Title: ARTERIAL PO_2 SHOULD BE CORRECTED FOR BODY TEMPERATURE DURING HYPOTHERMIA

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Introduction. Blood samples for gas and acid base analysis are usually measured at 37°C. In order to obtain the actual values at the patient's body temperature a correction algorithm must therefore be used. There is evidence that optimum function of several enzyme systems as well as cardiac function may occur when "uncorrected" pH is maintained at 7.40 independent of body temperature [1,2].

The appropriateness of uncorrected PO_2 values warrants some analysis, however. As blood from a hypothermic patient is warmed to an electrode temperature of 37°C PO_2 will rise because of lower solubility of oxygen in plasma as well as decreased O_2-Hb affinity. Uncorrected PO_2 will therefore be artifactually high. If PaO_2 is not corrected it is often tacitly assumed that the lower PaO_2 which will necessarily occur is permissible because of the decrease in tissue oxygen consumption (VO_2) at low temperatures.

Methods. We have estimated the effect of body temperature on tissue PO_2, maintaining either a constant corrected or uncorrected PaO_2. We made the following assumptions: (a) mixed venous PO_2 (PvO_2) is an estimate of tissue PO_2[3]; (b) VO_2 varies with temperature according to the following equation as previously described[4]:

$$\log_{10} VO_2 = 0.937T - 0.693$$

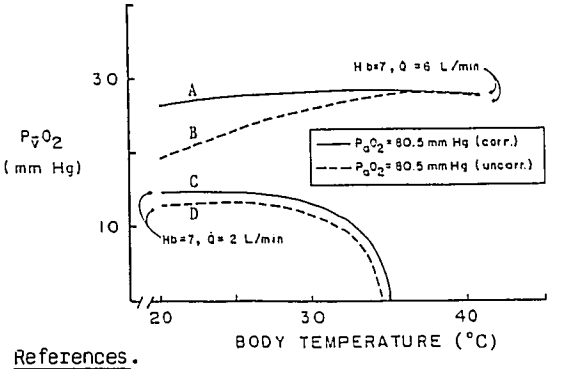
where T is body temperature (°C); (c) temperature corrections are made according to the standard algorithm incorporated into most blood gas machines[5]; (d) hemoglobin concentration = 7 g/dl. We have arbitrarily chosen a value for PaO_2 of 80.5 mm Hg since this will result in 95% Hb saturation at 37°C.

Results. The resulting PvO_2 values have been calculated for two different pump flow rates (low and high: 2 L/min and 6 L/min) as a function of body temperature and are shown in the figure. PvO_2 shown on the ordinate represents corrected values. At high flow using corrected PaO_2, PvO_2 is maintained at 26-28 mm Hg (curve A). At low flow the values are significantly lower (curve C). On the other hand, when a constant PaO_2 of 80.5 mm Hg is maintained uncorrected there is a significant reduction in PvO_2, particular at high flow (curves B and D).

Discussion. The plot demonstrates the expected lower PvO_2 at low pump flow. The decrease is temperature dependent because VO_2 is a function of temperature whereas we have assumed a constant flow independent of temperature. At low flow the temperature variation is extreme, with inability to maintain sufficient O_2 delivery to the tissues above 35°C. At high flow there is less temperature variation because a larger proportion of tissue O_2 requirement can be provided by dissolved O_2. PvO_2 is lower with the strategy of non-correction (see curves B and D). At high flow and low temperature a larger proportion of VO_2 can be provided by dissolved rather than Hb-bound O_2. Comparing correction with non-correction the largest difference in arterial O_2 content will be in the dissolved fraction. Therefore, the reduction in PvO_2 with non-correction is especially marked at high pump flow. At low body temperature complete cessation of blood flow has been noted in a proportion of tissue capillaries.[6] This vascular derecruitment may lead to a net increase in O_2 diffusion distance from capillary to mitochondrion. Therefore the maintenance of PO_2 at an adequate driving pressure is especially important during hypothermia.

We conclude that uncorrected PaO_2 values which would be safe at 37°C may be potentially detrimental during hypothermia. Decreased PvO_2 in addition to a possible increase in tissue diffusion distance may result in tissue hypoxia. Furthermore assessment of PvO_2 by direct measurement without correction will provide a false sense of security because of the artifactual elevation induced by warming the blood at the electrode. It is corrected PO_2 which determines physical and chemical behavior of O_2. We therefore suggest that temperature correction should be applied to PO_2 values during hypothermia.

ADULT MIXED VENOUS $P\bar{v}O_2$ VS BODY TEMPERATURE AT DIFFERENT BLOOD FLOW RATES USING PaO_2 = 80.5 mm Hg



References.
1. Govier, AV, Reeves, JG, McKay, RD, et al. Ann Thorac Surg 38:592-600, 1984.
2. Malan, A. Chapter in Animals and Environmental Fitness. Gilles, R (ed). Oxford: Pergamon Press, pp 487-501, 1980.
3. Tenney, SM. Respir Physiol 20:283-296, 1974.
4. Spurr, GB, Huth, BK, Horvath, SM. Am J Physiol 179:139-145, 1954.
5. National Committee for Clinical Laboratory Standards Publication 2:329-361, 1982.
6. Adolf, E.F. Chapter in The Physiology of Induced Hypothermia. Dripps, RD (ed), Washington: Nat. Aced. Sci-Nat. Res. Council pp 44-49, 1956.