Effect of Magnesium Deficiency on Cardiac and Skeletal Muscle Potassium During Dietary Potassium Restriction (37467)

MICHAEL P. RYAN,[1] ROBERT WHANG, AND W. YAMALIS
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The Department of Medicine, University of Connecticut Health Center, and the V. A. Hospital, Newington, Connecticut 06111

Magnesium (Mg) deficiency in the rat is accompanied by a small but statistically significant loss of muscle potassium (K) (1). This loss occurs despite adequate provision of K in the diet (2). Ascites tumor cells grown *in vivo* are dependent on adequate provision of Mg for maintenance of normal cell K (3). The importance of Mg for maintenance of cell K has also been demonstrated for a number of *in vitro* systems (2, 4). Repletion of skeletal muscle K following K depletion in rats is impaired by the presence of continuing Mg deficiency when KCl is administered either by gavage or by intraperitoneal injection (5, 6).

In human studies, consumption of Mg deficient diets results in decreased plasma K and negative K balance. These abnormalities are reversed with reinstitution of Mg (7).

Certain clinical circumstances predisposing to K loss, such as aggressive diuretic therapy, alcoholism, and protein-calorie malnutrition, are also known to be associated with loss of Mg (8–10). The present study was undertaken to investigate the role of Mg in maintenance of cardiac muscle K during dietary K depletion. Our results indicate that during K deficiency coexisting Mg depletion significantly enhances loss of cardiac and skeletal muscle K. Thus, a deficit of Mg exerts an important influence during K depletion as it does during K repletion.

Materials and Methods. Male Sprague–Dawley rats averaging 125 g were housed individually and given free access to deionized H_2O. Animals were divided into two groups: Group I, K deficient animals, served as the controls. Group II, Mg and K deficient rats, served as the experimental group. The animals were pair fed with an electrolyte-free, magnesium-free diet (Nutritional Biochemicals Corporation, Cleveland, OH). Group I (K deficient) received daily 5 ml of gavage solution containing 0.72 mmoles Mg, 1.15 mmoles Na, 0.5 mmoles Cl, and 0.75 mmoles P. Group II (Mg and K deficient) received a solution of the same composition but with no Mg.

After 10 days animals were killed by aortic exsanguination under light ether anesthesia. The heart was removed *in toto*. Skeletal muscle was sampled widely. Skeletal and cardiac tissue was blotted of all excess blood, weighed and dried to constant weight. Muscle tissue was ground and fat was extracted using a 1:1 mixture of petroleum and ethyl ether. Electrolyte analysis of skeletal and cardiac muscle tissue was carried out following wet ashing with 0.75 *N* HNO_3. Muscle and serum K and Na were determined by flame photometry using the Instrumentation Laboratories flame photometer. Tissue and serum Mg were determined using the Perkin-Elmer Model 303 atomic absorption spectrophotometer. Tissue and plasma chloride (Cl) were determined using the Buchler-Cotlove chloridometer. A nonpaired Student's *t* test was used to analyze for significance of differences (11).

Results. With coexisting Mg and K depletion (Group II) there was a significantly greater loss of K from both skeletal and cardiac muscle compared to the K depleted Group I (Table I). The K loss from skeletal muscle was relatively greater than that from cardiac muscle. There was no significant dif-

[1] On leave of absence from Department of Pharmacology, University College, Dublin, Ireland.

TABLE I. Comparison of Skeletal and Cardiac Muscle Electrolyte Contents in Rats on a Potassium Deficient Diet and Rats on a Combined Magnesium and Potassium Deficient Diet.

Group	No.	Skeletal muscle (mEq/100 g FFDS)				H_2O (g/100 g FFDS)	Cardiac muscle (mEq/100 g FFDS)				H_2O (g/100 g FFDS)
		K	Na	Mg	Cl		K	Na	Mg	Cl	
Potassium deficient (Group I)	7	38.3 ± 2.8[a]	13.2 ± 1.4	10.26 ± 0.84	8.0 ± 1.0	329 ± 21	32.5 ± 0.9	18.1 ± 0.3	9.26 ± 0.25	12.0 ± 0.6	333 ± 10
Magnesium and potassium deficient (Group II)	5	32.6 ± 1.7	13.3 ± 2.2	10.04 ± 0.48	6.4 ± 0.6	316 ± 9	30.9 ± 0.9	18.2 ± 1.4	9.08 ± 0.41	12.3 ± 1.2	335 ± 6
p		<0.0025	>0.05	>0.05	<0.005	>0.05	<0.01	>0.05	>0.05	>0.05	>0.05

[a] Values represent means ± standard deviation. FFDS = fat free dry solids. p values calculated from a nonpaired t test.

ference between the magnesium content of the skeletal or cardiac muscle. Neither was there a significant difference in sodium content of either skeletal or cardiac muscle. Hypokalemia was observed in both Groups I and II. Plasma Mg was reduced only in the K and Mg depleted Group II.

Discussion. This study demonstrates the importance of Mg for maintenance of cell K. Coexisting Mg deficiency during dietary K restriction accelerated the deficit of both skeletal and cardiac tissue K. Previous studies have demonstrated that the mobility of muscle K generally exceeds that of Mg (5, 12–14). Thus, in the present study, although coexisting Mg deficiency accentuated the loss of muscle K, no detectable loss of muscle Mg was observed.

Although the magnitude of K loss from cardiac tissue was not as great as that from skeletal muscle, coexisting Mg deficiency did significantly enhance loss of cardiac K. The increased incidence of digitalis toxicity associated with hypomagnesemia observed clinically (15) may be due to accentuated loss of cardiac K produced by coexisting Mg deficiency.

The present results lend support to our hypothesis that Mg deficiency may be a cause of reversible prerenal azotemia (16). The enhanced loss of cardiac K during coexisting Mg deficiency could result in decreased cardiac function, diminished renal perfusion with consequent azotemia. Thus the mechanism to account for the azotemia accompanying Mg deficiency may be a hemodynamic one. The present study together with earlier reports demonstrating impairment of K repletion during continuing Mg deficiency (7, 8) strongly suggests that coexisting Mg deficiency should be suspected clinically in patients with severe K depletion and also in patients in whom difficulty in K repletion is encountered.

Summary. The influence of coexisting Mg deficiency on cardiac and skeletal muscle K depletion was investigated. Rats were subject to either a K deficiency or K plus Mg deficiency regimen. It is concluded that:

1. K deficiency accompanied by coexisting Mg deficiency results in accelerated deficit of K in both cardiac and skeletal muscle when

contrasted to K deficiency alone.

2. In contrast to skeletal muscle, cardiac muscle was relatively resistant to K loss during K and Mg depletion.

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