# PARENTERAL FLUID THERAPY

## *(A General Consideration)*

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Parenteral fluid administration has been definitely established in the past three decades as a major therapeutic measure in preserving life and lessening morbidity in a great variety of pathologic states. These conditions include patients in both the so-called medical and surgical categories who present a common background of dehydration, starvation and acid-base imbalance. The value of this form of therapy lies in the ability to administer necessary fluid, electrolytes, and nutrients to patients in whom the normal gastro-intestinal function is temporarily in abeyance or relatively unable to supply the organism with adequate amounts. Ordinarily, the procedure has been carried on for short periods ranging from a few hours to a few days, but cases have been recorded of practically complete parenteral nutrition over a period of several weeks. The routes most commonly used are the intravenous and subcutaneous, but under special conditions the intraperitoneal, intrathecal, and intramedullary routes have also been utilized. The intravenous route is by far the most practical of these since it is readily available, and its use offers a minimum of discomfort to the patient. Since the infused fluid becomes quickly diluted in the veins, it is possible to administer both hypertonic and isotonic solutions with a considerable range in hydrogen ion concentration both above and below the plasma level. Fluids used subcutaneously must be isotonic and adjusted to a normal hydrogen ion concentration of tissue fluid in order to prevent local tissue irritation and damage.

The aims of parenteral fluid therapy are multiple, but largely interrelated. An adequate water intake is a major consideration. The importance of water in the economy of the body becomes apparent when one considers that it forms approximately 70 per cent of the body weight. Water exists in the body in three compartments all to some extent intercommunicating—intracellular, interstitial, and vascular. The intracellular compartment is greatest in volume and constitutes 50 per cent of body weight. The interstitial constitutes 15 per cent while the blood plasma and lymph make up 5 per cent. Loss of fluid from the interstitial and vascular compartments, which together constitute the extracellular fluid, occurs at an earlier stage than intracellular fluid loss and may seriously impede peripheral circulation and lessen renal function with attendant disturbance of physiologic and chemical balance in the body. Plasma volume must be maintained and replacement occurs at the expense first of the interstitial fluid. An adequate amount of water is also necessary for diaphoresis and efficient functioning of the heat control apparatus. In temporary disturbances incident to excessive loss of water or insufficient intake, simple water replacement may be all that is necessary. Water as such must not be given parenterally, but must contain electrolytes or other substances such as glucose in sufficient amount to make an isotonic or hypertonic solution. Electrolyte replacement assumes equal importance with fluid replacement and assures the maintenance of the necessary proper osmotic tension of body fluids. Sodium chloride is the primary salt used, but may be supplemented by salts of potassium, magnesium, and calcium in an attempt to imitate body chemistry as carefully as possible. Electrolyte imbalances incident to disease frequently alter the hydrogen ion concentration of body fluids either toward the acid or alkaline side. Clinical and laboratory recognition of such pathological imbalances is possible, and proper parenteral therapy should be given to aid in restoring the balance. Maintenance of the reaction of body fluid at pH 7.4 or close thereto is essential for proper metabolic processes. The caloric intake of the body may be maintained parenterally and all three of the major food factors may now be given in this manner. Carbohydrate usually represented by dextrose, protein by the amino acid mixtures produced by acid hydrolysis or enzymatic action on casein, and highly emulsified fat have been shown to be suitable for intravenous nutrition. The diet may be further supplemented by accessory food factors, all known vitamins, with the possible exception of the A-D group, having been successfully given parenterally. Plasma protein deficit may be counteracted by intravenous administration of plasma or serum or some fraction thereof, and anemia may be overcome by use of whole blood.

Clinically, the need for parenteral fluid therapy must be considered in every patient in whom there is a history of excessive weight loss or insufficient fluid intake over periods of more than a few hours, and in whom it is impossible to give adequate replacement by mouth. The indications include all lesions of the intestinal tract which are obstructive in nature and associated with excessive vomiting. In this connection, loss of fluid induced by use of the Wangensteen suction apparatus or Miller-Abbott tube must also be considered. In most of the clinical states described above, the tendency for alkalosis exists, due largely to the excessive loss of hydrochloric acid from the gastric secretion. Dehydration is, however, frequently accompanied by acidosis, partially because of the accompanying starvation and also because of deficient blood circulation with resultant anoxemia and impaired renal function with attendant retention of acid metabolites. Diabetic coma is accompanied by dehydration and an acidotic tendency from ketosis. The vomiting of uremia is accompanied by dehydration and acidosis from loss of fixed base, retention of acid metabolites, and failure of the ammonia-forming renal function. Excessive loss of fluids from the bowel in diarrhea or from intestinal, biliary, or pancreatic fistulae is usually accompanied by acidosis due to excessive loss of base. An acidotic tendency is usually present also in loss of fluids in acute infections and in hemorrhage.

The necessity for fluid therapy is usually evident from simple observation of the patient. The skin is dry and harsh, the tongue is dry and coated, and the mucous membranes lack the normal glistening, moist appearance. The subcutaneous tissues lack their normal turgor. The peri-orbital tissues appear depressed and tension of the eyeball is reduced. The pulse rate is increased and the peripheral circulation appears feeble. Deep and exaggerated respirations suggest the possibility of an acidotic state, but may be seen also in stimulation of the respiratory center as from an encephalitis or tumor and are then usually associated with respiratory alkalosis. More shallow and irregular respirations suggest the probability of an alkalotic tendency if shock and emphysema can be excluded. Oliguria is certain to exist with dehydration, but the urinary hydrogen ion concentration cannot be used as an indication of acidosis or alkalosis, since it may be affected by urinary tract infection and does not necessarily reflect the chemical balance in the body. Thus, urinary infection may render the urine alkaline in acidosis, and in dehydration with alkalosis the urine may be acid if the base concentration of the plasma is below normal.

Generally, the dehydrated patient shows mental sluggishness and drowsiness. He may complain of headache, weakness, thirst, or abdominal pain. Cyanosis may develop and if dehydration is unrelieved, coma may supervene sometimes with convulsions. Tetanic manifestations with muscular hypertonicity, hyperactive reflexes, a positive Chvostek or Trousseau sign or carpopedal spasm are frequently seen as part of the alkalotic picture and are explained on a basis of reduction of available ionizable calcium associated with decreased hydrogen ion concentration.

Careful clinical records of fluid intake and the amount and manner of fluid loss constitute valuable data on which parenteral therapy may be reasonably based. In addition, they suggest the probability of disturbances of acid-base balance which may be associated with dehydration. The amount of fluid which may be lost is much more than is generally appreciated. The average adult male secretes in a twenty-four hour period 2500 cc. of gastric juice, bile 500 cc., pancreatic juice 700 cc., and 3000 cc. from the intestinal mucosa. If to this amount is added saliva secretion of 1500 cc., a total twenty-four hour secretion of fluids of 8000 cc. from the gastro-intestinal tract is concerned which may in a large fraction fail to be normally reabsorbed. Some idea of the importance of this loss may be obtained by comparing this with the total plasma volume of 3500 cc. and a total extracellular fluid volume of 14,000 cc. It must be remembered that this gastro-intestinal fluid contains also the electrolytes of the extracellular fluid in different proportions, but at the same osmotic level. Excessive urinary output, as in diabetes mellitus and diabetes insipidus, must also be considered as well as excessive insensible fluid loss in perspiration and hyperpnoeic respiration. Serial determinations of body weight may offer some help in calculating the loss of fluid, since the greater proportion of weight loss in short periods must be in fluids, approximately one-half of which comes from the intracellular compartment.

The clinical appraisal of the patient should be supplemented by certain laboratory procedures which will be helpful in confirming the diagnosis and suggesting the proper line of therapy. The urine will usually be decidedly concentrated unless there has been pre-existing renal disease. Moderate amounts of albumin and a few casts may be present from toxic renal damage. Reductions of plasma volume may be evidenced by increased hemoglobin readings, increased red and white blood counts, and a rise in plasma protein concentration, but it must be remembered that these findings may be to some extent masked if there has been hemorrhage. A decrease in concentration of hemoglobin, blood counts and plasma protein will suggest the necessity for replacement with whole blood or plasma. Blood chloride estimations are of relatively little value, since the chloride ion level varies considerably with changes in acid-base balance. Total base levels give valuable information in regard to the fixed base of the extra-cellular fluid. Carbon dioxide combining power readings cannot be depended upon entirely without clinical correlative data to indicate either acidosis or alkalosis, although they are for the most part reliable where the acid-base imbalance is of metabolic origin. Where acid-base imbalance is of respiratory origin, significance of the findings is frequently reversed. Thus, in acidosis accompanying emphysema the carbon-dioxide combining power may be above normal and in alkalosis of primary hyperventilation it may well be beneath the average normal. The presence of acidosis or alkalosis may be definitely established by determining the serum hydrogen ion concentration, the outer limit compatible with life ranging from pH 7.0 to pH 7.8.

No specific rule of thumb is available for recognition of the degree of dehydration which exists in any particular patient and no mathematical formula may be used to calculate the amount of parenteral fluid necessary. Some help may be obtained from recognition of the amount necessary for daily requirement to which must be added the sum total of fluid loss or the deficit which has accumulated in the period during which the dehydration occurred. The normal adult requires the production of 800 to 1000 cc. of urine in order to excrete the nitrogenous waste products of metabolism. If the renal function is poor, either from previous renal parenchymatous disease or from toxic interference with renal function as the result of disease, an obligatory polyuria may necessitate double the usual amount. Water loss in the stool normally averages 100 cc., but may be many times that figure in the presence of diarrhea. The insensible loss from the body averages 600 to 1000 cc., but may be often double that amount in fever with excessive perspiration and under high environmental temperatures. A normal 2000 cc. intake may be entirely inadequate therefore, especially in the presence of antecedent dehydration which may approximate 6000 to 8000 cc. in severe cases. Partial replacement may be possible in many of these patients orally, but in general the patient who requires fluid replacement most urgently is able to secure only a fraction of the necessary amount by this route. It must be remembered that normally a considerable amount of water is obtained from water content of food and a smaller fraction from water of oxidation of food. Normally these two replace the insensible water loss of the body.

The main point in hydrating the patient is to provide the sodium chloride in water which supplies replacement of the main structural disturbance in the extracellular fluid. Distilled water as such cannot, of course, be given and in fact would not be satisfactory since water is held in the body only as a solvent, the chief solute of extracellular fluid being sodium chloride. Isotonic saline solution is, therefore, used as the main material, but obviously only a fraction of the fluid can be given in this way, since every 1000 cc. of isotonic saline solution carries with it 8.5 Gm. of sodium chloride. The daily requirement is about 6 Gm., and unless a considerable deficit has preceded the fluid administration an excess of salt may occur in the body. If renal activity is insufficient to remove the excess salt, fluid retention occurs, and a urinary output relatively low in relation to intake follows. This might readily be interpreted as indicative of the necessity for more fluid. It is important to remember that replacement of extracellular fluid requires sodium chloride solution, but that fluid for increased urine output can best be supplied in the form of glucose solution. The glucose is metabolized and the water having no saline content is readily available for urine formation. The combination of isotonic glucose (5 per cent) and isotonic saline (0.85 per cent) solutions, therefore, supplies material necessary for major replacement of extracellular fluid and for urinary function, and is in most cases an ideal one for initial therapy. Furthermore, the glucose solution provides a specific remedy for ketosis which accompanies starvation as well as diabetic acidosis. It has definite nutritive value also since glucose is readily available for metabolism and supplies approximately 4.5 calories per gram. Concentration of saline solution to 3 per cent may be given intravenously where there is an obvious need of larger quantities of chloride and where severe alkalosis exists, but administration of these higher concentrations requires careful observation, and they are not to be recommended in the average case. For clysis isotonic saline solution may be used or an isotonic solution of 2.5 per cent glucose in 0.45 per cent sodium chloride. In many instances of mild dehydration without serious disturbance of acid-base balance and without previous starvation, the use of such simple fluids for a day or two is all that is required to allow body processes to restore normal function. Simultaneously, all other smaller items of the chemical structure of extracellular fluid will be supplied by processes of metabolism, particularly if it is possible to use small oral feedings.

In case of disturbance of acid-base balance toward the alkaline side, the use of saline solution is all that is necessary since it adequately replaces the chloride ion deficit which is the main structural defect. Sodium chloride solution (isotonic) contains approximately one and one-half times more chloride ions than plasma and will, therefore, increase the plasma chloride at the expense of the elevated bicarbonate ion. The excess sodium ion must be excreted and this demands adequate renal function and output. Simultaneous administration of glucose solution supplies adequate water and improves renal function to allow such discriminatory power on the part of the kidneys. Simultaneous saline and glucose solution is, therefore, ideal for alkalosis. Even in acidosis adequate replacement of extracellular fluid and material for urinary formation may allow the body to adjust its chemical structure, but inasmuch as this may require several hours it is considered best to add bicarbonate ions directly in the presence of severe acidosis. Sodium bicarbonate solution, 5 per cent, may be used intravenously, but ordinarily its use is not advisable in view of the high alkalinity of the solution and the rapid change in the carbonic acid bicarbonate ratio. Hartmann's solution which essentially contains sodium lactate with sodium chloride may be used and combined with glucose solution. The lactic acid radical is oxidized after absorption and the bicarbonate ion is formed slowly. A simpler method of replacing bicarbonate deficiency is to use one-sixth molar sodium lactate solution, which is practically isotonic, combined with saline in proportion ranging from 1:5 to 1:2 depending upon the severity of the acidosis.

Where gastro-intestinal disability is of long duration or where there has been previous starvation, the use of parenteral therapy to supply caloric needs of the body becomes important. Glucose has been available for parenteral nutrition over a considerable period of time and until recent times has been the only source of energy available by this route. To increase the caloric value the use of higher concentrations than the isotonic 5 per cent has been advocated. However, only 10 to 12 Gm. of glucose may be oxidized per hour by the average normal adult and larger quantities may cause glycosuria and polyuria which will have an adverse effect in an already dehydrated patient. It has been shown, however, that approximately 4 times that amount may be given for short periods without significant hyperglycemia or glycosuria, and thus the caloric intake from carbohydrate may be increased. An adequate carbohydrate intake results in a body protein-sparing effect and keeps the nitrogen requirement at a minimum.

In recent years it has been possible to administer sufficient amino acids intravenously to meet at least basic protein needs. Amino acid preparations produced by acid hydrolysis of casein with added tryptophan were first used and have been largely supplemented by enzymatic hydrolysates of casein and pancreatic tissue. These contain approximately 80 per cent of nitrogen as amino acids and 20 per cent as dipeptide. The solution is protein free, biuret negative, and non-antigenic. Its use has been curtailed by the fact that reactions occur quite frequently if it is not introduced slowly. These reactions are characterized by nausea, vomiting, fever, polyuria, and at times, local venous thrombosis. Urinary nitrogen increases simultaneously with these reactions to a greater degree than is seen when a corresponding amount of plasma is used. The amino acid solutions are usually added to 5 per cent glucose or isotonic saline for intravenous use. The amount of amino acid administered should depend upon estimated nitrogen loss which has been sustained together with the maintenance requirement, the latter being kept at a minimum by adequate glucose therapy. Daily nitrogen loss in the adult under resting conditions may approximate 6.4 Gm. (40 Gm. of protein), but considerably more may be required under febrile conditions and in severely ill patients. With present materials it is rather difficult to supply adequate parenteral nitrogen intake, but hope exists that a better product may help to achieve this result. Protein deficits may also be overcome more promptly by use of whole blood or plasma, and these latter materials are essential where the object of therapy is control of shock or maintenance of osmotic pressure of the blood.

Fat may also be supplied in emulsified form, and a few reports are available in the literature of its successful use. Its use would appear to be attended by considerable difficulty and has not become general. The importance of emulsified fat would seem to be chiefly for the caloric value of the material and as a possible vehicle for the parenteral administration of fat soluble vitamins.

As a rule, parenteral therapy is not carried on for a sufficient period of time for the development of a marked avitaminosis. A latent avitaminosis may have been induced by antecedent starvation, and, inasmuch as thiamine deficiency is known to develop within a few days, its use in dosage of 5 to 10 mgm. daily would appear rational. Other vitamin B radicals such as nicotinic acid are available for intravenous use, and, in fact, the whole vitamin B complex may be used. Vitamin C and K may also be added to the parenteral fluid on specific indication.

The history of blood loss frequently indicates the necessity for whole blood transfusion, but it is well to remember that the same necessity may arise from toxic destruction of blood in the course of disease. Usually, parenteral fluid therapy should include a whole blood transfusion of approximately 500 cc. for the average adult every four or five days. Plasma transfusion may be indicated by low plasma concentration, and in recent years fractionation of plasma has allowed the use of albumin alone in conditions where this factor shows specific reduction. In low plasma protein concentration associated with nephrotic states, the correction of plasma protein deficit by transfusion has been disappointing. This may be due partly to the necessity of replacing very large amounts of protein, but it is surmised that in these conditions the plasma protein level is controlled in some way at a low level by a renal mechanism.

It may be said, therefore, that complete parenteral therapy with each of the major food elements, chief electrolytes and necessary water to adjust extracellular fluid, and vitamin therapy is now feasible for limited periods of time. Its use, however, is attended with definite mechanical difficulties and involves considerable discomfort to the patient. In its present stage, parenteral therapy is nutritionally inadequate as far as intracellular ions are concerned so that oral feeding with simple foodstuffs should be started as soon as feasible.

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