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Pediatric neurocritical care and neuromonitoring in 2018 – Maybe we need to go back to the basics?

Anita Patel, MD and Michael J. Bell, MD

Division of Critical Care Medicine, Children's National Medical Center and the George Washington University School of Medicine, Washington DC

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For more than a decade, the focus of pediatric critical care medicine has turned toward neurological injuries – with development of neurocritical care fellowships to train the next generation of clinicians, completion of interventional trials to improve outcomes for neurocritical care conditions, performance of observational studies to develop a greater understanding of the pathophysiology of the relevant disorders and recognition of new conditions that have heretofore been undiagnosed in critically-ill children. There are many reasons for this new found focus on pediatric neurocritical care including improved diagnostic tools (imaging, scoring systems, putative biomarkers, delirium screening tools, others), decreasing mortality for most critical care conditions and a recognition that children with neurocritical care conditions have unique risks for having a poor outcome. Indeed, evidence has suggested that the majority of deaths in a PICU were related to neurological injuries in an audit of consecutive patients (1) and up to 5% of children admitted to several academic PICUs in the US were discharged with a new disability (2). While this interest has been most welcome to some of us in the field, completed interventional trials have failed to prove their primary hypotheses to advance the field (3–7).

It seems plausible that a “back to basics” approach might be appropriate so that assumptions can be questioned regarding these resource-intense studies. In this issue of the Journal, Kirschen and colleagues provide substantial evidence to advance this approach (8). Fundamental to all clinical studies – and good clinical practice – is a common understanding of the child's neurologic condition. In this manuscript, the authors have surveyed pediatric intensive care unit leaders from programs with established training programs to determine their current practices related to neurologic assessments (components, frequency and documentation) along with their desired changes to their systems. The main findings of the paper are that (i) the overwhelming majority of responding institutions routinely assess

Address correspondence to: Michael J. Bell, MD, Professor, Pediatrics and Critical Care Medicine, Chief, Pediatric Critical Care Medicine, Endowed Chair, Pediatric Critical Care Medicine, Children's National Medical Center, The George Washington University School of Medicine, 111 Michigan Avenue, NW, Washington, DC 20010, mbell@childrensnational.org, Phone: 202-476-2037.

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neurologic condition in children (98%), (ii) similarly large majorities of respondents use a coma scale (93%, with 84% using the Glasgow Coma Scale score) and pupillary reflexes (92%), (iii) other neurologic testing is only sporadically administered (sedation scores, brain stem reflexes and tests of more sophisticated neurologic function), (iv) the timing of when assessments are done is based on physician (94%), nursing (23%) or institutional protocol (53%) with a very, wide range of time between assessments (1 – 12 h), (v) declines in function were generally reported to the medical team and, importantly, (vi) the majority of respondents (69%) felt their neuromonitoring systems were currently inadequate for the needs of their patients. There are several limitations to consider with this study. First, these are reported processes of care from leaders in the institutions rather than an observational study of what neurologic monitoring actually occurs in these institutions. However, it seems unlikely that the standardization or reproducibility of neurologic monitoring would be greater in an observational study than by this method – especially in a busy, chaotic environment of a PICU. Second, while there is an obvious selection bias for PICUs with training programs, there is little reason to believe that variations in clinical practices of neurological monitoring would be decreased in PICUs (or other places where critically-ill children are cared for) without such fellowship programs. Lastly, this study does not address the accuracy in nursing/medical teams in actually performing the tests. Nevertheless, it is clear that the pediatric critical care community is quite concerned that neurologic assessments at their institution could be vastly improved from the current practice.

To illustrate the importance of variations of neurologic monitoring, it is helpful to consider how clinical studies (interventional and observational) are undertaken and the implications of variations in neurologic monitoring identified by the current paper. For instance, stratification of traumatic brain injury (TBI) is based exclusively on GCS scores – with severe TBI defined as GCS $\leq$ 8, moderate TBI defined as GCS 9 – 12 and mild TBI defined as GCS $\geq$ 13. As Kirschen and colleagues found quite clearly, the GCS score is routinely used in PICUs but the frequency of the testing, the response to alterations and the documentation of the GCS score is quite varied across clinical centers. Thus, it is essential for the reader of this literature to have a critical eye toward how the GCS score was obtained so that variation in neurologic monitoring can be minimized so that the population of the study can be thoroughly understood. Without such a critique, it is difficult to interpret the results of either interventional or observational studies. For most TBI studies in children, the clinical context where the GCS score is assigned is not fully described in the report or even collected by the study team. For the Cool Kids study, the authors specified it was a “post-resuscitation” GCS score that was used to enroll subjects (3), while in the other interventional trials were less specific (4, 5). For observational studies, this problem is also quite common. Recently, Bennett and colleagues combined two large databases to generate a population of children ($n > 3000$) with TBI to test the effectiveness of ICP monitoring for children with severe TBI (9). However, given the findings of Kirschen and colleagues – and the implied challenges of standardized neurological assessment and documentation in routine practice – the reliability of the GCS score within these databases of dozens of institutions is difficult to measure. For the Approaches and Decisions for Acute Pediatric TBI (ADAPT) observational study, we used GCS scores obtained at the time of ICP monitoring to more fully explore the clinical context of these children in an attempt to

mitigate the variability of neurological monitoring (10). Nevertheless, variations in neuromonitoring assessments of clinical providers remain a challenge for the entire field of pediatric critical care medicine.

In summary, the current manuscript highlights that despite all of the resources and effort that have been expended in the field of pediatric neurocritical care, the basics of patient assessments remains a challenge for clinicians and researchers. This manuscript should serve as a reminder that neuromonitoring between (and likely, within) centers can vary substantially and must be accounted for in reviewing research studies. We hope that this work can serve to stimulate discussions in the community on getting back to basics so that optimal neurological monitoring programs can be developed for children at high risk for poor outcomes.

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