Letter to the Editor

Eva Rabing Brix Petersen*, Morten Pedersen, Helle Tanderup Kristensen, Lise Pedersen, Marianne Benn, Ole Winther Rasmussen and Ivan Brandslund

Concerning quality demands of arterial partial pressure of oxygen

https://doi.org/10.1515/cllm-2023-1022
Received September 12, 2023; accepted September 12, 2023; published online September 21, 2023

Keywords: quality demands; arterial partial pressure of oxygen; bias; CV%; pO2

To the Editor,

Searching the literature for quality demands or biological variation for arterial partial pressure of oxygen (pO2), we found no criteria that could be used for defining the necessary limits for neither bias nor Coefficient of Variation (CV%) of pO2.

Usually, according to the Stockholm criteria of 1999 and further revised in Milan 2014 [1, 2], the criteria should preferably be based on medical needs according to application, or if that cannot be done, according to intra- and interindividual variation.

When we constructed the Tempus600 system [3] and later documented the effect on biochemical parameters by transporting sample tubes through the system, we experienced an unacceptable effect on true values on especially O2-related parameters [4].

As no data is yet available through the Westgard: (Ricos et al.) or EFLMs databases on Coefficient of Variations and biological variation of pO2, we discussed with our clinicians how they use the pO2 in clinical application. Based on these clinical judgements and through the known information on the normal ranges, we defined the precondition for our considerations for pO2 quality specifications in arterial blood as follows:

1. The normal reference range is 11–14 kPa
2. An acceptable value in an emergency patient is down to 10 kPa
3. The definition of respiratory failure is a value below 8 kPa
4. A life-threatening value is 5 kPa

According to the clinician’s decision limits for acting on changes in pO2, the following could be deduced:

5. It is clinically relevant to detect a decrease from 10 to 9 kPa and from 9 to 8 kPa
6. It is clinically necessary to detect a decrease of 0.5 kPa at the level of 5 kPa
7. An acceptable total error at a level of 5 kPa is required

We assumed that in such situations the biological variation is unimportant, as the actual value is what determines the patient’s situation and the clinician’s corrective medical interventions. Therefore, at these critical values it is important to establish as accurately as possible the value, but also to detect an improvement or deterioration over time.

Consequently, the considerations on acceptable variation comprise both sampling, other pre-analytical and transport sources of variation, and the analytical variation itself. The measurement should thus be capable of detecting a change in pO2 from 10 to 9 kPa with at least a 95 % certainty.

In evaluating this decrease, the bias is of no importance if measured on the same instrument and thus, the critical difference mandatory to be able to detect with 95 % certainty is 1 kPa. Using analysis of variance, the difference should be

*Corresponding author: Eva Rabing Brix Petersen, Department of Biochemistry and Immunology, Lillebaelt Hospital, Beriderbakken 4, 7100 Vejle, Denmark, E-mail: eva.rabing.brix.petersen@rsyd.dk

Morten Pedersen, DEKS, Rigshospitalet, Copenhagen University Hospital, Glostrup, Denmark

Helle Tanderup Kristensen, Department of Clinical Biochemistry, Regionshospitalet Gødstrup, Herning, Denmark

Lise Pedersen, Department of Clinical Biochemistry, Holbæk Hospital, Holbæk, Denmark

Marianne Benn, Department of Clinical Biochemistry, Copenhagen University Hospital – Rigshospitalet, København Ø, Denmark; and Faculty of Health and Medical Sciences, University of Copenhagen, København, Denmark

Ole Winther Rasmussen, Department of Internal Medicine, Lillebaelt Hospital, Vejle, Denmark

Ivan Brandslund, Department of Biochemistry and Immunology, Lillebaelt Hospital, Vejle, Denmark; and Department of Regional Health Research, Faculty of Health Sciences, University of Southern Denmark, Odense, Denmark
within 2.77 times the total analytical and pre-analytical variation. This means that pre- and analytical variation of 0.36 kPa (1 SD) will fulfill this. At the pO2 level of 9 kPa, this is $0.36 \times 100/9 = 4\%$ corresponding to 4 %.

The maximal total analytical and pre-analytical variation are thus defined to be less than 4 %.

This defined minimum quality criteria for the pO2 measurement will consequently also enable a measurement of a decrease from 8 to 5 kPa with a certainty of above 99 %, fulfilling the ability to detect this life-threatening value.

For the absolute measurement of the value 5 kPa with a total error of <0.5 kPa giving the clinician’s limit for acting (Bullet 6: It is clinical necessary to detect a decrease of 0.5 kPa at the level of 5 kPa), the bias plus 1.65 times the total analytical variation should not exceed 0.5 kPa.

(Bullet 7: An acceptable total error at a level of 5 kPa is required).

This can be achieved with a maximal bias of 0.2 kPa and a total coefficient of variation of 4 % ($0.2 + 1.65 \times 4\%$ of 5.0 = 0.2) ~ 0.5). For the absolute measurement of a value, this means that the total coefficient of variation of sampling, transport, other pre-analytical sources, and the analytical uncertainty should be below 0.36 kPa at level 9 kPa and below 4 % through the range from 1 to 14 kPa.

This means that at 5 kPa, a significant change of 2.77 x 4 % of 5 kPa = 2.77 x 0.2 = 0.55 kPa is detectable, largely fulfilling the clinical needs for the application.

If these criteria of maximum bias of 0.2 kPa and a total coefficient of variation below 4 % are fulfilled, the quality specifications are satisfactory for all applications for arterial blood measurements of oxygen tension.

For the measurement of venous values, at least the same specifications are required.

In conclusion, we suggest that the quality demands for arterial partial pressure of oxygen are:

- **Bias** < 0.2 kPa
- **CV** < 4 %
- **TE** < 0.5 kPa at a level below 5 kPa and TE < 0.6 kPa at a level above 5 kPa

TE < 0.2 + (1.65 x 4 % of the actual level).

We have implemented these quality demands in our laboratories until more detailed scientifically based data are available.

The calculations and resulting specifications have been distributed to members of the Nordic lab Network CCL (Laboratory medicine in Nordic countries) for criticism, and remarks from Anders Kallner were subsequently incorporated.

**Research ethics:** Not applicable.

**Informed consent:** Not applicable.

**Author contributions:** The authors have accepted responsibility for the entire content of this manuscript and approved its submission.

**Competing interests:** The authors state no conflict of interest.

**Research funding:** None declared.

**Data availability:** Not applicable.

**References**