Published in final edited form as:

Crit Care Med. 2016 March ; 44(3): 592–600. doi:10.1097/CCM.0000000000001428.

The Preschool Confusion Assessment Method for the ICU (psCAM-ICU): Valid and Reliable Delirium Monitoring for Critically Ill Infants and Children

Heidi A.B. Smith, MD, MSCI^{a,b}, Maalobeeka Gangopadhyay, MD^c, Christina M. Goben, MD^b, Natalie L. Jacobowski, MD^d, Mary Hamilton Chestnut, NP^a, Shane Savage, MD^e, Michael T. Rutherford, MD^f, Danica Denton, MD^g, Jennifer L. Thompson, MPH^h, Rameela Chandrasekhar, PhD^h, Michelle Acton, RN^b, Jessica Newman, RN^b, Hannah P. Noori, RN^b, Michelle K. Terrell, NP^b, Stacey R. Williams, NP^b, Katherine Griffith, NP^b, Timothy J. Cooper, PsyDⁱ, E. Wesley Ely, MD, MPH^j, D. Catherine Fuchs, MD^g, and Pratik P. Pandharipande, MD, MSCI^a

^a Department of Anesthesiology, Vanderbilt University Medical Center ^b Department of Pediatrics, Monroe Carell Jr. Children's Hospital at Vanderbilt ^c Department of Psychiatry, New York-Presbyterian Morgan Stanley Children's Hospital ^d Department of Psychiatry, Massachusetts General Hospital ^e Department of Psychiatry, Georgia Regents University ^f Department of Psychiatry, Kalispell Regional Healthcare ^g Department of Psychiatry, Vanderbilt University Medical Center ^h Department of Biostatistics, Vanderbilt University School of Medicine ⁱ Department of Developmental Medicine, Monroe Carell Jr. Children's Hospital at Vanderbilt ^j Department of Internal Medicine, Center for Health Services Research and Division of Pulmonary and Critical Care Medicine, Vanderbilt University Medical Center, and the Tennessee Valley VA GRECC

Abstract

RATIONALE and OBJECTIVE—Delirium assessments in critically ill infants and young children pose unique challenges due to evolution of cognitive and language skills. The objectives of this study were to determine the validity and reliability of a fundamentally objective and developmentally appropriate delirium assessment tool for critically ill infants and preschool-aged children, and to determine delirium prevalence.

DESIGN and SETTING—Prospective, observational cohort validation study of the PreSchool Confusion Assessment Method for the ICU (psCAM-ICU) in a tertiary medical center pediatric ICU.

PATIENTS—Participants aged 6 months to 5 years and admitted to the pediatric ICU regardless of admission diagnosis were enrolled.

Address correspondence to: Heidi A. Beverley Smith, M.D., M.S.C.I., Vanderbilt University Medical Center, Department of Anesthesiology, 2200 Children's Way, Suite 3115, Nashville, TN 37232, Phone: 615-936-6808, Fax: 615-936-4294, heidi.smith@vanderbilt.edu.

Copyright form disclosures: The remaining authors have disclosed that they do not have any potential conflicts of interest.

INTERVENTIONS, MEASUREMENTS and MAIN RESULTS—An interdisciplinary team created the psCAM-ICU for pediatric delirium monitoring. To assess validity, patients were independently assessed for delirium daily by the research team using the psCAM-ICU and by a child psychiatrist using the Diagnostic and Statistical Manual of Mental Disorders criteria. Reliability was assessed using blinded, concurrent psCAM-ICU evaluations by research staff. A total of 530-paired delirium assessments were completed among 300 patients, with a median age of 20 months (IQR 11, 37) and 43% requiring mechanical ventilation. The psCAM-ICU demonstrated a specificity of 91% (95%CI 90, 93), sensitivity of 75% (72, 78), negative predictive value of 86% (84, 88), positive predictive value of 84% (81, 87), and a reliability kappa statistic of 0.79 (0.76, 0.83). Delirium prevalence was 44% using the psCAM-ICU and 47% by the reference-rater. The rates of delirium were 53% vs. 56% in patients < 2 years of age and 33% vs. 35% in patients 2 - 5 years of age using the psCAM-ICU and reference-rater respectively. The short-form psCAM-ICU maintained a high specificity (87%) and sensitivity (78%) in post-hoc analysis.

CONCLUSIONS—The psCAM-ICU is a highly valid and reliable delirium instrument for critically ill infants and preschool-aged children, in whom delirium is extremely prevalent.

Keywords

pediatric; critical care; encephalopathy; agitation; sedation

INTRODUCTION

Large cohort studies using valid and reliable delirium monitoring tools have demonstrated that delirium occurs in up to 80% of mechanically ventilated adults and 50% of lower severity of illness patients, (1) and is associated with worse outcomes including higher mortality, and development of long-term cognitive impairment (LTCI). (2) (3) (4) Small case series have reported pediatric delirium rates between 10-30%. (5) (6) (7) Prevalence studies based on consultations to the psychiatry service usually consist of patients with hyperactive delirium (i.e. agitated, combative patients). Hypoactive delirium, (i.e. patients who manifest negative symptomatology, apathy, or decreased level of consciousness), is frequently missed in routine clinical practice without use of a valid delirium tool and therefore rarely leads to psychiatry evaluation. Pediatric delirium research has lagged behind that of adult delirium research due to the paucity of pediatric-specific delirium assessment tools and resources, delaying the completion of large prospective cohort studies.

The Pediatric Confusion Assessment Method for the Intensive Care Unit (pCAM-ICU) was the first validated tool for objective delirium monitoring in critically ill children over 5 years of age, demonstrating a specificity of 99% and sensitivity of 83%. (6) The majority of pediatric ICU (PICU) patients are less than 5 years of age, in whom objective and interactive delirium monitoring is fraught with challenges as a result of variations in both language and cognitive development. Consequently, subjective and observational approaches to delirium screening in infants and young children have been validated. One such tool, the Cornell Assessment for Pediatric Delirium (CAPD) (8) was introduced as a subjective delirium screening tool in critically ill children with a reported specificity of 79% and sensitivity of 94%.

Despite the advances in pediatric delirium monitoring with the pCAM-ICU (objective, brief, in the moment assessment) and the CAPD (subjective scoring over a nursing shift), delirium remains under-recognized and poorly understood, especially among the very young. To address the challenges of delirium monitoring in pediatric patients, we designed this investigation 1) to create a principally objective and interactive, developmentally-targeted, delirium monitoring tool for critically ill infants and preschool-aged children, the Preschool Confusion Assessment Method for the ICU (psCAM-ICU); 2) to determine validity and reliability of objective delirium assessments using the psCAM-ICU; and 3) to simultaneously determine the prevalence of pediatric delirium in this population.

MATERIAL AND METHODS

We enrolled pediatric patients aged 6 months to 5 years who were hospitalized at the Monroe Carell Jr. Children's Hospital at Vanderbilt (MCJCHV) pediatric intensive care unit (PICU), regardless of diagnosis, either ventilated or non-ventilated, into this prospective cohort validation study of the psCAM-ICU. We excluded patients with hearing/visual impairments, developmental delay (cognition < 6 months of age), those who were non-English speaking, were transitioning out of the PICU, were moribund, or for whom we could not obtain consent. The institutional review board approved this study. In order to ensure accurate prevalence rates of delirium (i.e. to not miss presence of delirium due to an unavailable parent/guardian), we obtained an alteration of the consent process that allowed for collection of patient data and initial delirium assessments prior to consent when a surrogate was not immediately available. The parent/guardian then provided consent when able; if they refused consent, patients were withdrawn from the study, and all data were destroyed.

Phase I: Tool Development (psCAM-ICU)

An interdisciplinary team comprising of pediatric anesthesiology/critical care, neurodevelopmental pediatrics, and child and adolescent psychiatry developed the psCAM-ICU based on the hierarchical design of the pCAM-ICU and the CAM-ICU, (9) which required the following for delirium diagnosis: 1) fluctuation or acute change from baseline mental status, 2) inattention, and either 3) a current altered level of consciousness, or 4) presence of disorganized thinking. Valid pediatric neurocognitive assessments, (10) pain and behavior scales, (11) (12) and developmental milestones, (13) were reviewed and used as a guide to ensure the cognitive and consciousness assessments within the psCAM-ICU were appropriate for both infants and preschool-aged children. As with the adult CAM-ICU and pCAM-ICU, and in agreement with the recent DSM-V, the psCAM-ICU requires the presence of inattention, the most fundamental feature of delirium, and is based on objective and interactive patient assessments.

Phase 2: Validity and Inter-rater Reliability testing of the psCAM-ICU

Daily screening of the computerized census for the PICU (cardiac and medical) occurred Monday through Friday. Participants then underwent daily independent delirium assessments by a reference standard rater, a child and adolescent psychiatrist using DSM criteria for delirium, and by the research team using the psCAM-ICU. The independent

assessments by the two teams were required to occur no more than 3 hours apart. Daily delirium assessments continued until either the patient was identified for transfer/discharge from the PICU or 14 independent assessments had been completed.

Standardization for Delirium Assessment using the psCAM-ICU

Delirium assessments using the psCAM-ICU were conducted by the research team including a pediatric anesthesiologist, intensivist, nurse practitioners, and registered nurses. All psCAM-ICU assessments were completed using a two-step approach based on Plum and Posner's (14) categorization of consciousness: arousal and content. The first step was the assessment of patient arousal using the Richmond Agitation-Sedation Scale (RASS). (15) There are three major categories of an abnormal arousal state when using the RASS: agitation (RASS +1 through +4), decreased arousal, though reactive to voice (−1 through −3), and unreactive to voice (−4 or −5). A patient who is comatose (RASS −4 or −5) cannot be clinically assessed for delirium. The stage of sleep that a child is in determines ease of awakening; i.e. infants and young children may require a more pronounced period of stimulation if in a stage of deep sleep to differentiate deep sleep from an assessed level of consciousness of either moderate or deep sedation. Therefore, patients who were initially assessed as having a RASS −3, −4, or −5 were stimulated by physical touch for 15 seconds, followed by a non-stimulating period of 15 seconds, and then reassessed using the RASS. If the patient remained deeply sedated or comatose then they were deemed unable to be assessed (UTA). For patients who were at least responsive to voice (RASS −3), their content of consciousness or delirium assessment was then performed using the psCAM-ICU.

The psCAM-ICU delirium assessment is based on four features. An acute change or fluctuation from baseline mental status (Feature 1) was determined using the documented sedation or Glasgow coma scale scores (i.e. RASS, GCS) and/or patient evaluation. The sedation scores (RASS) were reviewed for the past 24 hours to establish whether fluctuation in consciousness was present, while an abnormal GCS score or patient history and examination helped to determine whether an acute alteration from their baseline mental status was present (i.e. when the patient's mental status is not the same as when they are in good health). Feature 1 was “present” with either a current alteration from baseline mental status or fluctuation in mental status noted over time. The presence of inattention (Feature 2) was assessed using a staged process of both visual and verbal stimuli. The patient was shown 10 cards consisting of alternating mirrors and elementary, colorful pictures, during which the assessor engaged the patient by saying, “Look at the little boy/girl (patients reflection in the mirror)” or “Is this a truck?” according to whether there was a mirror being shown or a picture on display. The assessor moved the cards slowly in front of the child's face from the left to the right and back again to evaluate for the patient's attention. Specific components of inattention that were evaluated included the absence of: 1) initial eye contact, 2) tracking of the mirrors and pictures, 3) purposeful actions (i.e. reaching out for the cards, babbling or smiling while looking at their reflections), 4) sustained attention to the mirrors/pictures during the assessment period, (i.e. paid attention to 7 or less mirrors/pictures when verbally prompted), and 5) ability to maintain spontaneous eye opening in between the verbal prompts. Patients 2 years of age were also scored on their ability to correctly identify the picture cards. Feature 2 was “present” (in keeping with valid thresholds of

positivity for inattention for the CAM-ICU and pCAM-ICU) when a patient demonstrated 3 or more components of inattention. Current alteration in the level of consciousness (Feature 3) was assessed using a sedation scale (RASS). Feature 3 was “present” when the patient demonstrated an acute altered level of consciousness (i.e. the patient was not currently alert and calm). Finally, when the brain has disorganization of thought or function due to a physiologic condition, it leads to behavioral or system dysregulation that can typically be observed. Sleep wake cycle disturbances have been consistently associated with ICU delirium in both children and adults. (16) Furthermore, pediatric patients with delirium more often can demonstrate subtle neuropsychiatric symptoms such as reduced awareness, purposeless actions, autonomic dysfunction, and inconsolability, when compared to adults. (17) Therefore, evidence of a disorganized brain (Feature 4), or the presence of dysregulated systems or behaviors was determined by the presence of at least two of the following components: 1) inconsolability, 2) unawareness of surroundings or parents/caregivers, and/or 3) a sleep-wake cycle disturbance. (16) (18) Delirium was diagnosed when patients demonstrated the presence of Feature 1 and Feature 2 plus either Feature 3 or 4. Delirium subtypes were designated as either hypoactive (RASS 0 to -3) or hyperactive (RASS +1 to +4) when accompanied by a positive evaluation for delirium with the psCAM-ICU.

The initial scoring algorithm for Features 1 – 4 and the final determination of delirium using the psCAM-ICU was based on expert opinion. We refer to this preliminary algorithm as the long-form or research version of the psCAM-ICU. We conducted post-hoc validity analysis using different cutoffs for the presence of each assessed feature to allow the data to guide the most efficient algorithm for delirium diagnosis. Thus the final form of the psCAM-ICU is referred to as the short-form or clinical version.

Standardization for Delirium Assessment by the Reference Standard

The reference standard team consisted of child and adolescent psychiatrists who used DSM criterion (19) (20) to complete a full consultative assessment for delirium on each patient. Delirium assessment and criteria did not require alteration with the revision of the DSM-IV-TR to the DSM-5 edition during the study period. The reference standard team had a standardized approach to diagnosis which included the flexibility of utilizing any and all means of patient evaluation and testing as well as data gathering from those who understood the patient's behavior and thinking the best, thus maximizing their ability to accurately assess cognitive functioning. The reference standard assessments were categorized as delirium present or absent. Delirium subtypes were designated as hypoactive, hyperactive, or mixed by the psychiatrist based on observed behavioral patterns. Patients who were comatose along with the lack of patient history or prior delirium assessment were considered UTA by the reference standard.

Validity Testing

Criterion validity is the extent to which the assessment instrument is consistent with an accepted or reference standard measure of the same construct, and indicates whether the instrument measures what it was intended to measure. In our case, criterion validity was determined by the ability of the psCAM-ICU to diagnose presence or absence of delirium compared to the reference standard rating, as measured by specificity, sensitivity, negative

predictive value (NPV), and positive predictive value (PPV). Criterion validity of the psCAM-ICU was also determined within subgroups based on both age (6 months - 2 years versus >2 - 5 years) and requirement of mechanical ventilation.

Inter-rater Reliability

Inter-rater reliability is the degree of consistency among raters, and indicates the extent that one rater is a substitute for another. During the psCAM-ICU assessment, two members of the research team were present. One member performed the delirium assessment with the psCAM-ICU and independently rated patient responses, while the second member observed the interaction and also rated patient responses. There were no discussions between team members regarding the patient's clinical status, or other issues pertaining to the evaluation. Scores were individually recorded and used to calculate a kappa statistic, which quantifies the magnitude of agreement between the two psCAM-ICU raters beyond that expected by chance. We chose the above-described method of inter-rater reliability rather than test-retest to avoid exhaustion on the part of the patient, and to avoid other inherent problems such as change in patient mental status, which could have been common if ratings were separated by a significant time lapse.

Sample Size Calculations

To achieve a precision of ± 8 percentage points for an expected sensitivity of 83% as demonstrated by the pCAM-ICU, we estimated a total sample size of 300 patients. This results in a 95% lower confidence limit of 74.5% for the estimate of sensitivity. Due to the impact of developmental variability, the goal was to enroll an equal number of infants (6 months - 2 years) and preschool-aged children (>2 - 5 years).

Statistical Analysis

Patient characteristics including demographics, admission diagnoses, the PICU clinical course, and outcomes were summarized using proportions for categorical variables and medians and interquartile ranges (IQR) for continuous variables. The criterion validity of the psCAM-ICU was quantified by the specificity, sensitivity, NPV, and PPV. Inter-rater reliability was quantified by the kappa statistic. Because we assessed patients on a daily basis while they were in the PICU, there are multiple assessments for some patients, which are more strongly than assessments from different patients. In order to account for this correlation, we used clustered bootstrapping to obtain estimates and their confidence intervals for both validity and reliability. (21) All analyses were performed using R version 3.1.3 (www.r-project.org).

RESULTS

Patient Characteristics

From March 2013 to October 2014, we enrolled a total of 320 patients who were admitted to the PICU at Monroe Carell Jr. Children's Hospital at Vanderbilt, aged 6 months to 5 years, regardless of diagnosis. **Figure 1** illustrates participant flow. Of the 320 consented patients, 20 patients did not complete the study protocol: 12 did not undergo paired independent assessments due to personnel unavailability, and 8 were identified with developmental delay

upon initial reference standard assessment. The study cohort had a median age of 20 months (IQR 10, 37), 63% were male, 76% were Caucasian, 43% required mechanical ventilation, with the most common admission diagnosis of acute respiratory distress syndrome (34%), and an observed in-hospital mortality of 3%. (**Table 1**)

Criterion Validity and Inter-rater Reliability of the psCAM-ICU

A total of 530-paired independent assessments were completed among 300 enrolled patients by the research team using the psCAM-ICU and the reference standard using DSM criterion. Validity: Compared with the reference standard for delirium diagnosis, the psCAM-ICU performed with a specificity of 91% (95%CI 90, 93), sensitivity of 75% (72, 78), NPV of 86% (84, 88), and PPV of 84% (81, 87). (**Table 2**) In patients < 2 years of age, the specificity and sensitivity of the psCAM-ICU was 93% (92, 95) and 78% (75, 81) respectively using 349 paired assessments. In patients requiring mechanical ventilation, the psCAM-ICU demonstrated specificity and sensitivity of 96% (93, 99) and 81% (77, 85) respectively using 185 paired assessments. Reliability: The psCAM-ICU was highly reliable with a kappa statistic of 0.79 (0.76, 0.83).

Validation of the short form (clinical) psCAM-ICU

Features 2 (inattention) and 4 (the disorganized brain) consisted of the highest number of assessed components, some of which could have been redundant and thus provided only modest additional value with regards to the specificity and sensitivity of the psCAM-ICU. Therefore, each component within both Features 2 and 4 underwent post-hoc analysis to determine their individual contribution towards the diagnosis of delirium using the psCAM-ICU compared to the reference standard. For Feature 2, using either the patient's attention to 7 or less mirrors/pictures with verbal prompts or the inability to maintain spontaneous eye opening in between verbal prompts performed as well as using all five original components for the assessment of inattention. (**Table 3**). The overlap of components within Feature 2 was not completely unexpected as the ability of the patient to demonstrate attention (i.e. watch the picture cards) required some meaningful degree of eye contact, tracking, or purposeful movement. Likewise, for Feature 4, the presence of a sleep wake cycle disturbance alone provided a similar specificity and sensitivity for the detection of a disorganized brain compared to using all three of the original components (i.e. inconsolability, unawareness of surroundings or caregivers, and sleep-wake cycle disturbance). The presence of inconsolability or unawareness of surroundings, subtle neuropsychiatric behaviors, may be more difficult for a clinician to routinely recognize and therefore not as sensitive or specific for delirium. Delirium diagnosis using the psCAM-ICU requires either an acute change or fluctuation from baseline mental status and inattention to be present prior to further assessment for disorganization of thought or systems. Thus, demonstration of a sleep wake cycle disturbance may provide further evidence of system dysregulation, but does not alone assure the presence of delirium. The final version or short-form (clinical) psCAM-ICU (**Figure 2**), uses the abbreviated assessment components for Features 2 and 4, and demonstrated a specificity of 86% (84, 88) and sensitivity of 78% (75, 80). Both the short-form and long-form of the psCAM-ICU demonstrated a high accuracy of 83% and 86% respectively.

Delirium Prevalence and Delirium Subtypes

Paired delirium assessments were attempted daily on all enrolled patients. The research team determined that 19 of 300 patients were persistently comatose during the assessment period and not assessable using the psCAM-ICU; thus 281 patients were eligible for delirium evaluation. In contrast, the reference standard team determined that 29 patients suffered from persistent coma during the study period and could not be assessed for delirium; thus 271 patients were eligible for delirium evaluation. The overall delirium prevalence of this cohort using the psCAM-ICU was 44%, with at least one delirium positive evaluation occurring in 124 of 281 assessed patients. Rates of delirium were 53% in patients < 2 years of age versus 33% in patients 2 – 5 years of age. Additionally using the psCAM-ICU, hypoactive delirium (81%) was extremely predominant compared to the hyperactive (19%) subtype. (**Table 4**) Similarly, per the reference standard evaluation, the overall delirium prevalence of this cohort was 47%, with delirium occurring at least once in 127 of 271 assessed patients. The rates of delirium were 56% in patients < 2 years of age versus 35% in patients 2 - 5 years of age. Additionally, hypoactive delirium (64%) was the most common motoric subtype determined by the reference-rater, compared to the less common observation of hyperactive (7%) and mixed (29%) subtypes. Among those ever delirious the median (IQR) duration of delirium was 1 (1, 2) day using both the reference standard and psCAM-ICU. Coma was diagnosed at least once in 27% of patients via the research team assessment using the RASS and 31% by reference standard determination.

DISCUSSION

This study demonstrates that delirium monitoring using the psCAM-ICU is highly valid and reliable in critically ill infants and preschool-aged children. The long-form (research) psCAM-ICU demonstrated a high specificity (91%), sensitivity (75%), NPV (86%), and PPV (84%) compared to the reference standard. In post-hoc analysis, the short-form (clinical) psCAM-ICU, with fewer required assessment components for Features 2 and 4, demonstrated improved sensitivity (78%) and maintained a high specificity (86%), taking less than 2 minutes to complete. Additionally, the psCAM-ICU demonstrated excellent reliability with a kappa statistic of 0.79. Both the adult and pediatric ICU landscapes now have access to different lines of evidence-based practices by which to measure ICU delirium, one being a brief “in the moment” assessment (psCAM-ICU, pCAM-ICU, CAM-ICU) (6) (9) and the other being performed over a nursing shift (CAPD, ICDCS) (8) (22).

Pediatric delirium prevalence of 44% and 47% as determined by the psCAM-ICU and reference standard, respectively, is higher than previously reported. (5) (6) (7) Historically, prevalence studies largely based on consultative psychiatry services consist of patients with hyperactive delirium. The more common hypoactive subtype can easily go undetected when relying on routine clinical practice without the benefit of a valid bedside delirium tool. Therefore, one would expect to identify a much larger number of patients with hypoactive delirium following the implementation of delirium monitoring in the PICU. Additionally, in this study we were able to assess for delirium prior to IRB consent if a surrogate was not immediately available allowing for earlier evaluation of patients during their critical illness and thus a more accurate assessment of delirium prevalence in all comers to the PICU.

Though our cohort had a moderate severity of illness, we were able to demonstrate a very high prevalence of delirium.

The specific associations between delirium and outcomes have not been delineated in children, though critically ill children who survive to home demonstrate decreases in spatial and verbal memory, inability to sustain attention, (23) have significantly longer school absences, (24) and demonstrate executive dysfunction months after discharge. (25) It is possible that elements of critical illness or management factors may contribute to these worse patient outcomes. Of these, sedation practices may be a modifiable risk factor for the development of delirium just as it has been reported in adults. (26) (27) (28) This is a poignant supposition given that 90% of pediatric patients are supported on sedative infusions, including high dose benzodiazepines, during mechanical ventilation. (29) In fact, benzodiazepine administration in critically ill children has previously been associated with the development of post-traumatic stress disorder and delusional memories following critical illness. (30) Using delirium tools such as the psCAM-ICU and pCAM-ICU, novel investigations can be conducted to answer key questions related to highly prevalent sedation practices and brain dysfunction outcomes (acute and long-term) in our sickest children.

The approach for delirium diagnosis differs among available bedside tools which allow clinicians a choice in deciding on a tool that best fits their needs, based on resources, and ease of implementation in their particular ICUs. For instance, the CAPD applies scoring of observations over time to screen for delirium, providing an opportunity for the detection of subtle changes in patient behaviors which may not be picked up by an “in the moment” delirium screening test. However, the CAPD requires anchor points for each developmental stage as one is assessing for a range of behavior from normal to varied levels of abnormal. To be done appropriately this detailed assessment using the CAPD takes time. In contrast, the psCAM-ICU does not require developmental anchor points as the tool assesses for the lowest common denominator which would be considered abnormal for the broader cohort. The psCAM-ICU is unique as a fast and largely objective delirium assessment tool that requires the presence of inattention, the most fundamental feature of delirium. Additionally, the psCAM-ICU can be used to detect abrupt changes in brain function during shock, respiratory insufficiency, or even indolent disease processes, and subsequently be used for efficient reassessment to reflect acute delirium resolution following appropriate interventions.

Limitations

Several limitations of this investigation merit discussion. Our study design permitted up to 3 hours between independent assessments by the research team using the psCAM-ICU and the reference standard due to personnel availability. Fluctuations in the clinical course and administration of sedatives, analgesics, and other psychoactive medications in between psCAM-ICU and reference standard assessments could have led to discordant findings. At the time of this study, delirium monitoring in this patient population had not yet been implemented and therefore routine pharmacologic and non-pharmacologic therapy was infrequent. The majority of discordant psCAM-ICU ratings consisted of false negative assessments, where the psCAM-ICU determination was absence of delirium though the

reference standard determination was delirium presence. Differences between the diagnostic approaches of using a fast, objective bedside tool such as the psCAM-ICU, versus the more thorough psychiatric assessment for delirium diagnosis may have led to these discrepancies. Delirium is a syndrome of brain dysfunction with fluctuations in mental status and inattention; this produces a continuum where a patient may be transitioning “out of” or “into” a state of delirium at the time of clinical assessment. The psCAM-ICU requires the presence of inattention at the time of delirium diagnosis. The psychiatry evaluation, however, assesses for inattention in the moment and also utilizes patterns over a 24-hour period, thus leading to the potential of additional delirium diagnoses. Even though there are innate differences between diagnostic strategies between the psCAM-ICU and reference standard assessment along with known fluctuations in clinical and neurological course, the psCAM-ICU performed with both high validity and accuracy. Finally, reliability assessment of the psCAM-ICU did not use individual assessments separated by time to avoid test-retest, which can lead to exhaustion on the part of the patient, and to avoid other inherent problems such as change in patient mental status. Despite the challenges of reliability testing, the psCAM-ICU demonstrated a high kappa statistic. Similar to other recent validation and reliability studies on pediatric delirium tool development, confirmation studies will be useful to better describe delirium monitoring and the epidemiology of pediatric delirium in different patient cohorts.

CONCLUSION

The psCAM-ICU is a highly valid and reliable delirium assessment tool for critically ill infants and preschool-aged children. It is structured such that delirium cannot be diagnosed without the presence of inattention, and provides for immediate delirium assessment. Delirium prevalence was extremely high, especially among infants. Similar to that in adults, hypoactive delirium was the most prevalent motoric subtype in this critically ill pediatric cohort. The availability of delirium monitoring instruments such as the psCAM-ICU and pCAM-ICU affords an opportunity for delirium detection in pediatric cohorts with a wide range of ages, useful for both the bedside clinician and clinical research team. Implementation of pediatric delirium monitoring will promote large, prospective, multi-center investigations advancing our understanding of the mechanism, epidemiology, and the clinical management of pediatric delirium.

Acknowledgements

We would like to thank Tyler Reimschisel MD for his expertise and collaboration as a scientific advisor in the area of pediatric neurodevelopmental biology.

Funding/Support:

Dr. Smith is supported by the Foundation for Anesthesia Education and Research (FAER) and supported in part by the Vanderbilt CTSA grant UL1 TR000445 from NCRR/NIH.

Dr. Pandharipande is supported by the by the National Institutes of Health HL111111, AG027472, and AG035117. Dr. Ely is supported by the Veterans Affairs Tennessee Valley Geriatric Research, Education and Clinical Center, the VA Clinical Science Research and Development Service, and the National Institutes of Health AG027472, AG035117, and HL111111.

Dr. Smith received support for article research from the Foundation for Anesthesia Education and Research (FAER) and is supported in part by the Vanderbilt CTSA grant UL1 TR000445 from NCRR/NIH. Dr. Gangopadhyay received support for article research from the National Institutes of Health (NIH). Her institution received funding from Vanderbilt CTSA Grant UL1 TR000445 from NCRR/NIH. Dr. Rutherford received support for article research from the NIH. His institution received funding from NCRR/NIH (Grant - Vanderbilt CTSA grant UL1 TR000445). Dr. Ely received support for article research from the NIH and VA Research funding and VA Merit Awards. He received funding from Abbott Laboratories, Orion, and Hospira. His institution received funding from the NIH and VA Funding and VA Merit Awards. Dr. Fuchs received support for article research from the NIH. His institution received funding from Vanderbilt CTSA Grant UL1 TR000445 from NCRR/NIH. Dr. Pandharipande received support for article research from the NIH. His institution received funding from Hospira Inc.

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Figure 1.

This CONSORT figure demonstrates participant flow including: initial screening, exclusions, eligibility, and the final enrolled cohort for the investigation. ^aEight patients were determined upon initial assessment by the reference standard to have cognition less than expected for 6 months of age after consent was obtained. Withdrawal was discussed with the family, no further delirium evaluation was completed, and obtained data was destroyed.

Figure 2.

The Preschool Confusion Assessment Method for the ICU (psCAM-ICU). The short-form (clinical) psCAM-ICU is used to assess for delirium in infants and children who are at least responsive to voice. Following the psCAM-ICU algorithm, once three features have been identified as “YES” or present then the patient has delirium and the assessment is complete. The cardinal features of an acute change or fluctuating mental status and inattention (Features 1 and 2) are required for delirium diagnosis. The presence of an acute altered level of consciousness (Feature 3) or a sleep wake cycle disturbance (Feature 4) may provide further evidence of system dysregulation, but do not alone assure presence of delirium. Compared to the reference standard (child psychiatrist using DSM criteria), the short form of the psCAM-ICU, requiring fewer assessment components within Features 2 and 4, performed with a high specificity of 86% (84, 88) and sensitivity of 78% (75, 80), similar to using the more elaborate diagnostic criteria in the long-form (research) psCAM-ICU.

Table 1

Demographics, Diagnoses, and Outcomes

Demographics^a	Infant N = 166	Preschool N = 134	Combined N = 300
Age at enrollment, months	11 (8, 16)	39 (31, 50)	20 (11, 37)
Sex			
Female	60 (36)	52 (39)	112 (37)
Male	106 (64)	82 (61)	188 (63)
Race			
Asian	2 (1)	3 (2)	5 (2)
Black or African American	30 (18)	30 (22)	60 (20)
Caucasian	132 (80)	97 (72)	229 (76)
Other	2 (1)	4 (3)	6 (2)
Mechanical ventilation	82 (49)	48 (36)	130 (43)
Diagnoses^a			
Acute Respiratory Distress Syndrome	63 (38)	38 (28)	101 (34)
Airway Protection	22 (13)	32 (24)	54 (18)
Altered mental status	13 (8)	20 (15)	33 (11)
Brain mass	3 (2)	8 (6)	11 (4)
Congenital heart disease	59 (36)	34 (25)	93 (31)
Electrolyte disturbance	13 (8)	8 (6)	21 (7)
Hydrocephalus	6 (4)	1 (1)	7 (2)
Intracranial hemorrhage	4 (2)	9 (7)	13 (4)
Pneumonia	10 (6)	11 (8)	21 (7)
Sepsis/septic shock	7 (4)	2 (1)	9 (3)
Status asthmaticus	2 (1)	8 (6)	10 (3)
Traumatic brain injury (TBI)	6 (4)	10 (7)	16 (5)
PICU Course^b			
PRISM score (Day 1)	4 (0, 10)	5 (0, 10)	5 (0, 10)
Length of mechanical ventilation, days	3 (1, 6)	2 (1, 5)	3 (1, 5)
Length of ICU stay, days	5 (3, 11)	4 (2, 8)	4 (3, 9)
Length of hospitalization, days	8 (5, 18)	6 (4, 14)	8 (4, 17)
Outcomes			
Delirium Prevalence (psCAM-ICU) ^c	83 (53)	41 (33)	124 (44)
Delirium Prevalence (RS) ^d	85 (56)	42 (35)	127 (47)
Duration of delirium (among exposed), days ^b	1 (1, 3)	1 (1, 2)	1 (1, 2)
In-hospital mortality ^a	7 (4)	3 (2)	10 (3)

^aData are presented as number of patients (%) or medians (interquartile ranges).

^b Data are presented as number of patients (%) or medians (interquartile ranges).

^c Per the research team, 19/300 patients were comatose throughout the assessment period and were therefore not assessed for delirium using the psCAM-ICU. Prevalence rates are therefore based on 281 patients that were further assessed for delirium using the psCAM-ICU.

^d Per the reference standard (RS), 29/300 patients were comatose throughout the assessment period and definitive diagnosis of delirium was unable to be determined. Prevalence rates are therefore based on 271 patients that were assessed further for delirium.

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Table 2

Criterion validity of the long-form (research) psCAM-ICU reported as Specificity, Sensitivity, NPV, and PPV.

	Assessments	Specificity (95%CI)	Sensitivity (95%CI)	NPV (95%CI)	PPV (95%CI)
All Patients	530	91 (90, 93)	75 (72, 78)	86 (84, 88)	84 (81, 87)
Age:					
2 years	349	93 (92, 95)	78 (75, 81)	86 (85, 88)	88 (86, 91)
>2 – 5 years	181	87 (83, 91)	66 (58, 74)	84 (80, 88)	71 (64, 79)
Mechanical Ventilation	185	96 (93, 99)	81 (77, 85)	82 (78, 86)	96 (93, 98)

Table 3

A comparison of assessment components for delirium features between the long and short forms of the psCAM-ICU.

	Long-form (research)^a	Short-form (clinical)^b
Feature 1: Mental Status	Acute change in mental status Fluctuation in mental status	Acute change in mental status Fluctuation in mental status
Feature 2: Inattention	No eye contact No tracking of the cards No purposeful action Attends to 7 cards Lack of attention between prompts	Attends to 7 cards Lack of attention between prompts
Feature 3: Altered level of consciousness	Alert and calm versus other	Alert and calm versus other
Feature 4: Disorganized Brain	Inconsolability Unawareness of surroundings Sleep-wake cycle disturbance	Sleep-wake cycle disturbance
Validation:		
Specificity (95% CI)	91 (90, 93)	86 (84, 88)
Sensitivity (95% CI)	75 (72, 78)	78 (75, 80)
NPV	86 (84, 88)	86 (85, 88)
PPV	84 (81, 87)	78 (74, 81)

^aThe long-form (research) psCAM-ICU demonstrated high specificity and sensitivity as compared to the reference standard, a child psychiatrist using DSM criteria.

^bThe short-form (clinical) psCAM-ICU is composed of fewer assessment components within both Feature 2 (inattention) and Feature 4 (disorganized brain) based on post-hoc analysis of validation data. Despite fewer components, the short-form maintained high specificity and demonstrated improved sensitivity.

Table 4Pediatric delirium motoric subtypes.^a

	< 2 years	2-5 years	Combined
psCAM-ICU^b			
Hypoactive	80%	84%	81%
Hyperactive	20%	16%	19%
Reference standard^c			
Hypoactive	60%	74%	64%
Hyperactive	7%	5%	7%
Mixed	32%	21%	29%

^aDelirium subtypes are presented as frequencies for patients aged < 2 years, patients 2 – 5 years, and the combined study cohort.

^bIn patients diagnosed with delirium using the psCAM-ICU, the motoric subtype was designated as either hypoactive (RASS 0 to –3) or hyperactive (RASS +1 to +4) based on the sedation scale score.

^cThe reference-rater determined motoric subtypes (hypoactive, hyperactive, or mixed) in all patients with delirium based on observations over time.