ANESTHESIA FOR MITRAL COMMISSUROTOMY

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THE margin of safety during anesthesia for mitral commissurotomy is extremely narrow. In most patients undergoing this operation, pathologic changes in the cardio-respiratory system have resulted in pulmonary hypertension. The major pulmonary arteries show atheromatous changes; the small vessels show various changes ranging from simple muscular hypertrophy to hyalinization and fibrosis. Unless these serious anatomicophysiologic changes are understood, anesthetic agents might cause death before valvulotomy is accomplished.

All of the ability and skill of the anesthesiologist is required to administer anesthesia successfully to one of these patients. Anoxia is prevented by supplying the alveoli with an oxygen-rich atmosphere; blood pressure is maintained and adequate respiratory excursions guaranteed. Most important of all the functions of the anesthesiologist are: determination and maintenance of the optimum plane of anesthesia for successful completion of mitral commissurotomy; and the use of the *least* amount of anesthetic agents and technic as possible. When deep levels are reached, the strain on the cardiac patient is too great for his compensatory ability; serious arrhythmias appear or a progressive bradycardia threatens cardiac arrest. Light anesthesia is characterized by its lack of influence upon the cardiac mechanism.

Adequate oxygenation must be guaranteed in all anesthetized patients. During intracardiac procedures, an already deficient oxygen saturation caused by anatomic changes of the disease itself is partially remedied by filling the alveoli with an oxygen-rich mixture. Full expansion of the lungs not only insures delivery of these mixtures but also accomplishes the removal of any carbon dioxide which may have accumulated. Distention of the lung will prevent collapse with the resultant loss of oxygenating capacity through the atelectatic portion. During intracardiac procedures, the myocardium is repeatedly irritated by manipulation, suturing and cutting. This irritation to the pathologic heart causes irregularities of rhythm which are held in abeyance by delivering blood totally saturated with oxygen to the coronary circulation.

To satisfy myocardial oxygen demands during anesthesia, there are three basic requirements which are accentuated by the particular needs of intracardiac surgery. (1) Sufficient oxygen content is required in the breathing mixture. The 20 per cent oxygen content of atmospheric air may or may not be sufficient for the patient's basal needs. During anesthesia a mixture of greater oxygen concentration is delivered, but a point is reached when further increase is ineffective in increasing the percentage of oxyhemoglobin. Therefore, during anesthesia it is necessary to deliver an anesthetic mixture of gases containing 20 per cent, but preferably 40 or 50 per cent oxygen. The decreased

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cardiac output caused by a stenosed valve can be partially compensated by completely saturating the hemoglobin in the pulmonary circulation. (2) Adequate amounts of hemoglobin must be present in the blood to satisfy the demand of the tissues for oxygen. (3) An adequate circulatory pressure must be provided to distribute oxygen to the vital centers. Blood pressure must be maintained within normal levels.

Hypercarbia is prevented by the use of the carbon dioxide absorption technic. The lung is fully expanded by sufficient volume and pressure, aerating as much of the lung as is possible, consistent with good surgical exposure. Obliteration of the field by the lung is prevented by the use of surgical retractors. Any unexpanded areas of lung may simulate an arteriovenous shunt, producing hypercarbia and suboxygenation of the arterial blood. Without consideration of the physiologic limitations of the cardiac patient, such quantities might seem trivial.

The ideal depth of anesthesia is the lightest level that permits successful surgery.[1] George W. Crile[2] stated: "The paramount object of anoci-association is to reduce the toxic action of the general anesthetic and the traumatic factor of the operative manipulations to a minimum."

Major surgery requires: (1) preoperative sedation; (2) hypnosis or loss of consciousness; (3) analgesia; and (4) relaxation. Any agent or group of agents in minimal doses which meets these requirements and produces no real physiologic aberrations is satisfactory. In our hands no one single agent is capable, and we therefore use a group of agents in minimal doses to produce light planes of anesthesia.[2]

TECHNIC

Premedication. Demerol or morphine is administered two hours before surgery in doses according to weight and age. Atropine is not used in valvular surgery because the resulting tachycardia allows insufficient filling of the heart. One cc. of 1/2000 solution of prostigmin methylsulfate is injected subcutaneously one hour preoperatively. Nembutal is given orally three to four hours before operation.

Induction. All patients are induced in their respective rooms. Forty to eighty mg. of pentothal is injected intravenously; if the patient asks the purpose of the injection he is told it is routine medication. In no case is the patient informed that he or she is going to the operating room.

When sufficiently sedated, the patient is wheeled to the operating room. It is seldom necessary to use more than 80 to 100 mg. of pentothal during the interim.

Preparation in Operating Room. An infusion of 500 cc. 5 per cent dextrose containing 2 cc. neosynephrine[4] is started intravenously by extremely slow drip sufficient to keep the needle open. Electrodes are placed and the

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continuous electrocardiogram started. Noise and talking in the operating room are held to a minimum, and the patient repeatedly reassured.

Intubation. The larynx and pharynx are sprayed with 4 per cent cocaine solution under direct vision. When small doses of pentothal are given, direct visualization of the larynx is quite easy. Laryngospasm results only when larger amounts of pentothal are given. But when 25 to 50 mg. is administered, the laryngeal reflex is not excited and the parasympathomimetic qualities of the drug not displayed.

With adequate cocainization, a Murphy endotracheal tube equipped with a Sander's cuff is inserted into the trachea and a gauze bite block placed between the incisor teeth.

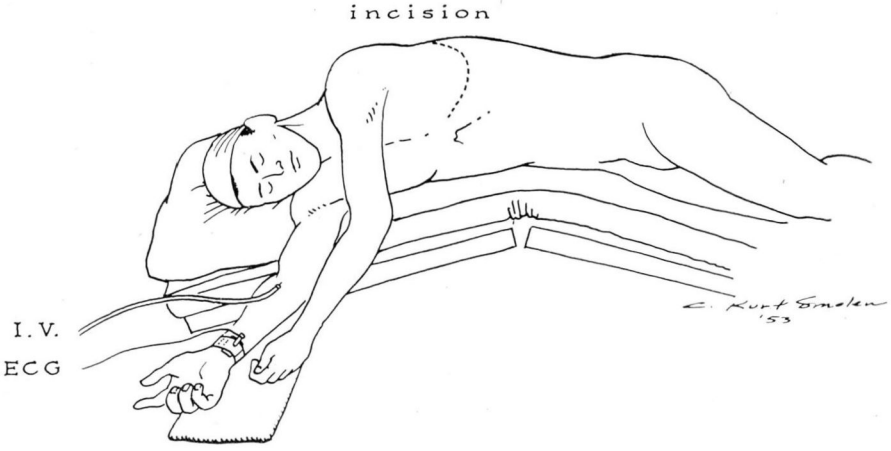

Fig. 1. Position of the patient for mitral commissurotomy showing sites of intravenous infusion and electrocardiograph electrode.

Positioning. Before other agents are given, the patient is placed in position by the surgical team. The right arm containing the intravenous needle is supported with an arm board extending from the table. The left arm, supported by a pad, is allowed to hang over the edge of the table and carries the scapula out of the surgical field.

Anesthesia. The level of hypnosis at this point varies but in the vast majority of cases, the patient will react to questioning by shaking his head and opening his eyes. Nitrous oxide (80 per cent) and oxygen (20 per cent) is started with a 5 L. flow. This overflow guarantees the percentage mixture, the nitrogen displacement with nitrous oxide, and the elimination of carbon dioxide. Variation of gaseous mixture is regulated according to the needs of the patient, but an oxygen concentration as high as possible is maintained at all times.

A mechanical respirator* can be interposed in the system. Curare is not necessary for its proper function and the patient will soon allow this machine

**The Rand Wolfe Respirator is used at the Clinic.*

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to take over respiration. The rate is set at 15 per minute. This slow rate is entirely satisfactory and is more constant and reliable than manual compression. Using a Rochester Model Heidbrink, the escape valve is set at 15 to 18 mm. pressure. The respirator with overflow of anesthesia gases guarantees the patient sufficient respiratory excursions, safe gas pressures, adequate oxygenation, and frees the anesthesiologist's hands for other exceedingly important duties.

The level of consciousness is lowered by pentothal and nitrous oxide, but the patient is never reduced to anesthesia levels where response to questioning disappears. Complete cortical release is avoided and the thalamic and hypothalamic reflexes are obtunded by this degree of consciousness. The intercostal space is infiltrated with procaine 1 per cent. The patient is unaware of the skin incision and pleural and visceral pain is not perceived.

Manipulation of the lung occasionally incites coughing. Restraint must be exercised not to inject superfluous quantities of anesthetic agents into the delicate balance so far secured. If the surgical field is too active, 1 or 2 cc. of d-tubocurarine is injected intravenously. Within a few minutes diaphragmatic and mediastinal activity lessens or disappears. The patient is quiet and perceives no pain. All nocuous physical and psychic stimuli have been excluded from the brain. The surgical field is quiet and mediastinal flutter nonexistent under light pentothal-nitrous-curare anesthesia.

If the patient fails to respond to questioning, the level of anesthesia is too deep. The concentration of nitrous oxide in the nitrous oxide-oxygen mixture is lessened from the 80/20 to ratios as low as 50/50. Within a few minutes the anesthesia will lighten to an optimum plane. When the patient is questioned about pain or discomfort, he denies its presence with a shake of his head. For the occasional patient in whom analgesia is insufficient, pentothal may be the immediate choice. This agent not only renders the patient totally unconscious, but also initiates the parasympathomimetic activities of the drug. Demerol or morphine lowers the basal metabolic rate, sedates the patient and raises the tolerance to pain. These agents permit any intrathoracic manipulation.

Occasionally nembutal or seconal is substituted for pentothal in the induction of anesthesia. Parasympathomimetic action is not predominant in these agents. The effect upon the vagus is minimal and laryngospasm and bradycardia become less of a hazard. However, the slow onset of hypnosis and delayed maximal effect render the agents difficult to use. Minimal calculated doses may turn out to be insufficient or excessive. To prevent such errors, oral nembutal is given for premedication and two hours later pentothal induces the anesthesia by fractional dose administration. The effect of this ultra fast-acting drug in 40 to 80 mg. doses can be instantly determined. Seldom is this amount depressive, and it can be immediately supplemented if found insufficient. To create the exact state of hypnosis requires an agent which can be easily administered and the effects of which are immediately evident.

During the closing of the thoracotomy wound, it is frequently necessary to reinforce the general anesthesia by local wound infiltration with procaine.

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The lungs are inflated by a continuous positive pressure varying between 5 and 20 mm. Hg. or prolonged positive pressure at the height of each inspiration, guaranteeing that no atelectatic areas remain. The thorax is then closed with this positive pressure until the "water-seal" suction apparatus is attached to a pleural catheter. The patient is moved from the right lateral position slowly and with great deliberation to avoid the hypotension which may be induced by position change. The respiratory tree is suctioned by inserting a catheter through the endotracheal tube. Long periods of suctioning are to be avoided. The patient at this time is fully awake and will cooperate by coughing. Extubation is performed as soon as is possible after the patient resumes the supine position. When the circulatory system is stable (characterized by adequate blood pressure and acceptable electrocardiographic readings) the patient is lifted to the bed and transported to the recovery room.

The tape recording electrocardiograph, a research model designed by Dr. W. L. Proudfit of the Department of Cardiovascular Disease at the Clinic, affords a continuous picture of the cardiac mechanism. The oscilloscopic screen depicts each contraction, and variation from normal can be instantly determined. The pulse is counted with each sweep of the screen. The continuous electrocardiograph of lead 2 on sound recording tape during surgery allows review by the internist at a later time.

DISCUSSION

Anoxia during anesthesia is to be avoided at all costs. Sufficient concentrations of oxygen are to be included in all anesthetic mixtures regardless of the type of surgery or the condition of the patient. Positive pressure respiration (manually or mechanically) sufficient to expand the lung during open thoracotomy and a circulation sufficient to carry an adequate supply of oxyhemoglobin to the tissues must be guaranteed. The mechanical respirator creates a simple respiratory cycle and can be adjusted as to rate and intrapulmonary pressure. By this means an adequate concentration of oxygen is delivered to the alveolar walls under sufficient pressure to fully expand the lungs rhythmically at a predetermined rate.

In the usual patient suffering from valvular stenosis, the red cell mass and hemoglobin are adequate. A tachycardia (which prevents adequate filling of the heart in diastole) and hypotension (stagnant anoxia) herald myocardial anoxia. Both are to be avoided with equal vigor to prevent changes in cardiac rhythm. Carbon dioxide retention is seldom a factor during this type of anesthesia. Soda lime absorption technics with a semi-closed positive pressure system minimize the probability of hypercarbia.

The level of anesthesia in many instances determines the outcome of the entire procedure. When the patient can react to questions and yet experiences no pain during commissurotomy, the ideal level is obtained. This statement sounds contradictory and inconsistent. During the actual commissurotomy, the patient shakes his head when asked if he is experiencing pain. Seldom is

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discomfort experienced except when skin is sutured without procaine infiltration. Cardiac arrhythmias during this light anesthesia are seldom in evidence. Frequently pre-existing arrhythmias will revert to a normal rhythm during anesthesia.

Other anesthetic agents are not utilized because they are neither necessary nor indicated. Nitrous oxide is a relatively inert gas producing no systemic changes in the body. Its anesthetic effect is of short duration, being exhaled within a few minutes. Few if any other anesthetic agents can qualify in this manner. Nitrous oxide is nonexplosive and does not affect cardiac conductivity or rhythm. It permits extra-coagulation of bleeding points,[3] which decreases operating time tremendously by rapid control of skin bleeding. Conversely, ether will cause pulmonary hypersecretion and all the resultant pulmonary dysfunction.[5]

In many instances the patient undergoing commissurotomy has tolerated a decreased peripheral circulation for a number of years. Adequate circulatory pressure, however, must be maintained to satisfy myocardial circulation. After valvulotomy the peripheral circulation and cardiac output is increased. Hypotension ensues and may progress to alarming levels. Blood pressure readings under 80 mm. Hg. are not well tolerated as evidenced by electrocardiographic changes in rhythm and rate. If further exploration or manipulation of the heart is performed during this period, exaggerated electrocardiographic variations appear and may persist for alarming periods in spite of the usual therapeutic measures. A rapid infusion of the neosynephrine/dextrose solution (.2 mg. in 500 cc. dextrose) converts a dangerous hypotension to a safe level.

Bradycardia may be produced by anoxia, in which case re-evaluating the oxygen concentration of the mixture constitutes a cure. Atropine sulfate increases the rate to safer levels when it persists below 60 per minute.

Tachycardia seldom occurs when prostigmin is given preoperatively. In most cases, the pulse rate is between 60 and 70 and seldom reaches 100 before valvulotomy. After the stenosed valve is fractured, it is not uncommon for the pulse rate to increase to 90 to 100 per minute. Rates above this figure occur concomitantly with an uncontrolled hypotension.

Pronestyl is used preoperatively. During anesthesia 2 cc. of 2 per cent procaine hydrochloride (40 mg.) is administered intravenously to control an arrhythmia such as ventricular tachycardia. Repeated injections of 40 mg. may be needed before the irritability of the myocardium decreases. When the integrity of the myocardium is compromised, as evidenced by ECG tracings of ventricular tachycardia, the surgeon is requested to desist. The patient is allowed to rest. The lungs are fully expanded and the entire gaseous mixture renewed.

With this type of anesthesia serious complications have been absent. Transient paroxysms of arrhythmias occur during fracture of the valves only to disappear spontaneously when surgical manipulation ends. Frequently this hypersensitivity is controlled by prophylactic use of procaine hydrochloride intravenously immediately preceding valvulotomy. In the last 50 cases using

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this type of anesthesia it has not been necessary to terminate any operation before a definitive procedure was accomplished. Cardiac arrest or other serious arrhythmias has not been encountered in this series.

Although the patients react to questioning during the valvulotomy, not one can recall anything about the operation. Usually they remember the venipuncture in their ward or room. Occasionally one remembers vaguely the bright lights of the operating room. None can recall the operation or pain.

SUMMARY

A system of pentothal-nitrous-oxide-curare anesthesia for mitral commissurotomy is presented; the salient feature of which is the light plane of anesthesia maintained with small doses of the agents. The patient is totally analgesic and amnesic, but will answer questions by shaking or nodding his head.

In no case in a series of 50 patients was it necessary to discontinue anesthesia before a definitive procedure was accomplished; nor was cardiac arrest encountered.

All patients were awake and extubated at the end of the operation.

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