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Effect of Different Heparin Volumes on Blood Gas Analysis

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Abstract

Background and Aim: Blood gas analysis is an important laboratory test for diagnosis and treatment of a variety of medical conditions in emergency rooms. Inaccurate sample collection is one of the reasons for errors in blood gas analysis. This study was conducted to evaluate different volumes of heparin in syringes and the effect of sample dilution on blood gas analysis as one of the main factors affecting the results of blood gas analysis.
Methods: One hundred children (4 months to 12 years) who presented to Loghman Hakim Hospital, Tehran, Iran, were enrolled in this study. Two samples were taken from each patient. For the first sample, the syringes were filled with heparin sodium and then emptied completely to achieve a very thin layer anticoagulant coating. For the second sample, the syringes were filled with 0.1 mL of liquid heparin sodium 5000 U/mL (5%). The blood gas parameters including pH, PO_2, PCO_2, HCO_3 and BE (base excess) were measured. Data were analyzed using SPSS version 18.
Results: All parameter had lower levels in second samples (0.1 mL heparin 5%) except for PO_2 compared to the first samples ($P < 0.001$).
Conclusion: This study found that a small amount of heparin in the syringe changed the result of blood gas analysis.

Keywords: Blood Gas Analysis; Heparin; pH; PCO_2; HCO_3.

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Introduction

Blood gas analysis is one of the most common tests for assessing the acid-base balance and oxygenation status of a patient (1, 2). Blood gas analysis has an important role in patient monitoring in Intensive Care Units (ICU), emergency departments, and in some disease in pediatrics such as gastroenteritis, respiratory distress, poisoning, sepsis, renal failure, cardiovascular disorders, diabetes, etc. (2-5) In fact, blood gas analysis should be considered as a gold standard test for diagnosis and treatment of some diseases (5, 6).
There is a standard method for blood gas analysis. Sample collection and pre-analytical errors may change the results of blood gas analysis. Therefore, some studies recommend each hospital should have a standard guideline for ABG (7-10).
The type of the syringe (plastic or glass), transport and storage status, air bubble contamination, blood volume, and anticoagulant concentration may cause errors in blood gas analysis (7, 11-13).
An anticoagulant is an important factor for ABG sampling. Although dried (lyophilized) heparin is available in plastic syringes and prevents PCO2 reduction, it is not available in low-income countries. Thus, in these countries, liquid heparin is frequently used for blood gas analysis (7, 14).
Some studies showed that an increased volume of liquid heparin decreased the levels of PCO_2, HCO_3, potassium, calcium, and magnesium and increased the levels of PO_2 and sodium. They suggested that the level of heparin should be less than 5% for prevention of erroneous results of ABG analysis (15, 16).

Chhapola and colleagues measured blood gases in various levels of heparin and found that syringes with lower levels of heparin were the best choice for evaluation of blood gas parameters. In fact, increased amounts of liquid heparin was the main cause of reduced PCO_2, HCO_3, and Na^+ (17).
Due to the common use of ABGs for the management of patients and pre-analytic errors, the aim of this study was to evaluate the effect of different volumes of heparin on ABG parameters in a large sample of pediatric patients.

Methods

Design and setting

This prospective self-controlled study was done from Jun 2018 to March 2018 in Loghman Hakim Hospital, Tehran, Iran. The study was approved by the Research Ethics Committee of Shahid Beheshti University of Medical Sciences (IR.SBMU.RETECH.REC.1397.264).

Sample size

The sample size included 100 children. Two VBG samples (1 mL per syringe) were obtained from each child. VBG sampling was selected because it is non-invasive and easier to perform.

Selection criteria

All stable children (4 months to 12 years old) who presented to the pediatrics emergency room were included in the study. Moreover, the pediatricians who ordered VBG for acid-base status assessment were enrolled in this study, too.
The children whose parents did not agree with their participation in this study were excluded from the study. There might be some problems in VBG sampling or storage process.

Data collection

In each child, a scalp vein set was used for peripheral venous sampling. Blood samples (1 mL) were collected in 2 mL sterile plastic syringes with an effective dead space of 0.1 ml. Two syringes were used for each child. One syringe was filled with heparin sodium (Caspian Pharmaceutical Co.) and then emptied completely to achieve a very thin layer of anticoagulant coating. The second syringe contained 0.1 mL liquid heparin sodium 5000 U/mL (5%). The syringes were filled with 1 milliliter of blood. Both syringes were sent to the hospital laboratory in less than 10 minutes and kept in an ice bag. The blood gases including pH, PO_2, PCO_2, HCO_3 and BE (base excess) were measured using the AVL Compact 3 blood gas analyzer (Roche Diagnostics, Austria). Demographic characteristics and VBG parameters (pH, HCO_3, PCO_2) were recorded in the questionnaire.

Statistical analysis

SPSS version 18 was used for data analysis. Descriptive statistics including mean, median, standard deviation, frequency and percentage were applied. Paired T test was administered to compare the mean values of quantitative variables after ensuring a normal data distribution. Chi-square test was used to compare qualitative variables.

Results

Of 100 children who participated in this study, 54 (54%) were male and 46 (46%) were female. The mean age of the participants was 3.8 ± 3 years. The main causes of hospitalization were methadone toxicity, epilepsy, and gastroenteritis.
The mean pH, PCO_2, PO_2, HCO_3 and base excess in both groups with different volumes of heparin are shown in Table 1. There was a significant difference in all parameters, and adding heparin 5% to the syringe reduced the levels of all parameters except PO_2.

Table 1. Mean VBG parameters and their standard deviations in two groups of blood samples with different volumes of heparin.

Blood gases	Sample coated with heparin	Sample with 5% heparin	P value
pH	7.4 ± 0.08	7.38 ± 0.09	< 0.001
PCO_2	36.7 ± 8.9	34.8 ± 9.1	< 0.001
PO_2	43 ± 8.02	47.1 ± 8.9	< 0.001
HCO_3	22.1 ± 5.8	20.2 ± 5.7	< 0.001
BE (Base Excess)	-1.3 ± 0.63	-4.3 ± 0.65	< 0.001

Discussion

Blood gas analysis is one of the most common paraclinical tests for diagnosing a wide range of diseases including respiratory and metabolic disorders. In addition, it is a crucial test for evaluation of treatment effectiveness. Despite the simplicity of this test, inattention to some details may affect the result of the test. Based on the low range of the results of this test, a slight change in the test results changes the diagnosis and the subsequent treatments, leading to inevitable damage. One of the effective factors in changing the results of a blood gas analysis is the volume of heparin in the syringe; however, there is still controversy about the effect of heparin on blood gas parameters (10, 18, 19).

Because of the unavailability of glass syringes, plastic syringes were used in this study. Although the use of glass syringes is recommended as stated in a study by Knowls, there will be no difference in the results of the test if the analysis is performed in less than 15 minutes (18, 20)**.** Although arterial blood remains the gold standard sample for blood gas analysis, considering the invasive nature and also the possible complications of arterial puncture, venous specimens were obtained in this study. Due to a very strong correlation between venous and arterial blood samples with respect to pH, HCO_3 and base excess, it seems the venous blood samples can substitute arterial blood specimens (20).

One of the main findings was that adding even heparin 5% to syringes can dilute the blood sample, which leads to decreased values of HCO_3, PCO_2, pH and BE and an increased PO_2 level.

Heparin is an anticoagulant with a group of anionic mucopolysaccharides known as glycosaminoglycan. Due to the presence of covalent bonds of sulfate and carboxylic acid groups, heparin is acidic; therefore, using more volumes of heparin decreases the pH of blood samples (21-23).

Although some previous studies found similar results, some studies reported different findings. Furthermore, few studies have been done in children, while this study was conducted in a large sample of children.

Higgins et al. found that high volumes of heparin affected blood electrolytes and gases like PO_2 and pH; they also reported that the magnitude of the changes increased with an increase in the amount of heparin (24, 25).

Contrary to the results of the present study, Wanda and colleagues found that heparin excess decreased blood pH, PO_2, and PCO_2 levels; therefore, further studies are required in this regard (26) .

Conclusion

The authors recommend that the physicians and nurses in the emergency room check the amount of heparin in syringes before ABG sampling. Since medical students are often responsible for obtaining ABG samples in teaching or governmental hospitals, it is important that they receive information on main points of ABG sampling and significance of pre-analytical errors and all medical institutions use practical guidelines for ABG sampling**.**

Conflict of Interest

The authors declare no conflicts of interest.

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