Pediatric RESEARCH

www.nature.com/pr

COMMENT

Commentary on "Validation of the Pediatric Stroke Outcome Measure for classifying overall neurological deficit"

Melissa G. Chung[1,2] and Warren Lo[1]

Pediatric Research (2020) 88:157–158; https://doi.org/10.1038/s41390-020-0921-7

Act I
Bernardo
'Tis here!
Horatio
'Tis here!
Marcellus
'Tis gone!

Measuring the outcomes of pediatric stroke is a challenge, and hitting the target has been difficult. There has been an explosion of research in pediatric stroke as clinicians and researchers have directed attention to what was once considered a rare disorder. Earlier investigators knew that systematic measurement of outcomes is essential but that measurement in pediatric stroke has been inconsistent in the literature. Only one stroke outcome measure is validated in children, the Pediatric Stroke Outcome Measure (PSOM). The PSOM has been used in a number of observational[1] and descriptive studies.[2,3] Over the years, investigators noted that the PSOM scored some patients as having more severe deficits than seemed clinically warranted. Accordingly, there was realization that the PSOM needed to be refined, but as one can imagine any attempt to modify or re-interpret a measure as important as the PSOM creates worries about how those modifications might affect the measure.

The PSOM has been widely used since it takes the clinical exam and converts it into an array of ordinal scales. It divides neurological function into five different components, right and left sensorimotor, language production, language comprehension, and the clinician's assessment of cognition and behavior. Each subscale ranges from 0, normal function, to 2, which is no or "missing" function. One adds up the scores to calculate the severity of neurological impairment, which initially seemed straightforward. Many earlier papers dichotomized the PSOM to "good" and "poor" outcomes, with scores of ≥1 labeled as poor outcome. Over time, it became apparent, however, that the dichotomized PSOM tended to categorize many children as having poor outcomes who otherwise seemed to have relatively mild impairments in their daily function.

To refine the PSOM, Slim and colleagues[4] examined a cohort of children who had arterial ischemic stroke, were aged ≥5 years, and had undergone the PSOM. The authors identified 117 children who also had post-stroke function measured by the Pediatric Evaluation of Disability Inventory (PEDI), which relies upon parental report, or the Pediatric Quality of Life measure (PedsQOL), which is based upon parental and patient report (Table 1). The authors used latent class analysis to examine their derivation cohort and found that a three-class model best characterized the deficits in the derivation cohort. The authors then used clinical judgment to sort the patients into normal–mild, moderate, and severely affected classes. This new classification of the PSOM was labeled as PSOM-SCS. (here we refer to the older version of the PSOM as PSOM-PRIOR) PSOM-SCS had a higher degree of concordance with the three-class model than PSOM-PRIOR. Importantly, the post-stroke function of these children was validated with an external cohort who had arterial ischemic stroke. This validation cohort had post-stroke function measured by the PSOM, the King's Outcome Scale for Childhood Head Injury (KOSCHI), a measure of post-TBI impairment, and the modified Rankin (mRS), a measure of post-stroke impairment widely used in adults (Table 1). The PSOM-SCS scores are more strongly associated with the KOSCHI and mRS classifications of impairment than those of the PSOM-PRIOR.

How does this study advance the field? The PSOM-SCS modification shifts the emphasis from simply tabulating the post-stroke deficits to focusing upon the patient's post-stroke functionality. The PSOM-SCS moves many patients from being labeled as severely impaired based only upon a score to being more realistically labeled as normal/mildly or moderately impaired. In other words, if a child has a mild sensorimotor deficit and mild language impairment but has otherwise normal or close to normal daily function, then the presence of two mild deficits should not add up to that child being labeled as severely impaired. Figure 3 in the article emphasizes this point where there is overlap between patients with scores of 2–4.5. Some of these children have complete loss of function in one subscale or another, while others have an aggregate of mild and moderate deficits. The PSOM-SCS more accurately describes this group than the PSOM-PRIOR, which would have characterized many of the children as severely impaired.

Despite these improvements over the PSOM-PRIOR, there are limitations, which the authors readily acknowledge. This was a retrospective study so only a limited number of children in the derivation cohort were assessed with the PEDI or PedsQOL as well as the PSOM. As a result, the derivation and internal validation cohorts were small. Indeed the PSOM-PRIOR scores correlated better with the PEDI mobility scales than do the PSOM-SCS. Most of the validation cohort patients were also part of the derivation cohort. Accordingly, the confidence we can place in the findings is less than ideal. The study design did not include children aged <5 years, for valid reasons, so the generalizability of the PSOM-SCS to this age range is unknown. One may argue that the validation

[1]Division of Pediatric Neurology, Department of Pediatrics, Nationwide Children's Hospital, The Ohio State University, Columbus, OH, USA and [2]Division of Critical Care, Department of Pediatrics, Nationwide Children's Hospital, The Ohio State University, Columbus, OH, USA
Correspondence: Melissa G. Chung (Melissa.chung@nationwidechildrens.org)

Received: 5 April 2020 Accepted: 9 April 2020
Published online: 2 May 2020

Table. 1. Suggested acute outcome measures for acute stroke studies in adults.

Name of the scale	Dimension that is measured
Kessler Foundation Neglect Assessment Process (KF-NAP)	Spatial neglect
SIS-16	Activities of daily living
2D-reaching assay	Motor performance[a]
Finger individuation	Motor performance[a]
Grip strength using calibrated dynamometer	Motor performance[a]
Precision grip between thumb and index finger using a calibrated dynamometer	Motor performance[a]
10 m walk test	Gait
Specific NeuroQoL short forms domains	Especially depression, social roles, and cognitive function
SAFE test (shoulder abduction and finger extension)	Motor performance
The PROMIS-10 functional scale	Patient-reported measure of global function

[a]Steven Cramer, MD, personal communication.

measures are not specific for pediatric stroke and are susceptible to bias. The PEDI and the PedsQOL depend upon parent report, the KOSCHI was developed for TBI, and the mRS uses adult activities to assess function. The reality is, however, there is no other independent measure of pediatric stroke to use for comparison.

One secondary item, but an important one for the future, is there will need to be a reminder, a sort of Rosetta stone, to help readers understand how the PSOM-SCS results differ from those of the PSOM-PRIOR. Readers who review the earlier papers that dichotomized PSOM-PRIOR into good or bad will need to be reminded that the PSOM scoring system has changed. What will be important to remember is that the older papers will appear to have more patients with poorer outcomes because of a change in definition rather than a change in true functional outcome.

Pediatric stroke trials currently are being developed, but the scope and specificity of outcome measures available for children are far fewer than those available for adult trials (Table 1). At best, the PSOM is a global measure of outcome, but it does not provide more granular detail. For example, a significant concern for parents and clinicians is whether a child has post-stroke cognitive or behavioral impairments. The PSOM provides only limited information in this area. There is a need for outcome measures of cognition and behavior that can readily be performed by research staff in multi-center studies. A past review noted that a range of measures were used in earlier studies of pediatric stroke.[5] However, there was no consistency in which measures were used and the use of different outcome measures makes it difficult to compare the results of these studies. Certainly, one challenge is no one outcome measure captures the range of pediatric development (motor, language, behavior, cognition/academic abilities) that occurs over the ages of 0–18 years. Another significant challenge is that funding for outcome measure development is difficult to find. So while this revision of the PSOM is an important step, certainly a first act, more needs to be done to hit the mark of post-stroke assessment in children.

AUTHOR CONTRIBUTIONS

M.G.C. contributed to the design of the manuscript and revision of the manuscript for intellectual content. W.L. contributed to the design of the manuscript, drafted the manuscript, and provided revisions for the intellectual content.

ADDITIONAL INFORMATION

Competing interests: The authors declare no competing interests.

Patient consent: Patient consent was not needed for this article.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

REFERENCES

1. Wintermark, M. et al. Arteriopathy diagnosis in childhood arterial ischemic stroke: results of the vascular effects of infection in pediatric stroke study. *Stroke* **45**, 3597–3605 (2014).
2. Steinlin, M. et al. Focal cerebral arteriopathy: do steroids improve outcome? *Stroke* **48**, 2375–2382 (2017).
3. Felling, R. J. et al. Predicting recovery and outcome after pediatric stroke: results from the International Pediatric Stroke Study. *Ann Neurol*. https://doi.org/10.1002/ana.25718 (2020).
4. Slim, M. et al. Validation of the Pediatric Stroke Outcome Measure for classifying overall neurological deficit. *Pediatr. Res*. https://doi.org/10.1038/s41390-020-0842-5 (2020).