

Letters

RE: A. Belboul, MD's article "The Effect of Hyperoxia During Cardiopulmonary Bypass on Blood Cell Rheology and Postoperative Morbidity Associated with Cardiac Surgery" (*J Extra-Corp Tech*, 1991; 23: 43-48).

Dear Dr. Belboul,

I read with great interest your article "The Effect of Hyperoxia During Cardiopulmonary Bypass on Blood Cell Rheology and Postoperative Morbidity Associated with Cardiac Surgery" in the *Journal of Extra-Corporeal Technology*, Volume 23, No. 2. Your findings could have a tremendous impact on perfusion techniques and therefore I have a few questions.

In your paper you had two groups of patients, one L-PO₂ with PaO₂ levels between 75 and 112 mmHg and one H-PaO₂ with levels between 190 and 300 mmHg. What determining factors led you to choose these specific numbers? What results have you observed in patients who have a PaO₂ between 112 mmHg and 190 mmHg? What do you recommend as to the upper limits for PaO₂ at various temperatures? Did you employ alpha-stat or pH-stat for your blood gas management? Did you monitor venous saturations in the two groups? If you did monitor venous saturations, did you accept lower venous saturations in the L-PO₂ group? Did you notice any increased frequency of metabolic acidosis in either group? Were the patients' respective PaO₂ levels maintained within their assigned range pre-CPB and post-CPB or only during CPB?

Arterial filtration was not employed in your study. Is there a possibility that incorporation of such a device might have reduced the morbidity observed in these patients due to removal of particulate matter?

Thank you for a very thought-provoking article. I feel it would be very interesting to see an expanded version of this study with incorporation of arterial filtration.

Sincerely,
Mary Winkler, RN, CCP
Cardiovascular Perfusion Inc.
San Diego, California

RE: Response from Dr. Belboul

Dear Editor,

Thank you for your letter, and I'm glad that this topic has stimulated further discussion. We are sorry for this apparent delay, as it took some time to reach a consensus from all the authors as to the content of this reply.

Answering Ms. Winkler's questions:

1. These groups were empirically determined. The L-PO₂ range was kept closer to physiological levels, and, in contrast, the H-PO₂ range was maintained as hyperoxic as clinically permissible to avoid the overlapping in the middle range of 112-190 mmHg. Patients between PaO₂ of 112 and 190 mmHg were not designed in this study. However, the L-PO₂ and H-PO₂ patients sometimes went into this range unavoidably but were quickly corrected. This was troublesome mainly in the initial 10 minutes and during rewarming where approximately 20% of the values tended to be in this range. Thus, we avoided too much overlapping of PaO₂ values in this range, making it feasible to do this study and compare the two groups.
2. Since the PaO₂ range of 112-90 mmHg was not specifically designed into the study, no exact data is available from this study. However, in clinical practice, we have collected preliminary data from 346 patients where a membrane oxygenator was used and the mean PaO₂ was maintained in this range. The results tend to show similar findings as in the H-PO₂ group as regards blood cell rheology, arrhythmias, bleeding and use of blood products. This suggests strongly that even keeping the oxygenation at this level may have potential toxic effects.
3. As regards temperature and PaO₂, we believe that an upper limit of 150 mmHg need not be exceeded for any temperature, and that PaO₂ can vary safely between 75 and 150 mmHg for most procedures.
4. We have used the alpha-stat for blood gas monitoring since 1985. The venous saturation was not studied and is not routinely used in our clinic. During our pilot studies we were worried about metabolic acidosis due to lack of adequate oxygen delivery with the L-PO₂ level of oxygenation but we did not find any such metabolic changes when compared to prevailing routine techniques.
5. The PaO₂ before and after CPB was not kept within their assigned ranges. This was planned in order to avoid postop-

eratively any bias in the clinical staff in treating the patients and following their routines without knowing what PaO₂ group the patient was assigned to. This step was added to give credibility to the observation on postoperative organ dysfunction and morbidity.

6. Since a membrane oxygenator and the avoidance of a bubble oxygenator is associated with fewer gaseous microemboli, the use of an arterial filter for this purpose is questionable. However, aggregates of blood cells or other debris might be filtered and help preserve organ function. In our experience the aggregation properties of blood cells as assessed by filterability studies showed that this is at its peak on the first or second postoperative day (1). However, a study with an arterial filter and with defined ranges of PaO₂ should be performed to define the usefulness of the filter. In such a study, the quantification of bubbles with a detector would be required. Taking the discussion further, one would have to define organ damage or dysfunction due to microbubbles by excluding or minimizing other factors, for example, free radicals, cytokines, leukotrienes, thromboxane, plasmin, etc. Most of these problems might be overcome by homogenizing the study material (age, sex, diagnosis, extent of disease, etc.) and by making it large enough to reduce the variations caused by the above biological variables and by well designed research techniques.

In this study, apart from the perfusionist, the other operation personnel (surgeon, anesthetic staff and other clinical staff) were blinded to the two groups. A tertiary blinded technique was added by keeping the laboratory staff from knowing the groups.

We assumed that biological variables would be equally distributed so as to overcome their interference. Furthermore, and although unproven, we assumed that blood cell rheology would reflect the biological responses of a high PaO₂, including the usual biological variables mentioned previously. Thus, in future studies the effect of PaO₂ on these variables is also an essential one and our preliminary data suggests that complement activation is lower when PaO₂ is nearer physiological ranges (Bergman, unpublished data).

It would appear that in ECC techniques the patho-physiological and metabolic responses using a more physiological PaO₂ range would appear to open a new challenge. More clinical studies are required to define fully the final place of such a technique today. At the moment it is enough to say that it appears to be safe enough with encouraging results. Our clinical routine in the past three years has been aimed at maintaining a L-PO₂ level, which is far easier with the on-line technique. However, when the on-line monitoring was not available, the perfusionist used the blood gas values to keep the oxygenation in the L-PO₂ range, but this is not as effective due to some delay.

Reference

1. N Al-Khaja, A Belboul, P Bergman, D Roberts, G William-Olsson. Cutaneous microcirculation and blood rheology following cardiopulmonary bypass: Laser doppler flowmetric and blood cell rheologic studies. *Scand J Thorac Cardiovasc Surg*, 1988; 22: 149-153.

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