Original Article

# Survival outcome and prognostic factors of remnant gastric cancer: a propensity score-matched analysis

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**Background:** Studies on survival and prognostic factors in individuals with remnant gastric cancer (RGC) after gastric cancer (GC) are rare. It is debatable whether prognosis of RGC after GC is worse than that of only primary GC (OPGC). The objective of this study is to compare the survival outcomes between post-GC RGC and OPGC undergoing surgical resection and to identify the prognostic factors of disease-specific survival (DSS) for RGC.

**Methods:** We retrospectively collected data from the Surveillance, Epidemiology, and End Results (SEER) database among patients who underwent GC surgery in 1988–2020. Propensity score matching (PSM) was conducted to balance baseline characteristics. Kaplan-Meier (KM) survival analysis was performed to compare their overall survival (OS) and DSS. Multivariable Cox analyses were performed to identify the independent prognostic factors of DSS for post-GC RGC by estimating hazard ratios (HRs) with 95% confidence intervals (CIs).

**Results:** There were 76 patients with RGC and 32,763 patients with OPGC included and analyzed. After balancing the baseline characteristics by PSM, no significant difference existed between OPGC and RGC groups in both OS (P=0.65) and DSS (P=0.28). Fixed-time analyses also showed no difference between the two groups for the 5-year (60.0%, RGC *vs.* 53.3%, OPGC, P=0.38) and 10-year DSS (56.7%, RGC *vs.* 48.3%, OPGC, P=0.34). Multivariable analysis revealed that area of lower income ($75,000+ *vs.* <$55,000, HR =0.21, 95% CI: 0.05–0.89, P=0.03), cardiac tumor [middle *vs.* cardia, HR =0.16, 95% CI: 0.03–0.77, P=0.02; distal *vs.* cardia, HR =0.10, 95% CI: 0.02–0.58, P=0.01; not otherwise specified (NOS) *vs.* cardia, HR =0.11, 95% CI: 0.03–0.51, P=0.004], deeper invasion (T3–4 *vs.* Tis–2, HR =5.19, 95% CI: 1.21–22.15, P=0.03), higher grade (G3 *vs.* G1–2, HR =7.35, 95% CI: 1.41–38.48, P=0.02) and not receiving chemotherapy (yes *vs.* no/unknown, HR =0.16, 95% CI: 0.04–0.60, P=0.007) were independent risk factors for postsurgical DSS in patients with post-GC RGC.

**Conclusions:** The prognosis of post-GC RGC was comparable to that of OPGC following surgical resection. The independent prognostic factors for RGC are similar to those established for OPGC. Our findings suggest that RGC following first GC might be the same entity to OPGC and curative resection should be considered in selected patients.

**Keywords:** Remnant gastric cancer (RGC); multiple primary gastric cancer (multiple primary GC); survival; prognostic factors; propensity score matching (PSM)

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## Introduction

Patients who have undergone partial gastrectomy are at an increased risk of carcinogenesis in the remnant stomach, namely remnant gastric cancer (RGC) (1-3). RGC is a less prevalent gastric cancer (GC), which was first described in 1922 by Balfour as a carcinoma occurring in remnant stomach at least five years after the initial surgery for gastric ulcer (4). Recently, RGC refers to a primary GC diagnosed more than 1 year after partial gastrectomy for both benign or malignant conditions (5-8). The incidence of RGC after gastrectomy ranges from 1% to 5% among all GC cases (9-11). While RGC following benign conditions has decreased due to improvement in anti-ulcer medications, the rate of RGC after gastrectomy for GC (namely post-GC RGC) increases because of prolonged survival, improved screening, and increased function-preserving gastrectomy (4,12).

We previously determined the incidence and increased risk of RGC after GC in the U.S. population using data from Surveillance, Epidemiology, and End Results (SEER) program (8). However, it is debatable whether RGC after GC has worse prognosis than only primary GC (OPGC, the GC which is the only primary tumor throughout a patient's life) (13). Due to the low incidence, only a few studies compared the prognosis between OPGC and RGC with adequate sample size (14-17) while none of them focused exclusively on RGC following malignant condition. In addition, the prognosis of these patients has not been reported in large nationwide population-based databases.

With this study, we intended to compare the survival outcomes between post-GC RGC and OPGC by a propensity score-matched approach utilizing data from SEER program [1988–2020], and to identify the prognostic factors of disease-specific survival (DSS) for patients with RGC following GC. Our hypothesis was that the survival outcomes are similar. We present this study in accordance with the STROBE reporting checklist (available at https://jgo.amegroups.com/article/view/10.21037/jgo-24-58/rc).

### Highlight box

**Key findings**

- Prognosis of remnant gastric cancer (RGC) following gastric cancer (GC) was not inferior to that of only primary GC (OPGC) following resection. Area of lower income, cardiac tumor, deeper invasion, higher grade and not receiving chemotherapy were identified as independent prognostic factors for RGC.

**What is known and what is new?**

- Few studies with limited sample size reported controversy whether RGC and OPGC have similar prognosis.
- Our study confirmed the comparable survival between post-GC RGC and OPGC in a population-based database for the first time.

**What is the implication, and what should change now?**

- RGC following GC might be the same entity to OPGC in terms of survival and prognostic factors. Curative resection should be considered in selected RGC patients.

## Methods

### *Database and patients*

This is a population-based retrospective cohort study using data from the SEER program of the National Cancer Institute. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Informed consent or ethical approval was waived by the institutional review board at Second Affiliated Hospital of Soochow University, for using anonymized publicly available data. The study's data source and patient selection are depicted in *Figure 1*. Patients diagnosed with GC [International Classification of Diseases for Oncology, 3rd edition (ICD-O-3) topography codes C16.0–16.9; malignant epithelial tumors and poorly differentiated endocrine carcinoma] between January 1, 1988 and December 31, 2020 were identified from three SEER databases (SEER 8, 12, and 17). Patients with unknown survival time, unknown cause of death, age under 18 years old at diagnosis, diagnosis not confirmed by histology, surgery not performed, and unknown information of interest were excluded. Sample size estimation was not performed given this database study, however all eligible patients in the database were included to maximize the statistical power.

### *Definition and follow-up of RGC*

As stated in the "Introduction", we defined post-GC RGC

 

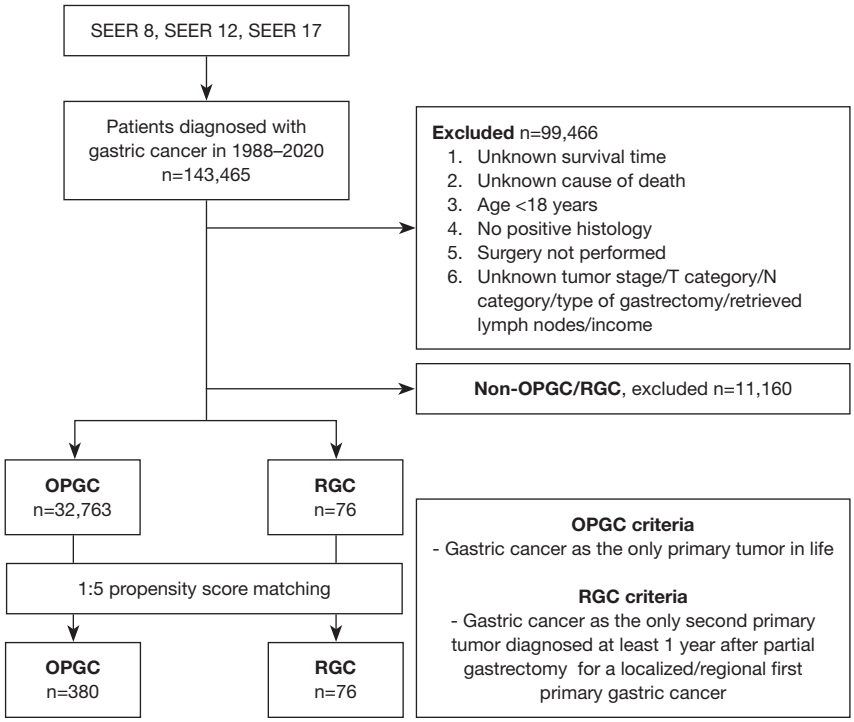


**Figure 1** Flowchart of patient selection. SEER, Surveillance, Epidemiology, and End Results; OPGC, only primary gastric cancer; RGC, remnant gastric cancer.

as metachronous primary GC diagnosed more than 1 year after partial gastrectomy for non-metastatic first primary GC (FPGC), in accordance to other studies (5-7) and our previous analysis (8). On the other hand, OPGC is defined when the patient's GC was the only primary tumor throughout his life. The number and sequence of the GC was indicated by "Sequence Number" in the SEER database. Because SEER database only records primary tumors, identification of recurrent GCs was not performed. All patients were followed-up until December 31, 2020, with exception of 2,496 patients (7.6%) whose follow-ups were incomplete. These patients were included given this low lost rate, nevertheless, as a sensitivity analysis, we excluded them and repeated all analyses.

### *Study variables*

For both OPGC and RGC groups, year of diagnosis, age at diagnosis, sex, race, marital status, area, income, tumor stage, tumor-node-metastasis (TNM) categories, tumor size, grade, Lauren classification, surgical mode, chemotherapy, radiotherapy and number of retrieved lymph node (rLN) were obtained from SEER database. For RGC group, latency between FPGC and RGC was also collected.

Race was analyzed in four groups: White, Black, Asian, and others. Area and income were classified based on rural-urban continuum codes and median household income respectively. Tumor site was divided into cardia (ICD-O-3 code C16.0), middle (C16.1, C16.2, C16.5, and C16.6), distal (C16.3 and C16.4), and not otherwise specified (NOS, C16.8 and C16.9). Tumor size was categorized as ≤5 cm, >5 cm and unknown according to previous studies and clinical practicability (18). Tumor stage was classified as *in situ*, localized, regional, and distant according to SEER stage. TNM categories and grade were redefined based on American Joint Committee on Cancer Staging Manual, 8$^{th}$ edition. Surgical mode was categorized into partial gastrectomy and total/near total gastrectomy (TG/NTG) based on SEER site-specific surgery codes.

### *Statistical analysis*

Study variables were summarized and compared between OPGC and RGC groups. Mann-Whitney *U* tests were used for non-normally distributed continuous variables, while categorical variables were compared using Chi-squared tests.

 

Due to an inhomogeneous distribution of baseline characteristics and uneven group sizes between OPGC and RGC, propensity score matching (PSM) was performed based on patient age, year of diagnosis, sex, race, marital status, area, income, tumor site, TNM categories, tumor size, grade, Lauren classification, surgical mode, chemotherapy, radiotherapy and rLN number. The PSM utilized a ratio of 1:5 and "optimal" method in R package "MatchIt".

Survival analyses were performed using R package "survival". Kaplan-Meier (KM) survival analysis with the log-rank test was used to assess the differences in overall survival (OS) and DSS between the OPGC and RGC groups, before and after PSM. Survival probabilities at 5 and 10 years were compared using "fixtdiff" function of R package "bpcp". Hazard ratios (HRs) with 95% confidence intervals (CIs) were estimated by Cox regression analyses to determine the prognostic factors for DSS in RGC patients. Proportional hazard assumption was tested using the Schoenfeld residuals both for univariable and multivariable analyses. Multivariable analyses were performed using variables with univariable P value <0.25. Goodness of fit was checked by Cox-Snell residual test.

Data extraction was performed in case listing session of the SEER*Stat (version 8.4.1.1, Surveillance Research Program, National Cancer Institute, Calverton, MD, USA). Data analyses were performed with R (version 4.2.1, R Core Team, Vienna, Austria). A two-sided P value <0.05 was considered statistically significant.

## Results

### *Patients' characteristics and PSM*

In total, 143,465 patients with GC were identified from SEER database. Through patient selection, 76 patients with RGC and 32,763 patients with OPGC who underwent surgical treatment were included in the final cohort (*Figure 1*), with the median follow-up time of 25 months (range, 0–370 months, mean 51.3 months). Before PSM, RGC and OPGC groups had significant differences in several variables (*Table 1*). Reasonably, compared with the RGC group, year of diagnosis was earlier (P<0.001) and the age at diagnosis was younger (P=0.005) for the OPGC group. There were significantly more Asian (40.8%, RGC *vs.* 21.5%, OPGC, P<0.001) but less White (23.7%, RGC *vs.* 46.5%, OPGC, P<0.001) in RGC group. In the RGC group, 36.8% patients had a NOS tumor site (P<0.001) while 55.2% patients were in localized or *in situ* stage (P<0.001). Simultaneously, T (P=0.009) and N categories (P<0.001) as well as tumor size (P=0.003) were smaller in the RGC group than those in the OPGC group. More patients underwent partial gastrectomy (76.1%, OPGC *vs.* 46.1%, RGC, P<0.001) and more LN were retrieved in the OPGC group (P<0.001). More OPGC patients received chemotherapy (46.8%, OPGC *vs.* 34.2%, RGC, P=0.04) or radiotherapy (28.5%, OPGC *vs.* 6.6%, RGC, P<0.001).

Given the imbalanced baseline distribution and uneven sample size, we matched 76 patients in the RGC group with 380 patients in the OPGC group based on propensity score. After PSM, each variable had an absolute standardized mean difference lower than 0.1 (*Figure 2*) while 94.7% of the variables had a P value >0.8 (*Table 1*), suggesting an appropriate balance between the groups.

### *Survival analysis*

Before PSM, there was no significant difference between groups when we compared the OS of the two groups (P=0.14) (*Figure 3A*). However, DSS was better in the RGC group than that of the OPGC group (P=0.04, *Figure 3B*), possibly due to RGCs' earlier stage. After PSM, no statistically significant difference between the two groups existed for both OS (P=0.65, *Figure 4A*) and DSS (P=0.28, *Figure 4B*). Similarly, fixed-time analyses revealed that 5-year (60.0%, RGC *vs.* 53.3%, OPGC, P=0.38) and 10-year DSS (56.7%, RGC *vs.* 48.3%, OPGC, P=0.34) were not different between the two groups. The sensitivity analysis showed similar results with 5-year (60.0%, RGC *vs.* 51.0%, OPGC, P=0.26) and 10-year DSS (56.4%, RGC *vs.* 45.4%, OPGC, P=0.22) not significantly different (Table S1 and Figures S1,S2).

### *Prognostic factors*

Univariable and multivariable Cox regression analyses were used to identify the independent prognostic factors for DSS for patients with RGC (*Table 2*). Schoenfeld residual test did not reject the proportional hazard assumption of each variable except for latency (P=0.03, Table S2). Univariable Cox analysis revealed that age, income, tumor site, tumor stage, T category, N category, tumor size, grade, and chemotherapy had P<0.25 and were included for multivariable analysis. Examination of Cox-Snell residuals showed good fit (Figure S3). Finally, significant increased risk of DSS was associated with area of lower income ($75,000+ *vs.* <$55,000, HR =0.21, 95% CI: 0.05–0.89, P=0.03), cardiac tumor (middle *vs.* cardia, HR =0.16, 95%

 

**Table 1** Clinicopathological characteristics of patients with OPGC and RGC before and after propensity score matching

| Variables | Before PSM | | RGC | After PSM | |
|---|---|---|---|---|---|
| | OPGC | P value | | P value | OPGC |
| Patients, n | 32,763 | | 76 | | 380 |
| Year of diagnosis, median [range] | 2007 [1990–2020] | <0.001 | 2013 [1990–2020] | 0.30 | 2015 [1993–2020] |
| Age (years), median [range] | 67 [18–90] | 0.005 | 73 [49–90] | 0.82 | 71 [30–90] |
| Sex, n (%) | | 0.77 | | >0.99 | |
| Male | 20,153 (61.5) | | 45 (59.2) | | 225 (59.2) |
| Female | 12,610 (38.5) | | 31 (40.8) | | 155 (40.8) |
| Race, n (%) | | <0.001 | | >0.99 | |
| White | 15,246 (46.5) | | 18 (23.7) | | 94 (24.7) |
| Black | 3,827 (11.7) | | 11 (14.5) | | 54 (14.2) |
| Asian | 7,033 (21.5) | | 31 (40.8) | | 156 (41.1) |
| Others | 6,657 (20.3) | | 16 (21.1) | | 76 (20.0) |
| Marital status, n (%) | | 0.39 | | 0.99 | |
| Married | 20,097 (61.3) | | 53 (69.7) | | 264 (69.5) |
| Widowed | 4,628 (14.1) | | 5 (6.6) | | 20 (5.3) |
| Single | 4,051 (12.4) | | 9 (11.8) | | 46 (12.1) |
| Divorced | 2,470 (7.5) | | 5 (6.6) | | 30 (7.9) |
| Others | 1,517 (4.6) | | 4 (5.3) | | 20 (5.3) |
| Area, n (%) | | 0.46 | | >0.99 | |
| Urban | 29,113 (88.9) | | 65 (85.5) | | 323 (85.0) |
| Non-urban | 3,650 (11.1) | | 11 (14.5) | | 57 (15.0) |
| Income, n (%) | | 0.62 | | 0.85 | |
| <$55,000 | 3,584 (10.9) | | 11 (14.5) | | 64 (16.8) |
| $55,000–64,999 | 4,408 (13.5) | | 8 (10.5) | | 30 (7.9) |
| $65,000–75,000 | 9,310 (28.4) | | 19 (25.0) | | 90 (23.7) |
| $75,000+ | 15,461 (47.2) | | 38 (50.0) | | 196 (51.6) |
| Tumor site, n (%) | | <0.001 | | 0.92 | |
| Cardia | 7,519 (22.9) | | 8 (10.5) | | 51 (13.4) |
| Middle | 9,571 (29.2) | | 26 (34.2) | | 130 (34.2) |
| Distal | 10,367 (31.6) | | 14 (18.4) | | 65 (17.1) |
| NOS | 5,306 (16.2) | | 28 (36.8) | | 134 (35.3) |
| Tumor stage, n (%) | | <0.001 | | >0.99 | |
| *In situ* | 288 (0.9) | | 2 (2.6) | | 11 (2.9) |
| Localized | 10,068 (30.7) | | 40 (52.6) | | 202 (53.2) |
| Regional | 19,176 (58.5) | | 28 (36.8) | | 139 (36.6) |
| Distant | 3,231 (9.9) | | 6 (7.9) | | 28 (7.4) |

**Table 1** *(continued)*

**Table 1** *(continued)*

| Variables | Before PSM | | RGC | After PSM | |
|---|---|---|---|---|---|
| | OPGC | P value | | P value | OPGC |
| T category, n (%) | | 0.009 | | 0.97 | |
| Tis | 288 (0.9) | | 2 (2.6) | | 11 (2.9) |
| T1 | 6,948 (21.2) | | 26 (34.2) | | 137 (36.1) |
| T2 | 3,920 (12.0) | | 9 (11.8) | | 45 (11.8) |
| T3 | 12,389 (37.8) | | 17 (22.4) | | 92 (24.2) |
| T4 | 9,218 (28.1) | | 22 (28.9) | | 95 (25.0) |
| N category, n (%) | | <0.001 | | >0.99 | |
| N0 | 12,947 (39.5) | | 52 (68.4) | | 258 (67.9) |
| N+ | 19,816 (60.5) | | 24 (31.6) | | 122 (32.1) |
| M category, n (%) | | >0.99 | | >0.99 | |
| M0/MX | 30,391 (92.8) | | 70 (92.1) | | 352 (92.6) |
| M1 | 2,372 (7.2) | | 6 (7.9) | | 28 (7.4) |
| Tumor size, n (%) | | 0.003 | | 0.94 | |
| ≤5 cm | 17,443 (53.2) | | 53 (69.7) | | 262 (68.9) |
| >5 cm | 10,246 (31.3) | | 10 (13.2) | | 47 (12.4) |
| Unknown | 5,074 (15.5) | | 13 (17.1) | | 71 (18.7) |
| Grade, n (%) | | 0.43 | | 0.84 | |
| G1 | 1,613 (4.9) | | 5 (6.6) | | 31 (8.2) |
| G2 | 8,110 (24.8) | | 14 (18.4) | | 61 (16.1) |
| G3 | 20,990 (64.1) | | 50 (65.8) | | 243 (63.9) |
| Unknown | 2,050 (6.3) | | 7 (9.2) | | 45 (11.8) |
| Lauren classification, n (%) | | 0.07 | | 0.83 | |
| Diffuse | 8,780 (26.8) | | 29 (38.2) | | 154 (40.5) |
| Intestinal | 21,742 (66.4) | | 44 (57.9) | | 207 (54.5) |
| Mixed/others | 2,241 (6.8) | | 3 (3.9) | | 19 (5.0) |
| Surgical method, n (%) | | <0.001 | | 0.83 | |
| PG | 24,948 (76.1) | | 35 (46.1) | | 183 (48.2) |
| TG/NTG | 7,815 (23.9) | | 41 (53.9) | | 197 (51.8) |
| Chemotherapy, n (%) | | 0.04 | | >0.99 | |
| No/unknown | 17,433 (53.2) | | 50 (65.8) | | 248 (65.3) |
| Yes | 15,330 (46.8) | | 26 (34.2) | | 132 (34.7) |
| Radiotherapy, n (%) | | <0.001 | | 0.88 | |
| No/unknown | 23,430 (71.5) | | 71 (93.4) | | 350 (92.1) |
| Yes | 9,333 (28.5) | | 5 (6.6) | | 30 (7.9) |
| rLN number, n (%) | | <0.001 | | 0.99 | |
| 1–16 | 16,937 (51.7) | | 49 (64.5) | | 241 (63.4) |
| 16+ | 14,108 (43.1) | | 11 (14.5) | | 57 (15.0) |
| None | 1,718 (5.2) | | 16 (21.1) | | 82 (21.6) |

OPGC, only primary gastric cancer; RGC, remnant gastric cancer; PSM, propensity score matching; NOS, not otherwise specified; PG, partial gastrectomy; TG/NTG, total/near total gastrectomy; rLN, retrieved lymph node.

 

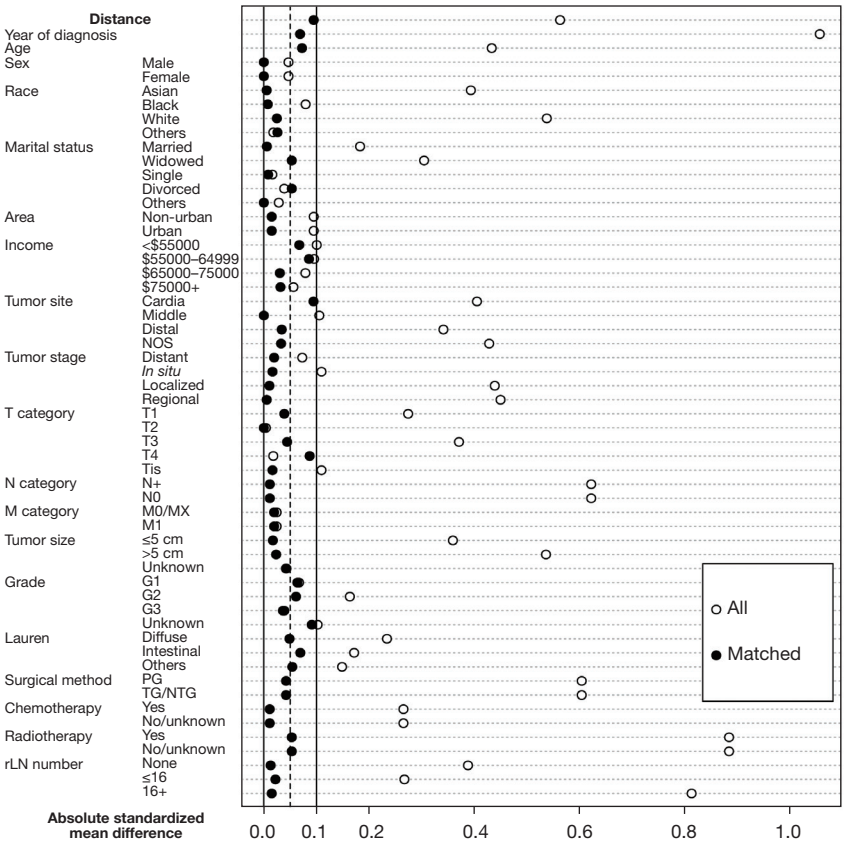


**Figure 2** Absolute standardized mean difference of variables before and after propensity score matching. NOS, not otherwise specified; PG, partial gastrectomy; TG/NTG, total/near total gastrectomy; rLN, retrieved lymph node.

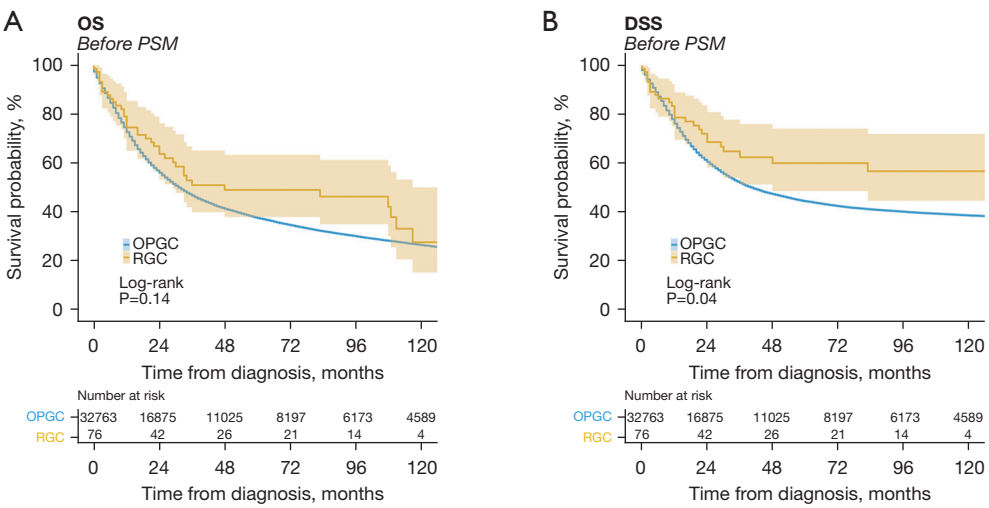


**Figure 3** Kaplan-Meier curves with risk tables for patients with OPGC and RGC before PSM. (A) OS; (B) DSS. OS, overall survival; DSS, disease-specific survival; PSM, propensity score matching; OPGC, only primary gastric cancer; RGC, remnant gastric cancer.

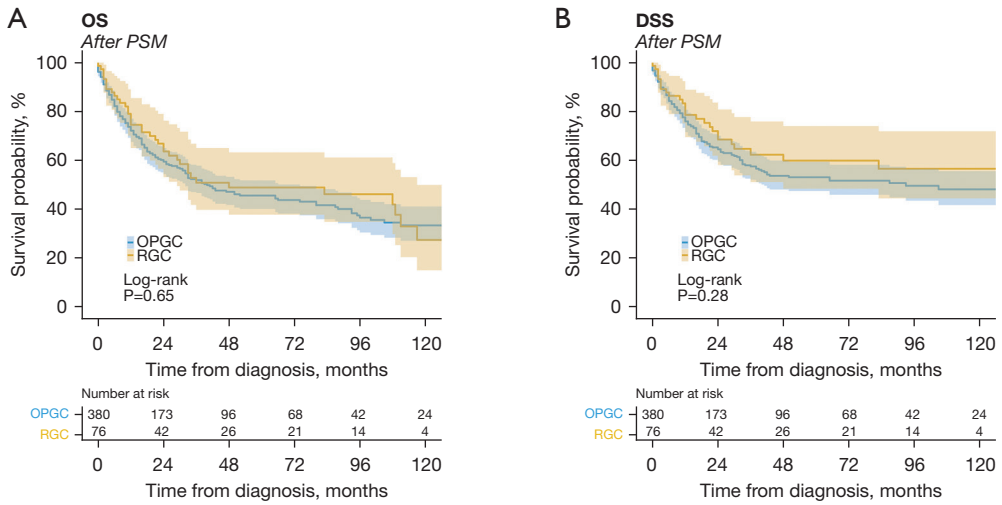


**Figure 4** Kaplan-Meier curves with risk tables for patients with OPGC and RGC after PSM. (A) OS; (B) DSS. OS, overall survival; DSS, disease-specific survival; PSM, propensity score matching; OPGC, only primary gastric cancer; RGC, remnant gastric cancer.

CI: 0.03–0.77, P=0.02; distal *vs.* cardia, HR =0.10, 95% CI: 0.02–0.58, P=0.01; NOS *vs.* cardia, HR =0.11, 95% CI: 0.03–0.51, P=0.004), deeper invasion (T3–4 *vs.* Tis–2, HR =5.19, 95% CI: 1.21–22.15, P=0.03), higher grade (G3 *vs.* G1–2, HR =7.35, 95% CI: 1.41–38.48, P=0.02) and not receiving chemotherapy (yes *vs.* no/unknown, HR =0.16, 95% CI: 0.04–0.60, P=0.007; *Table 2*). Similar results were obtained on sensitivity analysis (Tables S3,S4 and Figure S4).

## Discussion

In this SEER-based propensity score-matched study, we found that patients with RGC following GC had comparable survival outcome (OS and DSS) to those with OPGC. Additionally, median household income, tumor site, invasion depth (T category), grade and chemotherapy were associated independently with DSS of RGC. To our knowledge, this is the first report on postoperative survival and prognostic factors of RGC following malignant conditions using population-based database.

Our study confirmed no significant difference in the prognosis between RGC after FPGC and OPGC, which aligns with the findings in those after benign diseases (19-24). While most doctors agree that RGC is no difference from OPGC in terms of prognosis, there is still no definitive answer (13). Moreover, most past researches only studied small numbers of RGC patients and compared them with heterogeneous OPGC patients (3,10,25). Significant difference between the two groups in clinicopathological and socioeconomic variables were also found in our study. Therefore, PSM was applied to achieve covariate balance between RGC and OPGC, which is our main advantage. The post-PSM results further supported the idea that RGC itself does not adversely affect patient prognosis. One past study also used PSM to compare the prognosis, but only 14 patients after initial gastrectomy for malignant diseases were included (15). Our strength also lies in the population-based design with long follow-up, resulting in possible better generalizability. Intriguingly, DSS was shown to be significantly better in the RGC group than that in OPGC group before PSM (P=0.04). This phenomenon could be explained by the significant earlier stage in the RGC group. Despite the uncertain cause, similar findings have been revealed in Japan and Germany patients (15,26). It could be hypothesized that patients with previous GC have endoscopic surveillance more frequently than general population, which thus helps detect their RGC at earlier stage. These findings also further highlight the important role of early diagnosis in prognosis of RGC.

In this study, we also revealed that median household income, tumor site, invasion depth, grade and chemotherapy were independent prognostic factors for patients with RGC, which are similar to those established for OPGC. Consistent with other studies, tumor invasion depth was found to be an independent risk factor to long-term prognosis of RGC patients (14,16). To detect RGC earlier, it is necessary to recommend close endoscopic examination for as long as possible. Contrarily, LN metastasis was

 

**Table 2** Prognostic factors for DSS in patients with RGC based on univariable and multivariable Cox regression analyses

| Variables | Value | Univariable | | Multivariable | |
|---|---|---|---|---|---|
| | | HR (95% CI) | P value | HR (95% CI) | P value |
| Age, years (mean ± SD) | 70.3±10.2 | 1.09 (1.04–1.15) | <0.001 | 1.05 (0.98–1.12) | 0.17 |
| Year of diagnosis, years (mean ± SD) | 2013.1±5.4 | 0.99 (0.92–1.06) | 0.70 | | |
| Sex, n (%) | | | | | |
| Male | 45 (59.2) | Reference | | | |
| Female | 31 (40.8) | 0.70 (0.31–1.57) | 0.39 | | |
| Race, n (%) | | | | | |
| White | 18 (23.7) | Reference | | | |
| Black | 11 (14.5) | 1.11 (0.36–3.39) | 0.86 | | |
| Asian | 31 (40.8) | 0.65 (0.26–1.65) | 0.37 | | |
| Others | 16 (21.1) | 0.53 (0.14–1.99) | 0.34 | | |
| Marital status, n (%) | | | | | |
| Married | 53 (69.7) | Reference | | | |
| Divorced | 5 (6.6) | 0.48 (0.06–3.58) | 0.47 | | |
| Widowed | 5 (6.6) | 1.80 (0.53–6.17) | 0.35 | | |
| Single | 9 (11.8) | 1.04 (0.30–3.56) | 0.95 | | |
| Others | 4 (5.3) | 2.11 (0.49–9.17) | 0.32 | | |
| Area, n (%) | | | | | |
| Urban | 65 (85.5) | Reference | | | |
| Non-urban | 11 (14.5) | 0.82 (0.28–2.39) | 0.72 | | |
| Income, n (%) | | | | | |
| <$55,000 | 11 (14.5) | Reference | | Reference | |
| $55,000–64,999 | 8 (10.5) | 0.64 (0.15–2.70) | 0.55 | 0.14 (0.02–1.01) | 0.051 |
| $65,000–75,000 | 19 (25.0) | 0.88 (0.29–2.63) | 0.82 | 0.26 (0.06–1.09) | 0.07 |
| $75,000+ | 38 (50.0) | 0.50 (0.17–1.50) | 0.22 | 0.21 (0.05–0.89) | 0.03 |
| Tumor site, n (%) | | | | | |
| Cardia | 8 (10.5) | Reference | | Reference | |
| Middle | 26 (34.2) | 0.43 (0.14–1.32) | 0.14 | 0.16 (0.03–0.77) | 0.02 |
| Distal | 14 (18.4) | 0.24 (0.06–0.99) | 0.048 | 0.10 (0.02–0.58) | 0.01 |
| NOS | 28 (36.8) | 0.49 (0.17–1.44) | 0.19 | 0.11 (0.03–0.51) | 0.004 |
| Tumor stage, n (%) | | | | | |
| Localized/*in situ* | 42 (55.3) | Reference | | Reference | |
| Regional | 28 (36.8) | 3.32 (1.42–7.76) | 0.006 | 4.80 (0.85–26.94) | 0.08 |
| Distant | 6 (7.9) | 3.40 (0.92–12.64) | 0.07 | 2.86 (0.21–38.28) | 0.43 |

**Table 2** *(continued)*

**Table 2** *(continued)*

| Variables | Value | Univariable | | Multivariable | |
|---|---|---|---|---|---|
| | | HR (95% CI) | P value | HR (95% CI) | P value |
| T category, n (%) | | | | | |
| Tis–2 | 37 (48.7) | Reference | | Reference | |
| T3–4 | 39 (51.3) | 5.48 (2.16–13.87) | <0.001 | 5.19 (1.21–22.15) | 0.03 |
| N category, n (%) | | | | | |
| N0 | 52 (68.4) | Reference | | Reference | |
| N+ | 24 (31.6) | 2.59 (1.19–5.66) | 0.02 | 0.49 (0.11–2.23) | 0.36 |
| M category, n (%) | | | | | |
| M0/MX | 70 (92.1) | Reference | | | |
| M1 | 6 (7.9) | 1.93 (0.58–6.45) | 0.28 | | |
| Tumor size, n (%) | | | | | |
| ≤5 cm | 53 (69.7) | Reference | | Reference | |
| >5 cm | 10 (13.2) | 3.04 (1.18–7.82) | 0.02 | 1.17 (0.31–4.35) | 0.82 |
| Unknown | 13 (17.1) | 0.98 (0.33–2.95) | 0.98 | 0.49 (0.11–2.24) | 0.36 |
| Grade, n (%) | | | | | |
| G1–2 | 19 (25.0) | Reference | | Reference | |
| G3 | 50 (65.8) | 4.69 (1.10–20.03) | 0.04 | 7.35 (1.41–38.48) | 0.02 |
| Unknown | 7 (9.2) | 2.23 (0.31–15.86) | 0.42 | 6.08 (0.55–67.07) | 0.14 |
| Lauren classification, n (%) | | | | | |
| Diffuse | 29 (38.2) | Reference | | | |
| Non-diffuse | 47 (61.8) | 0.96 (0.43–2.11) | 0.91 | | |
| Surgical method, n (%) | | | | | |
| PG | 35 (46.1) | Reference | | | |
| TG/NTG | 41 (53.9) | 0.77 (0.35–1.66) | 0.50 | | |
| Chemotherapy, n (%) | | | | | |
| No/unknown | 50 (65.8) | Reference | | Reference | |
| Yes | 26 (34.2) | 0.49 (0.18–1.30) | 0.15 | 0.16 (0.04–0.60) | 0.007 |
| Radiotherapy, n (%) | | | | | |
| No/unknown | 71 (93.4) | Reference | | | |
| Yes | 5 (6.6) | 0.66 (0.09–4.92) | 0.69 | | |
| rLN number, n (%) | | | | | |
| 1–16 | 49 (64.5) | Reference | | | |
| 16+ | 11 (14.5) | 0.88 (0.26–3.04) | 0.84 | | |
| None | 16 (21.1) | 1.40 (0.57–3.40) | 0.46 | | |

DSS, disease-specific survival; RGC, remnant gastric cancer; HR, hazard ratio; CI, confidence interval; SD, standard deviation; NOS, not otherwise specified; PG, partial gastrectomy; TG/NTG, total/near total gastrectomy; rLN, retrieved lymph node.

 

not identified as an independent prognostic factor in our multivariable analysis. The role of LN metastasis remains debatable and an RGC-specific staging system is needed (27). In addition, patients with cardiac RGC had significant worse survival than RGC of other locations. Although the surgical details were unknown in SEER database, for RGC at cardia, surgeons might encounter more intraoperative difficulties while the completion rate of radical resection might be lower (28). Comparison between cardiac and non-cardiac RGCs as well as between different operations should be conducted in large multi-center studies.

This study had some limitations. Firstly, although our study took advantage of PSM and a national registry database, there was still some selection bias. Like previous studies (15,17,29), we only included patients who underwent surgery given the more complete histopathological information. The survival of RGC might be overestimated since some patients may present with inoperable RGC at diagnosis. Our results might only be generalized to RGC patients with operable disease. Secondly, the generalizability of our study might be limited because more patients of the SEER registries lived in urban areas with higher median income (30). This disproportion possibly led to the situation that 36.8% patients in our study were diagnosed with early RGC. Nevertheless, these findings further encourage patients with GC history to undergo close and lifelong surveillance. Thirdly, radiotherapy and chemotherapy in SEER database are categorized only as yes or no/unknown, introducing potential bias to our analysis. Fourthly, although not frequent, misclassification of primary RGC and recurrence might happen, as stated in prior multiple primary tumor studies (31,32). Finally, SEER database lacks several important factors such as nutritional status, comorbidities, anastomosis procedure, postoperative complications, lymphovascular invasion and resection margins. Future prospective investigations from a finer scale would be required to make up for the shortcomings of this database study.

## Conclusions

In conclusion, this large population-based analysis indicated that the prognosis of RGC following GC might be not inferior to that of OPGC following resection. Area of lower income, cardiac tumor, deeper invasion, higher grade and not receiving chemotherapy were identified as independent prognostic factors of postsurgical DSS for post-GC RGC. These findings suggest that RGC after GC might be the same entity to OPGC and curative resection should be considered in selected patients.

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## Footnote

*Reporting Checklist:* The authors have completed the STROBE reporting checklist. Available at https://jgo.amegroups.com/article/view/10.21037/jgo-24-58/rc

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*Conflicts of Interest:* All authors have completed the ICMJE uniform disclosure form (available at https://jgo.amegroups.com/article/view/10.21037/jgo-24-58/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). This study used publicly available de-identified data involving no human participants, and thus was granted exemption for informed consent or ethical approval by the institutional review board at Second Affiliated Hospital of Soochow University.



 

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