IJIRR

International Journal of Information Research and Review
Vol. 05, Issue, 08, pp.5650-5653, August, 2018

RESEARCH ARTICLE

CLINICAL EQUIVALENCE OF HEPARINIZED ARTERIAL PLASMA TO VENOUS SERUM SAMPLES FOR MAGNESIUM MEASUREMENT IN CRITICAL PATIENTS AT MOI TEACHING AND REFERRAL HOSPITAL, ELDORET KENYA

***[1]Dominic S O Alwala, [2]Bernard Guyah and [3]Onyambu F Gekara**

[1]MTRH Laboratory Department, Eldoret Kenya
[2]School of Public Health and Community Development Maseno University
[3]School of Health Sciences, Meru University of Science and Technology

ARTICLE INFO

Article History:

Received 20th May, 2018
Received in revised form
27th June, 2018
Accepted 06th July, 2018
Published online 30th August, 2018

Keywords:

Electrolytes, Magnesium,
Plasma, Serum,
Equivalence.

ABSTRACT

Electrolytes routinely measured in patients in Intensive Care Unit (ICU) are sodium, potassium, chloride, calcium and magnesium. Of these; sodium, potassium, chloride and calcium are measured as part of tests done during blood gas analysis (BGA) using arterial blood. However, magnesium is measured from a venous serum sample since measurement cannot be done during BGA. Both arterial and venous puncture are traumatizing to the patient and trauma increases when both are done numerous times on the same patient in a single day. Plasma obtained from sodium-heparin anticoagulant is yet to be used as a sample of choice for measuring magnesium since it is not clear whether there is clinical equivalence between magnesium concentration obtained from venous serum and arterial plasma. It is clinically important that those measurements should give equivalent results and confirm the closeness to the absolute value. The main objective was to assess the equivalence of arterial and venous blood magnesium concentration. The specific objectives were; to determine the mean difference between magnesium concentration in arterial blood plasma and venous blood serum and to determine the correlation between magnesium concentration in arterial blood plasma and venous blood serum and. This study used a cross-sectional research design and was carried out at Moi Teaching and Referral Hospital (MTRH) where one hundred and fifty-three patients admitted at MTRH ICU underwent arterial and venous puncture to obtain arterial and venous blood which was used for magnesium measurement on an automated chemistry laboratory analyzer. Mean difference between magnesium concentration in plasma and serum calculated using paired t-test was 0.03(t=1.23) p=0.22 and Magnesium correlation between plasma and serum was r=0.98 [P = 0.00 (< 0.05)]. The study indicates there is clinical equivalence between magnesium concentration in arterial blood plasma and venous blood serum, thus arterial blood plasma samples can be used in place of venous blood serum samples for magnesium measurement hence avoiding repeated punctures on patients thus improving healthcare of patients.

INTRODUCTION

In critical patients, electrolyte imbalance can lead to serious and critical events which might adversely affect the outcome of the patient hence quick and accurate assessment of these disturbances demands immediate medical attention (Alanazi, *et al*., 2015). The quickness of that assessment, especially in developing countries, is frequently restricted by the postponement in transporting samples to the laboratory, either because of deficiency of adequate couriers or the nonappearance of quick transport systems (Alanazi, *et al*., 2015). In Moi Teaching and Referral Hospital (MTRH), patient samples for magnesium and phosphate measurement are collected by venipuncture and transported to the central laboratory for analysis separately from samples collected for Blood Gas Analysis (BGA).

***Corresponding author: Dominic S O Alwala,**
P/O BOX 3837 -30100 Eldoret Kenya.

The same patient will then undergo an arterial puncture to obtain blood for BGA. Thus, the patient undergoes trauma twice. Magnesium is among the electrolytes found within the body and is involved in numerous metabolic processes (Moe, 2008). Almost all metabolic processes are dependent upon or are mediated by electrolytes (Budak, *et al*., 2012). Variation in electrolyte concentrations may be due to a variety of disorders and such disorders must be identified in time to ensure adequate and timely treatment as electrolyte abnormalities can represent significant risks to life (Budak, *et al*., 2012). Although frequent blood draws can destroy veins, cause pain, and lead to anemia, ICU patients typically have routine daily blood tests to help detect problems early (Eachempati, 2014). Under such circumstances it is important to obtain data quickly so as to optimize the therapeutic response interval and allow prompt treatment. In order to decrease the number of phlebotomies in the ICU, and thereby minimize the general discomfort and trauma patients undergo during such activities, it is preferable to measure blood electrolytes on the one single sample collected for blood gases rather than performing additional venipunctures to collect venous blood in order to check serum levels of magnesium as has been routinely done. Yu and colleagues (Yu, *et al*., 2011) analyzed the concentrations of 163 metabolites in plasma and serum samples collected simultaneously from 377 fasting individuals. Plasma and corresponding serum samples from 83 individuals were re-measured in the same plates and mean correlation coefficients (r) of all metabolites between the duplicates were 0.83 and 0.80 in plasma and serum, respectively, indicating significantly better stability of plasma compared to serum (p=0.01). Despite differences in absolute concentration between the two matrices, for most metabolites the overall correlation was high (mean r=0.81±0.10), which reflects a proportional change in concentration. The study showed that reproducibility was good in both plasma and serum.

A study was conducted by Jain and colleagues (Jain, *et al*., 2009) in India where 200 paired venous and arterial samples from patients admitted to the ICU were analyzed for electrolytes on the arterial blood gas (ABG) machine and the central laboratory auto-analyzers (AA). The mean ABG sodium value was 131.28 (SD 7.33), and the mean AA sodium value was 136.45 (SD 6.50) (p < 0.001). The mean ABG potassium value was 3.74 (SD 1.92), and the mean AA potassium value was 3.896 (SD 1.848) (p = 0.2679). Based on the analysis, the authors found no significant difference between the potassium values measured by the blood gas machine and the auto-analyzer. However, the difference between the measured sodium was found to be significant thus concluding that critical decisions can be made by trusting the potassium values obtained from the arterial blood gas analysis. Zhang and colleagues (Zhang, *et al*., 2015) did a study to determine whether the ABG and laboratory measurements of potassium, sodium, and hemoglobin levels are equivalent from 200 paired arterial and venous blood samples. The mean ABG and laboratory potassium values were 3.77±0.44 and 4.2±0.55, respectively (P<0.0001).

The mean ABG and laboratory sodium values were 137.89±5.44 and 140.93±5.50, respectively (P<0.0001). The mean ABG and laboratory Hemoglobin values were 12.28±2.62 and 12.35±2.60, respectively (P = 0.24). The results indicate that although there are the statistical difference and acceptable biases between ABG and laboratory measured potassium and sodium, the biases do not exceed United States Clinical Laboratory Improvement Amendments (USCLIA)-determined limits. In parallel, there are no statistical differences and biases beyond USCLIA-determined limits between ABG- and laboratory-measured hemoglobin. Therefore, all three variables measured by ABG were reliable. Gupta and colleagues (Gupta, *et al*., 2016) did a study to compare the sodium andpotassium results on ABG and electrolyte analyzers. Data for 112 samples was analyzed and results were the mean sodium level in serum sample was 139.4 ± 8.2 mmol/L compared to 137.8 ± 10.5 mmol/L in ABG (P< 0.05). The mean difference between the results was 1.6 mmol/L. Mean potassium level in serum sample was 3.8 ± 0.9 mmol/L as compared to 3.7 ± 0.9 mmol/L in ABG sample (P< 0.05). The mean difference between the results was 0.14 mmol/L. Statistically significant difference was observed in results of two instruments in low sodium (<135 mmol/L) and normal potassium (3.5-5.2 mmol/L) ranges. The 95% limit of agreement for sodium and potassium on both instruments was 9.9 to −13.2 mmol/L and 0.79 to −1.07 mmol/L respectively.

MATERIALS AND METHODS

Ethical approval for the study was sought from MTRH and Moi University Institutional Research and Ethics Committee (IREC) and approval number was 0002004. This was a cross-sectional study in which 153 paired samples were obtained by arterial puncture and venipuncture on patients in ICU for obtaining arterial blood and venous blood. Arterial blood was collected from the radial artery using heparinized syringes containing sodium heparin anticoagulant and centrifuged to obtain plasma while venous blood was collected from the antecubital vein using non-heparinized syringes and centrifuged to obtain serum. Plasma and serum obtained were transferred into a clean analyzer sample cup for magnesium measurement in the automated analyzer COBAS INTEGRA®400 plus (Roche diagnostics Germany) located in the Biochemistry Laboratory of MTRH.Magnesium measurement utilizes an arsenazo dye which binds preferentially with magnesium. The absorbance of the arsenazo-magnesium complex was measured at 572 nm. The optical density (OD) obtained was proportional to the concentration of magnesium present in the sample.

RESULTS

A total of 153 participants were recruited to the study from whom arterial and venous blood samples were obtained whose plasma and serum were analyzed for magnesium concentrations. Magnesium concentrations obtained from plasma and serum were entered a data collection form and analyzed statistically. The mean, SD, mean differences and correlationswere calculated. Mean difference between magnesium concentration in arterial and venous blood. In determining the mean difference between magnesium concentration in arterial blood plasma and venous blood serum, the mean magnesium concentration in plasma was 0.84mmol/L+0.22 and the mean magnesium concentration in serum was 0.87mmol/L+0.21. The mean difference between plasma and serum was done using paired t-test for Microsoft excel spreadsheet 0.03mmol/L (t=1.23, p=0.22).Table 1 shows these results.

Correlation between magnesium concentration in arterial and venous blood

The correlation between magnesium concentration in arterial blood plasma and venous blood serum from 153 patients was done using Pearson correlation and r value obtained was 0.97 [P = 0.00 (< 0.05)]. These results are shown in figure 1.

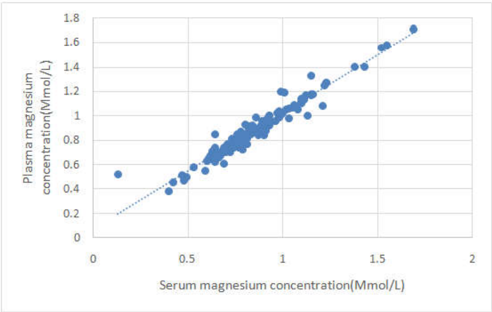
DISCUSSION

In determining the mean difference between magnesium concentration in arterial blood plasma and venous blood serum, the mean magnesium concentration in plasma was 0.84mmol/L+0.22 and the mean magnesium concentration in serum was 0.87mmol/L+0.21. The mean difference between plasma and serum was done using paired t-test for Microsoft excel spreadsheet and was 0.03mmol/L (t=1.23, p=0.22).

Table 1. Mean difference between magnesium concentration in arterial and venous blood

N	Arterial Blood Mean±SD	Venous Blood Mean±SD	Mean Difference	t-value	p-value
153	0.84±0.22	0.87±0.21	0.03	1.23	0.22

N (sample size) =153. Plasma and serum samples were obtained from 153 patients to measure magnesium levels. Each sample was measured once.



r = 0.97

P = 0.00 (< 0.05)

Figure 1. Correlation between magnesium concentration in arterial and venous blood

The p-value is not significant therefore null hypothesis is accepted. This means there is no difference in magnesium concentration between arterial blood plasma and venous blood serum in patients admitted to the ICU at MTRH. These results are comparable to a study done by Carey(Carey, *et al*., 2016) to find the relationshipbetween simultaneously drawn serum and plasma magnesium in 76 dialysis patientsand found a mean difference of 0.00 (p=0.66). Heparinized plasma samples showed no significant decreases relative to serum samples. This is comparable to the results obtained in the current study that indicates plasma and serum magnesium values are not significantly different from each other which suggests that magnesium electrolyte concentration is evenly distributed within serum and plasma components of blood.Zhang (Zhang, *et al.,* 2015) did a study to determine whether the ABG and laboratory measurements of potassium and sodium electrolyte levels are equivalent from 200 paired arterial and venous blood samples.

The mean ABG and laboratory potassium values were 3.77±0.44 and 4.2±0.55, respectively (P<0.0001) and the mean ABG and laboratory sodium values were 137.89±5.44 and 140.93±5.50, respectively (P<0.0001) which indicated that electrolyte concentration in serum and plasma are not significantly different as the results of the current study also indicate. This is possibly due to similarity in serum and plasma constituents and also anticoagulant used in plasma did not affect sample constituent as to alter magnesium concentration. Correlation between magnesium concentration in arterial blood plasma and venous blood serum from 153 patients admitted to the MTRH ICU was done using Pearson correlation and r value obtained was 0.97 [P = 0.00 (< 0.05)]. The r-value (0.97) shows there is a positive relationship between magnesium concentration in arterial plasma and venous serum. The p-value obtained is significant therefore null hypothesis is rejected and alternative hypothesis accepted. This means there is a correlation between magnesium concentration in arterial blood plasma and magnesium concentration in venous blood serum.

Zhonghao Yu (Zhonghao Yu, *et al.,* 2011) analyzed the concentrations of 163 metabolites in plasma and serum samples and found that despite differences in absolute concentration between the two matrices, for most metabolites the overall correlation was high (mean r=0.81±0.10). Carey (Carey, *et al*., 2016) did a study to find the relationship between simultaneously drawn serum and plasma magnesium in 76 dialysis patients and found r = 0.96. The results of the current study are comparable to these two studies and therefore indicate there is good correlation in magnesium concentration between serum and plasma. This suggests there is no marked alteration that occurs in magnesium concentration in plasma or serum obtained from the same individual and used for analysis.

Conclusion

- Magnesium concentration in arterial blood plasma and venous blood serum is not significantly different.
- There is correlation between magnesium concentration in arterial blood plasma and venous blood serum.

REFERENCES

Alanazi, Obaidi, Enezi, AlMutairi, Aljerian, Alsultan,. Qureshi. 2015. Correlation between the Measurements of Serum and Arterial Blood Gas (ABG) Electrolytes in Patients Admitted to the Intensive Care Unit at King Abdul-Aziz Medical City, Riyadh, Saudi Arabia. *American Journal of Clinical Medicine Research., 3(3)*, 55-59.

Budak, Huysal, Polat, Budak Y U, Huysal K, & Polat M. 2012. Use of a blood gas analyzer and a laboratory autoanalyzer in routine practice to measure electrolytes in intensive care unit patients. *BMC Anesthesiology.*, 12-17. Retrieved from http://doi.org/10.1186/1471-2253-12-17

Carey, Jani, C., Johnson, C., Pearce, J., Hui-Ng, P. and Lacson, E. 2016. Chemistry Testing on Plasma Versus Serum Samples in Dialysis Patients: Clinical and Quality Improvement Implications. *CJASN, (9)*, 1675-1679. doi:10.2215/CJN.09310915

Eachempati. 2014. Monitoring and Testing the Critical Care Patient [Electronic Version]. Approach to the Critically Ill Patient. Retrieved from http://www.msdmanuals.com/professional/critical-care-medicine/approach-to-the-critically-ill-patient/monitoring-and-testing-the-critical-care-patient

Gupta, Gupta S, Gupta AK, Singh K, Verma M, & A K. 2016. Are sodium and potassium results on arterial blood gas analyzer equivalent to those on electrolyte analyzer? *Indian Journal of Critical Care Medicine : Peer-Reviewed, Official Publication of Indian Society of Critical Care Medicine*, 233-237. Retrieved from http://doi.org/10.4103/0972-5229.180044

Jain, Subhan, Joshi, Jain A, Subhan I, & Joshi M. 2009. Comparison of the point-of-care blood gas analyzer versus the laboratory auto-analyzer for the measurement of electrolytes. *International Journal of Emergency Medicine, 2(2)*, 117-120. Retrieved from http://doi.org/10.1007/s12245-009-0091-1

Moe. 2008. Disorders Involving Calcium, Phosphorus, and Magnesium. *Primary Care*, 215. Retrieved from http://doi.org/10.1016/j.pop.2008.01.007

Yu, Kastenmüller, He Y, Belcredi P, Möller, Prehn C, & Wang-Sattler. 2011. Differences between Human Plasma and

Serum Metabolite Profiles. *PLoS ONE, 6(7)*, e21230. Retrieved from http://doi.org/10.1371/journal.pone.0021230

Zhang, Lin, Zhao, Zhang JB, Lin J, & Zhao XD. 2015. Analysis of Bias in Measurements of Potassium, Sodium and Hemoglobin by an Emergency Department-Based Blood Gas Analyzer Relative to Hospital Laboratory Autoanalyzer Results. *PLoS ONE, 10(4)*, e0122383. Retrieved from http://doi.org/10.1371/journal.pone.0122383

Zhonghao Yu, Gabi Kastenmuller, Ying He, Petra Belcredi, Gabrielle Moller, Cornelia Prehn, Norbert Dahmen. 2011. Differences between Human Plasma and Serum Metabolite Profiles. *PLoS ONE 6(7):*, e21230.

****