Effectiveness of the Stewart Method in the Evaluation of Blood Gas Parameters

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SUMMARY

Objectives

In 1981, Peter A. Stewart published a paper describing his concept for employing Strong Ion Difference. In this study we compared the HCO_3 levels and Anion Gap (AG) calculated using the classic method and the Stewart method.

Methods

Four hundred nine (409) arterial blood gases of 90 patients were collected retrospectively. Some were obtained from the same patients in different times and conditions. All blood samples were evaluated using the same device (ABL 800 Blood Gas Analyzer). HCO_3 level and AG were calculated using the Stewart method via the website AcidBase.org. HCO_3 levels, AG and strong ion difference (SID) were calculated using the Stewart method, incorporating the parameters of age, serum lactate, glucose, sodium, and pH, etc.

Results

According to classic method, the levels of HCO_3 and AG were 22.4±7.2 mEq/L and 20.1±4.1 mEq/L respectively. According to Stewart method, the levels of HCO_3 and AG were 22.6±7.4 and 19.9±4.5 mEq/L respectively.

Conclusions

There was strong correlation between the classic method and the Stewart method for calculating HCO_3 and AG. The Stewart method may be more effective in the evaluation of complex metabolic acidosis.

Key words: Blood gases; Stewart method.

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Introduction

Acid-based disorders are frequently seen problems in patients in the intensive care unit. Small changes in blood gases may cause life-threatening events. Therefore, it is essential that values such as pH, HCO_3 and PCO_2 are measured correctly. Although there are several methods currently available for the measurement of blood gas parameters, the basic bicarbonate method described by Henderson is often used.[1] However, in 1981, Peter Stewart published a new calculation method for acid-based disorders. In place of the bicarbonate-based traditional approach used in the diagnosis and treatment of acid-based disorders, Stewart defined several factors that affect H^+ ion concentration in biological solutions.[2] According to the Stewart method, there are three basic independent variables: the strong ion difference (SID) between the strong cation and anion total concentrations, the weak acid concentration, and the partial carbondioxide pressure (PCO_2). Until the 1990s, very little interest was shown in this method described by Stewart. More recently, several researchers have used this method, giving it a place in clinical applications.[3,4]

When looking changes in pH, the Stewart method allows for a more sensitive evaluation compared to traditional methods such as Henderson and Siggard, especially in patients with complex metabolic disorders. In cases caused by multiple factors such as complex metabolic disorders, electrolytes are potentially affected and therefore more information can be obtained with the use of the Stewart. The SID value is calculated with the equation, "*Na+K+Ca+Mg–Cl- Lactate – other strong ions*" The normal SID value is 38-42 mEq/L. A value below this interval indicates metabolic acidosis, and a value above indicates metabolic alkalosis. The Strong Ion Gap (SIG) is a parameter used in place of the Stewart Anion Gap. SIG is an indicator of abnormal ion presence in the plasma (Figure 1). Positive SIG shows the presence of metabolic acidosis. The most important weak acids in the plasma are proteins and phosphates. Of the plasma proteins, the most effective negative-loaded anion is albumin. Changes in the albumin level are of great importance in the calculation of the anion gap.[5]

This study examined arterial blood samples taken from patients undergoing treatment in the intensive care unit, and aimed to determine the consistency of results using the traditional and Stewart methods.

Material and Methods

Blood samples were examined from patients undergoing treatment in the intensive care unit for various diseases. This retrospective, cross-sectional study was conducted at Gülhane Military Medical Academy Intensive Care Unit between May 2010 and July 2010. The study included 409 blood gas samples, some of which were from the same patients on different days or during different disease states. The blood gas results in the study did not define the type or severity of metabolic disorder. The arterial blood gas samples were taken from the patients with an injector, washed with heparin, and transferred to the emergency biochemistry laboratory without delay. All the blood samples were measured with the same device (ABL 800 Blood Gas Analysis Device). Measurements were taken at 37°C. While pH and PCO_2 were measured directly, the Henderson-Hasselbach method was used to calculate HCO_3. The Siggard-Andersen formula was used to calculate base excess (HCO_3-24.4x[2.3XHbg+7.7] x[pH -7.4])x(1-0.023xHgb).[6] The equation ([Na]+[K])-([Cl] +[HCO_3]) was used for the calculation of the Anion Gap and [measured AG+0.25 X (normal albumin-measured albumin)] the corrected Anion Gap.[7]

The AcidBase.org website was used in the calculation of the blood gas parameters with the Stewart method. Age, gender and comorbidity status of the patient were recorded along with the pH, PCO_2, CL, base excess (BE), sodium and potassium. The values obtained from the emergency biochemistry laboratory for albumin, glucose, urea, lactate, calcium and magnesium were recorded on the same day. After inserting the data into the website, the HCO_3, anion gap, BE, chloride (corrected according to sodium), anion gap (calculated according to albumin), SID and SIG levels were calculated according to the Stewart method. The results were transferred to the computer.

In the study, the samples were also separated into 3 groups according to the sodium level (hyponatremia, hypernatremia and normonatremia). In each group, the chloride level was re-calculated according to the sodium level using the equation (*[Cl] corrected=[Cl] measuredx([Na] normal/[Na] measured*). The difference between the chloride level measured with the blood gas device and the corrected chloride level was examined in each group.

Statistical Analysis

The statistical analyses were applied using SPSS (version 13) software. Descriptive statistics (mean±SD, minimum, maximum) were calculated for the obtained data. Consistency between the results obtained with the blood gas device and the results with the Stewart method was evaluated using Intraclass Correlation Analysis (ICC). In addition, the direct relationship of the differences was examined with a simple regression model and Pearson correlation analysis. A value of $p<0.05$ was accepted as statistically significant.

Results

A total of 409 arterial blood gas samples were examined from 90 patients being treated in the intensive care unit.