Electromyographic changes associated with high level of magnesium in drinking water*)

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Zusammenfassung

125 Patienten erhielten einen Mg-Zusatz im Trinkwasser (90 mg/Tag/Patient). Am ersten und 15. Tag wurde das EMG abgenommen und das Plasma-Mg bestimmt. Am 15. Tag zeigten sich bei 47 % der Patienten im EMG keine pathologischen Zeichen mehr, so wie am ersten Tag. Gleichzeitig war das Plasma-Mg signifikant angestiegen.

Summary

Patients (125) received a magnesium supplementation (90 mg/day/patient) in drinking water. An electromyographic test and blood plasma analysis were performed the 1st and the 15th day of magnesium supplementation. In 47 % of the supplemented patients, the electromyographic test was negative on the 15th day whereas it was found positive the first day of this study. This effect was linked with a significant rise in the plasma magnesium level.

Resumé

Des adultes (125) ont été étudiés avant et 15 jours après une supplémentation en magnésium par l'eau de boisson (90 mg/jour/sujet) au cours d'une cure thermale. Chez les sujets ayant, en début de cure, un test électromyographique positif, cette supplémentation en magnésium a permis de rendre le test négatif dans 47 % des cas. Cet effet était associé à une élévation significative du magnésium plasmatique.

Introduction

Neuromuscular abnormalities linked to magnesium deficiency have been intensively studied in various animal species [2, 11]. The mechanism leading to this neuromuscular hyperexcitability are still debatable but it seems that this disturbance reflects more a central than a peripheral mechanism. The sites of chemical neurotransmission are most functionally vulnerable to the effects of acute changes in the concentration of extracellular magnesium, reflecting the interaction between magnesium and calcium in the presynaptic release and post-synaptic responses to neurotransmitters [3]. In man, magnesium subdeficiency has often been reported [4, 9] and could lead to neuromuscular abnormalities included in the clinical symptoms of spasmophilia [10, 5]. Therefore, an electromyographic study was carried out on the neuromuscular abnormalities observed in patients suspected to be magnesium-deficient, during the course of magnesium supplementation, produced by thermal spring water intake (Chatel-Guyon, France).

Material and methods

This study was performed on 125 patients aged 18 to 60 years: 24 men and 101 women were chosen for this study during a cure at a spa. Magnesium supplementation was given through thermal spring water ingestion leading to an average intake of 90 mg of magnesium per day per subject (Chatel-Guyon) for fifteen days.

Magnesium and calcium plasma levels and erythrocyte magnesium concentrations were determined at the onset of the thermal cure and fifteen days after. Electromyograms (EMG) were performed at the same time. The erythrocyte and plasma fractions of the blood samples taken on these days were immediately separated by centrifugation and kept frozen until analysis. Magnesium and calcium were determined according *Henrotte* [6] by atomic absorption spectrophotometry (Perkin Elmer 420 Apparatus) under strictly standard and comparable conditions.

Electromyograms were performed according to *Alajouanine* et al. [1]. A bipolar needle electrode was inserted into *"the 1st interosseous dorsal muscle"* of the left hand, and the electrical activity was recorded (Racia apparatus). After control of the resting electrical activity, ischemia was produced for 10 minutes. A blood pressure cuff was wrapped around the upper arm to obliterate the radial pulse. The 10-minute post-ischemic phase was followed by 5 minutes of volontary hyper-

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ventilation. Electromyograms were considered positive if regular repetitive activity persisted for 2 minutes, at least, (uniplets, doublets, multiplets) during one of these three phases (ischemic, post-ischemic, hyperventilation).

Statistical analysis

The plasma magnesium and calcium means are expressed with the SEM. The significance of the changes was analyzed by the Student's t test. Electromyographic modifications during magnesium supplementation were analyzed by a χ_2 test and the effect of the changes in the plasma magnesium levels on the results of the electromyograms was evaluated by variance analysis [12].

Results

The plasma calcium and magnesium levels and magnesium erythrocyte concentrations are shown in table 1. After fifteen days of magnesium supplementation, plasma magnesium levels were significantly increased ($P<0{,}001$). There was no change in the plasma calcium levels and erythrocyte magnesium concentrations.

Tab. 1: Blood electrolytes datas before and after magnesium supplementation.

	Magnesium		Calcium
	Plasma	Red blood cells	Plasma
Before magnesium supplementation	$1{,}89 \pm 0{,}02$[1]	$5{,}50 \pm 0{,}06$	$9{,}09 \pm 0{,}04$
After magnesium supplementation	$1{,}96 \pm 0{,}01$**	$5{,}44 \pm 0{,}05$	$9{,}07 \pm 0{,}04$

[1] Results expressed as means ± SEM (mg/100 ml) from 125 patients.

** Significant difference of the values (before and after magnesium supplementation), $P < 0{,}001$

The results of the electromyographic tests are summarized in table 2. EMG results indicate that 46 % of the patients had a positive test before magnesium supplementation. After fifteen days of supplementation, EMG tests were found to be negative in 47 % of the patients showing a positive EMG test before the first intake of water. The effect of magnesium supplementation on the electromyographic changes was found to be highly significant ($P<0{,}01$).

Tab. 2: Distribution of positive (EMG +) or negative (EMG −) electromyographic tests before and after magnesium supplementation.

Before Magnesium Supplementation		After Magnesium Supplementation		
58	EMG +	EMG + (27) EMG −	39	EMG +
		EMG + (31) EMG +		
67	EMG −	EMG − (59) EMG −	86	EMG −
		EMG − (8) EMG +		
(125)[a]			(125)	

[a] number of patients showing EMG + or EMG — before and after magnesium supplementation

Results for the EMG tests and blood parameters are shown in table 3. Before magnesium supplementation, the plasma magnesium levels were lower in the patients with a positive EMG test than in those having a negative EMG test ($P<0{,}001$). However, no difference could be observed in the plasma calcium levels and erythrocyte magnesium concentrations.

After magnesium supplementation, no difference in the plasma magnesium levels was observed between these two groups of patients, but the values measured were significantly higher than that measured at the onset of supplementation ($P<0{,}01$).

Discussion

Before magnesium supplementation, plasma magnesium levels were not particularly low; generally, normal plasma magnesium levels range between 1,90—2,20 mg/100 ml [8]. It should be stressed that the spa treatment produces an increase in plasma magnesium levels. Erythrocyte magnesium concentrations were not changed; the duration of magnesium supplementation was too short to produce an increase in these values. Moreover, the magnesium content of blood cells is known to be controlled in part by genetic factors [7], whereas magnesium plasma levels were influenced by magnesium intake.

In our study, the patients had normal plasma calcium levels. Although hypocalcemia could also led to a repetitive electrical activity [13], our results favour the hypothesis of a specific effect of magnesium deficiency on neuromuscular hyperexcitability. It is interesting to observe the high proportion of patients showing positive EMG tests, before magnesium supplementation and that the spa treatment increased magnesemia

Tab. 3: Electromyograms and blood electrolytes results before and after magnesium supplementation.

Before Magnesium Supplementation				After Magnesium Supplementation			
	Magnesium		Calcium		Magnesium		Calcium
	Plasma	Erythrocyte	Plasma		Plasma	Erythrocyte	Plasma
EMG +	1,87 ± 0,02 (58)	5,48 ± 0,09 (58)	9,15 ± 0,08 (58)	EMG +	1,94 ± 0,02+ (39)	5,46 ± 0,09 (39)	9,16 ± 0,07 (39)
EMG −	1,92 ± 0,02*** (67)	5,51 ± 0,08 (67)	9,04 ± 0,05 (67)	EMG −	1,96 ± 0,01++ (86)	5,42 ± 0,06 (86)	9,04 ± 0,06 (86)

Results expressed as means ± SEM (mg/100 ml)
*** Significant difference between EMG + and EMG − before magnesium supplementation ($P < 0,001$)
\+ Significant difference of EMG + before and after magnesium supplementation ($P < 0,01$)
++ Significant difference of EMG − before and after magnesium supplementation ($P < 0,01$)

and reduced the occurrence of positive EMG tests. Despite a significant rise in plasma magnesium levels, no normalization of EMG test occur in 27 patients suggesting that the hypomagnesemia correction seems to precede the improvement of the neurophysiological abnormalities and that the duration of the supplementation could be insufficient in such cases. However, other factors could be involved such as poor adaptation to treatment or stress produced by examination. However, the overall results indicate that the treatment during the fifteen days produced a normalization of the positive EMG test in 47 % of the cases, associated with an increase in the plasma magnesium levels. The variance analysis showed a significant interaction between these two factors.

In conclusion, our results show that magnesium supplementation performed by spring water intake, induces a significant rise in plasma magnesium levels. This supplementation is associated with a normalization of the positive EMG test. Results suggest the importance of magnesium in some states of neuromuscular hyperexcitability, characterized by regular repetitive electrical activity, during electromyographic test.

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