INDICATIONS FOR THE USE OF FLUIDS AND BLOOD BEFORE AND DURING OPERATION¹

KAI REHDER, M.D.,² and THOMAS H. SELDON, M.D.³

THE RESPONSIBILITY of the anaesthesiologist should not begin in the operating room. He should visit the patient preoperatively, review the medical history, and carry out a thorough examination if he deems it advisable. This preliminary visit of the anaesthesiologist to the patient has many facets and is most helpful in determining the need for fluids and blood.

In this presentation we are concerned primarily with three aspects of the use of fluids and blood transfusions. They are (i) the special indications for use of fluids and certain drugs before and during operation, (ii) the indications for blood transfusions during the same two periods with comments on the emergency use of substitutes and transfusion reactions, and (iii) practical hints concerning supportive measures.

FLUIDS AND CERTAIN DRUGS

The medical record plus the physical examination of the patient will reveal much information about the status of hydration and the blood electrolytes of the patient before operation. This is important as shown for instance in the recent reports of Keating and Tang (1) on neostigmine-resistant apnoea in the presence of hypokalaemia and the report of Foster (2) who presented evidence for a possible central action of curare with low levels of serum potassium in patients

Vomiting, protracted diarrhoea, gastric or intestinal suction, gastro-intestinal fistulas, unusual sweating, and burns are frequently accompanied by disturbances in the volume of the body fluids and with changes in the ion composition of the blood. Cardiac failure, cirrhosis of the liver with ascites, and renal insufficiency often also cause imbalances of the body fluids and blood electrolytes. Diseases of the endocrine glands especially are associated with disturbances of the body fluids and electrolytes. Diabetes mellitus and adrenal insufficiency are of major importance. All these conditions demand appropriate treatment. We shall restrict our discussion, however, to diabetes mellitus, adrenal insufficiency, water requirements of children after cardiac operations, and the changes associated with general anaesthesia.

Diabetes Mellitus

The surgical risk for patients with diabetes mellitus is not much increased if proper precautionary measures are taken. The blood sugar of any diabetic

¹Read at the meeting of the Canadian Anaesthetists' Society, Montebello, P.Q., May 4, 1959.

²Fellow in Anesthesiology, Mayo Foundation, Rochester, Minn. The Mayo Foundation is a part of the Graduate School of the University of Minnesota.

³Section of Anesthesiology, Mayo Clinic and Foundation.

patient should be checked before the operation, and no diabetic patient should undergo elective surgery unless his diabetes is under control. If a patient ordinarily takes a hypoglycaemic drug by mouth, administration of the drug should be discontinued, and the patient should be given insulin until he recovers from the operation which may require several days. Administration of insulin then may be discontinued, and oral medication may be started if the patient particularly requests it and his condition will tolerate it.

At the Mayo Clinic if possible all diabetic patients are scheduled for operation early in the morning. They receive a third to a half of the dose of their particular type of insulin on the morning of the operation. Breakfast is withheld. During the operation the patients receive by intravenous drip a 0.9 per cent solution of sodium chloride, or if sodium chloride is contraindicated, 5 per cent solution of glucose in distilled water. When 1,000 cc. of the 5 per cent solution of glucose is given, 10 units of regular insulin is added. Before the intravenous drip of 5 per cent glucose solution is started in the operating room, a sample of blood is withdrawn to determine the fasting level of the blood sugar. If administration of the glucose has been started inadvertently before the sample of blood has been taken, blood should be taken from another vein or preferably from another extremity to avoid faulty determinations of blood sugar due to glucose in the needle or in the particular vein used. If the patients receive only the 0.9 per cent solution of sodium chloride, blood is withdrawn for a determination of blood sugar 1 hour after operation. These determinations of blood sugar and the concentration of sugar and ketone bodies excreted in the urine postoperatively serve as a guide for the insulin requirements of the patient for the balance of the day.

If the patient does not regain consciousness as quickly as one would expect or if he reacts otherwise abnormally in the immediate postoperative period, hypoglycaemia must be suspected. A determination of blood sugar quickly establishes this possibility. The appropriate treatment is intravenous administration of glucose to combat this complication.

Adrenal Insufficiency

Adrenal insufficiency due to organic diseases of the adrenal cortex or the pituitary gland, or to suppression of adrenal function resulting from treatment with cortisone or similar compounds, presents special problems for the anaesthesiologist. An adrenal crisis may develop during the operation or during the postoperative period. When a patient has received cortisone or a similar compound in a physiological or larger dose for five to six days, one should assume that a significant suppression of the adrenal cortical function has taken place. Physiological doses of the commonly used steroid medicaments are: 25 mg. of cortisone daily, 20 mg. of hydrocortisone daily, or 5 mg. of prednisone daily. The suppression of the adrenal cortical function may last three to four weeks after administration of these medicaments has ceased. It is wise, however, to prepare patients for operation with parenteral administrations of cortisone if they have received suppressive doses of cortisone within six to eight weeks prior to operation. The cortisone is given intramuscularly in doses of 200 mg. one to two days

prior to operation and on the morning of the operation. During the operation the patient receives a 0.9 per cent solution of sodium chloride intravenously.

If the dose of cortisone which the patient received prior to the planned operation does not warrant preparation of the patient with cortisone, that is, if he received less than a physiological dose or if the interval between the last administration of cortisone and the operation is more than eight weeks, then certain other precautions are taken. The 0.9 per cent solution of sodium chloride is given intravenously during the operation. In case of impending or true shock, 100 mg. of hydrocortisone in 1,000 cc. of 0.9 per cent solution of sodium chloride is given intravenously. This solution is run in at a rate to provide 15 mg. of hydrocortisone or more per hour. The patient should be treated like a patient in adrenal crisis.

If the patient who has received suppressive doses of cortisone withstands the operation uneventfully, there is no need for a tapering-off of the cortisone medication postoperatively, but the blood pressure and pulse rate must be checked every 30 minutes for the first 24 hours after operation. The tapering-off, however, is imperative in that group of patients who suffer from adrenal insufficiency due to organic disease of the adrenal cortex or the pituitary gland. For such patients the dose of cortisone is diminished day by day until the patient's maintenance dose is reached (3).

Water Requirements of Children after Cardiac Operations

Sturtz and co-workers (4) found that 500 cc. of 5 per cent solution of glucose in water per square meter of body surface for the first postoperative day and 750 cc. on each of the second and third postoperative days kept patients in a near zero water balance, provided there was no unexpected loss of fluid. If there was abnormal loss of fluid, their patients were in negative water balance, which the authors thought most desirable for the days immediately after operation. They estimated the water balance by daily changes of the patient's body weight. They found this the simplest and most accurate clinical means of assessing the water requirements.

General Anaesthesia

The effect of general anaesthetic agents plus the stress of the operation will produce an increased secretion of the adrenal hormones. These hormones will cause increased retention of sodium and water and increased loss of potassium by renal excretion. The posterior lobe of the pituitary gland is stimulated and releases antidiuretic hormone. This hormone leads to a further retention of water. These factors associated with general anaesthesia explain the postoperative retention of water. The anaesthesiologist, therefore, should restrict the administration of fluids according to the loss of fluids.

Unless other methods are indicated, all patients who undergo major surgical procedures at the Mayo Clinic are given 5 per cent solutions of glucose in distilled water or in 0.2 per cent solution of sodium chloride. Postoperatively the fluid intake is guided by the patient's output and by changes in the patient's weight. If protracted intravenous administration of fluids is indicated, atten-

tion must be paid to the plasma electrolytes. The potassium level, for instance, is elevated during the day of the operation and from the second day on it is decreased. If the patient needs prolonged intravenous therapy because he is unable to take fluid by mouth, then the serum potassium level should be checked. If the renal output is adequate and if the serum potassium level is low, then potassium should be given intravenously. Potassium can be given as potassium chloride or phosphate. It is given in doses of 40 to 80 mEq. per day. Not more than 40 mEq. are given per litre at a rate of about 500 cc. per hour.

BLOOD TRANSFUSIONS

Many physicians have an ever-increasing concern about the number of transfusions being administered to patients in Canada and the United States. Unfortunately, at times it seems that unnecessary transfusions of blood are being given. Recently we heard of a transfusion being administered before the patient left the hospital only because the patient had a credit of 1 pint (500 c.c.) in the blood bank. Of course, this is the extreme example. In 1956, nearly 5,000,000 transfusions were administered in the United States. This number seems to be increasing faster than the population increases. A real indication should be present before blood is requested for a patient.

Not infrequently the anaesthesiologist at the time of his preoperative visit to the patient may need to request some laboratory tests and, on occasion, blood transfusions, or he may request that blood be cross-matched in anticipation of needing it during the operative procedure.

The three principal purposes for transfusion of whole citrated blood to patients anticipating or undergoing a surgical procedure are to increase (i) the oxygen-carrying power of the blood, (ii) the volume of the circulating blood, and (iii) the protein content of blood.

To Increase the Oxygen-Carrying Power of the Blood

Transfusions for this purpose are indicated for patients who have reduced values for haemoglobin and erythrocytes in the blood as in conditions such as acute and chronic anaemia, severe haemorrhage, certain blood dyscrasias or defective formation of blood. It is good practice to provide transfusions of whole blood for patients who are in need of more haemoglobin and erythrocytes when their physiological mechanism cannot produce these two products or cannot produce them soon enough. This is particularly true when the patient is seriously ill or is being prepared for operation.

Certain extremely anaemic persons, who have erythropania as well as a deficiency of haemoglobin, normally experience some difficulty in breathing. This difficulty will be increased when the patients are under the exertion associated with anaesthesia and operation if the anaemia is not corrected preoperatively. For such patients transfusions of whole blood are indicated.

To Increase the Volume of Circulating Blood

The maintenance of proper blood volume depends to a large degree on an adequate reserve of fluids in the tissues. Therefore, the correction of a state of

dehydration, anaemia, or hypoproteinaemia is of real importance. A reduction in the volume of circulating blood may result from a slow or sudden haemorrhage or from traumatic or operative shock.

The intravenous injection of blood into a patient with a normal heart produces exactly the opposite effect of haemorrhage. The immediate results are increased venous and right atrial pressure, increased ventricular inflow, and increased cardiac output. The increased cardiac output is directly related to the rate of transfusion and the total volume administered.

In the case of a damaged myocardium, sometimes cardiac failure may result from even a very small transfusion. If the blood volume is excessively increased, the left side of the heart becomes dilated and sometimes fails acutely.

If more than a third of the blood volume is lost during an acute haemorrhage, death usually results unless the blood volume is replaced quickly. When haemorrhage is slow, however, the loss of two-thirds of the volume of blood may be withstood because of peripheral vasoconstriction and the pouring of intracellular fluid into the vascular system.

The time to start replacing blood is when the pulse rate first increases. If one waits until the arterial pressure begins to fall, one is confronted with the treatment of hypovolaemic shock, rather than its prevention.

A simple observation which confirms the presence of a reduced blood volume is the poor distension of the veins on the dorsum of the hand, particularly when the hand is allowed to hang downward from the patient's side (5).

In general, a patient in shock with a systolic blood pressure of less than 85 mm. of mercury, usually indicates a loss of at least 25 per cent of the blood volume. In the average adult this loss is in the neighbourhood of 1,500 cc. A satisfactory response to transfusion usually raises the arterial systolic pressure 10 to 20 mm. of mercury for each 500 cc. of blood transfused.

Vasopressor drugs may have an undesirable effect when given to support a falling blood pressure in the presence of oligæmia. They, therefore, are not indicated in the treatment of shock consequent to loss of blood volume while waiting for compatible blood. Instead, one of the electrolyte solutions or blood volume expanders should be used (6).

Since the decrease in the blood volume itself, and not the decrease of erythrocytes, is the prime cause of death in such cases, the important point is to re-establish the volume of circulating blood quickly. In this way the patient's life may be saved until compatible blood for transfusion is made available.

To Increase Content of Protein in the Blood

Occasionally it is wrongly assumed that an intake of protein that is adequate for a healthy person is also adequate for a sick person. It is advisable to establish proper values for protein in the circulating blood prior to operative procedures and to maintain them during convalescence. If the amount of protein is inadequate, the tendency to shock is greater, and oedema of the intestines and other tissues may cause disruption of incisions, delayed wound healing, and reduced resistance to infections. It is possible to restore the total amount of protein in the blood of hypoproteinaemic patients by the intravenous administration of sufficient amounts of plasma proteins.

Assuming oral alimentation is impossible, the patient should receive no less than 100 cc. of blood for every pound of weight lost gradually during the two months before operation.

A transfusion of 500 cc. every second day is good treatment. If an emergency operation is impending, give 500 to 1,000 cc. of blood and follow with more blood during the operation (7).

Untoward Reactions

No matter how well a transfusion service supervises the laboratory work and no matter how well the administration of the blood is carried out, a certain calculated risk of an untoward reaction exists. In most institutions a 3 to 5 per cent reaction rate is accepted. In many instances, these untoward reactions may be hard to recognize. Their recognition is particularly difficult if the patient also is under the effects of a general anaesthetic. However, reactions do occur even when the patient is unconscious from a general anaesthetic, and a careful observer should recognize an untoward effect even then.

Untoward reactions are more likely to occur in the presence of certain conditions such as blood dyscrasias or chronic ulcerative colitis, after multiple transfusions or after one transfusion of several bottles of blood. The trend of the times, it seems, is for transfusions to be requested more and more frequently. It is the consensus of many that with this increase of transfusions, the difficulties of finding compatible donors in certain instances and the possibility of untoward reactions may become more and more evident.

At the Mayo Clinic we are conservative in the use of blood transfusions. In certain conditions involving thoracic surgery and cardiac surgery, we are careful not to overload the patients with blood. On the other hand, our experience also has led us to believe that certain surgical procedures such as operations on the hip, extensive dissections in the neck, laryngectomies and various other operations warrant the use of blood transfusions almost routinely as supportive therapy.

Transfusion reactions are of five categories, namely, hyperthermic or pyrogenic, allergic, circulatory, haemolytic, and an undetermined category that includes many bizarre happenings which do not fit into any of the other four categories. In a series of 8,222 transfusions the reaction rate at the clinic was 3.9 per cent.

It is not within the province of this presentation, however, to go into the care and treatment of patients who have had an untoward effect from the transfusions.

PRACTICAL HINTS CONCERNING SUPPORTIVE MEASURES

Technique of Administration

Physicians often do a very poor or inefficient venipuncture. Unfortunately, little or no instruction in the proper technique of introducing a needle into a vein is given to the intern. Too frequently we encounter advanced graduate students who still have not learned to do this procedure with finesse. As anaesthesiologists it behooves us to stress this particular procedure, because it may mean ability to carry out intravenous supportive therapy without sacrificing a

vein by cutting down to introduce a needle or plastic catheter. Cutting down on multiple veins is seen occasionally. This not only disfigures the patient but also has caused permanent loss of some veins.

In the event of marked peripheral vasoconstriction, shock, or other cause as a result of which the veins are unduly small or collapsed, hot packs applied to the extremities almost invariably will dilate the veins sufficiently to permit easier access to the lumen.

Another aid is to let the extremity hang in a dependent position to help engorge the veins. After the hot packs are removed, a warmed antiseptic solution should be applied as it will not produce so much vasoconstriction as a cold antiseptic solution will. Anyone having experienced the painful introduction of an 18-gauge or 15-gauge needle will appreciate the use of a cutaneous and subcutaneous injection of an anaesthetic solution before the needle is inserted intravenously.

In the event that it is desired to administer fluids intravenously for several days, a polythene tube may be introduced into the vein by threading the tube through a 15-gauge or 16-gauge needle already inserted in the vein.

The Plastic Needle

A later addition to the armamentarium is the plastic needle devised by Massa and co-workers (8). For most operative procedures it is our practice to insert at least one, and frequently two or three needles, for use during supportive therapy.

Dose and Rate of Administration

For an average adult 500 cc. of blood transfused usually raises the haemoglobin content of circulating blood 10 per cent (15 gm of haemoglobin per 100 cc) and the erythrocyte count 500,000 per cubic millimeter.

For an average safe rate of administration of blood to an adult, 5 to 10 cc per minute is adequate. For children the safe amount given per minute is less and varies with body weight. In emergencies, however, it is imperative that unusually large amounts of blood be introduced rapidly.

Care of the Recipient

It is essential that the first 100 cc. of blood in any transfusion be administered slowly to see if any untoward reaction may occur in the recipient. Every transfusion should be supervised throughout its entirety by a competent person. If the patient is seriously ill or has some cardiovascular disturbance, a physician should remain in constant attendance during the entire transfusion.

Vasopressor Drugs

Vasopressor drugs, although not of aid in support of falling blood pressure due to loss of blood, are the drugs of choice to support blood pressure in most instances of circulatory failure associated with normal blood volume. These conditions are myocardial infarction, pulmonary embolism, the "septic shock" of gram-negative bacillaemia, and the loss of vasomotor tone as a result of cerebral damage.

COMMENT

The judicious parenteral administration of fluids, plasma volume expanders, or whole citrated blood requires the careful attention of the attending physician. The injudicious use of these same fluids may interfere even to a dangerous degree with the physical well-being and convalescence of the patient.

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