Chasing the elusive cerebral autoregulation curve in pursuit of intraoperative brain protection

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Cardiac surgeons, anesthesiologists, and cardiopulmonary perfusionists have worked collaboratively for decades to optimize cerebral outcomes after cardiac surgery. In a superb article published in this issue of the *Journal*, Hori and colleagues¹ have combined data from several studies to address the question of whether the putative cerebral autoregulation curve can be observed and quantifiably monitored in clinical practice. And the answer is...sometimes yes, and sometimes no.

In the subset of patients in whom autoregulation was identified, there was significant variability among patients in their individual lower and upper limits of autoregulation. The sample average for optimal mean arterial pressure was below the lower limit in some patients and above the upper limit in others. The only reasonable conclusion is that clinicians cannot use demographic and disease-specific predictors to make a reliable determination a priori of the optimal mean arterial pressure range for any particular patient during cardiopulmonary bypass.

For practitioners of transcranial Doppler monitoring, the sense of reassurance that comes from continuous monitoring of cerebral blood flow velocity cannot be understated, nor can the anxiety of witnessing embolic phenomena and interruptions of cerebral perfusion during various surgical maneuvers and perfusion conditions. Yet there are real limitations in establishing and maintaining reliable monitoring in patients with ossified temporal bones and limited acoustic windows. The success rate of Hori and colleagues¹ likely reflects an extraordinarily talented and experienced team of clinicians, and their experience may not be reproducible.

Transient blood pressure excursions outside the limits of cerebral autoregulation may have subtle effects on neurocognitive outcome. A prospective trial of transcranial Doppler monitoring-guided cerebral blood flow optimization versus protocolized mean arterial pressure control that assesses neurologic outcomes is a likely prerequisite for wider adoption. In the absence of such data, the maturation of other cerebral monitoring

Cerebral vasculature.

Central Message

Transcranial Doppler-determined limits of adequate perfusion pressure and presence of autoregulation are variable. Cerebral oximetry and processed EEG may be more practical in nonresearch settings.

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technologies may provide alternatives to transcranial Doppler monitoring.

The evolution of near-infrared spectroscopy technology has resulted in the availability of several validated cerebral oximetry monitors.² Although these measurements are also influenced by hemoglobin concentration, arterial and venous blood content, and cranial bone transmission, there is preliminary evidence that goal-directed therapy guided in part by cerebral oximetry has resulted in improved overall outcomes.³⁻⁵

Processed electroencephalography, such as bispectral index, may also be of value in cerebral monitoring during cardiac surgery.⁶⁻⁸ The sudden onset of an isoelectric electroencephalographic pattern or a marked change in electroencephalographic activity in the face of stable temperature and anesthetic concentrations may portend a cerebral event.^{9,10} The ease of obtaining processed electroencephalographic signals in an era with markedly improved machine learning is an implicit call to action for researchers to identify whether limited channel electroencephalographic data are useful in guiding clinical care during cardiac surgery.

The complex interplay of underlying patient risk factors with perfusion pressure, hemodilution, anesthetic agents, Paco_2 , acid/base and temperature management, and myriad

surgical interventions will continue to complicate the slow yet steady progress towards more effective brain protection during cardiac surgery. We are a bit wiser in that regard thanks to the efforts of Hori and colleagues.¹

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