Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Relationship Between the Functional Status Scale and the Pediatric Overall Performance Category and Pediatric Cerebral Performance Category Scales

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IMPORTANCE Functional status assessment methods are important as outcome measures for pediatric critical care studies.

OBJECTIVE To investigate the relationships between the 2 functional status assessment methods appropriate for large-sample studies, the Functional Status Scale (FSS) and the Pediatric Overall Performance Category and Pediatric Cerebral Performance Category (POPC/PCPC) scales.

DESIGN, SETTING, AND PARTICIPANTS Prospective cohort study with random patient selection at 7 sites and 8 children's hospitals with general/medical and cardiac/cardiovascular pediatric intensive care units (PICUs) in the Collaborative Pediatric Critical Care Research Network. Participants included all PICU patients younger than 18 years.

MAIN OUTCOMES AND MEASURES Functional Status Scale and POPC/PCPC scores determined at PICU admission (baseline) and PICU discharge. We investigated the association between the baseline and PICU discharge POPC/PCPC scores and the baseline and PICU discharge FSS scores, the dispersion of FSS scores within each of the POPC/PCPC ratings, and the relationship between the FSS neurologic components (FSS-CNS) and the PCPC.

RESULTS We included 5017 patients. We found a significant ($P < .001$) difference between FSS scores in each POPC or PCPC interval, with an FSS score increase with each worsening POPC/PCPC rating. The FSS scores for the good and mild disability POPC/PCPC ratings were similar and increased by 2 to 3 points for the POPC/PCPC change from mild to moderate disability, 5 to 6 points for moderate to severe disability, and 8 to 9 points for severe disability to vegetative state or coma. The dispersion of FSS scores within each POPC and PCPC rating was substantial and increased with worsening POPC and PCPC scores. We also found a significant ($P < .001$) difference between the FSS-CNS scores between each of the PCPC ratings with increases in the FSS-CNS score for each higher PCPC rating.

CONCLUSIONS AND RELEVANCE The FSS and POPC/PCPC system are closely associated. Increases in FSS scores occur with each higher POPC and PCPC rating and with greater magnitudes of change as the dysfunction severity increases. However, the dispersion of the FSS scores indicated a lack of precision in the POPC/PCPC system when compared with the more objective and granular FSS. The relationship between the PCPC and the FSS-CNS paralleled the relationship between the FSS and POPC/PCPC system.

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Morbidity assessments are becoming a more important aspect of pediatric outcomes research, especially in studies with a significant risk for decreased functional status due to neurologic or other processes. Assessing functional status in children is particularly difficult when the method must be suitable for large-scale studies. First, functional status assessments that are reliable at the level of the individual are time-consuming and require considerable training; therefore, they are not practical for large-sample studies.[1-4] Second, methods of pediatric functional status assessment must incorporate the rapidly changing norms of growth and development, making them difficult to design and complex to develop.[5,6]

Two methods of assessing general functional status are suitable for large-scale pediatric studies. The Pediatric Overall Performance Category (POPC) and the Pediatric Cerebral Performance Category (PCPC) scales are qualitative assessments of performance based on the Glasgow Outcome Scale.[7,8] The POPC/PCPC system has been used in large pediatric studies.[8,9] More recently, the Collaborative Pediatric Critical Care Research Network (CPCCRN) developed and validated the Functional Status Scale (FSS), which has the potential advantages of increased objectivity, increased granularity, and greater quantification compared with the POPC/PCPC system.[10]

The aim of this report is to compare prospectively the performance of the POPC/PCPC system and the FSS in more than 5000 patients. Specifically, we investigated the association between POPC/PCPC and FSS scores at baseline and at discharge from the pediatric intensive care unit (PICU), the dispersion of FSS scores within each of the POPC/PCPC ratings, and the relationship between the FSS neurologic components (FSS-CNS) and the PCPC.

Methods

The present investigation was performed in the CPCCRN, which is composed of 7 sites and 8 children's hospitals that admit approximately 17 000 PICU patients per year.[11] Patients from newborns to adolescents (aged <18 years) were randomly selected to a maximum of 4 patients per day per site. We included patients from general/medical and cardiac/cardiovascular PICUs. No separate general surgical or neurologic PICUs were included. This report represents the initial set of 5017 patients from a larger data collection and includes all patients admitted from day 1 of the study (December 4, 2011) to the day when the 5000th patient was enrolled (August 2, 2012). Only the first PICU admission was included. The protocol was approved by the institutional review boards at all participating institutions; informed consent was not required.

Data for this analysis included diagnostic and demographic data and POPC (Supplement [eTable 1]), PCPC (Supplement [eTable 2]), and FSS (Supplement [eTable 3]) scores determined at admission to assess status at baseline (preadmission) and discharge. Researchers (including all the authors), research coordinators, and research assistants were trained in data collection for all scales, with in-person training on multiple occasions. In addition, questions and concerns were addressed during biweekly teleconference calls.

The POPC and PCPC are global scales based on observer impressions. Scores include 1 for good, 2 for mild disability, 3 for moderate disability, 4 for severe disability, and 5 for vegetative state or coma (6 indicates death, but was not included in the study). The FSS is composed of 6 domains (mental status, sensory, communication, motor function, feeding, and respiratory) with scores ranging from 1 (normal) to 5 (very severe dysfunction) for each domain. The operational definitions for the classifications have been published[10]; interrater reliability was very good to excellent. The POPC/PCPC system and the FSS were designed to be amenable to scoring using historical data. The PICU baseline functional status data represented historical data in the medical record, whereas the discharge functional status data were obtained from the medical records and/or the caregivers (nurses, physicians, and therapists) at the discretion of the research personnel, but they did not interact with the patients or families.

The analytic approach for this comparison addressed 3 major issues. First, we assessed the association between the POPC/PCPC and FSS scores at PICU admission (baseline) and discharge. We used these 2 periods to investigate whether the relationships were similar when the data were collected predominantly from the historical record vs in real time. For this analysis, FSS data are expressed as mean (SEM) to better reflect population data. The FSS scores in the POPC/PCPC ratings were compared using Wilcoxon 2-sample rank sum tests, and assessments of association between the POPC and PCPC scores (at each institution and overall) used the Spearman rank correlation. Second, we evaluated the dispersion of FSS scores within each POPC/PCPC rating. The dispersion was assessed by the standard deviation and the percentile ranges of the FSS scores (25th-75th percentile, 10th-90th percentile, and 5th-95th percentile) in the POPC/PCPC ratings. Third, we investigated the potential to decompose the FSS into its predominant neurologic components of mental status and communication (FSS-CNS) and compared this component score with the PCPC score as above. We did not use the motor function domain because it was likely to be influenced by casts, restraints, and traumatic injuries or the sensory domain because it predominantly assessed vision and hearing.

Results

We included 5017 patients, of whom 99 died (2.0% mortality). Each site contributed 12% to 16% of the sample. Patients had a median age of 3.6 (25th-75th percentile, 0.8-10.7) years and stayed in the PICU a median of 2.0 (25th-75th percentile, 1.0-4.8) days. A history of developmental delay was present for 1184 patients (23.6%). The admission physiological systems of primary dysfunction were respiratory (29.9%), cardiovascular (24.9%), neurologic (18.4%), hematology/oncology (4.8%), musculoskeletal (3.6%), gastrointestinal tract (3.1%), endocrine (2.9%), renal (0.9%), and miscellaneous (11.5%). Overall, 3967 patients (79.1%) were admitted to general medical/surgical PICUs, with the remainder admitted to cardiac/cardiovascular PICUs. A total of 1867 patients (37.2%) were admitted for postoperative care. The operative categories were

Table 1. Baseline Functional Status Assessment According to Baseline POPC and PCPC Ratings

Baseline Rating (Score)[a]	No. of Patients	FSS Score				
		Mean (SD)	SEM	Percentile Range (Width)		
				25th-75th	10th-90th	5th-95th
POPC						
Good (1)	2117	6.1 (0.4)	0.01	6-6 (0)	6-6 (0)	6-7 (1)
Mild disability (2)	1522	6.9 (1.6)	0.04	6-7 (1)	6-9 (3)	6-10 (4)
Moderate disability (3)	873	9.1 (3.0)	0.10	6-11 (5)	6-13 (7)	6-15 (9)
Severe disability (4)	471	14.9 (4.2)	0.19	12-18 (6)	10-21 (11)	8-22 (14)
Vegetative state or coma (5)	34	23.6 (3.0)	0.51	22-26 (4)	20-27 (7)	18-28 (10)
PCPC						
Good (1)	3466	6.4 (1.2)	0.02	6-6 (0)	6-7 (1)	6-9 (3)
Mild disability (2)	756	8.2 (2.4)	0.09	6-9 (3)	6-12 (6)	6-13 (7)
Moderate disability (3)	414	10.6 (3.2)	0.16	8-13 (5)	7-15 (8)	6-16 (10)
Severe disability (4)	348	16.1 (3.9)	0.21	13-19 (6)	11-21 (10)	10-23 (13)
Vegetative state or coma (5)	33	23.5 (3.0)	0.52	22-26 (4)	20-27 (7)	18-28 (10)

Abbreviations: FSS, Functional Status Score; PCPC, Pediatric Cerebral Performance Category; POPC, Pediatric Overall Performance Category.

[a] We found a significant ($P < .001$) difference between FSS scores (ranging from 1 [normal] to 5 [very severe dysfunction] in the mental status, sensory, communication, motor function, feeding, and respiratory domains) in each POPC and PCPC interval, with an FSS score increase with each worsening POPC/PCPC rating.

Table 2. PICU Discharge Functional Status Assessment According to PICU Discharge POPC and PCPC Ratings for Hospital Survivors

Discharge Rating (Score)[a]	No. of Patients	FSS Score				
		Mean (SD)	SEM	Percentile Range (Width)		
				25th-75th	10th-90th	5th-95th
POPC						
Good (1)	1467	6.5 (1.0)	0.03	6-7 (1)	6-8 (2)	6-9 (3)
Mild disability (2)	1903	7.4 (1.8)	0.04	6-8 (2)	6-10 (4)	6-11 (5)
Moderate disability (3)	984	9.6 (2.9)	0.09	7-11 (4)	6-13 (7)	6-15 (9)
Severe disability (4)	523	15.3 (4.1)	0.18	13-18 (5)	10-21 (11)	9-23 (1)
Vegetative state or coma (5)	41	24.2 (3.2)	0.51	23-27 (4)	20-28 (8)	20-28 (8)
PCPC						
Good (1)	3096	7.0 (1.6)	0.03	6-8 (2)	6-9 (3)	6-10 (4)
Mild disability (2)	973	8.6 (2.5)	0.08	6-10 (4)	6-12 (6)	6-14 (8)
Moderate disability (3)	436	11.2 (3.2)	0.15	9-13 (4)	7-16 (9)	7-17 (1)
Severe disability (4)	372	16.5 (3.8)	0.19	14-19 (5)	12-21 (9)	11-23 (12)
Vegetative state or coma (5)	41	24.2 (3.2)	0.51	23-27 (4)	20-28 (8)	20-28 (8)

Abbreviations: FSS, Functional Status Score; PCPC, Pediatric Cerebral Performance Category; PICU, pediatric intensive care unit; POPC, Pediatric Overall Performance Category.

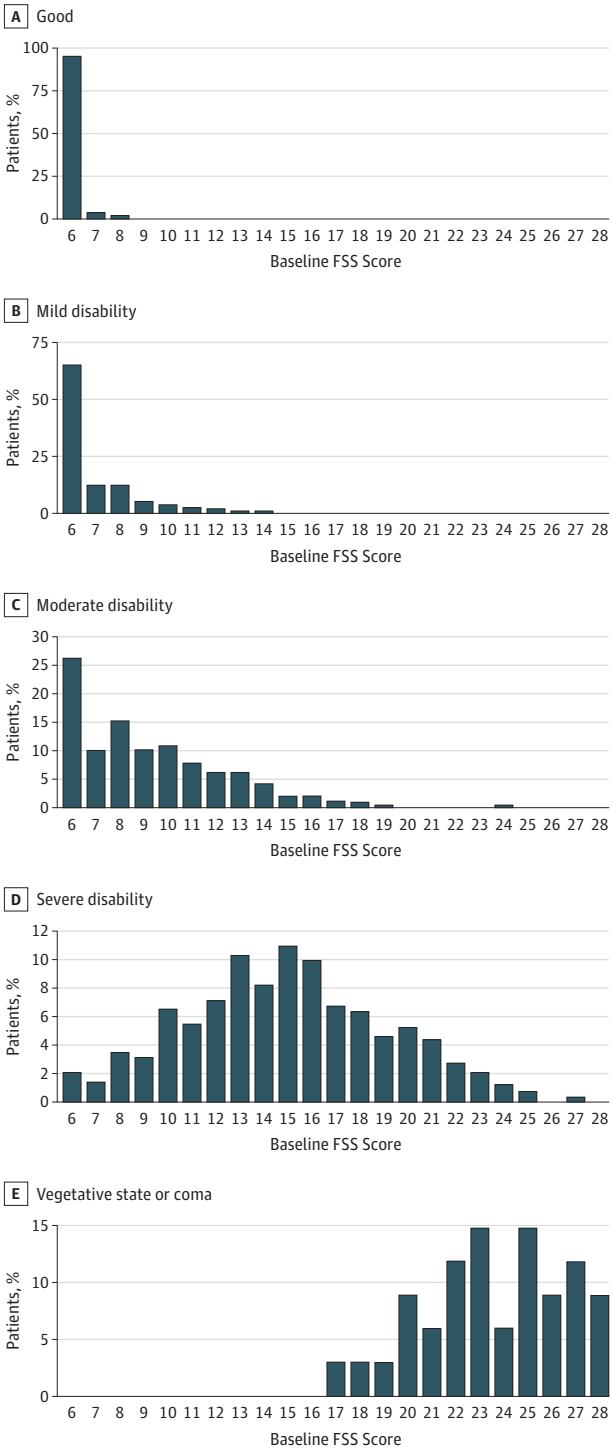
[a] We found a significant ($P < .001$) difference between FSS scores (ranging from 1 [normal] to 5 [very severe dysfunction] in the mental status, sensory, communication, motor function, feeding, and respiratory domains) in each POPC and PCPC interval, with an FSS score increase with each worsening POPC/PCPC rating.

cardiac (33.9%); neurosurgical (18.9%); ear, nose, and throat (15.3%); orthopedic (9.7%); general surgery (9.4%); interventional catheterizations (3.6%); and miscellaneous (9.2%).

The relationships between the baseline POPC/PCPC and FSS scores determined at PICU admission are shown in **Table 1**. Similarly, the relationship between discharge POPC/PCPC and FSS scores are shown in **Table 2**. Mean FSS scores for the good and mild disability categories were very similar and increased by 2 to 3 points for the POPC/PCPC change from mild to moderate disability, 5 to 6 points for the moderate to severe disability change, and 8 to 9 points for severe disability to vegetative state or coma. We found a significant ($P < .001$) difference between FSS scores in each POPC or PCPC interval, with an increase in FSS score in each worsening POPC/PCPC rating. The SEMs for the FSS scores reflect the mean population distributions. The FSS scores at discharge were slightly higher than the corresponding baseline FSS scores ($P < .05$ for all comparisons) for the POPC and PCPC ratings. In general, the difference between mean FSS scores in the POPC/PCPC ratings increased as the POPC/PCPC ratings worsened.

The dispersion of FSS scores within each POPC and PCPC rating was generally greater with worsening POPC and PCPC scores. This dispersion is shown as the range and the width of the range in Tables 1 and 2. For example, in the 10th to 90th percentile range for all baseline and discharge POPC and PCPC

Figure. Baseline Functional Status Scale (FSS) Scores in Each Pediatric Overall Performance Category (POPC) Rating



The vertical axes show the percentages of patients with the indicated FSS score for each POPC rating. Table 1 shows the total number of patients in each POPC rating. POPC ratings include good (A), mild disability (B), moderate disability (C), severe disability (D), and vegetative state or coma (E). Overall possible FSS scores range from 6 to 30; separate scores range from 1 (normal) to 5 (very severe dysfunction) in each of 6 FSS domains (mental status, sensory, communication, motor function, feeding, and respiratory).

Table 3. FSS-CNS for Baseline and PICU Discharge PCPC Score[a]

Baseline PCPC Score	Baseline FSS-CNS Score, Mean (SEM)	Discharge PCPC Score	Discharge FSS-CNS Score, Mean (SEM)
1	2.0 (<0.01)	1	2.1 (0.01)
2	2.6 (0.03)	2	2.6 (0.03)
3	3.3 (0.06)	3	3.3 (0.06)
4	5.1 (0.10)	4	5.2 (0.10)
5	8.5 (0.26)	5	8.8 (0.22)

Abbreviations: FSS-CNS, Functional Status Scale neurologic components; PCPC, Pediatric Cerebral Performance Category; PICU, pediatric intensive care unit.

[a] The PCPC scores are described in Tables 1 and 2. We found a significant ($P < .001$) difference between FSS-CNS scores in each PCPC interval, with an FSS score increase with each worsening PCPC category.

scores, dispersions of 0 to 3 FSS points in the POPC/PCPC good rating, 3 to 6 FSS points in the POPC/PCPC mild disability rating, 7 to 9 FSS points in the POPC/PCPC moderate disability rating, 9 to 11 FSS points in the POPC/PCPC severe disability rating, and 7 to 8 FSS points in the POPC/PCPC vegetative state or coma rating were found. Overall, we measured more than a 3-fold increase in the FSS scores from the good to the vegetative state or coma ratings. The dispersion of PICU baseline FSS scores within the PICU baseline POPC ratings is illustrated in the **Figure** and shows the increased dispersion of FSS scores as POPC ratings progress from good to clinically worse conditions, consistent with the larger standard deviations of the FSS scores in the worse categories.

To further investigate the consistency of the POPC-PCPC relationship, we correlated the POPC with the PCPC overall and at each site. The overall Spearman rank correlation of the PICU baseline POPC and PCPC scores was 0.69 and ranged from 0.54 to 0.98 at each site. The overall correlation of the PICU discharge POPC and PCPC scores was 0.68 and ranged from 0.54 to 0.99 at each site.

Finally, we investigated the association of the FSS-CNS score with the PCPC ratings. **Table 3** shows the FSS-CNS scores for the baseline and discharge PCPC ratings. We found a strong statistical difference ($P < .001$) in FSS scores among each of the PCPC ratings, with increases in the FSS-CNS for each worsening PCPC category. A greater similarity in the PICU baseline and discharge FSS-CNS scores was found compared with the full FSS score.

Discussion

The 2 methods suitable for assessing general functional status in large-scale pediatric studies are the POPC/PCPC system and the FSS. The POPC/PCPC system was developed first and has more widespread use.[7,8,12] These scales are global assessments of patients and have good face and content validity, because they were a pediatric adaptation of the Glasgow Outcome Scale widely used in adult medicine.[13] Initial statistical validation consisted of correlating changes in the POPC/PCPC ratings during PICU illness with severity of illness and length of stay.[7] The initial

assessment of interrater agreement was good, although the initial study had predominantly a single POPC/PCPC functional category.[7] A larger POPC/PCPC report found that interrater agreement was good, but only if it included ratings in the "neighboring class."[8] For example, ratings of normal and moderate disability are neighbors of mild disability and moderate disability and vegetative state or coma are neighbors of severe disability. Almost immediately after the initial publication, the potential for lack of precision of the POPC/PCPC scales surfaced, suggesting this system would enable investigators to detect only major health care changes and would be especially limited in young children.[14] Subsequent validation of the POPC and PCPC scales included the correlation of the discharge scores with more specific neuropsychological tests, namely the Bayley Mental Developmental Index, the Bayley Psychomotor Developmental Index, the Stanford Binet Intelligence Quotient, and a follow-up telephone-administered Vineland Adaptive Behavior Scale.[12] These studies demonstrated statistically significant differences in the means of these metrics among the POPC/PCPC ratings, but the variability of the more specific neuropsychological tests within each of the POPC/PCPC ratings was very large. This result indicated the POPC/PCPC system lacked precision and suggested that very large samples might be necessary if these scales were used as outcome variables in pediatric studies.

The second general functional status assessment method suitable for large-scale pediatric studies is the FSS.[10] The CPCCRN developed this scale as an objective and granular function status assessment based on a consensus approach of multiple disciplines of pediatric health care providers and validated it against the Adaptive Behavior Assessment Scale II, a validated measure of adaptive behavior.[10] The CPCCRN designed the FSS to be an objective, granular, relatively rapid, and reliable method to measure functional status and to improve the potential for using morbidity assessed through changes in functional status as an outcome measure in large-scale studies. Objectives for its development included not only content validation, but also age independence, relatively rapid patient assessment, and excellent interrater reliability. Its assessment in the present study varied from the original validation in that the admission data were not obtained by direct observation and the discharge data were obtained by examination of the medical records and observations by medical personnel. The FSS is currently being used in a study of more than 10 000 PICU patients in the CPCCRN network. The FSS was not developed to substitute for more patient-specific but greater time-consuming measures of functional status, and it does not measure quality of life.[1-5,15-19]

This study demonstrates that the FSS and the POPC/PCPC methods correlate very well. Their relationship was almost identical in the admission and discharge assessments. The FSS score increases with each higher POPC and PCPC score and it increases with greater magnitudes of change as the dysfunction becomes more severe. That is, we found a relatively small change of only 2 to 3 FSS points for the POPC/PCPC change from mild to moderate disability, a larger change of 5 to 6 FSS points for moderate to severe disability, and an even larger change of 8 to 9 FSS points for severe disability to vegetative state or coma.

However, as we suspected from the early POPC/PCPC studies, the dispersion of the FSS scores increased with increasing POPC/PCPC scores. Within the good and mild ratings, little dispersion occurred in the FSS scores but the dispersion became substantial with the moderate and severe disability and vegetative state or coma rating. This finding suggests increasing lack of precision in the POPC/PCPC system, in which the criteria determining mild, moderate, and severe disability require significant clinical judgment. The FSS has precise, objective definitions for all categories, largely eliminating the requirement for clinical judgment. This difference is also consistent with the variability in the institutional correlations of the POPC and PCPC scores.

Outcome studies of pediatric intensive care are expanding their focus beyond mortality to include functional status, quality of life, and other outcomes.[20-24] This expansion is important and justified. During the last several decades, the focus of pediatric intensive care has transitioned from saving lives to saving better, more functional lives. Therefore, more emphasis is needed on measuring outcomes that measure morbidity. This emphasis is especially true in quality studies in which mortality has decreased enough to make it a relatively uncommon outcome and more and more emphasis is placed on reducing morbidity. The pediatric critical care community's facility to keep up with this transition will be related directly to our ability to measure the right outcome. In this study, the FSS score significantly increased with each POPC/PCPC rating. More important, the increase paralleled the importance of the functional status change with increasing changes in FSS score as the categories became more clinically severe. The overall change in FSS score was more than 300% from good to the most severe POPC/PCPC ratings, indicating that the FSS could become a useful method to detect change in functional status in descriptive or interventional studies.

Conclusions

The FSS is a clear and easily learned measure of functional status suitable for use in large pediatric studies. The FSS has the potential to facilitate a significant advance in pediatric critical care outcomes research. Using the FSS, researchers might better describe the outcomes of critical care, increase the number of studies by making measurement of functional outcomes practical, and enable larger outcome studies that include functional status.

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