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Choice of α-stat or pH-stat Management and Neurologic Outcomes after Cardiac Surgery

It Depends

IT has been slightly more than 10 years since Murkin *et al.*[1] reported that *p*H-stat management results in greater cerebral blood flow (CBF) during cardiopulmonary bypass (CPB) than does α-stat management. After this landmark study, numerous animal and clinical studies have addressed the question of which technique might be best for the brain during cardiac surgery. It appears we may now have the answer—it depends. In children undergoing deep hypothermic circulatory arrest (DHCA), *p*H-stat should be used. In adults undergoing routine cardiac surgery, α-stat should be used. Why the difference?

> This Editorial View accompanies the following article: Kurth CD, O'Rourke MM, O'Hara IB: Comparison of *p*H-stat and alpha-stat cardiopulmonary bypass on cerebral oxygenation and blood flow in relation to hypothermic circulatory arrest in piglets. ANESTHESIOLOGY 1998; 89:110-8.

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Key words: Acidosis; brain; carbon dioxide; cardiopulmonary bypass; cerebral blood flow; hypothermia; hypoxia; ischemia; near infrared spectroscopy; neonate; oxygen.

Two clinical studies, one retrospective[2] and a recent prospective randomized trial,[3] find better neurologic outcome with *p*H-stat management in children undergoing DHCA. In this issue of ANESTHESIOLOGY, Kurth *et al.*[4] provide important new insight into two mechanisms by which *p*H-stat management may be helping the brain during DHCA. First, their work shows that *p*H-stat management increases the rate of brain cooling, probably on the basis of greater CBF with *p*H-stat. Although the effect is fairly small, it is nonetheless important because clinical studies suggest brain cooling often may be incomplete before DHCA when α-stat management is used.[5,6] Thus *p*H-stat management may provide extra brain protection during DHCA simply by increasing the likelihood that the desired level of cerebral hypothermia is actually clinically achieved. The other important finding of this experiment is that the rate of brain oxygen depletion during DHCA is considerably slower with *p*H-stat than with α-stat management. *p*H-stat management was found to substantively prolong the interval between onset of arrest and exhaustion of brain oxygen stores. At profound hypothermia (17°C), *p*H-stat management reduces brain oxygen consumption an additional 30-40% below that achieved with α-stat management.[7,8] This supplemental reduction of brain oxygen consumption may underlie Kurth's observation of a slower rate of oxygen depletion with use of *p*H-stat management. Prevention of cellular oxygen exhaustion may greatly increase the brain's tolerance to DHCA.

In contrast, in adults undergoing continuous moderately hypothermic CPB, three randomized prospective studies indicate postoperative neurologic or neuropsychological outcome is slightly, but consistently, better with α-stat.[9-11] The mechanism is not known, but it is presumed that the lesser CBF of α-stat management results in fewer cerebral emboli during CPB. In adult cardiac surgery patients, postoperative neurologic outcome is related, at least in part, to the number of cerebral emboli that occur during surgery.[12-15] In contrast to DHCA, global impairment of brain oxygenation during continuous CPB does not appear to be a major mechanism of neurologic injury in adults.[16,17] With use of membrane oxygenators or arterial line filters, the rate of cerebral embolization during CPB often is pretty low. Therefore, with short bypass runs, the number of emboli originating from the CPB circuit may be sufficiently small so that acid-base management may not significantly affect neurologic outcome. Consistent with this hypothesis, Murkin *et al.* reported that α-stat management was not associated with better neurologic outcome until CPB durations exceeded 90 min.[11] Overall in adults undergoing continuous CPB, the weight of current evidence favors use of α-stat.

During the past 10 years, integration of laboratory and clinical investigations have lead to mechanistic insight and improved neurologic outcomes after pediatric and adult cardiac surgery. Once mysterious, mechanisms of brain injury during cardiac surgery are becoming more clear. Because the brain can be injured in more than one way during cardiac surgery, our approach to prevention and treatment will depend on the nature of the injury.

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