# Comparison of arterial blood gas results obtained using two types of Heparinized Syringes

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**ABSTRACT**

**Objective:** The objective of this study was to compare the arterial blood gas results obtained using syringes heparinized with liquid heparin and syringes containing lyophilized balanced heparin.

**Study Design:** Comparative cross sectional.

**Place and Duration:** This study was conducted in the Chemical Pathology department at Combined Military Hospital, Lahore for a period of six months from November 2022 to March 2023.

**Methodology:** A total of 100 arterial blood samples were taken from 50 patients admitted in ICU using a regular plastic syringe flushed with 5000 IU/ mL liquid heparin and another containing lyophilized heparin. Samples were analyzed immediately after collection on Roche Cobas b121 ABG analyzer. Three of the measured parameters (pH, pCO2 and pO2) were then compared among both syringe groups. pH, pO2 and pCO2 were compared using mean difference.

**Results:** The difference of means for pH was insignificant (p- Value >0.05). But pCO2 and pO2 showed significant difference in means with p- Values <0.05 (0.007 and 0.037, respectively). Bland Altman plots were also plotted for all three parameters. 12% of the pH values, 8% pco2 and 6% pO2 values exceeded the total allowable error.

**Conclusion:** Arterial blood pH was comparable between the two types of syringes used. The pCO2 and pO2 differed significantly and where found to be lower in blood samples collected in the liquid heparin syringes.

**Keywords:** Liquid Heparin, Lyophilized Heparin, Arterial Blood Gas, pH, pO2, pCO2.

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## INTRODUCTION

Arterial blood gas (BG) analysis is one of the most commonly employed laboratory investigation in hospital emergencies and ICU to provide quick metabolic and respiratory assessment[1]. It is useful for determining the tissue oxygenation in patients with shock, ventilation status of patients on ventilator support and acid- base status in patients of renal failure, sepsis and many metabolic disorders[2]. BG analysis mainly includes the measurement of blood pH, pO2 and pCO2 using electrochemical analyzers in the laboratory setting and sometimes as point of care set ups at the bedside. Other parameters like bicarbonate and base excess are usually derived from the pH and pCO2[3].

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Accuracy of the results obtained is very crucial because of its importance in making urgent and critical medical decisions for patients. Like all lab tests, ABG results can be affected by analytical, pre-analytical and post-analytical factors. But blood gases are particularly sensitive to a number of pre-analytical factors that contribute most significantly in causing an error[4]. Apart from physiological factors like ongoing cellular metabolism in the blood specimen, proper sample collection also plays a major role in affecting patient results[5]. Anticoagulation of the collected blood is an important aspect of sample collection in BG analysis[6]. It is recommended to use specialized plastic syringes containing lyophilized balanced heparin for collecting arterial blood samples[3].

Liquid heparin is not preferred because firstly, there is always a risk of improper anticoagulant and blood mixing. Secondly, too much liquid heparin can dilute out some analytes or affect pO2 results because the liquid heparin itself has dissolved atmospheric pO2[6,7]. Heparin being a negatively charged molecule in solution can bind some of the cations and affect electrolyte concentrations too. Balanced heparin is bound to positive ions like lithium to prevent heparin from binding to cations in the blood[8].

Despite the recommendations of using dry balanced heparin as an anticoagulant, most hospitals of Pakistan still use plastic syringes that are self-heparinized with liquid heparin for reasons of expense and availability of dry heparin syringes.

The objective of this study is to compare the blood gas results

obtained from samples collected in the liquid heparin plastic syringes and those collected in the recommended dry heparin syringes.

## METHODOLOGY

A comparison study was conducted in the Chemical Pathology department, Combined Military Hospital (CMH) Lahore during a study period of six month from November 2022 to March 2023. Permission to conduct the study was taken from the ethical review board of the hospital (Research Review Board No 421/2022). Non probability consecutive sampling technique was used for sample collection. A total of 100 samples were taken from 50 patients using both syringes under study. Sample size was calculated to compare means using OpenEpi, version 3 at 95% confidence interval. These were adult patients aged 18- 70 years who were admitted in the intensive care unit of the hospital requiring frequent blood gas analysis. Both males and females were included. No discrimination was done based on the medical diagnosis ventilator status of the patient. Patients without an arterial line were not included to avoid the discomfort and pain caused by multiple needle pricks.

Arterial blood sampling was done from arterial lines inserted in the radial artery. Liquid heparin (LH) syringes were prepared by flushing 5 mL plastic syringes with 5000 IU/mL liquid sodium heparin by aspirating a small amount and coating the inside of the syringe by pulling back the plunger and then expelling the heparin out, leaving only a small amount in the dead space of the syringe. Dry balanced heparin (BH) syringes were already coated with lyophilized heparin to bring the concentration of heparin to 50 units per mL of blood. The syringes were attached to the arterial lines and were allowed to fill till the 1 mL mark. They were immediately capped after collection and sample integrity was checked by inspecting the volume of blood collected, checking for the presence of air bubbles and ensuring proper mixing of blood and anticoagulant. Samples failing to meet these criteria were rejected and sampling was repeated. Patient details like age, gender and time of sampling were also noted.

The samples were transported immediately to the laboratory according to recommended guidelines and blood gas analysis was done on Roche Cobas b121 blood gas analyzer[8]. Analytical accuracy was ensured by automatic calibration at regular intervals and by running 8-hourly blood gas controls using three control levels. Results of pH, pO2 and pCO2 from all the samples were noted. The collected data of pH, pCO2 and pO2 values were compared statistically between the two syringe groups.

### Data Analysis

Data was analyzed using SPSS version 21.0. Mean pH, pO2 and pCO2 were calculated among both groups (LH and BH) shown in Table I. Mean difference and 95% Limits of agreement (LOA) were calculated for each parameter. T- test was further applied to compare the means keeping p- Value <0.05 as significant. Bland Altman plots were constructed for all three parameters by plotting the difference of measurements against mean values. Percentage of differences falling outside the Total Allowable error (TEa) was also calculated. TEa for pH is 3.9%, and 5.7% for pCO2.

## RESULTS

In this study, a total of 100 arterial blood samples were collected from 50 patients using two different syringes and divided into two groups, LH and BH. Measured blood gas parameters pH, pCO2 and pO2 were compared between both syringe groups. For comparison, mean difference, 95% LOA and percentage beyond Total allowable error (TEa) were used. Table 1 summarizes the results obtained from this study. The mean pH was comparable among the two syringes. The mean difference for pH between LH and BH was -0.007 and was insignificant (p- Value >0.05). For $pCO_2$, the mean difference was -5.21 and mean difference for $pO_2$ was -13.29. All three parameters were on the lower side in the LH group as indicated by the negative mean differences. The difference of means was significant for both pCO2 and pO2. Bland Altman plots were also constructed for each parameter as shown in Figures 1-3. The 95% LOA and sample outside the TEa were calculated for all three parameters. The proportion of values outside the TEa was 12% for pH, 8% for $pCO_2$ and 6% for $pO_2$.

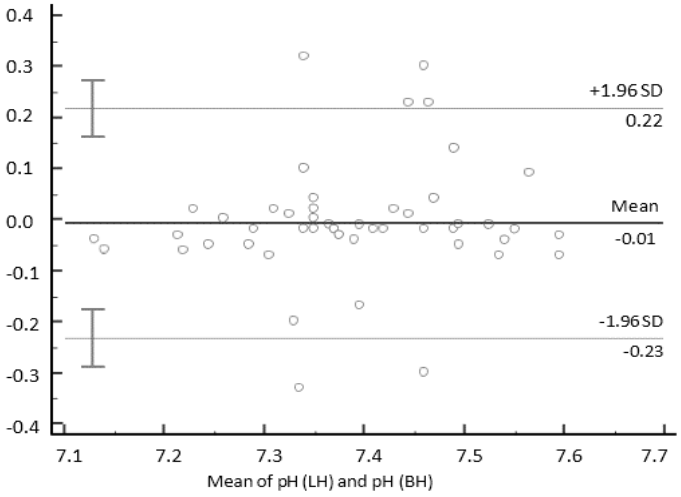


**Figure-1: Agreement between pH (Dry balanced heparin & Liquid heparin)**

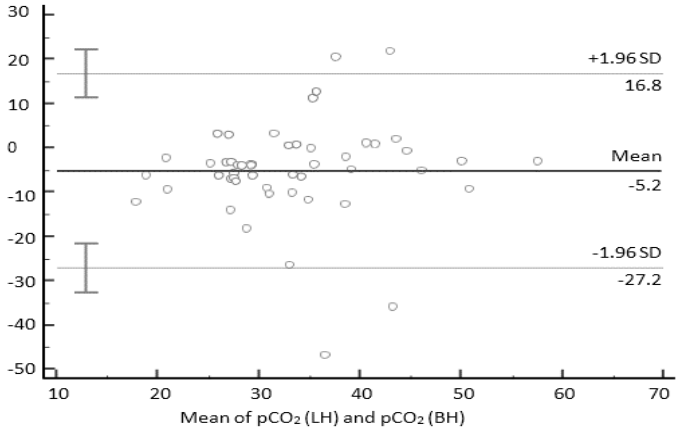


**Figure-2: Agreement between $pCO_2$ (mm Hg) (Dry balanced heparin & Liquid heparin)**

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**Table I: Comparison of Blood Gases (pH, pCO2 & pO2) between the conventional liquid heparin syringes and the recommended lyophilized heparin syringes**

| | Liquid Heparin (LH) | Dry Balanced Heparin (BH) | Mean Difference | P- Value (Ho:Mean=0) | 95% LOA | Proportion Beyond TEa |
|---|---|---|---|---|---|---|
| **n** | **50** | **50** | | | | |
| **pH** | 7.38 ± 7.11 | 7.39 ± 7.15 | -0.007 | 0.643 | -0.233 - 0.217 | 6/50=12% |
| **pCO2** | 30.86 ± 11.8 | 36.07 ± 22.10 | -5.21 | 0.001 | -27.17 - 16.75 | 4/50= 8% |
| **pO2** | 131.53 ± 76.3 | 144.83 ± 78.20 | -13.29 | 0.037 | -99.30 - 72.71 | 3/50= 6% |

**TEa:** Total allowable error
**LOA:** Limits of agreement

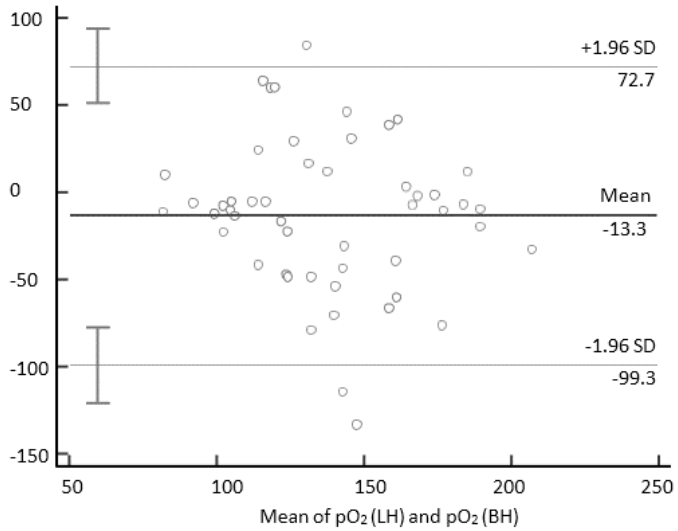


**Figure-3: Agreement between pO2 (mm Hg) (Dry balanced heparin & Liquid heparin)**

## DISCUSSION

Heparin is the most suitable anticoagulant for arterial blood gas analysis. By nature, it is a negatively charged molecule that enhances the proteolytic action of anti-thrombin III on thrombin and prevents clot formation[9]. The most commonly used form of heparin is liquid sodium heparin that is commercially available in vials of varying concentrations. On an average, the liquid heparin solution has an acidic pH of about 6.4 and dissolved O2 and CO2 of approximately in equilibrium with the atmospheric air (150 mm Hg pO2 and 07 mm Hg pCO2)[10]. Hence liquid heparin itself can alter the blood gases and pH of the collected blood, especially when mixed in inappropriate proportions. For these reasons, lyophilized heparin, balanced with lithium or zinc is the recommended form of heparin for arterial blood gas analysis. This study compared the blood gas results obtained using liquid heparin with those obtained with the recommended dry heparin syringes.

The results showed that pH was comparable among both types of syringes with very less mean difference. This was consistent with the findings of studies conducted by Chappola et al, Gholami et al and Shabani et al[11-13]. pH was observed to be the least affected parameter in these studies. This is probably due to the presence of efficient buffer mechanisms in blood that are able to resist any pH change caused by the acidic nature of heparin.

pO2 was significantly lower in the LH syringes when compared to BH syringes. The mean difference was significant between the two but percentage of samples outside the LOA was within the total allowable error.

Similarly, pCO2 differed significantly among both groups and like pO2, was decreased in the syringes flushed with liquid heparin. This negative difference observed in these parameters can be attributed to the diluting effect of liquid heparin, especially when mixed in inappropriate ratio. This effect was also seen in studies conducted by Gholami et al,Shabani et al and Chappola et al[11-13]. Dilution with excess heparin will cause a decrease in pCO2 as heparin itself has very low dissolved CO2. pO2 can rise or fall depending on the initial pO2 concentration of the blood compared to atmospheric air[14].

However, some studies differed in their findings. A study conducted by Sahu et al did not find any significant difference in any of the blood gas parameters under study[15]. Similarly, another study by Sezik et al also found no significant difference between the blood gas results obtained using liquid heparin or dry heparin[16]. This could have be possible because of efficient blood sampling, ensuring appropriate ratio of heparin and whole blood and efficient heparinization technique along with rapid analysis. Studies conducted by Borabadi et al and Shabani et al highlighted the importance of appropriate heparin concentration in minimizing the effects of liquid heparin on blood gas results[13-17]. Low concentration (1000 U/L) heparin caused less difference in results. Similarly, Gholami et al emphasized on the effect of heparin volume in the syringe as any residual amount of heparin would contribute to the dilutional changes in results[12].

Apart from respiratory parameters, electrolytes like sodium, potassium and calcium are also susceptible to changes due to heparin. Heparin being negatively charged tend to bind cations in blood leading to falsely low levels of cations like potassium and calcium[18-20].

Dry heparin syringes not only provide less biased blood gas and electrolyte results but are ergonomically designed to allow one hand operation, minimizing needle prick incidents and are less painful for the patient as well[21].

Although lyophilized heparin syringes have been recommended for blood gas analysis, self-prepared liquid syringes are still commonly used for ABG samples in many parts of the world mostly because it is more economical and easily available. ABG syringes with dry balanced heparin should be used where possible.

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## CONCLUSION

Arterial blood pH was comparable between the two types of syringes used. pCO2 and pO2 differed significantly and were found to be lower in blood samples collected in the liquid heparin syringes.

## AUTHOR'S CONTRIBUTION

**Mahmood A:** Acquisition of data for the work and Drafting the manuscript.
**Sattar A:** Conception and design of the work, revising it critically for important intellectual content, final approval.
**Shaheen S:** Conception and design of the work, revising it critically for important intellectual content.
**Ahmed S:** Analysis and interpretation of data
**Hafeez A:** Acquisition of data

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