Gastrointestinal Replacement Solution

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Summary: The mean sodium concentration of 61 gastrointestinal aspirations in peritonitis was 103 mEq/l. (S.D. 16.66), of 16 aspirations in vagotomy 88 mEq/l. (S.D. 19.49), of 12 aspirations in perforated duodenal ulcer 81 mEq/l. (S.D. 19.49), and of 15 aspirations in intestinal obstruction 89 mEq/l. (S.D. 19.49). The mean potassium concentrations were 9, 9.9, 13, and 8.8 mEq/l. respectively, and the mean chloride concentrations 122, 131, 125, and 112 mEq/l. respectively. It is suggested that a gastrointestinal replacement solution should contain 100 mEq of sodium, 12 mEq of potassium, and 122 mEq of chloride per litre; 50 g. of dextrose or 100 g. of fructose may be added to provide energy.

Introduction

The aim of replacement fluid therapy is to prevent electrolyte and water imbalances. Gastrointestinal aspirations commonly necessitated in surgery by conditions such as intestinal obstruction, paralytic ileus from diverse causes, and gastrointestinal surgery will result in metabolic problems if not properly replaced. The British practice appears to replace such losses volume for volume with normal saline, adding some potassium when necessary. Randall (1967), in the U.S.A., recommended replacement with varying mixtures of dextrose in water, dextrose in normal saline, M/6 lactate, or sodium bicarbonate with 20 mEq of potassium chloride per litre, the composition of the mixture depending on whether the loss is gastric, intestinal, biliary, or pancreatic. Cooke and Crowley (1952) suggested a gastric solution and an intestinal solution for replacement of gastric and intestinal losses, the solution used depending on the location of the drainage tube. Gastrointestinal decompression as practised in most hospitals, however, aspirates a mixture of gastric, intestinal, biliary, and pancreatic secretions except in gastroduodenal stenosis, when the aspiration is purely gastric. An attempt has therefore been made to determine the mean electrolyte concentration of such losses with a view to suggesting a solution suitable for the replacement of gastrointestinal aspirations.

Patients and Methods

Aspirations from patients on gastrointestinal decompression for acute intestinal obstruction, paralytic ileus following generalized peritonitis from diverse causes, and vagotomy with drainage were used for the study. Aspirations from vagotomy patients were used only after they had become macroscopically free of blood, usually after 48 hours. The 24-hour aspirations from each patient were pooled, and if the amount was over 500 ml. the sodium, potassium, and chloride concentrations were estimated. If the 24-hour collection was less than 500 ml. then the next 24-hour collection was added to it. Most of the aspirations were in fact over 1 litre. It was hoped that by using such large, and 24-hour, collections a fair estimate of the electrolyte losses would be obtained. The sources of the 104 specimens obtained are given in Table I. The age distribution of the 66 patients is shown in Table II.

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Results

Sodium.—The mean sodium concentration of gastrointestinal aspirations in peritonitis is given in Table III. The mean sodium concentration of aspirations in peritonitis is significantly different from those in vagotomy and drainage ($0.05 > P > 0.02$), perforated duodenal ulcer ($0.01 > P > 0.001$), and intestinal obstruction ($0.1 > P > 0.05$). There is no significant difference in the sodium concentrations in vagotomy with drainage, perforated duodenal ulcer, and intestinal obstruction.

Potassium.—The mean potassium concentration of the aspirations in peritonitis is given in Table III. There is no significant difference between peritonitis, vagotomy with drainage ($0.7 > P > 0.6$) and intestinal obstruction ($0.6 > P > 0.5$). The difference between peritonitis and perforated duodenal ulcer is only just significant ($0.1 > P > 0.05$).

Chloride.—The chloride concentrations in peritonitis, vagotomy with drainage, perforated duodenal ulcer, and intestinal obstruction are 122, 131, 125, and 112 mEq/l. respectively. There is no significant difference between them.

TABLE I.—Gastrointestinal Aspirations

No. of specimens		
Generalized peritonitis with ileus	..	61
(1) Typhoid perforation	..	40
(2) Acute appendicitis	..	10
(3) Traumatic perforation of bowel	..	9
(4) Postoperative	..	2
Perforated duodenal ulcer	..	12
Vagotomy with drainage	..	16
Intestinal Obstruction	..	15

TABLE II.—Age Distribution of Patients. Range 3-75 Years

Age	Male	Female	Total
0-9	5	5	10
10-19	12	3	15
20-29	20	1	21
30-39	6	4	10
40+	8	2	10
Total	51	15	66

TABLE III.—Electrolyte Concentration of Gastrointestinal Aspirations

	Sodium	Potassium	Chloride
<i>Peritonitis</i>			
No. of specimens	61	61	61
Range (mEq/l.)	64-144	4.6-17	58-152
Mean (mEq/l.)	103	9	122
Standard deviation	16.66	2.93	24.80
<i>Vagotomy and Drainage</i>			
No. of observations	16	16	16
Range (mEq/l.)	67-123	5.7-16.0	118-150
Mean (mEq/l.)	88	9.9	131
Standard deviation	19.49	4.02	22.01
<i>Perforated Duodenal Ulcer</i>			
No. of observations	12	12	12
Range (mEq/l.)	52-101	8.2-21	100-156
Mean (mEq/l.)	81	13.0	125
Standard deviation	19.49	4.02	22.01
<i>Intestinal Obstruction</i>			
No. of observations	15	15	15
Range (mEq/l.)	65-120	5.0-16.8	68-152
Mean (mEq/l.)	89	8.8	112
Standard deviation	19.49	4.02	22.01

Electrolyte Concentration in Children under 10.—In these 10 children (nine typhoid perforation and one intestinal obstruction) the mean electrolyte concentrations were sodium 106 (93-120) mEq/l., potassium 9.2 (6.1-17) mEq/l., and chloride 107 (84-128) mEq/l. The ranges were thus narrower than in the adults, but the mean concentrations did not differ significantly from those of the whole series.

Electrolyte Concentrations in 11 Patients with Three or Four Specimens.—In 11 patients three or four 24-hourly specimens were obtained, and the results (Table IV) show the well-known daily variations in the electrolyte concentrations of gastrointestinal secretions in the individual. The mean sodium for each individual, except No. 4, however, does not vary significantly from the mean of his pathological group.

Discussion

As the electrolyte concentrations of gastrointestinal aspirations vary daily the ideal method for replacing such aspirations would be to estimate the total daily electrolyte and fluid losses for the individual patient and replace them. But, apart from the cost and the expense in time, it is doubtful, as shown in Table IV, whether the results would vary significantly from the mean of a large series.

It is evident from this study that the current practice of replacing such losses with normal saline (sodium 154 mEq/l., chloride 154 mEq/l.) provides more sodium and chloride than is necessary and may in part account for the oedema and stiffness of the gut often noted on reopening the abdomen.

TABLE IV.—Electrolyte Concentrations (mEq/l.) in 11 Patients with 3 or 4 Specimens. Nos. 1-6 Peritonitis, Nos. 6-8 Vagotomy and Drainage, Nos. 9 and 10 Perforated Duodenal Ulcer, and No. 11 Intestinal Obstruction

No.	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Mean
Sodium					
1	88	104	105	110	102
2	106	94	110		103
3	110	107	96		104
4	83	74	84		80
5	87	89	102	97	94
6	110	123	83	117	108
7	67	80	80		78
8	88	102	105		98
9	93	67	52		74
10	80	80	100		87
11	133	70	69		91
Potassium					
1	10.6	11.2	7.6	7.9	9.2
2	6.2	7.2	12.0		8.5
3	6.0	6.5	6.1		6.2
4	10.6	17.0	10.4		12.7
5	8.4	15.0	7.2	8.0	9.7
6	9.0	6.2	14.8	7.8	9.5
7	9.2	9.5	9.5		9.4
8	11.6	10.0	8.8		10.1
9	21.0	19.0	16.0		18.7
10	9.6	20.0	9.4		12.7
11	5.3	7.6	9.0		7.3
Chloride					
1	141	143	152	147	146
2	136	137	128		137
3	139	97	93		110
4	132	149	144	140	141
5	128	140	123	105	124
6	137	140	133		137
7	116	103	116		112
8	115	120	126		120
9	100	136	121		119
10	129	137	129		132
11	118	140	140		133

Such oedema must delay the return of active intestinal motility necessary for the resumption of oral feeding. If large infusions of saline are necessitated by large gastrointestinal losses, more serious difficulties such as pulmonary oedema may result, especially if renal function is impaired. Failure to replace potassium losses as they occur may lead to subclinical hypopotaemia, again with delay in return of bowel function. It may be pointed out that the serum potassium concentration may apparently be normal while the total exchangeable potassium is considerably reduced, with low concentration in the cells. The method of replacement suggested by Randall (1967) and by Cooke and Crowley (1952) are difficult to apply, since gastrointestinal aspirations as practised in most hospitals are never purely gastric or intestinal.

TABLE V.—Recommended Gastrointestinal Replacement Solution

Concentration of electrolytes (mEq/l.)									
Na	..	..	..	..	..	..	..	..	100
K	..	..	..	..	..	..	..	..	12
NH ₄	..	..	..	..	..	..	..	..	10
Cl	..	..	..	..	..	..	..	..	122
Fructose/dextrose	..	..	..	..	..	..	..	100/500	g./l.
Cations	..	..	..	..	..	..	..	..	122
Anions	..	..	..	..	..	..	..	..	122

Composition: Each 100 ml. contains sodium chloride 0.59 g., potassium chloride 0.09 g., ammonium chloride 0.053 g., and dextrose 5 g., or fructose 10 g.

As a result of this study the gastrointestinal replacement solution shown in Table V is recommended. The additional 10 mEq of chloride is provided with ammonium chloride. Dextrose 5% or fructose 10% may be added to provide calories. For aspirations in peritonitis 100 mEq of sodium is adequate, and as it is within the mean-plus-one standard deviation of the sodium concentrations of aspirations from vagotomy with drainage (88+19.49=107.49), perforated duodenal ulcer (81+19.49=100.49), and intestinal obstruction (89+19.49=108.49), it is suitable for these as well; 12 mEq of potassium, which is a high average, ensures adequate potassium replacement for most aspirations. In a very small group, especially in perforated duodenal ulcer, the potassium loss is likely to exceed 16 mEq/l., but unless the aspirations are very excessive the supply of the daily requirements of about 40 mEq should rectify the small deficit. It is of interest that the concentrations of sodium and chloride suggested from this study are the averages of those recommended by Cooke and Crowley (1952) for gastric and intestinal solutions.

Our current practice is to replace gastrointestinal aspirations volume for volume by this replacement solution every six hours; 500 ml. can be given in one hour. By this method serious water and electrolyte imbalances are prevented.

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