Self-prepared heparinized syringes for measuring ionized magnesium in critical care patients

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We have compared ionized magnesium assays in the Nova 8 electrolyte analyser using dry balanced heparinized syringes and self-prepared heparinized syringes. Thirty blood specimens were obtained into syringes either operator-prepared with liquid sodium heparin or commercially manufactured dry balanced heparinized syringes. There was a good correlation between results from the two syringes. The mean difference between sampling methods was 0.01 mmol litre\(^{-1}\) (95% confidence index –0.05 to 0.08 mmol litre\(^{-1}\)). The correlations for sodium, potassium and ionized calcium assays were similarly close. The relationship between sampling methods was close enough to justify the clinical use of self-prepared syringes, with potential economies in clinical costs.

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Magnesium is an important cation in the assessment and management of critically ill patients and those undergoing major surgery. Blood magnesium concentrations in ICU patients can be deranged, with important cardiac, respiratory, muscular, metabolic and neurological consequences.\(^1\) Therapeutic magnesium administration requires measurement of magnesium concentration. Derangements in magnesium concentrations are often present in surgical patients before operation and can occur during cardiac\(^2\) and hepatobiliary surgery.\(^3\)

The anticoagulants used in sampling syringes can interfere with electrolyte assays from both dilutional and ion-binding effects of heparin.\(^4\) Several preparations of dry, electrolyte-balanced heparin have been developed to prevent these errors using various heparin salts. Manufacturers of analysers generally recommend that these heparin preparations are used. Nova, who market the Nova 8 electrolyte analyser, suggest the use of a dry, lithium–zinc balanced heparin syringe. These syringes are much more expensive than a normal syringe with a small amount of liquid sodium heparin added before blood sampling. However, this cheaper technique has not been validated with respect to ionized magnesium (iMg) assay. Therefore, we have compared iMg assays in critically ill patients using these two sampling methods.

Methods and results

Samples were obtained daily for 3 days from every patient in a 10-bed ICU. There were no exclusion criteria. All patients had multi-organ failure from a variety of primary pathologies and were undergoing mechanical ventilation. The unit frequently treated patients with hepatobiliary disease and those after neurosurgery.

The dry balanced heparin syringes (manufactured for Nova Biochemical by Waltham, MA 02254, USA) were pulsator-type 1-ml plastic syringes containing 15 u. of lyophilized lithium–zinc heparin derived from porcine intestinal mucosa blended in a 1:1 ratio of heparin activity. The sodium heparin syringes were prepared immediately before sampling by aspiration and complete expulsion of 2 ml of a standard sodium heparin solution of 1000 u. ml\(^{-1}\) (Multiparin, CP Pharmaceuticals Ltd, Wrexham, UK) into a 2-ml syringe (B-D Plastipak) so that the only heparin left was contained in the deadspace of the syringe hub. Blood was collected into the sampling syringes from the arterial line after standard removal of the deadspace. All syringes were filled completely with blood. The order of sampling was varied between patients and all samples were obtained by the same operator.

All samples were analysed within 30 min of collection on an automated potentiometric analyser: the Nova 8 electrolyte analyser (Nova Biochemical, Warrington, UK). The order of specimen analysis was varied between samples and all analysis was by the same operator. The Nova iMg analyser was calibrated with standard solutions according to the manufacturer’s instructions before and after the daily analysis of specimens. Between-run precision was assessed by analysis of these calibration results as recommended by the manufacturer.
Self-prepared syringes for magnesium assay

Data were analysed as recommended by Bland and Altman. Bias was calculated from the mean difference and sd of the differences between the methods, providing 95% confidence intervals (CI). The precision of the bias and limits of agreement were assessed from calculation of the standard error and a t value corresponding to \(P=0.05\) for our sample size.

There was a good correlation between iMg assays measured using syringes pre-prepared with dry balanced heparin and the self-prepared sodium heparin syringes. The mean difference between sampling (dry balanced minus self-prepared heparin) methods was 0.01 mmol litre\(^{-1}\) (95% CI \(-0.05\) to \(0.08\) mmol litre\(^{-1}\)). These results are shown in Figures 1 and 2. Limits of agreement for these results were as follows: 0 to 0.03 (bias), \(-0.07\) to \(-0.03\) (lower limit) and 0.06 to 0.1 (upper limit). Mean differences for sodium, potassium and ionized calcium were 1.4 (95% CI \(-0.6\) to \(3.5\)), \(-0.01\) (\(-0.1\) to 0.1) and \(-0.03\) (\(-0.1\) to 0.04) mmol, respectively. All calibrations of the Nova 8 analyser satisfied standard manufacturer quality control criteria.

Comment
Magnesium is primarily an intracellular cation with only 0.3% of total body stores present in serum. Approximately 60% of serum magnesium is in the free ionized state with the remainder bound to protein or complexed with anions. Laboratory assessment is therefore complicated as magnesium is only physiologically active in the ionized state. Until recently, methods available in clinical practice have been limited.

The magnesium loading test takes at least 24 h and relies on appropriate handling of the magnesium load by the patient. This allows assessment of magnesium status, as total serum magnesium concentrations can be misleading, particularly in pathological states encountered in critically ill patients with variable protein binding characteristics. Serum iMg, however, is in constant equilibrium with the intracellular component and recent technical advances have provided feasible means of determining iMg in whole blood. Measurement of iMg can be performed rapidly, near the patient and is theoretically more clinically relevant than other measures of magnesium status. Therefore, it is likely to supersede other measures of magnesium status in the critically ill and patients undergoing major surgery.

We have demonstrated a good correlation between measurement of ionized magnesium and other commonly measured electrolytes with the Nova 8 electrolyte analyser using dry balanced heparin syringes (as recommended by the manufacturer) and syringes prepared using sodium heparin solution. We examined the ionized magnesium concentration in a relevant population across a reasonable range of iMg values. In our view, a maximum error of less than 0.08 mmol litre\(^{-1}\) is small enough to justify the clinical use of self-prepared syringes. This has been the standard method for arterial blood sampling in our unit for several years and we have not experienced any damage to the analyser caused by exposure to inadequately anticoagulated blood. It should be stressed that particular attention was paid to the preparation of these syringes and this would have to be continued for these results to apply to clinical practice.

Our data demonstrated a small bias. The iMg concentration was less on average when measured with the self-prepared syringes. This was probably a result of a minor dilutional effect caused by liquid heparin. In our opinion, this trend of 0.01 mmol ml\(^{-1}\) is too small to warrant correction of the iMg result.

Knowledge of ionized magnesium concentration is considered increasingly important in the critically ill patient and the patient undergoing major surgery.

Our findings have obvious cost implications. In our unit a saving of £20 000–30 000 per annum would result.

References
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