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A Systematic Review

Accuracy of Arterial Blood Gas: Quality Improvement Study

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Abstract:

Background: Arterial blood gas (ABG) is indicated in almost all presenting problems in the emergency department (ED). When the clinical diagnosis does not match the ABG diagnosis, particularly in multiorgan failure, physicians level it as inaccurate. With the passage of time the role of ABG has been narrowed to the ICU as a monitor in ventilated patients. The accuracy of ABG can be tested by knowing and comparing the values of Hb% measured though ABG and CBC and by oxygen saturation measured though ABG and pulse oximetry.

Method: This was a prospective observational cohort quality improvement study and ABG vs. CBC hemoglobin and ABG vs. pulse-oximeter oxygen saturation in over 74 adult patients admitted to the ED were evaluated in a tertiary care center. Arterial blood was collected properly and ABG-Hb/ABG-SO_2 was measured at point-of-care testing with an ABG machine. Venous samples were collected at the same time and properly transported to the laboratory for CBC measurement. SpO_2 was measured at bedside through pulse oximeter. Data were entered into a specifically designed database and analyzed statistically.

Result: There was a strong positive correlation between ABG-Hb and CBC-Hb ($p<0.001$). The correlation between ABG-SO_2 and pulse-oxi-SpO_2 was also significant ($p<0.001$).

Conclusion: Both the ABG-Hb vs. CBC-Hb and ABG-SO_2 vs. pulse-oxi-SpO_2 methods can be used as tools for testing accuracy and improving the quality of ABG. Confident use of ABG in the management of severely ill patients significantly improves outcomes [3].

Keyword: ABG (arterial blood gas); ED (emergency department); CBC (complete blood count); Pulse-Oxi (pulse oximeter); PI (perfusion index).

Introduction

Arterial blood gas (ABG) has been a cornerstone in patient management since its availability in the early 1960s, and now it is widely used in hospitals. The point-of-care to perform ABG is confined in the ICU, where it is used to measure arterial blood samples taken from ventilated patients and patients who are severely ill for monitoring purposes. ABG is indicated in almost all patients admitted through the emergency department (ED) and thus the point-of-care. Its wide utility is narrowed on account of the diagnostic variability between the clinical and ABG. Here, the physician-level ABG is unacceptable. There is an established method for testing the accuracy of measured values through the base excess (BE) method, where the difference between the measured and derived HCO_3^- should fall between ±2. However, until now, no ABG machine has measured HCO_3^-, and HCO_3^- is always derived. Although in a study published in Clinical Chemistry, 2008, 0.65% of the population had a significant difference in measured and derived HCO_3^- [5]. In another study, it was found that HCO_3^- differences were >±2 in 13% of ED patients, however, the measurements were precise [3].

The second method available to observe accuracy is the relationship between pH and H^+. Here, pH is a measured value but H^+ is derived from HCO_3^- and measured $PaCO_2$ (by the Handerson equation) [1]. H^+ and HCO_3^- are both derived values, so it is doubtful that there is a correlation. There is a need for a method that can test the accuracy. The relationship between SO_2 (measured through ABG) and SpO_2 (measured through pulse-oximeter) will help. Another method to be adopted is hemoglobin measured through an autoanalyzer (CBC-Hb) and ABG machine (ABG-Hb) and then correlated.

The purpose of this study was to establish the correlation between ABG-SO_2 and pulse-oxi-SpO_2 and between CBC-Hb and ABG-Hb. Self-confidence among doctors in ABG will extend its utility in the ED and will improve outcomes worldwide.

Method

Study design: This is a prospective observational cohort, quality improvement study.

Study setting: The work was started in December 2019 after obtaining the college ethics committee approval and was completed in March 2020 in the emergency department (ED) of Darbhanga Medical College and Hospital Laheriasarai.

Participants: A total of 74 subjects were included in the study. Adult patients aged 18yrs to 65yrs in the ED were included in the study.

Procedure: The ABG machine used was an ABL 80 Flex Co-Ox Radiometer (USA). The machine was kept in a point-of-care room with the temperature maintained at 23°C around the clock. The incorporated cooximeter in the machine determines oxygen saturation. Quality control of the machine is done frequently and calibration is performed automatically at 8hr intervals. The reagent (sensor cassette and solution pack made in the USA with US and foreign components for radiometer medical APS DK-2700 marked by ABL) used was recommended and supplied by A B marketing, India. To minimized personal error, 02 ml arterial blood was collected in a heparinized syringe from the bed side in the ED and immediately transferred to the point-of-care where the result was obtained within minutes. Through ABG, we obtained ABG-SO_2 and ABG-Hb.

Venous blood was drawn from 74 time-matched patients for measurement of Hb through a Mindray international BC 6000 hematology autoanalyzer (USA). Quality control level 1-3 is done daily. Calibration is done monthly. Temperature is maintained 23°C ~ 32°C and humidity 30% ~ 85%. Reagent used was M-6 L H lyse; M-6 L D lyse; M-6 L N lyse. This machine is situated at the central laboratory, which is 400 meters apart from the ED. The samples were transported through a rapid transit pneumatic system for analysis.

SpO_2 was measured using an Easy Care finger pulse oximeter, which is made in Bangalore, at the bed side in the ED. The machine displays information on SpO_2, pulse rate, perfusion index (PI) pulse intensity (bar graph) and pulse waves. The measuring range of SpO_2 was 0%-100%.

Blinding: Allocation concealment was performed by a sequentially numbered sealed envelope. Patients and outcome accesses were blinded. This work was done by PG students. The recruitment period was 4 months. Work was started after written consent was obtained from the patient or attendant. No follow-up was performed, and the trial was stopped after the stipulation period. Patients who were in shock or who had nail-polish on all fingers were excluded from the study.

Data collection: The data we obtained were (ABG-Hb), (CBC-Hb), (ABG-SO_2) and (pulse-oxi-SpO_2), which were kept sealed in separate envelopes by PG students for a prospective quality improvement study.

Statistical analysis: The data were compared by the Wilcoxon sign rank test after the completion of data collection and entry into the database. The association of Hb and SpO_2 between the methods was done using Spearman's rank correlation coefficient, and the relationship between Hb and SpO_2 of the methods was done using regression analysis. The statistical software SPSS version 20 had been used for the analysis. Continuous variables were expressed as descriptive statistics. An alpha level of 5% had been taken i.e. if any p-value was less than 0.05 it had been considered as significant.

Result

Out of 74 subjects enrolled, 49% were male. Mean age was 47.10 ± 17.72. Continuous variables are expressed as descriptive statistics (Table- 1). The mean CBC-Hb was 11.90 ± 2.12 gm/dl, and the mean ABG-Hb was 12.57 ± 2.52 gm/dl, p-value <0.001(Table 1). These values are also depicted in the bar diagram (Diagram 1).

Table 1: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	95% CI	P Value
Age	71	11.00	78.00	47.10	17.72	42.53 - 50.9	
WT	70	22.00	95.00	52.69	13.54	49.46 - 55.91	
pH	74	7.31	7.60	7.45	0.04	7.44 - 7.46	
H+ (T)	74	25.00	49.00	35.28	3.59	34.43 - 36.14	0.191
H+ (HE)	74	24.22	98.27	36.22	8.20	34.53 - 36.31	
ABG-Hb(gm/dl)	74	4.70	22.10	12.57	2.52	12 - 13.23	<0.001
CBC-Hb(gm/dl)	74	4.50	17.40	11.90	2.12	11.38 - 12.42	
ABG SO_2 (%)	74	71.30	99.30	96.67	3.77	95.86 - 97.66	0.600
Pulse-oxy-SpO_2 (%)	74	70.00	100.00	96.62	4.33	95.48 - 97.6	
BE	74	-10.90	17.70	-1.51	3.64	-2.37 - - 0.6	
M Hco3	74	13.10	78.40	23.43	7.50	21.68 - 25.34	<0.001
D Hco3	74	13.90	42.40	21.66	4.04	20.72 - 22.69	

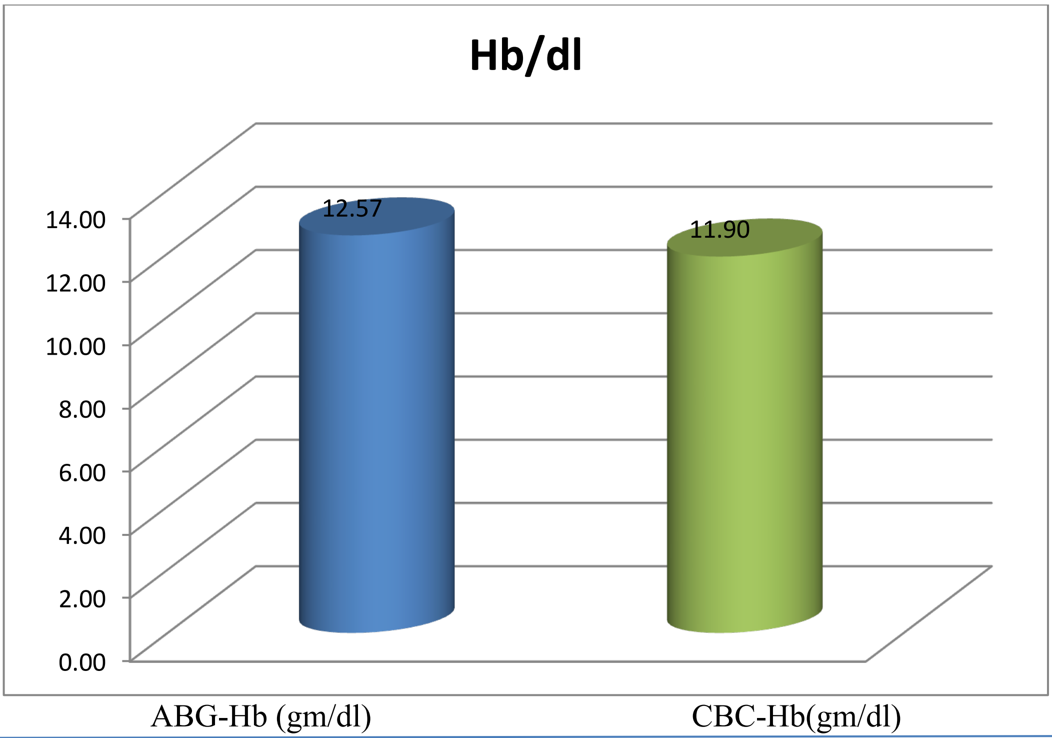


Diagram-01

The correlation was tight Spearman r=0.85; p<0.001 (Table 2). The regression analysis showed that on average, ABG-Hb was 0.737 higher than the CBC-Hb (95% confidence interval 0.642 to 0.832; p<0.0001) (Table 3). Regression analysis, as suggested in the scatter diagram-3, showed that CBC-Hb and ABG-Hb have a linear relationship.

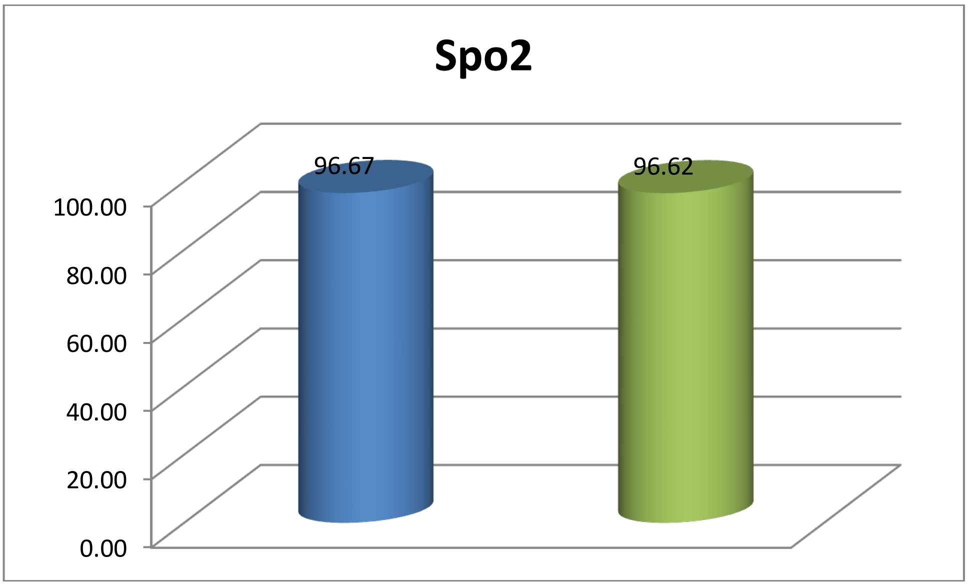
Table 2: Correlations

		CBC-Hb (gm/dl)
Sipearman's rho Correlation Coefficient	ABG-Hb(gm/dl) P value	0.850 <0.001
		Pulse-oxy-SpO_2 (%)
Sipearman's rho Correlation Coefficient	ABG-SO_2 (%) P value	0.491 <0.001

Table 3: Coefficients

Model		Unstandardized Coefficients	p Value	95.0% Confidence Interval for B	
		B		Lower Bound	Upper Bound
	(Constant)	2.643	0.000	1.428	3.858
	ABG-Hb(gm/dl)	0.737	0.000	0.642	0.832
	(Constant)	2.899	0.681	-11.084	16.882
	ABG-SO2 (%)	0.969	0.000	0.825	1.114

The mean of pulse-oxi-SpO_2 was 96.62 ± 4.33%, and the mean ABG-SO_2 was 96.67 ± 3.77%, p-value 0.600 (Table 1), which are also depicted in the bar diagram-2. Correlation was tight (Spearman r=0.491; p<0.001) (Table 2). The regression analysis showed that on average, ABG-SO_2 was 0.969% higher than pulse-oxi-SpO_2 (95% confidence interval 0.825-1.114; p<0.0001) (Table 3). Regression analysis, as suggested in the scatter diagram-4, showed that ABG-SO_2 % and Pulse-Oxi-SpO_2 % were also linearly related.



(ABG-SO_2 (%) Pulse-oxy SpO_2 (%)

Diagram-02

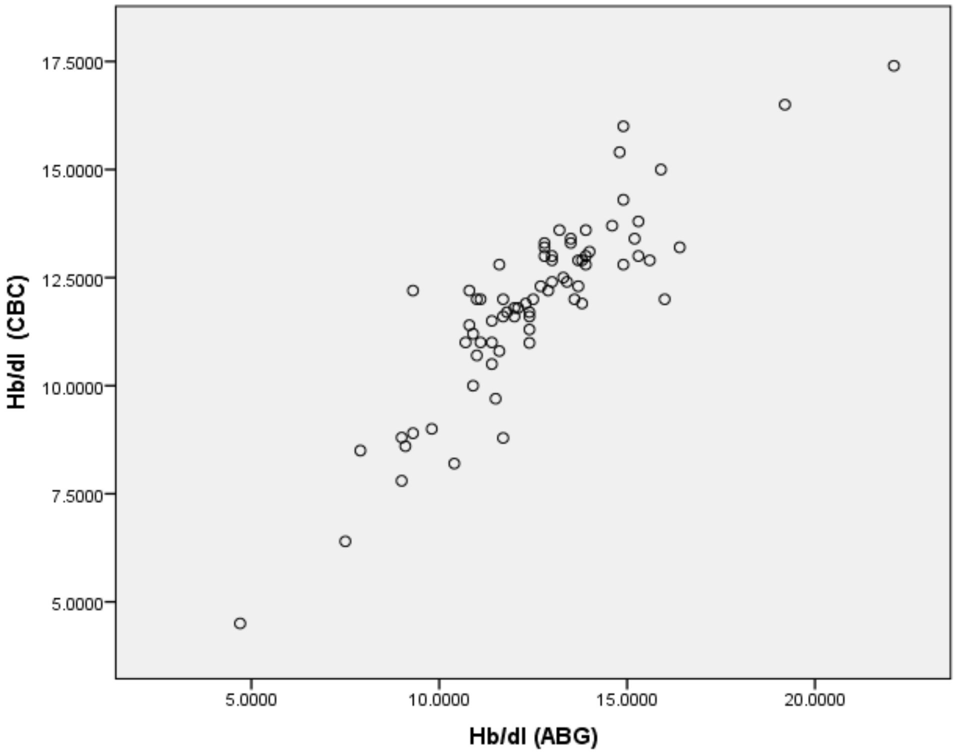


Diagram- 3

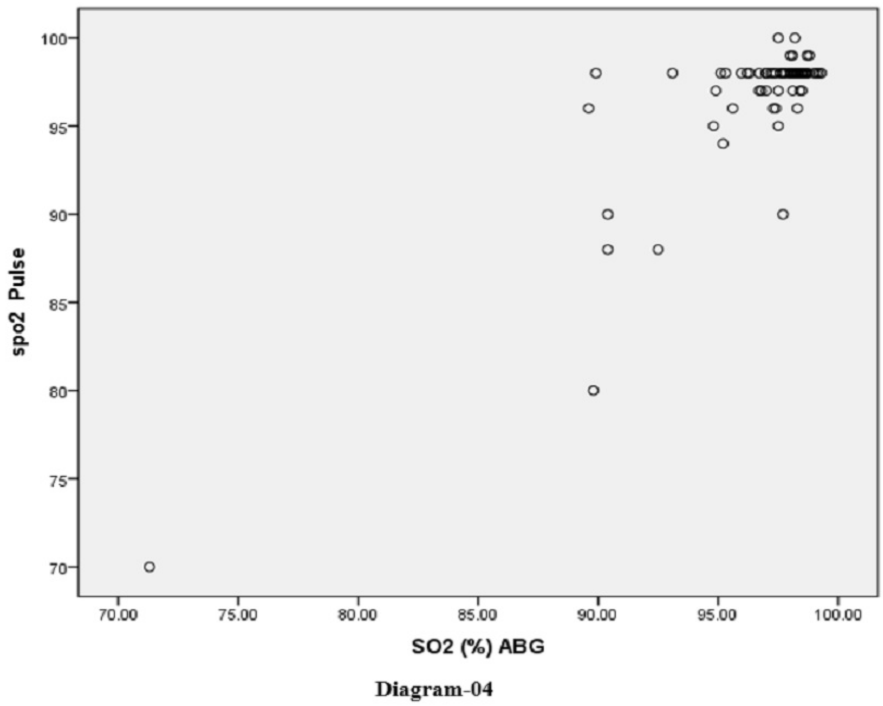


Diagram- 4

Discussion

Cox concluded that irregularities in the transport of samples to laboratories negatively affect the samples and the related output [2]. In the present study, we aimed to evaluate the correlation between ABG-Hb and CBC-Hb. The ABG-Hb value is higher than the CBC-Hb value but not significantly, which is against the finding of y and z w et al. [8] but is in agreement with Jiramethu et al., who also found ABG-Hb higher by 0.38% [6]. There is a strong positive correlation between ABG-Hb and CBC-Hb. This finding is in agreement with the work of Rayja et al. [7] and Farhan AL Enezi et al [4]. The use of this method will help physicians understand the accuracy of ABG and thus will help in correlating clinical and ABG diagnoses, to understand prognosis in some cases and to help in planning management.

Oxygen saturation (SO_2) is one of the different oxygenation parameters generated by a blood gas analyzer. ABG-SO_2 measurements are more accurate. Pulse-Oxi-SpO_2 is noninvasive and is a commonly used clinical monitor. Pulse-oximeters have limitations and their value is less than those achieved by ABG-SO_2, but the difference is not significant. On scatter diagram, they have a linear relationship.

My work has shown that there is a significant high positive correlation between the parameters measured by different sources. This work will add to the method of testing the precision of ABG measurements and ultimately will add to the confidence of treating physicians at all levels.

Conclusion

There is a linear correlation between ABG-Hb and CBC-Hb values and the difference between them is not significant. The ABG-Hb value was higher by 0.737% (confidence interval 0.642 to 0.832). Therefore, this method can be used for testing the accuracy of ABG and can be taken as a quality improvement in accuracy testing.

There is a linear correlation between ABG-SO_2 and pulse-oxi-SpO_2. The difference between them is not significant. ABG-SO_2

is higher than Pulse-Oxi-SpO_2 by 0.969% (95% confidence interval 0.825-1.114). Therefore, if the two values of oxygen saturation fall within the range, it can predict the accuracy of ABG.

These two methods can be used confidently for testing the accuracy of ABG measurements. In diagnostic variation the physician can change the clinical diagnosis according to ABG diagnosis in the early stage of management of the patient. Management started in the background of ABG analysis improved the outcome in multiorgan disease [3].

The utility of ABG will be broadened from the ICU to emergency departments worldwide from peripheral hospitals to tertiary care hospitals.

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