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The Reliability of Blood Gas Electrolytes

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Abstract

Objective: To evaluate the reliability of blood gas test electrolyte results by comparing them with biochemistry results.

Material and Methods: A total of 722 patients with blood gas (BG) and biochemistry results, admitted to our emergency department in May 2013, were evaluated retrospectively. Patients were grouped as acidosis group, normal pH group, and alkalosis group. The obtained data were analyzed with SPSS 16.0 software for their frequencies and distributions and then interpreted using paired-sample t-test.

Results: There was a statistically significant difference between BG and biochemistry potassium results in the normal pH group ($p<0.01$). Also, there was a statistically significant difference between blood gas and biochemistry chlorine results in acidic, normal pH, and alkaline blood samples ($p<0.01$). However, no statistical significance was found between BG and biochemistry sodium results in all pH values or between BG and biochemistry potassium results in acidic and alkaline blood ($p>0.01$).

Conclusion: It was found that BG potassium results in normal pH and BG chlorine results in all pHs were not statistically reliable. Blood gas electrolyte values should be used for the initial treatment of critically ill patients in the emergency department. However, we need to be aware that the results of blood gas electrolyte testing are not reliable. These results have to be confirmed with routine biochemistry electrolyte, EKG, and physical examination findings soon.

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Key words: Acidosis, alkalosis, blood gas analysis, potassium, sodium, chlorine

Introduction

To decide based on rapid and reliable blood results in cases increases the success of treatment. Venous and arterial blood gas analyses are commonly used in emergency departments. Biochemistry tests are performed with standard techniques in the serum from venous blood. It generally takes an hour to get the results. For the patient, it can be harmful to spend this time without receiving any treatment. Although biochemistry tests provide more precise results, blood gas analyses are more important in the immediate initiation of the treatment process for critically ill patients.

In practice, there may be some uncertainty about initiating the therapy considering blood gas electrolyte values or waiting for blood biochemistry results. A study revealed that 85% of physicians relied on blood biochemistry results obtained from the hospital, laboratory whereas 38% did not rely on bedside blood tests (1). In other studies, it was stated that clinicians did not rely on blood gas results, which were in fact reliable enough; so, they waited for the blood biochemistry results before beginning the treatment (2).

In this study, the accuracy and sensitivity of blood gas electrolyte results, which are rapid and valuable findings for emergency patients and beneficial for emergency practices; their usability in treatment; and their changes depending on pH value were investigated.

Material and Methods

Records of the patients who admitted to Istanbul Haydarpaşa Emergency Medicine Clinic in May 2013 were retrospectively examined through the automation system of the hospital. In the study, 894 patients who required blood gas analysis in addition to biochemistry tests were involved; 172 cases who were under the age of 18, whose blood samples were not taken simultaneously, whose blood results could not be obtained due to coagulation, or whose results included some lacks were excluded from the study. After all patients were put into groups of acidosis (pH <7.35), normal pH (7.35-7.45), and alkalosis (pH>7.45), their blood biochemistry electrolyte values were compared with blood gas potassium (K^+), sodium (Na^+), and chlorine (Cl^-) values.

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The blood gas samples of the patients examined in the emergency department of our hospital are drawn into 2-ml heparinized disposable syringes as 1 ml. Although there is no hospital recording showing that the blood samples taken for blood gas are from the artery or vein, it is known that most of them are taken from the vein. In the literature, there are some studies suggesting that venous blood gas can be used instead of arterial blood gas analysis (3-5). Therefore, arterial and venous blood gases were evaluated together in our study.

Blood samples are analyzed in the laboratory of the emergency department on the same floor. Results are obtained in 5 minutes and then loaded into the hospital's automation system. After blood biochemistry is taken into yellow tubes, it is centrifuged in the emergency laboratory and then put in the biochemistry device in open laboratory tubes. Results are seen on the computer system within an hour. The blood gas (Rapidlab 1265; Siemens, North Rhine-Westphalia, Germany) and blood biochemistry devices (Architect pus C 4000; Abbott, Illinois, USA) used are the products commonly preferred by nearby hospitals, and their maintenance and calibration are performed regularly.

Statistical Analysis

The SPSS 16.0 (SPSS 16,0; IBM, New York, USA) statistical program was used while analyzing the data obtained. In addition to the means of continuous variables, standard deviation (SD) and minimum (min) and maximum (max) values were presented in parentheses, and qualitative variables were expressed as numbers and percentages (%). Paired t-test was conducted to compare parametric variables. Correlation coefficient (r) and 95% confidence interval were used. A value of $p< 0.01$ was accepted as statistically significant.

Table 1. Distribution of all blood gas analyses and blood biochemistry values

Analysis	Minimum	Maximum	Mean	Standard deviation
pH	6.74	7.60	7.39	0.08
K^+ blood gas	1.95	8.89	4.01	0.59
K^+ biochemistry	1.90	9.20	3.95	0.61
Na^+ blood gas	113.70	164.70	137.28	4.61
Na^+ biochemistry	113.00	168.00	137.59	4.44
Cl^- blood gas	72.00	133.00	102.49	4.79
Cl^- biochemistry	72.00	133.00	104.13	4.74

Table 2. Distribution of electrolyte laboratory results in acidic blood

Analysis	Minimum	Maximum	Mean	Standard deviation
pH	6.74	7.34	7.26	0.13
K^+ blood gas	3.07	8.89	4.36	0.86
K^+ biochemistry	2.90	9.20	4.34	0.88
Na^+ blood gas	113.70	154.80	137.21	5.62
Na^+ biochemistry	114	149	137.27	5.30
Cl^- blood gas	89	116	103.11	5.02
Cl^- biochemistry	91	116	104.12	4.63

Results

Among 722 cases involved in the study, 47.6% was male (n=344) and 52.4% was female (n=380). The mean age was found to be 50.23 (SD 22.3, min 8, max 92). The distribution of all blood gas and biochemistry K^+, Na^+, and Cl^- results are demonstrated in the following table (Table 1).

The patients with acidic blood pH (pH <7.35) constituted 13% of all patients (n=94). The mean pH value for acidic blood gases was 7.26 (SD: 0.13, min: 6.74, max: 7.34). Distributions of acidic blood gas analysis and biochemistry electrolyte values are presented in the table below (Table 2).

The means of biochemistry electrolyte values and blood gas values for acidic blood were compared using paired t-test. Among the patients, the difference between blood gas- biochemistry mean values was found to be statistically significant for Cl^- but not for K^+ or Na^+ ($p>0.01$). For patients with acidosis, blood gas electrolyte values were reliable for K^+ and Na^+, while they were not reliable for Cl^- (Table 3).

The ratio of the patients with blood gas of normal pH (7.35-7.45) was 71.4% of all patients (n=516). Normal pH mean value was 7.39 (SD 0.02). Blood gas and biochemistry electrolyte values are shown in the following table (Table 4).

The means of blood gas and biochemistry electrolyte values for normal pH were evaluated with paired t-test. The difference between the means was statistically significant for K^+ and Cl^- ($p<0.01$) but insignificant for Na^+ ($p>0.01$). For this patient group, blood gas values were found to be reliable for Na^+ but unreliable for K^+ and Cl^- (Table 5).

It was found that the ratio of patients whose blood pH was >7.45 constituted 15.5% of all patients (n=112). The mean pH was 7.49 in alkaline blood (SD 0.3, min 7.46, max 7.60). The distribution of blood gas and biochemistry electrolyte values is summarized in the following table (Table 6).

The differences of blood gas-biochemistry electrolyte means in alkaline blood were interpreted with paired t-test. The blood results were statistically significant for Cl^-, whereas they were insignificant for K^+ and Na^+ ($p>0.01$). Moreover, in alkaline blood, blood gas K^+ and Na^+ values were found to be reliable, but Cl^- values were unreliable in our study (Table 7).

Discussion

Fluid and electrolyte balance disorders are frequently seen in clinical practice. Electrolyte concentrations of the body are primarily

Table 3. Comparison of the mean values of acidic blood gas- biochemistry electrolyte results (paired T-test)

	Mean Difference	*SD	*95% CI	*r	*p
K^+ blood gas-biochemistry	0.026	0.238	-0.022/ 0.075	0.963	0.281
Na^+ blood gas-biochemistry	-0.063	3.378	-0.755/ 0.628	0.810	0.855
Cl^- blood gas-biochemistry	-1.010	3.060	-1.637/ -0.383	0.802	0.002

*SD: Standard deviation, r: Correlation coefficient, CI: Confidence interval, p: Statistical significance level (Paired T-test) regulated by renal functions, but some hormonal activities, such as antidiuretic hormone, aldosterone, and parathyroid hormone, also contribute to this regulation process. Any dysfunction in these mechanisms, even severe physiological stress conditions, can disturb electrolyte balances and cause life-threatening emergency situations (3-6).

Blood gas analyses include electrolyte values, like K^+, Na^+, and Cl^-, as well as pH, PO_2, PCO_2, HCO_3, glucose, and lactate measures. Blood gas electrolyte is used for evaluating the anion gap in cases, such as diabetic keto-acidosis or methyl alcohol intoxication, and it can lead the treatment when methyl alcohol cannot be evaluated. It is not always possible to initiate the therapy with EKG in K^+ imbalances, which are frequently seen in diseases, like renal insufficiency, and can be fatal. In dehydrated patients with poor general health condition, Na^+ and Cl^- imbalances are seen frequently.

In a study conducted with 99 cases, venous blood gas and biochemistry laboratory results were compared, and it was found that the mean blood gas K^+ value was significantly lower than the mean biochemistry K^+ value (7). However, in emergency departments, especially for critical patients requiring immediate decision-making, it was decided that venous blood gas results could be used to estimate K^+ value until laboratory results were obtained. Also, in our study, a statistically significant difference was observed between the means of K^+ blood gas and biochemistry results in normal pHs (0.069 mmol/lt) ($p<0.01$). The result of our study correlates with this study, and it shows that K^+ results are not reliable in blood gas analysis.

In another study performed in Turkey, blood gas electrolyte and glucose and biochemistry values were compared, and the data were found to be consistent with each other. It was thought that the results of blood gas analysis, which is a rapid test, could be employed, especially during the treatment of critical patients in urgent cases until biochemical results were obtained (8). Study results on this point differ from each other. The reason for this can be that current studies include few samples. Our study involves 722 patients, which is over the patient number of the studies currently available in our country.

Venous blood gas analysis and serum electrolyte results of 46 patients with diabetic keto-acidosis were compared in another study. Correlation coefficients for Na^+ and Cl^- were 0.73 and 0.94, respectively. In conclusion, it is suggested that venous blood gas electrolyte results can be used instead of serum electrolytes for the diagnosis of diabetic keto-acidosis (9).

In research on the comparison of laboratory electrolyte and blood gas electrolyte results, 200 samples were compared, and no statistically significant difference was found between blood gas K^+ values and laboratory K^+ values. On the other hand, there was a significant difference between Na^+ values. It was concluded that critical treatments could be carried out based on arterial blood gas K^+ results (10).

In a study conducted with 200 cases in the intensive care unit, the use of blood gas and laboratory electrolyte and metabolic values instead of each other was investigated, and it was stated that blood gas K^+, Na^+, Ca^+, glucose, and lactate values can be used instead of laboratory values during the treatments of critical patients (11).

In a research paper, it was agreed by clinicians that 0.1 units for pH, 3 mEq/lt for $HCO3^-$, and 0.5 mmol/lt for K^+ were acceptable error values (12). Similar consensuses were also reached by other clinics (14). In the literature, it is mentioned that a 2% measurement error in the results of studies conducted with a single device can be tolerable for preventing the statistical results from being misinterpreted, compared to multicenter studies (13).

Our study revealed that there was a statistically significant difference between the means of blood gas and biochemistry K^+ results in the blood samples with normal pHs (0.069 mmol/lt) ($p<0.01$). For Cl^-, the difference between the means of blood gas and biochemistry values was found to be statistically significant in acidic, normal, and alkaline pHs (1.010/-1.812/-1.366) ($p<0.01$). In brief, blood gas K^+ can yield false results in normal pH and Cl^- in all pHs.

Study Limitations

While conducting the research, study groups and time factor in taking blood gas samples before and after treatment were not taken into consideration.

Conclusion

As in the literature, this study revealed that blood gas analysis values were statistically unreliable in different pHs. For patients for whom an immediate decision must be made, this is a risk that can

Table 4. Distribution of electrolyte results in normal pH

Analysis	Minimum	Maximum	Mean	Standard deviation
pH	7.35	7.45	7.39	0.02
K^+ blood gas	2.16	6.62	4.01	0.51
K^+ biochemistry	2.10	6.70	3.94	0.53
Na^+ blood gas	116.70	164.70	137.50	4.24
Na^+ biochemistry	117.00	168.00	137.79	4.03
Cl^- blood gas	85.00	130.00	102.65	4.30
Cl^- biochemistry	88.00	133.00	104.46	4.24

Table 6. Distribution of electrolyte results in alkaline blood

Analysis	Minimum	Maximum	Mean	Standard deviation
pH	7.46	7.60	7.49	0.03
K^+ blood gas	1.95	5.40	3.73	0.50
K^+ biochemistry	1.90	5.60	3.69	0.56
Na^+ blood gas	114.10	150.60	136.31	5.20
Na^+ biochemistry	113.00	151.00	136.90	5.34
Cl^- blood gas	72.00	117.00	101.22	6.36
Cl^- biochemistry	72.00	118.00	102.58	6.45

Table 5. Comparison of the mean values of blood gas- biochemistry electrolyte results in normal pH (paired T-test)

	Mean Difference	*SD	*95% CI	*r	*p
K^+ blood gas-biochemistry	0.069	0.199	0.052/0.086	0.928	0.00000000000001
Na^+ blood gas-biochemistry	-0.294	2.779	-0.535/-0.054	0.775	0.016
Cl^- blood gas-biochemistry	-1.812	2.209	-2.003/-1.620	0.866	0.00000001

*SD: Standard deviation, r: Correlation coefficient, CI: Confidence interval, p: Statistical significance level (Paired T-test)

Table 7. Comparison of the mean values of blood gas- biochemistry electrolyte results in alkaline blood (paired T-test)

	Mean Difference	*SD	*95% CI	*r	*p
K^+ blood gas-biochemistry	0.041	0.257	-0.006/0.089	0.892	0.088
Na^+ blood gas-biochemistry	-0.586	2.863	-1.122/-0.050	0.853	0.032
Cl- blood gas-biochemistry	-1.366	1.859	-1.714/-1.017	0.958	0.000000000004

*SD: Standard deviation, r: Correlation coefficient, CI: Confidence interval, p: Statistical significance level (Paired T-test)

be taken. Blood gas electrolytes can be life-saving for critical patients, and they should be used in the initial treatment. However, we should also know that blood gas electrolyte results are not reliable. We should confirm blood gas electrolyte values with biochemistry results, EKG, and physical examination findings as soon as possible.

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