ANESTHESIA FOR MITRAL COMMISSUROTOMY * † ‡ §

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INTRODUCTION

SUCH great strides have been made in cardiac surgery that its future is very bright indeed. Today we are able to operate not only upon but within the beating heart. With advances in cardiac surgery must come advances in anesthesia, built upon the experiences which many of us are now acquiring. Today we operate upon patients for mitral stenosis who only ten years ago would never have come to the operating room for any operation but the direst emergency procedure. These patients are being operated upon daily, and therefore it is advisable to study the results of cardiac surgery in these individuals. We have now operated upon 200 patients for mitral stenosis. No accident has occurred during the induction of anesthesia which required canceling a single case. No patient has died during anesthesia, and there have been no deaths within the first thirty-six hours after operation.

A total of 139 patients who had mitral commissurotomy has been analyzed, using the classification suggested by the American Heart Association and the New York Heart Association (1940). The distribution of the patients according to severity of the disease was as follows: 9 (6.5 per cent) had stage II disease; 91 (65.4 per cent) stage III disease, and 39 (28.1 per cent) stage IV disease. The total mortality, including late deaths during the follow-up period, was 17.3 per cent (24 patients). Of these 24 patients who died, 2 had stage II, 9 stage III, and 13 stage IV disease.

Seven of the 24 patients died while still in hospital after the operation; 3 of the 7 had stage III disease and 4 had stage IV disease. Four patients had fatal emboli (one peripheral and 3 cerebral); 5 patients had nonfatal cerebral emboli, and in 3 of these, permanent disability resulted.

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The average age of the 139 patients was 37.1 years. There were 78 females (average age 36.6 years) and 61 males (average age 37.7 years).

Management of patients for mitral commissurotomy must vary from group to group and depends largely upon individual experience and preferences of the various members of the surgical team. One of the most important factors for success is close teamwork between internist, surgeon, and anesthesiologist, each adding his particular knowledge to the over-all management of the patient.

PREPARATION OF THE PATIENT FOR OPERATION

Adequate preparation for operation and faultless judgment of the time for operation are essential prerequisites for success. Intervention too early, before the greatest improvement possible has been achieved, is as hazardous and deleterious to the patient as is undue delay of the operation after maximal improvement has been obtained.

A complete case history is obtained and a thorough physical examination is performed. Routine studies include roentgen examination and fluoroscopy. Electrocardiograms are taken and, if indicated, kidney and liver function tests are done. Cardiac catheterization has also been carried out on a number of patients but its routine use has been abandoned. Blood volume is determined, so that it may be corrected toward normal. The sedimentation rate is carefully followed during the patient's stay in the hospital. In some individuals the sedimentation rate had not been at a satisfactory level before operation despite all chemotherapy; nevertheless it was thought for other reasons that that particular time was the best for operation.

Preoperative treatment includes correction of any existing anemia, correction of electrolyte and water imbalance and of the patient's nutritional status. Cardiac function is improved to an optimal level by the use of glucosides, quinidine or procaine amide, diuretics, limitation of the intake of sodium, whichever of these may be indicated by the particular pathologic condition present. Antibiotics are used both locally and systemically when indicated. Potential foci of infection, such as those of the paranasal sinuses, teeth, gums, and urinary tract, are carefully searched for and when possible, infection is eliminated.

The patient must come to the operating room psychologically well adapted and in as cooperative a frame of mind as possible. He should be taught breathing and coughing exercises before operation, and should understand their importance in the prevention of postoperative complications, so that he may carry them out despite the acute discomfort they may cause after operation. He is also told that he will receive little in the way of narcotics in the postoperative period, his pain will be diminished but it may not be completely eliminated, and that the remaining discomfort is a small price for him to pay for the safety thus afforded him.

As an adequate transfusion system must be available during the operation, the state of the superficial veins should be determined before operation and preparations made for cannulization when indicated. Four or five units of blood should be available for instant use in case of emergency, although most patients do not require transfusions.

Preoperative medication is kept light, affording as much sedation as possible without depressing medullary functions. A small dose of barbiturates is prescribed the night before operation; one hour before induction of anesthesia, meperidine (demerol®) hydrochloride, 50 mg., and atropine sulfate, 0.4 mg. (g. 1/150 grain), are given. The dose of meperidine is adjusted to the individual requirement, and may be as little as 25 mg.; rarely, if ever, is more than 75 mg. given.

SPECIAL EQUIPMENT

The undeniable hazards of intracardiac surgical procedures and their seriousness and suddenness when emergencies arise require that certain specialized equipment be instantly available. The importance of an efficient transfusion system has already been stressed. This serves not only as an avenue for the fast administration of blood but also as an efficient and quick route for intravenous medication. Efficient pumps for delivery of blood under pressure must be in readiness; an intra-arterial transfusion set-up may be kept available, but we have never had occasion to make use of it. An electrical defibrillator is connected for immediate use, sterile electrodes being kept by the instrument nurse.

We keep the following drugs available for instant use: a number of vasopressors, among them methoxamine (vasoxyl®), desoxyephedrine, and phenylephrine (neosynephrine®) hydrochloride. Methoxamine is particularly valuable when vasopressor action is required in the presence of tachycardia. Epinephrine solution 1:1000, calcium chloride, 5 or 10 per cent solution, potassium chloride, 10 per cent, injectable quinidine, short-acting digitalis preparations, and atropine sulfate solution are available, as well as ouabain or strophantin K and aminophyllin. Procaine hydrochloride, 1 per cent, is used by the surgeon for infiltration of rib periosteum, pericardium, and myocardium, and 1 liter of procaine hydrochloride, 0.5 per cent, for intravenous infusion is part of the anesthetist's equipment.

Portable oxygen equipment is provided so that patients may be taken from their beds to the operating room and back without interruption of oxygen therapy, if continuous administration is advisable. Supplementary equipment such as the oximeter, the electrocardiograph, and machines providing artificial respiration are valuable adjuncts, but are by no means indispensable to the satisfactory management of these cases.

MANAGEMENT OF ANESTHESIA

The patient is placed in a comfortable position on the operating table. If necessary, anesthesia may be induced with the patient in the reverse Trendelenburg or semisitting position. Under local anesthesia, two intravenous infusions with 15 gauge needles are started. If the veins are collapsed or ill-defined, or if the patient is unusually apprehensive, an intravenous infusion may be started with an 18 gauge needle and through this the intravenous anesthetic agent can be administered. Before the patient is turned on his side, the two large gauge needles are inserted. We prefer to start the intravenous infusions with 5 per cent glucose in water; when indicated, one may be replaced by a solution of 0.5 per cent procaine hydrochloride in 5 per cent glucose in water. In recent months we have used intravenous administration of procaine less frequently than before, reserving it chiefly for those patients who show marked cardiac hyperirritability either before or during the operation and those who show evidence of reflex activity from operative stimuli.

Anesthesia is induced with thiopental (pentothal) sodium and a muscle relaxant. Our usual dosage of the muscle relaxant, dimethyl tubocurarine, is 6 to 8 mg. During the induction, oxygen is administered by mask. As soon as some evidence of curarization is noted by the patient, such as diplopia or difficulty in keeping the eyes open, thiopental is injected. In some instances, we have combined in one 20 cc. syringe, 6 to 8 mg. of dimethyl curarine with 500 mg. of 2.5 per cent thiopental. This is injected intermittently over a period of ninety to 120 seconds and the patient's reactions to each injection are observed. Oxygen is administered during the time the solution is injected; when respirations become depressed, they are assisted manually until a stage of marked relaxation has occurred and spontaneous respirations are almost completely absent. Then, controlled respiration is established for a period of approximately thirty seconds so as to ensure maximal oxygenation of the patient and elimination of as much carbon dioxide as possible. The dosage of the induction agents is varied depending upon the patient's over-all condition, cardiac status, body weight, size, muscle strength, and so forth. We prefer, however, to run the risk of a little excess thiopental and relaxant rather than have the slightest difficulty with the intubation. In those patients who are frightened by the face mask it is not applied until the patient has lost consciousness.

Oral endotracheal intubation is performed by direct vision using a cuffed endotracheal tube. The tube is quickly connected to the anesthetic apparatus and artificial respiration is continued with oxygen. The endotracheal cuff is then inflated if the depth of anesthesia is adequate. Otherwise inflation is delayed until sufficient depth of anesthesia has been attained to protect from autonomic reflexes.

It should be stressed that this technique of rapid induction and in-

tubation has not yielded evidence of unusual cardiac rhythm, cyanosis, or excess reaction to the endotracheal tube. The secret lies in careful timing, in the fact that the patient is adequately oxygenated, and that at the moment of intubation he is relatively deeply anesthetized from thiopental. We have seen few instances of fall of blood pressure and when a decrease occurred, it has been relatively slight.

Immediately upon intubation, expansion on both sides of the chest is checked. The color, pulse, blood pressure, and capillary refill time are noted, and the patient is then placed in the lateral position; he is turned very slowly and carefully. A pillow is placed between the legs; two pieces of adhesive tape, 3 or 4 inches wide, are applied near the iliac crest, split, and firmly attached to the table to hold the patient in position. A one inch pillow or towels are put into the right axilla to prevent obstruction of the veins and permit the use of this arm for additional intravenous fluids should they become necessary. The table is kept horizontal unless it is thought that a slight reverse Trendelenburg position would be advantageous. The left arm is placed on an adequately padded Mayo stand so that during the operation a slight pull can be exerted on the arm to abduct the scapula. No restraints, sandbags, or other apparatus are placed around the body. Frequently, and especially during warm weather, six to ten icebags are placed about the patient's body.

Ether, in extremely low concentrations, is gradually added to the oxygen mixture and is slowly increased over a period of five to ten minutes, depending upon the dose of thiopental given and the patient's reaction to it. In the first twenty minutes rarely more than 15 cc. is vaporized. When intravenous procaine is used, the rate of flow is usually increased gradually to about 70 to 90 drops per minute. Procaine and ether are added gradually so that the patient's reaction to these two agents can be observed. Undue rapidity in administration may cause vasodilatation and may necessitate the discontinuance of procaine or the increase of intravenous fluids to maintain blood pressure, both of which are undesirable. Controlled respiration is performed with a short positive phase and a long expiratory pause as this provides efficient circulation and encourages voluntary respiration. We prefer to supplement rather than control respiration when possible; however, when supplementary respiration cannot be done easily and efficiently, we do not hesitate to institute controlled respiration. Extreme care is taken to prevent hypoxia, hypercarbia, and hypotension.

The pulse is determined continuously. If the rate becomes unduly rapid or unduly slow, respirations are assisted more vigorously since we believe that hypoxia and hypercarbia are probably the two outstanding causes for deviation of the heart rate from normal. If tachycardia occurs, it indicates myocardial strain, increased carbon dioxide tension, or hypoxia. Since the lungs of many of these patients are diseased, even with apparently adequate respiration, carbon dioxide may be

present in excess. In these instances an increase in the amplitude or the frequency, or both, of respiration may correct the condition. At other times bradycardia may result from the same cause, although tachycardia more frequently occurs. Bradycardia is more likely to occur from manipulations in and about the heart, and will necessitate more vigorous assisted or controlled respiration. If the rate decreases below 60 per minute, however, we administer atropine intravenously in small increments, especially if the increased ventilation failed to result in a more satisfactory rate.

Blood pressure readings are taken, but are considered less significant than pulse characteristics and close direct observation of cardiac activity. Induction of anesthesia may be followed by a fall of blood pressure, but this is rarely severe or prolonged and is usually reversed by efficient assisted respiration. A second fall frequently accompanies placing the patient in position, but this too responds promptly to adequate ventilation with oxygen. Hypotension during and immediately after manipulation of the heart has frequently been noted, but does not call for special measures if blood and fluid replacements have been adequate and if signs of difficulty, such as pulse changes, sweating, air hunger, or retardation of capillary refill time, are not apparent.

Procaine is infiltrated freely in an attempt to prevent reflexes arising from the rib periosteum. Procaine is applied to the surface of the pericardium before the drug is injected at the site of the pericardial incision, taking care to avoid injury to the phrenic nerve. Procaine is then injected into the auricular appendage before any surgical manipulations are undertaken. It has been noted that procaine frequently causes irritation before depression of the myocardium. This drug is far from ideal for this purpose, or for topical application to the pericardium and myocardium. At no time should epinephrine or a similar agent be used in the local anesthetic solutions.

It is wise to deepen the anesthetic plane at the early phases of the operation, especially as the myocardium is approched, and gradually lighten the plane of anesthesia during the subsequent stages of the operation. Before the auricular appendage is palpated, pressure is placed bilaterally on the carotid arteries low in the neck so as to diminish the chance of a cerebral embolus. Pressure should be maintained for approximately fifteen seconds after the initial palpation. Pressure is also applied during the time that the surgeon's finger is passed through the mitral valve and maintained for as long as feasible during the finger fracture or the actual (commissurotomy with knife) valvulotomy.

After the valvulotomy (valve procedure) is accomplished, the blood is washed out of the chest with warm saline solution. The pericardium is closed very loosely. The intercostal nerves are blocked but care is taken not to get too close to the intervertebral foramen. We have been using lidocaine (xylocaine®), efocaine®, or similar agents for nerve block. Because of a number of adverse reports which have appeared

in the literature, recently we have discontinued the use of efocaine despite the fact that no difficulty has arisen from the use of this agent in our cases.

A drainage tube, usually of the mushroom catheter type is inserted into the chest. Care is taken that the tube is low in the thorax but not covered by the diaphragm, and that it is not placed too far posteriorly so that it becomes obstructed when the patient turns on his left side.

The lungs are carefully expanded before the closure; all areas are inspected carefully so as to diminish the chance of post-operative atelectasis. Care should be taken during expansion so not to press the lung into the claws of the rib approximator when it is used. A water seal is connected to the drainage tube so that the lungs can again be expanded gradually once the rib approximator is removed. Pressure is gradually increased during the positive phase until adequate negative pressure is obtained in the water seal bottle. The positive pressure should not be severe or maintained unduly long.

As soon as the closure of the pericardium is started, the anesthetic agent is changed to nitrous oxide and oxygen in approximately a 1 to 1 mixture; over a period of many minutes the nitrous oxide is gradually increased to 2 to 1 and finally 3 to 1. Pulse, respiration, and other physical signs are watched; oxygen concentration is increased if signs of difficulty, such as increase in pulse rate, appear. The total ether used is rarely in excess of 25 cc., and the average about 20 cc.

The rate of the procaine infusion is gradually slowed to about 40 drops per minute or less. With larger total dosage of procaine there is a gradually diminishing need for ether. Procaine seems to potentiate markedly the action of the muscle-relaxant used during induction. Most of our patients who have received procaine intravenously were given an average of 1.5 Gm. of the drug during the operative procedure.

Intravenous fluids are given sparingly. Five per cent glucose in water has been employed. The use of normal saline solution is avoided, especially if there is a history of myocardial failure. Blood is not given unless the estimated blood loss exceeds 250 cc. or the blood pressure is excessively low.

Tracheobronchial aspiration is repeated before the lungs are inflated. Tracheobronchial toilet is avoided if at all possible, but, if needed, it is best to aspirate secretions while the plane of anesthesia is still relatively deep. If toward the end of operation the endotracheal tube is poorly tolerated, the patient is hyperoxygenated and the tube quickly removed. Before this can be done, the anesthetist must be sure that the water trap is functioning, that the fluid level in the bottle is adequate, and that negative pressure is adequate.

POSTOPERATIVE MANAGEMENT

Most patients have reacted within five to six minutes from the time the last suture has been placed. They are reassured that everything

has gone well. The bed is brought to the operating room if possible and the patient is transferred directly from the operating table to the bed. Pulse, respiration, and the over-all condition of the patient are carefully watched and if evidence of any difficulty arises, the patient is not moved. Clamps are placed on the drainage tubes in the chest during the transfer. The intravenous infusions are maintained and are carefully watched so that they are not displaced. Oxygen may be administered during the return to the room if it is thought advisable.

As soon as possible after the patient is returned to his room, the water seal bottles are again put into use. Pulse and blood pressure readings are determined, as is expansion of the lungs. If necessary, slight positive pressure is applied by mask and negative pressure on the water seal to aid in the expansion, but this has been necessary only on one occasion as a result of a technical error. For oxygen therapy postoperatively we prefer to use the nasal catheter rather than the tent; however, in hot weather the tent may be used to keep the patient cool and comfortable, provided pharyngeal oxygen is given at the same time. A nebulizer is often employed for dispensing one of the wetting agents, such as alevaire®.

Fluids during the immediate postoperative period are continued very slowly. We give as little total fluid as possible. The usual order for relief of pain postoperatively is 25 mg. of meperidine. The patients talk and respond to command but as a result of the intravenous procaine, a degree of residual analgesia still prevails. Subsequent doses of meperidine are about 50 mg. "Stir-up" regimen is started immediately. The patient is asked to breathe deeply and cough vigorously. He is often asked to turn from side to side. Usually, postoperative pain is not too serious a problem with these patients, particularly when an anterior incision is used. When pain interferes with deep breathing and coughing, or if it causes much distress, paravertebral or intercostal blocks are performed. As soon as the patient is awake, he may have a pillow, and the reversed Trendelenburg position is adopted. Roentgenograms of the chest are ordered for later that afternoon and the following morning. A complete blood analysis is requested, and repeated searches are made for clinical evidence of thrombotic or embolic complications. Liquid oral feedings in small quantities may be given later in the afternoon or evening. The chest tubes are removed on the second day. Oxygen is discontinued gradually and the pulse rate is used as a guide in this. If the pulse does not accelerate, the oxygen may safely be discontinued.

CONCLUSIONS

From results in the series here presented, it seems quite obvious that the method of rapid induction for the operation of mitral commissurotomy is a relatively safe procedure, provided certain safeguards, especially with regard to adequate oxygenation, are carefully

observed. In no case in this entire series was it necessary to cancel an operation because of difficulty or untoward reactions on the part of the patient during induction or maintenance. Some patients have been easier to manage than others, but no situation arose which was beyond our control. The present outline of management is presented as a suggestion because of its apparent safety in the presence of adequate precautions.

REFERENCE

1. Julian, O. C.; Dye, W. S., and Grove, W. J.: Selection of Patients for Mitral Commissurotomy in Relation to Clinical Results, Arch. Surg. 69: 273 (Sept.) 1954.