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ORIGINAL ARTICLE – GASTROINTESTINAL ONCOLOGY

Low Preoperative Prognostic Nutritional Index Predicts Poor Survival Post-gastrectomy in Elderly Patients with Gastric Cancer

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ABSTRACT

Background. Preoperative nutritional status may predict short- and long-term outcomes of patients with cancer.

Objective. The aim of this study was to clarify the impact of preoperative nutritional status on outcomes of elderly patients who have undergone gastrectomy for gastric cancer (GC).

Methods. A review examining 147 patients treated for GC by gastrectomy at our institution between January 2004 and December 2011 was conducted. Onodera's prognostic nutritional index (PNI) was invoked, using an optimal cutpoint to stratify patients by high (PNI > 43.8; $n = 84$) or low (PNI ≤ 43.8; $n = 63$) nutritional status. Clinicopathologic features and short- and long-term outcomes, including the cause of death, were compared.

Results. In multivariate analysis, low PNI was identified as an independent correlate of poor 5-year overall survival (OS). In subgroup analysis, 5-year OS rates for patients with stage 1 GC were significantly worse in the low PNI (vs. high PNI) patient subset, which also posed a significantly higher risk of death from other disease; however, 5-year cancer-specific survival and PNI were unrelated. Deaths from recurrence in both groups were statistically similar, and morbidity rates did not differ significantly by group.

Conclusions. PNI is useful in predicting long-term outcomes of elderly patients surgically treated for GC, helping to identify those at high risk of death from other disease. In an effort to improve patient outcomes, nutritional status and oncologic staging merit attention.

In the past decade, gastrectomy for patients with gastric cancer (GC) has been safely undertaken in the elderly, who compare favorably with younger adults in terms of complication rate.[1–4] However, surgeons may be reluctant to treat the elderly because they are often malnourished and have various comorbid conditions, with declining organ function. Ultimately, this creates high-risk scenarios, raising the chances of severe or critical complications. In addition, decline in mobility threatens to prolong hospitalization, even if postoperative courses are uneventful, and the elderly have a higher chance of death from other benign or malignant diseases after gastrectomy than their younger counterparts. Hence, curability of GC does not always ensure better outcomes in older surgical candidates.

A recent report indicates that preoperative nutritional status impacts short- and long-term outcomes of patients with certain cancers.[5] In Japan, Onodera's prognostic nutritional index (PNI), originally developed as a predictor of postoperative complications suffered by patients with colon cancer in Japan,[6] is routinely used in hospitalized patients to gauge nutritional status. The PNI is calculated from serum albumin level and peripheral lymphocyte counts. Its formula is simple and it is easily implemented through the following scoring system: good nutrition, >50; mild malnutrition, 45–50; moderate malnutrition, 40–45; and severe malnutrition, <40. PNI scores also appear to be useful in predicting long-term outcomes of other cancers, aside from colonic primaries.[5,7]

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There are few studies assessing the impact of preoperative nutritional status on long-term outcomes of gastrectomy in elderly patients with GC.[8] The aim of this study was to clarify this relationship, using PNI to gauge nutritional states.

METHODS

Patients

A total of 147 patients >75 years of age undergoing curative gastrectomy for GC at the Department of Surgical Oncology, Osaka City University, between January 2004 and December 2011 were reviewed. Patients lacking requisite preoperative examinations and those undergoing R1 and R2 surgery (i.e. bypass or probe laparotomy) were excluded. Clinicopathologic variables and postoperative complications were extracted from medical records, operative records, and pathology reports, and the following variables were evaluated: age, sex, American Society of Anesthesiologists (ASA) physical status score, comorbidity, cancer histotype, depth of mural invasion, nodal metastasis, neoadjuvant chemotherapy (NAC), surgical details (i.e. type of gastrectomy), nature of procedure (open vs. laparoscopic), harvested lymph node count, postoperative complications, duration of postoperative hospital stay, and place of discharge. All pathologic terms and classifications were as stipulated by the Japanese Gastric Cancer Association.[9]

Assessment of Nutritional Status

Serum albumin (Alb; g/dl) and total lymphocyte counts (TLC; number/mm^2) obtained within 1 week prior to surgery were used to calculate PNI as follows: $PNI = 10 \times Alb + 0.005 \times TLC$. Receiver operating characteristic (ROC) curves were generated for multiple logistic regression analysis, using 5-year survival as the endpoint, and an optimal cutpoint of PNI was determined. Patients were then assigned to either the high- or low-PNI group.

Comorbidities

Comorbidity was classified as previously reported.[10] Ischemic heart disease was presumed in patients diagnosed with angina or myocardial infarction, or having undergone stent placement, bypass surgery, or medical therapy for coronary disease. Cerebrovascular disease was similarly acknowledged in patients diagnosed with cerebral infarction or cerebral hemorrhage. Diabetes mellitus was defined as the use of oral hypoglycemic drugs or insulin, or a hemoglobin A1c (HbA1c) level >6.2, reflecting our institutional criteria. Pulmonary disease was conceded in patients diagnosed with chronic obstructive pulmonary disease (COPD), tuberculosis, or lung cancer (surgically treated). Liver disease was implicit in patients with a history of viral hepatitis or cirrhosis, and renal disease was delimited by an estimated glomerular filtration rate (eGFR) <60 mL/min/1.73 m^2.[15]

Short- and Long-Term Outcomes

Postoperative complications were equated with grade II or higher events, using the Clavien–Dindo classification,[11] and intra-abdominal infection was defined as leakage, pancreatic fistula, or abscess. Our previously specified criteria[10] were applied for delineating hospital discharge. Transfer to another hospital was recommended if even one of these criteria was not met, whether or not the patient's condition was stable. Five-year rates of overall survival (OS) and cancer-specific survival (CSS) in the low- and high-PNI groups were compared. Patient mortality was tracked as death from GC recurrence or from other disease.

Statistical Analysis

Categorical variables were expressed as numerical values and percentages, and group data were compared via the χ^2 test. Fisher's exact test was used if the expected frequency was ≤ 5. Continuous variables with normal distributions were expressed as means and standard deviations, and mean values were compared using the Mann–Whitney *U* test. OS was defined as the time from operation until death, while CSS was defined as the time from operation until GC death. Survival curves were generated using the Kaplan–Meier method, analyzing differences using the log-rank test. Univariate and multivariate hazard ratios were calculated via Cox proportional hazard model, and all significant variables in the univariate analysis were entered into the multivariate analysis. All reported p values were two-sided, setting statistical significance at $p < 0.05$. The above computations relied on standard software (JMP v10; SAS Institute, Inc., Cary, NC, USA).

RESULTS

Receiver Operating Characteristic Curve

PNI ranged from 58.4 to 25.6 (mean 45.3). Area under the ROC curve in multiple logistic regression analysis (with 5-year survival as the endpoint) was 0.6481. At a PNI of 43.8, projected 5-year survival was optimal (sensitivity 0.5962; specificity 0.6531). Hence, this value was adopted as the cutpoint, stratifying subjects by low (PNI $\leq$ 43.8) or high (PNI > 43.8) nutritional status.

Clinicopathologic Patient Characteristics

Characteristics of the two study groups are shown in Table 1. Mean patient age did not differ significantly by group ($p = 0.3275$), and neither did sex ratios. In the low (vs. high) PNI group, body mass index (BMI) was significantly lower ($p = 0.0002$), and the proportion of patients with ASA scores of 3 was higher with a low (vs. high) PNI ranking ($p = 0.0004$). In terms of comorbidity, incidences of pulmonary and renal diseases were greater in the low (vs. high) PNI group, although not to statistically significant degrees. Otherwise, the two groups exhibited similar rates of ischemic heart, cerebrovascular, or liver disease, and diabetes mellitus. No significant differences were noted in tumor histotypes, by group. By comparison, the depth of tumor invasion and pathologic staging were more advanced in the low-PNI group, but statistical significance was not reached ($p = 0.0664$, $p = 0.0622$). The two groups were also similar in terms of lymph node metastasis ($p = 0.4858$), displaying comparable harvested lymph node counts in each stage of disease. Furthermore, no significant between-group differences were observed in the type or nature (open or laparoscopic) of gastrectomy procedures. The two groups were similar in proportionate recipients of NAC, but the need for intraoperative blood transfusion was significantly greater in the low (vs. high) PNI group ($p = 0.0091$). Postoperative stays and complication rates did not differ significantly by group ($p = 0.4494$, $p = 0.8681$). The proportion of patients released to another hospital was comparatively greater in the low-PNI group (3.2 vs. 1.2 %), albeit not to a statistically significant extent ($p = 0.5766$). Preoperative body weight (BW) in the low (vs. high) PNI group was significantly less ($p = 0.0099$), although no significant group differences in BW before discharge ($p = 0.0977$) or in percentage of BW change ($p = 0.4066$) were evident.

Short-Term Outcome

Postoperative complication rates did not differ significantly by group (low PNI, 23.8 %; high PNI, 25.0 %; $p = 0.8681$) and were distributed (low vs. high PNI) by Clavien–Dindo classification as follows: grade I, 1.6 vs. 3.6 %; grade II, 14.3 vs. 14.3 %; and grade III, 9.5 vs. 10.7 %. No grade IV or grade V complications were recorded in either group, and group differences by grade were not significant. Respective mean PNI values in patients with or without complications (44.7 ± 5.6 vs. 45.5 ± 5.6; $p = 0.5581$) and with or without intra-abdominal infections (45.5 ± 4.2 vs. 45.3 ± 5.7; $p = 0.9758$) were similar. PNI ranking and incidence of complications were unrelated.

Univariate and Multivariate Analysis

Univariate and multivariate analyses of OS data are shown in Table 2. Univariate analysis indicated that PNI ($p = 0.0013$), renal disease ($p = 0.0232$), p-stage 2 or greater ($p < 0.0001$), total gastrectomy ($p = 0.0090$), intraoperative blood transfusion ($p = 0.0021$), and infectious complications ($p = 0.0244$) were independent predictors of OS. In multivariate analysis of OS, low PNI and p-stage were independently associated with unfavorable outcomes in patients with GC. The hazard ratio for low PNI was 1.88 [95 % confidence interval (CI) 1.03–3.51; $p = 0.0394$].

Long-Term Survival Rate

Median duration of follow-up in this study was 51 months (range 4–115 months). Survival in patients with low PNI values was significantly shortened, relative to patients with high PNI values. In the low- and high-PNI groups, 5-year OS rates by disease stage were as follows: stage I, 57.8 versus 86.5 %; stage II, 31.4 versus 60.6 %; and stage III, 28.6 versus 34.8 % (Fig. 1). In stage I, outcomes were significantly worse in the low (vs. high) PNI group ($p = 0.0043$); however, in stages II and III, group outcomes did not differ significantly (stage II, $p = 0.2160$; stage III, $p = 0.7368$). On the other hand, 5-year CSS rates did not differ significantly by group, regardless of stage. In the low- and high-PNI groups, 5-year CSS rates by disease stage were as follows: stage I, 96.2 versus 100 % ($p = 0.1698$); stage II, 54.6 versus 60.6 % ($p = 0.9189$); and stage III, 48.4 versus 40.6 % ($p = 0.6614$) (see electronic supplementary Fig. 1).

Causes of Death

The causes of death in the low- and high-PNI groups are shown, by disease stage, in Table 3. The incidence of all deaths was significantly greater in the low (vs. high) PNI group ($p = 0.0375$). Death rates overall were significantly higher in the low (vs. high) PNI group at stage I disease ($p = 0.0296$), but at stages II and III, outcomes in both groups were similar (stage II, $p = 0.7337$; stage III, $p = 0.8228$). However, the rates of death from recurrence did not differ significantly by group, regardless of disease stage (stage I, $p = 0.3667$; stage II, $p = 0.6940$; stage III, $p = 0.8131$). On the other hand, rates of death from other disease were significantly higher in the low (vs. high) PNI group ($p = 0.0101$). At stage I disease, outcomes were significantly poorer in the low (vs. high) PNI group

TABLE 1 Clinicopathologic patient characteristics

	All patients (n = 147)	Low PNI (n = 63)	High PNI (n = 84)	p value
Age (mean)	79.0 ± 3.4	79.4 ± 3.7	78.7 ± 3.1	0.3275
Sex, male [n (%)]	95 (64.6)	41 (65.1)	54 (64.3)	0.9207
BMI	22.0 ± 3.5	20.8 ± 3.1	22.9 ± 3.5	0.0002
ASA [n (%)]				
1	5 (3.4)	3 (4.8)	2 (2.4)	0.0004
2	126 (85.7)	46 (73.0)	80 (95.2)	
3	16 (10.9)	14 (22.2)	2 (2.4)	
Comorbidity [n (%)]				
Ischemic heart disease	16 (10.9)	5 (7.9)	11 (13.1)	0.3203
Cerebrovascular disease	7 (4.8)	2 (3.2)	5 (6.0)	0.4338
Diabetes mellitus	22 (15.0)	7 (11.1)	15 (17.9)	0.2565
Pulmonary disease	23 (15.6)	14 (22.2)	9 (10.7)	0.0574
Liver disease	12 (8.2)	6 (9.5)	6 (7.1)	0.6018
Renal disease	21 (14.3)	13 (20.6)	8 (9.5)	0.0568
Histotype [n (%)]				
Differentiated	83 (56.5)	32 (50.8)	51 (60.7)	0.2299
Undifferentiated	64 (43.5)	31 (49.2)	33 (39.3)	
Depth of tumor, pT [n (%)]				
1	79 (53.7)	29 (46.0)	50 (59.5)	0.0664
2	20 (13.6)	9 (14.3)	11 (13.1)	
3	16 (10.9)	5 (7.9)	11 (13.1)	
4	32 (21.8)	20 (31.8)	12 (14.3)	
Lymph node metastasis, pN [n (%)]				
0	102 (69.4)	41 (65.1)	61 (72.6)	0.4858
1	15 (10.2)	6 (9.5)	9 (10.7)	
2	19 (12.9)	9 (14.3)	10 (11.9)	
3	11 (7.5)	7 (11.1)	4 (4.8)	
pStage [n (%)]				
I	89 (60.5)	32 (50.8)	57 (67.9)	0.0622
II	28 (19.0)	17 (27.0)	11 (13.1)	
III	30 (20.4)	14 (22.2)	16 (19.1)	
Gastrectomy type [n (%)]				
Total	51 (34.7)	19 (30.2)	32 (38.1)	0.3171
Partial	96 (65.3)	44 (69.8)	52 (61.9)	
Nature of procedure [n (%)]				
Open	114 (77.6)	52 (82.5)	62 (73.8)	0.2093
Laparoscopic	33 (22.4)	11 (17.5)	22 (26.2)	
Neoadjuvant chemotherapy [n (%)]	4 (2.9)	2 (3.2)	2 (2.4)	0.7698
Harvested lymph node count				
Stage I	25.6 ± 12.1	25.3 ± 11.4	25.7 ± 12.5	0.9171
Stage II	35.0 ± 13.2	35.8 ± 14.3	33.8 ± 11.9	
Stage III	39.1 ± 17.7	39.8 ± 20.9	38.6 ± 15.0	
Intraoperative blood transfusion [n (%)]	18 (13.1)	13 (21.7)	5 (6.5)	0.0091
Postoperative stay, days	18.1 ± 9.4	17.7 ± 10.0	18.4 ± 9.1	0.4494
Complications, all [n (%)]	36 (24.5)	15 (23.8)	21 (25.0)	0.8681
Discharge [n (%)]				
Home	144 (98.0)	61 (96.8)	83 (98.8)	0.5766
Other hospital	3 (2.0)	2 (3.2)	1 (1.2)	

TABLE 1 continued

	All patients ($n = 147$)	Low PNI ($n = 63$)	High PNI ($n = 84$)	p value
Preoperative body weight (kg)[a]	54.8 ± 10.5	52.2 ± 9.7	56.8 ± 10.7	0.0099
Body weight before discharge (kg)[a]	52.5 ± 9.4	50.5 ± 8.1	53.8 ± 10.0	0.0984
Body weight loss (%)[a]	−5.9 ± 3.7	−5.8 ± 3.9	−6.0 ± 3.6	0.4086

PNI prognostic nutritional index, *BMI* body mass index, *ASA* American Society of Anesthesiologists

[a] Data available for 101 patients (41 patients in the low-PNI group and 60 patients in the high-PNI group)

TABLE 2 Univariate and multivariate analyses of factors predicting overall survival (OS)

Variables	Univariate analysis		Multivariate analysis	
	HR (95 % CI)	p value	HR (95 % CI)	p value
Age ≥ 80 years	1.19 (0.67–2.07)	0.5449	–	–
Sex, male	1.16 (0.65–2.15)	0.6208	–	–
BMI ≥ 22	1.19 (0.68–2.07)	0.5302	–	–
Ischemic heart disease	1.58 (0.65–3.29)	0.2883	–	–
Cerebrovascular disease	2.42 (0.84–5.53)	0.0950	–	–
Diabetes mellitus	1.15 (0.50–2.31)	0.7292	–	–
Pulmonary disease	1.55 (0.73–2.98)	0.2345	–	–
Liver disease	0.95 (0.29–2.33)	0.9160	–	–
Renal disease	2.25 (1.13–4.18)	0.0232	2.02 (0.94–4.05)	0.0689
pStage 2, 3	3.40 (1.94–6.11)	<0.0001	2.97 (1.61–5.58)	0.0004
Type of gastrectomy (total)	2.10 (1.21–3.65)	0.0090	1.42 (0.76–2.65)	0.2684
Nature of procedure (open)	0.96 (0.52–1.92)	0.9118	–	–
Intraoperative blood transfusion	3.15 (1.57–5.88)	0.0021	1.95 (0.95–3.73)	0.0660
Complication (infection)	2.31 (1.12–4.35)	0.0244	1.47 (0.67–3.02)	0.3286
PNI (low)	2.48 (1.42–4.43)	0.0013	1.88 (1.03–3.51)	0.0394

HR hazard ratio, *CI* confidence interval, *BMI* body mass index

($p = 0.0477$), whereas outcomes at stages II and III did not differ significantly by group (stage II, $p = 0.1435$; stage III, $p = 0.6012$). Diseases contributing to mortality are shown in Table 4 and were distributed (low vs. high PNI) as follows: other malignancies, 9.5 versus 4.8 %; pneumonia, 3.2 versus 1.2 %; cholangitis, 0 versus 2.4 %; vascular disease, 4.8 versus 0 %; cirrhosis, 1.6 versus 0 %; renal failure, 3.2 versus 0 %; ileus, 1.6 versus 0 %; chemotherapy-related death, 1.6 versus 0 %; debility, 3.2 versus 1.2 %; unknown cause (sudden death at home), 3.2 versus 1.2 %.

DISCUSSION

Our study findings indicate that preoperative PNI values in elderly patients with GC are independently predictive of poor prognosis, reflecting pathologic disease stage as well. Long-term outcomes of patients with stage I disease were significantly poorer in patients with low (vs. high) nutritional status. Preoperative PNI may thus be a valid prognosticator in patients with stage I GC, in turn implying that determination of PNI prior to surgical resection is independently predictive of poor survival, even if expectations by staging are high.

On the other hand, OS did not differ significantly by PNI group in patients with GC at stages II and III, indicating a negligible impact of nutritional status on OS in elderly patients with advanced disease. Bachmann et al. have reported that, at stages 1a and 1b of the Union for International Cancer Control (UICC), nutrition risk score (NRS) ≥3 reflected significantly poorer survival, relative to NRS <3, whereas NRS held no significance in the later stages of tumor progression.[12] These authors concluded that, in advanced GC, the influence of an NRS on survival was marginal, corresponding with our analysis of long-term data.

Our investigation also demonstrated that death from non-GC causes, including other malignancies, pneumonia, renal failure, cirrhosis, etc., were statistically more frequent in the low-PNI group than in the high-PNI group. Thus, we have clarified that poorer OS in patients with low (vs. high) PNI determinations carried out prior to gastrectomy for GC

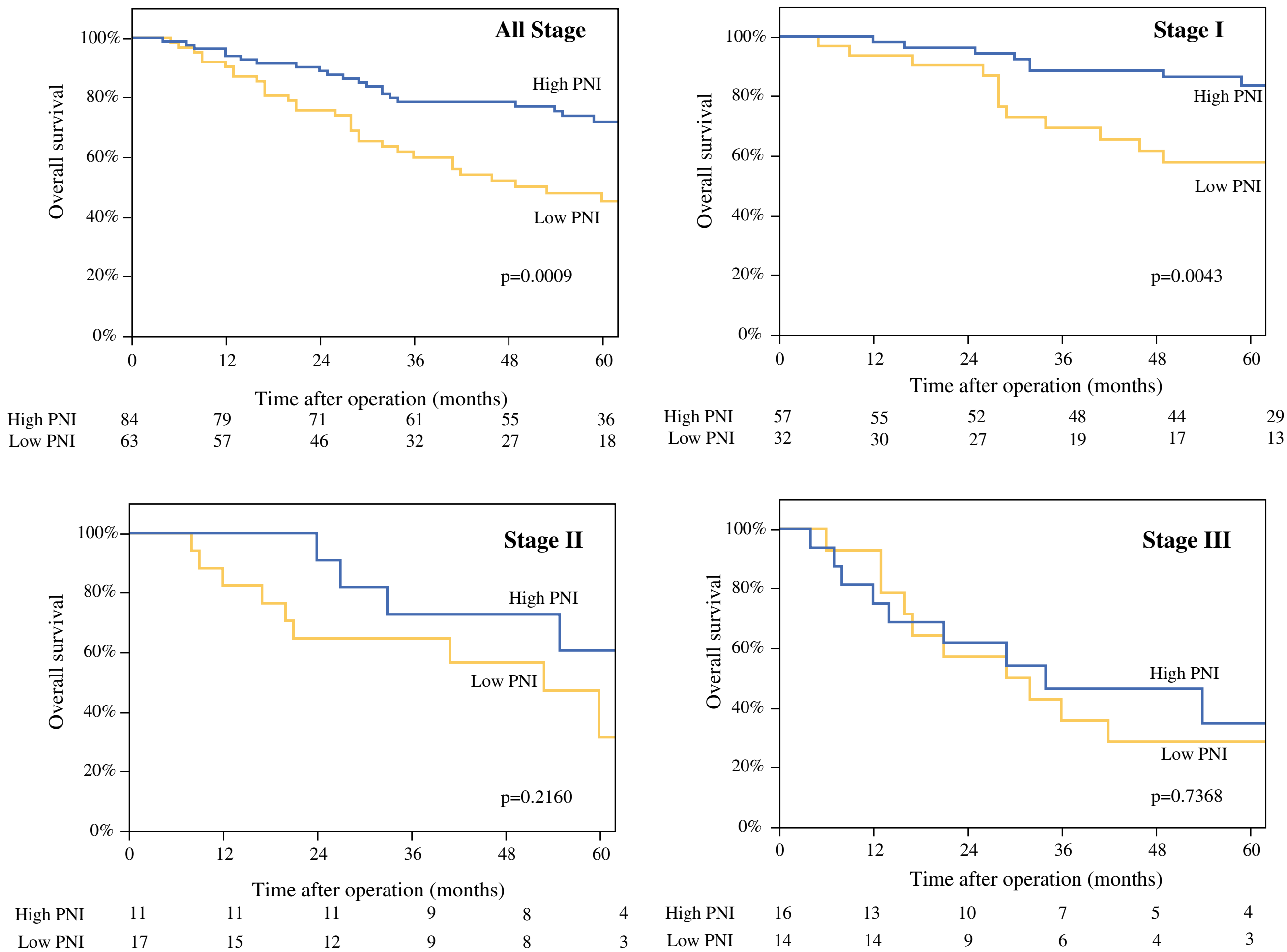

FIG. 1 Overall survival curve

is attributable to other diseases. Death from recurrent GC occurred with similar frequency in the two groups. From our perspective, pre- and postoperative management of nutritional status is needed for better long-term outcomes in this setting. This premise, of course, requires confirmation by randomized prospective study.

Of particular interest in the two groups studied is the percentage of BW loss (BWL), which did not differ significantly. Hence, it appears that gastrectomy actually perpetuates nutritional dysfunction in elderly malnourished patients with GC. However, Lee et al. have reported a relationship between high BMI (relative to normal range) and reduced overall mortality at postoperative year[1,13] implying that efforts to prevent postoperative BWL may well improve long-term outcomes. Hoover et al. have further shown that BW is well maintained after upper gastrointestinal surgery through enteral feeding by jejunostomy,[14] as did a randomized clinical trial conducted by Bowrey et al. The latter compared enteral feeding by jejunostomy with routine clinical care (no jejunostomy) in the aftermath of esophagectomy or total gastrectomy. Relative to routine care, a number of nutritional indices (including BW) fared significantly better in subjects after 6 weeks of feeding via jejunostomy;[15] observed benefits persisted at 3 and 6 months postoperatively. Jejunostomy is thus a promising means of improving outcomes by boosting nutrition in malnourished elderly patients post-gastrectomy.

In this study, an optimal cutpoint of 43.8 was established for PNI through ROC curve analysis, but at a PNI cutpoint of 45 (i.e. moderate malnourishment in patients with colon cancer), PNI also proved predictive of poor survival in elderly patients with GC via univariate and multivariate analyses (data not shown). A PNI cutpoint of 44.7 has been cited by Watanabe et al.[8] as predicting poor survival in patients with GC and, in patients with pancreatic cancer, Kanda et al.[7] found a PNI cutpoint of 45 was predictive of poor survival.[7] These results cumulatively support the utility PNI in gauging survival of patients with various cancers.

Although PNI values in patients developing complications tended to be lower by comparison, no significant

TABLE 3 Mortality by group and disease stage

	Low PNI (%)	High PNI (%)	*p* value
All deaths			
All stages	50.8 (31/63)	25.0 (21/84)	0.0375
pStage I	40.6 (13/32)	14.0 (8/57)	0.0296
pStage II	52.9 (9/17)	36.4 (4/11)	0.7337
pStage III	64.3 (9/14)	56.3 (9/16)	0.8228
Due to recurrence			
All stages	17.5 (11/63)	14.3 (12/84)	0.6549
pStage I	3.1 (1/32)	0 (0/57)	0.3667
pStage II	23.5 (4/17)	36.4 (4/11)	0.6940
pStage III	42.9 (6/14)	50.0 (8/16)	0.8131
Due to other disease			
All stages	31.7 (20/63)	10.7 (9/84)	0.0101
pStage I	37.5 (12/32)	14.0 (8/57)	0.0477
pStage II	29.4 (5/17)	0 (0/11)	0.1435
pStage III	21.4 (3/14)	6.3 (1/16)	0.6012

PNI prognostic nutritional index

TABLE 4 Other diseases by group (causes of death)

	Low PNI ($n = 63$) (%)	High PNI [$n = 84$] (%)
Other malignancies	6 (9.5)	4 (4.8)
Pneumonia	2 (3.2)	1 (1.2)
Cholangitis	0	2 (2.4)
Vascular disease	3 (4.8)	0
Cirrhosis	1 (1.6)	0
Renal failure	2 (3.2)	0
Ileus	1 (1.6)	0
Chemotherapy-related death	1 (1.6)	0
Debility	2 (3.2)	1 (1.2)
Unknown cause (sudden death at home)	2 (3.2)	1 (1.2)
Total	20 (31.7)	9 (10.7)

PNI prognostic nutritional index

relationship between preoperative PNI and postoperative complications was evident in the present investigation. These results are aligned with those of Watanabe et al.[8] However, in another study of patients undergoing surgery for GC, Pacelli et al. failed to correlate weight loss and hypoalbuminemia with increased mortality/morbidity risks.[16] We believe that recent gains in the safety of gastrectomy have nevertheless been achieved through improved perioperative management,[17,18] thus quelling the short-term negative consequences of gastrectomy in elderly malnourished patients.

Given that this was a retrospective single-center study, the observed negative impact of low preoperative PNI on OS in this setting must await confirmation in multicenter, prospective trials. Nevertheless, the importance of nutrition in elderly patients with GC who undergo gastrectomy must be emphasized.

CONCLUSIONS

Preoperative PNI proved independently predictive of OS in elderly patients treated by gastrectomy for GC. Patients with stage I GC and low preoperative PNI showed greater risk of death post-gastrectomy due to other diseases. The impact of low preoperative PNI on patient morbidity was negligible in this setting.

CONFLICT OF INTEREST Katsunobu Sakurai, Tatsuro Tamura, Takahiro Toyokawa, Ryosuke Amano, Naoshi Kubo, Hiroaki Tanaka, Kazuya Muguruma, Masakazu Yashiro, Kiyoshi Maeda, Masaichi Ohira, and Kosei Hirakawa declare no conflicts of interest.

REFERENCES

1. Takeshita H, Ichikawa D, Komatsu S, et al. Surgical outcomes of gastrectomy for elderly patients with gastric cancer. *World J Surg*. 2013;37(12):2891–8.
2. Oki E, Sakaguchi Y, Ohgaki K, et al. Totally laparoscopic distal gastrectomy for elderly patients with gastric cancer. *Fukuoka Igaku Zasshi*. 2013;104(9):290–8.
3. Kim MG, Kim HS, Kim BS, Kwon SJ. The impact of old age on surgical outcomes of totally laparoscopic gastrectomy for gastric cancer. *Surg Endosc*. 2013;27(11):3990–7.
4. Gretschel S, Estevez-Schwarz L, Hunerbein M, Schneider U, Schlag PM. Gastric cancer surgery in elderly patients. *World J Surg*. 2006;30(8):1468–74.
5. Sakurai K, Ohira M, Tamura T, et al. Predictive potential of preoperative nutritional status in long-term outcome projections for patients with gastric cancer. *Ann Surg Oncol*. 2016;23(2): 525–33.
6. Onodera T, Goseki N, Kosaki G. Prognostic nutritional index in gastrointestinal surgery of malnourished cancer patients [in Japanese]. *Nippon Geka Gakkai Zasshi* 1984;85:1001–5.
7. Kanda M, Fujii T, Kodera Y, Nagai S, Takeda S, Nakao A. Nutritional predictors of postoperative outcome in pancreatic cancer. *Br J Surg*. 2011;98(2):268–74.
8. Watanabe M, Iwatsuki M, Iwagami S, Ishimoto T, Baba Y, Baba H. Prognostic nutritional index predicts outcomes of gastrectomy in the elderly. *World J Surg*. 2012;36(7):1632–9.
9. Japanese Gastric Cancer Association. Japanese classification of gastric carcinoma 2010. 14th ed. Tokyo: Kanehara; 2010.
10. Sakurai K, Muguruma K, Nagahara H, et al. The outcome of surgical treatment for elderly patients with gastric carcinoma. *J Surg Oncol*. 2015;111(7):848–54.
11. Clavien PA, Barkun J, de Oliveira ML, et al. The Clavien-Dindo classification of surgical complications: five-year experience. *Ann Surg*. 2009;250(2):187–96.
12. Bachmann J, Muller T, Schroder A, et al. Influence of an elevated nutrition risk score (NRS) on survival in patients following gastrectomy for gastric cancer. *Med Oncol*. 2015;32(7):204.
13. Lee HH, Park JM, Song KY, Choi MG, Park CH. Survival impact of postoperative body mass index in gastric cancer patients undergoing gastrectomy. *Eur J Cancer*. 2016;52:129–37.
14. Hoover HC Jr, Ryan JA, Anderson EJ, Fischer JE. Nutritional benefits of immediate postoperative jejunal feeding of an elemental diet. *Am J Surg*. 1980;139(1):153–9.
15. Bowrey DJ, Baker M, Halliday V, et al. A randomised controlled trial of six weeks of home enteral nutrition versus standard care after oesophagectomy or total gastrectomy for cancer: report on a pilot and feasibility study. *Trials*. 2015;16:531.
16. Pacelli F, Bossola M, Rosa F, Tortorelli AP, Papa V, Doglietto GB. Is malnutrition still a risk factor of postoperative complications in gastric cancer surgery? *Clin Nutr*. 2008;27(3):398–407.
17. Yamada T, Hayashi T, Cho H, et al. Usefulness of enhanced recovery after surgery protocol as compared with conventional perioperative care in gastric surgery. *Gastric Cancer*. 2012;15(1):34–41.
18. Zhou H, Yi W, Zhang J, et al. Short- and long-term outcomes of LigaSure versus conventional surgery for curative gastric cancer resection: a matched pair analysis. *Gastric Cancer*. 2015;18(4): 843–9.