DETECTION OF PREANALITICAL ERRORS IN BLOOD GAS ANALYSIS

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INTRODUCTION

- Blood gas analysis is an urgent and essential test used in the hospital setting to evaluate the oxygenation status and acid-base balance of the high-risk patients. For the follow up, serial blood gas analysis is needed for clinical decision and therapy.
- Analyzing with only a small amount of arterial blood and obtaining with a high risk procedure, the most of the preanalytically rejected samples are blood gas materials. Mostly are obtained from critically ill patients in the intensive care unit who are usually under air therapy.
- Common causes of these rejections are air bubble, insufficient volume, coagulated sample and delayed transport.
- Studying with a whole blood, delay in analysis can cause a decrease in blood oxygen, and increase in carbon dioxide because of the continuing cell metabolism (1,2).

1. Srisan P, Udomsri T, Jetanachai P, Lochindarat S, Kanjanapattanakul W. Effects of temperature and time delay on arterial blood gas and electrolyte measurements. *J Med Assoc Thai.* 2011;**94 Suppl 3**:S9–14.
2. Dent RG, Boniface DR, Fyffe J, Yousef Z. The effects of time delay and temperature on capillary blood gas measurements. *Respir Med.* 1999;**93**(11):794–7

INTRODUCTION

- Therefore, blood gas analysis is a test that needs to be studied in a short time interval for its preanalytical instability. So it's a POCT (Point of Care Testing).
- The plastic syringes are the main sample tubes used for blood gas testing instead of glass syringes for being more safer, cheaper, sterile and disposable.
- There is still no consensus about the samples that has to be rejected for the storage time, amount of air bubble, and storage temperature if have to be put on ice or not for these samples in plastic syringes.
- As there are many types of plastic syringes supplied by various manufacturers, the materials change likewise blood sample tube materials, so we aimed to investigate the plastic syringes in use both cooled or stored at room temperature, with or without air bubble inside.

MATERIALS AND METHODS

- Arterial blood samples were collected from 20 patients in the Intensive Care Unit (ICU) from their intraarterial catheter into the 2 ml heparinized (electroliquid balanced dry lithium heparin) plastic syringes (Ayset, Adana, Turkey) supplied by the manufacturer in an eight-month period. The analyzer used was Radiometer ABL800 Flex (Radiometer, Copenhagen, Denmark).
- A total of 10 plastic tubes of arterial blood was collected, 2 cc for each sample. Each tube was thoroughly mixed gently up and down before the analysis. The samples were carefully collected to avoid air bubbles and were checked for clots and hemolysis. Analyses were performed with the same analyzer in the ICU so there was no delay for the initial analyze and were studied by the same laboratory practitioner to avoid possible preanalytical errors. The blood gas analyzer calibrates itself automatically every 4 hours. The quality control was performed daily before analysis.
- All samples were analyzed for partial pressure of oxygen (pO_2), carbon dioxide (pCO_2), the oxygen saturation level of hemoglobin (saO_2), bicarbonate (HCO_3), and pH.
- Bicarbonate was calculated from Hendelson-Hasselbach equation by using pH and pCO_2 by blood gas analyzer.
- For the samples to check the interference effect of air bubbles, we pulled down the plunger to force the air bubbles inside the syringe and resulted as 0.5 cc air plus 2 cc blood .

- **Accordingly the samples were grouped as;**

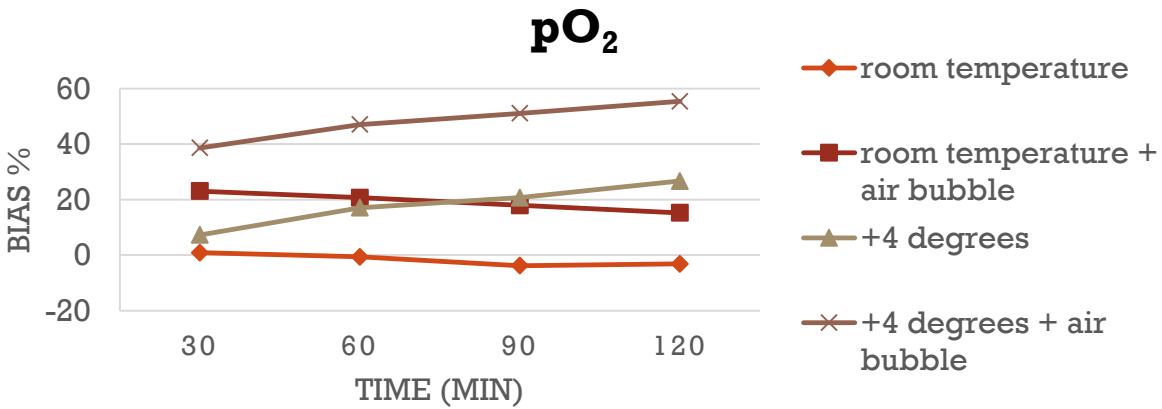
1. Sample: Baseline sample studied within 10 minutes and stored at +4°C in the refrigerator and studied in 30, 60, 90 and 120th minutes.
2. Sample: Stored at room temperature (22°C) and studied in 30, 60, 90 and 120th minutes.
3. Sample: 0.5 cc (25%) air bubble stored at room temperature (22°C) and studied in 30'.
4. Sample: 0.5 cc (25%) air bubble stored at room temperature (22°C) and studied in 60'.
5. Sample: 0.5 cc (25%) air bubble stored at room temperature (22°C) and studied in 90'.
6. Sample: 0.5 cc (25%) air bubble stored at room temperature (22°C) and studied in 120'.
7. Sample: 0.5 cc (25%) air bubble stored at +4°C in the refrigerator and studied in 30'.
8. Sample: 0.5 cc (25%) air bubble stored at +4°C in the refrigerator and studied in 60' .
9. Sample: 0.5 cc (25%) air bubble stored at +4°C in the refrigerator and studied in 90' .
10. Sample: 0.5 cc (25%) air bubble stored at +4°C in the refrigerator and studied in 120'.

Statistics

- Comparing each result with baseline, paired samples *t*-test or Wilcoxon signed rank test was used according to the distributions.
- A *p* value < 0.0125 was considered statistically significant according to the Bonferroni correction for multiple comparisons.
- Additionally, mean or median deviations from baseline value were calculated according to the formula:
- $[(C_X-C_B)/C_B] \times 100$
  - C_B: *Baseline value*
  - C_X: *The mean or median of the experimented sample.*
- The deviations calculated were compared with the desirable bias (DB) derived from biological variation by Ricos *et al*. (3)

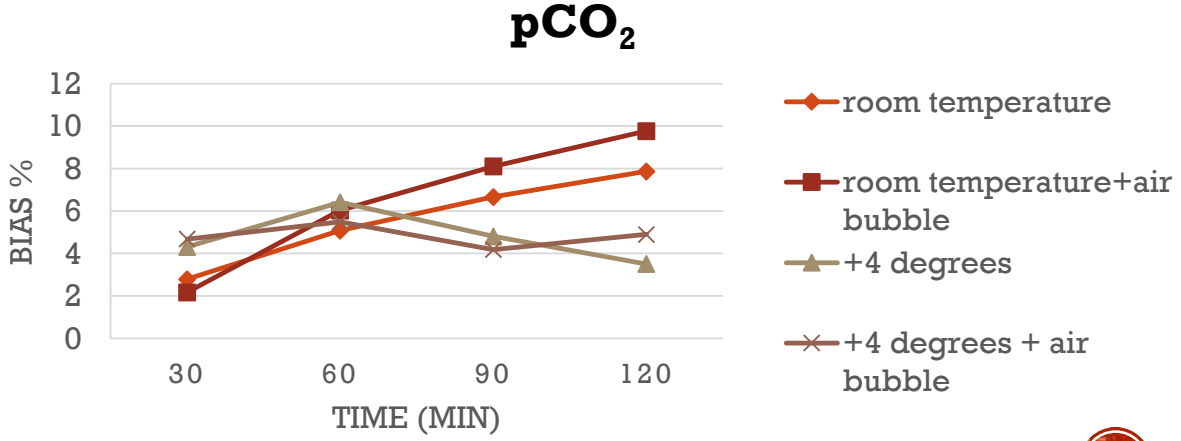
3. Ricos C, Alvarez V, Cava F, Garcia-Lario JV, Hernandez A, Jimenez CV, Minchinela J, Perich C, Simon M. "Current databases on biologic variation: pros, cons and progress." Scand J Clin Lab Invest 1999;59:491-500. updated in 2014.

RESULTS

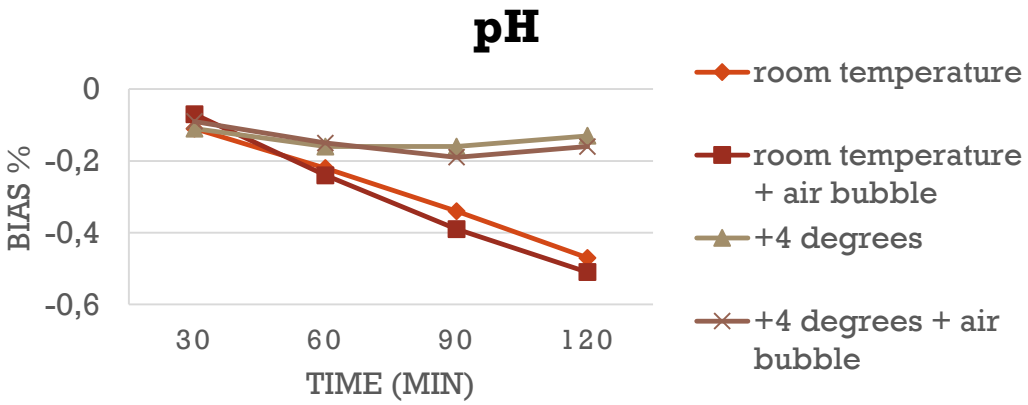


- As it is seen in the graph of pO_2, the bias is near zero up to 60 minutes at room temperature and decreased afterwards.
- pO_2 levels were unaffected at room temperature up to 60', but found as increased at 30' when cooled.

- PCO_2 results were increased significantly in all study groups.
- The biases are high enough to interfere clinically.
- Air bubble inside interfered pO_2 and pCO_2 at all time points.

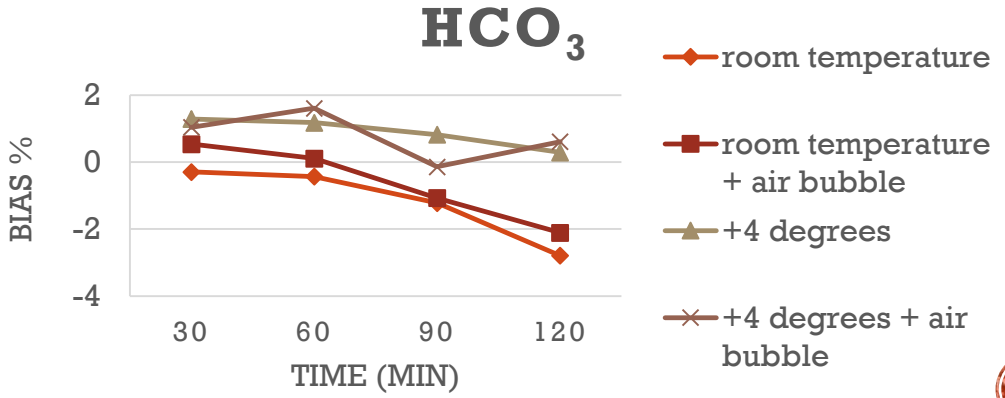


RESULTS

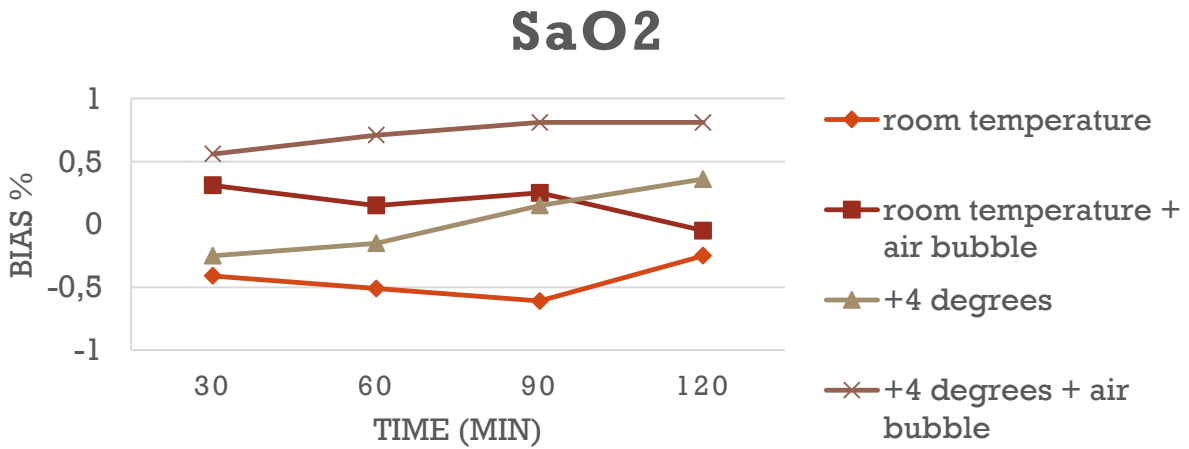


- pH levels' biases are very low and insignificant.

- HCO_3 was stable up to 90' at room temperature, with or without air bubbles, but stable up to 120 minutes when cooled with or without air bubbles.



RESULTS



- SaO_2 levels were affected less than 1% in all groups.

DISCUSSION

- Observed results in this study can be explained by the oxygen diffusion through the wall of plastic syringes when samples were cooled, however, it was found as stable up to 60' at room temperature.
- The aim of storing the blood gas samples on ice is to minimize the leukocyte metabolism and it is still the method of choice for the delayed analysis, however the cooling effect on blood oxygen doubles its solubility hence its fluctuation through the porous barriers(4). Glass syringes are superior to plastic ones due to its gas preservation capacity, especially for PaO_2, according to the published studies (5,6). The oxygen molecule itself is more vulnerable to diffuse across the plastic material because of the small size of the molecule (O_2) and because of the pore size and density of the plastic material (6).
- The size of the CO_2 molecule is higher than O_2 that the gas diffusion through the pore of both plastic and glass syringe wall material is uncommon (7). Therefore, for the delayed analysis, both plastic and glass syringes can be used interchangeably.
- The samples with air bubbles (0.5 cc air plus to 2 cc blood) did not show any significant bias for pH, SaO_2 during 2 hours and for HCO_3 up to 90 minutes.
- In conclusion, there is no need to cool the samples stored in plastic syringes for arterial blood gas analysis when analysis delayed up to one hour for pO_2 measurement.

4. Liss HP, Payne CJ. Stability of blood gases in ice and at room temperature. Chest. 1993;103(4):1120–2.
5. Knowles TP, Mullin RA, Hunter JA, Douce FH. Effects of syringe material, sample storage time, and temperature on blood gases and oxygen saturation in arterialized human blood samples. Respir Care. 2006;51(7):732–6.
6. Wiwanitkit V. Glass syringes are better than plastic for preserving arterial blood gas for oxygen partial pressure determination: an explanation based on nanomaterial composition. Int J Nanomedicine. 2006;1(2):223.
7.Mohammadhoseini E, Safavi E, Seifi S. Seifirad S,Firoozbakhsh S. Peiman S. Effect of Sample Storage Temperature and Time Delay on Blood Gases, Bicarbonate and pH in Human Arterial Blood Samples. Iran Red Crescent Med J. 2015 Mar 20;17(3):e13577