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Wellbeing in the ICU

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If It's Good for Calcium Why Not Magnesium?

Reasons to Measure iMg in the ICU

An overview of the importance of getting magnesium levels right in critically ill patients and the role ionised magnesium plays.

Background

Like all electrolytes, magnesium exists in the bloodstream in "bound" states, and in "free" or "ionised" states, which is the portion that is physiologically active. This ionised component (iMg) represents approximately 55-70% of the total Mg (tMg). Magnesium's role is protean in human physiology: it is a cofactor for > 600 enzymes, it is responsible for nerve conduction and muscle tone, it modulates inflammation by attenuating cytokine production, it is responsible for ion transport, cell signalling and protein synthesis, to name but a fraction of its functions. Yet despite its importance, it has not gotten the respect it deserves - while celebrity electrolytes such as sodium, potassium, and even chloride get invited to all the parties, magnesium stays home and just works away. When we measure these other electrolytes, most of the time we are, in fact, measuring their ionised forms by using an ion sensitive electrode (ISE). The development of an ISE for calcium was relatively recent, and we still talk about total Ca and ionised Ca (iCa), with iCa being commonly measured now. But when we measure Mg, we are still measuring tMg, because not many devices can measure iMg. So, should we be measuring iMg? (Spoiler alert: the answer is yes, especially in the ICU).

Clinical Situations Where iMg is Important

There are many clinical situations where iMg and tMg have been shown to be discrepant, and where measuring iMg is beneficial. These include critically ill patients, patients with kidney disease, asthma, cardiac surgery, stroke, head injury, alcoholism, liver disease, and eclampsia (Johansson and Whiss 2007). Scenarios where iMg and tMg are discrepant can occur during rapid changes in Mg (such as with Mg supplementation), and in situations where acid-base disturbances, hypoalbuminaemia, medications, and other metabolic derangements exist. All of these are common in ICU patients.

There is ample evidence that iMg and tMg do not correlate well in critically ill patients. A study from Sweden (Johansson and Whiss 2007) showed that in ICU patients with normal tMg, 25% had a low iMg and almost 10% had an elevated iMg. A report from Massachusetts General Hospital noted that 30% of tMg values did not correlate with iMg values in an ICU setting (Yeh et al. 2017). In this study, 80% of low tMg values were associated with normal iMg. This led to unnecessary administration of Mg to these patients and led to unnecessary testing. Importantly, based on this data, tMg does not reliably predict iMg levels. There are consequences from dysmagnesaemia: hypermagnesaemia may lead to prolonged mechanical ventilation (Sawalha and Kakkera 2020), and a Belgian study (Soliman et al. 2003) showed that ICU patients who developed a low iMg during their ICU stay had a higher mortality than those who didn't.

A recent paper showed that in over 40% of patients undergoing continuous venovenous haemofiltration (CVVH) with citrate anticoagulation that iMg and not tMg reflected true Mg status (Hutten et al. 2021). Since citrate binds Mg as well as Ca, the Mg/citrate complex is measured in the tMg value. Thus, in this patient group, iMg is the only accurate way to assess Mg status. According to the authors: "Almost half of the samples of CVVH-treated patients showed normal tMg and decreased iMg. This points out the importance of the measurement of iMg …in CVVH patients with citrate as an anticoagulant, iMg should be measured to determine if magnesium supplementation is needed."

A study in cardiac surgery patients (Wilkes et al. 2002) evaluated iMg and tMg, and Mg replacement was given to patients with low iMg. More than half the patients had low tMg, but only 13% had low iMg. Patients who received Mg supplementation for low iMg had a lower incidence of ventricular arrhythmia and were more likely to remain in sinus rhythm than those in the control group. It is well known that patients on cardiopulmonary bypass lose Mg, and it has now become routine to simply administer Mg to this patient group without measuring tMg or iMg. A more precise, goal-directed therapy may be more beneficial.

Conclusion

In critical care it is important to get the Mg level right, and the best way to do this is by measuring iMg. This will avoid complications arising from dysmagnesaemia. Inaccurate Mg measurements can also lead to unnecessary testing, overtreatment of hypermagnesaemia, or undertreatment of hypomagnesaemia. Since the ionised portion is measured for virtually every other electrolyte, it is now time that Mg joins the party. ■

References

Hutten TJA et al. (2021) Ionized and not total magnesium as a discriminating biomarker for hypomagnesaemia in continuous venovenous haemofiltration patients. Nephrol Dial Transplant.

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