A Nomogram for Predicting Cancer-Specific Survival of Patients with Gastrointestinal Stromal Tumors

Mengmeng Liu*
Chao Song*
Ping Zhang*
Yuan Fang
Xu Han
Jianang Li
Weixin Wu
Genwen Chen
Jianyong Sun

* Mengmeng Liu, Chao Song and Ping Zhang have contributed equally to this work

Corresponding Author: Jianyong Sun, e-mail: sunjianyong_sjy@163.com

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**Background:** The aim of this study was to construct a nomogram to predict the prognosis of patients with gastrointestinal stromal tumor (GIST).

**Material/Methods:** We enrolled 4086 GIST patients listed in the SEER database from 1998 to 2015. They were separated to 2 groups: an experimental group (n=2862) and a verification group (n=1224). A nomogram was constructed by using statistically significant prognostic factors.

**Result:** A nomogram that included age, sex, marital status, tumor location, grade, SEER stage, tumor size, and surgical management was developed. It can be used to predict overall survival (OS), while adding AJCC 7th TNM stage can predict cancer-specific survival (CSS). The C-index used to forecast OS and CSS nomograms was 0.778 (95% CI, 0.76–0.79) and 0.818 (95% CI, 0.80–0.84), respectively.

**Conclusions:** The nomogram can effectively predict 3- and 5-year CSS in patients with GIST, and its use can improve clinical practice.

**MeSH Keywords:** Nomograms • SEER Program • Stomach Neoplasms

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Background

Gastrointestinal stromal tumors (GIST) are interlobar tumors that most often occur in the gastrointestinal tract [1]. They originate from the stromal cells of Cajal or their stem cell precursors. In histology, GIST consists of fusiform cells, epithelial cells, or mixed cells, that are arranged in bundles or are diffused [2]. GIST includes 3 types: benign, uncertain malignant potential, and malignant [1]. They occur in every part of the digestive tract and are most common in the gastric stroma, accounting for about 60–70% of all cases. GIST has a broad prognostic spectrum; therefore, forecasting the prognosis of GIST patients based on clinicopathological factors is important and contributes to developing treatment plans.

A nomogram is considered a reliable tool for clinicians to use in predicting prognosis of patients with tumors. Compared with the AJCC system, TNM staging system can more accurately predict the survival time of patients with different tumors, and TNM staging system has been recognized in various studies [7–8]. Research using nomograms for GIST patients alone based on population-based data have not been reported. Thus, we used the database to develop a nomogram to more precisely predict the prognosis of GIST patients.

Material and Methods

Patients

We obtained patient data from the SEER database, and SEER*stat software (version 8.3.5; http://seer.cancer.gov/seerstat/) was used to screen the data. All patients were pathologically diagnosed as having GIST by morphological code (C22.0) between 1998 and 2015 from the SEER database. In accordance with the third edition of ICDO-3 for GIST (code 8936), 5381 patients with GIST were listed. Then, 4086 patients were selected from among the 5381 patients based on the following criteria: 1) no history of malignant tumor; 2) diagnosed with GIST; 3) followed up with known results; 4) detailed clinicopathological information.

Study variables

We calculated CSS and OS. For each patient, were obtained data on clinical variables, including age at diagnosis, race, sex, marital status, size, tumor grade, tumor site, SEER historical stage A, AJCC 7th edition TNM stage, mitotic count, surgical management, follow-up data, and cause of death. Tumor size and age were regarded as continuous variables.

Statistical analysis

We used the t test to construct nomogram baseline patient demographics. Differences between survival curves were analyzed using the log-rank test. We used univariate and multivariate Cox proportional hazards models to screen key prognostic factors. Univariate prognostic analysis was performed via log-rank and Kaplan-Meier analysis. The Cox proportional hazards model was used to obtain hazard ratios and 95% confidence intervals. A graphical nomogram was constructed from multivariate logistic regression models.

Verification of the nomogram

The nomogram was validated by measuring discrimination internally (training set) and externally (validation set). The discriminatory ability of every model was assessed using the concordance index (C-index). A high C-index indicates good capacity to distinguish patients with different survival conditions. SPSS 20.0 (IBM, Inc., Armonk, NY) and R software programs were used for analysis. P<0.05 indicated statistical significance.

Results

Demographic and pathological characteristics

We selected 4086 patients diagnosed with GIST. Patients were separated into a training group (n=2862) and a validation group (n=1224) group.

The flowchart of data selection for the training group (n=2841) and validation group (n=2781) is presented in Figure 1, and patient characteristics are listed in Table 1. The average age was 62.67 years old, and 49.7% of patients were male. Most patients in the 2 sets were married (56.3%) and 61.6% were white. In addition to the unknown location, the most common tumor site was the fundus (15.4%), followed by the greater curvature (13.3%), lesser curvature (11.6%), body (9.2%),
Excluded 956 patients had more than 1 primary cancer and the gastric GIST was not first

Excluded 191 patients without follow-up time

Excluded 27 patients age <18 years

Excluded 121 patients without information regarding surgical management

Figure 1. Flowchart of data selection.

Table 1. Patient demographics and pathological characteristics.

| Variables       | All patients (n=4086) | Training set (n=2862) | Validation set (n=1224) |
|-----------------|-----------------------|-----------------------|-------------------------|
| Age             |                       |                       |                         |
| <50             | 718 17.6              | 497 17.4              | 221 18.1                |
| 50–64           | 1429 35               | 1007 35.2             | 422 34.5                |
| 65–79           | 1481 36.2             | 1031 36               | 450 36.8                |
| ≥80             | 458 11.2              | 327 11.4              | 131 10.7                |
| Sex             |                       |                       |                         |
| Female          | 2054 50.3             | 1436 50.2             | 618 50.5                |
| Male            | 2032 49.7             | 1426 49.8             | 606 49.5                |
| Race            |                       |                       |                         |
| White           | 2517 61.6             | 1741 60.8             | 776 63.4                |
| Black           | 976 23.9              | 693 24.2              | 283 23.1                |
| Other/unknown   | 593 14.5              | 428 15                | 165 13.5                |
| Marital status  |                       |                       |                         |
| Married         | 2301 56.3             | 1618 56.5             | 683 55.8                |
| Single          | 685 16.8              | 473 16.5              | 212 17.3                |
| Unknown         | 1100 26.9             | 771 26.9              | 329 26.9                |
| Tumor site      |                       |                       |                         |
| Cardia          | 308 7.5               | 220 7.7               | 88 7.2                  |
| Fundus          | 630 15.4              | 418 14.6              | 212 17.3                |
| Body            | 376 9.2               | 278 9.7               | 98 8                    |
Table 1 continued. Patient demographics and pathological characteristics.

| Variables                                | All patients (n=4086) | Training set (n=2862) | Validation set (n=1224) |
|------------------------------------------|-----------------------|-----------------------|-------------------------|
|                                          | No. | %    | No. | %    | No. | %    |
| Antrum                                   | 314 | 7.7  | 213 | 7.4  | 101 | 8.3  |
| Pylorus                                   | 12  | 0.3  | 9   | 0.3  | 3   | 0.2  |
| Lesser curvature                          | 474 | 11.6 | 327 | 11.4 | 147 | 12   |
| Greater curvature                         | 545 | 13.3 | 383 | 13.4 | 162 | 13.2 |
| Overlapping stomach lesion                | 257 | 6.3  | 193 | 6.7  | 64  | 5.2  |
| Stomach NOS                               | 1170| 28.6 | 821 | 28.7 | 349 | 28.5 |
| Tumour size                               |     |      |     |      |     |      |
| £5                                       | 1329| 32.5 | 926 | 32.4 | 403 | 33   |
| 5.1–10                                    | 1016| 24.9 | 703 | 24.6 | 313 | 25.6 |
| >10                                      | 787 | 19.3 | 538 | 18.8 | 249 | 20.3 |
| Unknown                                  | 954 | 23.3 | 695 | 24.3 | 259 | 21.2 |
| Mitotic index, mitoses/50 HPF             |     |      |     |      |     |      |
| <5                                       | 1237| 30.3 | 849 | 29.7 | 388 | 31.7 |
| 5–10                                     | 170 | 4.2  | 129 | 4.5  | 41  | 3.3  |
| >10                                      | 174 | 4.3  | 123 | 4.3  | 51  | 4.2  |
| Unknown                                  | 2505| 61.3 | 1761| 61.5 | 744 | 60.8 |
| Grade                                    |     |      |     |      |     |      |
| I                                        | 514 | 12.6 | 357 | 12.5 | 157 | 12.8 |
| II                                       | 401 | 9.8  | 280 | 9.8  | 121 | 9.9  |
| III                                      | 163 | 4    | 118 | 4.1  | 45  | 3.7  |
| IV                                       | 240 | 5.9  | 162 | 5.7  | 78  | 6.4  |
| Unknown                                  | 2768| 67.7 | 1945| 68   | 823 | 67.2 |
| Stage                                    |     |      |     |      |     |      |
| Localized                                | 2739| 67   | 1904| 66.5 | 835 | 68.2 |
| Regional                                 | 397 | 9.7  | 296 | 10.3 | 101 | 8.3  |
| Distant                                  | 710 | 17.4 | 499 | 17.4 | 211 | 17.2 |
| Unknown                                  | 240 | 5.9  | 163 | 5.7  | 77  | 6.3  |
| Surgery                                  |     |      |     |      |     |      |
| Performed                                | 3371| 82.5 | 2361| 82.5 | 1010| 82.5 |
| None                                     | 715 | 17.5 | 501 | 17.5 | 214 | 17.5 |
### Table 2. Univariate and multivariate analyses of overall survival in the training set.

| Variable                  | Univariate analysis | Multivariate analysis |
|---------------------------|---------------------|-----------------------|
|                           | P value             | HR (95% CI)           | P value |
| **Age**                   |                     |                       |         |
| <50                       | <0.001              | Reference             |         |
| 50–64                     | 1.328               | (1.050–1.680)         | 0.018   |
| 65–79                     | 2.450               | (1.954–3.070)         | <0.001  |
| ≥80                       | 4.859               | (3.749–6.299)         | <0.001  |
| **Sex**                   | <0.001              |                       |         |
| Female                    | Reference           |                       |         |
| Male                      | 1.408               | (1.221–1.624)         | <0.001  |
| **Race**                  |                     |                       |         |
| White                     | Reference           |                       |         |
| Black                     | 1.107               | (0.942–1.301)         | 0.218   |
| Other/unknown             | 0.807               | (0.652–0.999)         | 0.049   |
| **Marital status**        | <0.001              |                       |         |
| Married                   | Reference           |                       |         |
| Single                    | 1.419               | (1.167–1.724)         | <0.001  |
| Unknown                   | 1.059               | (0.896–1.253)         | 0.5     |
| **Tumor site**            | <0.001              |                       |         |
| Cardia                    | Reference           |                       |         |
| Fundus                    | 0.682               | (0.516–0.901)         | 0.007   |
| Body                      | 0.734               | (0.540–0.997)         | 0.048   |
| Antrum                    | 0.537               | (0.372–0.774)         | <0.001  |
| Pylorus                   | 2.852               | (1.037–7.843)         | 0.042   |
| Lesser curvature          | 0.755               | (0.551–1.034)         | 0.079   |
| Greater curvature         | 0.735               | (0.551–0.981)         | 0.036   |
| Overlapping stomach lesion| 0.874               | (0.629–1.212)         | 0.418   |
| Stomach NOS               | 0.789               | (0.618–1.007)         | 0.057   |
| **Tumour size**           | <0.001              |                       |         |
| ≤5                        | Reference           |                       |         |
| 5.1–10                    | 1.230               | (0.964–1.568)         | 0.096   |
| >10                       | 1.462               | (1.124–1.903)         | 0.005   |
| Unknown                   | 1.850               | (1.472–2.326)         | <0.001  |
| **Mitotic index, mitoses/50 HPF** | <0.001 |                       |         |
| ≤5                        | Reference           |                       |         |
| ≤10                       | 0.902               | (0.469–1.736)         | 0.758   |
| >10                       | 1.107               | (0.586–2.088)         | 0.755   |
| Unknown                   | 1.109               | (0.716–1.717)         | 0.643   |
Table 2 continued. Univariate and multivariate analyses of overall survival in the training set.

| Variable          | Univariate analysis | Multivariate analysis |
|-------------------|---------------------|-----------------------|
|                   | *P* value           | HR (95% CI)           | *P* value |
| Grade             | <0.001              |                       |          |
| I                 | Reference           |                       |          |
| II                | 1.158 (0.760–1.766) | 0.494                 |          |
| III               | 2.083 (1.322–3.283) | 0.002                 |          |
| IV                | 1.823 (1.270–2.754) | 0.004                 |          |
| Unknown           | 1.132 (0.802–1.596) | 0.481                 |          |
| Stage             | <0.001              |                       |          |
| Localized         | Reference           |                       |          |
| Regional          | 1.464 (1.181–1.815) | <0.001                |          |
| Distant           | 2.339 (1.931–2.832) | <0.001                |          |
| Unknown           | 1.264 (0.969–1.649) | 0.084                 |          |
| AJCC 7th stage    | <0.001              |                       |          |
| I                 | Reference           |                       |          |
| II                | 0.603 (0.282–1.289) | 0.192                 |          |
| III               | 1.504 (0.684–3.306) | 0.31                  |          |
| IV                | 1.069 (0.612–1.845) | 0.812                 |          |
| Unknown           | 1.270 (0.734–2.196) | 0.392                 |          |
| Surgery           | <0.001              |                       |          |
| None              | Reference           |                       |          |
| Performed         | 0.435 (0.365–0.518) | <0.001                |          |

independent predictive factors: age, sex, marital status, tumor location, grade, SEER stage, tumor size, and surgical management. On the basis of these 8 variables, we built the overall survival (OS) nomogram in the training set (Figure 2A). For cancer-specific survival (CSS), 9 independent predictive factors were identified: age, sex, marital status, tumor location, grade, SEER stage, tumor size, AJCC 7th TNM stage, and surgical management (Table 3). The CSS nomogram is shown in Figure 2B.

**Verification of the nomogram**

Internal and external validation was performed for the nomogram. Internal validation showed that the C-index used to predict OS and CSS nomograms was 0.778 (95% CI, 0.76–0.79) and 0.818 (95% CI, 0.80–0.84), respectively (Table 4), and it was consistent with the actual OS and CSS. When the validation cohort for external validation was used, the C-index was 0.794 for OS (95% CI, 0.77–0.82) and 0.843 (95% CI, 0.82–0.87) for CSS, respectively. Moreover, the nomogram in the training set was internally validated using a bootstrap method with 1000 resamples (Table 5).
### A

| Points | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|--------|---|----|----|----|----|----|----|----|----|----|-----|
| Age    |   |    |    |    |    |    |    |    |    |    | >=80 |
| <50    |   |    |    |    |    |    |    |    |    |    |      |
| 50–64  |   |    |    |    |    |    |    |    |    |    |      |
| >=80   |   |    |    |    |    |    |    |    |    |    |      |
| Sex    |   |    |    |    |    |    |    |    |    |    |      |
| Female |   |    |    |    |    |    |    |    |    |    |      |
| Male   |   |    |    |    |    |    |    |    |    |    |      |
| Other/unknown | | | | | | | | | | | |
| Marital status | | | | | | | | | | | |
| Married | | | | | | | | | | | |
| Single | | | | | | | | | | | |
| Other/unknown | | | | | | | | | | | |
| Tumor site | | | | | | | | | | | |
| Antrum | | | | | | | | | | | |
| Fundus | | | | | | | | | | | |
| Overlapping Pylorus | | | | | | | | | | | |
| Cardia | | | | | | | | | | | |
| Size   | | | | | | | | | | | |
| <=5   | | | | | | | | | | | |
| 5–10  | | | | | | | | | | | |
| >10   | | | | | | | | | | | |
| Grade  | | | | | | | | | | | |
| I     | | | | | | | | | | | |
| II    | | | | | | | | | | | |
| III   | | | | | | | | | | | |
| IV    | | | | | | | | | | | |
| SEER stage | | | | | | | | | | | |
| Localized | | | | | | | | | | | |
| Regional | | | | | | | | | | | |
| Distant | | | | | | | | | | | |
| Surgery | | | | | | | | | | | |
| NO    | | | | | | | | | | | |
| YES   | | | | | | | | | | | |
| Total points | | | | | | | | | | | |
| 0     | | | | | | | | | | | |
| 50    | | | | | | | | | | | |
| 100   | | | | | | | | | | | |
| 150   | | | | | | | | | | | |
| 200   | | | | | | | | | | | |
| 250   | | | | | | | | | | | |
| 300   | | | | | | | | | | | |
| 350   | | | | | | | | | | | |
| 400   | | | | | | | | | | | |
| 450   | | | | | | | | | | | |
| 3-year survival | | | | | | | | | | | |
| 0.9   | | | | | | | | | | | |
| 0.8   | | | | | | | | | | | |
| 0.7   | | | | | | | | | | | |
| 0.6   | | | | | | | | | | | |
| 0.5   | | | | | | | | | | | |
| 0.4   | | | | | | | | | | | |
| 0.3   | | | | | | | | | | | |
| 0.2   | | | | | | | | | | | |
| 0.1   | | | | | | | | | | | |
| 5-year survival | | | | | | | | | | | |
| 0.9   | | | | | | | | | | | |
| 0.8   | | | | | | | | | | | |
| 0.7   | | | | | | | | | | | |
| 0.6   | | | | | | | | | | | |
| 0.5   | | | | | | | | | | | |
| 0.4   | | | | | | | | | | | |
| 0.3   | | | | | | | | | | | |
| 0.2   | | | | | | | | | | | |
| 0.1   | | | | | | | | | | | |

### B

| Points | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|--------|---|----|----|----|----|----|----|----|----|----|-----|
| Age    |   |    |    |    |    |    |    |    |    |    | >=80 |
| <50    |   |    |    |    |    |    |    |    |    |    |      |
| 50–64  |   |    |    |    |    |    |    |    |    |    |      |
| >=80   |   |    |    |    |    |    |    |    |    |    |      |
| Sex    |   |    |    |    |    |    |    |    |    |    |      |
| Female |   |    |    |    |    |    |    |    |    |    |      |
| Male   |   |    |    |    |    |    |    |    |    |    |      |
| Other/unknown | | | | | | | | | | | |
| Marital status | | | | | | | | | | | |
| Married | | | | | | | | | | | |
| Single | | | | | | | | | | | |
| Other/unknown | | | | | | | | | | | |
| Tumor site | | | | | | | | | | | |
| Antrum | | | | | | | | | | | |
| Fundus | | | | | | | | | | | |
| Overlapping Pylorus | | | | | | | | | | | |
| Cardia | | | | | | | | | | | |
| Size   | | | | | | | | | | | |
| <=5   | | | | | | | | | | | |
| 5–10  | | | | | | | | | | | |
| >10   | | | | | | | | | | | |
| Grade  | | | | | | | | | | | |
| I     | | | | | | | | | | | |
| II    | | | | | | | | | | | |
| III   | | | | | | | | | | | |
| IV    | | | | | | | | | | | |
| SEER stage | | | | | | | | | | | |
| Localized | | | | | | | | | | | |
| Regional | | | | | | | | | | | |
| Distant | | | | | | | | | | | |
| AJCC 7h stage | | | | | | | | | | | |
| I     | | | | | | | | | | | |
| II    | | | | | | | | | | | |
| III   | | | | | | | | | | | |
| IV    | | | | | | | | | | | |
| Surgery | | | | | | | | | | | |
| NO    | | | | | | | | | | | |
| YES   | | | | | | | | | | | |
| Total points | | | | | | | | | | | |
| 0     | | | | | | | | | | | |
| 50    | | | | | | | | | | | |
| 100   | | | | | | | | | | | |
| 150   | | | | | | | | | | | |
| 200   | | | | | | | | | | | |
| 250   | | | | | | | | | | | |
| 300   | | | | | | | | | | | |
| 350   | | | | | | | | | | | |
| 400   | | | | | | | | | | | |
| 450   | | | | | | | | | | | |
| 3-year survival | | | | | | | | | | | |
| 0.9   | | | | | | | | | | | |
| 0.8   | | | | | | | | | | | |
| 0.7   | | | | | | | | | | | |
| 0.6   | | | | | | | | | | | |
| 0.5   | | | | | | | | | | | |
| 0.4   | | | | | | | | | | | |
| 0.3   | | | | | | | | | | | |
| 0.2   | | | | | | | | | | | |
| 0.1   | | | | | | | | | | | |
| 5-year survival | | | | | | | | | | | |
| 0.9   | | | | | | | | | | | |
| 0.8   | | | | | | | | | | | |
| 0.7   | | | | | | | | | | | |
| 0.6   | | | | | | | | | | | |
| 0.5   | | | | | | | | | | | |
| 0.4   | | | | | | | | | | | |
| 0.3   | | | | | | | | | | | |
| 0.2   | | | | | | | | | | | |
| 0.1   | | | | | | | | | | | |

**Figure 2.** Construction of nomograms. (A) Nomogram for predicting the OS of GIST. (B) Nomogram for predicting CSS. CSS– cancer-specific survival; OS – overall survival; GIST – gastrointestinal stromal tumor.
### Table 3. Univariate and multivariate analyses of CSS in the training set.

| Variable                  | Univariate analysis | Multivariate analysis |
|---------------------------|---------------------|-----------------------|
|                           | $P$ value           | HR (95% CI)           | $P$ value |
| **Age**                   | <0.001              |                       |
| <50                       | Reference           |                       |
| 50–64                     | 1.101 (0.853–1.421) | 0.461                 |
| 65–79                     | 1.682 (1.300–2.175) | <0.001                |
| ≥80                       | 3.001 (2.193–4.106) | <0.001                |
| **Sex**                   | <0.001              |                       |
| Female                    | Reference           |                       |
| Male                      | 1.286 (1.073–1.543) | 0.007                 |
| **Race**                  | 0.003               |                       |
| White                     | Reference           |                       |
| Black                     | 1.105 (0.903–1.353) | 0.332                 |
| Other/unknown             | 0.866 (0.665–1.128) | 0.286                 |
| **Marital status**        | 0.001               |                       |
| Married                   | Reference           |                       |
| Single                    | 1.382 (1.093–1.749) | 0.007                 |
| Unknown                   | 0.969 (0.778–1.206) | 0.781                 |
| **Tumor site**            | <0.001              |                       |
| Cardia                    | Reference           |                       |
| Fundus                    | 0.621 (0.432–0.895) | 0.01                  |
| Body                      | 0.724 (0.488–1.074) | 0.108                 |
| Antrum                    | 0.542 (0.334–0.879) | 0.013                 |
| Pylorus                   | 2.589 (0.619–10.827)| 0.193                 |
| Lesser curvature          | 0.729 (0.481–1.104) | 0.136                 |
| Greater curvature         | 0.720 (0.495–1.046) | 0.085                 |
| Overlapping stomach lesion| 0.873 (0.578–1.318) | 0.519                 |
| Stomach NOS               | 0.770 (0.563–1.052) | 0.101                 |
| **Tumour size**           | <0.001              |                       |
| ≤5                        | Reference           |                       |
| 5.1–10                    | 1.285 (0.899–1.836) | 0.169                 |
| >10                       | 1.712 (1.200–2.445) | 0.003                 |
| Unknown                   | 2.380 (1.715–3.304) | <0.001                |
| **Mitotic index, mitoses/50 HPF** | <0.001 |                       |
| ≤5                        | Reference           |                       |
| ≤10                       | 0.877 (0.397–1.940) | 0.747                 |
| >10                       | 0.968 (0.446–2.096) | 0.933                 |
| Unknown                   | 1.108 (0.656–1.872) | 0.702                 |
Table 3. Univariate and multivariate analyses of CSS in the training set.

| Variable       | Univariate analysis | Multivariate analysis |
|----------------|---------------------|-----------------------|
|                | $P$ value           | HR (95% CI)           | $P$ value |
| Grade          | <0.001              |                       |          |
| I              |                     |                       |          |
| II             | 1.467 (0.719–2.990) | 0.292                 |          |
| III            | 2.961 (1.478–5.931) | <0.001                |          |
| IV             | 3.399 (1.797–6.429) | <0.001                |          |
| Unknown        | 1.712 (0.946–3.099) | 0.076                 |          |
| Stage          | <0.001              |                       |          |
| Localized      |                     |                       |          |
| Regional       | 1.917 (1.469–2.504) | <0.001                |          |
| Distant        | 3.103 (2.438–3.949) | <0.001                |          |
| Unknown        | 1.360 (0.959–1.928) | 0.085                 |          |
| AJCC 7$^\text{th}$ stage | <0.001 |            |          |
| I              |                     |                       |          |
| II             | 1.929 (0.602–6.179) | 0.269                 |          |
| III            | 5.485 (1.663–18.094)| 0.005                 |          |
| IV             | 3.101 (1.182–8.133) | 0.021                 |          |
| Unknown        | 4.062 (1.538–10.730)| 0.005                 |          |
| Surgery        | <0.001              |                       |          |
| None           |                     |                       |          |
| Performed      | 0.402 (0.324–0.499) | <0.001                |          |

Table 4. Discrimination efficiency.

|                      | Training cohort | Validation cohort |
|----------------------|-----------------|-------------------|
|                      | HR       | 95% CI   | HR       | 95% CI   |
| Nomogram             | 0.778    | 0.76–0.79| 0.794    | 0.77–0.82|
| SEER stage           | 0.665    | 0.65–0.68| 0.668    | 0.64–0.70|
| AJCC TNM 7$^\text{th}$ stage | 0.588 | 0.57–0.60| 0.6      | 0.57–0.63|
| Nomogram             | 0.818    | 0.80–0.84| 0.843    | 0.82–0.87|
| SEER stage           | 0.722    | 0.70–0.74| 0.737    | 0.70–0.77|
| AJCC TNM 7$^\text{th}$ stage | 0.625 | 0.61–0.64| 0.634    | 0.61–0.66|
group, the SEER stage, and the AJCC 7th TNM staging system were compared. The results showed that a nomogram for discriminating patients with GIST performed better than the SEER and TNM 7th edition staging systems (Table 4).

Discussion

Nomograms were introduced into the medical field by scholars in 1928 [9]. They are currently used in various cancers to evaluate the individualized prognosis [10–12]. Nomograms are simple and easy to use and exhibit high clinical precision. Moreover, they can elevate staging systems from the group level to the individual level and can be used to predict approximate survival under any circumstances [13]. In the present study, a nomogram was built to predict patient prognosis. We compared the performances of our nomogram, SEER staging, and the AJCC 7th TNM staging system in the training group. Our results showed the nomogram performed better than the SEER and TNM 7th staging systems.

We identified 9 factors that could predict the CSS of patients with GIST – age, sex, marital status, tumor location, grade, SEER stage, tumor size, AJCC 7th TNM stage, and surgical management – which were consistent with previous studies [14–16]. Age has been regarded as a key prognostic factor in some reports and old age as an independent risk factor in other studies, indicating a reduced survival rate [17–19]. The older and more anxious the patients were, the less their desire to know the prognostic outcome [20]. Moreover, most women prefer to talk with others, whereas men usually choose deal with their cancer on their own. Some studies suggest patients communicate without reservation with family members [21]. Women with lower education levels were much more interested in knowing their survival rate [22]. Moreover, the partner can improve the prognosis [23–25]. Notably, the prognosis in the cardia and pylorus is better than that in the antral and other parts, which may be related to the obvious obstruction of the gastric cardia and the pylorus than that of the gastric antrum, and the earlier clinical findings.

The method used in this study has several advantages. Our nomogram is more accurate than the AJCC TNM staging system [26]. It effectively uses a rigorous design to provide a solid foundation for the individualized treatment of different gastric stromal tumors for clinicians. The prognoses of stage-III patients with the same TMN stage vary according to sex, age, marital status, and location of the tumor in the stomach. Prognostic differences are visually observed in the nomogram, which may result in different treatments. We calculated the scores of each individual. Discrimination and calibration indicated that the models were valid. Different nomogram-integrating anticancer treatments might further improve survival prediction. From the nomogram, 9 variables were obtained, which provided information on GIST and could also determine the correlation of developed tools. Although the model was built on the basis of a large population-based cohort and could increase the accuracy of the nomogram, the SEER database contained no data on chemotherapy and other targeted therapy, which could lead to bias. In addition, many possible predictive variables were excluded, such as pain, C-reactive protein, albumin, and molecular markers. Therefore, the use of this model, combined with tumor markers and other indicators, may more accurately predict patient prognosis.

Conclusions

The nomogram in our study was constructed by using statistically significant prognostic factors, including age, sex, marital status, tumor location, grade, SEER stage, tumor size, and surgical management. It performs better than the SEER and TNM 7th edition staging systems in discriminating patients with GIST. Our nomogram can more precisely predict the prognosis of GIST patients, and has clinical significance as it can guide individualized treatment.

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