Letter to the Editor

Is mixing of blood gas syringes after collection really necessary?

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Current guidelines and recommendations for blood gas analysis specify a number of procedures that must be followed for collecting diagnostic samples, specifically defined to ensure the overall quality of the testing procedure (1,2). Like any other area of laboratory testing, blood gas analysis is susceptible to a variety of preanalytical errors that can negatively impact the reliability of test results. Specifically for sample collection, it is usually recommended that the blood and the additive (usually heparin) present in the syringe should be gently mixed by rotating the syringe either manually or using a mechanical rotating device (1-3). Because there is no evidence that this practice is carefully followed by all health care workers responsible for blood collection, especially outside the laboratory boundaries where most blood gas analyzer are installed, we planned this study to investigate whether mixing the blood gas syringe immediately after collection would be really necessary.

Venous blood was collected from of 19 health care workers (12 women, 63%; age range, 24–61 years) working in the local medical laboratory at the University Hospital of Verona (Italy). One of the initial cohorts of 20 subjects was excluded due to a technical failure occurred while performing the blood gas analysis. A visible vein of the upper arm was punctured with a 21 gauge ×3/4" (0.8 mm × 20 mm) butterfly kit (Safety Blood Collection Set, CMC Medical Devices & Drugs, Malaga, Spain). Venous blood was first collected into an evacuated 3.5-mL lithium heparin blood tube (Vacutest Kima, Padova, Italy) to remove residual air in the tube, followed by manual blood collection with two consecutive 1.0-mL syringes containing 23 IU/mL dry lithium heparin (Syringe Arterial Blood Sampling Kit, Smiths Medical ASD IN, Minneapolis, MN, USA), filled at half their fill volume (i.e., 0.5 mL), as this is the typical filling volume of the syringes in clinical wards belonging to our healthcare facility. Both syringes were immediately capped, the first was gently mixed by rotation between the palms for 10 seconds to allow accurate mixing of additive and venous blood, whilst the second syringe was left unmixed until blood gas analysis.

Blood gas analysis was performed immediately after collection, using the same analyzer and test cartridge (GEM Premier 5000, Instrumentation Laboratory, Monza, Italy). In our study, the following parameters were analyzed: pH, partial pressure of carbon dioxide (pCO_2), partial pressure of oxygen (pO_2), oxygen saturation (sO_2), sodium, potassium, chloride, ionized calcium (iCa^{2+}), glucose (Glu), lactate (Lac), hematocrit (Hct), total hemoglobin (tHb), carboxyhemoglobin (COHb), and methemoglobin (MetHb). Test results were expressed as mean and standard deviation (SD), using the results obtained with the mixed syringe as the reference. A significant bias was defined as that exceeding the limits of the performance specifications reported in the study by Kuster *et al.* (4) for parameters showing a statistically significant variation (*Table 1*). All subjects provide a written informed consent for participating to this study, which was conducted according to the Declaration of Helsinki (as revised in 2013) and was approved by the Ethical Committee of the University Hospital of Verona (970CESC; July 20, 2016).

The main results of this study are summarized in *Table 1*. No statistically significant differences could be observed for any of the parameters tested, except Glu (1.0% decrease) and Lac (2.8% increase). However, the bias of both these analytes failed to exceed the limits of performance

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Table 1 Effects of mixing or not 1.0-mL lithium-heparin syringes immediately after collection

Analyte	Performance specification	Syringe mixed	Syringe unmixed		
		Value	Value	P*	Bias (95% CI)*
pH	±1.5%	7.37±0.02	7.37±0.03	0.280	–
pCO_2 (mmHg)	±2.4%	47.8±5.0	47.4±5.3	0.124	–
pO_2 (mmHg)	±1.5%	30.8±11.8	31.4±11.9	0.218	–
sO_2 (%)	±1.5%	46.7±21.0	47.7±20.4	0.262	–
Sodium (mmol/L)	±0.3%	136.5±1.4	136.6±1.3	0.363	–
Potassium (mmol/L)	±2.3%	4.2±0.3	4.3±0.4	0.325	–
Chloride (mmol/L)	±0.6%	102.2±1.7	102.5±2.1	0.184	–
iCa^{2+} (mmol/L)	±0.9%	1.3±0.1	1.2±0.1	0.248	–
Glu (mmol/L)	±2.8%	5.19±0.40	5.14±0.40	0.014	–1.0% (–2.0% to –0.1%)
Lac (mmol/L)	±13.6%	1.07±0.24	1.11±0.27	0.025	2.8% (0.0% to 6.2%)
Hct	±1.4%	44.7±4.6	44.5±5.0	0.399	–
tHb (g/L)	±1.4%	145.1±14.6	145.4±16.5	0.445	–
COHb (%)	±7.5%	0.9±1.1	0.9±1.1	0.444	–
MetHb (%)	±11.3%	0.6±0.2	0.6±0.2	0.415	–

Results are shown as mean ± SD, or mean and 95% CI, when appropriate. *, compared to the reference mixed syringe. 95% CI, 95% confidence interval; pCO_2, partial pressure of carbon dioxide; pO_2, partial oxygen pressure; sO_2, oxygen saturation; iCa^{2+}, ionized calcium; Glu, glucose; Lac, lactate; Hct, hematocrit; tHb, total hemoglobin; COHb, carboxyhemoglobin; MetHb, methemoglobin; SD, standard deviation.

specifications reported in the study by Kuster *et al.* (4) (i.e., ±2.8% and ±13.6%, respectively).

Under the specific experimental conditions of this study (i.e., collection of venous blood so as not to injure the patient with an arterial puncture, half-filled syringes as these are common in our institution, blood gas analysis performed immediately after drawing blood), our results indicate that avoidance to immediately mix the blood gas syringe after collection does not appear to be a cause of clinically significant bias in blood gas analysis. We could only observe a modest variation of Glu and Lac, showing an opposite trend. This is probably due to initial Glu consumption by blood cells in the unmixed sample, which is accompanied by generation of Lac. Thus, further studies would be needed to assess whether leaving blood gas syringes unmixed for longer time may cause a more evident bias.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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