Letter to the Editor

Acid-Base Management and Temperature Control during Hypothermic Circulatory Arrest

[Letter regarding "Apostolakis E, Akinosoglou K. The Methodologies of Hypothermic Circulatory Arrest and of Antegrade and Retrograde Cerebral Perfusion for Aortic Arch Surgery." (Ann Thorac Cardiovasc Surg 2008; 14: 138–48)]

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To the Editor:

We read with great interest the review from Drs. Efstratios Apostolakis and Karolina Akinosoglou[1)] regarding strategies of cerebral protection during hypothermic circulatory arrest (HCA) with antegrade cerebral perfusion (ACP) and retrograde cerebral perfusion (RCP) for aortic arch surgery. In this literature review, the authors summarized the methodologies of deep HCA (DHCA) and various perfusion strategies for aortic arch surgery. We congratulate the authors on the extraordinary achievement of synthesizing a broad spectrum of literature on the topic of brain protection in the area of aortic arch surgery. This review certainly has and will continue to have an important impact on the perfusion management of patients during HCA with ACP and RCP undergoing aortic arch surgery.

Currently, there is no widely accepted guideline of perfusion management during HCA with ACP and RCP for aortic arch surgery. Heart centers use varied perfusion protocols or guidelines in processing strategies for cerebral protection during DHCA for aortic arch surgery. In this review, the authors have incorporated their own clinical experiences and knowledge of the principles of these procedures into the evolution of guidelines to provide valuable insight into cerebral protection. We would like to make several comments concerning the conclusions or guidelines drawn by authors on this topic. First, the authors did not mention the acid-base management section in this review or guideline. We believe that acid-base environment has great effects on cerebral protection. However, the optimal acid base management strategy for aortic arch surgery in adults remains undetermined. Using alpha-stat pH management allows pH to change with falling temperature as the buffering capacity for hydrogen ions increases, resulting in a relative alkalosis. Alpha-stat management preserves flow: metabolism is matched during cooling until the temperature at which autoregulation is uncoupled. The alternative pH management approach is pH-stat, which maintains pH during cooling by adding CO_2. This uncouples cerebral autoregulation so that cerebral blood flow (CBF) varies directly with cerebral perfusion pressure. The addition of CO_2 during pH-stat management causes cerebral vasodilatation and increased CBF.[2)]

Finally, the management of temperature is very important during the entire procedure of HCA. We agree with the authors that rewarming should be slow and gradual, but we do not think that it is beneficial for the patients to rewarm the body from around 20°C to normal body temperature in 20–30 minutes, with a differential temperature (esophageal blood) gradient of < 10°C. In a recent study at the Texas Heart Institute, it was found that the bladder temperature was more than 4°C lower than the jugular bulb temperature during some periods of rewarming, and nasopharyngeal and esophageal temperatures differed from jugular bulb temperature by as much as 2°C during much of the rewarming phase.[3)] Because it affects the outcome of cerebral ischemic events, brain temperature may influence the extent of neurological injury during and after cardiac surgery with cardiopulmonary bypass (CPB). Therefore, when hypothermia is used to protect vital organs during CPB, the cooling phase should be adequate and rewarming must be carefully managed. In

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our opinion, monitoring the blood temperature is very important, rewarming should be slow and gradual, and the differential temperature (esophageal blood) gradient should be lower, around 5°C.[4] Moreover, pH-stats were adopted in our procedure for patients under DHCA.

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Reply:

We will agree with Ji et al.[1] that acid base management during aortic arch surgery is one of the key factors determining optimal clinical outcomes. However, for the sake of brevity in our review, we did not go through the issue very extensively.[2] In our opinion, the potential positive role of alpha-stat or pH-stat has not been totally proven to this very day. It's commonly accepted, though, that understanding and revealing the mechanisms of cerebral metabolism during surgery remains the key to successful outcomes. It is well known that CBF depends on three factors: (1) CO_2 concentration, (2) H^+ concentration, and (3) O_2 concentration. CO_2 concentration seems to be the most important, since a 70% increase of its levels results in a 2-fold increase of CBF.[3] As a consequence, pH-stat—which you seem to support—corrects the extremely toxic-to-brain alkalosis by adding CO_2 to the O_2 supply of CPB, but it also increases CBF (because of acidosis), thus O_2 supply to the brain.[4] Experimental studies have shown that pH-stat is correlated with statistically significant increased CBF, compared to alpha-stat.[5] Furthermore, the resulting vasodilation means, by itself, uniform distribution of blood across the brain, thus an avoidance of ischemic cerebral regions.

Nevertheless, increased cerebral flow is related to the following complications: (a) deterioration of the edema, through the damaged membrane, that has already increased penetrability to the cerebral vessels;[3] and (b) increased possibility of emboli in the cerebral blood course. Still, a study on the levels of galactic acid of the brain,[6] as well as neurobehavioral scoring in guinea pigs,[5] showed no statistically significant difference between the two methods. On the other hand, studies focusing on dopamine levels did show that pH-stat instead of alpha-stat can prolong the "safety-duration" of hypothermic arrest (HCA) for 15 minutes.[7] The latter may mean that all the above advantages and disadvantages of the aforementioned methods do not actually play a substantial role in protecting the patient's brain. In our opinion, pH management is an important parameter; nevertheless, it is an important detail among many others, such as final systemic temperature, duration of cooling and rewarming, Ht levels, age of patient, and quality of cerebral vessels.

As far as rewarming duration is concerned, we never supported that it should take 20 minutes[2] because this also depends on the parameters of the patient (mostly somatometric). On the contrary, we stressed that initially, and for at least 5 minutes (up to 20 minutes),[8] the reestablishment of CPB should be isothermic (to the final temperature). Following that it should slow rewarming commence until the final temperature of 36.5°C is achieved, considering also this temperature as a new isothermic plateau for 10–20 minutes.[9] You are absolutely right to support that esophageal-blood temperature gradient shouldn't reach extreme levels, i.e., 10°C. These kinds of temperature gradients are responsible not only for severe hemolysis in organs with normal vessels, but also for nonuniform blood distribution, thus regional cerebral ischemia

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