Impact of nutritional screening index on perioperative morbidity after colorectal cancer surgery as a independent predictive factor

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Purpose: Nutrition status is an important factor for perioperative morbidity in cancer surgery. The aim of this study was to evaluate the impact of the malnutrition risk, determined by Seoul National University Hospital-nutrition screening index (SNUH-NSI), on operative morbidity after colorectal surgery for cancer.

Methods: This study enrolled 2,462 patients who had undergone colectomy for initially diagnosed colorectal cancer at Seoul National University Hospital from January 2011 to December 2014. We collected general patient information, SNUH-NSI and prognostic nutritional index (PNI) at administration and related parameters (serum albumin, cholesterol, total lymphocyte counts, hemoglobin and body mass index), operative method, hospital stay and operative morbidity.

Results: Patients’ mean age was 62.12 years, and 423 patients (17.18%) were rated as severe malnutrition risk. Patients with high risk of malnutrition by SNUH-NSI or PNI, men, higher American Society of Anesthesiologists (ASA) class, palliative operation, and higher stage showed higher operative morbidity (P < 0.05). On multivariate analysis, significant independent risk factors for operative morbidity were severe malnutrition by SNUH-NSI (odds ratio [OR], 1.868; 95% confidence interval [CI], 1.429–2.442; P < 0.001) or PNI (OR, 1.596; 95% CI, 1.258–2.025; P < 0.001), men (OR, 1.483; 95% CI, 1.174–1.876; P = 0.001), or high ASA class (OR, 1.782; 95% CI, 1.136–2.795; P = 0.012).

Conclusion: Overall nutritional status, rather than single data, shows significant association with postoperative morbidity in patients who underwent colectomy. Especially severe malnutrition determined by SNUH-NSI, is an independent risk factor for perioperative morbidity. Nutritional support to severely malnourished patient by SNUH-NSI is expected to be effective in preventing complications after colectomy of colorectal carcinoma patients.

Keywords: Colorectal cancer, Colectomy, Malnutrition, Screening, Morbidity

INTRODUCTION

Colorectal cancer is the third most commonly occurring cancer in the world, and its incidence is gradually increasing [1]. Despite advances in treatment methods, the rates of recurrence and mortality from colorectal cancer remain high [2]. Surgery is an important treatment method, but it may lead to surgical complications, which are associated with poor patient prognosis. The identification of factors predictive of complications can result in better patient prognosis.

Cancer patients are more likely to be malnourished than patients with other diseases [3], and association between preoperative nutrition and surgical outcome has been reported [4]. Malnutrition can delay treatment; increase infection, complication, and mortality rates; and prolong duration of hospital stay, leading to increased medical costs [5]. Since surgery may have major effects on treatment outcomes, surgical outcomes may be improved by investigating nutritional and immune status.

The 2006 the European Society of Parenteral and Enteral Nutrition guidelines suggest that patients undergoing upper gastrointestinal surgery who are at risk of severe malnutrition require preop-
operative nutritional support, even if surgery is delayed [6]. These guidelines, however, do not provide recommendations for colorectal cancer patients, and few studies have described the association between nutritional status and postoperative outcomes in patients with colorectal cancer.

Various preoperative nutrition screening tools have been developed [4,7-11]. The prognostic nutritional index (PNI) is commonly used, with many studies showing that the PNI is a significant indicator of postoperative outcomes [4,7-11]. In addition, malnutrition risk, as determined by the Seoul National University Hospital—nutrition screening index (SNUH-NSI), was found to have a significant impact on postoperative complications in patients with gastric cancer [12].

The present study was designed to evaluate the risk of malnutrition at admission, as determined using nutrition screening tools, in patients undergoing colectomy for colorectal cancer, and to inves-

Table 1. Seoul National University Hospital—nutrition screening index (SNUH-NSI)

| Variables                        | r1          | r2          | r3          |
|----------------------------------|-------------|-------------|-------------|
| Appetite                         | Normal/Good | -           | Bad         |
| Change of weight                 | No          | -           | Yes         |
| Difficulty in digesting          | No          | Yes         | -           |
| Diet type                        | Normal      | Soft blended| Fluid diet  |
| Serum-albumin                    | ≥ 3.3       | ≥ 2.8, < 3.3| < 2.8       |
| Serum-cholesterol                | ≥ 130       | < 130       | -           |
| Total lymphocyte count           | ≥ 1,500     | ≥ 800, < 1,500| < 800     |
| Hemoglobin                       | Male ≥ 13.0 | < 13.0      | -           |
|                                  | Female ≥ 12.0| < 12.0      | -           |
| C-reactive protein               | ≤ 1         | > 1         | -           |
| Body mass index (kg/m²)          | ≥ 18, < 25  | < 18 or ≥ 25| -           |
| Age (yr)                         | ≤ 75        | > 75        | -           |

High risk group, (more than 2 of r3) or (1 of r3+more than 2 of r2); Low risk group, the others.

Table 2. Definition of complications

| Group                         | Classification         | Definition                                                                 |
|-------------------------------|------------------------|-----------------------------------------------------------------------------|
| Wound complication            | Wound infection        | Re-suture (wound repair) or delay in discharge                             |
| Operation related complication| Intraabdominal fluid collection/abscess | Confirmed by CT, NPO or PCD required                                        |
|                               | Intraabdominal bleeding | Transfusion or intervention (angiography, reoperation) required            |
|                               | Intraluminal bleeding   | Transfusion or intervention required                                        |
|                               | Intestinal obstruction  | Obstruction point (+), NPO or reoperation required, re-admission or ER visit |
|                               |                         | (within 30 days)                                                           |
| Ileus                          |                         | Obstruction point (−), delay in discharge due to NPO                       |
| Anastomosis stenosis          |                         | Confirmed by colonoscopy or colon study, intervention required             |
| Anastomosis leakage           |                         | Confirmed by fistulogram                                                   |
| Pancreatitis                   |                         | Confirmed by CT, delay in discharge due to NPO                             |
| Enterocutaneous fistula       |                         | Confirmed by fistulogram                                                   |
| Lymphatic leakage             |                         | Chylous drainage via Jackson-Pratt drainage, NPO or low fat diet required   |
| Stoma complication            |                         | Prolapse, necrosis, bleeding, retraction                                   |
| Systemic complication         | Pulmonary               | Pleural effusion, pneumonia                                               |
|                               | Renal/urinary           | Urinary tract infection, acute renal failure                               |
|                               | Hepatic                 | Liver abscess, liver failure                                               |
|                               | Cardiac                 | Myocardial infarction, heart infarction, arrhythmia                        |
|                               | Endocrine               | Diabetes Insipidus, diabetic ketoacidosis, syndrome of inappropriate secretion of antidiuretic hormone |
|                               | Neurologic              | Delirium, cognitive disorder, psychosis                                    |
|                               | Thromboembolism         | Deep vein thromboembolism, pulmonary thromboembolism                      |

CT, computed tomography; NPO, nil per os (nothing by mouth); PCD, percutaneous drainage; ER, emergency room.
tigate the effects of preoperative malnutrition on the occurrence of postoperative complications.

**METHODS**

This retrospective study evaluated 3,746 patients who were admitted to Seoul National University Hospital (SNUH) for primary colorectal cancer and who underwent colectomy from January 2011 to December 2014. Patients with a history of other cancers, recurrent colorectal cancer, or hereditary colorectal cancer; and patients who underwent combined resection of other organs or had insufficient data for analysis were excluded from this study. The study cohort consisted of 2,462 patients, with patient data retrospectively collected from electronic medical records. The study protocol was approved by the Institutional Review Board of SNUH (IRB no. H-1712-043-905).

### Table 3. General characteristics of the subjects

| Variable              | Total (n = 2,462) | SNUH-NSI | High risk group (n = 423) | Low risk group (n = 2,039) | P-value |
|-----------------------|-------------------|----------|--------------------------|-----------------------------|---------|
| **Age (yr)**          |                   |          |                         |                             |         |
| < 60                  | 996 (40.45)       | 145 (34.28) | 851 (41.74)               |                             | 0.004   |
| ≥ 60                  | 1,466 (59.55)     | 278 (65.72)  | 1,188 (58.26)             |                             |         |
| **Sex**               |                   |          |                         |                             | 0.851   |
| Male                  | 1,500 (60.93)     | 256 (60.52)  | 1,244 (61.01)             |                             |         |
| Female                | 962 (39.07)       | 167 (39.48)  | 795 (38.99)               |                             |         |
| **ASA classification**|                   |          |                         |                             | <0.001  |
| 1                     | 938 (38.10)       | 129 (30.50)  | 809 (39.68)               |                             |         |
| 2                     | 1,420 (57.68)     | 255 (60.28)  | 1,165 (57.14)             |                             |         |
| 3                     | 103 (4.18)        | 38 (8.98)    | 65 (3.19)                |                             |         |
| 4                     | 1 (0.04)          | 1 (0.24)     | 0 (0.0)                  |                             |         |
| **Body mass index (kg/m²)** |              |          |                         |                             | <0.001  |
| < 18.5                | 145 (5.89)        | 59 (13.95)   | 86 (4.22)                |                             |         |
| ≥ 18.5, < 23          | 1,030 (41.84)     | 202 (47.75)  | 828 (40.61)              |                             |         |
| ≥ 23, < 25            | 580 (23.56)       | 71 (16.78)   | 509 (24.96)              |                             |         |
| ≥ 25                  | 707 (28.72)       | 91 (21.51)   | 616 (30.21)              |                             |         |
| **Smoking**           |                   |          |                         |                             | 0.727   |
| No                    | 1,946 (79.04)     | 337 (79.67)  | 1,609 (78.91)             |                             |         |
| Yes                   | 516 (20.96)       | 86 (20.33)   | 430 (21.09)              |                             |         |
| **Alcohol intake**    |                   |          |                         |                             | 0.040   |
| No                    | 1,707 (69.33)     | 311 (73.52)  | 1,396 (68.46)             |                             |         |
| Yes                   | 755 (30.67)       | 112 (26.48)  | 643 (31.54)              |                             |         |
| **Stage**             |                   |          |                         |                             | <0.001  |
| 0–1                   | 512 (20.80)       | 45 (10.64)   | 467 (22.90)              |                             |         |
| 2                     | 703 (28.55)       | 124 (29.31)  | 579 (28.40)              |                             |         |
| 3                     | 868 (35.26)       | 132 (31.21)  | 736 (36.10)              |                             |         |
| 4                     | 379 (15.39)       | 122 (28.84)  | 257 (12.60)              |                             |         |
| **Curative/Palliative surgery** |     |          |                         |                             | <0.001  |
| Curative              | 2,251 (91.47)     | 328 (77.73)  | 1,923 (94.31)             |                             |         |
| Palliative            | 210 (8.53)        | 94 (22.27)   | 116 (5.69)               |                             |         |
| **Surgical approach** |                   |          |                         |                             | <0.001  |
| Open                  | 1,743 (70.80)     | 337 (79.67)  | 1,406 (68.96)             |                             |         |
| Laparoscopic          | 719 (29.20)       | 86 (20.33)   | 633 (31.04)              |                             |         |
| **Tumor location**    |                   |          |                         |                             | <0.001  |
| Colon                 | 799 (32.45)       | 173 (40.90)  | 626 (30.70)              |                             |         |
| Rectosigmoid          | 1,658 (67.34)     | 247 (58.39)  | 1,411 (69.20)             |                             |         |
| Both                  | 5 (0.2)           | 3 (0.6)     | 2 (0.1)                 |                             |         |
| **Hospital stay (day)**|                  |          |                         |                             | <0.001  |
|                      | 7.94 ± 5.07       | 9.85 ± 6.99 | 7.55 ± 4.47              |                             |         |

Values are presented as mean ± standard deviation or number (%).

SNUH-NSI, Seoul National University Hospital—nutrition screening index; ASA, American Society of Anesthesiologists.
Nutrition screening tools

The risk of malnutrition in patients was assessed within 24 hours of admission using the SNUH-NSI. The SNUH-NSI was determined from parameters such as age, body mass index (BMI), changes in weight, appetite, digestive disorders, and meal pattern at admission. Other factors included in the SNUH-NSI were serum albumin, total cholesterol level, and C-reactive protein (CRP) concentrations; total lymphocyte count; and hemoglobin level measured within 2 weeks before admission. Based on these parameters, the risk of malnutrition was classified as r1, r2, and r3 [13-16], with the patients classified into a high-risk group and a low-risk group for malnutrition (Table 1).

Nutrition status was also classified using the PNI, a widely used nutrition screening tool. The PNI was calculated using the formula: albumin concentration (g/dL) x 10 + total lymphocyte count x 0.005 (/mm³).

Patient data

Baseline demographic and clinical information collected from patients’ electronic medical records included age, sex, American Society of Anesthesiologists (ASA) classification, smoking status, history of alcohol intake, clinical stage, radical or palliative surgery, operative methods, tumor location, presence or absence of postoperative complications, and nutritional risk group. The postoperative complications were classified as shown in Table 2.

Table 4. Incidence of postoperative morbidity (P<0.001)

| Complication                        | High risk group (n = 423) | Low risk group (n = 2,039) | Total (n = 2,462) |
|-------------------------------------|---------------------------|---------------------------|-------------------|
| Wound infection                     | 14 (3.3)                  | 32 (1.6)                  | 46 (1.9)          |
| Intraabdominal fluid collection/abscess | 4 (0.9)                | 8 (0.4)                   | 12 (0.5)          |
| Intraabdominal bleeding             | 1 (0.2)                   | 0                         | 1 (< 0.1)         |
| Intestinal obstruction              | 0                         | 0                         | 0                 |
| Ileus                               | 7 (1.7)                   | 36 (1.8)                  | 43 (1.7)          |
| Stenosis                            | 9 (2.1)                   | 24 (1.2)                  | 33 (1.3)          |
| Anastomotic leakage                 | 0                         | 3 (0.1)                   | 3 (0.1)           |
| Enterocutaneous fistula             | 0                         | 2 (0.1)                   | 2 (0.1)           |
| Lymphatic leakage                   | 3 (0.7)                   | 15 (0.7)                  | 18 (0.7)          |
| Stoma                               | 0                         | 2 (0.1)                   | 2 (0.1)           |
| Pancreatitis                        | 0                         | 0                         | 1 (0.03)          |
| Pulmonary                           | 9 (2.1)                   | 16 (0.8)                  | 25 (1.0)          |
| Renal/Urinary                       | 2 (0.5)                   | 18 (0.9)                  | 20 (0.8)          |
| Cardiac                             | 1 (0.2)                   | 3 (0.1)                   | 4 (0.2)           |
| Hepatic dysfunction                 | 0                         | 0                         | 0                 |
| Neurologic                          | 1 (0.2)                   | 3 (0.1)                   | 4 (0.2)           |
| Thromboembolism                     | 0                         | 1 (< 0.1)                 | 1 (< 0.1)         |
| Multiple                            | 57 (13.5)                 | 121 (5.9)                 | 178 (7.2)         |
| Total                               | 108 (25.5)                | 283 (13.9)                | 391 (15.9)        |

Statistical analysis

General characteristics and anthropometric factors were expressed as mean ± standard deviation, and its number and percentage was counted. Continuous variables were compared using t-tests and analysis of variance test, and categorical variables were compared using chi-square tests. Multivariate logistic regression analysis was performed to analyze factors independently predictive of the risk of complications. Statistical significance was defined as a P-value < 0.05. All statistical analyses were performed using SPSS ver. 22.0 K for Windows (IBM Corp., Somers, NY, USA).

RESULTS

General characteristics of the subjects

The demographic and clinical characteristics of the 2,462 patients in the study population are shown in Table 3. Preoperative nutritional screening showed that 423 patients (17.18%) were in the high-risk group for malnutrition and 2,039 (82.82%) were in the low-risk group for malnutrition according to SNUH-NSI scores. The mean age of all patients was 62.12± 11.25 years, and was significantly higher in the group at high than at low risk for malnutrition (64.22 ± 12.12 vs. 61.84 ± 11.01 years, P<0.001). The mean postoperative length of stay was 7.94± 5.07 days and was significantly longer in the group at high than at low risk for malnutrition (9.85± 6.99 vs. 7.55 ± 4.47 days, P<0.001). The mean BMI was 23.38 ± 3.36 kg/m², with 145 (5.89%) patients having a BMI < 18.5
kg/m² and 707 (28.72%) having a BMI ≥ 25 kg/m².

Of the 2,462 patients in the study cohort, 1,247 (50.65%) had stages 3 and 4 colorectal cancer, 1,658 (67.34%) had cancers in the rectum and sigmoid colon and 1,743 (70.80%) underwent open surgery. The risk of malnutrition did not differ according to sex or smoking status, but differed significantly according to age, ASA class, BMI, drinking status, clinical stage, radical resection, operative method, and tumor location (P < 0.05 each).

Postoperative complications

Of the 2,462 patients, 391 (15.9%) experienced postoperative complications. As a single complication, wound infection was the most frequent complication, which occurred in 46 subjects (1.9%). Other single postoperative complications included intestinal obstruction in 43 patients (1.7%), colonic stricture in 33 (1.3%), pulmonary complications in 25 (1.0%), and renal and urologic complications in 20 (0.8%) (Table 4). The incidence of complications was significantly higher in the group at high than at low risk for malnutrition (25.5% vs. 13.9%, P < 0.001).

The relationship between the incidence of complications and risk of malnutrition differed, however, when the complications were classified as wound-related, operation-related, and systemic complications (Table 2). The incidence of wound-related complications was significantly higher in the group at high than at low risk for malnutrition (3.3% vs. 1.6%, P = 0.016). However, the rates of operation-related complications (5.2% vs. 4.4%, P = 0.480) and systemic complications (3.3% vs. 2.0% P = 0.100) did not differ significantly in the groups at high risk than at low risk of malnutrition.

Factors affecting the occurrence of complications

Univariate analysis showed that factors associated with a higher incidence of overall postoperative complications included a higher risk of malnutrition (P < 0.001), male sex (P = 0.001), a higher ASA score (P < 0.001), palliative surgery (P = 0.004), and higher clinical stage (P = 0.004) (Table 5). History of smoking, history of alcohol intake, operative method, and tumor location of tumors did not affect the incidence of overall complications. Multivariate analysis showed that a high risk for malnutrition according to both the SNUH-NSI score (odds ratio [OR], 1.868; 95% confidence interval [CI], 1.429–2.442; P < 0.001) and PNI score (OR, 1.596; 95% CI, 1.258–2.025; P < 0.001), male sex (OR, 1.483; 95% CI, 1.174–1.876; P = 0.001), and a high ASA class (OR, 1.782; 95% CI, 1.136–2.795; P = 0.012) were independent risk factors for the occurrence of complications (Table 6).

**DISCUSSION**

Surgery or trauma may increase catabolism and result in hypermetabolism, increasing protein and energy requirements [17]. This may lead to postoperative complications. Many factors have been associated with the occurrence of complications, including nutritional status [4,18,19]. Indeed, malnutrition has been reported in 30%–50% of patients who undergo gastrointestinal surgery [20]. Complications associated with nutritional status may prolong length of hospital stay and increase medical costs [21].

The present study provides additional evidence that nutritional status may affect surgical outcomes. This study found that the risk of malnutrition, in addition to low ASA class and sex, were factors

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**Table 5. Univariate analysis of risk factors for postoperative morbidity**

| Variable                              | No. of patients | No. with complications (%) | P-value |
|---------------------------------------|----------------|---------------------------|---------|
| Sex                                   |                |                           |         |
| Male                                  | 1,500          | 269 (17.9)                | 0.001   |
| Female                                | 962            | 122 (12.7)                |         |
| ASA class 1, 2                        | 2,358          | 360 (15.3)                | <0.001  |
| 3, 4                                  | 104            | 31 (29.8)                 |         |
| Smoking                               |                |                           | 0.275   |
| No                                    | 1,946          | 301 (15.5)                |         |
| Yes                                   | 516            | 90 (17.4)                 |         |
| Alcohol                               |                |                           | 0.710   |
| No                                    | 1,707          | 256 (15.0)                |         |
| Yes                                   | 755            | 135 (17.9)                |         |
| Curative/Palliative surgery           |                |                           | 0.004   |
| Curative                              | 2,251          | 343 (15.2)                |         |
| Palliative                            | 210            | 48 (22.9)                 |         |
| SNUH-NSI                              |                |                           | <0.001  |
| Low risk group                        | 2,039          | 279 (13.7)                |         |
| High risk group                       | 423            | 112 (26.5)                |         |
| PNI                                   |                |                           | <0.001  |
| Low risk group (>45.5)                | 1,732          | 226 (13.0)                |         |
| High risk group (≤45.5)               | 730            | 165 (22.6)                |         |
| Surgery approach                      |                |                           | 0.175   |
| Open                                  | 1,743          | 288 (16.5)                |         |
| Laparoscopic                          | 719            | 103 (14.3)                |         |
| Tumor location                        |                |                           | 0.125   |
| Colon                                 | 799            | 144 (18.0)                |         |
| Rectosigmoid                          | 1,658          | 246 (14.8)                |         |
| Both                                  | 5              | 1 (20.0)                  |         |
| Stage 0–1                             |                |                           | 0.005   |
| 2                                     | 703            | 116 (16.5)                |         |
| 3                                     | 868            | 128 (14.7)                |         |
| 4                                     | 379            | 81 (21.4)                 |         |

ASA, American Society of Anesthesiologists; SNUH-NSI, Seoul National University Hospital-nutrition screening index; PNI, prognostic nutritional index.
Many attempts have been made to develop nutritional screening indices to assess patients’ nutritional status. Serum albumin concentration has been the most commonly used single factor, with many studies suggesting that serum albumin level < 3.5 g/dL is an independent risk factor for postoperative complications [22-24]. Because serum albumin has a relatively long half-life, and its concentration is highly affected by changes in non-nutritional factors, such as volume status or disease status, it may not accurately reflect recent nutritional status [22]. Other factors, such as serum total cholesterol concentration and total lymphocyte count, have been used to assess nutritional status in many clinical settings. However, these biochemical markers are also likely affected by factors other than nutritional status, limiting their individual value [22,25,26].

To overcome the limitations of these single factors, various nutrition screening tools have been developed to assess patients’ overall nutritional status [7]. These include the PNI, the Nutrition Risk Screening-2002 (NRS-2002), the Malnutrition Universal screening tool, the Mini Nutritional Assessment, the Short Nutritional Assessment Questionnaire, and the malnutrition screening tool (MST). The PNI was found to be a significant factor affecting postoperative outcomes in patients with colorectal cancer [11]. The NRS-2002 classifies nutritional status based on three factors, nutritional status based on BMI, weight loss and changes in intake; severity of disease by diagnosis; and age, with nutritional risk being a significant predictor of postoperative complications [4,9].

Although use of these screening tools may enable effective nutritional assessment, differences in the characteristics of patients between hospitals may result in differences in screening criteria that can sensitively reflect the risk of malnutrition. Some medical institutions have therefore developed their own nutritional screening tools and are making efforts to verify their validity. The SNUH has developed its own screening tool, the SNUH-NSI, to assess the nutritional status of patients [27]. The SNUH-NSI includes several parameters, including age; BMI; changes in body weight; appetite; digestive disorders and meal patterns at admission; serum concentrations of albumin, total cholesterol, and CRP; total lymphocyte counts, and hemoglobin level measured within 2 weeks before admission. In addition to measures of current weight, such as BMI, weight changes over time are recognized as important indices reflecting malnutrition [13,14,22]. Other factors included in the SNUH-NSI, such as appetite status, meal pattern and digestive symptoms, are also included in other nutritional assessment and screening tools, such as the Subjective Global Assessment (SGA), the Patient Generated-SGA (PG-SGA) and the NRS-2002. CRP is not a direct indicator of malnutrition, but is associated with inflammation and infection, which increase nutritional requirements. Elevated CRP is negatively associated with nutrition-related markers, such as prealbumin concentration, and has been reported to be an index associated with mortality of hospitalized patients [28]. The SNUH-NSI is a practical index for use in clinical settings with limited manpower and resources, because information on each parameter can be collected using an automatic screening system in the hospital. This tool can provide more specific information than a single parameter such as albumin concentration, and is relatively convenient to use compared with other nutritional assessment tools.

Other nutrition screening tools developed by individual medical institutions include the Gangnam Severance Hospital Nutritional Risk Screening Tool, the National Cancer Center Malnutrition Screening Tool for Cancer patients, and the Seoul National University Bundang Hospital nutrition screening index [7]. Both the SNUH-NSI and the NRS showed moderate agreement with the

| Table 6. Multivariate analysis of risk factors for postoperative morbidity |
|-----------------------------|-----------------|---------------------------------|-----------------|
| Variables                  | No.             | P-value            | Odds ratio | 95% Confidence interval |
|-----------------------------|-----------------|--------------------|------------|-------------------------|
| SNUH-NSI                    |                 |                    |            |                         |
| Low risk group              | 2,039           | Reference          | 1.868      | 1.429–2.442             |
| High risk group             | 423             | < 0.001            | 1.596      | 1.258–2.025             |
| PNI                         |                 |                    |            |                         |
| Low risk group (> 45.5)     | 1,732           | Reference          | 1.483      | 1.174–1.876             |
| High risk group (≤ 45.5)    | 730             | < 0.001            | 1.782      | 1.136–2.795             |
| Sex                        |                 |                    |            |                         |
| Female                      | 962             | Reference          | 1.596      | 1.258–2.025             |
| Male                        | 1,500           | 0.001              | 1.483      | 1.174–1.876             |
| ASA class                   |                 |                    |            |                         |
| 1, 2                       | 2,358           | Reference          | 1.483      | 1.174–1.876             |
| 3, 4                       | 104             | 0.012              | 1.782      | 1.136–2.795             |

SNUH-NSI, Seoul National University Hospital-nutrition screening index; PNI, prognostic nutritional index; ASA, American Society of Anesthesiologists.
results of in-depth nutritional assessment using the PG-SGA, confirming that the SNUH-NSI and the NRS are suitable for use as nutrition screening tools [7].

Although many studies have assessed preoperative nutritional status in patients with cancers of the upper gastrointestinal tract and other organs, relatively few studies have analyzed preoperative nutritional status in patients with colorectal cancer. The present study used both the PNI and the SNUH-NSI to assess nutritional status, finding that these preoperative screening tools differed significantly in predicting complications, with the SNUH-NSI (OR, 1.868) being a stronger predictor of complications after colorectal cancer surgery than the PNI (OR, 1.596), indicating that the SNUH-NSI can be of value as a nutritional screening tool.

This study had several limitations, including its retrospective design and its inclusion of patients at a single institution. However, the number of patients was significantly larger compared with those of previous studies. In addition, it was difficult to determine the details of each operation that could affect postoperative complications. However, because they were elective surgeries, performed by experienced surgeons using standardized surgical procedures, these effects were regarded as not significant.

Despite these limitations, the use of nutritional screening tools to identify patients at risk of malnutrition may be clinically useful in predicting postoperative complications in patients with colorectal cancer. Nutritional screening tools such as the SNUH-NSI can be used to more easily predict complications in patients undergoing colorectal cancer surgery. As individualized and personalized health care is becoming more important these days, nutritional assessment of an individual by optimized tool will be useful.

The SNUH-NSI, a nutritional screening tool, based on blood test results, such as serum albumin and total cholesterol and hemoglobin concentrations, appetite, weight changes, dyspepsia, meal pattern, age and BMI at admission is an independent risk factor for complications in patients undergoing surgery for colorectal cancer. Preoperative nutritional screening may help predict postoperative complications and improve clinical prognosis. Further studies on more specific clinical effects are needed.

**CONFLICT OF INTEREST**

No potential conflict of interest relevant to this article was reported.

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