

COMPARISON OF ARTERIAL BLOOD GAS ANALYSIS VERSUS CENTRAL LABORATORY ELECTROLYTE AND HEMOGLOBIN DETERMINATION IN BIRAT MEDICAL COLLEGE AND TEACHING HOSPITAL

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ABSTRACT

Introduction

Electrolyte and hemoglobin measurement are the integral part of management of critically ill patient. There can be a wide variation in the electrolyte and hemoglobin measurement in critically ill patient between arterial blood gas analyzer and central laboratory auto analyzer.

Objective

To compare the electrolytes (sodium, potassium and chloride) and hemoglobin level measured by arterial blood gas analyzer and laboratory analyzer.

Methodology

This was a prospective cross-sectional comparative study comparing the electrolytes (sodium, potassium and chloride) and hemoglobin measurement between arterial blood gas analyzer and laboratory auto analyzer. The study included 124 paired blood samples from the patient admitted in intensive care unit of Birat Medical College Teaching Hospital in two months duration. The arterial sample and venous sample for electrolytes and hemoglobin measurement were taken simultaneously or not more than one hour apart and analysis was done by arterial blood gas analyzer and central laboratory auto analyzer accordingly. The values of electrolytes and hemoglobin measured by two different analyzers were finally compared for variation.

Result

The mean difference calculated for sodium potassium and chloride in ABG machine and Auto-analyzers were 0.57 mmol/l-0.04mmol/l and 1.71mmol/l respectively. These data were within the acceptable range of United States Clinical Laboratory Improvement Amendments(USCLIA). The mean difference derived for hemoglobin in ABG and Auto-analyzers was 0.16g/dl which was not consistent with the range of United States Clinical Laboratory Improvement Amendments (USCLIA)

Conclusion

The measurement of electrolyte namely sodium, potassium and chloride in ABG machines and Auto-analyzers of central lab were comparable while hemoglobin was not comparable under the USCLIA guidelines.

KEY WORDS

Auto-analyzers, ABG machine, chloride, hemoglobin, potassium, sodium.



INTRODUCTION

Electrolyte imbalance is the common clinical and laboratory abnormality in critically ill patient.¹ Unnoticed or undiagnosed electrical abnormalities can increase the morbidity and mortality in critically ill patients. Therefore, these electrolytes are very important in determining the outcome of critically ill patient²

Most of the major electrolytes including sodium, potassium and chloride can be measured by Arterial Blood Gas analyzer. Besides, hemoglobin and hematocrit can also be measured as a point of care test by ABG machine.³ Though ABG has become a gold standard in ICU setup, electrolytes and hemoglobin are being sent on a regular basis to the laboratory despite the time lag. However, when processed by a central laboratory the results are delayed by a few hours that can affect the clinical management of the critically ill patients.⁴ This delay in reporting time does not allow the clinician to correct the electrolyte abnormality or anemia promptly, hence hindering the improvement of the patient.

ABG analyzer measures electrolytes by direct ion-selective electrolyte method and uses undiluted sample while central laboratory auto analyzer measures the electrolyte by indirect ion-selective electrolyte method and uses diluted samples.⁵ Besides, ABG analyzer uses whole blood and takes shorter processing time while laboratory auto analyzers use serum blood and take longer time.⁶ These two fact can lead to the discrepancy in the values measured by the two analyzers.

ABG machines are primarily designed to analyze the blood gas parameters and not for the electrolytes or hemoglobin. Though ABG machine provides a point of care testing for electrolyte measurement, the change in pH can lead to variable degree of membrane permeability which in turn leads to displacement of electrolyte. Thus, the variable effect of pH in the electrolyte displacement specifically potassium can contribute to the unreliability of electrolyte measurement by ABG machine.⁷ Many times clinicians prefer to measure the electrolytes and confirm in the central laboratory by Auto-analyzer. Moreover, there have been numerous studies which have shown that ABG measurements have not been consistent with central laboratories in hospital even with the same sample.⁸

There is a wide disparity in the literature regarding recommendation for electrolytes measurement by ABG and laboratory auto analyzer without any conclusive recommendation. Thus, this study had been designed to enrich the data bank and access the reliability of electrolytes and hemoglobin measurement by ABG machine. The study compared the differences in the measurement of three major electrolytes sodium, potassium and chloride with additional hemoglobin measurement between ABG machine as a point of care testing and laboratory Auto-analyzer in the critically ill patients in the intensive care unit of Birat Medical College and teaching hospital.

METHODOLOGY

This was a comparative prospective study conducted in

patients admitted between 15-6-2019 to 15-8-2019 in critical care unit of Birat Medical College and Teaching Hospital. All the blood samples that were sent for ABG analysis and central laboratory, during this period of time, were included in the study. The samples which had error in sampling techniques were not included in the study. A total of 124 paired blood samples from critically ill patients in ICU were included in the study for electrolyte and hemoglobin analysis by ABG machine (ABL flex 80) in ICU and Auto-analyzer (Medonic M series in central laboratory of Birat Medical College and teaching hospital).

Under all the aseptic precautions an ABG sample of 1ml of blood was collected in a pre-heparinized BD (Bacton Dickson) syringes. This arterial sample collected for ABG was processed in ABL flex 80 analyzer to draw the values of electrolytes and hemoglobin. Simultaneously another venous sample of 4-5 ml of blood was extracted of which 1 ml was transferred to an EDTA tube (levacvacutainer) for complete blood count reporting and next 2 ml of blood was transferred to other levacvacutainer for electrolytes. These samples were drawn by trained health care professionals. These venous samples were sent to laboratory for further evaluation. The blood sample collected in an EDTA tube for CBC (complete blood count) was directly analyzed in Auto-analyzer (Medonic M series) while, the blood sample collected in the vacutainer for serum electrolytes was centrifuged for 5 minutes before being analyzed in Humalyte plus 3. The Auto-analyzers and the ABG analyzer were calibrated each time a new reagent was installed. This was done for quality control.

The values of electrolytes and hemoglobin obtained from ABG and central laboratory auto analyzer were saved in Microsoft excel. Statistical analysis was done by IBM SPSS version 23. The continuous data were used for analyzing the mean and standard deviation, while student t test was used to compare the data between AA and ABG. The p value <0.05 was considered to be significant.

The accepted level of variation among the two groups was considered according to US-CLIA (United States Clinical Laboratory Improvement Amendments) guidelines. The guideline accepts differences as; sodium ± 4.0 mmol/L, potassium ± 0.5 mmol/L, chloride ± 5 mmol/L; hemoglobin $\pm 7\%$ compared to the target values.⁵

RESULTS

Table 1. Electrolyte and hemoglobin in Arterial blood gas and Auto analyzer

	Arterial blood gas	Auto analyzer (Central lab)	P value	Mean difference
Sodium n \pm SD mmol/l	140.63 \pm 8.08	140.06 \pm 7.54	0.00	0.57
Potassium n \pm SD mmol/l	4.08 \pm 0.75	4.12 \pm 0.71	0.00	-0.04
Chloride n \pm SD mmol/l	104.61 \pm 6.61	102.9 \pm 6.62	0.00	1.71
Hemoglobin n \pm SD g/dl	10.47 \pm 2.64	10.31 \pm 2.72	0.00	0.16



The analysis of sodium values (table 1) showed that mean sodium in ABG was 140.63 ± 8.08 mmol/l and the mean sodium in auto analyzer was 140.06 ± 7.54 . The mean difference in sodium level was 0.57 mmol/l (SD- 0.51 mmol/l). When the mean sodium level was evaluated for ABG and autoanalyzer, a significant difference was evident ($p < 0.05$).

The mean potassium level measured in ABG was 4.08 ± 0.75 mmol/l while the value in autoanalyzer was 4.12 ± 0.71 mmol/l (table 1). The mean difference in potassium level was 0.04 mmol/l (SD- 0.3881 mmol/l). A significant difference was evident ($p < 0.05$) when mean value for potassium was observed.

The evaluation of chloride value (table 1) showed that mean chloride in ABG was 104.61 ± 6.61 mmol/l and the mean chloride in auto analyzer was 102.9 ± 6.62 mmol/l. The mean difference in chloride level was 1.71 mmol/l (SD- 0.45 mmol/l). When mean chloride level was evaluated for ABG and AA a significant difference was evident ($p < 0.05$).

The mean hemoglobin level (table 1) measured in ABG was 10.47 ± 2.64 gm/dl while the value in autoanalyzer was 10.31 ± 2.72 gm/dl. The mean difference in hemoglobin level was 0.16 gm/dl (SD- 0.08 gm/dl). A significant difference was evident ($p < 0.05$) when mean value for hemoglobin was observed.

DISCUSSION

As electrolyte abnormality is a frequent clinical condition in critically ill patient, early detection and early management of this reversible changes is very important. Initiating early treatment in such conditions benefit the patient clinically and also decreases the economic burden.⁹

The present study showed that the mean difference of sodium in ABG and AA was 0.57 mmol/l. This is within the acceptable range of USCLIA as discussed earlier. There are 7 values (<6%) of sodium during the comparison in our study, which did not fall in USCLIA guidelines. The reason behind this inappropriate report might be due to hypoalbuminemia, which was not evaluated in our study. The overestimation of sodium in indirect ion selective electrodes method was reported by Shalini G et al. to be linked with serum protein and albumin. It was further stated that, this could be the cause of overestimation of sodium in hypoalbuminemia by Auto-analyzers.⁵

Zhang JB et al. from their study concluded that the mean bias of sodium and potassium in ABG was comparable to that of Auto analyzers.¹⁰ In a study conducted on 352 patients by Gibson M et al. it was agreed that >95% sodium values was comparable between ABG and AA agreeing to accept the reports to make decisions in critical care setting.¹¹

A large study was conducted in supramaximal care hospital to evaluate the accuracy of point of care machines by Dolscheid-Pommerich, R.C. et al. It was noted that there is no inconsistency in the reports of sodium. Despite which it was concluded that further evaluation is required for the ABG machine, since they did not take albumin and protein into consideration.¹²

In the present study, difference for mean of potassium

between ABG and AA was measured to be -0.04 mmol/l. This is within the range of CLIA. In a study conducted on 200 samples by Anunaya Jain et al. it was stated that the potassium value of ABG machine correlated with that of Auto-analyzers (Central laboratory). Since the mean difference in all the conditions namely hypokalemia, normokalemia and hyperkalemia was within the CLIA limits, it was suggested that ABG machine could be trusted for the early intervention by the medical professional.⁸

Shivesh Prakash and his colleagues after conducting similar study agreed that the concordance was moderate to substantial. It was also suggested that except for potassium, result of the other electrolytes in two tests should not be interchanged.¹³

The result of the comparison of potassium level measured by two auto analyzer in our study was supported by the previously published studies^{7,14} except for Y U Budak et al.¹⁵ who disagreed and concluded that the data was not inter interchangeable.

After finding weak correlation with chloride and none for potassium, Jérôme Allardet - Servent et al. concluded that chloride and potassium are least affected by hypoalbuminemia. They also noted that measuring chloride by the two techniques do not show any difference.¹⁶

In the present study mean difference in chloride for the test was 1.71 mmol/l. This difference was within the limits of CLIA.

Uysal E et al in their study concluded that despite sodium and potassium having strong correlation, chloride had moderate correlation.¹⁷ While Begs A and his colleagues suggested that ABG is a reliable option to analyze chloride along with sodium potassium and hemoglobin.¹⁸

The mean difference calculated for hemoglobin for ABG and auto analyzer in our study was 0.16 . This value does not match with the limits provided by CLIA. This result was consistent with the one conducted by Gavala A and his colleagues, who concluded that the hemoglobin level measured by ABG analyzer was lower as compared to the central autoanalyzer.¹⁹ A study conducted by Leino A and Kurvinen K stated that hemoglobin was incomparable between the two analyzers. They concluded that in a clinical condition where hemoglobin was low, it over diagnosed anemia.²⁰ This discrepancy was well explained by Jérôme Allardet-Servent et al. who considered the confounding factors like cell fragments from incomplete hemolysis and high bilirubin level and high lipid fractions and the method of analysis.¹⁶

Triplet K E et al. concluded that, there was no significant difference in the hemoglobin values measured by the two analyzers (Auto Analyzer and Arterial Blood gas), suggesting that it is not necessary to send concurrent samples to ABG and auto analyzers in central laboratory.²¹

CONCLUSION

The sodium, potassium and chloride values measured by the arterial blood gas analyzer were comparable with the values obtained by the laboratory autoanalyzer and thus the



arterial blood gas analyzer could be considered as a point of care testing in ICU for the electrolyte measurement. However, the hemoglobin level measured by arterial blood gas analyzer was not comparable with that measured by laboratory auto-analyzer. Hence, we conclude that arterial blood gas analyzer could be not used as a point of care testing for hemoglobin.

LIMITATIONS OF THE STUDY

Factors like arterial and venous blood, serum and whole blood for analysis of electrolytes and hemoglobin were not considered to nullify the potential effect of these factors on the result of the study. The pre-analytic factors like two different pricks to procure the sample, sample handling, the time frame required in analyzing the sample in central laboratory were not assessed. We also did not take into

account the protein and albumin of the patient which could be the cause of some unexpected values as discussed.

FINANCIAL DISCLOSURE

None

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