindication to its use is stenosis or obstruction of the left main bronchus. In such cases it is not possible to introduce the catheter into the left main bronchus. Up to the present time this technic of endobronchial anesthesia has been employed in about 500 cases.

The advantages of endobronchial anesthesia in lung resections are as follows:

1. Once the chest is opened the diseased lung may be deflated to provide greater operating space when the lung is separated from the chest wall (fig. 7).

2. The lung can be inflated when lobar or intersegmental planes are developed (fig. 8).

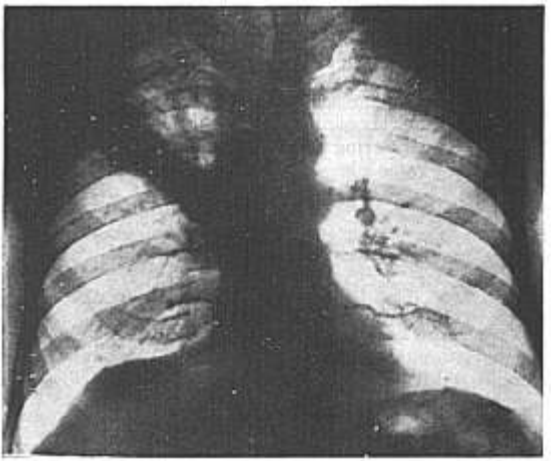


FIG. 11. *a*, Bronchiogenic carcinoma and segmental atelectasis in the right upper lobe. *b*, Oxygen determinations in the arterial blood during operation on the patient shown in *a*, demonstrating considerable decrease when the right lung is deflated. This is due to a shunt of venous blood from the nonventilated lung. When the pulmonary artery is ligated the shunt is eliminated and normal arterial oxygen saturation is achieved.

3. The bronchus can be divided whenever this is suitable during the resection and left open until it is convenient to close it. During the time the bronchus is open a small plastic catheter is left in place for continuous suction, with the suction tip close to the opening in the bronchus to collect blood and secretion.

4. It is not necessary to apply a clamp on the proximal part of the bronchus. Thus, injury to the bronchial wall is avoided.

5. The bronchial tree may be inspected and aspirated by a small rubber catheter through the open bronchus.

6. Bronchotomies and resection of the carina and of the tracheal wall are facilitated by this method of endobronchial anesthesia (fig. 9).

7. In "wet" cases during repeated aspirations one lung is always ventilated and the same plane of anesthesia can be maintained more easily.

Some Points Concerning the Anesthetic and Some Physiologic Aspects of Endobronchial Anesthesia and Controlled Respiration

After the double lumen tube has been fixed in proper position with tape and a gauze roll has been inserted between the teeth, the patient is placed in the lateral position. Anesthesia is induced with an ultrashort-acting barbiturate, such as pentothal or surital®. The main agent commonly employed is nitrous oxide, which usually is given with 33 per

TABLE 1*

Test Arterial Blood	Number of cases	Mean Value and Standard Error
pH	39	7.41 ± 0.007
Vol. % CO_2 (Conway)	34	49.8 ± 1.06
Vol. % CO_2 (Van Slyke and Neill)	19	46.8 ± 0.81
Alkali reserve (Conway)	37	49.7 ± 1.17

* These values are within normal limits. Because of admixture of nitrous oxide in the arterial blood it was not possible to determine accurate tension values.

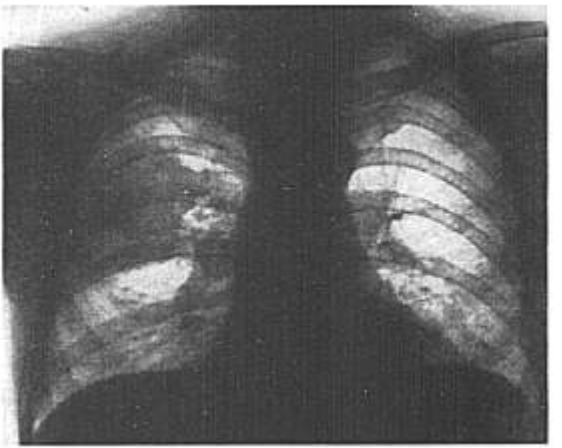
cent oxygen. The oxygen concentration in some cases or at certain moments is increased to 50 per cent according to the patient's condition. When saturation with nitrous oxide is complete, the anesthesia is deepened to a proper level by giving more basal anesthetic; an ultrashort-acting barbiturate, a short-acting barbiturate (nembutal®) or an analgesic (demerol®) is used according to the situation.

Shortly before the pleura is opened, spontaneous respiration is completely stopped by paralyzing the respiratory muscles with curare. Controlled respiration is started and continued until the chest is closed air tight. Controlled respiration is maintained with the aid of a machine, the spiropulsator. Inspiration is produced, in adults, by increasing the pressure to between 15 and 20 cm. of water and then suddenly dropping it to zero; passive expiration follows. The expiratory phase is longer than the inspiratory phase because of the interval between expiration and the next inspiration. The length of the interval is regulated on the machine (fig. 10).

When one lung is disconnected using the double lumen tube, it has often been found necessary to increase the pressure of the inspiratory phase to approximately 25 cm. of water owing to the increased resist-

ance, which in turn is the result of the smaller lumen. Accordingly, the interval between the sudden decrease in pressure and next inspiration is prolonged.

This mechanically controlled respiration has proved to produce efficient ventilation. It has been used in several thousands of cases. The venous return and the minute volume are not diminished to such



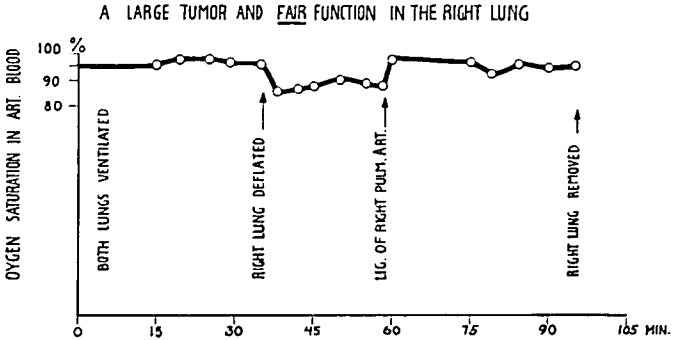


FIG. 12. *a*, A tumor can be seen involving most of the right upper lobe. *b*, Arterial oxygen determination during operation on the patient shown in *a*, demonstrating a fair shunt when the right lung is deflated. The shunt is eliminated by ligation of the right pulmonary artery.

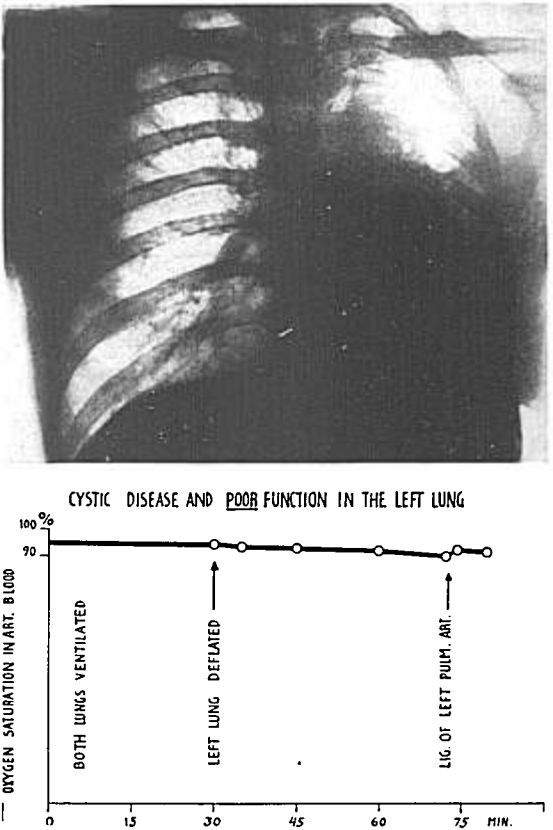


FIG. 13. *a*, Cystic disease of the left lung, with poor function. *b*, Arterial oxygen saturation during operation on the patient shown in *a*, demonstrated a negligible shunt of venous blood when the left lung was deflated. Ligation of the left pulmonary artery did not produce any significant change in the arterial oxygen saturation.

a degree as to decrease the arterial blood pressure. No untoward effect has been noted after operations of six to seven hours' duration. The efficiency of the ventilation has been demonstrated by analysis of the gases in the arterial blood at the end of intrathoracic operations. Samples were taken with the chest open and with controlled ventilation, just before the pleura is closed (table 1).

When one lung suddenly is deflated, the same amount of blood passes through the nonventilated lung without being oxygenated. In animal experiments it has been shown that a decrease of the blood flow through the atelectatic lung is noted only after many hours have elapsed. The blood, therefore, continues to circulate through the nonventilated lung and returns to the heart without being oxygenated, producing an arteriovenous shunt. It is possible to estimate the shunt by determining the oxygen saturation of the arterial blood. The magnitude of this shunt is dependent chiefly upon the function of the nonventilated lung.

In diseased lungs occasionally there may be some circulation even in nonventilated parts, but usually the blood flow through the pulmonary artery is diminished (2, 6). With the aid of an oximeter we have studied the relative changes of oxygen saturation in the arterial blood during operation in 20 cases. In some cases samples of arterial blood have also been taken and analyzed according to the method of Van Slyke and Neill to obtain absolute values of the saturation. Figures 11, 12 and 13 illustrate 3 cases in which the magnitude of the shunt is influenced chiefly by the supposed function of the diseased lung. In most cases the oxygen saturation returns to the normal level as soon as the pulmonary artery is ligated. If the healthy lung is in a good condition, deflation of the diseased lung has little influence on the oxygen saturation and the operation can be continued without inflating it again. In cases in which the condition of the better lung is not good enough for adequate oxygenation, both lungs are ventilated except during short periods for suction. These periods can be lengthened considerably without danger and suction can be much more carefully done when a double lumen catheter is used than when a single lumen catheter is employed.

Other factors may influence oxygen saturation as, for instance, kinking or compression of the bronchus on the healthy side. The main problem is to maintain free passage and good ventilation to the healthy lung during the entire operation, and we think this is more easily and safely accomplished with endobronchial than with endotracheal intubation.

SUMMARY

A new technic for endobronchial anesthesia has been developed and utilized in approximately 500 cases of lung resections. Indications for its use are given. The physiologic findings during controlled respiration and endobronchial anesthesia are discussed.

REFERENCES

1. Björk, V. O., and Carlens, E.: The Prevention of Spread during Pulmonary Resection by Use of Double-lumen Catheter, J. Thoracic Surg. **20**: 151–157 (July) 1950.
2. Björk, V. O., and Salén, E. F.: Blood Flow Through an Atelectatic Lung, J. Thoracic Surg. **20**: 933–942 (Dec.) 1950.
3. Björk, V. O.; Carlens, E., and Crafoord, C.: Open Closure of Bronchus and Resection of Carina and Tracheal Wall, J. Thoracic Surg. **23**: 419–428 (April) 1952.

4. Carlens, E.: New Flexible Double-lumen Catheter for Bronchospirometry, J. Thoracic Surg. 18: 742–746 (Oct.) 1949.
5. Crafoord, C.: On Technique of Pneumonectomy in Man, Acta chir. Scandinav. (Suppl. 54) 81: 1–142, 1938.
6. Keeley, J. L., and Gibson, J. G.: Experimental Atelectasis in Dogs, Survey 11: 527–543 (April) 1952.
7. Magill, I. W.: Anesthetics in Thoracic Surgery with Special Reference to Lobectomy, Proc. Roy. Soc. Med. 29: 643–653 (April) 1936.
8. Moody, J. D.; Trent, J. C., and Newton, G. W.: Endobronchial Balloon for Control of Bronchial Secretions during Lobectomy and Pneumonectomy, J. Thoracic Surg. 16: 258–264 (June) 1947.
9. Moody, J. D.: Endobronchial Occlusion during Pulmonary Resection, J. Thoracic Surg. 18: 82–89 (Feb.) 1949.
10. Nosworthy, M. D.: Anaesthesia in Chest Surgery with Special Reference to Controlled Respiration and Cyclopropane, Proc. Roy. Med. 34: 479–506 (June) 1941.
11. Overholt, R. H.; Langer, L.; Szypulski, J. T., and Wilson, N. J.: Pulmonary Resection in Treatment of Tuberculosis; Present-Day Technique and Results, J. Thoracic Surg. 15: 384–413 (Dec.) 1946.

(*Continued from page 52*)

Friday, April 10, 1953

Muscle Relaxants and Their Antagonists—Stuart C. Cullen, M.D., Professor of Surgery, Chairman Division of Anesthesiology, University Hospitals, State University of Iowa, Iowa City.

Newer Analgetic Agents and Their Antagonists—Curtiss B. Hickcox, M.D., Associate, Department of Anesthesiology, Hartford Hospital, Hartford, Connecticut.

Complications of Spinal Anesthesia and Their Treatment—Morris J. Nicholson, M.D.

Round Table—Complications to the Nervous System—Spinal and Nerve Injuries.

Morris J. Nicholson, M.D.—Moderator
E. M. Papper, M.D.—Anesthesiologist
Henry W. Dodge, Jr., M.D.—Neurosurgeon
Angus Wright, M.D.—Pathologist
Clarence J. Berne, M.D.—Surgeon

Round Table—Malpractice.

Douglass H. Batten, M.D.—Moderator
Stanley N. Barnes, J.D.—Judge of Superior Court
Harold Hunter, LL.B.—Trial Attorney
Louis Regan, M.D., LL.B.—Legal Consultant
John Feldman, M.D.—Industrial Surgeon
Charles F. McCuskey, M.D.—Anesthesiologist