

Effects of post-sampling analysis time, type of blood samples and collection tubes on values of blood gas testing

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ABSTRACT

Aim To investigate effects of post-sampling analysis time, a type of blood samples and collection tubes on blood gas testing.

Methods This study included 100 patients at the Clinic for Pulmonary Diseases, Clinical Centre Sarajevo. The partial pressure of oxygen (pO₂) and carbon dioxide (pCO₂), and the oxygen saturation level of hemoglobin (sO₂) were analyzed in the arterial blood samples (ABS) and capillary blood samples (CBS) by a potentiometric method using a blood gas analyzer ABL 555 (Radiometer, Copenhagen, Denmark). Paired measurements of ABS were performed within 15 minutes and after 60 minutes from sampling and compared. The results of CBS obtained within 15 minutes were compared with matching ABS results, as well as the results obtained from CBS within 15 minutes taken into glass and plastic tubes.

Results pO₂ and sO₂ values were significantly lower after 60 minutes compared to those within 15 minutes in ABS (9.20±1.89 vs. 9.51±1.95 and 91.25±5.03 vs. 92.40±4.5; p<0.01, respectively). Values of pO₂ and sO₂ in CBS were significantly lower than values obtained in ABS (8.92±2.07 vs. 9.51±1.95 and 91.25±4.86 vs. 92.40±4.50; p<0.01, respectively). Obtained pO₂ and sO₂ values in CBS in the plastic tubes were higher than those in the glass tubes (8.50±1.98 vs. 7.89±2.0 and 89.66±11.04 vs. 88.23±11.22, p<0.01 respectively). pCO₂ blood values were not influenced significantly (p>0.05).

Conclusion The length of post-sampling analysis time, a type of blood samples and collection tubes have significant impact on blood oxygen parameters. Analysis within 15 minutes after blood sampling is considered as appropriate.

Key words: blood gas analysis, capillary tubing, syringes, glass, plastics.

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Original submission:

27 May 2015;

Revised submission:

06 July 2015;

Accepted:

08 July 2015.

INTRODUCTION

Blood gas testing is a common analysis in critically ill patients that provides important information for their treatment. It comprises an analysis of partial pressures of oxygen (pO_2) and carbon dioxide (pCO_2), blood pH and oxygen saturation level of haemoglobin (sO_2) in arterial, venous or capillary blood, depending on a clinical question. The interval between sampling and analysis, as well as a type of blood samples and collection tubes are important pre-analytical factors that can affect blood gas testing (1).

The gold standard samples for blood gas analysis are arterial blood samples (ABS) collected from arterial catheter or by arterial puncture. Properly arterial blood sampling is difficult and painful for the patient, but a clinician is able to get a true picture about oxygen supply. Venous blood sampling is less painful and risky, but venous blood samples are not an adequate replacement for ABS in routine blood gas testing (2). Capillary blood samples (CBS), least painful and easiest to obtain, from the fingertip, heel or earlobe, can also be used in routine practice (3,4). Obtaining CBS is less invasive and can be performed by various healthcare professionals, while arterial blood sampling requires specially trained medical personnel (5).

Proper time processing of blood samples is a critical pre-analytical step in the integrity of laboratory results because of continued metabolism in the blood that can alter blood gas values during the time between sampling and analysis or by diffusion of gases through the wall of the collection device (6,7).

A type of collection tubes can also affect blood gas analysis (8). While glass tubes were common collection devices in the past, today plastic devices are mainly used because of safety concerns (1).

The study aim was to investigate the effects of time interval between sampling and analysis, a type of blood samples and collection tubes on blood gas testing.

PATIENTS AND METHODS

The study included analysis of blood samples obtained from 100 hospitalized patients and outpatients at the Clinic for Pulmonary Diseases,

Clinical Centre University of Sarajevo during a six-month period in 2007. From 50 patients, two types of blood samples, arterial and capillary, were collected at the same time. Arterial blood samples were collected by arterial puncture of radial artery into the heparinized plastic syringes, while CBS were collected by skin puncture of fingertip into heparinized capillary plastic tubes. From other 50 patients, CBS were collected both in glass and plastic heparinized capillary tubes at the same time. Samples were thoroughly mixed with metal stirrer and magnet to obtain proper anticoagulation, and to avoid contamination by clots. Care was taken that no air entered the collection devices.

Arterial blood samples were analyzed within 15 minutes, and after 60 minutes from sampling. Capillary blood samples were analyzed within 15 minutes from sampling. Blood gas analyses of pO_2 , pCO_2 and sO_2 were performed at the room temperature. All determinations were performed at the Clinical Chemistry and Biochemistry, Clinical Centre University of Sarajevo by potentiometric method using a blood gas analyzer ABL 555 (Radiometer, Copenhagen, Denmark), according to the manufacturer's instructions. Tubes and syringes for blood sampling were purchased from Radiometer.

The research was done respecting ethical standards of the Declaration of Helsinki. Ethics approval was obtained from the Ethics Committee of School of Medicine, University of Sarajevo.

Variables are presented as a mean \pm standard deviation. Comparison of means between two groups was analyzed by the Student t-test for independent samples. The *paired-samples t-test* has been used to compare the means *between two* related *groups* on the same *continuous*, dependent *variable*. Values of $p < 0.05$ were considered as statistically significant.

RESULTS

One hundred arterial blood determinations from 50 patients were performed, e. g., 50 measurements for each of the two experimental conditions, within 15 minutes and after 60 minutes from sampling. Values of pO_2 and sO_2 in ABS after 60 minutes were significantly lower compared to those analyzed within 15 minutes ($p = 0.007$ and $p = 0.0001$, respectively), while no statistically si-

gnificant differences were found for pCO₂ values (p=0.17) (Table 1).

Table 1. Arterial blood gas testing during two post-sampling time points

Parameters	0-15 min	after 60 min	p
pO ₂ (kPa)	9.51±1.95	9.20 ± 1.89	0.007
sO ₂ (%)	92.40±4.5	91.25 ± 5.03	0.0001
pCO ₂ (kPa)	5.36± 1.99	5.77 ± 2.03	0.17

pO₂, partial pressure of oxygen; sO₂, oxygen saturation level of hemoglobin; pCO₂, partial pressure of carbon dioxide

Blood gas testing in CBS within 15 minutes from blood sampling were performed for the same patients in order to investigate the influence of a sample type on blood gas values. Results showed significantly lower values of pO₂ and sO₂ in CBS compared to ABS (p=0.009 and p=0.0001, respectively), while no statistically significant differences were found for pCO₂ values (p=0.348) (Table 2).

Table 2. Arterial and capillary blood gas testing within 15 minutes of post-sampling period

Parameters	ABS	CBS	p
pO ₂ (kPa)	9.51 ± 1.95	8.92 ± 2.07	0.009
sO ₂ (%)	92.40 ± 4.50	91.25 ± 4.86	0.0001
pCO ₂ (kPa)	5.36 ± 1.99	5.16 ± 1.02	0.348

ABS, arterial blood samples; CBS, capillary blood samples; pO₂, partial pressure of oxygen; sO₂, oxygen saturation level of hemoglobin; pCO₂, partial pressure of carbon dioxide

For other 50 patients, blood gas analyses of CBS in glass and plastic tubes were performed, also within 15 minutes, in order to investigate the impact of a type of sampling tubes on blood gas values. Results showed significantly higher values of pO₂ and sO₂ in CBS in the plastic tubes compared to CBS in the glass tubes (p=0.0001 and p=0.002, respectively), while no statistically significant differences were found for pCO₂ values (p=0.278) (Table 3).

Table 3. Capillary blood gas testing in different tube types

Parameters	Glass tube	Plastic tube	p
pO ₂ (kPa)	7.89 ± 2.0	8.50 ± 1.98	0.0001
sO ₂ (%)	88.23 ± 11.22	89.66 ± 11.04	0.002
pCO ₂ (kPa)	5.13 ± 1.36	5.00 ± 1.45	0.278

pO₂, partial pressure of oxygen; sO₂, oxygen saturation level of hemoglobin; pCO₂, partial pressure of carbon dioxides.

DISCUSSION

The results of our study showed that arterial blood gas testing were affected by the length of post-sampling time, but only pO₂ and sO₂ blood values showed statistically significant changes. Similar

to our findings, previous studies described the influence of time between sampling and analysis on blood gas values. Beaulieu at al. concluded that pO₂ in blood samples stored on ice, should be analyzed within 30 minutes compared to pCO₂ which showed no clinically significant changes within 60 minutes (7). Knowles at al. found significantly higher pO₂ values in the samples kept for 30 minutes compared to those analyzed immediately (8). Observed results can be explained by the oxygen diffusion through the wall of plastic syringes. Although insignificantly, Mohammadhoseini at al. showed that pO₂ values in ABS stored for 60 minutes at 22°C were lower compared with those analyzed immediately. They also found statistically significant higher values of pCO₂ in those samples but those changes were not clinically significant (9). Our study results are mainly consistent with the previous finding that post-sampling time significantly affects pO₂ and sO₂, so we have to analyze these parameters immediately, or as soon as possible. Statistically significant decrease of pO₂ and sO₂ that we found in ABS analyzed after 60 minutes at room temperature indicates that metabolic consumption of oxygen exceeds its diffusion through the wall of plastic syringes.

Values of pO₂ and sO₂ in CBS in our study were significantly lower in relation to those measured in ABS within 15 minutes. Statistically significant differences were not found for pCO₂ values. Zavorski et al. showed that fingertip blood sample analysis can predict arterial pCO₂, but not pO₂ and sO₂ (10). Murphy at al. found that agreement between measurements of arterial and capillary blood gases were good for pCO₂, but poor for pO₂ and that continuous pulse oximetry is more suitable for ensuring adequate and controlled oxygenation of the patient (11). Zavorsky et al. considered that CBS may be an appropriate replacement for ABS when analyzing pO₂, except residual standard error of 6 mmHg is required for precision, and that capillary pCO₂ accurately reflects arterial pCO₂ over a wide range of values (12). Lower values of pO₂ and sO₂ in CBS are expected due to the fact that capillary blood is a mixture of capillary, arteriolar and venial blood as well as interstitial and intracellular fluid. Values of pCO₂ have no significant differences in the ABS and CBS because of lower arteriovenous gradient (1).

Comparison of our findings for sO_2 and pO_2 values in CBS within 15 minutes from sampling, between samples in the glass and plastic tubes showed that values obtained in the plastic tubes were higher compared to those in the glass tubes ($p < 0.01$). Statistically significant differences were not found for pCO_2 blood values. The plastic containers for blood gas testing are partially gas permeable with increasing oxygen permeability at lower temperature (7,8,13,14). Our findings confirmed that pO_2 values in the plastic tubes at room temperature increase within 15 minutes, despite ongoing cellular metabolism which is dominant in the glass tube, because of the differences in gas partial pressures between blood and ambient. Historically implemented practice of keeping glass syringes on ice is not recommended for plastic syringes any more (1,9).

Finally, we conclude that getting an accurate result for blood gas testing, special attention should be devoted to many pre-analytical activities. The length of post-sampling analysis interval has significant impact on blood oxygen parameters. Although there is no doubt that blood samples should be analyzed as soon as possible, analysis within 15 minutes of blood sampling is also con-

sidered as appropriate. Even though the gold standard samples for blood gas testing are ABS, when the circumstances do not permit taking such samples, CBS can be taken as an alternative sample. On such occasions, pO_2 and sO_2 results should be taken with caution. For the patients requiring continuous monitoring of blood gases it is best to analyze ABS, but also it can be extremely beneficial to analyze CBS in combination with pulse oximetry. Since type of collection tubes also affect the oxygen parameters significantly, samples should be taken into glass tubes if we are not able to analyze it in appropriate time.

ACKNOWLEDGEMENT

The authors would like to thank Professor Hasan Žutić and all medical staff at the Clinic for Pulmonary Diseases and Clinical Chemistry and Biochemistry, Clinical Centre University of Sarajevo, who participated in the study.

FUNDING

No specific funding was received for this study.

TRANSPARENCY DECLARATIONS

Competing interests: none to declare.

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Učinak vremena proteklog od uzorkovanja do analize, vrste uzoraka krvi i cjevčica za uzorkovanje na analiziranje gasova u krvi

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SAŽETAK

Cilj Istražiti učinke vremena od uzorkovanja krvi do analiziranja, vrste uzoraka krvi i cjevčica za uzorkovanje na analiziranje gasova u krvi.

Metode Ispitivanje je uključivalo 100 pacijenata Klinike za plućne bolesti Kliničkog centra Univerziteta u Sarajevu. Parcijalni pritisak kiseonika (pO₂) i ugljen dioksida (pCO₂), te nivo saturacije hemoglobina kiseonikom (sO₂) analizirani su u arterijskim i kapilarnim uzorcima krvi potenciometrijskom metodom na analizatoru *ABL 555* (Radiometer, Kopenhagen, Danska). Upoređivana su uparena mjerenja uzoraka arterijske krvi izvođena unutar 15 minuta i nakon 60 minuta od uzorkovanja. Rezultati dobijeni iz kapilarnih uzoraka unutar 15 minuta upoređivani su s odgovarajućim rezultatima arterijskih uzoraka, kao i rezultati dobijeni iz kapilarnih uzoraka uzetih u roku 15 minuta u staklene i plastične cjevčice.

Rezultati Vrijednosti pO₂ i sO₂ nakon 60 minuta bile su signifikantno niže u poređenju s rezultatima dobijenim unutar 15 minuta u arterijskim uzorcima krvi (pO₂-9.20±1.89 vs. 9.51±1.95; sO₂-91.25±5.03 vs. 92.40±4.5; p<0.01). Vrijednosti pO₂ i sO₂ u kapilarnim uzorcima također su bile signifikantno niže od vrijednosti dobijenih iz arterijskih uzoraka (pO₂-8.92±2.07 vs. 9.51±1.95; sO₂-91.25±4.86 vs. 92.40±4.50; p<0.01). Dobijene vrijednosti pO₂ i sO₂ u kapilarnim uzorcima u plastičnim kapilarnim cjevčicama bile su veće od onih u staklenim cjevčicama (pO₂-8.50±1.98 vs. 7.89±2.0; sO₂-89.66±11.04 vs. 88.23±11.22, p<0.01). Utjecaj na vrijednosti pCO₂ u krvi nije bio signifikantan (p>0.05).

Zaključak Vrijeme od uzimanja uzorka krvi do analiziranja, vrsta uzoraka i cjevčica za uzorkovanje imaju signifikantan učinak na parametre kiseonika u krvi. Analiza unutar 15 minuta od uzorkovanja smatra se prihvatljivom.

Ključne riječi: analiza gasova u krvi, kapilarne cjevčice, šprica, staklo, plastika