Original Article

# Score for predicting overall survival in pancreatic adenocarcinoma patients with positive lymph nodes after surgery: a novel nomogram-based risk assessment

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**Background:** Pancreatic adenocarcinoma (PaC) patients with positive lymph nodes (PLNs) have a dismal prognosis and lack a specific prognostic stage. This study aimed to construct a nomogram for the prediction of overall survival (OS) in these patients.

**Methods:** A total of 1,340 patients screened from the Surveillance, Epidemiology, and End Results database were included and randomly divided at a ratio of 7:3 into a training set (n=940) and an internal validation set (n=400). Cox regression analyses were conducted to select independent predictors in the training set, and a nomogram was constructed. The model was verified in the internal validation set and in an external validation set, which comprised 64 patients from a Chinese institute.

**Results:** Six independent prognostic factors (age at diagnosis, tumor grade, lymph node ratio, T stage, radiotherapy, and chemotherapy) were identified in PaC patients with PLNs and were entered into the nomogram. The final model had a higher C-index for predicting OS than the American Joint Committee on Cancer-8th edition staging system (training set: 0.658 *vs.* 0.546; internal validation set: 0.661 *vs.* 0.546; external validation set: 0.691 *vs.* 0.581). The 1-, 2-, and 3-year area under the receiver operating characteristic curve values indicated better discrimination power for the established nomogram with respect to the prediction of OS in the training, internal validation, and external validation sets than for the American Joint Committee on Cancer-8th edition staging system. Furthermore, the nomogram performed well in both calibration and decision curve analyses (DCA) of clinical applicability. OS in PaC patients with PLNs was significantly distinguished among the three risk groups stratified according to the nomogram score (P<0.001).

**Conclusions:** The well-calibrated nomogram was determined to be extremely efficient in predicting survival, and defining a high-risk population based on the nomogram score among PaC patients with PLNs after surgery.

**Keywords:** Positive lymph nodes (PLNs); pancreatic adenocarcinoma (PaC); nomogram; overall survival (OS); C-index

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## Introduction

Pancreatic adenocarcinoma (PaC) represents one of the most lethal malignancies among humans. Surgical resection remains the mainstay therapy for PaC; nonetheless, <20% of patients are considered candidates for resection (1,2), and the 5-year survival remains disappointing even if a curative resection is performed (3-5). It is likely that the implementation of a reasonable treatment strategy remains imperfect. Considering the high rate of postoperative local recurrence (6), most PaC patients will ultimately die from local progression.

The National Comprehensive Cancer Network (NCCN) guidelines clearly state that PaC patients with positive lymph nodes (PLN-PaCs) are specific individuals with a high recurrence risk (7). While lymph node (LN) status is a strong prognosticator for overall survival (OS) (8), insufficient LN examination may lead to the misclassification of N1 disease as N0 disease in some PaC patients (9). Therefore, PLN-PaCs with a high recurrence risk should be regarded as a population distinct from other PaC patients.

The American Joint Committee on Cancer (AJCC) staging system is currently the tool widely used by oncologists for predicting the prognosis of PaC patients (10). However, the AJCC staging system does not consider specific individuals, including the tumor differentiation grade (11), therapy method (12,13), and number of regional LNs examined. In reality, various factors can influence the cancer course and prognosis of PaC patients, and refining and establishing a new model for specific individuals (i.e., PLN-PaCs) are thus important.

The use of a nomogram, a novel statistical prediction model, can accurately estimate individual survival and guide plans for follow-up by integrating multiple factors (14). Furthermore, several studies have indicated the favorable results of nomogram (15) and its utility in various cancers (16-19). To date, an effective nomogram for PLN-PaCs has never been developed. Hence, the present study aimed to explore critical prognostic factors and construct a novel nomogram for predicting the prognosis of PLN-PaCs based on the Surveillance, Epidemiology, and End Results (SEER) database, which contains data from a large population. Furthermore, the novel nomogram was validated using data from Guangdong Provincial People's Hospital in China.

We present the following article in accordance with the TRIPOD reporting checklist (available at http://dx.doi.org/10.21037/gs-20-597).

## Methods

### *Patient selection*

Data of PLN-PaCs were acquired from the SEER database using SEER*Stat software version 8.3.5 (www.seer.cancer.gov/seerstat). These patients were selected based on the 2nd and 3rd editions of the International Classification of Diseases for Oncology (ICD-O-2/3), and "8140/3" was used as the ICD-O-3 diagnosis to identify PaC.

Patients were included only if they were PLN-PaCs. The exclusion criteria were as follows: fewer than 11 regional LNs examined or unknown number of regional LNs; distant metastases; receiving other forms of treatment aside from surgery; survival time ≤1 month; second primary cancer; and missing or incomplete data (*Figure 1*).

### *Data processing*

A total of 1,340 eligible PLN-PaCs from the SEER database were finally included in our retrospective study based on the above mentioned inclusion and exclusion criteria. External validation data (n=64) were collected from Guangdong Provincial People's Hospital in China. Data on pathological and clinical variables [e.g., age at diagnosis, sex, tumor size, tumor differentiation, tumor-node-metastasis (TNM) stage, chemotherapy, radiotherapy, LNs] as well as follow-up information were extracted from the Guangdong Provincial People's Hospital and SEER databases. LN ratio (LNR) was defined as the ratio of the number of metastasized LNs to the total number of resected LNs. Information on TNM-8th edition staging was gathered based on the 7th edition of the AJCC staging system (2010+), and tumor size and number of PLNs were used to estimate the AJCC-8th edition stage.

Risk factors were extensively evaluated by conducting a univariate analysis of all included variables, and a multivariate analysis was adopted to select independent risk factors. A nomogram was constructed based on these independent risk factors and was validated in both training and external validation cohorts.

### *Nomogram development and external validation*

For nomogram construction, PLN-PaCs (n=1,340) from the SEER database [2010–2015] were randomly divided at a ratio of 7:3 into a training set (n=940) and an internal validation set (n=400). The training set was used to construct the nomogram, and the benefits of the novel model were evaluated by internal and external validation. The second

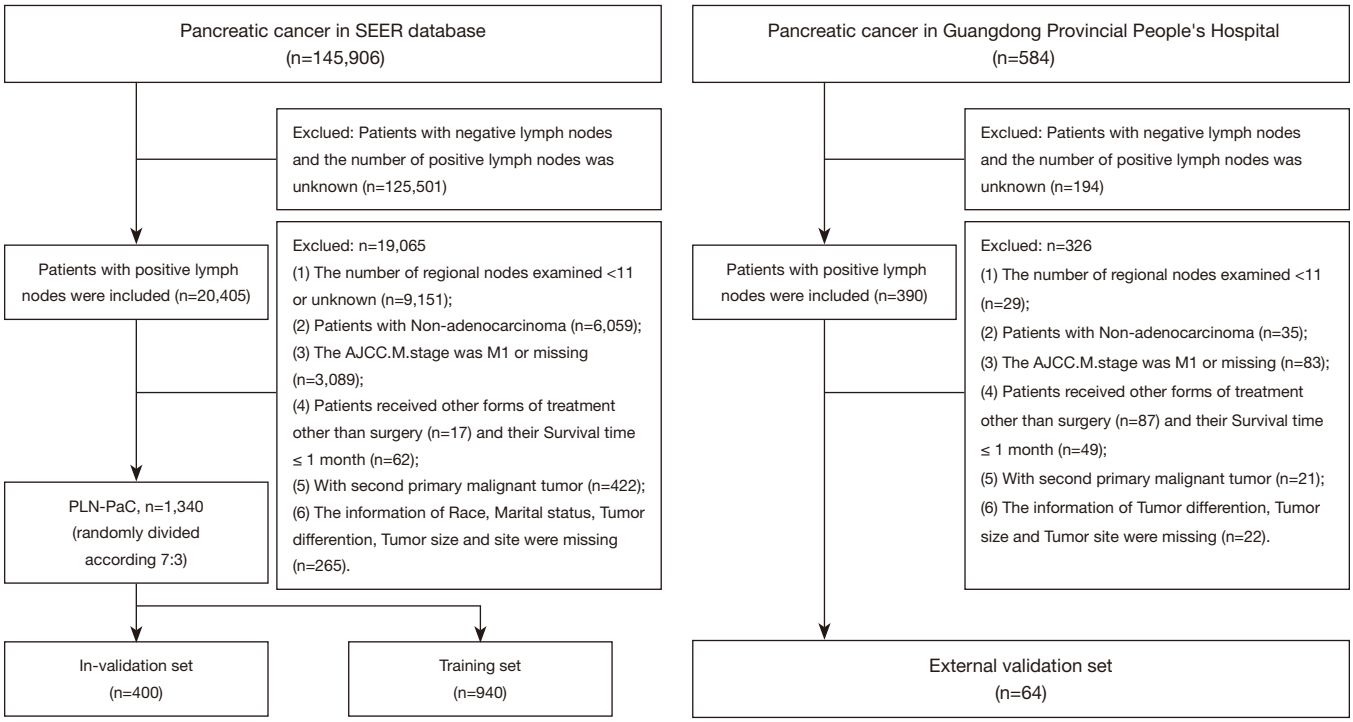


**Figure 1** Flow diagram illustrating patient selection.

cohort consisted of patients from Guangdong Provincial People's Hospital (n=64) and was used as an external validation cohort [2010–2019]. Furthermore, the predictive power of the established nomogram was compared with that of the 8th edition of the TNM staging system.

### *Statistical analyses*

Baseline patient demographics and disease features were compared using the chi-square test or Fisher's exact test, as appropriate. Statistical analyses were performed using SPSS software version 25 (IBM Corp., Armonk, NY, USA). Cox multivariate regression and the nomogram were constructed using the rms package in R version 3.6.1 (http://www.r-project.org/). For outcome-based optimization, the best cut-off points for age, LNR, tumor size, and nomogram score (nomo-score) were calculated using X-tile software (Yale School of Medicine, New Haven, CT, USA). P values were two-sided, and P values lower than 0.05 were considered statistically significant. The C-index and area under the receiver operating characteristic (ROC) curve (AUC) were used to evaluate the discriminative ability of the nomogram (20). Calibration curves were utilized to examine the association between actual outcomes and predicted probabilities (21). The clinical usefulness and benefits of the prediction model were estimated using decision curve analyses (DCA) (22).

### *Ethical statement*

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

## Results

### *Characteristics of PLN-PaCs*

The PLN-PaCs (n=1,340) from the SEER database were randomly divided at a ratio of 7:3 into a training set (n=940) and an internal validation set (n=400). For these PLN-PaCs from the SEER database, the median survival time (MST) was 20 months, whereas the 1-, 2-, and 3-year OS rates were 70.5%, 40.3%, and 25.1%, respectively.

A total of 64 PLN-PaCs from Guangdong Provincial People's Hospital were allocated to the external validation set. The clinicopathological characteristics, including age, sex, radiotherapy, chemotherapy, and TNM stage, are summarized in *Table 1*. The MST was 23.8 months, whereas

the 1-, 2-, and 3-year OS rates were 77.3%, 47.5%, and 30.7%, respectively. Additionally, for these 64 PLN-PaCs, the median disease-free survival (DFS) was 10.3 months, whereas the 1-, 2-, and 3-year DFS rates were 44.3%, 26.8%, and 22.4%, respectively.

### *Screening of prognostic factors for PLN-PaCs*

Multivariate analysis was performed to identify independent prognostic factors in the training set. In order to avoid the influence of tumor size on AJCC T stage and of AJCC N stage on LNR, tumor size and AJCC N stage were not included in the multivariate analysis. Univariate and multivariate analyses revealed that age, tumor differentiation grade, LNR, AJCC T stage, radiotherapy, and chemotherapy were independent prognostic factors for OS (*Table 2*).

### *Nomogram construction*

Based on the above mentioned results of multivariate analysis from the training set, we integrated these independent prognostic factors to establish a satisfactory nomogram for OS prediction in PLN-PaCs (*Figure 2*). The detailed scores of all variables in the nomogram are presented in Table S1. By summing the detailed score of each variable, we could obtain a nomo-score to predict the possibility of 1-, 2-, and 3-year OS, with a higher nomo-score indicating worse prognosis.

### *Validation and calibration of the nomogram*

With respect to the 1-, 2-, and 3-year OS, the AUC values indicated better discriminative ability for this model than for the traditional AJCC-8th edition staging system in the training set (1-year: 0.717 *vs.* 0.565, 2-year: 0.675 *vs.* 0.549, 3-year: 0.678 *vs.* 0.562; *Figure 3A*,*B*), internal validation set (1-year: 0.721 *vs.* 0.577, 2-year: 0.719 *vs.* 0.541, 3-year: 0.700 *vs.* 0.544; *Figure 3C*,*D*), and external validation set (1-year: 0.898 *vs.* 0.626, 2-year: 0.748 *vs.* 0.677, 3-year: 0.775 *vs.* 0.629; *Figure 3E*,*F*). Furthermore, the nomogram had a higher C-index than the AJCC staging system only in the training set (0.658 *vs.* 0.546) and internal validation set (0.661 *vs.* 0.546). The C-index of the nomogram was also higher than that of the AJCC staging system in the external validation set (0.691 *vs.* 0.581).

The calibration curves indicated an acceptable agreement between the actual and predicted outcomes for the 1-, 2-, and 3-year probabilities of OS in the training set (*Figure 3G*), internal validation set (*Figure 3H*), and external validation set (*Figure 3I*). Importantly, the DCA of clinical applicability revealed that the established nomogram had greater net benefits across a range of death risk than the AJCC-8th edition staging system in the training cohort (*Figure 4*).

### *Performance of the nomogram in stratifying patient risk*

The training set was stratified into three risk groups according to the nomo-score, with the cut-off value determined by X-tile software—namely, low-risk group: 0≤ nomo-score ≤174; middle-risk group: 177< nomo-score ≤262; and high-risk group: nomo-score >264. Kaplan-Meier survival curves for OS in the three risk groups according to the nomo-score were plotted (*Figure 5*), which showed an obvious grading ability based on the new risk group model (P<0.001).

## Discussion

PaC is a heterogeneous disease that may lead to different prognoses in different patients, even after radical resection (23). PLN-PaCs are a population distinct from PaC patients owing to their low resection rates and high recurrence risk, making prognostic studies on PLN-PaCs who had undergone surgical resection difficult. Several previous studies have attempted to predict the prognosis of PaC patients; nevertheless, most of these studies lack representativeness because they were based on a broad pancreatic cancer population and had no restrictions on pathological type, specific individuals, number of regional LNs examined, or surgery status (24,25). Therefore, developing and validating an effective nomogram with better applicability for PLN-PaCs is still necessary. To the best of our knowledge, the present study is the first large-sample study to identify critical prognostic factors for PLN-PaCs. Importantly, we established an easy-to-use nomogram based on clinicopathological and personalized characteristics to predict the prognosis of specific PaC individuals at a personal level, which is consistent with the concept of individualized treatment for cancer patients.

In the present study, we established a novel nomogram for PLN-PaCs by integrating age, tumor differentiation grade, AJCC T stage, LNR, chemotherapy, and radiotherapy. In the clinic, the 1-, 2-, and 3-year OS rates can be easily predicted using this nomogram, as it only includes six parameters, all of which are easy to acquire. Importantly, our nomogram exhibited higher predictive power than the AJCC-8th edition staging system in both the training and validation sets, which

**Table 1** Demographics and clinical characteristics of eligible patients with PLN-PaC

| Characteristics | Training set (n=940, %) | In-validation set (n=400, %) | Ex-validation set (n=64, %) |
|---|---|---|---|
| Age, years | | | |
| <50 | 68 (7.3) | 23 (5.7) | 6 (9.4) |
| 50–70 | 555 (59.0) | 233 (58.3) | 45 (70.3) |
| ≥70 | 317 (33.7) | 144 (36.0) | 13 (20.3) |
| Race | | | |
| Black | 105 (11.2) | 38 (9.5) | NA |
| White | 764 (81.3) | 336 (84.0) | NA |
| Other | 71 (7.5) | 26 (6.5) | 64 (100) |
| Sex | | | |
| Female | 460 (48.9) | 190 (47.5) | 32 (50.0) |
| Male | 480 (51.1) | 210 (52.5) | 32 (50.0) |
| Tumor location | | | |
| Head | 818 (87.0) | 342 (85.5) | 14 (21.9) |
| Body/Tail | 97 (10.3) | 43 (10.7) | 43 (67.2) |
| Overlapping | 25 (2.7) | 15 (3.8) | 7 (10.9) |
| Grade | | | |
| Well | 83 (8.8) | 32 (8.0) | 12 (18.7) |
| Moderate | 463 (49.3) | 194 (48.5) | 38 (59.4) |
| Poor | 394 (41.9) | 174 (43.5) | 14 (21.9) |
| Radiotherapy | | | |
| Yes | 570 (60.6) | 254 (63.5) | 14 (21.9) |
| No | 370 (39.4) | 146 (36.5) | 50 (78.1) |
| Chemotherapy | | | |
| Yes | 200 (21.3) | 89 (22.3) | 61 (95.3) |
| No | 740 (78.7) | 311 (77.7) | 3 (4.7) |
| Tumor size (mm) | | | |
| ≤26 | 288 (30.6) | 109 (27.3) | 7 (10.9) |
| 26–40 | 428 (45.6) | 185 (46.2) | 27 (42.2) |
| ≥40 | 224 (23.8) | 106 (26.5) | 30 (46.9) |
| LNR | | | |
| ≤0.12 | 361 (38.4) | 144 (36.0) | 32 (50.0) |
| 0.12–0.38 | 424 (45.1) | 188 (47.0) | 28 (43.7) |
| ≥0.38 | 155 (16.5) | 68 (17.0) | 4 (6.3) |
| Marital | | | |
| Yes | 614 (65.3) | 246 (61.5) | 50 (78.1) |

**Table 1** *(continued)*

**Table 1** *(continued)*

| Characteristics | Training set (n=940, %) | In-validation set (n=400, %) | Ex-validation set (n=64, %) |
|---|---|---|---|
| No | 326 (34.7) | 154 (38.5) | 14 (21.9) |
| AJCC 8th stage | | | |
| IIB | 482 (51.3) | 198 (49.5) | 45 (70.3) |
| III | 458 (48.7) | 202 (50.5) | 19 (29.7) |
| T stage | | | |
| T1 | 103 (11.0) | 35 (8.7) | 6 (9.4) |
| T2 | 580 (61.7) | 251 (62.7) | 24 (37.5) |
| T3 | 217 (23.0) | 93 (23.3) | 20 (31.2) |
| T4 | 40 (4.3) | 21 (5.3) | 14 (21.9) |
| N stage | | | |
| N1 | 498 (53.0) | 209 (52.3) | 56 (87.5) |
| N2 | 442 (47.0) | 191 (47.7) | 8 (12.5) |

PLN-PaC, pancreatic adenocarcinoma with positive lymph nodes; in-validation set, internal validation set; ex-validation set, external validation set; AJCC, American Joint Committee for Cancer; LNR, lymph nodes ratio.

**Table 2** Univariate and multivariate cox regression analysis based on all variables for overall survival (training cohort)

| Characteristics | Univariate analysis | | | Multivariate analysis | | |
|---|---|---|---|---|---|---|
| | HR | 95% CI | P value | HR | 95% CI | P value |
| Age, years | | | | | | |
| <50 | Reference | | | Reference | | |
| 50–70 | 1.09 | 0.80–1.48 | 0.57 | 1.12 | 0.82–1.52 | 0.47 |
| ≥70 | 1.51 | 1.10–2.06 | 0.01 | 1.51 | 1.10–2.08 | 0.01 |
| Race | | | | | | |
| Black | Reference | | | | | |
| White | 0.94 | 0.77–1.16 | 0.576 | | | |
| Other | 1.04 | 0.91–1.20 | 0.544 | | | |
| Grade | | | | | | |
| Well | Reference | | | Reference | | |
| Moderately | 1.38 | 1.03–1.85 | 0.032 | 1.59 | 1.18–2.15 | 0.002 |
| Poorly | 1.79 | 1.33–2.40 | <0.001 | 2.07 | 1.53–2.79 | <0.001 |
| Sex | | | | | | |
| Female | Reference | | | | | |
| Male | 1.10 | 0.94–1.27 | 0.232 | | | |
| Tumor location | | | | | | |
| Head | Reference | | | | | |

**Table 2** *(continued)*

**Table 2** *(continued)*

| Characteristics | Univariate analysis | | | Multivariate analysis | | |
|---|---|---|---|---|---|---|
| | HR | 95% CI | P value | HR | 95% CI | P value |
| Body/tail | 0.89 | 0.68–1.15 | 0.366 | | | |
| Overlapping | 1.90 | 1.24–2.92 | 0.003 | | | |
| Radiotherapy | | | | | | |
| No | Reference | | | Reference | | |
| Yes | 0.67 | 0.57–0.78 | <0.001 | 0.83 | 0.70–0.99 | 0.03 |
| Chemotherapy | | | | | | |
| No | Reference | | | Reference | | |
| Yes | 0.48 | 0.40–0.57 | <0.001 | 0.49 | 0.40–0.59 | <0.001 |
| LNR | | | | | | |
| ≤0.12 | Reference | | | Reference | | |
| 0.12–0.38 | 1.29 | 1.09–1.52 | 0.002 | 1.30 | 1.09–1.53 | 0.002 |
| ≥0.38 | 1.85 | 1.50–2.29 | <0.001 | 1.88 | 1.51–2.34 | <0.001 |
| Marital | | | | | | |
| No | Reference | | | | | |
| Yes | 1.14 | 0.97–1.33 | 0.11 | | | |
| AJCC T stage | | | | | | |
| T1 | Reference | | | Reference | | |
| T2 | 1.40 | 1.08–1.81 | 0.009 | 1.35 | 1.04–1.75 | 0.02 |
| T3 | 1.78 | 1.34–2.35 | <0.001 | 1.76 | 1.32–2.34 | <0.001 |
| T4 | 2.13 | 1.45–3.23 | <0.001 | 2.25 | 1.47–3.43 | <0.001 |
| Surgery status | | | | | | |
| Partial-PC | Reference | | | | | |
| Whipple | 1.07 | 0.86–1.34 | 0.524 | | | |
| Total-PC | 1.14 | 0.86–1.51 | 0.362 | | | |
| Size (mm) | | | | | | |
| ≤26 | Reference | | | | | |
| 26–40 | 1.36 | 1.14–1.62 | <0.001 | NA | NA | NA |
| ≥40 | 1.61 | 1.32–1.97 | <0.001 | NA | NA | NA |
| AJCC N stage | | | | | | |
| N1 | Reference | | | | | |
| N2 | 1.34 | 1.16–1.55 | <0.001 | NA | NA | NA |
| AJCC 8th stage | | | | | | |
| IIB | Reference | | | | | |
| III | 1.36 | 1.18–1.58 | <0.001 | NA | NA | NA |

Partial-PC, partial pancreatectomy; total-PC, total pancreatectomy; AJCC, American Joint Committee for Cancer; LNR, lymph nodes ratio.

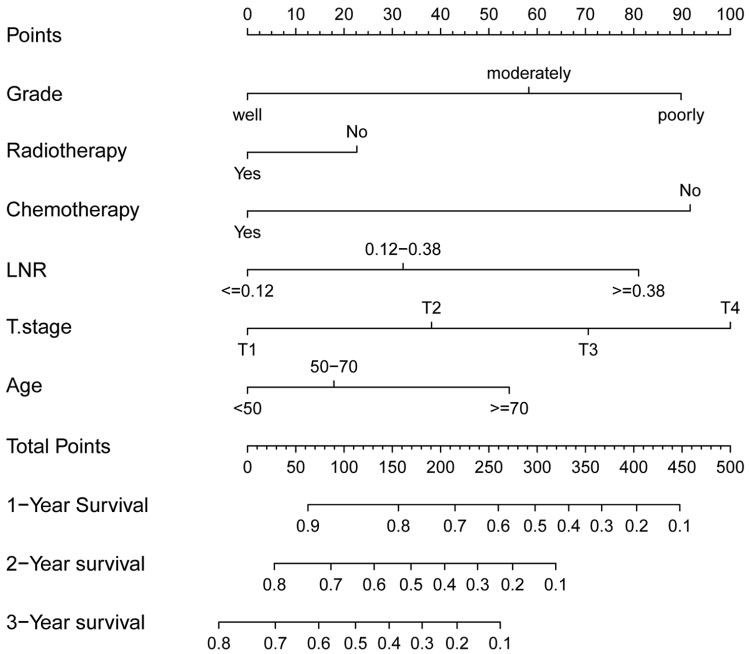


**Figure 2** Nomogram for the prediction of overall survival in pancreatic adenocarcinoma patients with positive lymph nodes after surgical resection.

was confirmed by the higher C-indexes and AUC values. The most likely reason for this is that the AJCC staging system takes the tumor size, number of PLNs, and metastasis into consideration; however, the differentiation grade and number of regional LNs examined are also independent critical factors for survival (26-28).

Indubitably, higher tumor differentiation grade and AJCC T stage are strongly associated with worse survival, as shown in our study and other previous investigations (25,29). Unsurprisingly, LN status is an important predictor of survival. Recommendations for the number of LNs that should be examined range from 11 to 20 (30-35) in the case of pancreatectomy, and variable LNR categories are discussed in various studies (34-36). Additionally, several studies have reported that LNR may be a better prognostic indicator than the total number of positive nodes in node-positive patients (30,37). Consequently, a sufficient number of regional LNs examined and accurate LNR enable accurate staging of patients and diminish the disparities in survival outcomes. To avoid understaging, we selected PLN-PaCs who underwent pancreatectomy and had at least 11 removed and examined LNs in our study. Our results indicated worse survival for PLN-PaCs who underwent pancreaticoduodenectomy and had ≥11 LNs examined than for those who had <11 LNs evaluated [MST: 14 *vs*. 20 months; hazard ratio (HR), 0.7; 95% confidence interval (CI), 0.61–0.80; P<0.0001]. Moreover, our analysis showed that a greater LNR resulted in worse survival (HR, 1.88; 95% CI, 1.51–2.34; P<0.001).

Currently, adjuvant multi-agent chemotherapy followed by surgical resection is strongly recommended for resected PaCs (38). Correspondingly, our study also showed that chemotherapy was a protective factor, which was consistent with the findings of a clinical randomized controlled trial (39,40).

Nevertheless, whether the administration of adjuvant radiotherapy to patients with resected PaC has a different effect on prognosis remains controversial. Some investigators argued that adjuvant radiotherapy did not significantly improve the OS of PaC patients, which was proven in our other studies (data are being published). However, we determined in our current study that radiotherapy was a critical factor that improved survival in PLN-PaCs. Based on the above mentioned results, the reasons for this may be that previous studies mixed up different histological types and recurrence risk groups in analyzing survival and did not identify specific individuals. Our results revealed that adjuvant radiotherapy did not improve survival in PaC patients with negative LNs (HR, 0.889; 95% CI, 0.788–1.004;

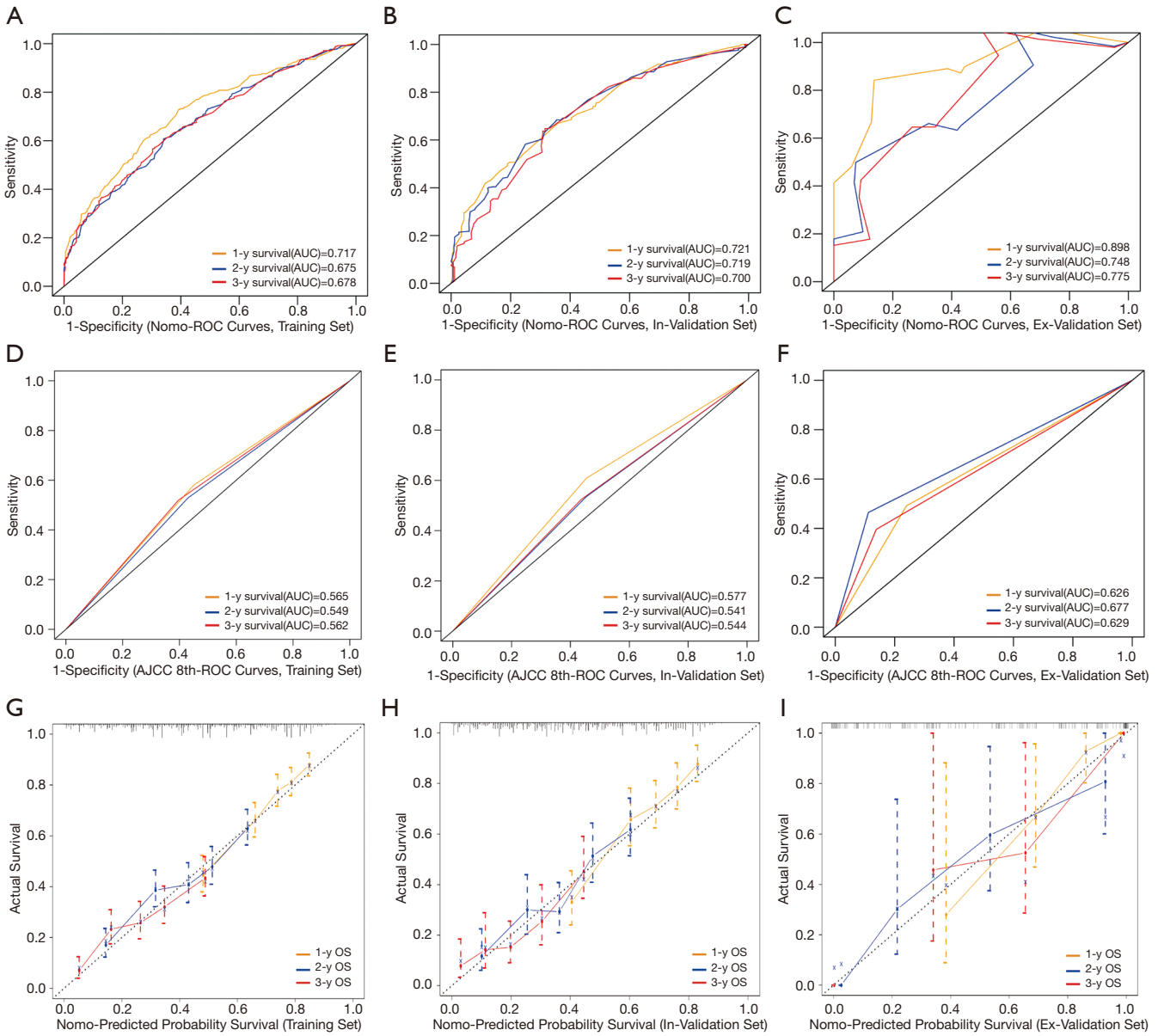


**Figure 3** (A,C,E) Receiver operating characteristic (ROC) curves for the prediction of 1-, 2-, and 3-year overall survival (OS) based on the nomogram in the training, internal validation, and external validation sets. (B,D,F) ROC curves for the prediction of 1-, 2-, and 3-year OS based on the AJCC-8th edition staging system in the training, internal validation, and external validation sets. (G-I) Calibration plot for 1-, 2-, and 3-year OS prediction based on the nomogram in the training, internal validation, and external validation sets.

P=0.06) but was a protective critical factor in PLN-PaCs (HR, 0.830; 95% CI, 0.700–0.990; P=0.03). The NCCN guidelines point out that the role of adjuvant radiotherapy is still being evaluated in clinical studies; nonetheless, these guidelines also suggest that PLN-PaCs may receive radiotherapy after resection, which is consistent with our results. As PaC is a heterogeneous disease that may lead to different prognoses in different patients even after radical resection, we should therefore treat specific PaC patients individually rather than generally.

The novel nomogram described in this study can be used to define a high-risk population with a total nomo-score of

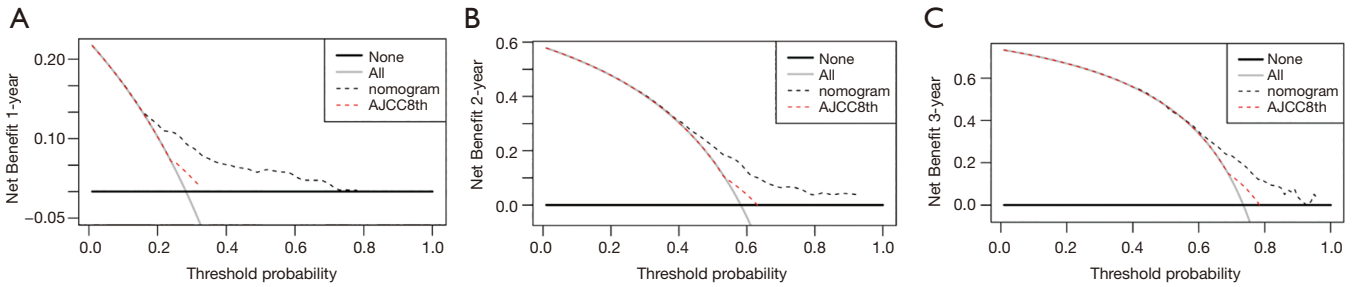


**Figure 4** Decision curve analyses (DCA) of the nomogram and the American Joint Committee on Cancer (AJCC)-8th edition staging system in the training set. DCA of (A) 1-year risk, (B) 2-year risk, and (C) 3-year risk.

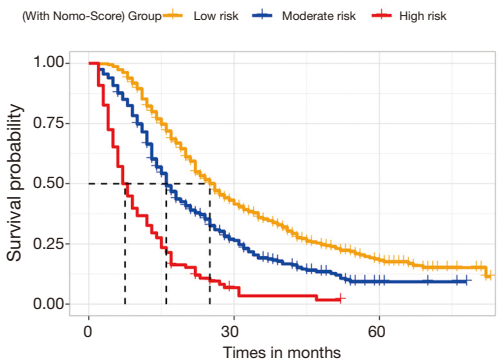


**Figure 5** Kaplan-Meier curves for patients' overall survival (OS) among the low-risk, moderate-risk, and high-risk groups stratified according to the nomo-score in the training set.

>264 among PLN-PaCs. As shown in *Figure 5*, the Kaplan–Meier survival curves for OS indicate an obvious grading ability according to the new risk group model. Additionally, this effective nomogram was established for the first time using a Western database and validated using an Eastern database, suggesting that it is applicable across races.

The present study has some limitations. First, our study was a retrospective observational study exposed to potential confounding bias; a larger multicenter prospective study may be required. Second, we not only constructed an easy-to-use model but also used an Eastern database for the external validation cohort. However, the sample for the external validation cohort was small, and some meaningful metrics, such as carbohydrate antigen 19-9, surgical margin, platelet-to-lymphocyte ratio, and oncogene expression, were lacking. Multidimensional factors pertaining to the tumor, microenvironment, and host should be considered in a good prediction model, as adding these factors may improve the quality of the nomogram. Therefore, a larger multicenter prospective study should be performed to verify the conclusions of our study.

## Conclusions

Distinct clinical characteristics among different individuals lead to different outcomes after curative resection. We established a novel nomogram that combined clinicopathological features, AJCC T stage, and therapy methods, showed satisfactory predictive power in PLN-PaCs following surgical resection, and might be a good model for application in the clinic. Our easy-to-use nomogram could not only define a high-risk population based on the nomo-score but also indicate that adjuvant radiotherapy was a critical prognostic factor in PLN-PaCs. Based on these findings, more laboratory indexes and genetic information should be explored in the future to promote individualized treatment for PLN-PaCs.

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## Footnote

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## Supplementary

**Table S1** Detailed scores of all variables in the nomogram.

| Variables | Nomogram score for OS |
|---|---|
| Grade | |
| Well | 0 |
| Moderately | 58 |
| Poorly | 90 |
| Radiotherapy | |
| No | 23 |
| Yes | 0 |
| Chemotherapy | |
| No | 92 |
| Yes | 0 |
| LNR | |
| ≤ 0.12 | 0 |
| 0.12- 0.38 | 32 |
| ≥ 0.38 | 81 |
| AJCC T.stage | |
| T1 | 0 |
| T2 | 38 |
| T3 | 71 |
| T4 | 100 |
| Age | |
| < 50 | 0 |
| 70 | 18 |
| ≥ 70 | 54 |

OS, overall survival, AJCC, American Joint Committee for Cancer; LNR, lymph nodes ratio.


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