Plasma Ultrafiltrable Magnesium in Respiratory Alkalosis and Acidosis.* (23558)

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Recently changes in the plasma ultrafiltrable calcium during and following hyperventilation and respiratory acidosis have been reported(1,2). A rebound increase in level of ultrafiltrable calcium in the recovery phase following hyperventilation and a similar but inverse rebound following respiratory acidosis experimentally produced in dogs were observed. It was also considered desirable to investigate the status of ultrafiltrable magnesium under these conditions.

Methods. Nine mongrel dogs anesthetized with thiopental sodium were used in this study. Five were subjected to 30 minutes of hyperventilation produced by a positive pressure respirator set to deliver 20 cm of water pressure at a rate of 30-40 breaths/minute and 4 were made acidotic by breathing 30% CO_2 and 70% O_2 from an open system for 30 minutes. Forty ml blood samples were drawn under oil from the femoral artery into a tube containing powdered heparin. Plasma was separated under oil. Samples were drawn before, at the end of the 30 minute experimental period, and 25 minutes after return to normal breathing in both sets of experiments. The method of obtaining an ultrafiltrate of plasma with a minimum shift in pH during ultrafiltration has been previously described (3). Magnesium in plasma and ultrafiltrate was determined(4). Phosphate was determined by the method of Fiske and Subbarow (4). Plasma pH was determined by means of anaerobic electrodes using a research model Cambridge pH meter at 37°C. In 4 *in vitro* experiments 160 ml of freshly drawn heparinized dog blood was divided into four 40 ml aliquots. These portions of blood were placed in 500 ml tonometers and equilibrated with various gas mixtures as follows: Sample I, 5% CO_2—95% O_2; II, 30% CO_2—70% O_2; III, 30% CO_2—70% O_2 followed by 5% CO_2—95% O_2; IV, 5% CO_2—95% O_2. Monobasic sodium phosphate was added to each of the latter 3 samples in amount sufficient to raise plasma concentration to approximately 14 mg%. Equilibrations with gas mixtures were carried out in a water bath maintained at 38°C and were continued for 30 minutes. After 15 minutes of equilibration the proper gas mixture was flushed through the tonometer a second time. In the case of sample III, equilibration with 30% CO_2 mixture was carried out for 30 minutes followed by equilibration with the second mixture for 30 minutes.

Results. Table I presents the means, with their standard deviations, for total and ultrafiltrable plasma magnesium concentration and plasma pH range in which ultrafiltration was carried out, for both sets of experiments. Ultrafiltrable magnesium showed a significant increase within 25 minutes after cessation of hyperventilation as compared with the samples obtained prior to and during hyperventilation. Total magnesium showed no significant changes. Total and ultrafiltrable magnesium showed essentially no change during respiratory acidosis but both decreased somewhat following return to air breathing. The *in vitro* experiments (Table II) revealed no significant changes in level of total and ultrafiltrable magnesium in all 4 samples.

Discussion. The changes observed in ultrafiltrable magnesium are similar to that of calcium in hyperventilation experiments. A rebound increase in level of ultrafiltrable magnesium 25 minutes after return to air following hyperventilation was noted. It was suggested(1) that the rebound increase in level of ultrafiltrable calcium following hyperventilation was related to a decrease in serum phosphate and change from alkalosis to normal pH. Recently, an increase in level of

* This study was supported in part by grant from N.I.H., P.H.S.

TABLE I. Mean Values for Plasma Total and Ultrafiltrable Magnesium Concentration in meq/l in 5 Dogs in Gr. I and 4 Dogs in Gr. II. Mean value for pH of the plasma immediately before and after ultrafiltration is tabulated with each value for ultrafiltrable magnesium. P = .05 when mean Uf Mg during hyperventilation is compared with mean Uf Mg 25 min. after hyperventilation. P = .05 when mean Uf Mg during respiratory acidosis is compared with mean Uf Mg 25 min. on air.

I	Initial sample		During hyperventilation		25 min. after hyperventilation	
	Total Mg	Uf Mg	Total Mg	Uf Mg	Total Mg	Uf Mg
	2.18 ± .3	1.39 ± .26	1.95 ± .26	1.21 ± .21	2.07 ± .22	1.60 ± .36
	pH 7.29 ± .06 – 7.54 ± .15		pH 7.52 ± .06 – 7.81 ± .07		pH 7.27 ± .06 – 7.47 ± .06	

II	Initial sample		Breathing 30% CO_2		25 min. on air	
	Total Mg	Uf Mg	Total Mg	Uf Mg	Total Mg	Uf Mg
	1.96 ± .17	1.37 ± .06	2.07 ± .24	1.39 ± .03	1.84 ± .2	1.16 ± .24
	pH 7.37 ± .04 – 7.63 ± .03		pH 6.92 ± .02 – 7.33 ± .06		pH 7.41 ± .06 – 7.62 ± .03	

plasma citrate has been observed following hyperventilation(6). It seems probable that increased citrate level is responsible for the increase in level of ultrafiltrable calcium and magnesium by forming a filtrable citrate complex. Plasma proteins do not change significantly to account for these changes(1).

During acidosis ultrafiltrable magnesium showed no changes. However, total and ultrafiltrable magnesium both showed a slight decrease. 25 minutes on return to air. Thus, changes in magnesium in these experiments were unlike those observed with respect to calcium(1). The ultrafiltrable calcium increases slightly during acidosis and falls below control level following return to air breathing. The total calcium shows no change. The decrease in level of ultrafiltrable calcium during recovery phase is believed to be due to an increase in phosphate level. The *in vitro* experiments (Table II) show that increased phosphate level and pH changes have no effect on ultrafiltrable magnesium. It may be possible that the decrease in total and ultrafiltrable magnesium observed in post hypercapnia period is due to a shift of this ion into the cells.

TABLE II. *In Vitro* Experiments. Mean values for 5 experiments on dog blood. Stand. error is given with each mean. Samples I and IV were equilibrated with 5% CO_2, Sample II with 30% CO_2 and Sample III with 30% CO_2 and then with 5% CO_2. NaH_2PO_4 was added to Samples II, III and IV before equilibration. Gas mixtures were CO_2 and O_2. Equilibration was carried out for 30 min. at 38°C.

	Total Mg	Uf Mg	PO_4	pH
I	1.78 ± .28	1.50 ± .17	4.7 ± .30	7.28 ± .027
II	1.88 ± .34	1.60 ± .22	14.6 ± .34	6.77 ± .017
III	1.89 ± .40	1.56 ± .34	14.4 ± .31	7.22 ± .019
IV	1.83 ± .38	1.59 ± .28	14.8 ± .40	7.24 ± .018

Summary. (1) Ultrafiltrable magnesium shows a significant increase within 25 minutes after cessation of hyperventilation in dogs as compared to the sample taken during hyperventilation, whereas total magnesium showed no changes. (2) Total and ultrafiltrable magnesium showed no significant changes during respiratory acidosis, as compared to the initial sample. A significant decrease in level of ultrafiltrable magnesium after 25 minutes on return to air breathing, as compared to the sample taken during 30% CO_2 breathing, was noted. A shift of magnesium ion intracellularly is a possible explanation. (3) The results obtained in *in vitro* experiments show that increased phosphate level and pH changes, under the conditions of the experiments, show no effect on ultrafiltrable magnesium level, in contrast to changes previously observed with respect to ultrafiltrable calcium.

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Received August 1, 1957. P.S.E.B.M., 1957, v96.