Summary

The forward surgeon dealing with abdominal injuries must be in the right place with the right support at the right time. His operations will be based on ordinary civilian surgery, but must be

made through adequate incisions to allow treatment of injuries which are likely to be multiple. His post-operative care must be simple and carried on long enough to ensure safe travel to the next unit behind.

THE MANAGEMENT OF THE FLUID BALANCE IN INTESTINAL OBSTRUCTION IN INFANCY AND CHILDHOOD

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Delays in diagnosis and mistakes in the management of the fluid balance are responsible for nearly all the difficulties which arise in cases of intestinal obstruction in the paediatric age group. The technical procedures required to correct the obstruction, whether in the newborn period or later, are now done so well that they seldom cause trouble. This article will deal with the management of the fluid balance in four types of case: the newborn with oesophageal atresia or with obstruction lower down in the gastrointestinal tract, infantile hypertrophic pyloric stenosis, acute intussusception and appendicitis with peritonitis.

Some general principles will first be stated. The aim of fluid administration is to provide (1) water and electrolytes in the amounts which the child would require if he were not ill—i.e. maintenance requirements—and (2) a replacement for those lost through vomiting, gastric or duodenal suction, or diarrhoea.

The maintenance requirements for children of different ages and weights have now been worked out and it is seldom necessary, or advisable, to take blood from the infant for biochemical examinations to be made in the laboratory. The maintenance requirements by age and weight are shown in the following table (modified after Dodd and Rapoport):

WATER			
First five days	..	..	40 ml./kg.
Up to one year	..	..	160 ml./kg.
One to two years	..	..	120 ml./kg.
Two to four years	..	..	100 ml./kg.
Ten years	..	..	70 ml./kg.

SODIUM AND CHLORIDE

	g. NaCl	ml. 'physiological' saline
First five days	 None	None
Up to one month	 0.25-0.5	25-50
One month to six months	 1.0	100
Six months to two years	 1.5-2.0	150-200
Older children	 2-4	200-400

Because the administration of some glucose prevents as much tissue breakdown from occurring as would occur if the patient were completely starved, the water requirements are given as a solution of glucose. Dextrose has at least two other important actions in starvation, namely, reducing the sodium loss in the urine and reducing the output of organic acids. It is desirable to spread the administration of the maintenance electrolyte requirement over as long a period as possible. Thus a most useful solution is 1/5 'physiological' saline made isotonic with glucose (i.e. 0.18 per cent. NaCl and 4.3 per cent. dextrose). Recently it has been suggested that cane sugar may be used to supply more energy than glucose, as it can be given in a 10 per cent. solution without causing glycosuria, whereas glucose, if given in more than a 5 per cent. solution, tends to cause glycosuria and have a dehydrating effect; the continuance of intravenous fluids is usually only necessary for such a short time that, in the writer's opinion, the proper use of glucose and electrolyte solutions gives very satisfactory results.

The route of administration of parenteral fluids should be the intravenous one, unless, as is the case in most cases of pyloric stenosis, it is only

necessary to give 100 to 200 ml. of normal saline. The prolonged administration of a hypotonic solution subcutaneously, even when hyaluronidase is given at the same time, is dangerous, since after the first few hundred millilitres absorption is unsatisfactory. It appears that, because of the different rates of diffusion of glucose and electrolytes, the infant may lose much of his circulating sodium and chloride into the unabsorbed depots of hypotonic fluid. The site of intravenous infusion depends on the skill of the operator and the amount of movement of the infant that may be necessary. If the infant has to be taken from the ward to the operating theatre and back, it is usually wise to perform a 'cut-down' at the wrist or ankle (it should practically never be necessary to 'cut-down' in the antecubital fossa). If the infant has returned from the theatre, it is usually possible to avoid cutting down, and to give 'stick-in' infusions into a vein on the scalp, the dorsum of the hand, or the surface of the wrist. To do this type of infusion successfully a short-bevelled needle, gauge S.W.G. 24, 22, or 20, is required. The needle can usefully be attached to semi-transparent plastic tubing, so that the operator can see at once when the needle is in the vein. Some house surgeons prefer to use the Kempton set.

The actual measurement of the fluid withdrawn by duodenal or gastric suction is most important and should be considered a very special responsibility. A volume equal to that withdrawn of a solution of 'physiological' sodium chloride, or preferably a solution containing 12 m.Eq./l. potassium in addition should be given intravenously over and above the maintenance requirement. Such a solution can be prepared by adding 4.4 ml. of 2 per cent. potassium chloride (from a sterile ampoule) to 100 ml. of the sodium chloride solution.

The occurrence of a hypokalaemic hypochloraemic alkalosis is to be expected in cases of intestinal obstruction. It occurs to some degree after all operations. The reasons why it occurs in intestinal obstruction are not altogether clear, but it seems to be established that paralytic ileus can often be prevented by the judicious administration of potassium in severe cases of obstruction. The solution referred to above when used to replace fluids withdrawn by suction would seem to provide a suitable amount of potassium.

Obstruction in the newborn. During the first three days of life the infant requires very little fluid; in many maternity units it is the custom to withhold all fluids from premature, but otherwise normal, babies for the first 72 hours after birth. It follows that if a baby is born with intestinal obstruction (and a high proportion of such babies

are premature), the surgeon must be most careful not to give too much fluid intravenously. Gross states that he has seen many more newborn babies requiring surgery die of overhydration than from dehydration: to borrow his phrase, the surgeon must have 'a pre-set limitation of the 24-hour fluids.' So often one has seen the house surgeon, justifiably proud of setting up an infusion on such a small subject, meeting with disaster because he has let 'a little more fluid run in to keep the drip going.' The total amount of fluid given during the first five days of life should not exceed 20 ml./lb./24 hours plus blood to replace any lost at operation; no sodium chloride is required during this time. Perhaps it is not out of place to stress the importance of keeping the infant warm and undisturbed (Lee, 1951).

Pyloric stenosis. The infant may have become severely alkalotic as a result of the vomiting of gastric contents. Therefore, if the stomach is washed out, a saline solution and not a bicarbonate solution should be used.

This is one of the few occasions when a chemical examination is desirable. The extent of the chloride loss should be assessed by an estimation of the serum chloride. This can be performed on blood obtained by heel prick and a venepuncture is not necessary. The incidence of post-operative complications is greatly reduced if the chlorides lost by vomiting are replaced by subcutaneous infusion before the operation. If the serum chlorides are below 90 m.Eq./l. (normal 100 m.Eq./l.) 'physiological' 0.9 per cent. sodium chloride should be given subcutaneously; quicker absorption is obtained if 1 ml. hyaluronidase is added to each 100 ml. saline. It is not possible to give a precise figure for the amount of sodium chloride required. An approximate guide is 70 ml. for each 10 m.Eq./l. fall in serum chloride, but it is wise to check the serum chloride after 120 ml. saline have been given.

Acute intussusception. The prognosis in acute intussusception varies directly with the time which elapses between the onset of the condition and the operation, and the longer the time interval the worse the outlook and the greater the degree of shock. In practice, if the degree of shock is great, the advantages of a couple of hours spent in resuscitating the patient certainly outweigh the disadvantages of the slight additional delay. The principles already outlined apply, but because of the shock it is wise to start intravenous therapy with a blood transfusion, a dextran infusion, or an infusion of small pool plasma. The infant with acute intussusception is often plump, but this should not be considered an excuse for substituting subcutaneous infusions for intravenous

ones during the post-operative period; the writer has seen serious trouble from this cause.

Acute appendicitis with peritonitis. The straightforward case of appendicitis diagnosed early does not require any intravenous fluids. Once severe peritoneal irritation has occurred, there is an increased danger of paralytic ileus developing. In treating such cases intestinal suction is used. The volume of fluid aspirated must be replaced by the intravenous route, giving the solution of sodium and potassium chloride described earlier. In summary, fluid balance can be maintained

in intestinal obstruction in children without many laboratory investigations, so long as the measurements of the volumes of fluid removed by suction, lost at operation, and given intravenously are made accurately.

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FLUID BALANCE IN INTESTINAL OBSTRUCTION

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The last 20 years have seen a great improvement in the results of treatment of patients with acute intestinal obstruction. In the main this improvement is due to an increasing understanding of the importance of the two basic pathological effects of obstruction, namely, intestinal distension, and the loss from the body of large quantities of fluid and electrolytes. It is now well recognized that in the treatment of intestinal obstruction the relief of this distension and the replacement of fluid losses play as great a part in the successful outcome of the case as the release of the obstruction itself. In many cases the management of the patient's water and electrolyte equilibrium will pose very complex problems, and in all cases an exact analysis of the exchanges taking place will require intricate biochemical calculations, but these considerations must not be allowed to obscure the fact that the great majority of these cases can be successfully handled by attention to a few simple concepts.

The Nature of the Fluid Losses

The crux of the problem of the maintenance of fluid and electrolyte equilibrium in patients with intestinal obstruction consists in the assessment and replacement of the abnormal losses which occur from the alimentary tract. These abnormal losses consist of the secretions into the intestinal canal, which accumulate proximal to the obstruction and are to a varying extent vomited up, or

TABLE I

Source	Volume
Saliva	1500 ccs.
Gastric secretion	2500 ccs.
Bile	500 ccs.
Pancreatic juice	700 ccs.
Secretion of intestinal mucosa ..	3000 ccs.
Total	8200 ccs.
Normal Plasma Vol.	3500 ccs.

The normal volume of digestive juices secreted per 24 hours, by an adult. (From Gamble, 1950.)

removed by intestinal suction. Certain salient facts about these secretions must be borne in mind. First, the total volume of fluid secreted into the alimentary tract each 24 hours amounts to over 8 litres (Table I). When it is remembered that the normal circulating plasma volume is only 3 litres, it is apparent that losses from the intestine can readily and rapidly lead to a dangerously large fluid deficit. Secondly, such losses consist not of water but of a solution of electrolytes which, though varying in composition in each secretion, is in all of them essentially isotonic with the plasma electrolytes. Fig. 1 shows the composition of these secretions in their pure form, but as lost from the body in intestinal obstruction they are, of course, diluted to a variable extent by ingested water, and Table 2