POSTOPERATIVE CARE OF THE OPEN-CARDIOTOMY PATIENT

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OPEN-CARDIOTOMY patients require a postoperative program that is individualized and meticulously supervised. There are no rules that can serve as a fixed guide for proper care. Experience in 103 operations, in 86 of which we performed elective cardiac arrest with potassium citrate,[1,2] has established for us a set of procedures useful in the postoperative care. It is the intent of this paper to elaborate upon these basic observations. It is not necessary to review the general care of patients recovering from thoracic surgical procedures; our interest is confined at present to patients who have undergone open cardiotomy. The details of this postoperative program are of particular import in the care of children; adults do not require such precise attention, as their larger body mass makes small variations relatively less important.

Immediately Postoperative Care

The changes in patients during the hours immediately after open cardiotomy are sufficiently rapid and severe that it is mandatory to have a qualified team in constant attendance. This is best accomplished with a special-care unit designed and equipped exclusively for these patients. The basic team should include a resident physician well trained in thoracic surgery, and experienced nurses who are particularly interested in the field of cardiac surgery. A fortunate selection of capable personnel may be rewarded by a self-perpetuating system as the service demands grow. A detailed description of the equipment will not be given here; suffice it to say that the usual implements of the recovery room are basic and must be augmented by such specialized equipment as Croupettes, intermittent positive-pressure-demand valves (such as the Bennett device), a large-screen monitor for the electrocardiogram, and specialized emergency pharmaceuticals. Equally as important is the need for prompt and accurate laboratory support that will include the radiologic services, blood bank facilities, and the all-important clinical laboratory. Without this extensive and expensive basic support, the mortality rate of open-heart operations will soar.

Although there is still much to be learned about the care of these patients, we have tried to consolidate our observations under three headings that we consider to represent the basic guiding principles of management.

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1. Establishment of minimal metabolism to lessen cardiac work. During the first 24 postoperative hours the traumatized myocardium has a better opportunity to perform its functions if it is spared sudden or excessive demands. In patients with severe pulmonary hypertension, avoidance of effort may make the difference between survival and death. It has been our misfortune to have two patients die while they were being needlessly disturbed. For this reason we temper our zeal for examination by avoiding any act that imposes strain or emotional stress on the patient. Excess activity is prevented by giving the patient sedatives for restlessness. In children, aspirin given rectally frequently is effective; otherwise, we use meperidine (Demerol) hydrochloride or small doses of a barbiturate. The frequent occurrence of hyperpyrexia in the early postoperative hours necessitates frequent recordings of the body temperature. It is well to note that electrical devices may become unreliable and body temperature should be repeatedly checked with a mercury thermometer. Aspirin given rectally and the use of a cool oxygen tent generally suffice to prevent an undue rise in temperature. However, if fever persists, alcohol sponging or ice packs are employed. In our experience, the ice-water mattress has proven unsatisfactory. Hypopyrexia in the patient with a small body mass may be just as serious a problem, particularly in the immediately postoperative period. It is our impression that hypopyrexia in part causes or aggravates cyanosis and metabolic acidosis. We make every effort to raise the body temperature of a cold patient by using hot-water bottles or warm blankets.

2. Establishment and maintenance of cardiovascular stability. To establish a base line, careful preoperative and postoperative weighings of children are performed. A close balance is established between the amount of blood lost and the amount transfused during operation. This blood replacement must be consistent with optimal filling of the cardiovascular system, as evaluated while the chest is open. The balance between blood lost and blood replaced will be a direct guide to additional transfusions during the postoperative course. The clinical evaluation of the cardiovascular system at operation, when the heart and the great vessels can be seen and palpated, is a reliable guide. It is our practice to use high saphenous vein cannulations on all of our patients. A constant recording of the central venous pressure is then obtained and is a helpful guide to the status of the blood volume and cardiac dynamics. A corollary to establishing a careful base line is to establish careful postoperative control. Hemoglobin and hematocrit determinations are performed immediately after operation. Using chest suction of from 10 to 15 cm. of water and bilateral trap bottles, the amount of bleeding from each side of the chest is carefully recorded and blood replacement made as indicated. This method is of particular value in children, in whom even small blood loss is important. Additional adjuncts include frequent recordings of the blood pressure, pulse, and a visual electrocardiographic recording for the first few hours. Excessive postoperative bleeding in the open-cardiotomy patient is a worrisome complication and of far greater significance than when encountered in standard thoracotomy procedures. This is in part due to the extensive operation itself, but also to acquired tendencies

to bleed which may be induced by the heparin, the pump-oxygenator, or the multiple transfusions. Meticulous hemostasis is a surgical necessity. When unexpected bleeding occurs, clotting time should be determined. The possibility of "heparin rebound"[3] should be considered and additional protamine may be required. Excessive bleeding in spite of an adequate clotting time must be regarded as a technical problem and prompt reoperation must be considered.

3. Establishment and maintenance of an optimal respiratory function. Adequate oxygenation and prevention of significant laryngeal edema have been accomplished by the use of cold humidified oxygen administered by the Croupette for children and the Melco nebulizer for adolescents and adults. Tracheotomy is useful for those patients who develop bronchorrhea or pulmonary edema. Prophylactic tracheotomy facilitates tracheal toilet; it also permits the use of intermittent positive pressure to supplement the natural pulmonary exchange. It is particularly helpful in those patients who manifest severe pulmonary hypertension prior to operation; such patients are prone to "wet lungs" during the immediately postoperative period. We have intravenously administered a constant drip of aminophylline for the first 12 to 24 hours in an attempt to decrease the pulmonary hypertension and thereby lessen the load on the traumatized right side of the heart; however, we are not convinced that this procedure is beneficial.

Incisional pain during the first 24 hours may severely limit pulmonary excursion, particularly in older children and adults. Intercostal nerve blocks, repeated as needed, will add to the patient's comfort and improve respiratory exchange. Occasionally, a positive-pressure respirator of the demand type may be effective in improving an otherwise inadequate ventilation. A portable anteroposterior chest roentgenogram is taken from four to six hours after operation to evaluate pulmonary expansion and thoracic drainage.

Gastric distention is a common and unpleasant complication. In all patients, a gastric tube is left in place for from 24 to 36 hours, after which time oral feedings are started.

Fluid and electrolyte imbalances have not been a major problem. We routinely use 5 per cent dextrose or fructose in water as the intravenous solution. Saline solution should be avoided. Unless these patients have polycythemia, they are kept slightly underhydrated. In calculating the fluid requirements, it must be remembered that the amount of insensible water loss is decreased while the patient is breathing highly humidified air.

Surgery with extracorporeal circulation usually is associated with some degree of metabolic acidosis. The effect of the procedure on serum carbon dioxide content depends in part on the type of oxygenator employed, as each oxygenator varies in the amount of carbon dioxide it releases during the oxygenation process. When more carbon dioxide is released than normally would be released through the alveolar membrane, a partial balance is established between respiratory alkalosis and metabolic acidosis. Thus, the changes in the pH of the serum vary with the type of oxygenator. As a general rule, unexpected cyanosis suggests the presence of significant acidosis, and prompt pH determina-

tions of the serum are indicated. If the determinations confirm the clinical suspicion, a sodium bicarbonate infusion is given.*

Antibiotics are included in routine care. It is our practice to begin the course of antibiotics two days prior to operation and to continue for about one week. The usual antibiotic therapy is a combination of penicillin and streptomycin.

If the patient's condition appears to be stabilized on the evening of the day of operation, the constant recording of temperature and the electrocardiographic tracing may be discontinued. If bleeding is no longer a problem, the chest suction is discontinued and the thoracotomy tubes are then connected to waterseal drainage.

Later Postoperative Care

After the first day postoperative care becomes an individual matter that depends entirely upon the patient's progress. The need for oxygen is extremely variable and in most cases its administration will be reduced or terminated within 24 hours. Cold steam, however, may be required for an indefinite period in those patients who demonstrate pulmonary vascular changes. An upright chest roentgenogram is desirable on the first postoperative day if the patient's condition permits. There is little doubt that a good roentgenogram is of greater value than the most skilled physical examination. Diet is another individual matter and will be influenced by the presence and persistence of gastric dilatation. An effort is made to start clear liquids by mouth within 24 hours. By from 36 to 48 hours postoperatively, the thoracotomy tubes usually have stopped functioning and are removed. For a child we do not use a low-salt diet unless there is evidence of cardiac failure or unless such a diet had been used prior to operation.

Digitalis is used only if it had been given preoperatively or if there is evidence of cardiac failure. If the patient is progressing satisfactorily, movement in bed is encouraged on the second postoperative day, and on the third day after operation ambulation gradually is begun. Chest roentgenograms and electrocardiograms are taken as indicated by the patient's clinical course. A complete electrocardiogram and chest roentgenograms for cardiac size are taken before the patient is discharged from the hospital. This discharge occurs in the uncomplicated cases about two weeks after operation.

Complications

Open cardiotomy is associated with many postoperative complications, some of which already have been mentioned but merit repetition. A temperature running as high as 104 degrees Fahrenheit without known specific etiology

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**Sodium bicarbonate, in an amount equal to 4.5 milliequivalents per liter per kilogram of the patient's weight, administered intravenously for a period of two to six hours has proved satisfactory.*

is common. This usually is self-limited and subsides within five days; if the fever is severe, aspirin can be given in regular doses for its control.

As stated before, metabolic acidosis is a common problem and usually occurs in the immediately postoperative period. The exact cause of this acidosis is not entirely understood but inadequate perfusion, prolonged hypotension, and inadequate ventilation are known contributory factors. Metabolic acidosis will be reflected by a drop in the pH of the serum, and we believe that the laboratory facility for this determination is mandatory. In most cases, the pH will rise and the patient's condition will improve after the administration of sodium bicarbonate. Persistent acidosis is an ominous finding and implies irreversible damage, the exact nature of which is poorly understood.

A combination of fever, cough, chest pain, and roentgen evidence of a bilateral patchy pneumonitis occurs in a number of cases. This syndrome closely resembles the postmitral commissurotomy syndrome. This also appears to be a self-limited disease, but lasts from one to three weeks. Therapy consists of the usual doses of aspirin or, if not controlled by this drug, steroids are given in doses sufficient to overcome the signs and symptoms.

Acute and subacute bacterial endocarditis occurring in either traumatized valve leaflets or intracardiac suture lines is a grave complication. Treatment is the same as for any other case of subacute bacterial endocarditis, that is, supportive measures with massive doses of bactericidal antibiotics. *Aerobacter aerogenes* was isolated from our only proven case.

Chylothorax occurring from eight to ten days postoperatively complicated two of our cases. It is our belief that the thoracic duct, or a major radical, was damaged inadvertently during the dissections for cannulation of the subclavian artery. The insertion of a water-seal drainage tube, as reported by one of us (D. B. E.),[4] has been effective treatment.

Cardiac failure may result as a consequence of altering the cardiac dynamics during the open-heart procedure. The common causes of cardiac failure are: (1) severe pulmonary hypertension with fixed resistance, (2) residual outflow obstruction of the right ventricle, and (3) uncorrected mitral or tricuspid insufficiency. This complication is manifested by elevation of the venous pressure, enlargement of the liver and, in the acute phase, air hunger and poor color. Obstruction to the right ventricular outflow tract, which is not completely relieved at the time of operation or perhaps is produced by the surgical procedure, should be suspected when there is a significant gradient between the ventricular and the pulmonary artery pressures after operation.

Heart block of varying degrees is not at all unusual; however, complete atrioventricular dissociation has occurred only nine times in our series, and it has been permanent in only three patients. The action of isopropylarterenol (Isuprel) hydrochloride, although not consistent, is at times of value in increasing the ventricular rate.

Summary

The open-cardiotomy patient requires individualized attention. Our postoperative care is based upon three principles:

1. Establishment of a minimal metabolism to lessen cardiac work.
2. Establishment and maintenance of cardiovascular stability.
3. Establishment and maintenance of optimal respiratory function.

The postoperative complications are many; the most significant ones are: (a) a febrile course resembling a postmitral commissurotomy syndrome, (b) acute or subacute bacterial endocarditis, and (c) cardiac failure.

References

1. Effler, D. B.; Groves, L. K.; Sones, F. M., Jr., and Kolff, W. J.: Elective cardiac arrest in open-heart surgery; report of three cases. Cleveland Clin. Quart. **23**: 105-114, April 1956.
2. Kolff, W. J.; Effler, D. B.; Groves, L. K., and Moraca, P. P.: Elective cardiac arrest with potassium citrate during open-heart operations; report of thirty-seven cases. J.A.M.A. **164**: 1653-1660, Aug. 10, 1957.
3. Kolff, W. J.; Effler, D. B.; Groves, L. K.; Peereboom, G., and Moraca, P. P.: Disposable membrane oxygenator (heart-lung machine) and its use in experimental surgery. Cleveland Clin. Quart. **23**: 69-97, April 1956.
4. Effler, D. B.: Chylothorax; a conservative method of management. Cleveland Clin. Quart. **19**: 6-11, Jan. 1952.