Development and validation of a nutrition screening tool for hospitalized cancer patients

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Original article

1. Introduction

It is widely acknowledged that approximately 20–60% of hospitalized patients suffer from malnutrition at the time of admission. Malnutrition risk during a hospital stay may increase with higher rates of complications and longer lengths of hospital stay (LOS). The prevalence of malnutrition in cancer patients is higher than in general patients because of cancer-specific characteristics and treatment processes. Patient malnutrition, in turn, can increase infection risks, side effects of cancer treatment, and mortality rates. Approximately 20–50% of deaths in cancer patients are suspected to be associated with malnutrition rather than the cancer itself.

Most cancer patients undergo surgery, radiotherapy, chemotherapy, and/or other treatments depending on the type and stage of cancer; these treatments are associated with various side effects. Among these side effects, loss of appetite, sore mouth or throat, dry mouth, change in taste, vomiting, nausea, diarrhea, constipation, and fatigue can negatively affect dietary intakes. Weight loss in cancer patients due to inappropriate food intake is not unusual and may subsequently lead to progressive functional impairment, in up to 80% of progressive cancers. There is an emerging consensus that a preventive, rather than therapeutic, approach for cancer cachexia syndrome would be more effective. The best way to confront cancer cachexia syndrome is to identify malnutrition through nutrition screening as early as possible and to treat the nutritional problems through nutrition intervention.

Nutrition screening is intended to quickly identify malnourished patients or those at high risk for malnutrition.
Commission on Accreditation of Healthcare Organizations advised a nutrition assessment within 24–48 h of admittance to manage nutrition risks from the onset of hospitalization. There are many nutrition screening tools, of which the Nutrition Risk Index (NRI), Malnutrition Universal Screening Tool (MUST), Nutritional Risk Screening (NRS) 2002, and Mini Nutritional Assessment (MNA) are the most popular. These tools, however, were developed for general patients; thus, they are not well suited for cancer patients. Furthermore, the prevalence of malnutrition exhibits a large difference of 25–40%, depending on the screening tool used. Sensitivity and specificity also differed significantly among the tools.

The Scored Patient-Generated Subjective Global Assessment (PG-SGA), a popular nutrition assessment tool for cancer patients, was developed based on SGA and has been used in the evaluation of nutritional status in many studies. The Oncology Nutrition Dietetic Practice Group of the American Dietetic Association adopted the Scored PG-SGA as a standard nutrition assessment tool for cancer patients. Because the Scored PG-SGA is based on anthropometrics, intakes, symptoms, activities, ages, and metabolic stresses, applying it to the identification of nutrition risk groups for all hospitalized patients is associated with large costs in terms of time and manpower.

The leading cause of death among Koreans for the past 10 years has been cancer. The most commonly diagnosed cancers in Koreans are gastric, thyroid, colorectal, lung, liver, and breast cancer. Wie et al. reported that 61.3% of patients with cancer were found to be malnourished, with 36.5% being at high risk of malnutrition and 24.8% being at moderate risk of malnutrition. Moreover, the prevalence of malnutrition was high in patients with liver cancer (86.6%), lung cancer (60.6%), gastric cancer (56.7%), and colorectal cancer (52.8%). Despite the high prevalence of malnutrition among cancer patients, the medical care system in Korea does not include a nutrition program because the manpower of clinical dieticians is insufficient for using the PG-SGA in screening malnourished cancer patients and because other validated nutrition screening tools have not yet been developed for cancer patients. Thus, this study was undertaken to develop and validate a new malnutrition screening tool for hospitalized cancer patients (MSTC) in Korea. The tool must be easy to use and must accurately

![Flow of recruiting participants](image-url)
identify cancer patients who are malnourished or are at risk of becoming malnourished.

2. Methods

2.1. Subjects

Of 3010 patients admitted to the National Cancer Center between April 1 and June 2, 2008, 2651 patients with gastric, colon, lung, liver (pancreas and gallbladder), breast, prostate, uterus, brain and spinal cord, head and neck, or urinary organ cancer, all of which have shown high morbidity and mortality among Koreans, were selected; 359 patients with cancer at other sites were excluded. Among the selected patients, those who were deconditioned (118), had undergone surgery and could not be interviewed (726), were discharged before the interview (360), and were absent for checkups or refused to be interviewed for other reasons (390) were excluded. Thus, in total, 1057 patients comprised the study population. By a stratified sampling method, 800 of 1057 patients (75%) were assigned to the development study and 257 (25%) were assigned to the validation study of the development of the MSTC (Fig. 1).

2.2. Development of the MSTC

Trained registered dietitians performed nutrition assessments of 257 cancer patients using the MSTC and PG-SGA and classified each patient as malnourished or well-nourished. The cutoff points for malnourished in the MSTC were determined by reading the optimal cutoff point in the receiver operator characteristic (ROC) curve.

The validity of the MSTC was analyzed by sensitivity, specificity, and negative and positive predictive values. The correlation between the MSTC and PG-SGA was checked by the ROC curve with the area under the curve. Consistency between the PG-SGA and MSTC was evaluated with kappa (κ) statistics.

2.4. Statistical analysis

Data analyses were performed using the SAS software (V 9.1., SAS Institute Inc., Cary, NC, USA). P-values of < 0.05 were considered significant.

3. Results

3.1. General characteristics of study participants

Detailed characteristics of the study participants are shown in Table 1. The mean age was 58.3 ± 11.0 years in the development study group (n = 800), which consisted of 461 (58%) men and 339 (42%) women. The mean age was 59.4 ± 11.2 years in the validation study group (n = 257), which consisted of 161 (63%) men and 96 (37%) women. No difference in age was observed between the study groups. The PG-SGA diagnosed 203 patients (25.4%) as malnourished (Stage B + C) in the development study group, and the percentage (86.2%) of internal medicine patients in the malnourished group was higher than that of 64.5% in the well-nourished group (P < 0.0001). In the validation study group, 67 (26.1%) patients were diagnosed with malnutrition (Stage B + C), which was similar to the number of patients diagnosed with malnutrition in the development study group. The percentage (88.1%) of internal medicine patients in the malnourished group was higher than that of 72.5% in the well-nourished group.

Table 1

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Total</th>
<th>Development study (n = 800)</th>
<th>Validation study (n = 257)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Malnourisheda</td>
<td>Well-nourishedb</td>
<td>Malnourisheda</td>
</tr>
<tr>
<td></td>
<td>(Stage B + C)</td>
<td>(Stage B + C)</td>
<td>(Stage B + C)</td>
</tr>
<tr>
<td>n (%)</td>
<td>1057</td>
<td>203 (25.4)</td>
<td>67 (26.1)</td>
</tr>
<tr>
<td>Gender (men/women) (%) men</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>622/435 (58.8)</td>
<td>114/89 (56.2)</td>
<td>41/26 (61.2)</td>
</tr>
<tr>
<td>Internal medicine/surgery (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>725/322 (68.5)</td>
<td>175/28 (86.2)</td>
<td>59/8 (38.1)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>58.6 ± 11.1</td>
<td>59.1 ± 11.6</td>
<td>60.1 ± 12.1</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>23.0 ± 3.4</td>
<td>23.3 ± 3.5b</td>
<td>21.5 ± 3.9b</td>
</tr>
<tr>
<td>Serum albumin (g/dL)</td>
<td>3.7 ± 0.6</td>
<td>3.4 ± 0.7b</td>
<td>3.4 ± 0.6b</td>
</tr>
<tr>
<td>Total lymphocyte count (cell/mm³)</td>
<td>1504.9 ± 732.0</td>
<td>1248.6 ± 641.5c</td>
<td>1166.8 ± 631.7c</td>
</tr>
<tr>
<td>Weight loss (%)</td>
<td>0.8 ± 3.9</td>
<td>3.1 ± 5.6b</td>
<td>2.7 ± 5.1c</td>
</tr>
<tr>
<td>Length of stay (days)</td>
<td>8.9 ± 9.1</td>
<td>12.1 ± 12.5c</td>
<td>10.8 ± 10.1c</td>
</tr>
</tbody>
</table>

a PG-SGA Stages B + C according to PG-SGA assessment.

b PG-SGA Stage A according to PG-SGA assessment.

c P-values designate differences of distribution and mean values between the development and validation studies.

d Fisher’s exact test between malnourished and well-nourished, P < 0.0001.

e P-value = SD, General Linear Models (GLM) procedure between malnourished and well-nourished, P < 0.0001.
(55.8%) of patients in the well-nourished group (P < 0.0001); these results were similar to those of the development study. The average weight losses were 0.9 ± 4.0 kg and 0.8 ± 3.3 kg for the development and validation study groups, respectively, and were not statistically different. Weight loss was significantly higher in malnourished patients in all study groups (P < 0.0001).

The average BMIs were 23.1 ± 3.4 kg/m² and 23.0 ± 3.4 kg/m² for the development and validation study groups, respectively, and there was no significant difference between the study groups. For both groups, BMIs were significantly lower for malnourished than well-nourished patients, at 21.7 ± 3.5 kg/m² and 21.5 ± 3.9 kg/m² for the development and validation study groups, respectively (P < 0.0001). In the development study group, the average LOS was 9.0 ± 9.5 days. The mean LOS was longer in malnourished (12.1 days) than in well-nourished patients (7.9 days, P < 0.0001). LOS was 8.8 ± 7.8 days in the validation group. The mean LOS was longer in malnourished (10.8 days) than in well-nourished patients (8.1 days, P < 0.0001).

3.2. Development of the MSTC

The candidate variables for the MSTC, which used at least two screening tools among the PG-SGA, NRS 2002, NRI, and MNA and must be simple and quick to administer, use routinely available data, and minimize incomplete screening due to missing data, were reviewed. Age, weight loss, intake change, BMI, and activity, s-alb, TLC, and albumin, which satisfied the selection criteria, were chosen for multiple logistic regressions. Gender and department were controlled in regression.

Multiple logistic regression identified significant explanatory variables in nutritional status, such as intake change (odds ratio [OR] 5.778 [4.413; 7.567], P < 0.0001), weight loss (OR 1.230 [1.154; 1.311], P < 0.0001), ECOG performance status (OR 3.410 [2.531; 4.594], P < 0.0001), and BMI (OR 0.842 [0.782; 0.906], P < 0.0001; Table 2).

The MSTC is given in Table 3. Intake change was scored as 0 (no change in intake), 1 (medium change), or 2 (large change), based on the results of the intake change questionnaire of the MNA. The amount of intake change was defined with the OR for malnutrition. The OR for intake change ≥ 91% of usual intake versus 71–90% of usual intake was 20.491 [8.954; 46.894], and for ≥ 91% of usual intake versus < 70% of usual intake, the OR was 51.568 [30.930; 85.977], which were higher than other categories. Thus, the category of no diet change was defined as ≥ 91% of usual intake, that of medium change was defined as 71–90%, and a large change was defined as < 70%. The weight loss group was determined using the previous month’s weight as the base. The functional status was assessed by means of the ECOG performance status.

The probability of a patient being malnourished can be predicted by a following logistic regression equation in which the categorization is based on a continuous function of P between 0 and 1: P (Malnourished) = exp (model)/(1 + exp (model)) (Table 3).

Goodness of the model was checked with the area under the ROC curve, which showed high accuracy of 0.9431 (data not shown).

3.3. Validity of the MSTC

When the MSTC cutoff point for malnutrition was set as the highest score (Youden’s index = 0.7538), there were 93 malnourished patients (36%). ROC analysis for the cross-validity of the MSTC is presented in Fig. 2. Goodness of the MSTC model was checked with the area under the ROC curve for the MSTC compared with a PG-SGA of 0.948, which showed high accuracy according to an arbitrary guideline. Sensitivity and specificity of the MSTC for the Scored PG-SGA (gold standard) were 94.0% and 84.2%, respectively. The degree of agreement between the two methods was high, with k = 0.70 (P < 0.0001; Table 4).

Table 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Log (OR)</th>
<th>OR (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>3.361</td>
<td></td>
<td>0.0189</td>
</tr>
<tr>
<td>Intake change</td>
<td>1.754</td>
<td>5.778 (4.413–7.567)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>ECOG performance status</td>
<td>1.227</td>
<td>3.410 (2.531–4.594)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Weight loss</td>
<td>0.207</td>
<td>1.230 (1.154–1.311)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>BMI</td>
<td>0.172</td>
<td>0.842 (0.782–0.906)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Department</td>
<td>0.753</td>
<td>2.123 (1.123–4.015)</td>
<td>0.0205</td>
</tr>
<tr>
<td>Gender</td>
<td>0.427</td>
<td>1.533 (0.921–2.550)</td>
<td>0.1002</td>
</tr>
<tr>
<td>Age</td>
<td>0.017</td>
<td>1.017 (0.994–1.039)</td>
<td>0.1433</td>
</tr>
<tr>
<td>TLC</td>
<td>1.000</td>
<td>1.000 (0.999–1.000)</td>
<td>0.0415</td>
</tr>
<tr>
<td>Albumin</td>
<td>−0.413</td>
<td>0.662 (0.440–0.995)</td>
<td>0.0474</td>
</tr>
</tbody>
</table>

Table 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model</th>
<th>P (Malnourished) = exp (model)/(1 + exp (model))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.0116 + (1.777 × intake change) + (1.568 × weight loss) + (1.304 × ECOG) − (0.187 × BMI)</td>
<td></td>
</tr>
</tbody>
</table>

Elaborative variables: intake change, Eastern Cooperative Oncology Group (ECOG) performance status, weight loss, body mass index (BMI), department, gender, age, total lymphocyte count (TLC), and albumin.

OR: odds ratio; CI: confidence interval.

* Dependent variable: Patient-Generated Subjective Global Assessment (PG-SGA) stages.

Fig. 2. Receiver operator characteristic (ROC) curve for the newly developed malnutrition screening tool for cancer patients (MSTC).
Table 4
Validity of the newly developed malnutrition screening tool for cancer patients (MSTC).

<table>
<thead>
<tr>
<th></th>
<th>PG-SGA</th>
<th>MSTC</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low risk</td>
<td>High risk</td>
<td>200 (100%)</td>
</tr>
<tr>
<td>Well-nourished,a n (%)</td>
<td>160 (84.2)</td>
<td>30 (15.8)</td>
<td>190</td>
</tr>
<tr>
<td>Malnourished,b n (%)</td>
<td>4 (6.0)</td>
<td>63 (94.0)</td>
<td>67</td>
</tr>
<tr>
<td>Total</td>
<td>164 (63.8)</td>
<td>93 (36.2)</td>
<td>257</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>94.0</td>
<td>85.4–98.3</td>
<td></td>
</tr>
<tr>
<td>Specificity</td>
<td>84.2</td>
<td>78.2–89.1</td>
<td></td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>67.8</td>
<td>57.3–77.1</td>
<td></td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>97.6</td>
<td>93.9–99.3</td>
<td></td>
</tr>
<tr>
<td>Kappa value(s)</td>
<td>0.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P < 0.0001 for percent of agreement between PG-SGA and MSTC at $k$ statistic. CI, confidence interval.

a PG-SGA Stage A according to PG-SGA assessment.
b PG-SGA Stages B + C according to PG-SGA assessment.

4. Discussion

In this study, a new MSTC was developed and confirmed to be valid and suitable for the screening of malnutrition in hospitalized cancer patients.

The prevalence of malnutrition differs across tools applied to the same individuals. Kyle et al. and Kondrup et al. reported differences in the prevalence of malnutrition among nutrition screening tools even when applied to the same patients. In this study, we found significant differences in the prevalence of malnutrition among cancer patients using different tools: NRI, 40.5%; NRS 2002, 32.0%; and PG-SGA, 25.4% (data not shown). The specificity and sensitivity of NRI and NRS 2002 against the PG-SGA (gold standard) were 81.8%, 48.7% and 72.9%, 81.9%, respectively. Because these tools are not specific for cancer patients, require quite a long time to interview individual patients, and need trained dietitians to collect many variables, developing a new nutrition screening tool that is tailored for cancer patients, simple to use, and accurate is needed in the clinical setting in Korea.

In this study, a MSTC was developed that could be readily used in hospital practice (Table 3). The screening tool consisted of four indicators: intake change, weight loss, ECOG performance status, and BMI. Among them, intake change had the highest OR of 5.778 ($[4.413; 7.567]$, $P < 0.0001$; Table 2).

Many studies have used logistic regression to select indicators for the development of nutrition screening tools. Nourissat et al. developed a model using logistic regression with weight loss as a significant indicator. Kim et al. applied logistic regression with s-alb, BMI, TLC, and age for predicting PG-SGA and developing a nutrition screening tool and reported that s-alb showed the highest significance in screening for malnutrition. The difference may have resulted from the characteristics of the study subjects and classification of malnutrition. The subjects in Kim's study had malignant tumors (30.3%), digestive organ disease (11.4%), hepatobiliary and pancreatic disease (10.3%), cardiovascular disease (6.3%), and kidney disease (5.7%), and no information on surgery was obtained prior to interview. Kim et al. defined malnourished patients as PG-SGA Stage C, while our study defined malnourished patients as PG-SGA B + C.

Youden's index (Sensitivity + Specificity - 1) was calculated to establish the cutoff point for malnutrition. The cutoff point for the MSTC was set at the highest Youden's index: area under the curve = 0.948 (Fig. 2). Youden's index was used for setting criteria from the ROC curve; the area under this curve measured the accuracy of prediction. Kondrup et al. suggested that the ROC curve was effective for the MSTC for the development of nutrition screening tools. Smith et al. also used the ROC curve to verify screening tools.

Following a statistician's advice to consider the goal and applicability of our logistic model, we consulted with dietitians, doctors, and statisticians before finalizing the model selection. Multicollinearity was not observed when correlation or variance inflation factors were considered. If multicollinearity was present in regression, it became more difficult to estimate the correct partial effect of interesting variables because of the large standard error of the estimated coefficients.

The MSTC was highly comparable with the PG-SGA, for which the kappa value was 0.7, sensitivity 94.0%, and specificity 84.2% (Table 4). The validity of the MSTC was high compared with that of the NRI (kappa value 0.22) and NRS 2002 (kappa value 0.5), commonly used screening tools (data not shown). Kyle reported that the validity of screening tools against the PG-SGA differed: NRS 2002 (sensitivity 62.0%, specificity 93.1%, kappa value 0.48), NRI (sensitivity 43.1%, specificity 89.3%, kappa value 0.24), and MUST (sensitivity 61.2%, specificity 78.6%, kappa value 0.26). Lee et al. reported that the kappa value was 0.34, sensitivity 60.7%, and specificity 81.2% for a newly developed nutrition screening tool against the PG-SGA. These results suggest that the MSTC be a valid nutrition screening tool with high validity over currently available tools. The MSTC requires less than 5 min to collect data and does not use a calculating process because it uses data from the electrical medical record of the hospital, which is collected at admission.

Our study has some limitations. First, interviewer bias due to variation in the style of questioning can be a potential limitation, which may contribute to classification between the MSTC and PG-SGA. Second, respondent bias may be present, with patients answering questions differently depending on varying states of alertness and medical conditions on the day of assessment. Patients with discomfort, pain, or cognitive impairment may have less motivation to respond to questions. Third, the MSTC includes indicators that are supposed to be collected by trained registered dietitians, whereas nurses are more likely to perform such a survey in practice. Duerksen et al. and Sacks et al. suggested that consistency between investigators in the evaluation of the validity and reproducibility of nutrition indicators is required.

Further studies on consistency between dietitians and nurses who perform the survey are necessary.

In conclusion, the MSTC is a new nutrition screening tool that uses intake change, weight loss, BMI, and ECOG performance status and has high validity compared with other currently available screening tools. The MSTC could be a useful malnutrition screening tool for cancer patients. The MSTC is the first nutrition screening tool tailored for cancer patients in Korea, and further studies on its applicability are needed.

Statement of authorship

All of the authors have made substantial contributions to the study design, acquisition, analysis, and interpretation of data, drafting of the article or revising it, and final approval of the version to be submitted. All authors read and approved the final manuscript.

Conflict of interest

None of the authors has a conflict of interest.

Acknowledgments

We are indebted to the dietitians at the National Cancer Center for data collection. JK, GW, and HJ participated in the design of the study and wrote the manuscript. JK, YC, SK, SK, and KS carried out the study. JK
performed the statistical analysis. SP helped to draft the manuscript. BN helped to analyze and interpret the data.

This manuscript has not been published previously and is not simultaneously under consideration elsewhere.

References


