EXCRETION OF MAGNESIUM BY THE DOG KIDNEY FOLLOWING ITS INJECTION INTO THE RENAL ARTERY

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Following unilateral injection of $MgCl_2$ solution into the renal artery of dogs, the excreted fraction of magnesium as a proportion of the total quantity filtered increased practically equally in both kidneys. These results indicate that the magnitude of the excreted fraction of magnesium is determined not so much by the load of magnesium ions on the nephron as by the action of extrarenal regulatory systems.

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The excretion of Mg^{++} by the kidney is increased following parenteral injection of its salts. However, it is not yet clear whether this is due to an increase in the load of the nephron following an increase in the Mg^{++} concentration in the blood, or whether the reabsorption of Mg^{++} is reduced as a result of the activation of intrarenal or extrarenal mechanisms regulating homeostasis of Mg^{++} [5-7, 10].

In the present investigation excretion of Mg^{++} by the kidneys of a dog was compared after unilateral injection of $MgCl_2$ solution into the renal artery. In this way the excretion of Mg^{++} by the kidneys could be studied in the presence of different loads of Mg^{++} ions on the nephron.

EXPERIMENTAL METHOD

Experiments were carried out on dogs weighing 25-30 kg with the ureters exteriorized separately [3] and with a catheter preliminarily tied into the left renal artery [9]. The dogs were kept on a normal diet. On the day of the experiment a polyethylene catheter filled with heparin solution was introduced through a thick needle into the dog by puncture of one of its leg veins. After introduction of the catheter into the vein the needle was removed and the catheter fixed to the leg by adhesive plaster. At the end of the experiment the catheter was withdrawn from the vein.

After several samples of urine and blood had been taken in the control period, injection of $MgCl_2$ solution into the renal artery was started by means of a perfusion syringe apparatus enabling the solution to be injected for a longer period at a uniform assigned rate. In the various experiments, 2, 5, 10, and 20% solutions of $MgCl_2$ were injected at the rate of 0.12 ml/min for 20-120 min. In some experiments successive injections of $MgCl_2$ were given both into the renal artery and into the leg vein in the same dose. In other experiments different doses of $MgCl_2$ were injected rapidly into the vein. Urine was collected separately from the two kidneys every 5-10 min. Blood was taken every 10-20 min in the course of the experiment. Altogether 23 tests were carried out on three dogs. Creatinine in the urine and blood samples was determined by the method of Bonsnes and Taussky [4], and Mg^{++} by a fluorimetric method [1].

EXPERIMENTAL RESULTS

During injection of 10% $MgCl_2$ solution into the left renal artery the excretion of Mg^{++} with the urine ($U_{Mg} \times V$) from the left kidney was considerably greater than from the right kidney throughout the period of injection. This was associated with a higher concentration of Mg^{++} in the blood supplying the left kidney

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TABLE 1. Excretion of Mg^{++} by Kidneys of a Dog (weight 30 kg) during Injection of 10% $MgCl_2$ Solution into Left Renal Artery

Time from beginning of injection (in min)	P_{Mg} in meq/liter		C_{Cr} in ml/min		$U_{Mg} \times V$ in μeq/min		% E_{Mg}		Dose of $MgCl_2$ (in mg/kg)
	right kidney	left kidney	right kidney	left kidney	right kidney	left kidney	right kidney	left kideny	
0	0,83	0,83	23,9	21,4	0,70	0,86	3,5	4,0	—
10% $MgCl_2$, 0.12 ml/min into left renal artery									
10	0,93	2,76	27,8	23,7	1,04	4,42	4,0	6,7	4
20	1,05	2,87	25,4	25,5	3,17	12,2	11,8	16,0	8
30	1,12	2,94	38,7	34,3	8,88	19,0	14,3	18,7	12
End of injection of solution									
80	0,94	0,94	24,1	25,9	3,36	3,36	14,7	13,9	—

TABLE 2. Excretion of Mg^{++} by Kidneys of a Dog (weight 24 kg) during Injection of 2% $MgCl_2$ Solution into Left Renal Artery

Time from beginning of injection (in min)	P_{Mg} in meq/liter		C_{Cr} in ml/min		in μeq/min		% E_{Mg}		Dose of $MgCl_2$ (in mg/kg)
	right kidney	left kidney	right kidney	left kidney	right kidney	left kidney	right kidney	left kidney	
0	0,81	0,81	26,5	19,8	0,55	1,16	2,6	7,1	—
10% $MgCl_2$, 0.12 ml/min into left renal artery									
10	0,82	1,18	25,0	22,0	0,50	1,40	2,4	5,3	1
30	0,86	1,22	31,8	25,2	1,25	2,40	4,5	8,1	3
50	0,86	1,22	28,3	30,7	2,16	4,20	8,8	11,2	5
70	0,90	1,26	33,4	32,3	4,10	6,60	14,2	16,2	7
90	0,93	1,29	27,6	30,1	4,30	7,68	16,7	19,2	9
End of injection of solution									
120	0,90	0,90	33,0	26,6	5,18	6,12	17,4	25,5	—

Note. In Tables 1 and 2: P_{Mg} is ultrafiltered fraction of Mg^{++}, or 75% of its total blood concentration [9]. Mg^{++} concentration in blood for left kidney calculated allowing for renal blood flow and for amount of $MgCl_2$ reaching left renal artery per minute. C_{Cr} denotes filtration, $U_{Mg} \times V$ excretion of Mg^{++} in urine.

and an increase in the filtered Mg^{++} load. The excreted fraction of Mg^{++} ($\%E_{Mg}$)*, giving an idea of the proportion of reabsorbed ion relative to that filtered in the glomeruli, was increased during injection of $MgCl_2$ practically equally in both kidneys (Table 1). The increase in $\%E_{Mg}$ continued for some time after the end of injection of the $MgCl_2$ solution (Table 1), although the Mg^{++} concentration in the venous blood after 50 min was only very slightly higher than its level in the control period.

* The excreted fraction of Mg^{++} relative to the quantity filtered was calculated at the ratio:

$$\%E_{Mg} = \frac{U/P_{Mg} \cdot 100}{U/P_{Cr}},$$

where U is the concentration and P the ultrafiltered fraction of magnesium (Mg) or creatinine (Cr.)

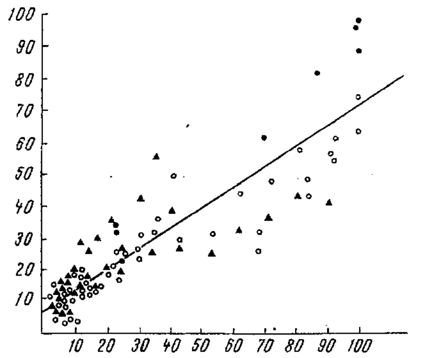

Fig. 1

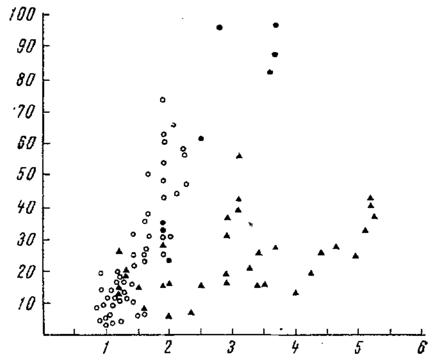

Fig. 2

Fig. 1. Relationship between quantity of injected $MgCl_2$ and $\%E_{Mg}$. Triangles denote injection into renal artery; circles injection into leg vein continuously over different periods of time; dots denote rapid intravenous injection. Regression line $y = 6.89 + 0.638\times$; $r = 0.604$; $P < 0.001$. Abscissa, dose of injected $MgCl_2$ (in mg/kg); ordinate, $\%E_{Mg}$.

Fig. 2. Relationship between size of excreted Mg^{++} fraction and blood concentration of Mg^{++}. Abscissa, Mg concentration in blood (in/meq liter); ordinate, $\%E_{Mg}$. Remainder of legend as in Fig. 1.

In the experiments with 2-5% $MgCl_2$ solution, the analogous increase in excreted Mg^{++} fraction took place after a longer period of injection. The increase in $\%E_{Mg}$ also followed a parallel course in the two kidneys. The Mg^{++} concentration both in the venous and in the arterial blood of the left kidney was increased by only 0.1-0.5 meq/liter (Table 2). Following rapid intravenous injection of the solutions, the excretion of Mg^{++} ion reached a maximum after 15-20 min.

Consequently, the degree of increase in the excreted fraction of Mg^{++} depended not on the method of injection of the ion, but on the dose of the substance injected. A definite correlation was found between the injected dose and the increase in $\%E_{Mg}$ (Fig. 1), whereas no relationship could be found between the Mg^{++} concentration in the blood and the size of its excreted fraction (Fig. 2).

It can be concluded from these results that the increase in $\%E_{Mg}$ in the kidney during injection of $MgCl_2$ both intravenously and into the renal artery does not depend on the filtration load but is the result of activation of certain mechanisms depressing the relative reabsorption of the ion in the kidney during its entry into the body in excess. This mechanism is evidently specific for the Mg^{++} ion, for in experiments with injection of $MgCl_2$ the increase in excretion of other cations (Na^+, K^+, Ca^{++}) were incomparably small compared with the excretion of Mg^{++} [2].

The results thus demonstrate that the decrease in relative reabsorption of Mg^{++} after injection of $MgCl_2$ into a dog is not due to an increase in the load of Mg^{++} ions on the nephron, but results from the action of regulatory factors on the systems of cells in the nephron reabsorbing Mg^{++}.

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