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ALPHA-STAT VERSUS pH-STAT: WE DO NOT PAY IT MUCH MIND

Video clip is available online.

Reply to the Editor:

We thank Dr Jonas for his letter to the Editor¹ in response to our recent publication regarding our favorable long-term experience with deep hypothermic circulatory arrest (DHCA) in aortic arch surgery.² Dr Jonas is an absolute world leader in the physiology of DHCA in pediatric cardiac surgery.

There are 2 general approaches to pH management in DHCA intended to address the increased solubility of carbon dioxide (CO₂) at subphysiologic temperatures; each approach has proponents and detractors. In the alpha-stat approach, pH is managed in a “temperature-corrected” format, keeping the carbon dioxide partial pressure (pCO₂) in the normal range at 37°C, recognizing that the true pCO₂ in the patient will be lower, given the lower body temperature. In the pH-stat approach, CO₂ is added to maintain a pCO₂ of 40 at the patient’s true (low) temperature. The addition of CO₂ has well-known cerebral vasodilatory effects and results in increased brain perfusion.

Dr Jonas has unequivocally demonstrated improved brain blood flow in infants undergoing operations under DHCA when their anesthetic management takes a pH-stat approach.³

However, the following reasons motivate us to continue as we have been doing successfully for more than 3 decades.

FIGURE 1. Clean, uncluttered field offered by DHCA for aortic arch replacement.

1. Excellent clinical results. Our mortality (overall, 2.9%; elective, 1.5%) and stroke (overall, 2.0%; elective, 1.2%) rates are among the lowest reported in large series of aortic arch operations conducted under DHCA^{2,4} and supported by clinical⁵ and quantitative neuropsychologic testing.⁶
2. Strokes in adult aortic surgery are generally embolic, not ischemic.^{4,7} A pH-stat approach would not be protective against particulate embolization.
3. No randomized trials in adults. We are not aware of randomized trials of the 2 pH management strategies in adults undergoing DHCA.
4. Potential for deleterious “brain steal” with the alpha-stat approach. The resultant global cerebral vasodilation of pH-stat can reduce cerebral perfusion pressure and result in “brain steal,” in which blood flow is shunted away from poststenotic regions in adult humans.⁸
5. Theoretical beneficial shift in the oxygen dissociation curve. We have come across no evidence to show that this theoretical benefit of higher CO₂ has clinical impact.

VIDEO 1. Total aortic arch replacement under DHCA. Video available at: [https://www.jtcvs.org/article/S0022-5223\(18\)30869-9/fulltext](https://www.jtcvs.org/article/S0022-5223(18)30869-9/fulltext)

Authors have nothing to disclose with regard to commercial support.

6. Enhanced cerebral metabolism suppression. The very same article cited in the letter¹ (to support benefits of alpha-stat) makes it abundantly clear that there is controversy and inconsistency in animal studies.⁹
7. Infants are not adults. The prospective, randomized study in infants mentioned in the letter¹ to support a pH-stat approach³ (page 997) actually discusses several reasons why those data are not applicable to adults (including “brain steal”).
8. Contradictory studies, even among children. A landmark study on pH management in DHCA in infants was unable to detect any significant differences in long-term developmental outcomes.¹⁰
9. Wide use of alpha-stat. In a straw poll (personal communication, February 28, 2018), the majority of institutions polled used alpha-stat for pH management (Shock Trauma, University of Maryland Medical System, Baltimore, Md; Baystate, Springfield, Mass; University of Ala, Tuscaloosa, Alabama; Wake Forest, Winston-Salem, NC; Cleveland Clinic, Cleveland, Ohio).

We agree wholeheartedly with Dr Jonas’ insightful suggestion that optimal hematocrit for DHCA is important and needs investigation.

Sometimes a picture is worth a thousand words (Figure 1), and a video can be worth a thousand pictures. We have included with this response a video (Video 1) of a case performed while we were preparing this response. We display a time clock and chemical and metabolic parameters corresponding to the surgical steps being displayed at any given time. We basically ignore the pH status and just perform the operation, stopping the pump at the onset of DHCA and restarting it at the completion. A short patient segment demonstrates the immediate high functional acuity of the patient’s “dry” (nonedematous) brain conferred by straight DHCA without adjunctive (and often excessive) brain perfusion.

We express appreciation to Ayman Saeyeldin, MD, Mohammad A. Zafar, MBBS, Mohamed R. Abdelbaky, MBChB, and Camilo A. Velasquez, MD, for their work in recording and editing this video.

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