MCRR JOURNAL

mcrr.info / MCRR

Research Article

JOURNAL OF MEDICAL CARE RESEARCH AND REVIEW

an Open Access Publication ISSN: 2589-8949 | 2589-8930

Cardıac Arrhythmıas and Magnesıum

Isa Ardahanli[1], Okan Akyuz[2], Halil Ibrahim Ozkan[3]

[1]Department of Cardiology, Bilecik State Hospital, Turkey
[2]Department of Nephrology, Bilecik State Hospital, Turkey
[3]Department of Medical Biochemistry, Atatürk University Medical School

ARTICLE INFO

Recived article: 05-01-2020
Accepted article: 15-02-2020
Published article: 18-02-2020

Corresponding Author:
Isa Ardahanli

ABSTRACT

Magnesium is one of the intracellular cations that play an essential role in many biological reactions. Intracellular magnesium is an important cofactor for various enzymes, carriers and nucleic acids required for normal cellular function, energy metabolism and replication. It is required for normal cardiac electrical activity. Magnesium deficiency can cause many disorders including cardiac arrhythmias. Intravenous magnesium has long been used in the treatment and prevention of arrhythmia since it has a high therapeutic to toxic ratio and minimal negative inotropic effect. Many studies have shown a beneficial effect of intravenous Mg administration in tachycardia attacks. But this positive effect varies according to the type of tachycardia. Especially in the treatment of supraventricular tachycardia and in the acute treatment of atrial fibrillation with a ventricular rate ≤ 100/ min, the beneficial effects are more pronounced.

The administration of intavenous magnesium appears to be useful in the treatment and prevention of cardiac arrhythmias and is a common component of a complex antiarrhythmic treatment.

Keywords: Magnesium, Cardiac arrhythmia.

Doi: https://doi.org/10.15520/mcrr.v3i2.88

Introduction

Magnesium (Mg) is an essential mineral presents naturally in the organism. It acts as a cofactor in many enzymatic reactions such as adenosine triphosphate (ATP) production, nucleotide synthesis, lipid peroxidation and blood pressure control (1). Besides that, magnesium ions have an important role in the functioning of many ion channels. Such as cardiac Mg^{2+}- sensitive K^+ channels, which normally allow potassium to pass more easily inward than outward. Mg regulates the outward movement of potassium. Therefore, in Mg deficiency, potassium acts equally in both directions. As a result, Mg deficiency leads to a decrease in the amount of intracellular potassium (K^+), disrupting the resting membrane potential of the myocardium and may cause cardiac arrhythmias.

Heart Conduction System

Dysrhythmia is defined as disturbances in heart rate or heart rate due to impaired conduction of the heart. Normal sinus rhythm begins with an electrical signal generated by the sinoatrial node (SAN) in the right atrium (RA). This node is the dominant pacemaker region (Figure 1). The electrical impulses are then transmitted from the SAN to the left atrium (LA) through special interatrial

connections, including Bachmann's bundle. The signal then moves downward to a group of cells called the atrioventricular node (AVN), which is normally the only electrical connection between the atrium and the ventricle. The impulses transmitted via the electrical AVN are rapidly carried out via the His bundle branching into a right and left bundle. Terminal Purkinje fibers are connected to the ends of the bundle branches and form a touching network on the endocardial surface, so that a cardiac impulse is transmitted almost simultaneously to the cardiac muscle cells of both ventricles. This may cause arrhythmia when there is a disturbance in any part of the conduction system.

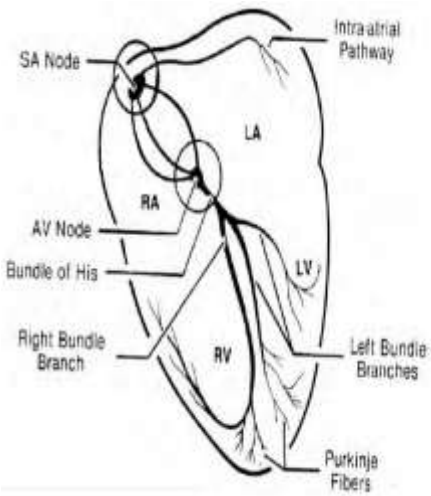

Figure 1: Cardiac conduction system, RA: right atrium, LA:left atrium, RV: right ventricle, LV: left ventricle

Heart and Magnesium

Magnesium is an essential mineral that plays an important role in various cardiovascular and metabolic conditions. It is a defence against recurrent oxidative damage (2-4), a physiological Ca^{2+} antagonist that contributes to membrane potential modifications (5), a regulator of platelet adhesion and aggregation (6,7), and modulator of endothelial functions. (8). Mild level hypomagnesemia is a common electrolyte abnormality, especially in elderly adults with increased urinary magnesium loss due to interstitial kidney disease or receiving diuretic treatment (9). It is unclear whether this abnormality can be treated or prevented by prophylactic magnesium administration. The biggest concern is whether mild magnesium deficiency is prone to cardiac arrhythmias (10,11).

The mechanisms of magnesium in preventing arrhythmias are only partially known. Magnesium is a cofactor of the membrane Na-K pump. In case of deficiency, the activity of the pump may decrease. This may result in partial depolarization and changes in the activity of many potentially dependent membrane channels (12). The most common indication for the use of Mg in daily practice is the prevention and treatment of cardiac arrhythmias. Because Mg^{2+} deficiency disrupts homeostasis of intra- and extracellular ions leads to prolongation of the QT segment, ST depression and low amplitude T waves (13). In a meta-analysis of 22 randomized trials investigating the role of Mg in reducing cardiac arrhythmias, it was observed that MgSO4 reduced ventricular arrhythmias by 32% and supraventricular arrhythmias by 42% (14). This suggests that MgSO4 may be a safe, effective and cost-effective strategy for the protection of the health of heart patients (14). The importance of Mg^{2+} in arrhythmias has been observed in the prevention of postoperative atrial fibrillation after coronary artery bypass (15) or cardiac surgery (16,17). It was also found that the administration of potassium and magnesium solution had a positive effect on the success rate of electrical cardioversion in patients with permanent atrial fibrillation (18). The risk of developing ventricular arrhythmias is also influenced by Mg concentrations. Hypomagnesemia increases the risk of a unique form of polymorphic ventricular tachycardia called Torsades de Pointes (Figure 2).

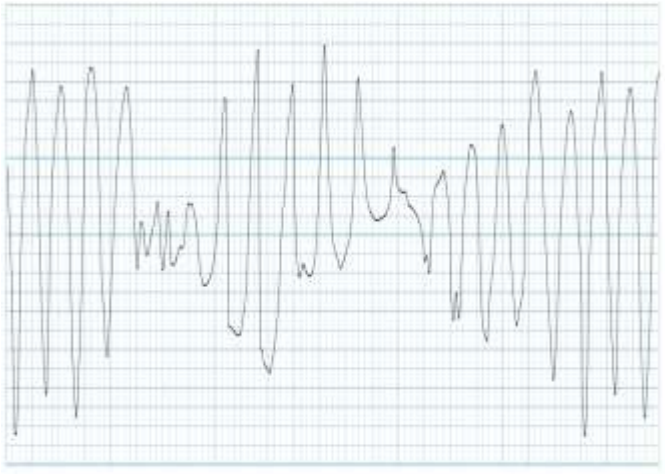

Figure 2: Torsades de pointes

The risk is increased especially in patients receiving class IA or class III antiarrhythmic drugs. The American Heart Association Cardiopulmonary Resuscitation and Emergency Cardiac Care Guidelines recommend the addition of magnesium sulfate for the management of torsades de pointes, severe hypomagnesemia, or refractory ventricular fibrillation (19,20). Treatment aims to accelerate heart rate and/or shorten the QT interval. Intravenous magnesium is now considered the treatment of choice, even if there is no

hypomagnesemia(21). Torsade de Pointes episodes are known to respond well to Magnesium sulfate (MgSO4). Because it can stop early after depolarizations (EADs) and automaticity by decreasing IKr current and blocking long-lasting type (L-type) Ca^{2+} activity (22). In addition, the efficacy of Mg^{2+} supplementation, which helps thrombolytic therapy in acute coronary syndromes, has been shown to prevent ventricular arrhythmias and to reduce short-term mortality after acute myocardial infarction (23). The importance of magnesium in ventricular arrhythmias has not been investigated in as much detail as in supraventricular arrhythmias, but magnesium has been shown to increase the threshold for both ventricular tachycardia (and ventricular fibrillation). As a result, the European Society of Cardiology guidelines recommends that Mg^{2+} be used in the prevention and management of certain types of cardiac arrhythmia (24).

Conclusions

Intravenous magnesium seems to be useful in the prevention and treatment of various cardiac arrhythmias, being especially effective in cases of polymorphic ventricular tachycardia (Torsade de Pointes). Moreover, magnesium therapy is well-tolerated, with sporadic, mild and quickly subsiding adverse effects (heat, flushing, hypotension). Therefore, magnesium is a common component of complex antiarrhythmic therapy. However, it should be noted that magnesium is not registered as an antiarrhythmic drug and should be treated rather as an adjuvant to antiarrhythmic therapy.

References

1. National Institutes of Health, Magnesium, National Institutes of Health, Bethesda, Maryland, USA, 2018, https:// ods.od.nih.gov/factsheets/Mg2+-HealthProfessional/.
2. A. A. Zheltova, et al., “Magnesium deficiency and oxidative stress: an update,” BioMedicine, vol. 6, no. 4, pp. 8–14, 2016.
3. C. P. Hans, D. P. Chaudhary, and D. D. Bansal, “Magnesium deficiency increases oxidative stress in rats,” Indian Journal of Experimental Biology, vol. 40, no. 11, pp. 1275–1279, 2002.
4. A. Kuzniar, et al., influence of hypomagnesemia on erythrocyte antioxidant enzyme defence system in mice,” Biometals, vol. 16, no. 2, pp. 349–357, 2003.
5. J. Y. Wu and S. L. Lipsius, “Effects of extracellular Mg2+ on T- and L-type Ca2+ currents in single atrial myocytes,” American Journal of Physiology-Heart and Circulatory Physiology, vol. 259, no. 6, pp. H1842–H1850, 1990.
6. D. L. Hwang, C. F. Yen, and J. L. Nadler, “Effect of extra- cellular magnesium on platelet activation and intracellular calcium mobilization,” American Journal of Hypertension, vol. 5, no. 10, pp. 700–706, 1992.
7. V. Rukshin et al, “Comparative antithrombotic effects of magnesium sulfate and the platelet glycoprotein IIb/IIIa inhibitors tirofiban and eptifibatide in a canine model of stent thrombosis,” Circulation, vol. 105, no. 16, pp. 1970–1975, 2002.
8. J. Maier, et al., “Low magnesium promotes endothelial cell dysfunction: implications for atherosclerosis, inflammation and thrombosis,” Biochimica et Biophysica Acta (BBA)-Molecular Basis of Disease, vol. 1689, no. 1, pp. 13–21, 2004.
9. Schimatschek HF, Rempis R. Prevalence of hypomagnesemia in an unselected German population of 16,000 individuals. Magnes Res 2001; 14:283.
10. Millane TA, Ward DE, Camm AJ. Is hypomagnesemia arrhythmogenic? Clin Cardiol 1992; 15:103.
11. Gettes LS. Electrolyte abnormalities underlying lethal and ventricular arrhythmias. Circulation 1992; 85:I70.
12. Angus M., Angus Z. Cardiovascular actions of magnesium. Crit. Care. Clin., 53: 299- 307. 2001.
13. W. H. Davis and F. Ziady, “)e effect of oral magnesium chloride therapy on the QTc and QUc intervals of the electrocardiogram,” South African Medical Journal, vol. 53, no. 15, pp. 591–593, 1978.
14. S. Salaminia, et al, “Evaluating the effect of magnesium supplementation and cardiac arrhythmias after acute coronary syndrome: a systematic review and meta-analysis,” BMC Cardiovascular Disorders, vol. 18, no. 1, p. 129, 2018.
15. A. A. Alghamdi, O. O. Al-Radi, and D. A. Latter, “Intravenous magnesium for prevention of atrial fibrillation after coronary artery bypass surgery: a systematic review and meta-analysis,” Journal of Cardiac Surgery, vol. 20, no. 3, pp. 293–299, 2005.
16. D. C. Burgess, M. J. Kilborn, and A. C. Keech, “Interventions for prevention of post-operative atrial fibrillation and its complications after

cardiac surgery: a meta-analysis," European Heart Journal, vol. 27, no. 23, pp. 2846–2857, 2006.
17. S. Miller, et al., "Effects of magnesium on atrial fibrillation after cardiac surgery: a meta-analysis," Heart, vol. 91, no. 5, pp. 618–623, 2005.
18. Sultan A., et al. 2012. Intravenous administration of magnesium and potassium solution lowers energy levels and increases success rates electrically cardioverting atrial fibrillation. J. Cardiovasc. Electrophysiol., 23(1): 54-59. DOI: 10.1111/ j.1540-8167.2011.02146.x
19. Antman EM, Anbe DT, Armstrong PW, et al. ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction--executive summary. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to revise the 1999 guidelines for the management of patients with acute myocardial infarction). J Am Coll Cardiol 2004; 44:671.
20. Canadian Cardiovascular Society, American Academy of Family Physicians, American College of Cardiology, et al. 2007 focused update of the ACC/AHA 2004 guidelines for the management of patients with ST-elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol 2008; 51:210.
21. Banai S, Tzivoni D. Drug therapy for torsade de pointes. J Cardiovasc Electrophysiol 1993; 4:206.
22. S. Kaseda, R. F. Gilmour, and D. P. Zipes, "Depressant effect of magnesium on early afterdepolarizations and triggered activity induced by cesium, quinidine, and 4-aminopyridine in canine cardiac Purkinje fibers," American Heart Journal, vol. 118, no. 3, pp. 458–466, 1989.
23. Magnesium in Coronaries (MAGIC) Trial Investigators. Early administration of intravenous magnesium to high-risk patients with acute myocardial infarction in the Magnesium in Coronaries (MAGIC) Trial: a randomised controlled trial. Lancet 2002; 360:1189.
24. S. G. Priori, C. Blomstrom-Lundqvist, A. Mazzanti et al., "2015 ESC guidelines for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death," Europace, vol. 17, no. 11, pp. 1601–1687, 2015.