Impaired cerebral autoregulation, cerebral perfusion pressure, and intracranial pressure in eclampsia

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REFERENCES

1. Bergman L, Cluver C, Carlberg N, et al. Cerebral perfusion pressure and autoregulation in eclampsia-a case control study. Am J Obstet Gynecol 2021;225:185.e1–9.
2. Belfort MA, Tooke-Miller C, Varner M, et al. Evaluation of a noninvasive transcranial Doppler and blood pressure-based method for the assessment of cerebral perfusion pressure in pregnant women. Hypertens Pregnancy 2000;19:331–40.
3. Armstead WM. Cerebral blood flow autoregulation and dysautoregulation. Anesthesiol Clin 2016;34:465–77.
4. Klein SP, Depreitere B, Meyfroidt G. How I monitor cerebral autoregulation. Crit Care 2019;23:160.
5. Murata T, Dietrich HH, Horiuchi T, Hongo K, Dacey RG Jr. Mechanisms of magnesium-induced vasodilation in cerebral penetrating arterioles. Neurosci Res 2016;107:57–62.

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Thank you for giving us the opportunity to reply to the letter from Drs Nivetida and Ajay regarding our study, "Cerebral perfusion pressure and autoregulation in eclampsia—a case control study."[1] We thank them for their interest in our work and for taking the time to provide us with their comments.

Regarding the formula to calculate cerebral perfusion pressure (CPP), this was validated in pregnant women by Belfort et al[2] in 2000, in a comparison between the estimated CPP (derived from transcranial Doppler and noninvasive blood pressure measurements) and the measured CPP (using spinal epidural pressure as a surrogate for intracranial pressure [ICP]). This study showed acceptable correlation between the estimated and measured CPP in terms of both Bland-Altman analysis and an R^2 of 0.86 ($P<.0001$). The estimated CPP calculated using this formula was found to differ from the measured CPP (calculated using mean arterial pressure [MAP]——ICP) by a pressure of 7.4 mm Hg lower to 11.8 mm Hg higher, rendering a variability of 7%. Thus, if we use that same 7% variability, a CPP value of 109.5 mm Hg in the eclampsia group in the current study could range from 101.8 to 117.2 mm Hg with a standard deviation of 17.7 mm Hg.

Although a validation study of the CPP formula has not been conducted in women with eclampsia or severe preeclampsia (a recognized weakness in the study design), the formula by Belfort et al[2] has been validated in other critically ill patient populations, for example in patients with traumatic brain injury.[3] Transcranial Doppler (TCD)-based methods to determine ICP noninvasively (nICP) are based on the assumption that nICP=arterial blood pressure (ABP)−noninvasive CPP. ICP is determined by the volumes of the intracranial contents, namely blood (arterial and venous), brain, and cerebrospinal fluid. Because the TCD technique depends on cerebral blood flow velocity (CBFV), this method of ICP monitoring is limited to detecting vasogenic changes in the arterial bed.[4]

In healthy patients with a constant ICP, the ABP can vary widely without altering the CPP or cerebral blood flow (CBF) because of cerebral autoregulation. If cerebral autoregulation is disturbed, as in the case of eclampsia and severe preeclampsia, autoregulatory breakthrough may occur and CBF may become directly dependent on MAP in a linear fashion. Small inaccuracies in the TCD measurement or method and differences in the time at which CBFV and MAP are measured at different sites may then lead to negative values.

Drs Nivetida and Ajay raise an important point regarding the negative mean value for ICP in patients with eclampsia. These nonphysiological negative values are also a persistent problem in studies on the critical closing pressure (CrCP), which is assumed to reflect ICP and arterial tone. It has been suggested that if CrCP>ICP, which is often the case, then it would be more correct to express CPP=MAP−CrCP. One study explored 7 different ways to estimate CrCP (and corresponding resistance-area product [RAP]) and all 7 approaches (or equations) lead to a number of estimated values of CrCP that are negative. As said, the reasons for these negative, nonphysiological estimates are not clear, but are likely related to measurement error, time delays, and the inherent numeric extrapolation of values below the measured values of diastolic ABP and CBFV. Of the 7 methods, the lowest rate of negative values was seen for the "first harmonic method" and the use of mean and diastolic values for CBFV and ABP to estimate RAP and CrCP.[5] According to that formula, the RAP = (mean BP−diastolic BP)/(mean velocity−diastolic velocity). Given that mean velocity=(mean BP−CrCP)/RAP and if one assumes that CPP=mean BP−CrCP, then using these expressions, it leads to the same equation as validated in the study by Belfort et al.[2] When encountering negative values of CrCP, or alternatively CPP>MAP, many investigators will reject these cases or artificially set CrCP=0, leading to

CPP=MAP. Despite its nonphysiological nature, negative values for CrCP can be informative when they change with time, posture, or patient groups, because these values retain their sensitivity to reflect changes in vasomotor activity and ICP.[5] Clearly, validation of our noninvasive method for CPP estimation in women with preeclampsia and women with eclampsia using a gold standard invasive measurement of ICP would be more accurate and ideal. Direct measurement of ICP at the time of spinal anesthesia combined with direct measurement of arterial pressure is possible, however logistically and ethically problematic. These measurements were not available for our population. We acknowledge that such a validation would strengthen the case for further use of these noninvasive formulas for CPP and dynamic cerebral autoregulation in preeclampsia and eclampsia. ■

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REFERENCES

1. Bergman L, Cluver C, Carlberg N, et al. Cerebral perfusion pressure and autoregulation in eclampsia-a case control study. Am J Obstet Gynecol 2021;225:185.e1–9.
2. Belfort MA, Tooke-Miller C, Varner M, et al. Evaluation of a noninvasive transcranial Doppler and blood pressure-based method for the assessment of cerebral perfusion pressure in pregnant women. Hypertens Pregnancy 2000;19:331–40.
3. Edouard AR, Vanhille E, Le Moigno S, Benhamou D, Mazoit JX. Non-invasive assessment of cerebral perfusion pressure in brain injured patients with moderate intracranial hypertension. Br J Anaesth 2005;94:216–21.
4. Cardim D, Robba C, Bohdanowicz M, et al. Non-invasive monitoring of intracranial pressure using transcranial Doppler ultrasonography: is it possible? Neurocrit Care 2016;25:473–91.
5. Panerai RB. The critical closing pressure of the cerebral circulation. Med Eng Phys 2003;25:621–32.

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