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Original article

Association between early nutritional risk and overall survival in patients with advanced pancreatic cancer: A single-center retrospective study

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SUMMARY

Background & aims: We investigated the predictors of overall survival (OS) among Korean patients with advanced pancreatic cancer (PC) according to their baseline nutritional status.
Methods: We retrospectively reviewed the data of 412 inpatients with PC between January 2007 and February 2015 at the Department of Oncology of the Gangnam Severance Hospital, Korea. Data on demographic and clinical parameters were collected from electronic medical records, and OS was estimated using the Kaplan–Meier method. Stepwise Cox regression analysis was used to determine the factors associated with survival. Patients with a Nutritional Risk Screening (NRS) 2002 score <3 were classified as "no-risk; " those with a score of 3 were classified as "moderate-risk; " and those with a score of ≥4 were classified as "high-risk."
Results: Following nutritional screening at baseline, 194 patients (47.1%, mean age 61.8 ± 9.9 years) were classified as the "no risk" group; 81 patients (19.7%, mean age 65.4 ± 10.8 years), as the "moderate risk" group; and 137 patients (33.3%, mean age 67.8 ± 12.0 years), as the "high risk" group. Predictors of survival were NRS 2002 score (hazard ratio [HR] = 1.238; 95% confidence interval [CI] = 1.143–1.341), percentage of lymphocytes (HR = 0.973; 95% CI = 0.962–0.984), C-reactive protein level (HR = 1.003; 95% CI = 1.001–1.006), carcinoembryonic antigen level (HR = 1.000; 95% CI = 1.000–1.000), and carbohydrate antigen 19-9 level (HR = 1.000; 95% CI = 1.000–1.000). Kaplan–Meier survival analysis showed significant differences in the median OS among the NRS 2002 groups: "no risk" group: 12.3 ± 0.4 months (95% CI: 11.47–13.13 months); "moderate risk" group: 6.5 ± 0.9 months (95% CI: 4.78–8.17 months); and "high risk" group: 5.5 ± 0.6 months (95% CI: 4.31–6.69 months).
Conclusions: A good baseline nutritional status was associated with OS among Korean patients with advanced PC. An improvement in the nutritional status of patients with advanced PC through baseline nutritional interventions is therefore necessary to prolong OS.

1. Introduction

Pancreatic cancer (PC) is the fourth leading cause of cancer-related deaths in the United States, with an estimated 43,090 deaths in 2017 [1]. The 5-year survival rate is 8%, with a median survival of 5 months [2,3]. Malnutrition characterized by weight loss, and the rapid development of anorexia-cachexia-syndrome is common among patients with advanced PC [4]. Unexplained weight loss may occur as a result of anorexia or malabsorption due to pancreatic exocrine insufficiency [5]. More than 80% of patients suffer significant weight loss at diagnosis and over time develop

Abbreviations: Bioelectrical impedance analysis, BIA; blood urea nitrogen, BUN; body mass index, BMI; confidence interval, CI; Eastern Cooperative Oncology Group, ECOG; European Society for Clinical Nutrition and Metabolism, ESPEN; hazard ratio, HR; neutrophil to lymphocyte ratio, NLR; Nutritional Risk Screening 2002, NRS 2002; pancreatic cancer, PC.

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severe cachexia. Cachexia was shown to decrease survival and increase treatment failure in patients with PC [5–8].

Nutritional problems, which are common in patients with advanced PC, not only affect disease progression but also increase mortality rates. Various studies have revealed that malnutrition leads to skeletal muscle wasting and fat degradation, a longer hospital stay, an increased risk of complications, a lower response to treatment, shorter survival time, as well as increased morbidity and mortality [9–11]. Because of the high prevalence of malnutrition and the rapid development of anorexia-cachexia-syndrome in patients with advanced PC, it is reasonable to conclude that the risk of adverse outcomes is greatly increased in patients with advanced PC.

Previous studies of PC have demonstrated the benefits of weight stabilization in terms of patient outcomes. Patients who maintained a stable weight and body composition were shown to have better prognosis [12,13]. Further, among cases of unresectable PC, weight stabilization was associated with improved survival [14]. These results indicate that baseline nutritional status and nutritional interventions are crucial to patient outcomes in general and, possibly, to outcomes among patients with advanced PC. It would therefore be advantageous to study the potential predictors of overall survival (OS) in patients with advanced PC. To our knowledge, no such study has been conducted.

In the present study, we aimed to examine the associations between baseline nutritional risk and OS among adult Korean patients with advanced PC. We also investigated the predictors of OS. On the basis of previous literature, we hypothesized that it is important to improve most nutritional significant predictors of OS via a baseline nutritional intervention in order to prolong OS in patients with advanced PC.

2. Methods

2.1. Patients

A retrospective study was conducted in 412 in-patients with advanced (metastatic) PC between January 2007 and February 2015 at the Pancreato-biliary Cancer Clinic of the Gangnam Severance Hospital in Korea. The study participants were all fourth-stage, metastatic PC patients and were selected using the systematic random sampling method.

In March 2015, this study protocol was approved by the Institutional Review Board of the Yonsei University Medical Center, IRB number 3-2015-0318. Data collection was carried out between April and July 2015. The requirement for patient consent was waived because of the retrospective study design.

2.2. Data collection

Anthropometric and biochemical data were collected at baseline from electronic medical records. Screening for the risk of malnutrition was performed using the Nutritional Risk Screening 2002 (NRS 2002). The NRS 2002 is a screening tool recommended by the European Society for Clinical Nutrition and Metabolism (ESPEN) for nutritional screening in hospitals. It assesses nutritional risk by collecting data on weight loss, body mass index (BMI), food intake, disease severity, and age. Patient scores in the NRS 2002 are calculated as the score of impaired nutrition status + disease severity. If the patient's age is $\geq$70 years, 1 is added to the total score [15]. Patients with an NRS 2002 score <3 were classified as "no-risk; " those with a score of 3 were classified as "moderate-risk; " and those with a score of $\geq$4 were classified as "high-risk."

2.3. Statistical analysis

All data were analyzed using SPSS (Statistical Package for Social Science), version 23.0 (SPSS Inc., IBM, USA). Means and standard deviations were calculated for each measurement value. We used ANOVA followed by the Scheffe method to compare the NRS 2002 groups ("no-risk," "moderate-risk," and "high-risk"). Stepwise multivariable Cox regression analysis was used to determine factors associated with OS. The statistical significance threshold was 0.05. Actuarial life table analysis was used to estimate the cumulative proportion of surviving patients, and the Kaplan–Meier survival function was used to estimate mortality. Finally, the log-rank test was conducted to compare the time to death among the NRS 2002 groups.

3. Results

3.1. Baseline clinical outcomes by NRS 2002 groups

Among the 412 patients with advanced PC under investigation, 203 were men (49.3%, mean age 63.1 ± 10.7 years) and 209 were women (50.7%, mean age 65.9 ± 11.4 years). Regarding the baseline nutritional risk groups based on the NRS 2002 score, 194 patients (47.1%, mean age 61.8 ± 9.9 years, BMI 23.60 ± 3.87 kg/m^2) were in the "no-risk" group, 81 patients (19.7%, mean age 65.4 ± 10.8 years, BMI 21.30 ± 2.59 kg/m^2) were in the "moderate-risk" group, and 137 patients (33.3%, mean age 67.8 ± 12.0 years, BMI 20.36 ± 3.36 kg/m^2) were in the "high-risk" group.

At baseline, several demographic characteristics and clinical parameters were significantly different between the nutritional risk groups. The "moderate-" and high-risk" groups had an higher mean age than the "no-risk" group ($p < .001$), whereas the "no-risk" group showed a higher BMI than the "moderate-" and high-risk" groups ($p < .001$). The "no-" and "moderate-risk" groups had higher albumin and protein levels that the "high-risk" group ($p < .001$). The "high-risk" group exhibited higher C-reactive protein levels than the "no-risk" group ($p < .01$), whereas the "moderate-risk" group showed a higher neutrophil count than the "no-risk" group ($p < .05$). A higher lymphocyte count was seen in the "no-risk" group when compared to the "high-risk" group ($p < .001$), and the percentage of lymphocytes was higher in the "no-risk" group than in the "moderate-" and high-risk" groups ($p < .001$). The CA 19-9 was higher in the "moderate-" and high-risk" groups than in the "no-risk" group ($p < .05$). The CEA as well as location (head of pancreas involvement), stage IV (all metastatic), two or more metastatic lesions, presence of invasion to the digestive tract, and type of therapy were not significantly different between the nutritional risk groups (Table 1).

3.2. Associations between baseline clinical characteristics and overall survival

We found that a high percentage of lymphocytes (hazard ratio [HR] = 0.960; 95% confidence interval [CI] = 0.950–0.970), high lymphocyte count/1000 (HR = 0.640; 95% CI = 0.539–0.759), high albumin level (HR = 0.598; 95% CI = 0.495–0.722), and high BMI (HR = 0.935; 95% CI = 0.905–0.967) were associated with improved OS. Conversely, many variables were predictive of poorer survival. A high NRS 2002 score (HR = 1.503; 95% CI = 1.340–1.687), high C-reactive protein level (HR = 1.007; 95% CI = 1.005–1.008), high white blood cell/1000 count (HR = 1.101; 95% CI = 1.064–1.139), high neutrophil/1000 count (HR = 1.124; 95% CI = 1.088–1.160), high blood urea nitrogen level (HR = 1.021; 95% CI = 1.009–1.033), older age (HR = 1.016; 95% CI = 1.007–1.026), high CEA level (HR = 1.000; 95% CI = 1.000–1.000), high CA 19-9 level (HR = 1.000;

Table 1
Comparison of baseline demographic and clinical parameters by NRS 2002 groups in Korean patients with advanced pancreatic cancer (n = 412).

		"No-risk" group (n = 194, 47.1%) (A)	"Moderate-risk" group (n = 81, 19.7%) (B)	"High-risk" group (n = 137, 33.2%) (C)	P value	Scheffe
Sex	Male	110 (56.7%)	37 (45.7%)	56 (40.9%)		
	Female	84 (43.3%)	44 (54.3%)	81 (59.1%)		
Age (years)		61.81 ± 9.90	65.38 ± 10.76	67.82 ± 11.97	<.001	A < B,C
BMI (kg/m^2)		23.60 ± 3.87	21.30 ± 2.59	20.36 ± 3.36	<.001	C,B < A
Albumin (g/dL)		4.22 ± 0.46	4.07 ± 0.58	3.87 ± 0.60	<.001	C < B,A
Protein (g/dL)		6.90 ± 0.65	6.79 ± 0.58	6.52 ± 0.73	<.001	C < B,A
CRP (mg/L)		16.54 ± 34.99	26.23 ± 47.52	33.62 ± 55.39	<.01	A < C
T-cholesterol (mg/dL)		169.67 ± 45.93	169.36 ± 53.28	169.60 ± 57.14	NS	
WBC (10^3/μL)		7152.42 ± 2708.74	7934.07 ± 3771.12	7132.92 ± 2979.45	NS	
Hg (g/dL)		12.74 ± 1.81	12.37 ± 1.67	12.99 ± 12.51	NS	
Neutrophils (10^3/μL)		4621.29 ± 2577.15	5589.14 ± 3636.49	4994.31 ± 2781.93	<.05	A < B
Lymphocyte count (10^3/μL)		1734.43 ± 716.42	1539.14 ± 670.14	1382.63 ± 585.61	<.001	C < A
Lymphocytes (%)		26.55 ± 11.19	21.68 ± 9.52	21.90 ± 10.64	<.001	B,C < A
BUN (mmol/L)		14.75 ± 6.70	16.02 ± 11.45	15.71 ± 11.65	NS	
PLT (10^3/μL)		262.10 ± 107.36	253.07 ± 94.79	256.88 ± 95.14	NS	
CEA (ng/ml)		85.20 ± 626.77	43.70 ± 141.93	95.33 ± 347.83	NS	
CA 19-9 (IU/ml)		2122.23 ± 4847.60	3513.96 ± 6480.10	3560.00 ± 6066.31	<.05	
Location (head of pancreas involvement)		117 (60.3%)	42 (51.9%)	71 (51.8%)	NS	
Stage IV (all metastatic)					NS	
Two or more metastatic lesions		99 (51.0%)	47 (58.0%)	86 (62.8%)	NS	
Presence of invasion to the digestive tract		76 (39.2%)	36 (44.4%)	69 (50.4%)	NS	
Type of therapy						
CTX		160 (82.5%)	65 (80.2%)	77 (56.2%)	NS	
CCRT		23 (11.9%)	4 (4.9%)	5 (3.6%)	<.05	
Surgery			1 (1.2%)		NS	
Surgery + CTX				1 (7%)	NS	
No treatment		11 (5.7%)	11 (13.6%)	54 (39.4%)	<.001	

All data are presented as means ± standard deviations except for sex, location, stage, and treatment which are shown as n (%).
P < 0.05 indicates statistically significant differences.
BMI: body mass index; BUN: blood urea nitrogen; CA 19-9: carbohydrate antigen 19-9; CCRT: concurrent chemoradiation therapy; CEA: carcinoembryonic antigen; CRP: C-reactive protein; CTX: chemotherapy; Hg: hemoglobin; NS: not significant; PLT: platelet count; T-chol: total cholesterol; WBC: white blood cell count.

95% CI = 1.000–1.000), CCRT (HR = 1.852; 95% CI = 1.252–2.740), and Chemotherapy (HR = 1.740; 95% CI = 1.390–2.177) were associated with poorer survival. The platelet count as well as hemoglobin, protein, and total cholesterol levels were not significantly associated with survival among patients with advanced PC (Table 2).

3.3. Predictors for overall survival

Stepwise multivariable Cox regression analysis, adjusted for various prognostic factors, was used to determine the predictors of OS among Korean patients with advanced PC. In Model 1, with various prognostic factors plus concurrent chemoradiation therapy, the NRS 2002 score was the most predictive factor of poor OS among patients with advanced PC (HR = 1.238; 95% CI = 1.143–1.341). The percentage of lymphocytes was a significant predictor of improved OS (HR = 0.973; 95% CI = 0.962–0.984). The C-reactive protein level was a significant predictor of poorer OS (HR = 1.003; 95% CI = 1.001–1.006). The carcinoembryonic antigen was significant predictor of poorer OS (HR = 1.000; 95% CI = 1.000–1.000). Lastly, the carbohydrate antigen 19-9 was significant predictor of poorer OS (HR = 1.000; 95% CI = 1.000–1.000). This is what we had in mind. In Model 2, with various prognostic factors plus chemotherapy, chemotherapy was the most predictive factor of poor OS among patients with advanced PC (HR = 1.924; 95% CI = 1.496–2.475). The NRS 2002 score was a significant predictor of poor OS among patients with advanced PC (HR = 1.234; 95% CI = 1.138–1.338). The percentage of lymphocytes was a significant predictor of improved OS (HR = 0.971; 95% CI = 0.960–0.983). The C-reactive protein level was a significant predictor of poorer OS (HR = 1.003; 95% CI = 1.001–1.005). The carcinoembryonic antigen was significant predictor of poorer OS (HR = 1.000; 95% CI = 1.000–1.000). Lastly, the carbohydrate antigen 19-9 was significant predictor of poorer OS (HR = 1.000; 95% CI = 1.000–1.000). Age, BMI, and levels of total cholesterol, albumin, protein, white blood cells, platelets, neutrophils, lymphocytes, hemoglobin, and blood urea nitrogen did not reach statistical significance as confounding variables in our models (Table 3).

Table 2
Univariate Cox regression analysis of the association between demographic and clinical characteristics and overall survival in Korean patients with advanced pancreatic cancer.

Variable	HR (95% CI)	P value
High NRS 2002 score	1.503 (1.340–1.687)	<.001
High C-reactive protein level	1.007 (1.005–1.008)	<.001
High white blood cell/1000 count	1.101 (1.064–1.139)	<.001
High neutrophil/1000 count	1.124 (1.088–1.160)	<.001
High blood urea nitrogen level	1.021 (1.009–1.033)	<.001
Older age	1.016 (1.007–1.026)	<.001
High CEA level	1.000 (1.000–1.000)	<.001
High CA 19-9 level	1.000 (1.000–1.000)	<.001
CCRT	1.852 (1.252–2.740)	<.01
Chemotherapy	1.740 (1.390–2.177)	<.001
High percentage of lymphocytes	0.960 (0.950–0.970)	<.001
High lymphocyte count/1000	0.640 (0.539–0.759)	<.001
High albumin level	0.598 (0.495–0.722)	<.001
High body mass index	0.935 (0.905–0.967)	<.001
High platelet count	1.000 (0.999–1.002)	NS
High hemoglobin level	0.984 (0.953–1.016)	NS
High protein level	0.896 (0.770–1.044)	NS
High total cholesterol level	1.000 (0.998–1.002)	NS

CA 19-9: carbohydrate antigen 19-9; CCRT: concurrent chemoradiation therapy; CEA: carcinoembryonic antigen; CI: confidence interval; HR: hazard ratio; NRS: Nutritional Risk Screening 2002; NS: not significant.

3.4. Overall survival by NRS 2002 groups

The overall estimated median OS of patients with advanced PC in the Kaplan–Meier survival analysis was 8.3 ± 0.5 months (95% CI: 7.39–9.21 months). The number at risk for all patients was 218

Table 3
Stepwise multivariable Cox regression analysis for overall survival, adjusted for various prognostic factors.

Factor	HR (95% CI)	P value
Model 1) Various prognostic factors plus concurrent chemoradiation therapy		
High NRS 2002 score	1.238 (1.143–1.341)	<.001
High percentage of lymphocytes	0.973 (0.962–0.984)	<.001
High C-reactive protein level	1.003 (1.001–1.006)	<.01
High CEA level	1.000 (1.000–1.000)	<.001
High CA 19-9 level	1.000 (1.000–1.000)	<.05
Model 2) Various prognostic factors plus chemotherapy		
Chemotherapy	1.924 (1.496–2.475)	<.001
High NRS 2002 score	1.234 (1.138–1.338)	<.001
High percentage of lymphocytes	0.971 (0.960–0.983)	<.001
High C-reactive protein level	1.003 (1.001–1.005)	<.01
High CEA level	1.000 (1.000–1.000)	<.05
High CA 19-9 level	1.000 (1.000–1.000)	<.01

CA 19-9: carbohydrate antigen 19-9; CEA: carcinoembryonic antigen; CI: confidence interval; HR: hazard ratio; NRS: Nutritional Risk Screening 2002.

(52.9%). When we analyzed the survival time by baseline nutritional status, we found significant differences in cumulative OS among the NRS 2002 groups (log-rank test $X^2 = 53.512$, $p < .001$). The "no-risk" group had a median survival of 12.3 ± 0.4 months (95% CI: 11.47–13.13 months); the "moderate-risk" group had a median survival of 6.5 ± 0.9 months (95% CI: 4.78–8.17 months); and the "high-risk" group had a median survival of 5.5 ± 0.6 months (95% CI: 4.31–6.69 months) (Fig. 1).

4. Discussion

This retrospective study investigated the predictors of OS among patients with advanced PC at a single center. Predictors investigated for possible associations with OS included baseline demographic and clinical characteristics.

The baseline NRS 2002 score was the best predictor of OS among patients with advanced PC patients and was associated with poorer survival. This finding supports previous evidence from a study

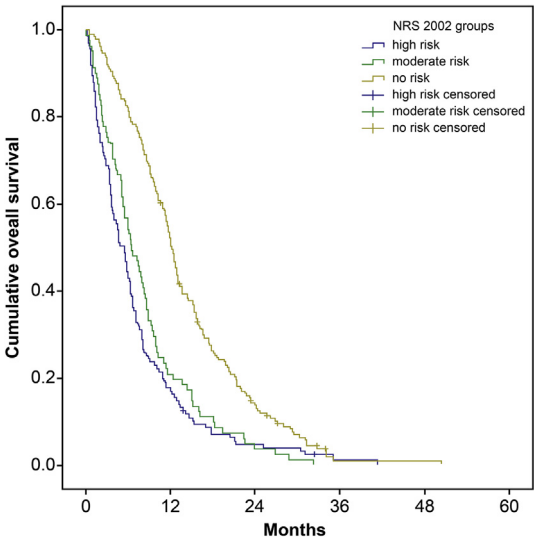

Fig. 1. Comparison of overall survival by NRS 2002 groups. The Kaplan–Meier survival analysis showed significant differences in OS among the NRS 2002 groups: Patients in the "no-risk" group were predicted to live 1.89 times longer than those in the "moderate-risk" group and 2.24 times longer than those in the "high-risk" group ($p < .001$). Overall, 412 patients were included in the NRS 2002 groups; with 194 patients (47.1%) in the "no-risk" group, 81 patients (19.7%) in the "moderate-risk" group, and 137 patients (33.3%) in the "high-risk" group.

demonstrating an association between the NRS 2002 score and a greater risk of in-hospital death [16] as well as evidence on the association between maintaining a stable weight/body composition and a better prognosis [12,13]. Moreover, our data are in line with previous studies showing that malnutrition leads to skeletal muscle wasting and fat degradation, a longer hospital stay, an increased risk of complications, a worse response to treatment, shorter survival, and increased mortality [9–11].

We also found that the percentage of lymphocytes was a significant predictor of improved survival. This finding is supported by the evidence that the reduction in total lymphocytes in the blood is the main immunologic change in advanced PC [17]. Physiologically, a low lymphocyte count indicates a possible suppression of the immune system. In contrast, a high lymphocyte count indicates the possibility of a reduced systemic inflammatory response caused by an impaired nutritional status [9].

The C-reactive protein level also significantly predicted OS, but unlike the percentage of lymphocytes, it was associated with poorer survival [18–20]. Cancer-related inflammation affects tumor malignancy, including tumor proliferation and survival, metastasis, and treatment response [21]. Systemic inflammation is a significant indicator of a poor prognosis in cancers, including PC [22,23]. Elevated biochemical and hematologic markers, including C-reactive protein and neutrophils, characterize the systemic inflammatory response [24–26]. Previous research has reported that cancer cachexia affects nearly 50% of cancer patients at the time of diagnosis. The mechanism of cancer cachexia is thought to involve the host's production of inflammatory cytokines. These cytokines act in an acute metabolic reaction, facilitating the production of acute reactive substances like C-reactive protein [27]. Therefore, inflammatory markers such as C-reactive protein are likely better predictors of clinical outcomes than conventional tumor markers.

In our study, several baseline demographic and clinical characteristics were significantly different among the NRS 2002 groups. Patients in the "high-risk" group were older and had higher levels of C-reactive protein than those in the "no-risk group"; they also had a lower BMI, albumin and protein levels, lymphocyte count, and percentage of lymphocytes. These findings support previous studies demonstrating an association between a greater risk of in-hospital mortality and the NRS 2002 score, age, BMI, and higher C-reactive protein/albumin ratio; however, this study also found that higher blood albumin concentrations and lymphocyte counts were associated with a reduced risk of in-hospital mortality [16].

Albumin concentration is one of the most commonly used indicators of nutritional status in a wide variety of patient populations [28]. Preoperative hypoalbuminemia is a major risk factor for postoperative complications and an independent predictor of poor perioperative outcomes [29–31]. These studies are consistent with our findings showing that a high baseline level of albumin was associated with improved OS.

The lymphocyte count plays a fundamental role in the cell-mediated immunologic response to cancer cells and predicts clinical outcomes in patients with PC [17,32,33]. This marker is used to calculate prognostic inflammatory and nutritional index [34]. The blood neutrophil to lymphocyte ratio (NLR), a marker of systemic inflammatory response, is an important prognostic predictor in several malignancies. An elevated NLR is a useful predictor of worse survival in patients with advanced PC [35]. The findings of these studies are in line with our findings, showing that a high baseline lymphocyte count was associated with improved survival, whereas a high baseline neutrophil level was associated with poor survival.

Our study revealed significant differences in OS among the NRS 2002 groups. The association between malnutrition and survival has been described in previous studies [9–11]. Lim et al. reported a significant difference in 1-year survival between malnourished and

non-malnourished patients ($p < .001$) [36]. In a study by Agarwal et al., a significantly higher risk of 3-month (in-hospital) mortality was found in malnourished patients [37]. Rondel et al. showed that malnourished patients had significantly lower survival rates than non-malnourished patients [38]. Lastly, baseline hospital malnutrition has been shown to be associated with increased mortality [39–41]. Malnutrition characterized by weight loss and a decreased dietary intake is common among patients with PC [6]. Most patients deemed to be 'at risk of malnutrition' have lower OS [42]. These studies are in line with our findings, showing that patients with a high baseline level of malnutrition, (the "high-risk" group) had the poorest survival.

The ESPEN guidelines on nutrition in cancer patients outline the need for the early detection and treatment of malnutrition [43]. Nutritional therapy in cancer patients who are malnourished or at-risk of malnutrition, has been shown to improve body weight and energy intake [44,45]. When oral nutritional intake is not sufficient, alternative nutritional therapies (such as special nutritional supplements as well as enteral and parenteral nutrition) are available for patients with advanced PC. It is essential to initiate nutritional therapy in patients with advanced PC who are at risk of malnutrition and the rapid development of anorexia-cachexia-syndrome [4].

This study had some limitations. During data collection, bioelectrical impedance analysis (BIA) devices were not used for the measurement of body composition and weight, because of financial limitations. BIA is a noninvasive and reproducible technique to evaluate changes in body composition and nutritional status. The phase angle, determined by BIA, has been found to be a prognostic indicator in several diseases, including advanced PC. The phase angle can also be interpreted as one of the most sensitive indicators of malnutrition [46]. Therefore, BIA is needed to determine the baseline nutritional status of patients with advanced PC. Future studies on the baseline nutritional status of patients with advanced PC should include BIA measurements of body weight, body composition, and the phase angle. This study was only conducted at a single center; therefore, a large-scale multicenter study should be planned to confirm our findings.

5. Conclusions

The OS of patients with advanced PC was strongly associated with their baseline nutritional status. To prolong OS in these patients, it is important to improve their nutritional status via a baseline nutritional intervention aimed at enhancing immune function. Ideally, patients in the "moderate-risk" group should be targeted so that they can achieve a "no-risk" status.

Statement of authorship

JSP, HMK, SAK, and HCJ designed the research. JSP, HMK, and SAK conducted the research. JSP and HMK analyzed the data and performed the statistical analyses. JSP, SAK, and HCJ wrote the manuscript. HCJ had primary responsibility for the final content. All authors read and approved the final version of the manuscript.

Conflict of interest statement

The authors declare that they have no conflicts of interest.

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