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Research Article

GASTRODIALYSIS IN THE TREATMENT OF ACUTE RENAL FAILURE * †

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The objectives of dialysis in the management of acute renal failure include both correction and prevention of various electrolyte disorders and removal of nitrogenous products responsible for the uremic syndrome.

In the past, gastric lavage has failed as a method of dialysis because of uncontrollable electrolyte transfers and loss of large amounts of dialysis fluid to the patient. The use of a cellophane bag, suggested originally by Schloerb (1, 2), has solved these problems and has made gastrodialysis technically possible. The theoretical advantage of a method of continuous dialysis as compared with intermittent dialysis offers great appeal in that it might be possible to obviate the major fluctuations in the uremic state inherent in intermittent dialysis. Further, if continuous dialysis were sufficiently effective in removing metabolic wastes, as well as in correcting electrolyte abnormalities, it might be possible to avoid the costly, time-consuming, highly technical procedure of hemodialysis or significantly decrease the number of hemodialyses necessary to sustain the patient through a period of renal failure.

The present study was undertaken to evaluate the use of dialysis of the stomach as an adjunct in management of patients with acute renal failure. This paper describes a technique of gastrodialysis and the evaluation of this procedure in the treatment of twelve adults and two children.

THE TECHNIQUE OF GASTRODIALYSIS

Gastrodialysis is carried out through a cellophane bag which is tied to the end of a nasogastric tube and swallowed. Construction of a bag from a flat sheet of cellophane is shown in Figure 1. Although any no. 14 French plastic gastric tube may be used, we prefer, because it is stiff when cold, a no. 14 French Bardic tube.[1] This tube is cut about 6 inches from the end which is to be inserted. A one inch length of glass tubing that will fit tightly inside the plastic tubing is used to rejoin the two pieces of tubing (Figure 1a). This joint is wrapped tightly with surgical silk. The tip is cut off a small rubber balloon; the balloon is then slipped over the joint (Figure 1b). A cellophane bag is made from a 24 by 25 inch sheet of plain, non-waterproof cellophane (PT 300)[2] by wetting the sheet and gathering all the edges around the plastic tube. The cellophane bag is tied over the glass joint and rubber with a single, firm tie which is placed near the end of the glass tube away from the bag (Figure 1c). The edges of cellophane are cut close to the single tie (Figure 1c) and the rubber folded over the top of the cellophane bag. Two more ties are placed (Figure 1d). The rubber is then folded back over these last ties to protect the esophagus from abrasion (not shown in Figure 1). The final volume of bags made in this manner will be 1,000 to 1,200 ml. The larger bags provide more surface area for dialysis.

Insertion of the bag into the stomach is accomplished using a technique similar to that used in passing a stomach tube. Because the bag is bulky, it is necessary to pass the tube through the mouth. It is advisable to anesthetize the pharynx. Anethesia is accomplished with 0.25 per cent pontocaine or 5 per cent Cyclaine in a spray atomizer. Care is taken not to anesthetize the vocal cords. With the patient's head tilted slightly forward, the cooled bag is then pushed into the esophagus. After this maneuver the patient can swallow, permitting the bag to enter the stomach. The tube then can be threaded retrograde through the nose if desired. Once in place, the bag causes a minimum of discomfort even when full.

Dialysis fluid is placed in the bag and changed every 20 minutes thereafter. It is advisable to start with a 200 to 300 ml cycle which is then gradually increased to 600 to 800 ml over a period of a few hours. This procedure permits the patient to become accustomed to the

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[1] Manufactured as item No. 1005 by C. R. Bard, Summit, N. J.

[2] A thinner cellophane is manufactured by J. P. Bemberg Co., Wuppertal-Barmer, Germany. This cellophane is less bulky and appears to permit more efficient dialysis.

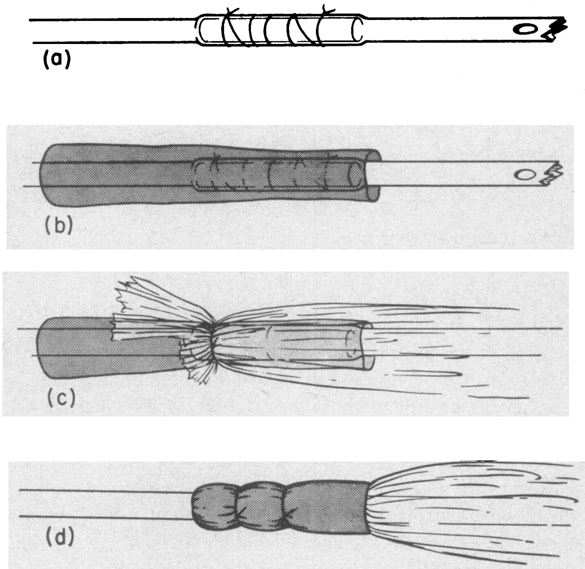

FIG. 1. CONSTRUCTION OF CELLOPHANE GASTRODIALYSIS BAG. See text for details.

rapid filling and emptying of his stomach. The dialysis is usually continued 24 hours per day until renal function improves.

Cycling can be accomplished manually by attaching the gastric tube through a "T" tube to a reservoir above the bed and a drain below. Clamps or glass stopcocks on the two branches control the flow in from the reservoir and out into the drain. Drainage of the bag can be hastened by suction.

As manual filling and emptying of the bag requires nearly the full time service of an attendant, an automatic cycling apparatus has been devised that permits continuous dialysis with only occasional attention. This apparatus automatically heats and cycles any preselected volume of dialysis fluid in and out of the cellophane bag (Figure 2).[3]

It is advisable to warm the dialysis fluid to body temperature to avoid the patient's expending his own calories to heat the dialysate.

MATERIALS AND METHODS

In 14 patients with acute renal failure gastrodialysis was performed for varying lengths of time ranging from 2 to 16 days, with a mean of 6 days. Data were obtained in 98 balance periods ranging from 20 minutes to 24 hours, but averaging 12 hours.

Dialysis fluid was compounded in 20 L volumes by addition of previously weighed glucose, NaCl, and $NaHCO_3$. Nonprotein nitrogen in the dialysate was determined using a modified micro-Kjeldahl method (3) and subsequent Nesslerization (4). Nonprotein nitrogen in blood and urine was determined by the Nesslerization method (4). Sodium and potassium were determined by Baird flame photometry using an internal standard. Chloride (5), bicarbonate (6), and titratable acid (7) were performed by titration methods. Glucose analysis in the dialysate was performed by vacuo-drying (8) with correction for other salts. Blood glucose was measured by the method of Benedict (9). Water transfer was determined by the total change of weight of dialysate in patients in whom there was no significant sodium transfer.

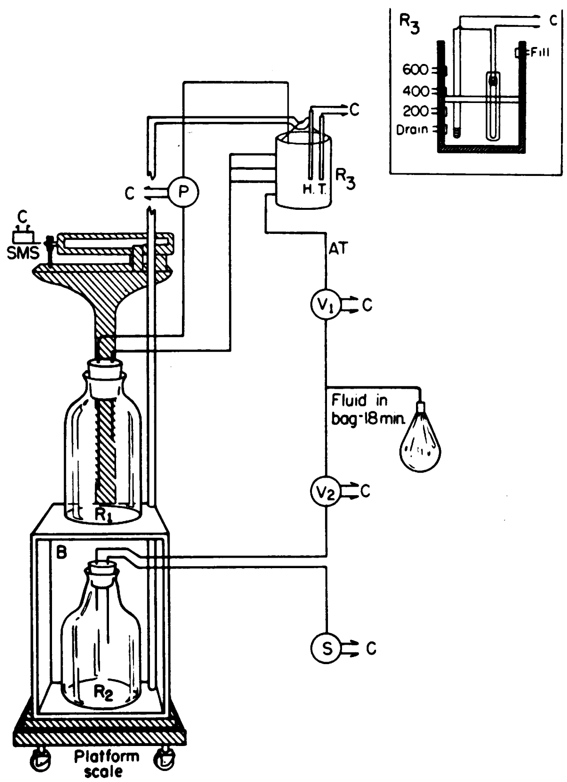

FIG. 2. SCHEMATIC DRAWING OF CYCLING APPARATUS. R_1: 20 L glass or plastic carboy containing fresh dialysate which is pumped by pump P to reservoir R_3. Cross-section of R_3 in cut at upper right. Fluid is warmed or cooled as desired here and flows by gravity into bag. V_1 and V_2 are solenoid valves that control inflow and outflow, respectively, of the bag. Fluid is pumped from bag to reservoir R_2 by vacuum created by pump S. The entire apparatus is controlled by clock C, which activates the various components at the correct time. Should the bag break and the patient begin to absorb dialysate, the loss of water from the system moves the scale. This activates SMS, a safety micro-switch, which turns off the clock, starts gastric suction, and turns on the nurse's call light.

[3] Detailed plans of the automatic cycling device or the completed device may be obtained from Mr. Wayne Quinton, Medical Instrument Shop, Health Sciences Building, University of Washington, Seattle 5, Wash.

TABLE I

Sodium and chloride transfer during dialysis

Sodium dialysate composition	Patients	Mean duration dialysis	Mean cycle vol	Transfer per 24 hours Range	Transfer per 24 hours Mean
	no.	*hrs*	*ml*	*mEq*	*mEq*
No electrolyte	6	51	340	−80 to −190	−115
50 mEq Na/L	4	59	400	0 to −70	−17
100 mEq Na/L	4	176	233	10 to 192	+90
Chloride					
0 mEq Cl^-	3	72	370	−139 to −275	−224
50 mEq Cl^-	2	70	320	−192 to +16	−60
100 mEq Cl^-	4	93	230	−114 to +54	+12

RESULTS

Magnitude of solute transfers. The magnitude of solute transfers is a function of many variables. These include membrane characteristics, temperature, time, volume, and chemical constitution of gastric secretions and dialysis fluid. In these studies, PT-300 wettable cellophane was used throughout. The temperature of the dialysate was elevated to 37° C. A cycle time of 20 minutes was selected after preliminary studies showed a rapid decrease in nitrogen after this period. The transfer data were obtained at cycle volumes ranging from 150 to 700 ml per cycle. The capacity of the gastrodialysis bags ranged from 1,000 to 1,500 ml.

Results of gastrodialysis can be considered in two general areas: *1*) correction and prevention of various electrolyte disorders; and *2*) nitrogen removal and prevention of uremia.

Sodium transfer. Transfer data were obtained using dialysate with sodium concentrations of 0, 50, and 100 mEq per L. The data summarized in Table I suggest that the concentration of sodium in the dialysis fluid for zero net transfer of sodium was about 50 mEq per L. Concentrations above this figure added sodium to the patient, while absence of sodium resulted in removal of sodium from the patient.

In six patients no sodium was added to the dialysate. The mean duration of dialysis was 51 hours. The mean cycle volume was 340 ml per cycle, or slightly greater than 1 L per hour. Removal of sodium ranged from 80 to 190 mEq per 24 hours with a mean removal of 115 mEq per 24 hours. In four patients, a dialysate sodium concentration of 50 mEq per L resulted in sodium removal ranging from 0 to 70 mEq per 24 hours; mean removal was 17 mEq per 24 hours. In four patients dialysis with a fluid containing 100 mEq per L of sodium resulted in the addition of from 15 to 192 mEq of sodium per 24 hours. The mean net transfer to each patient was 90 mEq per 24 hours.

Chloride transfer. Chloride transfer was studied in three patients (Table I) dialyzed with no chloride in the dialysate. The removal rate varied from 139 to 275 mEq per 24 hours; the mean was 224 mEq per 24 hours. At times it became necessary to limit or to prevent chloride removal. In two patients studied at dialysate concentrations of 50 mEq per L, the removal averaged 60 mEq per 24 hours. In four patients dialyzed against concentrations of chloride of 100 mEq per L, there was the addition to each patient of a mean of 12 mEq per 24 hours.

Correction and prevention of acidosis. Alterations of the acid-base status during gastrodialysis can take place in two ways. First, if dialysis is performed with a nonhydrogen ion-containing fluid, hydrogen ions may be removed. Second, if the dialysate contains hydrogen ion acceptors, such as bicarbonate ions, the addition of bicarbonate will buffer hydrogen ions within the body. Such transfer takes place either in exchange for chloride or as an addition with sodium ions.

Hydrogen ion transfer is summarized in Table

II. In nine patients dialyzed a mean of 33 hours, the mean hydrogen ion removal was 110 mEq per 24 hours. Bicarbonate ion transfer cannot be easily studied. If the bicarbonate is measured in the dialysate after passage through the stomach, the decrease measures the sum of the bicarbonate transferred to the patient plus hydrogen ion removal from the stomach. Without measurement of CO_2 gas evolved, $H^+ + HCO_3^- \rightarrow H_2CO_3 \rightarrow H_2O + CO_2 \uparrow$, there is no way of measuring the amount of decrease in HCO_3^- attributable to H^+ removal. However, the total fall in HCO_3^- does measure the total alkalinizing effect on the patient. In three patients dialyzed at a HCO_3^- concentration of 50 mEq per L, the mean loss from dialysate was 138 mEq per 24 hours. In two patients dialyzed at a HCO_3^- concentration of 100 mEq per L, the mean HCO_3^- decrease was 190 mEq per 24 hours.

In all 14 patients it was possible to effect rates of combined hydrogen ion and bicarbonate transfer without sodium intake which were sufficient to correct and prevent acidosis. If no acidosis existed, no HCO_3^- was added to the dialysate. If acidosis was severe, 100 mEq per L of HCO_3^- was added to the dialysate. Vigorous attempts to correct acidosis can result in very rapid exchanges. It is advisable, therefore, to monitor both the transfers in the bath and also to perform daily serum bicarbonate determinations in order to avoid metabolic alkalosis. In only one patient was it necessary to add acid to the dialysate. Addition of 50 mEq per L of HCl resulted in the transfer to the patient of 112 mEq per 24 hours of hydrogen ions.

Due to the very large potential rate of hydrogen and bicarbonate exchange, much smaller gastrodialysis bags and cycle volumes can be used, provided the sole object of gastrodialysis is correction of acidosis. This possibility is illustrated by the following case.

A 32 year old woman with acute renal failure and generalized edema suffered from acidosis out of proportion to other complications. Her serum bicarbonate was 7.5 mEq per L. A gastrodialysis bag was made from a 24 inch length of cellophane tubing one inch in diameter with a capacity of about 200 ml. One hundred ml of solution containing 50 mEq per L sodium bicarbonate in dextrose was cycled every 20 minutes for 12 hours. This resulted in a decrease in dialysate HCO_3^- of 190 mEq in 12 hours and no net transfer of sodium. She received in addition 50 mEq of sodium lactate intravenously. Her serum bicarbonate rose from 7.5 to 12.5 mEq per L. Subsequently, gastrodialysis using only dextrose and water was sufficient to restore normal acid-base status balance and to remove sodium, decreasing the edema.

Potassium removal. This was usually desired. When potassium was omitted from the dialysis fluid, potassium was invariably removed. In six patients who were studied a mean of 82 hours each with a mean cycle volume of 280 ml, potassium removal ranged from 6 to 21 mEq per 24 hours, with a mean removal of 13 mEq per 24 hours. In six patients studied a mean of 30 hours each with a mean cycle volume of 450 ml, removal ranged from 8 to 43 mEq with a mean of 25 mEq per 24 hours. It appears likely that larger cycle volumes will be associated with removal of larger amounts of potassium.

These rates are sufficient to remove significant quantities of potassium if gastrodialysis is begun

TABLE II

Hydrogen and bicarbonate ion transfer during dialysis

Hydrogen dialysate composition	Patients	Mean duration dialysis	Mean cycle vol	Transfer per 24 hours: Range	Transfer per 24 hours: Mean
	no.	*hrs*	*ml*	*mEq*	*mEq*
No HCl Added	9	33	295	22–400	−110
50 mEq/L of HCl	1	36	330	96–120	+112
Bicarbonate					
50 mEq/L of HCO^-_3	3	11.5	280	40–180	+138
100 mEq/L of HCO^-_3	2	16	250		+190

TABLE III
Removal of nonprotein nitrogen

Cycle volume	Patients	Mean duration dialysis	Mean cycle vol	Removal per 24 hours	
				Range	Mean
ml	*no.*	*hrs*	*ml*	*g*	*g*
200–400	8	99	270	0.6–2.5	2.0
400–600	6	34	530	1.1–5.6	3.0

early in the course of renal failure. Gastrodialysis will prevent serious hyperkalemia unless there is marked catabolic activity. Correction of acidosis helps ameliorate the problem of hyperkalemia since increasing pH is associated with lowering of the serum potassium level (10).

Water removal. The term water removal is used to connote the transfer of water free of electrolyte. Data were obtained at dialysate sodium concentrations of 50 mEq per L. Thus, since sodium transfer at this concentration was near zero, increase in the weight of the dialysate reflected removal of solute free water from the patient.

Transfer of water was controlled by the regulation of the concentration of dextrose in the dialysate. In virtually all patients, dialysis was performed using 20 per cent dextrose. The use of 40 per cent dextrose in two patients resulted in water removal of up to 1,000 ml in 24 hours. Water transfer data using 20 per cent N dextrose were obtained in six patients. In these, the duration of dialysis averaged 82 hours with mean cycle volumes of 270 ml. Water removal ranged from zero to 600 ml per 24 hours, the mean removal was 200 ml per 24 hours. As long as the dialysate concentration was hyperosmolal, there were no instances of water absorption by the patient. Thus, in patients in whom it was desirable to have a negative free water balance, the total of sensible, insensible, urinary and dialytic losses permitted a negative balance of 1 to 3 L per 24 hours.

Glucose administration. Glucose transfer at a 20 per cent concentration was studied in six patients dialyzed a mean of 45 hours and a mean cycle volume of 390 ml. The transfer to the patient ranged from 26 to 452 g per 24 hours with a mean of 150 g per 24 hours. If 40 per cent glucose was used, the mean addition to two patients studied was 450 g per 24 hours. In most patients, slightly elevated blood glucose concentrations were maintained. In one patient the blood glucose concentration rose to slightly more than 1,000 mg per 100 ml.

Nonprotein nitrogen removal. Nonprotein nitrogen removal was used as an index of the removal of substances responsible for the uremic syndrome. In eight patients studied at a mean cycle volume of 270 ml for a mean of 99 hours each, nonprotein nitrogen removal ranged from 0.6 to 2.5 g per 24 hours. The mean was 2.0 g per 24 hours (Table III).

In six patients studied at a mean cycle volume of 530 ml for a mean duration of 34 hours, the nonprotein nitrogen removal ranged from 1.1 to 5.6 g per 24 hours with a mean of 3.0 g per 24 hours.

An additional variable affecting nitrogen removal appears to be the body concentration of nitrogen. Figure 3 illustrates the influence of cycle volume in three patients having different

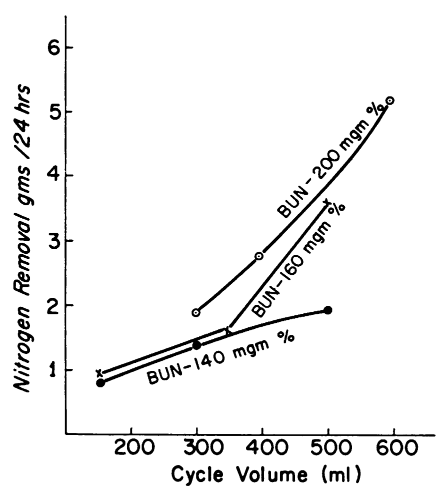

FIG. 3. THE INFLUENCE OF CYCLE VOLUME OF DIALYSIS FLUID ON NITROGEN REMOVAL IS PLOTTED FOR THREE PATIENTS AT DIFFERENT ELEVATIONS OF BLOOD UREA NITROGEN.

concentrations of urea nitrogen. It can be seen that not only does nitrogen yield increase as cycle volume increases, but also as the blood urea nitrogen increases.

The use of a small number of patients to evaluate the efficacy of gastrodialysis in the prevention of the uremic syndrome is fraught with hazard. The individual variation in the course of the disease is too great to permit definite conclusions. The blood urea nitrogen (BUN) was stabilized in several patients, and it appeared that gastrodialysis delayed or prevented the development of the uremic syndrome. In 7 of 14 patients with mean urinary nitrogen excretions of 1.8 g per day, gastrodialysis stabilized a previously rapidly rising blood urea nitrogen for a mean period of 7 days. The stabilization was associated with a maintenance of a uremia-free clinical state. In two of these patients the onset of diuresis led to premature discontinuance of gastrodialysis. In both there was a prompt rise in BUN and the rapid development of uremic symptoms requiring hemodialysis. The following cases selected from the 14 studied provide the best evidence that gastrodialysis may have helped to delay or prevent the symptoms of uremia.

CASE STUDIES

Case 1. A 52 year old man developed acute renal failure following an episode of hypotension during a transurethral resection of the prostate. Gastrodialysis was performed from the seventh to the fourteenth day of oliguria. Simultaneous gastric suction also was carried out. Figure 4 shows the amount of nitrogen removed by gastrodialysis, by gastric suction, and through the urine, and its effect on his serum nonprotein nitrogen (NPN). The sudden rise in the NPN from Day 8 to Day 9 was believed to be due to a 9 L decrease in the size of his extracellular space effected by gastrodialysis plus gastric suction. On Day 11 the patient began to show signs of the uremic syndrome manifested by mental confusion, restlessness and irritability. These signs did not progress. On Day 14 a diuresis began, and he made an uneventful recovery. In this patient, gastrodialysis plus gastric suction removed over 2 g of nitrogen per day and it was associated with a plateau effect on his rising NPN. Also, in addition to removing 15 pounds of extracellular fluid, his serum bicarbonate was maintained at 27 to 30 mEq per L. Potassium excess was never a problem, and sufficient calories were administered to make intravenous feeding unnecessary. It was felt that hemodialysis was averted by gastrodialysis.

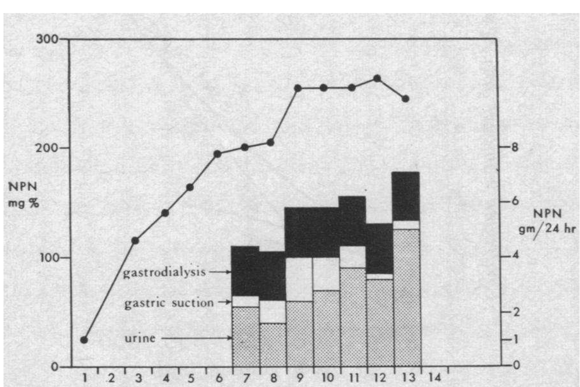

FIG. 4. THE EFFECT OF GASTRODIALYSIS. Case 1, a 52 year old man with acute renal failure complicating transurethral resection of the prostate.

Case 2. A 42 year old man developed acute renal failure following exposure to carbon tetrachloride. He was subjected to gastrodialysis continuously from the third to the seventeenth day of oliguria. During this period his urine volume averaged less than 100 ml per day. Potassium removal averaged 21 mEq per day. The patient absorbed 100 to 500 g of glucose per day, the concentration in the bath being 10 per cent. Water removal varied from none to 200 ml per day. In no period was water absorbed by the patient. With the exception of one day when the serum HCO_3^- rose to 41 mEq per L as a result of miscalculation of the amount of HCl in the bath, the serum HCO_3^- was maintained near 25 mEq per L. Nitrogen removal averaged 2.0 g per day. The BUN rose about 10 mg per cent per day and on the tenth day of oliguria was 160 mg per cent. On the following day, because of increasing mental confusion, hemodialysis was carried out with clinical improvement. Gastrodialysis was continued over the next 6 days, and the BUN rose slowly to 144 mg per 100 ml. At this time a urine volume of 500 ml per day was attained, so gastrodialysis was discontinued. However, despite urine volumes averaging 2,700 ml per day, the BUN climbed rapidly over the next 4 days reaching 296 mg per 100 ml. Again, because of symptoms of the uremic syndrome, another hemodialysis was performed. Following this he made a rapid uneventful recovery. The rapid deterioration prior to the second hemodialysis was associated with no event or change in the patient's condition other than discontinuance of gastrodialysis. It seems likely that the second hemodialysis could have been averted had gastrodialysis been continued further into the diuretic period.

Case 3. A 3 year old boy developed acute renal failure following an intramuscular injection of bismuth. He was gastrodialyzed for 9 days from the sixth to the fifteenth day of oliguria. During this period his urine volume did not exceed 100 ml per day. His BUN was maintained at 100 mg per 100 ml. On the eighth day of gastrodialysis catabolism increased because of the development of bilateral bronchopneumonia. Gastrodialysis was no longer able to handle the increased nitrogen load, and his BUN rose rapidly. A replacement transfusion was carried out on the sixteenth day of oliguria with good results. The patient, however, succumbed to a progressive pneumonia at a time when his urine volume had reached 400 ml per day and recovery from the renal lesion seemed likely. In this patient gastrodialysis seemed effective in controlling his uremia until catabolism increased secondary to the pneumonia.

COMPLICATIONS

Gastrodialysis was performed in 14 patients studied a total of 65 days. The procedure was generally well tolerated. Complications were infrequent and not of major consequence. One patient developed precordial and epigastric pain considered to be regurgitant esophagitis; this was not a serious problem.

One patient with advanced uremia developed hematemesis following which the cellophane bag was immediately removed and no further bleeding occurred. Postmortem examination performed 2 days later (and also in 6 other patients, each of whom had been subjected to gastrodialysis for many days) revealed no significant pathology in the esophagus or stomach that could be attributed to the procedure.

Two confused patients, while attempting to remove the gastric tube, pulled the cellophane bag off the end of the tube. In neither instance did this result in complication.

One patient developed atelectasis and pneumonitis. It could not be ascertained that gastrodialysis contributed, although this possibility exists.

DISCUSSION

In the management of patients with acute renal failure, the magnitude of electrolyte transfer by gastrodialysis is adequate to manipulate body water (osmolality), extracellular volume, and acid-base status. In general, the serum sodium is used as a guide to regulation of osmolality and, therefore, water requirements (11). Water losses—sensible, insensible, renal, and to the dialysate—if allowed to go unreplaced, will be accompanied by elevation in the serum sodium concentration. If no alteration of osmolality is desired, it may be necessary to give water to the patient or to decrease the glucose concentration in the dialysate. Since most patients at the outset were hyponatremic, this was rarely necessary.

The extracellular volume was used to determine the need for sodium removal (11), which was undertaken in all patients with edema. Sodium removal was not attempted in patients who did not have systemic edema or pulmonary congestion until it could be ascertained that the extracellular volume was greater than normal. This was done by making use of changes in body weight. The method used requires two assumptions: first, that there is osmotic equality between extra- and intracellular compartments; and second, that in these patients there was continued loss of weight due to catabolism of fat and protein. It was concluded that the extracellular volume was greater than normal if the body weight remained above normal after removal of water restored osmolality to normal. The following is a typical illustration. A man who weighed 70 kg before elective surgery, weighed 79 kg three days after surgery. Systemic edema was not present. At this time his serum sodium concentration was 120 mEq per L. Three days after gastrodialysis was begun his serum sodium concentration had risen to 140 mEq per L and his weight was 72.6 kg. Therefore, his extracellular volume was increased above normal by 2.6 L, plus an amount equal to the weight lost from catabolism. The calculation permits the conclusion that the patient was not saline-depleted and, unless catabolism had been marked, excludes significant saline excess.

In two patients removal of sodium and water by gastrodialysis reduced extracellular volume below normal as judged from decrease in body weight. This was associated with a prompt reversible decrease in urine volume.

If patients were severely acidotic at the outset, 100 mEq per L of sodium bicarbonate was added to the dialysate. Under these circumstances, in 24 hours the patient gained approximately 100 mEq of bicarbonate and lost approximately 100 mEq of hydrogen ions. This was associated with prompt repair of acidosis. After correction, the removal of approximately 100 mEq per 24 hours of hydrogen ions was adequate to prevent recurrence of acidosis.

Potassium removal was adequate to avert hyperkalemia in most patients. However, removal of 25 mEq per day in patients with major catabolic loads associated with infection or injured tissue would prove inadequate to prevent potassium accumulation and hyperkalemia.

The wide variation in transfers, especially hydrogen ion transfers, might suggest that it would be difficult to arrive at the correct composition of dialysis fluid for a given patient. Actually, this is not true. A dialysis fluid containing 50 mEq per L NaCl and 20 per cent dextrose would result in near zero net transfer of sodium. Water removal would average 200 ml per 24 hours, thus the increase in serum sodium concentration would depend largely upon the magnitude of sensible, insensible, and urinary losses of free water. Hydrogen ion removal would vary with gastric acid production, often being small in the elderly patient. This loss would, in general, be approximately equal to the rate of H^+ production secondary to catabolism. Any alkalosis would be easily detected by measurement of the serum bicarbonafe and readily corrected by addition of acid to the dialysate. Potassium removal would be small in magnitude and hypokalemia unlikely to result. Even more important is the fact that once the general range of transfers was established for any given patient, the range of variation was small. Sudden, unexpected transfers were not encountered.

It is our impression that gastrodialysis was beneficial in delaying the onset of the uremic syndrome. In three patients with urine volumes of less than 300 ml per 24 hours, gastrodialysis was continued for five, seven and ten days, respectively. None required hemodialysis. It seems likely that the clinical course was better than could be expected with conservative management alone.

In one patient, severely injured and with a large catabolic load, gastrodialysis was ineffectual in both potassium removal and in prevention of uremia.

Recently we have undertaken prophylactic hemodialysis in the management of patients with acute renal failure (12, 13). The goal is to prevent any manifestation of the uremic syndrome and thus provide the patient with optimal opportunity to recover from his basic illness. Preliminary experience with prophylactic hemodialysis has been encouraging. If this approach proves sound, gastrodialysis would be effectual only in those patients who had no increase in catabolism secondary to the basic disease process, i.e., infection or trauma. Unfortunately, this group is a small minority of all cases of acute renal failure.

SUMMARY AND CONCLUSIONS

A technique of gastrodialysis has been described that is safe, practical, and without serious complications.

Although probably the least efficient of present-day methods of dialysis, gastrodialysis has proven useful in the treatment of certain aspects of acute renal failure. Gastrodialysis is satisfactory as a means of regulation of osmolality, extracellular volume, and acid-base status. Dextrose can be given by the alimentary route and without administration of water.

The removal of nitrogen and potassium does not compare favorably with extracorporeal dialysis. However, in patients without a large catabolic load, gastrodialysis appears adequate to prevent hyperkalemia and to avoid or decrease the number of hemodialyses required.

Gastrodialysis, to be effective, must be begun early and continued throughout the course of acute renal failure. Hemodialysis should also be available in case the patient cannot be maintained by means of gastrodialysis.

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