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Original paper

MAGNESIUM SERUM AND URINE CONCENTRATION IN PATIENTS WITH ACUTE AND CHRONIC PULMONARY DISEASE

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Summary: In this study we determined magnesium concentration in serum and in 24-hour urine, at the start (To) and at the end of treatment (T1), in 56 patients with acute pulmonary disease (B1) and in 58 patients with chronic obstructive pulmonary disease – COPD (B2). In group B1 there was disbalance of Mg in serum in 14–25% patients at the start of treatment (To) which decreased significantly at the end of treatment (T1) and persisted in 4–7.1% patients ($p < 0.05$). In group B2 distribution of normal, decreased and increased values of Mg in serum was similar in patients in period To and T1 ($p > 0.05$). In group B1, 9 (16.1%) patients had hypomagnesemia at the start of treatment (To), which was accompanied by increased concentration of Mg in 24-hour urine of only 4 (7.2%) patients. There is a possibility that there was extrarenal elimination of Mg in patients with acute pulmonary disease or there was some kind of transcellular distribution. In group B2 in period To, there was proportional ratio between hypomagnesemia (12–20.7% patients) and increased concentration of Mg in 24-hour urine (20–34.5% patients). This could be because of renal loss. Simultaneous determination and follow up of magnesium in serum and in 24-hour urine can give us reliable information about homeostasis of this electrolyte in acute and chronic pulmonary diseases.

Key words: magnesium, serum, urine, pulmonary disease

Introduction

Body magnesium is distributed in three major compartments: extracellular fluid (1.3%), intracellular fluid (13%) and bone (67%). Thus, Mg is mainly located in areas that are poorly accessible to study: the intracellular and body compartments. Unfortunately, most of the available data on electrolyte metabolism is derived from measurements of the blood concentration of Mg. Today we can diagnose Mg disbalance measuring this electrolyte in extracellular fluid (serum), intracellular fluid (erythrocyte, lymphocyte) and urine (1, 2). Lymphocyte and skeletal muscle Mg have been used for research purposes, but usually are not available in clinical practice because of the complexity of their determination. Determination of erythrocyte Mg value is the most precise, since Mg is primarily an intracellular cation, but many laboratories are deficient in this method. It is sometimes extremely difficult to precisely judge body Mg content in clinical reports and experimental studies that measure only the serum levels. Hypomagnesemia can develop without concomitant magnesium losses and cellular magnesium depletion can occur in the presence of normomagnesemia (3). However, with all its limitations, a serum Mg concentration remains the prime clinical diagnostic tool. Simultaneous investigation of Mg in serum and in 24-hour urine is a precious method for observation of Mg disbalance in clinical practice. Serum Mg concentration is not routinely measured when physicians initiate a request for determination of serum electrolytes. Various studies indicated that patients with acute and chronic pulmonary disease may have Mg disbalance (1–2, 4–5).

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Materials and Methods

Materials

We investigated 114 patients, 56 with acute pulmonary disease (B1) (with the subgroups B1-1: 18 patients with pneumonia, B1-2: 22 patients with pulmonary thromboembolism, B1-3: 16 patients with acute asthma attack) and 58 patients with acute exacerbation of chronic obstructive pulmonary disease - COPD (B2). The following ratio between males and females were in group B1 = 34–60.7% : 22–39.3% (B1-1 = 14–77.8% : 4–22.2%; B1-2 = 13–59.1% : 9 –40.9%; B1-3 = 7–43.8% : 9–56.2%) and in group B2 = 33–56.9% : 25–43.1%. In group B1 patients were of mean age 46.8 ± 15.3 years (B1-1: 47.1 ± 15.9; B1-2: 49.7 ± 13.4; B1-3: 42.2 ± 16.9) and 61.7 ± 7.7 years in group B2.

Methods

We measured Mg concentration in serum and 24-hour urine in patients by colorimetric Calmagite method using biochemical analyzer IL Monarch 2000 (Instrumentation Laboratory, Milano, Italy). Reference values for Mg in serum were 0.70–1.15 mmol/L and in 24-hour urine were 3–5 mmol/day (6).

We determined Mg concentration in serum and 24-hour urine in patients at the start (To) and at the end of hospital treatment (T1). All patients were first admitted in Pulmonary Intensive Care Unit and after stabilization of disease they continued treatment in the clinical department.

In this study there were not patients with associate diseases which can be a potential risk factor for electrolyte disbalance like: gastrointestinal diseases (Malabsorption syndromes, ulcus disease, malnutrition for hard dietary, severe diarrhoea, pancreatitis, etc.), pregnancy and prolonged lactation, hormonal diseases (Diabetes mellitus, hyperthyroidism, hypothyroidism, diseases glandulae suprarenalis, etc), renal failure, malignant disease, and alcoholism.

The results are presented as mean values ($\bar{x}$) with dispersion measures: standard deviation (SD), coefficient of variation (CV) and standard error (SE), minimal and maximal values (Min-Max) and median values. A statistical analysis was performed using Student's t-test, Mann-Whitney test and Pearson's χ^2 test. Differences were considered as statistically significant at $p < 0.05$.

Results

In the group of patients with acute pulmonary disease (B1) 22 patients (39.3%) had high temperature over 38 °C and in the group with acute exacerbation of chronic obstructive pulmonary disease – COPD (B2) were 27 patients (18.7%) ($\chi^2 = 0.614$; DF = 1, $p > 0.05$). On hospital admission 45 patients (80.3%) with acute pulmonary diseases (B1) had acute disturbance of respiratory gasses in arterial blood. Partial pressure of oxygen in arterial blood (Pa_{O_2}) was lower than 8 kPa in 7 patients (38.9%) with pneumonia (B1-1), in 5 patients (22.7%) with pulmonary thromboembolism (B1-2) and in 9 patients (56.3%) with acute asthma attack (B1-3). In group B2 on admission all 58 patients (100%) had acute exacerbation of chronic respiratory failure. Mean value of Pa_{O_2} in group B1 was 8.85 ± 1.65 kPa and in B2 4.86 ± 0.92 kPa (t = 15.964; DF=1, p<0.001). Decompensation status of cor pulmonale chronicum persisted in 39 patients (67.2%) with acute exacerbation of COPD (B2).

Table I Magnesium concentration in serum (mmol/L) at the start (To) and at the end of treatment (T1) in groups of patients

To							
Group	n	$\bar{x}$	SD	SE	CV (%)	Min-Max	Median
B1	56	0.88	0.16	0.02	18.2	0.48–1.27	0.87
B1-1	18	0.88	0.14	0.03	15.9	0.62–1.21	0.89
B1-2	22	0.86	0.15	0.03	17.4	0.65–1.27	0.85
B1-3	16	0.90	0.21	0.05	23.3	0.48–1.23	0.91
B2	58	0.86	0.16	0.02	18.6	0.58–1.45	0.85
t = 0.649; DF = 112; p > 0.05*							
T1							
Group	n	$\bar{x}$	SD	SE	CV (%)	Min-Max	Median
B1	56	0.94	0.17	0.02	18.0	0.68–1.86	0.95
B1-1	18	0.91	0.12	0.02	13.1	0.69–1.10	0.91
B1-2	22	0.97	0.23	0.05	23.7	0.68–1.86	0.96
B1-3	16	0.92	0.13	0.03	14.1	0.70–1.16	0.93
B2	58	0.87	0.14	0.02	16.0	0.66–1.19	0.88
t = 2.094; DF = 112; p < 0.05* B1 – t = 1.788; p > 0.05* B2 – t = 1.631; p > 0.05*							
* Student's t-test							

In patients with acute pulmonary disease (B1) the most lowest value of Mg in serum on admission (To) was 0.48 mmol/L and the highest was 1.27 mmol/L. The mean concentration of this electrolyte was in reference range (0.88 ± 0.16 mmol/L). In patients with acute exacerbation of COPD (B2) mean concentration of Mg in serum in period To (0.86 ± 0.16 mmol/L) was normal like in group B1 (B1:B2 t = 0.649; DF=112, p>0.05). After administered therapy at the end of hospitalization (T1) in both groups mean concentration of Mg in serum was normal but lower in group B2 (0.87 ± 0.14 mmol/L) than in group B1 (0.94 ± 0.17 mmol/L) (t = 2.094; DF = 112, p < 0.05). By comparing individual analyses within group B1 and group B2 there were not statistically significant differences in mean concentrations of Mg in serum before (To) or after treatment (T1) (p > 0.05) (*Table I*).

Table II. Distribution of magnesium concentration in serum at the start (To) and at the end of treatment (T1)

Group	N	To						T1						p
		Normal*		Decreased*		Increased*		Normal*		Decreased*		Increased*		
		n	%	n	%	n	%	n	%	n	%	n	%	
B1	56	42	75.0	9	16.1	5	8.9	52	92.9	3	5.3	1	1.8	<0.05
B1-1	18	15	83.3	2	11.1	1	5.6	17	94.4	1	5.6	–	–	>0.05
B1-2	22	18	81.8	3	13.6	1	4.5	19	86.4	2	9.1	1	4.5	>0.05
B1-3	16	9	56.2	4	25.0	3	18.8	16	100	–	–	–	–	<0.05
B2	58	43	74.1	12	20.7	3	5.2	46	79.3	10	17.2	2	3.4	>0.05
B1:B2		$\chi^2 = 0.032$; DF=1; $p > 0.05$**						$\chi^2 = 4.33$; DF=1; $p < 0.05$**						

*In comparison with reference values
**χ^2-test

Table III Magnesium concentration in 24-hour urine (mmol/day) at the start (To) and the end of treatment (T1) in groups of patients

To							
Group	n	$\bar{x}$	SD	SE	CV (%)	Min–Max	Median
B1	56	3.04	1.87	0.25	61.5	0.08–8.40	2.99
B1-1	18	2.84	1.46	0.36	51.4	0.24–4.90	3.24
B1-2	22	2.73	2.06	0.43	75.4	0.20–7.32	2.58
B1-3	16	3.67	1.92	0.48	52.3	0.08–8.40	3.58
B2	58	3.98	2.41	0.31	60.5	0.05–11.20	3.97
Z = 2.553; p < 0.015*							
T1							
Group	n	$\bar{x}$	SD	SE	CV (%)	Min–Max	Median
B1	56	2.67	1.69	0.27	63.2	0.05–6.60	2.85
B1-1	18	2.76	1.57	0.45	56.8	0.48–5.90	2.72
B1-2	22	1.44	1.86	0.62	129.1	0.05–5.05	0.50
B1-3	16	3.28	1.39	0.34	42.3	0.94–6.60	3.33
B2	58	4.28	2.82	0.37	65.8	0.09–17.70	3.71
Z = 5.492; p < 0.001* B1 – Z = 0.958; p > 0.05* B2 – Z = 0.019; p > 0.05*							
*Mann-Whitney test							

In comparison with reference values (normal, decreased and increased), patients with acute pulmonary disease (B1) had important differences in distribution of Mg serum concentration at the start (To) (normal = 75.0%; decreased = 16.1%; increased = 8.9%) and at the end of treatment (T1) (normal = 92.9%; decreased = 5.3%; increased = 1.8%) ($p < 0.05$). There is an interesting occurrence disbalance in this electrolyte in serum in patients with acute asthma attack (To) (43.8% patients had disturbance). Among them, 25% of patients had decreased and 18.8% increased concentration of magnesium. After therapy (T1) this disbalance was completely corrected and all patients had normal concentration of Mg ($p < 0.05$). Patients with acute exacerbation of COPD (B2) had similar values, normal, decreased and increased concentrations before and after therapy ($p > 0.05$). Comparing Mg distribution in serum between groups B1 and B2 we registered not significant differences in period To ($\chi^2 = 0.032$; DF = 1, $p > 0.05$) but significant in period T1 ($\chi^2 = 4.33$; DF = 1, $p < 0.05$) (*Table II*).

Mean concentration of Mg in 24-hour urine in patients from group B1 and group B2 at period To and T1 was shown in *Table III*.

In *Table IV* we can see distribution normal, decreased and increased concentrations of Mg in 24-hour urine in patients from group B1 and group of B2. There are interesting findings in group B2 where patients had high percentage of increased concentration of Mg in 24-hour urine both at the start (To) and at the end of treatment (T1).

Discussion

Disbalance of Mg serum concentration is not a rare appearance in patients with pulmonary diseases (1–4). Results from literature described frequency of hypomagnesemia in 10–60% among hospital treated patients, especially in patients who were medically treated in Intensive Care Units. Greater mortality was seen in patients with hypomagnesemia, comparing with patients who had normal concentrations, especially when they were treated in Intensive Care Unit (7).

Results of this study showed that mean concentration of Mg in serum at the start (To) and at the end of medical care (T1) were in referential value in group B1 and group B2.

Analyzing various patients in group B1 we found that patients with acute asthma attack (B1-3) had the lowest Mg serum concentration in period To (0.48 mmol/L) while the highest concentration (1.27 mmol/L) was found in patients with pulmonary thromboembolism (B1-2).

Patients with acute pulmonary disease (B1) had important differences in distribution of Mg serum con-

Table IV Distribution of magnesium concentration in 24-hour urine at the start (To) and at the end of treatment (T1)

Group	N	To						T1						p
		Normal*		Decreased*		Increased*		Normal*		Decreased*		Increased*		
		n	%	n	%	n	%	n	%	n	%	n	%	
B1	56	25	44.6	27	48.2	4	7.2	26	46.4	26	46.4	4	7.2	>0.05
B1-1	18	12	66.7	6	33.3	–	–	10	55.5	7	38.9	1	5.6	>0.05
B1-2	22	5	22.7	14	63.6	3	13.6	7	31.8	13	59.1	2	9.1	>0.05
B1-3	16	8	50.0	7	43.7	1	6.3	9	56.3	6	37.5	1	6.2	>0.05
B2	58	21	36.2	17	29.3	20	34.5	27	46.5	15	25.9	16	27.6	>0.05
B1:B2		$\chi^2 = 0.84$; DF = 1; $p > 0.05$**						$\chi^2 = 0.03$; DF = 1; $p > 0.05$***						

* In comparison with reference values
** χ^2 – test

centrations between the start (To) and the end of treatment (T1) ($p < 0.05$). They had hypomagnesemia (16.1% patients) more frequently than hypermagnesemia (8.9% patients) at the start of hospitalisation. Total Mg serum disbalance was present in 25% patients of group B1 in period To, which is similar to results of other authors. They therefore recommended that serum Mg be included routinely when serum electrolyte measurements are required in the care of patients (8, 9). Hypomagnesemia in patients with acute pulmonary disease may be a result of severe infections, inappropriate secretion of antidiuretic hormone (ADH), antibiotic administration (aminoglycoside) (3), etc.

Hypomagnesemia was more frequently found in patients with acute asthma attack (B1-3: 25.0% patients) than in patients with pneumonia (B1-1: 11.1% patients) and patients with pulmonary thromboembolism (B1-2: 13.6% patients).

There was an interesting appearance that 43.8% patients with acute asthma attack (B1-3) had Mg serum disturbance in a period of bronchoobstruction which was the reason for hospital care. After medical treatment all disbalances were corrected ($p < 0.05$). Patients had hypomagnesemia (25.0%) more commonly than hypermagnesemia (18.8%). Some authors did not discover Mg disbalance in patients with asthma attack (10), but others confirmed significant disturbance of this electrolyte usually as hypomagnesaemia (11). Mg depletion may affect muscle function (3), so hypomagnesemia can be one of the reasons for appearance of bronchoobstruction in patients with asthma attack. Various medicaments can produce Mg and other electrolyte disturbance. Frequently administered nebulized albuterol (beta-adrenergic agonist) during the emergency treatment of acute bronchospasam in patients with asthma decreases serum potassium, magnesium and phosphate (12). Intravenous theophylline administered in patients with asthmatic attacks can produce hypophosphatemia, hypomagnesaemia and hypocalcaemia (2). Hashimoto (11) confirmed decreased Mg in 40% patients with asthma and he compared it with severity of bronchoobstruction. The majority of authors advised administration of magnesium-sulfate to improve pulmonary function in patients with acute asthma attack (13–15). Continuous medical treatment with oral magnesium 300 mg/day during two months reduces asthma morbidity in children and adolescents, and helps to improve their lung function (14). Besides recommended treatment by Global Strategy for Asthma Management and Prevention (16), administration of 2 g IV magnesium sulfate improves pulmonary function when used as an adjunct to standard therapy in patients with very severe acute asthma (15).

We can expect different electrolyte disbalance, also Mg disturbance in patients with acute pulmonary disease (17).

In 25.9% patients at the start acute exacerbation of COPD (B2) Mg serum disbalance persisted more frequent as hypomagnesaemia (20.7% patients) than hypermagnesiemia (5.2% patients). Comparing distribution of Mg in serum between patients in group B1 and B2 we confirmed not significant differences et the start (To) ($\chi^2 = 0.032$; DF = 1; $p>0.05$) but significant differences at the end of treatment (T1) ($\chi^2 = 4.33$; DF=1; $p < 0.05$).

Various electrolyte disbalance is not an uncommon appearance in patients with acute exacerbation of COPD (18). In this study there were a greater number of patients with decreased Mg in serum (20.7%) than in results of Hogg et al (11.8%) (19). There is a study which shows that exacerbation of COPD significantly affected magnesium levels in erythrocytes, while in plasma levels it remained unchangeable (20). Administration of systemic corticosteroids and diuretics can be a possible reason for hypomagnesemia in patients with acute exacerbation of COPD (4).

Comparing distribution of Mg concentration in serum and in 24-hour urine in patients of group B1 at the start of treatment (To), it was not confirmed that hypomagnesemia (16.1% patients) was in proportional ratio with increased urine concentration (7.2% patients). Therefore was suspected that patients with acute pulmonary disease had extrarenal electrolyte

elimination or transcellular arrangement from extracellular to intracellular space. In patients of group B2 also at the start of hospital care (To) there was a better proportional ratio between decreased Mg in serum (20.7% patients) and increased urine level (34.5% patients). We explained these results by renal electrolyte elimination, mostly because of using loop diuretics in patients who had cor pulmonale chronicum in decompensated state.

Results of this study showed that we can expect magnesium disbalance in patients with acute and chronic pulmonary diseases. Measuring Mg in serum and in 24-hour urine is a very useful method for follow-up of electrolyte disturbance. We recommend that should be determined and followed up Mg concentration in pulmonary diseases especially in patients with acute asthma attack.

KONCENTRACIJA MAGNEZIJUMA U SERUMU I URINU KOD BOLESNIKA SA AKUTNIM I HRONIČNIM PLUĆNIM BOLESTIMA

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Kratak sadržaj: U ovom radu određivana je koncentracija magnezijuma u serumu i u 24-urinu, na početku (To) i na kraju hospitalnog lečenja (T1) kod 56 bolesnika sa akutnim plućnim bolestima (B1) i kod 58 sa hroničnim plućnim bolestima (B2). U grupi B1 postojao je disbalans Mg u serumu kod 14–25% bolesnika na početku lečenja (To) koji se značajno smanjio na kraju lečenja (T1) i postojao je kod 4–7,1% bolesnika ($p < 0,05$). U grupi B2 distribucija normalnih, snizenih i povišenih vrednosti Mg u serumu bila je slična u periodu To i T1 ($p > 0,05$). Hipomagnezemiju u grupi B1 imalo je 9 (16,1%) bolesnika na početku lečenja (To) što je bilo praćeno povećanom koncentracijom Mg u 24-časovnom urinu samo kod 4 (7,2%) bolesnika. Ovo je bilo moguće zbog ekstrarenalnog gubitka elektrolita ili je došlo do transcelularne preraspodele. U grupi B2 u periodu To postojao je proporcionalni odnos hipomagnezemije (12,0–20,7% bolesnika) sa povećanom koncentracijom Mg u 24-časovnom urinu (20,0–34,5% bolesnika). Ovo je bilo moguće zbog renalne eliminacije elektrolita. Istovremeno određivanje i praćenje magnezijuma u serumu i 24-časovnom urinu daje pouzdane informacije o homeostazi ovog elektrolita kod akutnih i hroničnih plućnih bolesti.

Ključne reči: magnezijum, serum, urin, plućne bolesti

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