DOI: 10.7860/NJLM/2024/67333.2853

Original Article

Biochemistry Section

Comparison of Liquid Sodium Heparin Syringe and Preheparinised Syringe for Sample Rejection in Arterial Blood Gas Analysis: A Cross-sectional Study

C SUMITHRA N UNNI[1], SREEJITH J KISHORE[2], PP SAJITHA KRISHNAN[3]

ABSTRACT

Introduction: In hospital settings, Arterial Blood Gas (ABG) analysis is a routine investigation. Many errors can arise in the process, with 70% of errors in ABG analysis occurring during the preanalytical phase. Liquid heparin is commonly used as an anticoagulant in sample collection devices for Blood Gas (BG) analysis; however, inadequate heparin concentration and improper mixing of blood samples after collection often lead to incorrect results. This can be prevented by using syringes preloaded with lyophilised heparin.

Aim: To monitor the prevalence of sample rejection collected by the device using liquid sodium heparin and calcium-balanced dried lithium heparin.

Materials and Methods: This cross-sectional study was conducted at the ABG laboratory, Department of Biochemistry, Amrita Institute of Medical Sciences and Research Centre, Amrita Viswavidyapeetham University, Kochi, Kerala, India over a 4-month period from December 2022 to March 2023. ABG samples collected using either of the techniques were included, while venous BG samples were excluded. The sample size was 10,957 for each of the two groups- Group A and Group B. Group A included samples collected using liquid sodium heparin, and group B included spray-dried, calcium-balanced lithium heparin from different departments. The incidence of blood clots, air bubbles, and inadequate volume was studied. For all categorical variables, the results were expressed as the frequency and percentage of errors. An unpaired t-test (two-tailed) was used for data analysis.

Results: In comparison with liquid sodium heparin collection, errors in the quality of the specimen such as blood clots (1.7% to 1.1%), air bubbles (0.04% to 0%), and inadequate volume (0.2% to 0.03%) were significantly reduced (p-value=0.002) with spray-dried, calcium-balanced lithium heparin (BD Preset™ Safety BG Syringe).

Conclusion: The present study found that using calcium-balanced lithium heparin syringes over manually flushed liquid sodium heparin syringes reduces the risk of clots, thus preventing equipment malfunction and maintenance costs. With the introduction of preset syringes, the chance of air bubbles and insufficient volume can also be overcomed.

Keywords: Air bubbles, Analyser breakdown, Blood clots, Insufficient volume

INTRODUCTION

Blood gas (BG) testing is frequently requested in hospital settings, playing a pivotal role in guiding immediate or urgent responses to patient conditions [1]. In the context of evidence-based medicine, accurate test results are paramount for sound diagnosis and treatment decisions. Unfortunately, the process of arterial BG analysis is susceptible to multiple errors, with approximately 70% of these errors stemming from the preanalytical phase [2]. Liquid Sodium heparin is the commonly used anticoagulant, and even with careful attention during specimen collection, inadequate concentration of heparin and improper mixing of blood samples after collection lead to blood clots, which are a reality. The compromised sample not only loses its utility but, if introduced into the instrument, may also render the machine non functional. In situations where this is the sole available instrument, such an occurrence has the potential to cause delays in obtaining results for all patients [3-5]. This can be prevented using syringes preloaded with lyophilised heparin [3,6]. Liquid sodium heparin can have various impacts on BG analysis, primarily attributed to its dilutional effect on plasma. This dilutional effect can lead to alterations in parameters like the partial pressure of arterial Carbon Dioxide (pCO_2) and electrolytes [7-9]. Additionally, the binding of liquid heparin to positive ions such as $Ca2^+$, Na^+, and K^+ may result in falsely low values for these ions [9]. Literature review shows multiple studies on ABG sampling, type of syringe, result accuracy [4,7,9-11]. However, data is scarce regarding preanalytical errors occurring with the usage of liquid sodium heparin syringes when compared with calcium balanced dried lithium heparin syringes. Hence, the purpose of the present study was to monitor the incidence of sample rejection due to blood clots, air bubbles, and inadequate volume in ABG samples collected by liquid sodium heparin and calcium balanced dried lithium heparin.

MATERIALS AND METHODS

A cross-sectional study was designed at the ABG laboratory, Department of Biochemistry, Amrita Institute of Medical Sciences and Research Centre, Amrita Viswavidyapeetham University, Kochi, Kerala, India over a study period of 4 months from December 2022 to March 2023. The study was reviewed and approved by the Institutional Ethics and Scientific Review Committee (ECASM/AIMS-2023-296). Written informed consent was obtained from participants.

Inclusion criteria: A total of 10,957 ABG specimens collected at various departments of the hospital and manually transported to the ABG laboratory were included.

Exclusion criteria: Venous Blood Gas (BG) samples were excluded.

Sample size calculation: The calculated sample size was 10,957 for each group A and B. Based on the proportion of clot formation in ABG blood samples in preheparinised syringes (5%) and in liquid sodium heparin syringes (25%) observed in a small pilot study, and

with 80% power and 95% confidence, the minimum sample size was determined to be 50 in each group, totalling 100 samples.

Study Procedure

Specimens collected at various departments of the hospital were manually transported to the ABG laboratory, where they were assessed for the quantity and quality of the specimen. All specimens were visually inspected to record the number of blood clots, air bubbles, and volume insufficiency. The data collected was transcribed into the data register at the end of each day by adequately trained technicians.

The ABG samples were collected using liquid sodium heparin (Group A: Sample collection by 5 mL Syringe flushed with liquid sodium heparin, 23G Needle) in some departments and spray-dried, calcium-balanced lithium heparin (Group B: BD Preset™ Safety BG Syringe 1 mL, 23G Needle) in other departments.

STATISTICAL ANALYSIS

Statistical analysis was conducted using International Business Machines (IBM) Statistical Package for Social Sciences software version 20.0 (SPSS Inc., Chicago, USA). For all categorical variables, the results were expressed as the frequency and percentage of errors. To test the statistical significance, an unpaired t-test (two-tailed) was utilised, and a p-value of <0.05 was considered statistically significant.

RESULTS

On comparison with liquid sodium heparin collection, specimen quality errors such as blood clots and air bubbles were significantly reduced (p-value=0.002) with spray-dried, calcium-balanced lithium heparin (BD Preset™ Safety BG Syringe). On comparison with liquid sodium heparin collection, specimen quantity errors like inadequate volume were also significantly reduced (p-value=0.002) with spray-dried, calcium-balanced lithium heparin (BD Preset™ Safety BG Syringe) [Table/Fig-1].

ABG samples		Liquid sodium heparin, N=10,957		Spray dried calcium balanced lithium heparin, N=10,957		% Reduction in error	p-value
		No. of errors	%	No. of errors	%		
Specimen quality	Blood clots	187	1.7%	124	1.1%	0.6%	0.002
	Air bubble	5	0.04%	0	0.0%	0.0 %	
Specimen quantity	Inadequate volume	27	0.2%	4	0.03%	0.2 %	0.002

[Table/Fig-1]: The impact of specimen collection methodology on the preanalytical errors in ABG samples.

DISCUSSION

The diagnosis and management of changes in respiratory and metabolic parameters in the body often involve an essential tool: ABG analysis. The accuracy of this diagnostic method hinges on several preanalytical steps, including precise sampling, appropriate syringe volume, proper sample quantity, specific type and quantity of heparin, as well as considerations like storage conditions, transport, and timing of analysis-all crucial for accurate result interpretation.

Despite its significance, the potential for preanalytical errors during blood sample collection can result in inaccurate BG values [1]. While the guidelines from the National Committee for Clinical and Laboratory Standards Institute (CLSI) in Wayne, Pennsylvania, United States recommend the utilisation of commercially prepared Dry Bound Heparin (DBH) syringes, which prevent dilution issues associated with dried heparin, it is noteworthy that self-prepared liquid sodium heparin syringes continue to be employed in numerous emergency and Intensive Care Units (ICUs) for BG analysis [7,8]. Many syringes have been studied from the aspects of the success rate of blood collection, associated patient pain, and other parameters [10-14]. The results have confirmed the disadvantages of regular syringes when compared with the clinical applicability of preheparinised syringes. However, limited by the sample size of those studies, there was no in-depth quantitative study on the incidence of air bubbles, microclots, and insufficient volume.

In the present study, 10,957 samples from each group were analysed simultaneously, which was more statistically representative. When arterial blood passes through a needle, slight platelet aggregation will be caused by the thin needle, leading to blood clots. The comparison of the blood clots from the samples collected using liquid sodium heparin and spray-dried calcium-balanced lithium heparin indicated a greater risk of blood clots with liquid sodium heparin. Blood samples with clots are prone to clog instrument tubes, leading to incorrect results during the analysis of BG and blood cells [6]. The clogging will not only greatly increase the instrument maintenance costs of the hospital but also compromise the normal function of the instrument, thus obviously affecting the daily work of the hospital and seriously delaying the diagnosis and treatment of patients.

The BG analysis plays a vital role in the diagnosis and treatment of critical patients [15], and any delay or error will lead to serious clinical consequences. The presence of small blood clots and coagulation not only leads to instrument failure but also affects the accuracy of results for haematocrit [16]. For a BD preset syringe, the accurate dose of heparin therein can produce a rapid and complete anticoagulation effect and eliminate the interference of sample dilution and anticoagulants with the ion detection results [17], ensuring the accuracy of test results. However, it is still necessary to fully mix the heparin with blood during blood collection to prevent blood coagulation. As for the BD preset syringes, the blood collection volume can be preset (recommended dose: 0.6 mL). Therefore, there is no need to pull the needle plug during blood collection. After the puncture, the arterial blood can automatically flow into the needle and fill the entire preset space, without creating any bubbles. The cap can be closed immediately, avoiding artificial exhaust, and reducing the risk of sharps injury [18].

Limitation(s)

In the present study, the prevalence of preanalytical errors was not compared in paired samples (i.e., two samples from the same patient with different methods of collection). Additionally the authors did not analyse whether there were any changes in the individual analytical parameters with the two methods.

CONCLUSION(S)

The current study has demonstrated that the prevalence of preanalytical challenges such as clots, air bubbles, and samples with insufficient volume were reduced with the usage of calcium-balanced lithium heparin syringes compared to manually flushed liquid sodium heparin syringes. Authors also observed that equipment maintenance and downtime were reduced with the decrease in clots. This improvement helped them to enhance the turnaround time and decrease the expenditure on instrument maintenance. With the introduction of BD preset syringes, the likelihood of air bubbles and insufficient volume can also be overcomed.

REFERENCES

[1] Baird G. Preanalytical considerations in blood gas analysis. Biochemia Med. 2013;23(1):19-27.
[2] Mahto HL, Sasikumar S. Blood gas sampling- Pre-analytical issues. Ind J Resp Care. 2017;6(1):758-61.
[3] D'Orazio P. Effects of blood clots on measurements of ph and blood gases in critical care analyzers. Point of care: The Journal of Near-Patient Testing & Technology. 2011;10(4):186-88.

[4] Chhapola V, Kumar S, Goyal P. Is liquid heparin comparable to dry balanced heparin for blood gas sampling in intensive care unit? Indian J Crit Care Med. 2014;18(1):14-20.
[5] Lippi G, Fontana R, Avanzini P, Sandei F, Ippolito L. Influence of spurious hemolysis on blood gas analysis. Clin Chem Lab Med. 2013;51(8):1651-54.
[6] Nigam PK. Correct blood sampling for blood gas analysis. J Clin Diagn Res. 2016;10(10): BL01-BL02.
[7] Higgins C. The use of heparin in preparing samples for blood-gas analysis. MLO Med Lab Obs. 2007;39(10):16-18. 20, quiz 22-23.
[8] National Committee for Clinical Laboratory Standards. Procedures for Collection of Arterial Blood Specimens; Approved Standard- Fourth Edition. NCCLS: Wayne, PA; 2004.
[9] Küme T, Sişman AR, Solak A, Tuğlu B, Cinkooğlu B, Coker C. The effects of different syringe volume, needle size and sample volume on blood gas analysis in syringes washed with heparin. Biochem Med (Zagreb). 2012;22(2):189-201.
[10] Meng C, Jin X. Comparison of the effects of ABG arterial preset syringe and plastic syringe in extracting arterial blood. Journal of Bengbu Medical College. 2010;35(10):1067-69. Available from: http://open.oriprobe.com/articles/25128983/abg_dong_mai_xue_qi_zhen_yu_su_liao_zhu_she_qi_cho.htm.
[11] Pan Y, Xie Y, Huang Y. Comparison of clinical effects of BD preset arterial syringe and common syringe in extracting arterial blood. Nursing Practice and Research. 2010;7(15):01-03. Available from: https://www.oriprobe.com/journals/c.html
[12] Zheng Q, Yang J. Comparison of BD preset arterial syringe and common glass syringe in extracting arterial blood. Clinical Medicine. 2008;28(6):86-87. Available from: https://www.oriprobe.com/journals/lcyx.html, https://www.oriprobe.com/journals/lcyx/2008_6.html
[13] Huang Q, Xu H, Cai Y. Comparison of BD arterial preset syringe and plastic syringe in extracting arterial blood. China Journal of Emergency Resuscitation and Disaster Medicine. 2007;2(4):219-21. Available from: http://caod.oriprobe.com/articles/12382654/Comparative_study_of_the_effects_of_BD_Vacutainer_and_plastic_syringe_.htm
[14] Zhang R. Discussion on the effect of ABC arterial preset syringe and syringe in extracting arterial blood. Journal of Heze Medical College. 2004;16(4):66-67. Available from: https://www.oriprobe.com/journals/hzyzxb.html
[15] Andrew M. A primer on arterial blood gas analysis. http://courses. washington.edu/med610/secure/print/ gprimer.prlf. Available from: https://courses.washington.edu/med610/abg/abg_primer.html
[16] Na Z. Collection of arterial blood gas fractions in the analysis of clinical care. Contemporary Medicine. 2010;16(9):106. Available from: https://dergipark.org.tr/en/pub/jcm
[17] Jin J, Chen S, Shentu Y. Effect of solid anticoagulant on arterial blood electrolytes. Chinese Journal of Nursing. 2006;41(7):646-47. Available from: https://www.oriprobe.com/journals/zhhlzz/2006_7.html, http://caod.oriprobe.com/order.htm?id=11213903&ftext=base
[18] Sahu MK, Yagani S, Singh D, Singh U, Singh SP, Choudhary SK. Comparing the liquid heparin syringe with dry bound heparin syringe for Blood Gas Analysis. Journal of Cardiac Critical Care TSS. 2020;3(02):59-67. Doi: 10.1055/s-0040-1709624.

PARTICULARS OF CONTRIBUTORS:
1. Associate Professor, Department of Biochemistry, Amrita Institute of Medical Sciences and Research Centre, Amrita Viswavidyapeetham University, Kochi, Kerala, India.
2. Assistant Professor, Department of Biochemistry, Amrita Institute of Medical Sciences and Research Centre, Amrita Viswavidyapeetham University, Kochi, Kerala, India.
3. Professor, Department of Biochemistry, Amrita Institute of Medical Sciences and Research Centre, Amrita Viswavidyapeetham University, Kochi, Kerala, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. C Sumithra N Unni,
Associate Professor, Department of Biochemistry, Amrita Institute of Medical Sciences and Research Centre, Amrita Viswavidyapeetham University, AIMS Ponekkara P.O, Kochi-682041, Kerala, India.
E-mail: sumithra.unni234@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Sep 12, 2023
- Manual Googling: Jan 19, 2024
- iThenticate Software: Feb 16, 2024 (7%)

ETYMOLOGY: Author Origin

EMENDATIONS: 8

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Sep 09, 2023**
Date of Peer Review: **Nov 18, 2023**
Date of Acceptance: **Feb 17, 2024**
Date of Publishing: **Jul 01, 2024**