Subjective Global Nutritional Assessment for children

Donna J Secker and Khursheed N Jeejeebhoy

ABSTRACT

Background: Subjective Global Assessment (SGA), a method of nutritional assessment based on clinical judgment, has been widely used to assess the nutritional status of adults for both clinical and research purposes.

Objective: Foreseeing benefits of its use in children, we chose to adapt SGA and test its validity and reproducibility in the pediatric population.

Design: We prospectively evaluated the preoperative nutritional status of 175 children (aged 31 d to 17.9 y) having major thoracic or abdominal surgery with the use of Subjective Global Nutritional Assessment (SGNA) and commonly used objective measurements. Each child underwent nutritional assessment by 2 independent assessors, one performing measurements of anthropometrics and handgrip strength and one performing SGNA. To test interrater reproducibility, 78 children had SGNA performed by a third assessor. Occurrence of nutrition-associated complications was documented for 30 d postoperatively.

Results: SGNA successfully divided children into 3 groups (well nourished, moderately malnourished, severely malnourished) with different mean values for various anthropometric and biochemical measures ($P < 0.05$). Malt nourished children had higher rates of infectious complications than did well-nourished children ($P = 0.042$). Postoperative length of stay was longer for malnourished children ($8.2 \pm 10$ d) than for well-nourished children ($5.3 \pm 5.4$ d) ($P = 0.002$). No objective nutritional measures showed association with outcomes, with the exception of serum albumin, which was not clinically predictive because mean concentrations were in the normal range irrespective of the presence or absence of complications.


KEY WORDS Malnutrition, children, surgery, nutritional assessment, Subjective Global Assessment, SGA, outcomes

INTRODUCTION

Current methods of assessing nutritional status in children rely on a combination of objective anthropometric, dietary, biochemical, and immunologic measures. Although epidemiologically useful, these measures have several shortcomings that hamper their effectiveness in clinical practice, and no single objective marker has the sensitivity and specificity to be a reliable index of protein-energy malnutrition or predictive of nutrition-related complications (1–5).

Almost 25 y ago, Baker et al (6) published a study showing that nutritional assessment using clinical judgment was a reproducible and valid technique for evaluating the nutritional status of adults. With the use of a Bayesian analysis of pretest and posttest probabilities they showed that a structured clinical approach, called Subjective Global Assessment (SGA), was able to predict nutrition-associated complications (NACs; ie, infections, use of antibiotics, length of stay) better than serum albumin, transferrin, delayed cutaneous hypersensitivity, the Prognostic Nutrition Index, creatinine-height index, triceps skinfold thickness, and various combinations of these measures (7–10). The method of SGA was since refined (11, 12) and was applied and validated internationally for clinical, epidemiologic, and research purposes (13–20).

We hypothesized that SGA could be adapted to identify pre-surgical malnutrition and to predict postsurgical nutrition-associated morbidities that lead to prolonged hospital stay in pediatric patients. The adapted version was called Subjective Global Nutritional Assessment (SGNA). We then performed a prospective cohort study to determine whether SGNA could better predict NACs and length of hospital stay than current objective methods of pediatric nutritional assessment.

SUBJECTS AND METHODS

Subjects

Consecutive children scheduled for surgery by surgeons in the Division of General Surgery at The Hospital for Sick Children, a large pediatric academic health science center located in Toronto, Canada, were considered for the study. Children were deemed eligible if they were aged 31 d to 17.9 y, required major abdominal or noncardiac thoracic surgery on a nonemergency basis, University of Toronto, Toronto, Canada (DJS), and the Division of Gastroenterology, St Michael’s Hospital and the Institute of Medical Sciences, University of Toronto, Toronto, Canada (KNJ).

2 Supported by the Canadian Foundation for Dietetic Research, the Canadian Institutes of Health Research (CIHR) Doctoral Research Award (DJS), the CIHR Clinician Scientist Training Program in Clinical Nutrition (DJS), and the Hospital for Sick Children Research Institute Research Training Centre (Restracomp) (DJS). CDC growth charts were provided by Abbott Laboratories, Ltd.

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Study design

Five staff dietitians served as assessors for the study after training for standardized performance of objective measurements and the SGNA. Study results are not based on a single assessor but are a composite of the data from the 5 different assessors, who performed the assessments in random order. Each child underwent nutritional assessment by 2 independent assessors blinded to the results of the other, one performing measurements of anthropometrics and handgrip strength, and one performing the SGNA. To test interrater reproducibility of the SGNA, a subset of 78 children were seen by a third assessor who also performed the SGNA. Nutritional assessments were performed the day before surgery for prior-day admissions or inpatients and the morning of surgery for same-day admissions; assessments took place in the Clinical Investigation Unit, the patient’s individual hospital room, or the General Surgery Same-Day Admission Unit. A blood sample for measurement of serum albumin and transferrin was obtained coincidental with routine preoperative blood work (ie, complete blood count) or by the anesthetist at the time of intravenous induction. Children were followed in a purely observational fashion, from the day of surgery until 30 d after surgery, for the development of nutrition-associated infectious and noninfectious morbidities related to their surgical procedure. Medical and surgical risk factors that might influence the occurrence of complications and outweigh nutritional risk were documented. Data were accrued prospectively and entered into a database (MICROSOFT ACCESS 2000, version 9.0; Microsoft Corp, Redmond, WA) and then partially exported to NUTSTAT (Epi Info, version 3.3.2; Centers for Disease Control and Prevention, Atlanta, GA) for calculation of age, body mass index (in kg/m²), and anthropometric z scores. Analyses compared the ability of SGNA and anthropometric and biochemical measures to identify malnourished children and those at increased risk of developing complications, as well as the rate of agreement between the pairs of dietitians who performed SGNA on the same child.

Objective nutritional assessment

We examined the following objective markers of nutritional status: length or height; weight; percentage of ideal body weight for height; body mass index-for-age; midarm circumference; triceps skinfold thickness; midarm muscle area; handgrip strength; concentrations of serum albumin, transferrin, and hemoglobin; and total lymphocyte count. Prealbumin measurement was unavailable at our center and therefore was not included. Measurements were performed with the use of calibrated equipment and standardized techniques (21–23). Anthropometric z scores were calculated with the use of NUTSTAT anthropometric software package (Epi Info, version 3.2.2; Centers for Disease Control and Prevention) (24) or common reference data (25, 26). Preterm infants (n = 22) were assessed with the use of corrected age up to age 2 y.

Biochemical analysis was performed by the hospital’s Department of Pediatric Laboratory Medicine with the use of the bromocresol green dye–binding method for serum albumin and immunonephelometry for serum transferrin. The z scores for hemoglobin and transferrin were calculated from data from the American National Health and Nutrition Examination Survey (27).

Outcome measures

Patients were followed for 30 d after surgery for the development of NACs related to their surgical procedure. Complications were subdivided into infectious and noninfectious complications, as well as major and minor complications, according to published objective criteria (28–31). Secondary outcomes were length of postoperative hospitalization, use of nonprophylactic antibiotics, and unplanned rates of reoperation and readmission. Monitoring after discharge continued until 30 d after surgery and occurred by either a routine follow-up clinic visit or telephone interview shortly thereafter.

Statistical analyses

According to previous observations (6, 32), we planned to enroll 175 children for the study to have the capacity to detect a 3-fold difference in incidence of postoperative complications between the malnourished and well-nourished groups (two-sided α level: <0.05; β level: 0.8). To examine the relation among SGNA and individual objective measurements, means of the objective measures for the 3 groups defined by SGNA were
tested with analysis of variance or the Kruskal-Wallis nonparametric test and Tukey’s honest significant difference or the Mann-Whitney nonparametric test for post hoc analysis. Associations among numerical equivalents of the SGNA groups with objective measures were tested by correlation analysis (Kendall’s τ). Correlation analysis (Kendall’s τ) and multinomial logistic regression were used to explore the relation of individual components of SGNA with the final SGNA rating. The association between SGNA and clinical morbidity was tested with the use of the chi-square test or Kendall’s τ test for categorical variables and the Kruskal-Wallis and Mann-Whitney U nonparametric tests for length of stay. Relations between objective measures of nutritional status and morbidities were examined by the Student’s t test, Mann-Whitney U nonparametric test, or correlation analysis (Kendall’s τ).

Analysis was performed with the use of SPSS 14.0 for WINDOWS GRADPACK (SPSS Inc, Chicago, IL). Data collection, entry, and analysis were performed by the principal author (DJS). Results are reported as means ± SDs, unless stated otherwise. Results were considered significant at \( P < 0.05 \).

RESULTS

Between February 2003 and August 2004, 180 children were enrolled and completed the study. One hundred seventy-five children (99 males, 76 females) ranging in age from 31 d to 17.9 y \((\bar{x} ± SD: 8.1 ± 6.1 \text{ y})\) made up the final study group. Although heterogeneous in terms of age, distribution by age group was fairly even (Table 1). Data from 5 children were excluded from final analysis for either discharge within 24 h of surgery \((n = 4)\) or preemptive surgery before the assessments were completed \((n = 1)\). Because of an outbreak of severe acute respiratory syndrome, study activity was held for an 8-wk period between March and May 2003.

Almost half of the children \((n = 80, 46\%)\) had one or more disease processes or anomalies \(\text{[eg, inflammatory bowel disease; Hirschsprung disease; vertebral, anal, cardiac, tracheal, esophageal, renal, and limb anomalies (VACTERL association; a random association of birth defects); cerebral palsy; Down syndrome; cystic fibrosis; sickle cell disease].}\) Sixteen children \(\text{(9\%)}\) had cancer. On a 6-point scale of medical complexity \(\text{[American Society of Anesthesiologists (ASA) classification of physical status score (33)]}, with 1 being the lowest complexity and 6 being the highest, the majority of children were rated preoperatively by the anesthetist as either ASA 2 \((47\%)\) or ASA 3 \((32\%).\) All but 8 children \((5\%)\) received prophylactic antibiotics before surgery. The most commonly performed surgical procedures are listed in Table 1. Distribution of surgical procedures classified by risk of microbial infection \(\text{(clean, clean-contaminated, contaminated, dirty) did not differ across the 3 SGNA groups \((P = 0.88)\) nor did the proportion of children with cancer \((P = 1.0)\).}\)

**Concurrent validity of SGNA**

Nutritional status, as determined by SGNA, was compared with objective measurements. With the use of SGNA, 85 children \((49\%)\) were classified as well-nourished, 64 children \((36\%)\) were classified as moderately malnourished, and 26 children \((15\%)\) as severely malnourished. The 3 groups of children had mean ages that did not differ, but they had significantly different mean values for 7 of the 8 anthropometric measures, including handgrip strength and serum albumin, but not transferrin, hemoglobin, or total lymphocyte count (Table 2). It should be noted that, although the mean serum albumin concentrations of the 3 groups of children classified by SGNA were statistically different, they were not clinically different in that even the lowest mean serum albumin \(\text{(ie, the severely malnourished group,} 38 ± 7 \text{ g/L})\) fell well within the hospital’s normal reference range. SGNA, with the use of numerical equivalents of the clinical groups, showed moderate-to-fair correlation with all of the objective anthropometric and biochemical measurements of nutritional status, except transferrin \(z\) score and total lymphocyte count (Table 2). Handgrip strength, as a surrogate marker of muscle function and impaired functional status, decreased with worsening nutritional status \((P = 0.001)\).

**Predictive validity of SGNA**

Seventy children had at least one complication, experiencing 97 complications in total; no deaths occurred. The majority of complications were infectious in origin \((80\%)\), with an equal percentage being major \((49\%)\) or minor \((51\%)\) in nature. Occurrence of complications did not differ by sex or by age, with the

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**TABLE 1**

Characteristics of the study population \((n = 175)\)

<table>
<thead>
<tr>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td><strong>Sex ([n (%)])</strong></td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td><strong>Age (y)</strong></td>
</tr>
<tr>
<td>31 d–2 y ([n (%)])</td>
</tr>
<tr>
<td>2–5 y ([n (%)])</td>
</tr>
<tr>
<td>5–12 y ([n (%)])</td>
</tr>
<tr>
<td>12–18 y ([n (%)])</td>
</tr>
<tr>
<td><strong>ASA score ([n (%)])</strong></td>
</tr>
<tr>
<td>1) Normally healthy patient</td>
</tr>
<tr>
<td>2) Patient with mild systemic disease</td>
</tr>
<tr>
<td>3) Patient with severe systemic disease that is not incapacitating</td>
</tr>
<tr>
<td>4) Patient with incapacitating systemic disease that is a constant threat to life</td>
</tr>
<tr>
<td>5) Moribund patient not expected to survive for 24 h with or without operation</td>
</tr>
<tr>
<td>6) Patient declared brain dead whose organs are being removed for donation</td>
</tr>
<tr>
<td><strong>Primary surgical procedures ([n (%)])</strong></td>
</tr>
<tr>
<td>Bowel resection, abdominal pull-through, ostomy closure</td>
</tr>
<tr>
<td>Excision of tumors and cysts</td>
</tr>
<tr>
<td>Cholecystectomy</td>
</tr>
<tr>
<td>Fundoplication</td>
</tr>
<tr>
<td>Interval appendectomy</td>
</tr>
<tr>
<td>Pectus repair</td>
</tr>
<tr>
<td>Lung lobectomy</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

\(1\) ± SD; range in parentheses.

\(2\) American Society of Anesthesiologists (ASA) classification of physical status score (32). Higher score reflects more severe illness. Eighteen of 175 children did not have an ASA score recorded by the anesthetist.
TABLE 2
Relation between Subjective Global Nutritional Assessment (SGNA) and anthropometric measures of nutritional status

<table>
<thead>
<tr>
<th>SGNA classification</th>
<th>No. of subjects</th>
<th>Well nourished</th>
<th>Moderately malnourished</th>
<th>Severely malnourished</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td></td>
<td></td>
<td></td>
<td>P^2</td>
</tr>
<tr>
<td>Age (y)</td>
<td>175</td>
<td>8.3 ± 6.2 (85)^a</td>
<td>8.2 ± 6.2 (64)</td>
<td>7.2 ± 6.0 (26)</td>
<td>0.621</td>
</tr>
<tr>
<td>Weight-for-age (z score)</td>
<td>175</td>
<td>0.12 ± 1.20 (85)</td>
<td>-0.68 ± 1.23^b (64)</td>
<td>-1.88 ± 1.18 (26)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Height-for-age (z score)</td>
<td>175</td>
<td>0.06 ± 1.13 (85)</td>
<td>-0.51 ± 1.22^b (64)</td>
<td>-1.47 ± 1.57^b (26)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Ideal body weight (%)</td>
<td>175</td>
<td>103.1 ± 16.0 (85)</td>
<td>98.3 ± 17.2^b (64)</td>
<td>92.0 ± 14.8^b (26)</td>
<td>0.002</td>
</tr>
<tr>
<td>BMI-for-age (z score)</td>
<td>124</td>
<td>0.25 ± 1.15 (59)</td>
<td>-0.30 ± 1.25^b (47)</td>
<td>-1.21 ± 1.15^b (18)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Midarm circumference (z score)</td>
<td>154</td>
<td>0.25 ± 3.8 (76)</td>
<td>-0.52 ± 1.07^b (58)</td>
<td>-1.28 ± 0.81^b (20)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Tricep skinfold thickness (z score)</td>
<td>135</td>
<td>0.35 ± 4.3 (67)</td>
<td>-0.10 ± 0.84 (51)</td>
<td>-0.38 ± 0.73 (19)</td>
<td>0.065</td>
</tr>
<tr>
<td>Midarm muscle area (z score)</td>
<td>137</td>
<td>0.11 ± 1.17 (67)</td>
<td>-0.55 ± 1.09^b (51)</td>
<td>-1.27 ± 0.82^b (19)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Handgrip (z score)</td>
<td>91</td>
<td>-0.69 ± 1.38 (49)</td>
<td>-1.22 ± 0.96^c (32)</td>
<td>-2.12 ± 0.99^c (10)</td>
<td>0.001</td>
</tr>
<tr>
<td>Albumin (g/L)</td>
<td>171</td>
<td>41 ± 4^a (83)</td>
<td>40 ± 6^a (62)</td>
<td>38 ± 7 (26)</td>
<td>0.027</td>
</tr>
<tr>
<td>Transferrin (z score)</td>
<td>109</td>
<td>0.24 ± 1.47 (55)</td>
<td>0.46 ± 2.05 (39)</td>
<td>0.22 ± 1.75 (15)</td>
<td>0.925</td>
</tr>
<tr>
<td>Hemoglobin (z score)</td>
<td>154</td>
<td>-0.46 ± 1.60 (76)</td>
<td>-1.03 ± 1.87 (56)</td>
<td>-1.19 ± 2.08 (22)</td>
<td>0.100</td>
</tr>
<tr>
<td>Total lymphocyte count (×10^3/L)</td>
<td>110</td>
<td>4.3 ± 3.1 (49)</td>
<td>3.9 ± 3.3 (42)</td>
<td>4.2 ± 3.4 (19)</td>
<td>0.681</td>
</tr>
</tbody>
</table>

^1 Values in the same row with different superscript letters are significantly different, P < 0.05 (Tukey’s honestly significant difference or Mann-Whitney nonparametric test, as appropriate).
^2 P values were determined with the use of ANOVA or the Kruskal-Wallis nonparametric test.
^3 Kendall’s τ correlation coefficient was used for ordinal data.
^4 ± SD; n in parentheses (all such values).

exception of minor complications, which occurred more often in younger children. A breakdown of complications is provided in Table 3. Children identified by SGNA as malnourished (mod-erately or severely) experienced a higher rate of infectious complications (P = 0.04) and minor (infectious and noninfectious) complications (P = 0.03) compared with children classified as well-nourished (Table 4).

Postoperative length of stay was more than twice as long for severely malnourished children (19.0 ± 58.8 d) compared with well-nourished (5.3 ± 5.4 d) and moderately malnourished (8.4 ± 11.1 d) children (P = 0.002, Kruskal-Wallis nonparametric test). Mean postoperative hospitalization for severely malnourished children was skewed by 1 child whose postoperative stay was 306 d. Although unusual, an extreme length of stay such as this does occur in malnourished patients and was not seen in

TABLE 3
Breakdown of postoperative complications

<table>
<thead>
<tr>
<th>No. of episodes</th>
<th>Children n (% of sample)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major infectious complication</td>
<td>39 36 (21)</td>
</tr>
<tr>
<td>Bacteremia or fungemia</td>
<td>4</td>
</tr>
<tr>
<td>Clinical sepsis</td>
<td>2</td>
</tr>
<tr>
<td>Severe surgical site infection (deep incisional, organ, or space)</td>
<td>5</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>8</td>
</tr>
<tr>
<td>Significant surgical site infection (superficial incisional)</td>
<td>18</td>
</tr>
<tr>
<td>Major symptomatic urinary tract infection</td>
<td>1</td>
</tr>
<tr>
<td>Major febrile atelectasis</td>
<td>1</td>
</tr>
<tr>
<td>Major noninfectious complication</td>
<td>9 9 (5)</td>
</tr>
<tr>
<td>Anatomastic stricture</td>
<td>1</td>
</tr>
<tr>
<td>Gastrointestinal bleeding</td>
<td>1</td>
</tr>
<tr>
<td>Gastrointestinal obstruction</td>
<td>6</td>
</tr>
<tr>
<td>Persistent air leak</td>
<td>1</td>
</tr>
<tr>
<td>Minor infectious complication</td>
<td>39 37 (21)</td>
</tr>
<tr>
<td>Gastroenteritis</td>
<td>12</td>
</tr>
<tr>
<td>Secondary surgical site infection (superficial incisional)</td>
<td>9</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>4</td>
</tr>
<tr>
<td>Eye, ear, nose, throat, mouth infection</td>
<td>4</td>
</tr>
<tr>
<td>Lower respiratory tract infection</td>
<td>2</td>
</tr>
<tr>
<td>Skin infection (ie, candida)</td>
<td>2</td>
</tr>
<tr>
<td>Minor early sepsis</td>
<td>6</td>
</tr>
<tr>
<td>Minor noninfectious complication</td>
<td>10 8 (5)</td>
</tr>
<tr>
<td>Atelectasis</td>
<td>5</td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>5</td>
</tr>
</tbody>
</table>

TABLE 4
Relation between malnutrition and outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Group (^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infectious complications (^2)</td>
<td>24 (28) 39 (43) 0.042</td>
</tr>
<tr>
<td>Noninfectious complications (^2)</td>
<td>7 (8) 10 (11) 0.614</td>
</tr>
<tr>
<td>Major complications (^2)</td>
<td>16 (19) 27 (30) 0.114</td>
</tr>
<tr>
<td>Minor complications (^2)</td>
<td>14 (17) 28 (31) 0.033</td>
</tr>
<tr>
<td>Nonprophylactic antibiotic use (^2)</td>
<td>27 (32) 34 (38) 0.404</td>
</tr>
<tr>
<td>Unplanned reoperation (^2)</td>
<td>5 (6) 7 (6) 0.831</td>
</tr>
<tr>
<td>Unplanned readmission (^2)</td>
<td>5 (6) 12 (13) 0.096</td>
</tr>
<tr>
<td>Postoperative length of stay (d) (^2)</td>
<td>5.3 ± 5.4 8.2 ± 10 0.001</td>
</tr>
</tbody>
</table>

^1 Data presented as the number of children with that outcome; % within nutritional classification in parentheses.
^2 P values were determined with the use of Pearson chi-square test for all outcomes except postoperative length of stay, which was tested with the Mann-Whitney nonparametric test for independent means.
^3 ± SD; 1 child with severe malnutrition and a postoperative stay of 306 d was removed from this analysis as an extreme outlier.
our well-nourished population. When this child was excluded as an extreme outlier, the overall difference in mean stay across the 3 groups remained significant (P = 0.02, Kruskal-Wallis). When the moderately and severely malnourished children were grouped together, mean length of postoperative hospitalization was 2.9 d (55%) longer than for the well-nourished children (P = 0.001) (Table 4). The percentages of children receiving nonprophylactic antibiotics or requiring unplanned reoperation or readmission were not significantly different between the well-nourished and malnourished children (Table 4).

No association was observed among any of the objective measures of nutritional status and outcomes, with the exception of height-for-age and postoperative length of stay (r = −0.18, P = 0.001), and serum albumin, which was associated with infectious (no complication, 41.4 ± 4.5 g/L; complication, 38.2 ± 5.9 g/L; P < 0.001) and minor (no complication, 40.8 ± 5.2 g/L; complication, 38.6 ± 5.3 g/L; P = 0.01) complications, postoperative length of stay (r = −0.20, P < 0.001), and use of nonprophylactic antibiotics (no antibiotic, 41.4 ± 4.5 g/L; antibiotic, 38.2 ± 5.9 g/L; P < 0.001). However, it must be emphasized that mean serum albumin concentrations were within the normal reference range for all 3 nutritional groups; therefore, serum albumin was clinically not useful in identifying malnutrition or predicting outcomes.

**Interobserver reproducibility of SGNA**

Interrater agreement occurred in 44 (56%) of 78 children having duplicate SGNA assessments (unweighted κ: 0.28). This represents only fair agreement between the assessors (34, 35). More discrepancies occurred between classifications of normal-to-moderate malnutrition (22 of 34; 65%) than moderate-to-severe malnutrition (11 of 34; 32%).

**Individual components of SGNA and their contribution to the overall SGNA rating**

Each of the individual historical and physical characteristics was univariately correlated with the overall SGNA ratings. For infants and toddlers, the individual SGNA components that most influenced the overall SGNA rating were physical signs of wasting, gastrointestinal symptoms, and the metabolic stress of the underlying disease. For the older age groups, controlling for age, the most influential components were physical evidence of fat wasting, serial weight loss, gastrointestinal symptoms, and stunting of height.

**DISCUSSION**

This study shows that SGNA is capable of identifying malnutrition, NACs, and increased length of stay in hospitalized children. As such, it is a useful clinical tool that links nutritional status to outcome and distinguishes children at risk of an adverse outcome and prolonged hospitalization. Although serum albumin showed a significant relation to the occurrence of complications, it was abnormal in only 11 children and was clinically nondiscriminatory because the mean concentrations for the 3 nutritional groups were in the normal range.

The relation of SGNA with commonly used objective measurements of nutritional status was as good as that reported in studies of SGA in adult surgical patients (6, 10, 36). A commonly overlooked marker of nutritional status is functional capacity and muscle power (37). With the use of maximal handgrip strength as a surrogate measure of muscle function, we showed that malnourished children had physical evidence of lower functional capacity than did children who were well nourished, a relation not previously shown. Hand dynamometry was easy to perform and the children enjoyed testing their strength.

Children classified by SGNA as malnourished experienced more frequent infectious complications than well-nourished children as well as more minor infectious and noninfectious complications combined. None of the objective anthropometric or biochemical markers of nutritional status, aside from albumin, showed association with complications or other morbidity. Others have also found a lack of association with biochemical markers of visceral proteins or immune function that have been said to be useful techniques of assessing nutritional status (6, 36) but are now thought to be indicators of inflammation or infection rather than malnutrition (1, 38, 39).

The finding of longer postoperative stays for children identified by SGNA as malnourished is particularly important because extended hospitalization translates into increased hospital costs where, at our center, the average cost of an inpatient day on the general surgery ward is $587. On the basis of the lengths of postoperative stay observed in this study, the average malnourished child would stay 2.9 d (55%) longer than a well-nourished child and generate added costs of $1702. Adult studies have also reported significantly longer postoperative hospitalization for malnourished persons (6, 40–42) and associated increases in hospital and home-care costs (42, 43).

In contrast with the other objective measurements, serum albumin was associated with infectious and minor complications and 2 of the 4 markers of morbidity. Although correlated with outcomes, serum albumin concentrations were well within the normal reference range for even the severely malnourished children and could not have been used clinically to identify malnutrition. Only 11 (6%) of 171 children were hypalbuminemic. All 11 children were identified by SGNA as malnourished; hence, the addition of albumin to SGNA would not have identified any additional children as malnourished.

Concordance between assessors performing duplicate SGNA in this study was lower than desired and lower than reported in original studies of SGA in adults (agreement range: 79–91%; κ: 0.66–0.78) (6, 10, 36). Considerable variability was observed among the 5 dietitian assessors in terms of their years of work and pediatric experience. Unlike the original SGA studies, in which assessors were members of the gastroenterology team who frequently performed rounds and discussed patients and therapy together, none of the dietitians had previous experience with the general surgery population. Training has perhaps the most significant impact on concordance or reproducibility. After reviewing all factors, we believe that more hands-on refresher training several times throughout the study would have resulted in improved rates of interrater agreement. Despite reduced concordance based on formal testing, SGNA performed by 5 different assessors nevertheless identified children likely to have complications and prolonged hospital stay and therefore is likely to be clinically useful for this purpose. In contrast, currently used techniques for identifying malnutrition were not able to detect the risk of complications or longer length of stay.

Whereas objective measures of nutritional status cannot take into account all of the variables that a clinician should consider to identify malnutrition, SGNA represents an explicit model of the thought process to be used in assessing nutritional status. It
directs the clinician to piece together the nutritional components to make a complete picture; that is, is this child short or thin? is it by nature or because of inadequate intake? if intake is inadequate, what is the cause? is there physical evidence of wasting to support the historical findings? are losses of body mass affecting the child’s ability to perform? is the child’s nutritional status and functioning worsening or beginning to improve? is the child likely to continue to have problems? what needs to be treated? as a result, after completing the SGNA and identifying the malnourished child, the clinician has determined whether the child’s nutritional status is likely to improve or worsen, has established the potential cause or causes of malnutrition, and identified where to target intervention.

A possible source of bias in our study is our exclusion of non-English–speaking children and caregivers; however, it is unlikely that this would have altered our conclusions about the ability of SGNA to predict the risk of morbidity, because the bias would potentially reduce the numbers of severely malnourished children that we saw. Because such a reduction would make it more difficult to show statistical differences in outcomes, the inclusion of such patients would only reinforce our findings.

In conclusion, SGNA and its use of clinical judgment is a valid method for assessing nutritional status in children. SGNA showed good correlation with currently used objective nutritional measures of nutritional status and was the only true nutritional measure that identified children with higher incidence of infectious and minor complications and longer postoperative hospital stays, undesirable consequences for children and families that also increase hospital costs. Is SGNA valid in all children? We suggest that SGNA will be a useful tool in a wide variety of children with chronic and systemic conditions, given that our study included children with mild–to–moderate medical complexity and a wide assortment of comorbidities and underlying illnesses, most of which involved the gastrointestinal tract. Further study is needed to determine whether the fair degree of reproducibility that we observed in this study was a function of the heterogeneity of the patients, the assessors in our study, or both and whether ongoing training throughout the study period can effectively improve interrater agreement.

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DJS conceived the hypothesis and study design, conducted the statistical analyses, and drafted the manuscript. KNJ contributed to the concept and design of the study and interpretation and discussion of the results. Both authors critically revised the drafted manuscript. Neither author had any conflict of interest.

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