Current status of cerebral protection for aortic arch surgery

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The landmark article in 1975 by Griep and colleagues¹ describing 4 patients subjected to profound hypothermic circulatory arrest for aortic arch replacement represented a monumental advancement in our approach to surgery on the aortic arch. Since that time, innumerable reports have been published documenting different approaches to cerebral protection during aortic arch surgery. During this period, substantial focus was placed on the identification of safe temperatures for profound hypothermic circulatory arrest, followed by the introduction of adjunct perfusion strategies, either retrograde cerebral perfusion (RCP) or ACP, intended to protect the brain further and prolong the safe period of profound hypothermic circulatory arrest. Evidence began to accumulate that the introduction of an adjunct perfusion strategy might offer advantages to deep hypothermic circulatory arrest alone,^{2,3} although some authors have reported outstanding success with straight deep hypothermic circulatory arrest.⁴ Interestingly, and perhaps not surprisingly, the use of these cerebral perfusion strategies has resulted in aortic surgeons' "pushing the envelope" to increase the minimum temperature for circulatory arrest by using a strategy of "mild to moderate hypothermia."

Two articles in the *Journal of Thoracic and Cardiovascular Surgery* address these issues. The first article, by Okita and colleagues,⁵ reports a study that examined a total of 16,280 patients listed in the Japan Adult Cardiovascular Surgery database who underwent total arch replacement between 2009 and 2012. In this series, 8169 patients were studied, 7038 of whom had hypothermic circulatory arrest with ACP and 1141 of whom had profound hypothermic circulatory arrest with or without RCP (HCA/RCP). From each of these groups, it was possible to draw for analysis 1141 patients for whom a nonmatched comparison was made and a propensity score analysis was performed. The matched paired analysis showed that the minimal rectal temperature was 3°C

higher at 24.2°C in the ACP group, with no significant differences between the groups with regard to 30-day mortality, stroke, or transient neurologic events. The HCA/RCP group, however, had significantly longer ventilation times and intensive care unit stays. The article has as limitations a lack of documentation of the total circulatory arrest times and cerebral perfusion rates, as well as wide variations in circulatory arrest temperatures in both groups. The HCA/RCP group is further heterogeneous in that not all patients had RCP for the entirety of the circulatory arrest period.

The second article, by Algarni and associates,⁶ reports a study that examined 128 patients with acute type A aortic dissections between 1990 and 2010 who underwent surgical repair in which either profound hypothermia (defined as circulatory arrest at a temperature <20°C, with a mean temperature in this series of 18°C) or moderate hypothermia (defined as a temperature of 22°C-28°C, with a mean of 24°C) was used for interventions on the aortic arch. Formal arch replacement was performed in 7 of 75 patients in the moderate hypothermia group and 8 of 53 patients in the profound hypothermia group. The primary outcome was a composite outcome of major cardiac and cerebrovascular events defined as death, stroke, or low cardiac output syndrome during the index hospitalization. The results showed that the composite outcome was significantly worse in the profound hypothermia group. Cardiopulmonary bypass time and blood transfusions were significantly higher in the profound hypothermia group and use of profound hypothermia was an independent predictor of composite outcome according to multivariable analysis. This article has as limitations that this was an observational single-center study that used complex statistical analysis to control for confounders. Circulatory arrest times were relatively short (25 ± 13 minutes for moderate hypothermia and 29 ± 15 minutes for profound hypothermia), reflective of primarily hemiarch replacements.

These 2 reports encapsulate some of the ongoing controversies and summarize current trends regarding cerebral protection strategies for aortic arch surgery. Retrograde cerebral perfusion was first introduced by Ueda and associates⁷ in 1990; they reported that safe circulatory arrest periods could be extended to as long as 80 minutes with this adjunct. Numerous authors have reported success with this strategy, but concerns have been raised regarding the adequacy of brain perfusion with this technique,⁸ as well as regarding increased incidence of transient neurologic dysfunction with longer circulatory arrest times.² Antegrade cerebral perfusion, first described

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by Bachet and colleagues⁹ and Kazui and associates,¹⁰ maintains physiologic blood flow to the brain and can be delivered in a variety of ways. Analysis of the Japan Adult Cardiovascular Surgery database¹¹ of procedures performed between 2005 and 2008 compared 2209 ACP cases with 583 RCP cases and showed no differences in 30-day mortality and stroke but a higher incidence of transient neurologic dysfunction in the RCP group. In contrast, a recent meta-analysis encompassing 15 studies and a total of 5060 patients showed no differences in 30-day mortality, permanent neurologic dysfunction, or transient neurologic dysfunction.¹² The study by Okita and colleagues⁵ did not show differences in neurologic events, but it did document longer ventilation times and intensive care unit stay in the HCA/RCP group. The general consensus seems to be that the neuroprotective potential of RCP may be limited, and as result many centers have abandoned this technique in favor of ACP.

Trials from numerous centers from around the world have demonstrated the clinical efficacy of adult aortic arch repair with ACP and mild to moderate hypothermia in the range of 22°C to 30°C. A contemporary review of questionnaires distributed at international conferences in Beijing and Milan in 2010 showed that the typical strategy for adult aortic arch repair was moderate hypothermia with bilateral ACP, with that strategy particularly prevalent in Europe.¹³ Tian and colleagues¹⁴ reported a meta-analysis of 9 studies and 1783 patients in which 813 patients received deep hypothermic circulatory arrest and 970 patients received moderate hypothermia and ACP. The results showed a significant reduction in stroke in the moderate hypothermia group, with comparable results observed for transient neurologic deficits, mortality, renal failure, and bleeding. The study by Algarni and associates⁶ identified the use of profound hypothermia as a predictor of adverse outcome. Further scrutiny of the study of Okita and colleagues⁵ reveals that only 36.7% of patients in the ACP group and 9.6% of patients in the HCA/RCP group had the lowest arrest temperatures below 20°C, with 43.9% in the ACP and 18.1% in the HCA/RCP having the lowest temperatures no lower than 25°C. Both studies highlight the trend toward the use of mild to moderate hypothermia.

The potential benefits of limiting cooling are obvious, with shorter cardiopulmonary bypass and operative times and potentially decreased bleeding and accumulation of cardiac and systemic edema. These advantages, however, are offset by concerns regarding adequacy of spinal cord

and end-organ protection, especially with longer arrest times. Although these latter issues remain incompletely addressed, the evidence base is clear that the use of moderate hypothermia with antegrade cerebral perfusion represents a paradigm shift, perhaps for the better, in the cerebral protection strategy for thoracic aortic surgeons around the world.

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