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The Effect of Insulin on Gastric Secretion of Potassium

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IN THE TREATMENT of hyperkalemia secondary to renal failure, gastrodialysis is a moderately effective procedure. In patients whose catabolism is not excessive gastrodialysis can prevent increases in the plasma potassium concentration and avoid or reduce the need for hemodialysis.[5]

In view of the safety of gastric aspiration there are obvious advantages to the recent development of the dialysis bag technic, which allows the selective removal of specific ions without transferring fluid into a subject with renal incapacity.[6, 7] However, an important drawback of this method is the relatively slow rate of potassium withdrawal. In humans approximately 1 mEq. of potassium can be removed during an hour of continuous gastrodialysis.[5] Measures which could safely increase the gastric output of potassium to allow more effective extraction of that cation would be desirable.

The ability of insulin to increase the volume of gastric secretion and to lower plasma potassium concentration suggests the use of the hormone in conjunction with gastrodialysis. The following study was undertaken to evaluate the effectiveness of insulin as an adjunct to removal of potassium from the body via the stomach.

MATERIALS AND METHODS

The subjects of these experiments were 10 female mongrel dogs weighing from 9 to 15 kg. The animals had been maintained on a constant diet for at least one week prior to use. Twenty-four hours after the last feeding they were intubated with a double-lumen tube. Air was delivered through one lumen under constant pressure and suction was applied through the other lumen with equal pressure.[1] Continuous gastric aspiration was maintained for 4 hours. At the end of the first 2 hours, regular

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insulin (1 U./kg.) was injected subcutaneously. In all 10 dogs blood glucose levels were less than 40 mg.% within 2 hours after administering insulin. Gastric aspirates were divided into the first and second 2-hour samples. Blood specimens were obtained at the start of each experiment, at the end of 2 hours, and at the end of the experiment.

Prior to use, the collecting tube and vessels were thoroughly cleansed and rinsed 3 times with distilled water and again rinsed 3 times with deionized water. The syringes, needles, and blood storage bottles received the same cleansing and rinsing. The anticoagulant contained no potassium.

The potassium concentration of the two gastric and three blood samples from each dog were determined by flame photometry using an internal standard soon after obtaining the samples. The volume of juice secreted during each 2-hour collection period was also measured.

For purposes of calculation it was assumed that the extracellular fluid volume was one fifth the weight of the dog. The amount of potassium removed in the gastric aspirate during each collection period was calculated. The change in extracellular potassium during each 2-hour period was determined from the change in plasma concentration (usually a decline) in relation to the total extracellular volume. The Student t-test was applied to the values obtained for gastric potassium secreted and to the plasma potassium changes in the 10 experiments during each 2-hour period.[8]

RESULTS

Potassium Secretion

During hypoglycemic stimulus there was a slight increase in the amount of potassium secreted by the stomach. This was primarily due to the increased volume of secretion which accompanies insulin-induced hypoglycemia. The average output of potassium in these dogs was 0.304 ± 0.340 mEq. for the 2-hour basal period. This was increased to 0.341 ± 0.170 mEq. in the 2 hours following administration of insulin. However, this increase was not considered significant. The results are shown in Table 1.

Insulin stimulation induced marked increases in the volume of gastric secretion in only 5 of the animals (Dogs A, C, E, H, and I). In these 5, mean gastric potassium output for the 2-hour basal period was 0.112 ± 0.110 mEq. The output increased to 0.443 ± 0.197 mEq. during the hypoglycemic interval; this increase is significant ($p = <.02$).

Since the basal gastric potassium concentration did not differ signifi-

TABLE 1. GASTRIC POTASSIUM SECRETION AND PLASMA POTASSIUM CHANGES DURING 2-HOUR PERIODS OF GASTRIC ASPIRATION IN THE BASAL AND HYPOGLYCEMIC STATES

			Basal collection period†				*Hypoglycemic collection period*†			
Dog	*Wt.* (*kg.*)	*ECV** (*L.*)	*S* *Vol.* (*ml.*)	*S* K^+ *conc.* (*mEq./L.*)	*S* *Total* K^+ (*mEq.*)	*P* K^+ *conc. change* (*mEq./L.*)	*S* *Vol.* (*ml.*)	*S* K^+ *conc.* (*mEq./L.*)	*S* *Total* K^+ (*mEq.*)	*P* K^+ *conc. change* (*mEq./L.*)
A	17.0	3.4	43	6.8	0.292	−0.6	123	4.8	0.590	−0.1
B	9.0	1.8	29	9.8	0.284	−0.1	33	9.1	0.300	−0.9
C	9.0	1.8	10	6.9	0.069	−0.6	23	7.7	0.177	−0.4
D	11.0	2.2	128	9.2	1.177	−0.2	35	7.0	0.245	−1.0
E	13.0	2.6	5	4.5	0.023	−0.7	52	6.7	0.348	−0.1
F	15.0	3.0	27	9.4	0.254	−0.4	29	7.0	0.203	−0.9
G	15.0	3.0	35	9.0	0.315	−0.5	27	6.4	0.173	−1.6
H	14.0	2.8	9	5.6	0.050	0.0	116	5.8	0.673	−2.0
I	13.5	2.7	15	8.4	0.126	−0.2	52	8.2	0.426	−1.0
J	14.0	2.8	36	12.6	0.454	+0.4	30	9.1	0.273	−1.7
MEAN	13.0	2.6	34	8.2	0.304	−0.3	52	7.2	0.341	−1.0

*Calculated extracellular volume.
†S indicates stomach secretion; P, plasma.

cantly from the hypoglycemic concentration (6.4 and 6.6. mEq./L., respectively), the increase in total potassium aspirated from the stomach was a function of the greater volume of secretion obtained during hypoglycemia in these animals. Furthermore, the mean decline in plasma potassium concentration following insulin administration in these 5 animals was actually less than the mean decline for the entire group of 10 dogs (−0.7 and −1.0 mEq./L., respectively).

Plasma Potassium Concentration

Two hours of continuous gastric aspiration induced a mean fall in plasma potassium concentration of 0.3 ± 0.3 mEq./L. After insulin was given, a fall in plasma potassium levels of 1.0 ± 0.6 mEq./L. followed during the subsequent 2-hour aspiration period. A difference of this magnitude is significant ($p = <.01$). These results are summarized in Table 1.

DISCUSSION

It appears that the use of insulin hypoglycemia is not consistently effective in enhancing the removal of potassium from the stomach of normal dogs. In those 5 animals whose gastric secretory volumes were increased by hypoglycemia there was a fourfold increase in potassium removal. In the remaining 5 dogs, the failure of gastric secretion to increase in response to hypoglycemia was associated with a decline in potassium obtained from the stomach.

The major benefit of inducing insulin hypoglycemia as an adjunct to gastrodialysis would be the rapid fall in plasma potassium concentration effected by the hormone. Patients requiring a rapid lowering of plasma potassium levels would be those with very high potassium concentrations and, therefore, candidates for hemodialysis rather than gastrodialysis.

It is known that histamine increases gastric potassium excretion.[3] Unfortunately it also causes a rise in plasma potassium concentration by driving the cation from the cells into the extracellular space.[4] It would appear that stimulation of the gastric secretory rate by either insulin hypoglycemia or histamine offers only limited advantage in the management of hyperkalemia by gastrodialysis.

The aspiration method described here for dogs was capable of removing approximately 0.15 mEq. potassium per hour compared with 1 mEq. per hour in humans by use of a dialysis bag. Calculated on a body weight basis, simple gastric aspiration appears to be as effective as gastrodialysis for potassium removal.

SUMMARY

The effect of insulin hypoglycemia on the amount of potassium that could be removed from the stomach of 10 normal dogs was studied. In 5 dogs the gastric secretory volume and the amount of potassium aspirated from the stomach were both increased greatly. In the other 5 dogs, there was no increase in either the volume of secretion or the potassium secreted. A decline in plasma potassium concentration was observed in all 10 animals in response to insulin administration.

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