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Reliability of point of care assessments of hemoglobin, hematocrit and electrolytes obtained with blood gas device and central laboratory blood gas analyzer in critical emergency clinical setting

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ABSTRACT

Background: The point of care blood gas measurements are designed to aid immediate patient management right at their bedside. Objective: This study aimed to determine the association of parameters-hemoglobin, hematocrit, sodium, potassium levels obtained with blood gas device versus central laboratory analyzer and to evaluate their co-relation in different ranges of pH, age groups and gender**. Methodology:** This cross sectional study was carried out for six months in emergency treatment unit (ETU), National Hospital of Sri Lanka, Colombo. In recruited patients, venous blood samples were obtained at the admission for both measurements of central laboratory and blood gas analysis. **Results:** A total of 440 patients were included, of them 49.8% was male. Mean age 56.9 years (SD 22.33). Mean values of sodium, potassium, hemoglobin, hematocrit in blood gas analysis were 137.15(range 97.6-162), 3.99(1.9-7.4), 12.55(5.9-19.2), 35.65(40-58) respectively. In contrast, the laboratory values for the same parameters were 137(98-163), 4.09(1.99-7.0), 12.24(5.66-19.0), 35.94(19.5-56.9). There was a significant difference between the laboratory and blood gas hematocrit values (p=0.04), however mean values were closely lined. Subgroup analysis in gender, values were not statistically significant except hemoglobin levels (p=0.02). Further subgroup analysis among age and pH groups did not show significant difference. **Conclusion:** The critical decision can be made by trusting sodium, potassium and hemoglobin values obtained from blood gas analysis. The hematocrit values need to review once laboratory results are available before making a critical decision.

Keywords: Point of care blood gas, electrolytes, hemoglobin, hematocrit, emergency setting

INTRODUCTION

The point of care tests (POCTs) are usually designed to aid immediate patient management right at their bedside. There are several POCTs available, of those blood gas analysis, electrocardiogram and trauma ultrasound scan have usually been incorporated in to emergency medicine practice. Blood gas measurements are performed in almost all patients with an acute illness in emergency setting where facilities available (1). Those testing allow the clinician to start on optimal treatment for critically ill patients.

Blood gas analysis provides the results in acid base status of the patient. In addition, other important biochemical and hematological values

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such as electrolytes and hemoglobin level can also be obtained. In order to assess the reliability of POC-blood gas analysis it is compared with values generated by central laboratory auto-analyzer.

The characteristic features of POC-blood gas analyzer are; it analyses whole-blood, use either arterial or venous sample conventionally, utilizes direct ion selective electrodes, processing time is minimal, heparin diluted samples are used and no effects in relation to protein levels in blood. In comparison, auto analyser has following characteristics; it analyses serum, venous-samples are used conventionally, indirect-ion-selective electrode is used, long processing time, sample diluted with fixed volume diluent and non-heparin and being affected by protein levels in blood (2, 3).

This study mainly considers four parameters; hemoglobin, hematocrit, sodium and potassium levels, as their deviation are common in clinical practice.

Hemoglobin concentration has got significant impact on the management of patients in emergency-care setting. Clinically low hemoglobin has devastating consequence if it is not corrected timely. Patient may have symptomatic anemia, ongoing blood loss, where transfusion becomes urgent. Therefore, knowing correct hemoglobin concentration urgently is very important for emergency care team.

The sequential measurements of hemoglobin and hematocrit using blood gas analyzer could be useful for monitoring during transfusion, hemorrhage and rapid alterations in hemodynamic conditions.

The parameters such as hemoglobin, hematocrit alters with the stage and severity of dengue/dengue hemorrhagic fever or with other associated conditions like dehydration. Patients with dengue hemorrhagic fever develop hemo-concentration due to plasma leakage which will make hematocrit to rise from baseline. Early detection of these derangements has a huge impact on patient management and prognosis.

In addition, electrolyte abnormalities are very common in emergency practice. Of those potassium and sodium abnormalities predominate. It is very important to have correct and reliable values immediately. Otherwise delaying treatment in these settings puts the patient’s life in danger.

Point of care (POC) blood gas analysis is used in emergency practice as it has several advantages. The benefits of POC-blood gas assessment include, requiring relatively low sampling volume, elimination of sample-preparation procedure and reducing long-transport time (4).

However, reliability of the results generated from POC-blood still remains controversial. Some clinicians tend to agree with the results while others do not, who still request values from central laboratory. In literature, there is significant disparity reported between two values especially for the electrolytes (5, 6). Various factors might lead to these discrepancies. These can be divided in to pre-analytic and analytic phase. Pre-analytically, blood gas sample should be clot free and analysis should be done without delay as metabolism can alter the results (7,8). The instrument type and calibration methods are involved in analytic phase.

According to the US Clinical Laboratory Improvement Amendment (US CLIA) 2006, it accepts a deviation of the results of 0.5 mmol/l in measured K (potassium) and 4 mmol/l in measured Na (sodium), from the gold-standard measurement.

In literature, several review articles and multiple research studies have pointed out the importance of identifying association between POC-blood gas values and central laboratory values for individual institution/hospital (9). Also they suggest formulating their own correlation factor.

Objectives

To determine the association of time-critical-parameters-hemoglobin, hematocrit, sodium, potassium levels obtained with blood gas device versus central laboratory blood analyzer. In addition, to identify association of above parameters in following subgroups; different pH ranges, different age groups and gender subgroups.

METHODOLOGY

A descriptive cross sectional study was conducted. This study was carried out at emergency treatment unit (ETU), National Hospital of Sri Lanka, Colombo, Sri Lanka for a period of 6 months. Patients who are clinically unstable, unable to give informed-consent and suspected to have ongoing hemorrhage were excluded from the study. A total of 440 adult patients (equal or more than 18years old) who are able to provide consent were included as a convenient sample. A blood sample was obtained from each patient at the admission for both measurement of central-laboratory and blood gas analysis. Same sampling point selected and only one venous sample was sent for analysis to facilitate a "single-blood draw". No multiple samples were done on the same patient. The blood samples were analyzed immediately after collection using a GEM 3000 machine. Machine calibration was done in every 50 sampling point, where commended by manufacture to make reliable assessment of the report. Serum parameters were analyzed in the central-laboratory using a chemistry analyzer Olympus AU2700. A single data collection sheet was used for each patient. It composed of demographic details of the patient, clinical details and details on blood gas and laboratory values.

The statistical analyses were carried out using the latest version of Statistical-Package for Social-Sciences (SPSS). The association between variables were analyzed using T tests and subgroup analysis were done using kruskal-wallis test

RESULTS

A total of 440 paired samples were analyzed, of them 49.8% was male. Mean age 56.9 years (standard deviation of 22.33 and range of 18-98 years). Among the study population approximately one third of them were below 50 years (36.4%).

The mean values of sodium, potassium in blood gas analysis were 137.15mmol/L , 3.99 mmol/L respectively in comparison to 137mmol/L , 4.09 mmol/L obtained by laboratory analyzer. There was no statistically significant difference between the two. (P values are 0.062 and 0.1 respectively). The hemoglobin values showed no significant difference (p = 0.3). Interestingly there was a significant difference between the laboratory and blood gas hematocrit values. (p=0.04). However, mean values are closely lined showing no clinical significance.

Table 1: Statistical output from paired t test with their significant values for research parameters

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	BG_Na - LAB_Na	.14795	6.33822	.30216	-.44591	.74182	.490	439	.625
Pair 2	BG_K - LAB_K	-.09406	.32923	.01570	-.12491	-.06322	-5.993	439	.100
Pair 3	BG_Hb - LAB_Hb	.30664	6.19737	.29545	-.27403	.88730	1.038	439	.300
Pair 4	BG_HCT LAB_HCT	-.28152	2.91584	.13901	-.55473	-.00832	-2.025	439	.043

BG=blood gas, LAB=laboratory values, Na=sodium, K=potassium, Hb= hemoglobin, HCT=hematocrit

Further analysis was done to determine the association of sodium (table 2 and 3) and potassium (table 4 and 5) levels beyond the physiological range. This revealed closely lined mean values with only a few decimal points difference and clinically not significant.

Table 2: Statistical comparison of hypo-natremia between blood gas and central laboratory

	Hypo-Na in BG	Hypo-Na in LAB
Number of values	146	146
Minimum	97.6	97
Maximum	134.8	134.9
Mean	126.3	126.9
Std. Deviation	6.657	7.265
Mean of differences	-0.6267	
95% confidence interval	-1.062 to -0.1911	

BG= blood gas, LAB = laboratory values, Na=sodium

Table 3: Statistical comparison of hyper-natremia between blood gas and central laboratory

	Hyper-Na in BG	Hyper-Na in LAB
Number of values	84	84
Minimum	145.5	145.2
Maximum	162	163
Mean	151.2	150.7
Std. Deviation	4.289	4.712
Mean of differences	0.5321	
95% confidence interval	0.1620 to 0.9023	

Table 4: Statistical comparison of hypo-kalaemia between blood gas and central laboratory

	Hypo-K in BG	Hypo-K in LAB
Number of values	100	100
Minimum	1.9	1.99
Maximum	3.4	3.44
Mean	2.883	3.065
Std. Deviation	0.4416	0.5829
Mean of differences	-0.1821	
95% confidence interval	-0.2634 to -0.1008	

BG= blood gas, LAB = laboratory values, K=potassium

Table 5: Statistical comparison of hyper-kalaemia between blood gas and central laboratory

	Hyper-K in BG	Hyper-K in LAB
Number of values	55	55
Minimum	5.1	5.2
Maximum	7.4	7
Mean	6.029	5.926
Std. Deviation	0.6568	0.6497
Mean of differences	0.1031	
95% confidence interval	0.006255 to 0.1999	

The subgroup analysis was done among different pH levels, gender and age groups. It was found that there was no significant difference between the two analytical methods (Table 6, 7, and 8).

Table 6: Subgroup analysis according to age

	Age less than 50 years		Age equal or more than 50 years	
	Mean	**SD**	**Mean**	**SD**
Blood gas-Sodium	137.87	10.31	136.74	10.00
Blood gas-Potassium	3.98	1.07	4.00	0.95
Blood gas-hemoglobin	12.31	2.39	12.69	8.04
Blood gas-hematocrit	35.53	8.81	35.74	6.78
LAB-Sodium	137.96	10.33	136.46	12.33
LAB-Potassium	4.08	1.05	4.10	0.91
LAB-hemoglobin	12.37	2.31	12.17	2.14
LAB-hematocrit	36.00	7.85	35.91	6.70

Table 7: Subgroup analysis according to pH values

	Mean values		
	Normal	**Acidic**	**Alkaline**
Blood gas-Sodium	136.80	138.30	135.87
Blood gas-Potassium	4.12	3.98	3.76
Blood gas-hemoglobin	12.42	12.74	12.51
Blood gas-hematocrit	36.15	35.29	35.26
LAB-Sodium	136.16	138.41	136.34
LAB-Potassium	4.22	4.05	3.89
LAB-hemoglobin	12.44	11.92	12.40
LAB-hematocrit	36.67	35.56	35.03

Table 8: Subgroup analysis according to gender

	Male		Female	
Parameters	**Mean**	**SD**	**Mean**	**SD**
Blood gas-Sodium	137.25	9.52	137.05	10.70
Blood gas-Potassium	4.07	1.04	3.93	0.95
Blood gas-hemoglobin	13.10	9.03	12.01	2.20
Blood gas-hematocrit	36.28	7.38	35.04	7.73
LAB-Sodium	136.99	12.59	137.01	10.67
LAB-Potassium	4.14	1.00	4.04	0.93
LAB-hemoglobin	12.49	2.18	12.01	2.20
LAB-hematocrit	36.49	7.18	35.40	7.06

DISCUSSION

In this study point of care blood gas analysis was done with Gem premier 3000, central laboratory hematology analysis was done with Mindray BC-6200 and serum values were analyzed with Beckman Coulter AU680 which uses direct iron selective electrode technique. Whole blood sample assessed immediately with POC blood gas device. Blood for central laboratory analysis were sent within 15 minutes of drawing. Samples were marked as "emergency" which enabled immediate processing and providing results within 1 hour.

This study has demonstrated there is no significant difference between electrolyte values and hemoglobin levels obtained from whole-blood samples estimated at blood gas-analyzer and values obtained from central-laboratory analyzer. However, there is a significant difference (p=0.04 from paired t test) in hematocrit values observed between these two measuring devices, but their mean values are closely lined and clinically not significant.

The study was able to demonstrate that the agreement between whole-blood (from blood gas) and serum (from laboratory) electrolytes is uniform across the entire spectrum of values. In addition, subgroup analysis (i.e. between gender, age groups and different pH ranges) did not show any discrepancy of electrolyte values in blood gas analysis compared to central laboratory values. Therefore this observation has a clinical implication when managing critically ill patient in emergency setting. The usual practice is to act on initial blood gas if it is abnormal and then send a follow up sample to laboratory to assess the outcome of the intervention. This intervention is by means of replacing electrolytes or measures to reduce them. Therefore, the results generated from this study are useful for deciding initial treatment and even for following up after the intervention.

A study conducted in Italy, showed same result as in this study and found out that there is high-correlation between sodium and potassium values measured by POC-blood gas machine and central lab analyzer (9). In addition, Jain et al demonstrated that there is a significant association between the potassium levels obtained from both analytic methods. However that study did not find an accurate association in sodium levels. However, Budak et al, displayed there is a significant deviation of results obtained from POC-blood gas and central laboratory, and they emphasize that POC test results cannot be used in routine clinical-practice (10).

In this study, a disagreement was observed between the hematocrit values determined by blood gas analysis and those obtained from the central laboratory hematology analyzer; however mean values are closely lined. In comparison, Bosshart et al (11), found out that there is a significant co-relation between the 2 methods (blood gas Vs central lab value) used to ascertain hematocrit (PCV) values. They noticed the calculated-difference of 1.4 percent between two methods.

This study found out that Hemoglobin values measured by these two methods showed no significant difference. This finding is valuable when managing patient with acute changes in hemoglobin levels, such as hemorrhage in trauma. In contrast, Chirino et al. discovered that blood gas equipment tends to overestimate lab values when assessing hemoglobin level; however their mean difference was small and not clinically significant. They concluded that blood gas equipment is a reliable method for hemoglobin evaluation.

Finally, in comparison to other studies on this topic, this research is different in the following-ways: (a). A "single draw" venous sample for both the analysis; (b). in comparison to some earlier studies[5], in which both samples were analyzed in the central laboratory; in this-study whole-blood samples were analyzed at the bedside and serum/hematology samples were analyzed in the main laboratory.

CONCLUSION

The critical decision can be made by trusting sodium, potassium and hemoglobin values obtained from blood gas analysis. The hematocrit values need to review once laboratory results are available before making a critical decision.

This study shows different concordance between blood gas values and laboratory values compared to published researches. Since there are different confounding factors at each setting, e.g. type of machine, different-calibration, etc. it is important for institutions to arrange their own studies to know the association between blood gas values and laboratory values.

Author declaration

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Conflicts of interest:

I declare that there are no conflicts of interest regarding the publication of this paper. No financial or personal relationships have influenced the work reported in this study.

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Ethics statement:

The ethical clearance was obtained from the Ethics Review Committee (ERC) of the Postgraduate Institute of Medicine, Colombo (ERC No. ERC/PGIM/2021/030). Consent was obtained after appropriate verbal and written explanation from each subject on recruitment.

Statement on data availability:

The data supporting the findings of this study are available from the corresponding author upon reasonable request. All data have been anonymized to ensure the privacy and confidentiality of the participants. Both paper and electronic versions of the data are available.

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