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Editorial

Prognosis at the speed of sound: Measuring optic nerve sheath diameter after cardiac arrest

Intracranial pressure-volume dynamics have been understood for close to two centuries.[1] The intracranial system has some compliance because circulating blood and cerebral spinal fluid volumes can shift in response to increased pressure. However, changes in component volumes within the calvarium that are more than trivial rapidly overcome this compliance, and thereafter small changes in volume result in significant changes in intracranial pressure (ICP). After many forms of acute neurological injury, elevated ICP is associated with more severe injury, and thus also portends worse outcomes. Increases in ICP can also result in reduced cerebral blood flow (CBF), making high ICP a potentially treatable cause of secondary brain injury.[2] After brain trauma, invasive ICP monitoring is routinely accomplished through placement of a burr hole and introduction of an external ventricular drain or parenchymal pressure transducer.[3] By contrast, although elevations in ICP may be common after cardiac arrest,[4] invasive monitoring is often viewed as impractical or infeasible, creating a need for non-invasive alternatives.

In this issue of *Resuscitation*, Park et al., explore one such non-invasive measure: optic nerve sheath diameter (OSND) measured at the bedside using ultrasound.[5] Their work focuses primarily on the potential value of OSND as a prognostic modality. The optic nerve itself is in continuity with the subarachnoid space, the nerve sheath is comprised of all meningeal layers, and as ICP rises, the diameter of the optic nerve sheath increases.[6] Prior studies of general patient populations, and those conducted after resuscitation from cardiac arrest in particular, consistently find a weak positive correlation between invasively measured ICP and OSND.[7,8] A notable strength of the present study is the serial assessment of OSND, with the first measurement obtained an average of just 5 h after return of spontaneous circulation (ROSC). It is well known that some patients develop early cerebral edema after cardiac arrest,[9] but the exact timing of edema formation is poorly characterized making such repeated measures of particular interest. Despite lacking invasive intracranial monitoring as a gold standard, the authors were able to validate noninvasive OSND measures against ICP estimated by serial lumbar puncture (surely a non-trivial effort). Across monitoring modalities and time, OSND only 24 h after ROSC best predicted Cerebral Performance Category at 3 months.

Although the area under the curve (AUC) for the receiver operating characteristics describing the relationship between OSND at 24 h and long-term outcome is impressive, AUC is a poor metric of prognostic performance in this clinical domain. For clinicians treating patients after anoxic brain injury, early prognostication typically focuses on the binary decision to withdraw or continue life-sustaining therapies. In this framework, despite differing substantially from a statistical perspective, discriminating between a patient with a 30% probability of recovery and one with a 70% probability of recovery may have little meaning. Rather, prognostic tests should be optimized to maximize sensitivity (i.e. identification of patients will not recover) while maintaining false positive rate (i.e. incorrect prediction of no recovery potential in a patient who actually would have recovered) close to zero. Interestingly, ICP measured via LP at 24 h has just such a performance characteristic. A classification threshold of ~14 mmHg correctly identifies more than 60% of non-survivors with no false positives. Judged according to this performance metric, OSND does not perform well in isolation. Nevertheless, the impressive AUC of OSND at 24 h combined with the ease with which the data can be acquired suggests it may be a valuable addition to a multimodality prognostic framework that ultimately could allow outcome prediction sooner than currently possible.

The present study confirms prior observations that elevated ICP is an ominous sign after cardiac arrest,[2] but the mechanistic underpinnings of this association remain unclear. The observed association may not be causal at all: high ICP may simply be an epiphenomenon of severe injury for which no proven therapies currently exist. Such injury may be manifest by diffuse cerebral edema (i.e. increased extravascular brain water volume), or through loss of cerebrovascular pressure reactivity resulting in increased intravascular blood volume. Both pathologies have been associated with devastating anoxic brain injury, and both may raise ICP.[9,10] Even without causality, either or both of these mechanisms would be sufficient to explain the prognostic value of OSND. Intriguingly, indirect evidence suggests that after more mild anoxic injury, insufficient CBF—as might result from elevated ICP—may be a treatable cause of brain tissue hypoxia and secondary brain injury.[11] Should such a causal association be confirmed, serial assessment of OSND might also be used to guide clinical care in isolation or in combination with other non-invasive brain monitoring like electroencephalography (EEG) or near infrared spectroscopy (NIRS). Finally, regardless of its causal relationship with outcome, OSND measurement is a potentially useful tool to identify a clinically important—but previously difficult to measure—source of between-patient heterogeneity. Defining the dominant anoxic injury phenotype(s) present in an individual patient may one day inform individualized patient management or targeted enrollment of optimal patient subgroups in future therapeutic trials.

During most of the two centuries since Monroe, Kellie and other great anatomists physiologists first formulated hypotheses about the dynamics of the intracranial system,[1] individual patients' brain physiology and pathophysiology have remained both a major driver of outcome and difficult to assess. Park et al., are to be commended for their contribution to a growing literature describing a range of of easy-to-use, non-invasive, and repeatable measures that shed light on to what was once a "black box." We look forward to future work validating and incorporating such measures into established multimodality prognostic frameworks,[12] and exploration of the potential for OSND to guide individualized patient management to optimize recovery from cardiac arrest.

Disclosures

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Conflict of interest

The author declares that he has no conflicts of interest.

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