Original Article

Nomogram for predicting 10-year postoperative recurrence of stage I gastric cancer

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Background: With the advancement of various auxiliary examination techniques, the detection rate of stage I gastric cancer has gradually increased, and its clinical first-choice treatment is surgery. Although patients with stage I gastric cancer generally have a good postoperative survival rate, there is still a certain probability of recurrence. Given the large number of gastric cancer cases, there is a vast population of patients with stage I disease. We are aiming to identify the risk factors for postoperative recurrence of stage I gastric cancer and to establish a reliable predictive model to assess the risk of recurrence in the population for clinical practice.

Methods: In this retrospective cohort study, we utilized the Surveillance, Epidemiology, and End Results (SEER) database to investigate predictive factors for recurrence among stage I gastric cancer patients who underwent curative gastrectomy between 2000 and 2018. The cohort was divided into training and validation sets for the development and validation of a nomogram. Prognostic factors were evaluated through univariate and multivariate Cox regression analyses. Significant variables identified by the concordance index (C-index) and calibration plots were used to construct nomograms predicting the probability of 5- and 10-year recurrence.

Results: Risk factors for recurrence included sex, age, race, histology, tumor size, American Joint Committee on Cancer Tumor (AJCC T) and primary site, which were used to construct the nomogram. The C-index for both the training and validation cohorts indicated that the nomogram possessed good calibration and discrimination abilities in predicting the probability of 5- and 10-year recurrence after curative surgery for stage I gastric cancer.

Conclusions: This study established a reliable predictive model for recurrence following curative gastrectomy in stage I gastric cancer based on a population cohort. The findings of this study have the potential to significantly impact clinical practice by providing clinicians with tools for personalized risk assessment and for making informed treatment decisions.

Keywords: Gastric cancer; nomogram; risk; recurrence; stage I

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Introduction

Gastric cancer represents a significant health issue worldwide, being the fifth most common cancer globally and the fourth leading cause of cancer-related mortality. In 2020, approximately 1.1 million new cases of gastric cancer were reported, with about 770,000 deaths resulting from the disease (1). Risk factors for gastric cancer include Helicobacter pylori infection, dietary factors, tobacco use, obesity, and radiation exposure (2). Preventive measures for gastric cancer (3) encompass several aspects: eradication of Helicobacter pylori; lifestyle modifications to eliminate risk factors, such as smoking cessation and obesity control; early detection through screening activities; and monitoring of precancerous lesions. In terms of diagnosing gastric cancer, the utilization of various auxiliary technologies such as gastroscopy (4), breath tests (5), blood and biomarker testing (6,7) has improved the detection rate of gastric cancer. The primary treatment modality for gastric cancer in clinical practice is surgical intervention (8). Common patterns of recurrence following curative surgery for gastric cancer include local regional relapse, peritoneal dissemination, and distant metastasis (9). Postoperative recurrence is a significant factor impacting the prognostic survival of patients; overall survival rates post-surgery are significantly reduced compared to patients without recurrence (10).

Several studies have been conducted to investigate the recurrence of gastric cancer following surgery. With regard to serum and plasma markers, Saito *et al.* evaluated preoperative and postoperative serum NY-ESO-1 in 1,001 patients with gastric cancer, suggest that it may be an effective predictive marker for postoperative recurrence of gastric cancer (11). Yuan *et al.* found that patients with postoperative ctDNA positivity had an increased risk of recurrence, and this risk was even higher in patients who remained ctDNA positive after adjuvant chemotherapy, indicating that postoperative circulating tumor ctDNA is an important risk factor for recurrence (12). In terms of body fluid testing, Okuno *et al.* established a miRNA-based liquid biopsy method to predict the early recurrence of postoperative gastric cancer patients (13). In terms of omics, Kaji *et al.* conducted a metabolomic analysis of 140 gastric cancers and adjacent tissues. β-alanine was identified as an independent predictor of postoperative peritoneal recurrence of gastric cancer (14). For predicting postoperative gastric cancer recurrence via computed tomography (CT) images, Jiang *et al.* developed a deep learning model. Utilizing preoperative CT to predict postoperative peritoneal recurrence and disease-free survival (15). Feng *et al.* established a robust artificial intelligence model combining CT and artificial intelligence to identify high-risk patients for postoperative gastric cancer recurrence across multiple centers (16). However, the recurrence of early-stage gastric stomach cancer after surgery still lacks does not receive due attention.

Given the substantial number of patients with early-stage gastric cancer, attention must be given to the cohort experiencing postoperative recurrence. Therefore, accurate assessment of recurrence risk is critical for determining personalized and precise treatment strategies for gastric cancer patients, thereby improving survival rates. American Joint Committee on Cancer (AJCC) and the Tumor Node Metastasis (TNM) staging system is currently the most common international tumor staging system at present, and it is also the standard method for staging malignant tumor staging tumors in the clinic (17). Prognostic survival assessments for gastric cancer patients primarily rely on the TNM staging system (18). However, even among patients within the same stage, there is a significant variance in prognostic survival, with the TNM staging lacking consideration for tumor heterogeneity and patient-specific predictive information (19). An increasing number of scholars advocate for nomograms as

Highlight box

Key findings

- There is insufficient attention to the recurrence of stage I gastric cancer after surgery. We have created a nomogram for predicting 10-year postoperative recurrence of stage I gastric cancer.

What is known and what is new?

- For the recurrence of gastric cancer, most reports focus on the postoperative recurrence of advanced gastric cancer, such as the recurrence rate and recurrence mode, the recurrence site of gastric cancer, and the impact of postoperative infection on the recurrence of gastric cancer, while the recurrence of early gastric cancer has received significantly less attention.
- For early gastric cancer, especially for patients undergoing radical surgery, an effective clinical prediction model was constructed based on the advantages of large samples of the most common risk factors such as age, sex, primary site, race, histology, American Joint Committee on Cancer Tumor (AJCC T), tumor size and Surveillance, Epidemiology, and End Results (SEER) database.

What is the implication, and what should change now?

- This study provides clinicians with tools for personalizing risk assessment and for making informed treatment decisions.

more effective tools for predicting tumor progression and guiding clinical decisions (20). Therefore, to improve the survival conditions following curative surgery for early-stage gastric cancer, to achieve simplicity, efficiency, and low thresholds, we included and noted factors such as age, sex, race, histology, AJCC T, primary site, tumor size, and established a personalized nomogram for predicting the 10-year recurrence risk post-surgery, aiming to identify high-risk populations for gastric cancer recurrence and assist clinicians in devising effective follow-up strategies and guidance. We present this article in accordance with the TRIPOD reporting checklist (available at https://tcr.amegroups.com/article/view/10.21037/tcr-24-692/rc).

Methods

Data extraction

This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). We searched and downloaded medical records of gastric cancer patients from the SEER database (SEER Research Plus Data, 18 Registries, Nov 2020 Sub, 2000–2018), which covers over a third of the U.S. population's cancer incidence and survival data. The aim of our study was to explore the probability of recurrence within 10 years in patients diagnosed with stage I gastric cancer for the first time between 2000–2018 and who underwent curative surgery. We set a 10-year observation period to ensure a full decade of follow-up for each patient, treating death as a censoring event. The screening process was carried out in three steps: The first step is to screen out no-recurrenced patients with stage I gastric cancer who have undergone surgery, and the second step is to screen out recurrenced patients with stage I gastric cancer who have undergone surgery, and the third step was to merge the patient information from the first and second steps.

In the initial step of our analysis, we identified patients with gastric cancer who experienced recurrence within ten years post initial diagnosis and had undergone curative surgery based on the following criteria: we downloaded the records of all gastric cancer patients from 2000–2018, with sequence numbers labeled as '1st of 2 or more primaries' and '2nd of 2 or more primaries', totaling 26,488 cases. Subsequently, we excluded patients who did not meet our inclusion criteria through the following steps: (I) we eliminated patients without duplicate patient IDs; (II) we excluded patients whose first diagnosis stage was not stage I; (III) we removed patients who had not undergone curative surgery; (IV) we excluded patients who experienced a recurrence within three months, as this group may have been misdiagnosed as stage I or had incomplete surgical resection; (V) we excluded patients who died from gastric cancer within three months since this is not characteristic of stage I patients; (VI) we labeled this group as 'recurrence' and excluded all secondary diagnosis data; (VII) since our follow-up duration was ten years, we excluded patients who experienced recurrence after ten years. We categorized patients who experienced recurrence within ten years as 'recurred' as 'A1'.

In the second step of our analysis, we selected patients who were initially diagnosed with gastric cancer and did not experience recurrence within ten years post-curative surgery from a cohort of 5,703 cases based on the following criteria: (I) the sequence number was 'one primary only'; (II) the time of diagnosis ranged from 2000 to 2018; (III) the diagnosis was gastric cancer; (IV) the patient had undergone curative surgery; (V) the cancer was classified as stage I; (VI) patients who died from the tumor within three months were excluded. We denoted the remaining dataset as 'B1'. Then we marked the dataset of patients who died from gastric cancer within ten years, labeled as 'C', considering these patients likely had tumor recurrence.

In the third step, we merged datasets A1 and B1 from the first and second steps, and subsequently screened the final cohort of 5,008 patients according to the following criteria: (I) we excluded patients who received chemo-radiotherapy during the perioperative period; (II) we excluded patients whose TNM staging does not meet the requirements; (III) we excluded patients whose histology is gastrointestinal stromal sarcoma for it is not classified as gastric cancer; (IV) we excluded those patients with unknown race or under 18 years old. The flowchart of the inclusion and exclusion process for participants is presented in *Figure 1*. Ethical approval was not required for this study since the clinical data of the gastric cancer patients recruited were collected from publicly available SEER dataset's open access and anonymized data. Patient and tumor features [sex (female, male), age (18–40, 41–60, 61–80, >80 years), race (White, Black, Asian or Pacific Islander, others), histology (adenocarcinoma, signet ring cell carcinoma, others/unknown), tumor size (<3, ≥3 cm, unknown), primary site (cardia, fundus, gastric antrum, greater curvature, lesser curvature, pylorus, others/unknown), AJCC T (T1, T2)] were extracted with the SEER*Stat software. The outcome variables were the occurrence of recurrence within ten years

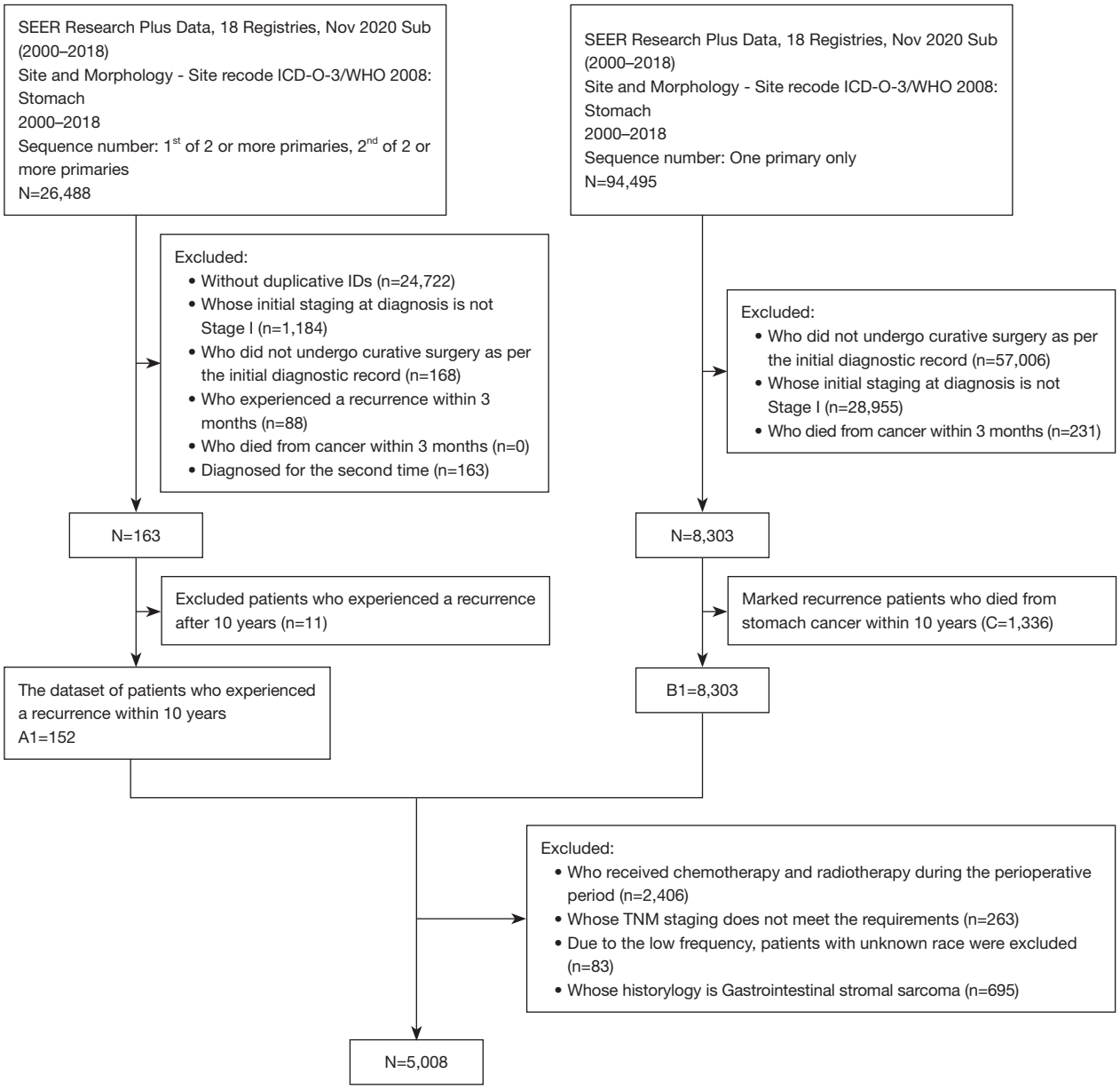

Figure 1 The flow diagram of participant inclusion and exclusion. SEER, Surveillance, Epidemiology, and End Results; WHO, World Health Organization; TNM, Tumor Node Metastasis.

and the interval time from curative surgery to recurrence.

Statistical analysis

This study is a retrospective cross-sectional survey with statistical analysis. With patient and tumor characteristics presented as percentages, the data were ultimately analyzed using Chi-squared tests. A statistically significant difference was considered when $P<0.05$. All statistical analyses were conducted using SPSS (Statistical Product and Service Solutions) version 25.0.

To assess the relative risk of each predictive factor on the outcome, control for confounding bias, both univariate and multivariate Cox regression analyses were conducted using SPSS version 25.0. Hazard ratios (HRs) were calculated using Multifactor Cox proportional risk model; these models were adjusted for sex, age, race, histology, tumor size, AJCC T and primary site. Comparisons were made

using the log-rank test. Statistical significance was defined as P<0.05.

Nomograms were constructed for predicting recurrence in stage I gastric cancer using statistically significant variables, and they were evaluated by the concordance index (c-index) and calibration plots. Specific scores for each factor within the nomograms were calculated using the coefficients from the Logit model. Nomograms based on regression models, calibration curves, and survival-related curves were generated utilizing various functional packages, including Root Mean Square (RMS), Foreign, Survival, Cmprsk, among other software tools. A two-tailed P value <0.05 was taken to indicate statistical significance (*P<0.05, **P<0.01). The receiver operating characteristic (ROC) curve was used to illustrate the sensitivity and specificity of the constructed nomogram, calibration plots were used to assess and validate its accuracy, and decision curve analysis (DCA) was employed to determine the clinical utility of the model. Patients were stratified into high risk, normal risk, or low risk categories based on their risk scores for different tumor characteristics within the nomogram.

Results

Baseline characteristics of enrolled patients

In *Table 1*, there is a total of 5,008 patients, of whom 840 experienced ipsilateral recurrence within 10 years. Significant differences were observed in the clinical pathological characteristics of sex, age, race, histology, tumor size, AJCC T stage, and primary site under the Chi-square test (P<0.05). Among these, there were 2,878 male and 2,130 female patients. In terms of age, the proportion of patients between 61–80 years was the highest (54.79%), secondly 41–60 years (23.9%), >80 years (18.15%), 18–40 years (3.15%). Regarding the distribution by race, Whites at most (63.18%), secondly Asians or Pacific Islanders (24.7%) and Blacks (12.12%). In histology, most are adenocarcinomas (74.1%), the second was signet-ring cell carcinoma (15.04%). Analysis of tumor size, the maximum proportion is 0–3 cm (50.68%). Patients with T1 stage disease had a significantly higher proportion 70.07%. Patients with tumors located at the Gastric antrum occupy the largest proportion 31.39%. Besides, there is confounding bias due to the uneven distribution of each factor. In Table S1, we conducted correlation analysis for each factor, there was correlation among multiple factors (P<0.05).

Univariate and multivariate Cox regression analyses with recurrence within 10 years as the outcome

As seen in *Table 2*, we conducted univariate and multivariate logistic regression analyses on all prognostic factors that showed statistical significance. (I) Regarding sex, male patients had an increased risk of recurrence compared to females [HR =1.16, 95% confidence interval (CI): 1.01–1.33]. (II) Concerning age, patients over 81 years old showed a significantly increased risk of recurrence compared to those aged 18–40 (HR =2.42, 95% CI: 1.39–4.21). Univariate logistic regression indicated an increased risk for patients aged 61–80 (HR =2.01, 95% CI: 1.18–3.43), but this was not significant in the multivariate logistic regression (P=0.068). (III) In terms of race, compared to Asians or Pacific Islanders, both Black patients (HR =1.62, 95% CI: 1.26–2.08) and White patients (HR =1.40, 95% CI: 1.16–1.68) had an elevated risk of recurrence. (IV) Regarding histology, univariate logistic regression showed that Signet ring cell carcinoma had a reduced risk of recurrence compared to adenocarcinoma (HR =0.75, 95% CI: 0.61–0.92), although this difference was not observed in the multivariate logistic regression (P=0.283). (V) In terms of tumor size, univariate logistic regression revealed that patients with tumor size >3 cm had an increased risk of recurrence (HR =1.89, 95% CI: 1.63–2.19), the multivariate logistic regression show this as a significant risk factor when compared with tumor size 0–3 cm (P=0.024). (VI) In terms of AJCC T staging, patients with T2 stage disease had a significantly higher risk of recurrence than those with T1 stage (HR =2.46, 95% CI: 2.11–2.87). (VII) Regarding the primary tumor site, in comparison to tumors located in the cardia, those in the gastric antrum (HR =0.54, 95% CI: 0.44–0.66) and lesser curvature (HR =0.63, 95% CI: 0.49–0.81) were associated with a reduced risk of recurrence. Meanwhile, the fundus (P=0.775) and greater curvature (P=0.14) and pylorus (P=0.084) did not show a significant difference in recurrence risk.

Nomogram for prediction of recurrence

In the original cohort of 5,008 patients, we allocated 3,756 to the training set (75%) and 1,252 patients to the validation set (25%). The flow diagram of participant inclusion and exclusion is shown in *Figure 1*. We created a nomogram to visually display the allocation of scores, the predicted probability of risk factors and the 5- or 10-year probability of recurrence free probability corresponding

Table 1 Statistical description of the dataset for the overall population after conducting a chi-square test

Variables	Total (n=5,008)	No recurrence (n=4,168)	Recurrence (n=840)	Statistic	P
Sex, n (%)				χ^2=2.65	0.104
Female	2,130 (42.53)	1,794 (43.04)	336 (40.00)		
Male	2,878 (57.47)	2,374 (56.96)	504 (60.00)		
Age (years), n (%)				χ^2=76.64	<0.001
18–40	158 (3.15)	144 (3.45)	14 (1.67)		
41–60	1,197 (23.90)	1,072 (25.72)	125 (14.88)		
61–80	2,744 (54.79)	2,261 (54.25)	483 (57.50)		
>80	909 (18.15)	691 (16.58)	218 (25.95)		
Race, n (%)				χ^2=32.00	<0.001
Asian or Pacific Islander	1,237 (24.70)	1,094 (26.25)	143 (17.02)		
Black	607 (12.12)	496 (11.90)	111 (13.21)		
White	3,164 (63.18)	2,578 (61.85)	586 (69.76)		
Histology, n (%)				χ^2=10.56	0.005
Adenocarcinoma	3,711 (74.10)	3,051 (73.20)	660 (78.57)		
Others/unknown	544 (10.86)	467 (11.20)	77 (9.17)		
Signet ring cell carcinoma	753 (15.04)	650 (15.60)	103 (12.26)		
Tumor size (cm), n (%)				χ^2=138.45	<0.001
0–3	2,538 (50.68)	2,141 (51.37)	397 (47.26)		
>3	1,208 (24.12)	884 (21.21)	324 (38.57)		
Unknown	1,262 (25.20)	1,143 (27.42)	119 (14.17)		
AJCC T, n (%)				χ^2=279.87	<0.001
T1	3,509 (70.07)	3,123 (74.93)	386 (45.95)		
T2	1,499 (29.93)	1,045 (25.07)	454 (54.05)		
Primary site, n (%)				χ^2=45.06	<0.001
Cardia	956 (19.09)	750 (17.99)	206 (24.52)		
Fundus	169 (3.37)	126 (3.02)	43 (5.12)		
Gastric antrum	1,572 (31.39)	1,368 (32.82)	204 (24.29)		
Greater curvature	266 (5.31)	214 (5.13)	52 (6.19)		
Lesser curvature	630 (12.58)	530 (12.72)	100 (11.90)		
Others/unknown	1,251 (24.98)	1,050 (25.19)	201 (23.93)		
Pylorus	164 (3.27)	130 (3.12)	34 (4.05)		

AJCC T, American Joint Committee on Cancer Tumor.

Table 2 Results of univariate and multivariate Cox regression analyses on the dataset of the total population

Variables	Univariate					Multivariate				
	β	SE	Z	P	HR (95% CI)	β	SE	Z	P	HR (95% CI)
Sex										
Female					1.00 (reference)					1.00 (reference)
Male	0.13	0.07	1.87	0.06	1.14 (0.99–1.31)	0.14	0.07	1.98	0.047	1.16 (1.01–1.33)
Age (years)										
18–40					1.00 (reference)					1.00 (reference)
41–60	0.12	0.28	0.43	0.67	1.13 (0.65–1.96)	−0.03	0.28	−0.09	0.93	0.97 (0.56–1.70)
61–80	0.7	0.27	2.58	0.01	2.01 (1.18–3.43)	0.5	0.28	1.82	0.07	1.65 (0.96–2.84)
>80	1.15	0.28	4.18	<0.001	3.17 (1.84–5.44)	0.88	0.28	3.13	0.002	2.42 (1.39–4.21)
Race										
Asian or Pacific Islander					1.00 (reference)					1.00 (reference)
Black	0.52	0.13	4.1	<0.001	1.68 (1.31–2.15)	0.48	0.13	3.75	<0.001	1.62 (1.26–2.08)
White	0.53	0.09	5.72	<0.001	1.70 (1.42–2.05)	0.33	0.1	3.47	<0.001	1.40 (1.16–1.68)
Histology										
Adenocarcinoma					1.00 (reference)					1.00 (reference)
Others/unknown	−0.18	0.12	−1.49	0.14	0.84 (0.66–1.06)	0.06	0.12	0.46	0.64	1.06 (0.83–1.35)
Signet ring cell carcinoma	−0.29	0.11	−2.74	0.006	0.75 (0.61–0.92)	0.12	0.11	1.07	0.28	1.13 (0.91–1.40)
Tumor size (cm)										
0–3					1.00 (reference)					1.00 (reference)
>3	0.63	0.07	8.48	<0.001	1.89 (1.63–2.19)	0.19	0.08	2.25	0.02	1.20 (1.02–1.42)
Unknown	−0.17	0.1	−1.61	0.11	0.84 (0.69–1.04)	−0.05	0.11	−0.44	0.66	0.95 (0.78–1.18)
AJCC T										
T1					1.00 (reference)					1.00 (reference)
T2	1.09	0.07	15.78	<0.001	2.98 (2.60–3.42)	0.9	0.08	11.47	<0.001	2.46 (2.11–2.87)
Primary site										
Cardia					1.00 (reference)					1.00 (reference)
Fundus	0.23	0.17	1.4	0.16	1.26 (0.91–1.76)	0.05	0.17	0.29	0.78	1.05 (0.75–1.47)
Gastric antrum	−0.5	0.1	−5.08	<0.001	0.61 (0.50–0.73)	−0.62	0.11	−5.81	<0.001	0.54 (0.44–0.66)
Greater curvature	−0.08	0.16	−0.52	0.60	0.92 (0.68–1.25)	−0.23	0.16	−1.47	0.14	0.79 (0.58–1.08)
Lesser curvature	−0.3	0.12	−2.5	0.01	0.74 (0.58–0.94)	−0.46	0.13	−3.6	<0.001	0.63 (0.49–0.81)
Others/unknown	−0.26	0.1	−2.64	0.008	0.77 (0.63–0.94)	−0.32	0.1	−3.09	0.002	0.72 (0.59–0.89)
Pylorus	0.01	0.19	0.05	0.96	1.01 (0.70–1.45)	−0.33	0.19	−1.73	0.08	0.72 (0.50–1.04)

SE, standard error; HR, hazards ratio; CI, confidence interval; AJCC T, American Joint Committee on Cancer Tumor.

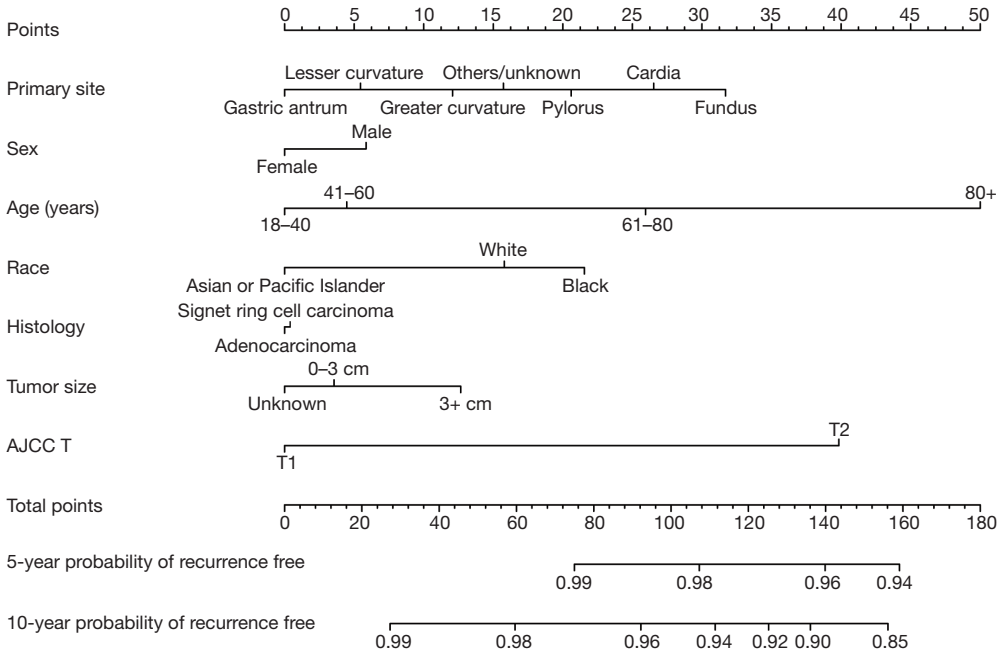

Figure 2 Predictive nomogram for recurrence in stage I gastric cancer. AJCC T, American Joint Committee on Cancer Tumor.

to the nomogram total score (*Figure 2*, *Tables 3-5*). The consistency index of the 5-year ROC curves for the training and test sets was 0.718 (95% CI: 0.695–0.742) and 0.716 (95% CI: 0.677–0.754), respectively, and for the 10-year ROC curves, it was 0.710 (95% CI: 0.688–0.732) and 0.714 (95% CI: 0.679–0.748), respectively. This indicates a very strong consistency between actual observations and predicted probabilities (*Figure 3A-3D*). The calibration curves for the test and validation sets at both 5 and 10 years closely adhere to the diagonal, showing no deviation from our predicted outcomes (*Figure 3E-3H*). The 5-year DCA for the training and validation sets indicates an effective range of predicted probabilities between 5–20%, and the 10-year DCA curves show an effective range of predicted probabilities between 10–30% (*Figure 3I-3L*).

Discussion

This study focuses on the likelihood of recurrence following radical surgery for early-stage gastric cancer, yet due to its early disease progression stage, the clinical evidence available is relatively scant. The research focuses on basic data such as sex, age, histology, race, primary site, tumor size, and AJCC T, striving for simplicity and efficacy. Utilizing the SEER database's advantage of having large sample size, this study incorporated patient data from 5,008 cases to construct nomograms for predicting the probability of recurrence within 5 and 10 years post-surgery for early-stage gastric cancer, with the aim of guiding clinical follow-up treatment. Through Chi-squared testing and multivariate analysis, risk factors for post-surgical recurrence in early-stage gastric cancer were identified, which included sex, age, race, histology, tumor size, AJCC T stage, and primary site. In the nomogram, we can rank the contribution weight of each risk factor towards the outcome of recurrence: sex (male > female), age (80+ years > 61–80 years > 41–60 years > 18–40 years), race (White > Black > Asian or Pacific Islander), histology (adenocarcinoma > signet ring cell carcinoma), tumor size (3+ cm > 0–3 cm), AJCC T (T2 > T1), primary site (pylorus > cardia > fundus > greater curvature > lesser curvature > gastric antrum). In both univariate and multivariate Cox regression analyses, we found that ages 61–80 years, histology of signet ring cell carcinoma were significant ($P<0.05$) in the univariate Cox analysis but not significant in the multivariate Cox regression analysis, suggesting the influence of confounding bias with the aforementioned factors on the outcome.

In our observations regarding age, the likelihood of postoperative recurrence in early-stage gastric cancer increases with age. Saito *et al.* and Yang *et al.* also believed that age is associated with recurrence in gastric cancer (21,22). The same idea has been found in other cancers, for

Table 3 The scores of various clinical and pathological factors obtained in the nomogram

Variables	Points
Primary site	
Cardia	27
Fundus	32
Gastric antrum	0
Greater curvature	12
Lesser curvature	5
Others/unknown	16
Pylorus	21
Sex	
Female	0
Male	6
Age (years)	
18–40	0
41–60	4
61–80	26
>80	50
Race	
Asian or Pacific Islander	0
Black	22
White	16
Histology	
Adenocarcinoma	0
Others/unknown	6
Signet ring cell carcinoma	0
Tumor size (cm)	
0–3	4
>3	13
Unknown	0
AJCC T	
T1	0
T2	40

AJCC T, American Joint Committee on Cancer Tumor.

Table 4 Five-year probability of recurrence free probability corresponding to the nomogram total score

Total points	5-year probability of recurrence free
75	0.99
107	0.98
140	0.96
159	0.94

Table 5 Ten-year probability of recurrence free probability corresponding to the nomogram total score

Total points	10-year probability of recurrence free
27	0.99
60	0.98
92	0.96
111	0.94
125	0.92
136	0.9
156	0.85

example Algara *et al.* on breast cancer, and Damhuis *et al.* on the relationship between age and recurrence in colorectal cancer (23,24). Concerning race, Asian or Pacific Islanders have a lower probability of recurrence compared to other races. Analysis by Chen *et al.* on gastric cancer patients in a single center in Australia demonstrated Asians had a higher survival rate (25). Ikoma *et al.* considered ethnicity a risk factor for lymph node metastasis in gastric cancer patients, suggesting that race affects survival and recurrence rates, with Asian or Pacific Islanders showing lower recurrence rates than other races (26). In terms of histology, Signet ring cell carcinoma has a lower recurrence rate than adenocarcinoma. Signet ring cell carcinoma is considered to have a poorer prognosis in advanced gastric cancer due to its lower chemotherapy sensitivity, yet in early-stage gastric cancer, signet ring cell carcinoma's prognosis is better than other pathological types, which aligns with our recurrence prediction model (27). Regarding tumor size, a size >3 cm significantly increases the probability of recurrence.

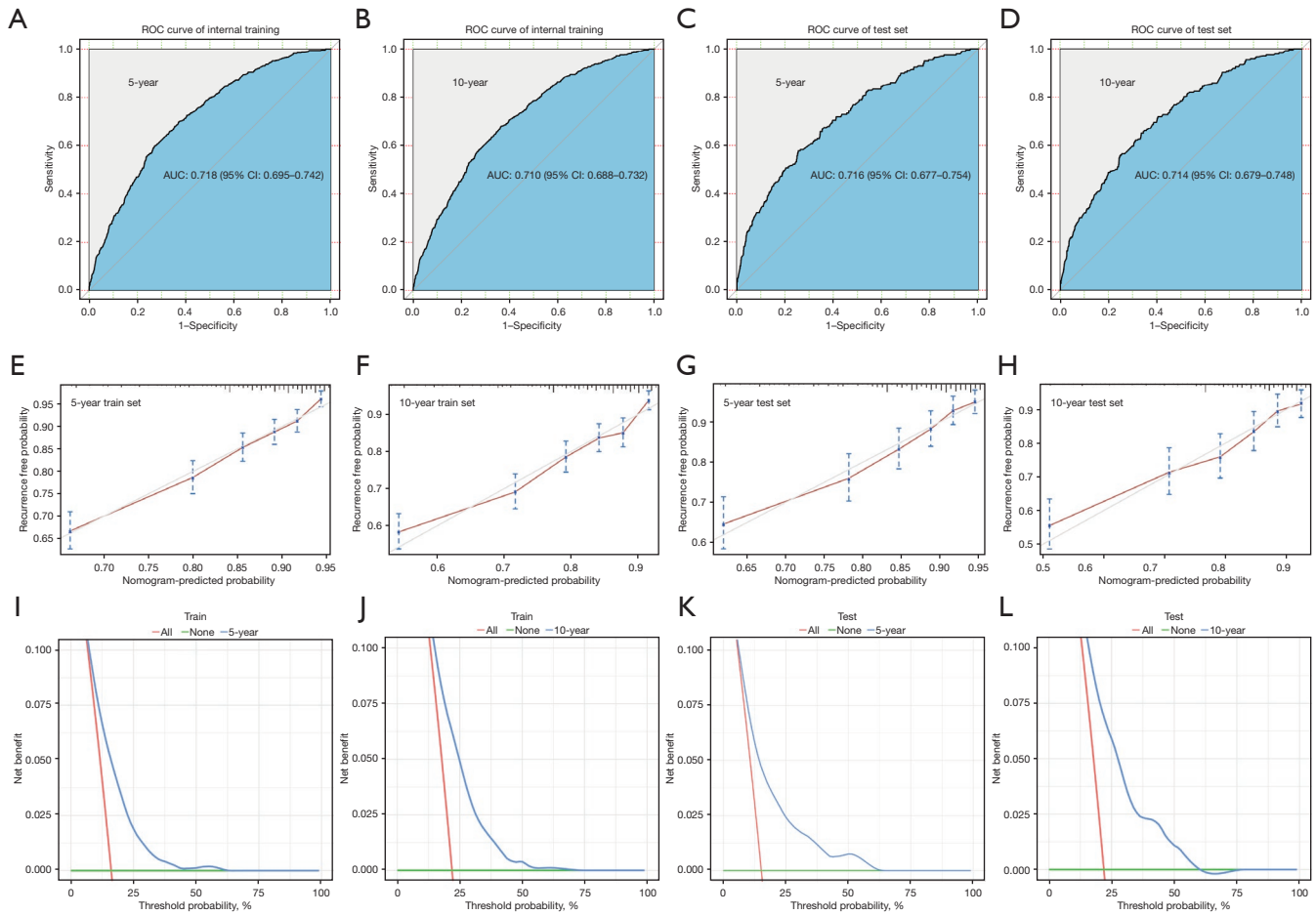

Figure 3 Evaluate the prognostic potential of the nomogram. (A) The ROC curve of the nomogram for predicting recurrence within 5 years in the training set of patients. (B) The ROC curve of the nomogram for predicting recurrence within 10 years in the training set of patients. (C) The ROC curve of the nomogram for predicting recurrence within 5 years in the testing set of patients. (D) The ROC curve of the nomogram for predicting recurrence within 10 years in the testing set of patients. (E) The calibration curve of the nomogram for predicting recurrence within 5 years in the training set of patients. (F) The calibration curve of the nomogram for predicting recurrence within 10 years in the training set of patients. (G) The calibration curve of the nomogram for predicting recurrence within 5 years in the testing set of patients. (H) The calibration curve of the nomogram for predicting recurrence within 10 years in the testing set of patients. (I) The DCA curve of the nomogram for predicting recurrence within 5 years in the training set of patients. (J) The DCA curve of the nomogram for predicting recurrence within 10 years in the training set of patients. (K) The DCA curve of the nomogram for predicting recurrence within 5 years in the testing set of patients. (L) The DCA curve of the nomogram for predicting recurrence within 10 years in the testing set of patients. (E-H) Gray line means Ideal; red line means Apparent. ROC, receiver operating characteristic; AUC, area under the curve; CI, confidence interval; DCA, decision curve analysis.

Hsu *et al.* considered tumor size a major determinant for recurrence after radical surgery for gastrointestinal malignancies, with recurrence risk significantly increasing when tumor size >10 cm (28). Hafez *et al.* suggested that a tumor size >4 cm significantly raises the risk of recurrence in renal cell carcinoma (29); Wang *et al.* considered tumor size a risk factor for early recurrence of cervical cancer (30); Sozzi *et al.* believed that tumor size should be regarded as an independent predictor for local recurrence in endometrial cancer (31).

Finally, there are some limitations in our study, such as the inability to obtain information on CA199, lymphovascular invasion, perineural invasion, and tumor budding from the SEER database to refine our model. In terms of the time period of the data set, we chose the data from 2000 to 2018, but the latest population data could

not be obtained to build the model. It should be pointed out that in terms of pathological classification, as the main pathological type of gastric cancer is adenocarcinoma, and sig-ring cell carcinoma is one of the subtypes of adenocarcinoma. Considering the high malignancy degree of sig-ring cell carcinoma, we singled it out and compared it with non-sig-ring cell carcinoma adenocarcinoma. However, this is indeed not precise and may cause some confusion. In terms of age, due to the rarity of stage I gastric cancer surgery in adolescents (less than 18 years old), moreover, our model is suitable for adults, we selected patients over 18 years old for statistics. This makes the applicable population reference range of our Nomo chart narrow, and may produce a certain bias in its results. Lymph node metastasis is also an important risk factor for recurrence (32,33). However, because the positive rate of lymph nodes was too small to support the establishment of the model, the factor of lymph nodes was not included. Moreover, a lack of clinical data for an external validation cohort to assess the performance of the nomogram and improve predictive accuracy is also a deficiency. Additionally, the nomogram has certain performance limitations, with our effective prediction range being between 10–30%; probabilities outside this range may not be as accurate.

Conclusions

This study established a reliable predictive model for recurrence following curative gastrectomy in stage I gastric cancer based on a population cohort. The findings of this study have the potential to significantly impact clinical practice by providing clinicians with tools for personalized risk assessment and for making informed treatment decisions.

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Footnote

Reporting Checklist: The authors have completed the TRIPOD reporting checklist. Available at https://tcr.amegroups.com/article/view/10.21037/tcr-24-692/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tcr.amegroups.com/article/view/10.21037/tcr-24-692/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

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