**Abstract:** Objective: Measurements of electrolyte levels made by blood gas analyzers or routine methods based on membrane and selective electrodes are expected similar performance characteristics that do not show significant differences. It is clinically important that those measurements should give equivalent results and confirm the closeness to the absolute value. In this study, it was aimed to compare sodium (Na), potassium (K), chlorine (Cl), hemoglobin (Hb) and hematocrit (Hct) values measured with blood gas analyzer and standard automatic devices in the laboratory (lab) from venous blood samples. Methods: A prospective, randomized study was conducted in simultaneous venous samples from antecubital regions of patients admitted to emergency department for various reasons, were analyzed for Na, K, Cl, Hb and Hct values on blood gas analyzer and standard automatic devices in the lab. The obtained data were compared statistically. Results: A total of 100 patients were included in the study. A statistically significant correlation was found between laboratory and venous blood gas (vbg) Na, K, Cl, Hb and Hct values (p<0.001). The average difference between them was -7.9 mEq/L (r=0.720) for Na, 0.5 mEq/L (r=0.785) for K, -5.1 mEq/L (r=0.790) for Cl, -0.14 grams/dL (r=0.757) for Hb and -% 1.54 (r=0.749) for Hct, respectively. Their correlation was formulated (Lab Na=vkg Nax0.621+46.081; Lab K=vkg Kx0.23+1.977; Lab Cl=vkg Clx0.847+11.050; Lab Hb=vkg Hbx0.583+5.015; Lab Hct=vkg Hctx0.565+15.024). Conclusion: In our study, it was detected that there is a statistically significant positive correlation between venous blood Na, K, Cl, Hb and Hct values of blood gas analyzer and standard automated devices in lab, and closeness of the desired performance is provided.

**Keywords:** Blood gas, sodium, potassium, chlorine, hemoglobin, hematocrit

**Özet:** Amaç: Kan gazı analiz cihazları ile veya membran ve seletif elektroda dayanın rutin metotlarla yapılan elekrolit düzeyleri ölçümünün önemli farklılık göstermemesi beklenen bir performans özelliği. Klinik açıdan bu ölçümlerin eşdeğer sonuc vermesi ve mutlak değere yakınlığının teyit edilmesi önemlidir. Bu çalışmada kan gazı analiz cihazı ve standart otomatik ölçüm cihazları ile ölçülen venöz kan örneklerinde sodyum (Na), potasyum (K), klor (Cl), hemoglobın (Hb) ve hematokrit (Htc) değerlerinin karşılaştırılması amaçlanmıştır.

Metod: Prospektif, randomize olarak çeşitli nedenlerle acil servise başvuran ve çalıştırılların dahil edilen hastaların an-
kübital bölgelerinden eş zamanlı olarak alınan venöz kan örneklerindeki Na, K, Cl, Hb ve Htc değerleri kan gazı analiz cihazı ve laboratuvarındaki standart otomatik cihazlarla ölçüldü. Elde edilen veriler istatistiksel olarak karşılaştırıldı. Bulgular: Çalışmaya toplam 100 hasta dahil edildi. Laboratuvar (lab) ile venöz kan gazı (vkg) Na, K, Cl, Hb ve Hct değerleri arasında istatistiksel olarak anlamlı ilişki saptandı (p<0.001). Aralarda ortalamalar farkı; Na için -7.9 mEq/L (r=0.720), K için 0.5 mEq/L (r=0.785), Cl için -5.1 mEq/L (r=0.790), Hb için -0.14 gram/dL (r=0.757), Htc için %1.54 (r=0.749) idi. Aralarda korelasyon formülize edildi (Lab Na=vkg Nax0.621+46.081; Lab K=vkg Kx0.23+1.977; Lab Cl=vkg Clx0.847 +11.050; Lab Hb=vkg Hbx0.583+5.015; Lab Htc=vkg Htctx0.565+15.024).

Sonuç: Çalışmamızda kan gazı analiz cihazı ve standart otomatik cihazlarla ölçülden venöz kan örneklerindeki Na, K, Cl, Hb ve Hct değerleri arasında istatistiksel olarak anlamlı derecede pozitif korelasyon olduğu ve istenen performans yakınısının sağlandığı saptanmıştır.

Anahtar Kelimeler: Kan gazı, sodyum, potasyum, klor, hemoglobin, hematokrit

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Introduction

Today, emergency departments are usually the first reference location in the hospital for patients with life-threatening diseases. In these patients, hemoglobin (Hb) and hematocrit (Hct) decreases due to bleeding caused by traumatic or non-traumatic causes, fluid-electrolyte and acid-base balance disorders are often seen [1]. Detection of these disorders in a short time is vital for the patient’s management and initiation of appropriate therapy.

Emergency physicians prefer bedside tests such as blood gas measurement, which provides quick results, in management of treatment. Arterial or venous blood gas measurement in critically ill patients is often used in the emergency departments. Most devices can also measure glucose, sodium (Na), potassium (K), calcium (Ca), chlorine (Cl), Hb and Hct values in addition to pH, pO2, pCO2 and HCO3 in blood gas samples. Arterial blood Na, K and Cl measurements with blood gas analyzer and standard automatic devices in the laboratory were reported to be compatible [2–5]. However, there is no comprehensive study in the literature comparing venous Na, K, Cl, Hb and Hct values and formulating the correlation between. In cases requiring immediate results, venous blood gas samples can also be taken in during blood sampling for laboratory work and obtaining results in a short time such as 5 minutes is an important advantage for the diagnosis and treatment of patients. Also it is clinically important that measurements of electrolyte and Hb levels made by blood gas analyzers or routine methods based on membrane and selective electrodes should give equivalent results and confirm the closeness to the absolute value.

In this study, it was aimed to compare venous Na, K, Cl, Hb and Hct values measured with blood gas analyzer and standard automatic devices in the laboratory.

Materials and Methods

After approval by the ethics committee, a prospective study was conducted in 100 patients admitted to Emergency Department of Antalya Training and Research Hospital because of various reasons between 01/10/2014 and 01/11/2014. Vascular access was made at antecubital regions of patients who consent. Simultaneous venous blood samples were obtained and Na, K, Cl, hemoglobin and hematocrit values were measured with blood gas analyzer and standard automatic devices in the laboratory. A synchronous samples or samples not reaching the laboratory simultaneously and samples from different vascular accesses were excluded from the study.

For venous blood gas analysis, 1 ml of venous blood was taken into a 2 ml syringe that was washed with sodium heparin immediately prior to sampling. Venous blood samples taken for biochemical tests were evacuated to standard tubes. As samples for blood gas analysis and biochemical tests are being studied in the emergency department laboratory, samples were sent to the laboratory with personnel without loss of time. Blood gas was studied in the laboratory without delay with Radiometer ABL-700 brand blood gas analyzer. Electrolytes (Na, K, Cl) and complete blood count from venous blood serum were simultaneously studied with Beckman coulter Au 680 and Beckman coulter LH 780 brand standard automatic devices in emergency laboratory. The results obtained were recorded and compared statistically.

Statistical analysis

SPSS 21 statistical software was used for statistical analysis. In statistical analysis; Kolmogorov-Smirnov analysis
was performed firstly to evaluate whether the distribution of values are normal or not. As a result of normality test; Pearson correlation analysis was performed for variables showing normal distribution (p>0.05; hemoglobin, hematocrit) and Spearman correlation analysis was performed for variables not showing normal distribution (p<0.05; sodium, potassium, chlorine). The estimation of laboratory blood sample values (measured by laboratory auto-analyzer) from venous blood gas sample values (measured by blood gas analyzer) were performed by using linear regression equations (Regression Equation \((y) = bx + a\) \((y\): venous blood gas values; \(x\): venous blood values; \(a\) and \(b\): constant coefficients), \(p<0.05\) was accepted as statistically significant. Compliance between laboratory and blood gas values was analyzed with Bland-Altman plot.

Results

A total of 100 patients were included in the study. Mean and standard deviation (SD) values of Hb, Hct and electrolyte measurements with blood gas analyzer and standard automatic devices are shown in Table 1. The mean difference between laboratory measurements and venous blood gas (Mean Difference (MD)) were found -7.9 mEq/L for Na, 0.5 mEq/L for K, -5.1 mEq/L for Cl, -0.14 g/dL for Hb and -1.54% for Hct. The results obtained in each test are collected in the area close to average and zero, as shown in Bland-Altman plot, and the values were found compatible with each other (Figures 1, 2, 3, 4, 5). The correlation coefficient was found \(r=0.720\) for Na, \(r=0.785\) for K, \(r=0.790\) for Cl, \(r=0.757\) for Hb and \(r=0.749\) for Hct, and \(p<0.001\) for all values.

As there is a significant positive correlation between laboratory and venous blood gas values and 95% confidence interval, formula were generated in order to calculate laboratory values from venous values (Table 2).

Discussion

For correct diagnosis and planning of management of critically ill patients in the emergency room, it is important that electrolytes and blood counts should result in a very short period. Normal lab results last an average of between 30–45 minutes. In some patients with life-threatening diseases, immediate diagnosis and treatment needs to be done. In several studies, arterial Na, K, Cl and glucose measurements with blood gas analyzer and standard laboratory equipment were reported to be compatible [2–5]. However, taking arterial blood samples to measure biochemical values can impair the patient’s comfort and cause additional complications. Lately, due to many advantages, use of venous blood gas rather than arterial blood gas in cases of metabolic and respiratory disorders has been raised [5–9].

Although difference between two measurements were

| Table 1: Mean and mean difference in blood values between laboratory and venous blood gas sampling with their 95% limits of agreement. |
| --- |
| **Laboratory** Mean±SD | **Venous blood gas** Mean±SD | **MD Mean±SD** | r | p | **Bland-Altman 95% limits of agreement** |
| Sodium 134.49±5.75 | 142.37±7.13 | -7.9±4.6 | 0.720 | <0.001 | -8.78 to -6.97 |
| Potassium 4.46±0.77 | 3.96±0.86 | 0.5±0.65 | 0.785 | <0.001 | 0.36 to 0.62 |
| Clor 100.70±5.9 | 105.8±5.96 | -5.1±3.18 | 0.790 | <0.001 | -5.73 to -4.47 |
| Hemoglobin 12.22±2.44 | 12.36±3.17 | -0.14±2.07 | 0.757 | <0.001 | -0.55 to 0.27 |
| Hematocrit 36.51±7.19 | 38.05±9.54 | -1.5±6.32 | 0.749 | <0.001 | -2.79 to -0.29 |

SD: Standard deviation; MD: Mean difference; r: Pearson correlation coefficient; p: probability of hypothesis.

| Table 2: The estimation of laboratory blood sample values (measured by laboratory auto-analyzer) from venous blood gas sample values (measured by blood gas analyzer) were performed by using linear regression equations. |
| --- |
| **Laboratory blood sample values** | **Regression Equation \((y) = bx + a\)** |
| Laboratory sodium (Na) | Venous blood gas \(Nax0.621+46.081\) |
| Laboratory potassium (K) | Venous blood gas \(Kx0.23+1.977\) |
| Laboratory clor (Cl) | Venous blood gas \(Clx0.847+11.050\) |
| Laboratory hemoglobin (Hb) | Venous blood gas \(Hbx0.583+5.015\) |
| Laboratory hematocrit (Hct) | Venous blood gas \(Hctx0.565+15.024\) |

\(y\): Venous blood gas values (dependent group); \(x\): Venous blood values (independent group); \(a\) and \(b\): Constant coefficients.
found in studies evaluating the correlation between arterial blood gas analysis and laboratory values, significant correlation was also found. When arterial blood gas and laboratory K and Na values were compared, Jain et al. reported the average difference between K values as 0.46 mmol/L (r=0.72) and statistically significant differences between Na values [1]. Budak et al. found Na difference as 4.9 mmol/L (r=0.90) and K difference as 0.25 (r=0.88) mmol/L [10]. In a study by Quinn and colleagues on critically ill patients, they reported that there is no significant difference between Na and K values in venous biochemistry and arterial blood gases within physiological limits, but results should be interpreted carefully if K value is >5 mmol and measurements should be verified with standard venous samples [3]. Arterial blood gases taken at different times and from different vessels may affect the results. Indeed, a difference of 1.77 mmol/L for Na and 0.19 mmol/L for K was found by King and colleagues in a study in which all sampling was done from arterial cannula [11].

In a study by Bloom et al. on comparison of electrolyte measurements in venous blood gas instead of arterial blood gas, the difference between Radiometer point-of-care (POC) analyzer and laboratory was found to be 3.36 mmol/L for Na, 0.46 mmol/L for K and -0.29 g/dl for Hb. Although negative bias was detected for Na and K, they have proposed to use it clinically [2]. In the study by Bozkurt et al. on venous blood gas, laboratory K values were found to be higher than venous blood gas K values in 97% of patients and the mean difference between the results was 0.56 mmol/l (r=0.882, p<0.001) [12]. In a study by Menchine et al. on diagnostic accuracy of electrolyte values of venous blood gases in diabetic ketoacidosis
in emergency department; venous blood gas and serum electrolyte values of a total of 342 matched patients were compared. 2meq/L (r=0.90) difference for sodium and 4.0 meq/L (r=0.73) difference for chlorine were found [9]. In our study, the differences were 7.9 mEq/L for Na, 0.5meq/L for K and 5.1 meq/L for Cl. However, 95% confidence interval was narrow in all and significant positive correlation was found between venous gas and laboratory values. The correlation coefficients were 0.720, 0.785 and 0.790 for Na, K and Cl, respectively.

Patients with active bleeding due to traumatic and non-traumatic causes are frequently encountered in the emergency department. It is necessary to regularly determine the need of these patients for blood transfusion with anemia severity and assess their metabolic status with given treatment. Quinn et al. reported a significant average difference of 0.91 g/dl (range: 0-4.3 g/dl) between arterial Hb values measured with blood gas analyzer versus standard automated devices in the lab [3]. In contrast, King et al. detected a 0.19 g/dl difference in Hb values from arterial cannula samples [11]. In a study by Bloom et al. on venous blood samples, it was reported that Hb values are compatible and an average of 0.29 g/dl difference is present [2]. In our study, the mean difference for Hb was 0.14 g/dL and 1.54% for Hct. Correlation coefficient values for Hb and Hct were calculated as 0.757 and 0.749, respectively. High correlation in our study may be due to simultaneously taken blood gas and laboratory sampling from the same intravenous route. This correlation for Hb and Hct can facilitate the clinician’s job in terms of following bleeding status and requirements for early blood replacement in patients with active bleeding.

In conclusion, it was detected that there is a statistically significant positive correlation between venous blood Na, K, Cl, Hb and Hct values of blood gas analyzer and standard automated devices in lab, and closeness of the desired performance is provided.

**Conflict of Interest:** The authors have no conflict of interest.

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