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ORIGINAL ARTICLE

# Surgical outcomes of elderly patients with Stage I gastric cancer from the nationwide registry of the Japanese Gastric Cancer Association

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## Abstract

**Background** The proportion of elderly patients undergoing surgery for gastric cancer is increasing. However, limited number of therapeutic outcomes in the elderly has been reported. Here we examined the surgical results based on a nationwide survey of elderly patients who underwent surgery for Stage I gastric cancer.

**Methods** Data from 68,353 Stage I patients who underwent gastrectomy between 2001 and 2007 were retrospectively collected. The accumulated data were reviewed and analyzed by the Japanese Gastric Cancer Association registration committee. We first classified the patients as those aged ≤ 74 years and ≥ 75 years. We further classified those patients aged ≥ 75 years into groups by 5-year increments to examine their short- and long-term postoperative outcomes.

**Results** Patients aged ≥ 75 years accounted for 46.5%. The 30-day mortality rate was < 0.7% for any age group, but for those aged ≥ 75 years, the 60-day and 90-day mortality rates were 0.9–2.3% and 1.2–5.1%, respectively. An examination of long-term survival indicated that, as the class of age increased, the 5-year overall survival (OS) was 47.0–93.1% and disease-specific survival (DSS) was 91.4–98.2%, respectively. Although high DSS rates of ≥ 90% were found for all age groups, OS only accounted for ≤ 82% of patients aged ≥ 75 years.

**Conclusion** Among elderly patients with Stage I gastric cancer, deaths due to other diseases were frequently observed in the long term. Thus, for elderly patients, it may be appropriate to reconsider the treatment strategy with respect to the balance between the invasiveness of the treatment and the prognosis.

**Keywords** Stage I gastric cancer · Elderly patients · Nationwide survey

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## Introduction

The proportion of the elderly in the general population has been increasing in Japan. According to a Cabinet Office report, the percentage of elderly people aged ≥ 65 years was 27% in 2017, and the average life expectancy was 81 years for men and 87 years for women [1]. The proportion of elderly patients with gastric cancer undergoing surgery also has been increasing along with an increasing infection rate of *Helicobacter pylori* among the elderly [2]. However, many factors regarding health care of the elderly have yet to be identified, such as how well elderly patients tolerate surgery and how short- and long-term therapeutic outcomes are affected by general patient condition. The surgical outcomes in elderly patients in large case series remain unclear.

Here, we used a nationwide survey by the Japanese Gastric Cancer Association (JGCA) to examine the short-term outcomes and long-term prognosis of elderly patients who underwent surgery for Stage I gastric cancer.

## Patients and methods

Leading hospitals in Japan voluntarily downloaded and fulfilled the requirements for the database requested by the JGCA and sent the anonymized patient data 5 years after they had undergone surgery to the JGCA data center. Between 2001 and 2007, 125,284 patients with primary gastric carcinoma were enrolled from 367 institutions from all areas in Japan. There was no prefecture without registration, and 98% of prefecture cancer base hospitals participated in the study.

Of the 125,284 patients, 1770 were excluded because the type of surgery was not specified. A total of 120,202 of these patients underwent gastric resection, the remaining 3312 did not undergo resection, and 1835 patients had missing values (sex, age, vital status, survival period). Data representing Japan from 118,367 patients who underwent resection between 2001 and 2007 were retrospectively collected. The JGCA registration committee reviewed and analyzed the accumulated data pertaining to a total of 53 items, including the surgical procedures, pathological diagnosis, and prognosis according to previously reported methods [3]. The definition and documentation of the items were based on the Japanese Classification of Gastric Carcinoma (14th edition) [4].

The data of the remaining 118,367 patients who underwent gastric resection were used for the survival analysis; of these, 17,944 patients were lost to follow-up, yielding a follow-up rate of 84.8%. The median hospital volume was 58 patients per year. A high-volume center (HVC) was defined as a center in which gastric cancer surgery had been performed > 100 times a year in the survey. A non-high-volume center (non-HVC) was defined as a center in which gastric cancer surgery had been performed < 100 times per year. HVC cut-off was 100 cases from facilities that performed surgery twice a week or more in the top 15% of the whole.

In total, survival analysis was conducted in 118,367 patients who underwent gastric resection; of these, 68,353 patients were classified as Stage I with curative resection.

In this study, 68,353 Stage I patients were selected as the subject base for the collected data.

We first classified the patients as those aged ≤ 74 years and ≥ 75 years. We further classified only patients aged ≥ 75 years into groups by 5-year increments to examine their short-term and long-term postoperative outcomes. For each group, postoperative short-term outcomes of 30-, 60-, and 90-day mortality and long-term outcomes of 1-, 3-, and 5-year overall survival (OS) and disease-specific survival (DSS) rates were calculated. In terms of short-term outcomes, we examined differences by sex, volume of the institution, and whether or not the operation was a total or non-total gastrectomy. For long-term outcomes, we also examined differences by invasion depth in addition to differences by sex, volume of the institution, and whether or not the operation was a total or non-total gastrectomy.

The 1-, 3-, and 5-year OS rates were calculated for various subsets of factors using the Kaplan–Meier method. Deaths from any cause observed during the 5-year postoperative period were counted as events in the survival analysis. The 1-, 3-, and 5-year DSS rates were also calculated. This nationwide registration program was approved by the Ethics Committee of the JGCA.

Differences were assessed using the $\chi^2$ test for categorical variables. All tests were two tailed, and a $p$ value < 0.05 was considered statistically significant for all analyses. Data were analyzed using the Japanese version of SPSS Statistics software package (version 25.0, IBM Japan, Tokyo, Japan).

## Results

Patients aged ≥ 75 years accounted for 21.8% of patients, with 0.3% of the patients aged ≥ 90 years.

The most common procedure was a distal gastrectomy accounting for 67.4% of procedures, which demonstrated a significantly higher frequency than those of the other procedures, whereas a total gastrectomy was performed in 17.8% of the cases (Table 1). There were significant differences in the mortality rates of all variables in Table 1.

Table 2 presents the postoperative 30-, 60-, and 90-day mortality rates for patients in the study. The 30-day

**Table 1** Characteristics of patient with Stage I gastric cancer who underwent gastrectomy

| Variables | *n* | % | Mortality | | *p* value |
|---|---|---|---|---|---|
| | | | *n* | Rate | |
| Sex | | | | | |
| Male | 47,102 | 68.9 | 5123 | 10.9 | < 0.001 |
| Female | 21,251 | 31.1 | 1329 | 6.3 | |
| Age (y. o.) | | | | | |
| ≤ 74 | 53,468 | 78.2 | 3457 | 6.5 | < 0.001 |
| 75–79 | 9282 | 13.6 | 1575 | 17.0 | |
| 80–84 | 4306 | 6.3 | 966 | 22.4 | |
| 85–89 | 1121 | 1.6 | 378 | 33.7 | |
| ≥ 90 | 176 | 0.3 | 76 | 43.2 | |
| Location | | | | | |
| Upper | 13,081 | 19.1 | 1658 | 12.7 | < 0.001 |
| Middle | 31,253 | 45.7 | 2351 | 7.5 | |
| Lower | 23,537 | 34.4 | 2349 | 10.0 | |
| Overlapped | 338 | 0.5 | 81 | 24.0 | |
| Size (mm) | | | | | |
| < 20 | 17,855 | 26.1 | 1312 | 7.3 | < 0.001 |
| ≥ 20 | 49,518 | 72.4 | 5026 | 10.1 | |
| Procedure | | | | | |
| DG | 46,072 | 67.4 | 3845 | 8.3 | < 0.001 |
| TG | 12,158 | 17.8 | 1631 | 13.4 | |
| PG | 4438 | 6.5 | 505 | 11.4 | |
| PPG | 3758 | 5.5 | 175 | 4.7 | |
| Local | 1927 | 2.8 | 296 | 15.4 | |
| LN dissection | | | | | |
| D0 | 2737 | 4.0 | 442 | 16.1 | < 0.001 |
| D1 | 38,687 | 56.6 | 3687 | 9.5 | |
| ≥ D2 | 25,927 | 37.9 | 2242 | 8.6 | |
| pN stage | | | | | |
| pN0 | 63,885 | 93.5 | 5875 | 9.2 | < 0.001 |
| pN1 | 4468 | 6.5 | 577 | 12.9 | |
| Histologic type | | | | | |
| Differentiated | 41,806 | 61.2 | 4564 | 10.9 | < 0.001 |
| Undifferentiated | 26,336 | 38.5 | 1847 | 7.0 | |
| Lymphatic invasion | | | | | |
| ly0 | 46,842 | 68.5 | 3664 | 7.8 | < 0.001 |
| ≥ ly1 | 20,938 | 30.6 | 2726 | 13.0 | |
| Vascular invasion | | | | | |
| v0 | 55,044 | 80.5 | 4548 | 8.3 | < 0.001 |
| ≥ v1 | 12,712 | 18.6 | 1846 | 14.5 | |

mortality rate was < 0.7% for any age group, but for those aged ≥ 75 years, the 60-day and 90-day mortality rates were 0.9–2.3% and 1.2–5.1%, respectively. The 90-day mortality rate in patients aged 85–90 years was 2.6%. Table 3 shows the mortality rates by sex. The 90-day mortality was > 1% in male patients > 75 years old and female patients > 80 years old. Mortality rates by operative method are presented in Table 4. The 90-day mortality rates were > 2% for the patients aged ≥ 80 years in the total gastrectomy group and for the patients aged ≥ 85 years in the non-total gastrectomy group. The rates of surgery-related deaths within the 90-day postoperative period in patients aged 75–79 years and 80–84 years at HVCs were 0.7% and 0.9%, respectively, whereas those in the same age groups at non-HVCs were 1.4% and 1.8%, respectively (Table 5).

**Table 2** Post-operative 30-day, 60-day, and 90-day mortality rates for patients with Stage I gastric cancer according to class of age

| Class of age (years old) | *n* | Within 30 days *n* (%) | Within 60 days *n* (%) | Within 90 days *n* (%) |
|---|---|---|---|---|
| ≤ 74 | 53,468 | 71 (0.1) | 134 (0.3) | 172 (0.3) |
| 75–79 | 9282 | 49 (0.5) | 84 (0.9) | 109 (1.2) |
| 80–84 | 4306 | 26 (0.6) | 45 (1.0) | 65 (1.5) |
| 85–89 | 1121 | 8 (0.7) | 20 (1.8) | 29 (2.6) |
| ≥ 90 | 176 | 1 (0.6) | 4 (2.3) | 9 (5.1) |

Median follow-up was 1825 ± 490.7 (1–1825) days (median ± SD [range]). The 5-year follow-up was completed in 78.1% patients. Further, 14.9% patients were lost to follow-up, and 7% were excluded due to poor outcome.

An examination of long-term survival indicated that the 5-year OS and 5-year DSS were 87.9% and 97.8%, respectively, for all patients in this study. As the class of age increased, the 5-year OS ranged from 47.0 to 93.1% and DSS ranged from 91.4 to 98.2%, respectively (Fig. 1a, b; Table 6). Although high DSS and OS rates ≥ 90% were found in all age groups, the rates were ≤ 82% for patients aged ≥ 75 years.

Although both male and female patients had high gastric cancer-specific survival rates by sex, the 5-year OS rate decreased to ≤ 80% for males aged ≥ 75 years and for females aged ≥ 80 years (Fig. 2a–d; Table 7). When analyzed according to invasion depth, the 5-year survival rate and gastric cancer-specific survival rate both decreased depending on invasion depth (Fig. 3a–f; Table 8). The survival results by operative methods revealed that the 5-year OS rate decreased to ≤ 75% among patients aged ≥ 75 years in the total gastrectomy group, whereas it decreased to approximately 75% among patients aged ≥ 80 years in the non-total gastrectomy group (Fig. 4a–d; Table 9).

DSS rates were good for patients treated at both HVCs and non-HVCs, and OS rates were similar between HVCs and non-HVCs in patients aged 75–79 years and patients aged 80–84 years (Fig. 5a–d; Table 10).

**Table 3** Post-operative 30-day, 60-day, and 90-day mortality rates for patients with Stage I gastric cancer according to class of age by sex

| Class of age (years old) | Sex | *n* | Within 30 days *n* (%) | Within 60 days *n* (%) | Within 90 days *n* (%) |
|---|---|---|---|---|---|
| ≤74 | Male | 37,389 | 62 (0.2) | 114 (0.3) | 145 (0.4) |
| | Female | 16,079 | 9 (0.1) | 20 (0.1) | 27 (0.2) |
| 75–79 | Male | 6309 | 38 (0.6) | 66 (1.0) | 86 (1.4) |
| | Female | 2973 | 11 (0.4) | 18 (0.6) | 23 (0.8) |
| 80–84 | Male | 2653 | 17 (0.6) | 31 (1.2) | 47 (1.8) |
| | Female | 1653 | 9 (0.5) | 14 (0.8) | 18 (1.1) |
| 85–89 | Male | 660 | 5 (0.8) | 12 (1.8) | 15 (2.3) |
| | Female | 461 | 3 (0.7) | 8 (1.7) | 14 (3.0) |
| ≥90 | Male | 91 | 1 (1.1) | 3 (3.3) | 5 (5.5) |
| | Female | 85 | 0 (0) | 1 (1.2) | 4 (4.7) |

**Table 4** Post-operative 30-day, 60-day, and 90-day mortality rates for patients with Stage I gastric cancer according to class of age by surgical procedure

| Class of age (years old) | Procedure | *n* | Within 30 days *n* (%) | Within 60 days *n* (%) | Within 90 days *n* (%) |
|---|---|---|---|---|---|
| ≤74 | Total | 9501 | 19 (0.2) | 36 (0.4) | 48 (0.5) |
| | Non-total | 43,967 | 52 (0.1) | 98 (0.2) | 124 (0.3) |
| 75–79 | Total | 1765 | 12 (0.7) | 19 (1.1) | 24 (1.4) |
| | Non-total | 7517 | 37 (0.5) | 65 (0.9) | 85 (1.1) |
| 80–84 | Total | 723 | 9 (1.2) | 11 (1.5) | 16 (2.2) |
| | Non-total | 3583 | 17 (0.5) | 34 (0.9) | 49 (1.4) |
| 85–89 | Total | 147 | 1 (0.7) | 2 (1.4) | 5 (3.4) |
| | Non-total | 974 | 7 (0.7) | 18 (1.8) | 24 (2.5) |
| ≥90 | Total | 22 | 0 (0) | 1 (4.5) | 1 (4.5) |
| | Non-total | 154 | 1 (0.6) | 3 (1.9) | 8 (5.2) |

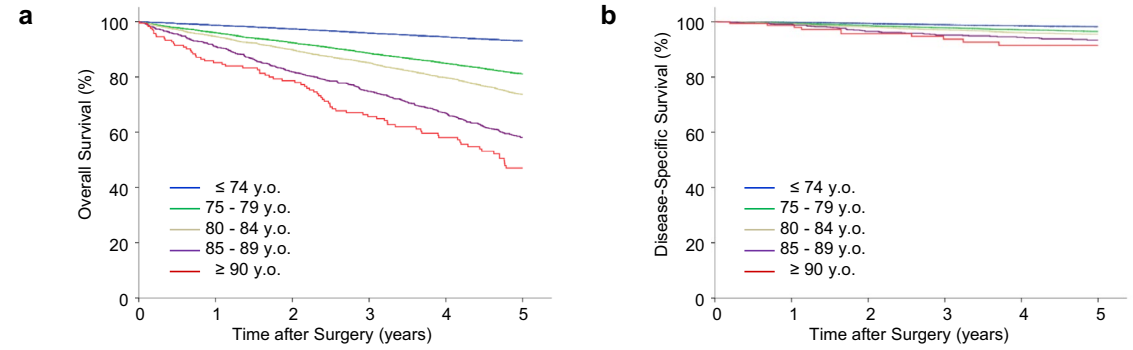
**Table 5** Post-operative 30-day, 60-day, and 90-day mortality rates for patients with Stage I gastric cancer according to class of age by hospital volume

| Class of age (years old) | Hospital volume | *n* | Within 30 days *n* (%) | Within 60 days *n* (%) | Within 90 days *n* (%) |
|---|---|---|---|---|---|
| ≤74 | HVC | 20,309 | 15 (0.1) | 25 (0.1) | 33 (0.2) |
| | Non-HVC | 33,159 | 56 (0.2) | 109 (0.3) | 139 (0.4) |
| 75–79 | HVC | 3031 | 11 (0.4) | 17 (0.6) | 21 (0.7) |
| | Non-HVC | 6251 | 38 (0.6) | 67 (1.1) | 88 (1.4) |
| 80–84 | HVC | 1319 | 4 (0.3) | 7 (0.5) | 12 (0.9) |
| | Non-HVC | 2987 | 22 (0.7) | 38 (1.3) | 53 (1.8) |
| 85–89 | HVC | 310 | 3 (1.0) | 4 (1.3) | 7 (2.3) |
| | Non-HVC | 811 | 5 (0.6) | 16 (2.0) | 22 (2.7) |
| ≥90 | HVC | 40 | 0 (0) | 2 (5.0) | 3 (7.5) |
| | Non-HVC | 136 | 1 (0.7) | 2 (1.5) | 6 (4.4) |

*HVC* high-volume center, *non-HVC* non-high-volume center

## Discussion

We used the data collected from a nationwide survey by the JGCA to study the short- and long-term prognoses of elderly Stage I gastric cancer patients. Because these investigations were based on nationwide surveys, details on the early postoperative surgical outcomes could not always be confirmed in elderly Stage I gastric cancer. Thus, the calculations assumed that mortality events within 90 days of the surgery were surgery-related deaths. Even though there are no clear trends within the 30-day postoperative period in elderly Stage I patients, surgery-related deaths in the 60- and 90-day postoperative periods increased with




No. at risk

| | | | | | | |
|---|---|---|---|---|---|---|
| ≤ 74 y.o. | 53468 | 51058 | 49342 | 47390 | 45339 | 41812 |
| 75 - 79 y.o. | 9282 | 8458 | 8145 | 7251 | 6695 | 5876 |
| 80 - 84 y.o. | 4306 | 3762 | 3407 | 3074 | 2693 | 2266 |
| 85 - 89 y.o. | 1121 | 901 | 763 | 654 | 537 | 406 |
| ≥ 90 y.o. | 176 | 134 | 117 | 92 | 73 | 50 |

No. at risk

| | | | | | | |
|---|---|---|---|---|---|---|
| ≤ 74 y.o. | 53468 | 51060 | 49271 | 47392 | 45342 | 41812 |
| 75 - 79 y.o. | 9282 | 8458 | 8145 | 7251 | 6696 | 5877 |
| 80 - 84 y.o. | 4306 | 3762 | 3407 | 3075 | 2693 | 2266 |
| 85 - 89 y.o. | 1121 | 901 | 763 | 654 | 537 | 406 |
| ≥ 90 y.o. | 176 | 134 | 117 | 92 | 73 | 50 |

**Fig. 1** **a** Overall survival by age group in Stage I gastric cancer patients who underwent curative gastrectomy. **b** Disease-specific survival by age group in Stage I gastric cancer patients who underwent curative gastrectomy

**Table 6** Long-term outcomes of 1-year, 3-year, and 5-year overall survival and disease-specific survival rates in the patients with Stage I gastric cancer

| Class of age (years old) | 1-Year OS (%) | 1-Year DSS (%) | 3-Year OS (%) | 3-Year DSS (%) | 5-Year OS (%) | 5-Year DSS (%) |
|---|---|---|---|---|---|---|
| Total | 97.9 | 99.7 | 93.9 | 98.6 | 89.7 | 97.8 |
| ≤ 74 | 98.7 | 99.8 | 95.9 | 98.9 | 93.1 | 98.2 |
| 75–79 | 96.0 | 99.4 | 88.6 | 97.8 | 81.1 | 96.5 |
| 80–84 | 94.6 | 99.1 | 85.1 | 97.1 | 73.7 | 95.5 |
| 85–89 | 91.0 | 99.1 | 74.7 | 95.2 | 58.1 | 93.4 |
| ≥ 90 | 85.2 | 97.9 | 65.7 | 93.7 | 47.0 | 91.4 |

*OS* overall survival, *DSS* disease-specific survival

increasing patient age, with mortality events in the 90-day period surpassing 1% in patients aged ≥ 75 years. Thus, the 90-day postoperative mortality appears to be a meaningful outcome measure.

Men aged ≥ 75 years had approximately the same rate of 90-day mortality events as that of women aged ≥ 80 years, which suggests that the rates of mortality events in men are equivalent to mortality events in women in the next higher age category. Although a comparison between total and non-total gastrectomy revealed that total gastrectomy predicts poor prognosis in the short term, this factor was not a predictor of poor outcome in males. Furthermore, 90-day postoperative mortality was somewhat lower among patients treated at HVCs than at non-HVCs. However, a detailed comparison that accounted for background factors, such as comorbidities, was challenging within this study because of the limitations of the survey data. Thus, it was difficult to evaluate short-term outcomes on the basis of institutional volume alone.

In terms of long-term outcomes, our study data indicated that OS decreased with increasing age and that the gap between OS and DSS widened with increasing age. This finding presumably reflects the fact that deaths from other causes increase with age, and age is an important factor in considering surgical treatments. Furthermore, the OS was lower in men than in women and patients who underwent a total gastrectomy than in those who underwent a non-total gastrectomy procedure, which suggests that these factors are also important in determining treatment strategies for elderly gastric cancer patients. The long-term outcomes of patients treated at HVCs and non-HVCs aged ≥ 75 years were comparable both in terms of OS and DSS. Even though the patient backgrounds were probably diverse, our study results suggest that the volume of a clinical center does not

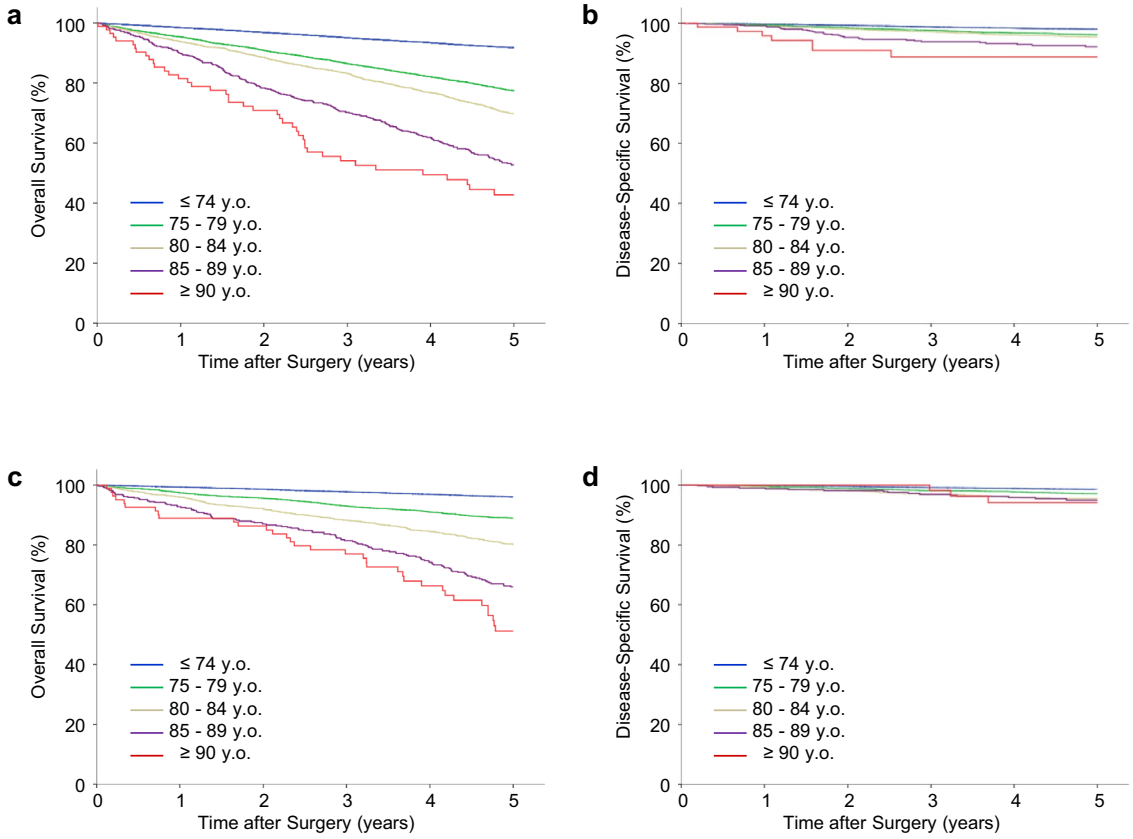



**Fig. 2** **a** Overall survival by age group in male Stage I gastric cancer who underwent curative gastrectomy. **b** Disease-specific survival by age group in male Stage I gastric cancer patients who underwent curative gastrectomy. **c** Overall survival by age group in female Stage I gastric cancer patients who underwent curative gastrectomy. **d** Disease-specific survival by age group in female Stage I gastric cancer patients who underwent curative gastrectomy

**Table 7** Long-term outcomes of 1-year, 3-year, and 5-year overall survival and disease-specific survival rates in the patients with Stage I gastric cancer by sex

| Class of age (years old) | Sex | 1-Year OS (%) | 1-Year DSS (%) | 3-Year OS (%) | 3-Year DSS (%) | 5-Year OS (%) | 5-Year DSS (%) |
|---|---|---|---|---|---|---|---|
| Total | Male | 97.6 | 99.7 | 92.9 | 98.5 | 88.2 | 97.6 |
| | Female | 98.6 | 99.8 | 96.0 | 98.8 | 93.2 | 98.1 |
| ≤74 | Male | 98.4 | 99.8 | 95.1 | 98.8 | 91.8 | 98.0 |
| | Female | 99.3 | 99.9 | 97.7 | 99.2 | 96.0 | 98.6 |
| 75–79 | Male | 95.3 | 99.4 | 86.5 | 97.6 | 77.4 | 96.2 |
| | Female | 97.4 | 99.5 | 93.0 | 98.2 | 88.9 | 97.2 |
| 80–84 | Male | 93.8 | 99.1 | 83.2 | 97.2 | 69.8 | 95.4 |
| | Female | 95.9 | 99.3 | 88.2 | 96.9 | 80.1 | 95.5 |
| 85–89 | Male | 89.8 | 99.1 | 70.1 | 93.9 | 52.7 | 92.2 |
| | Female | 92.7 | 99.0 | 81.4 | 96.9 | 65.9 | 95.0 |
| ≥90 | Male | 81.5 | 95.8 | 54.1 | 88.8 | 42.7 | 88.8 |
| | Female | 88.9 | 100.0 | 76.9 | 98.2 | 51.2 | 94.2 |

*OS* overall survival, *DSS* disease-specific survival

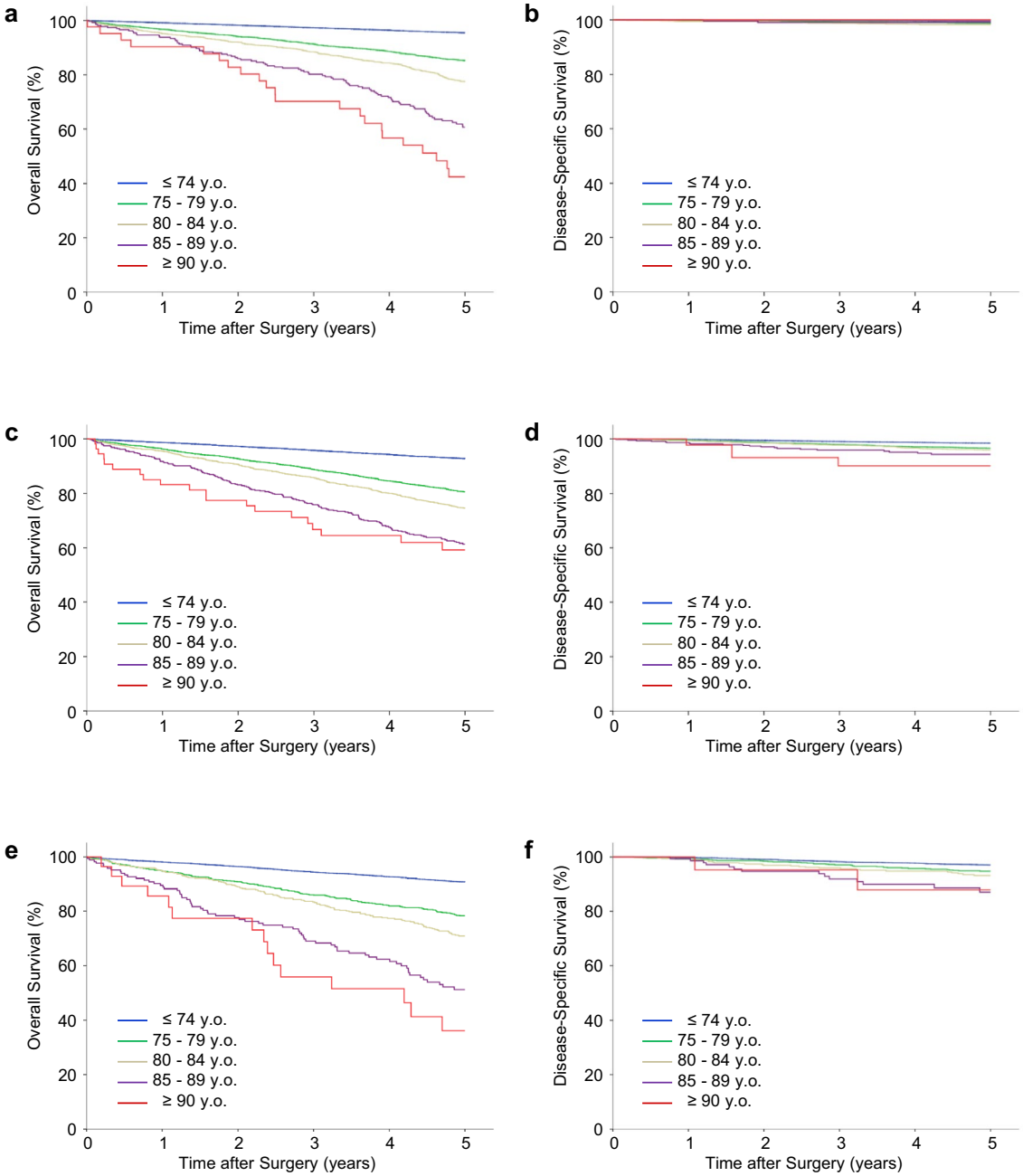



**Fig. 3** **a** Overall survival by age group in patients with Stage I gastric cancer within mucosa who underwent curative gastrectomy. **b** Disease-specific survival by age group in patients with Stage I gastric cancer within mucosa who underwent curative gastrectomy. **c** Overall survival by age group in Stage I gastric cancer patients with submucosal invasion who underwent curative gastrectomy. **d** Disease-specific survival by age group in Stage I gastric cancer patients with submucosal invasion who underwent curative gastrectomy. **e** Overall survival by age group in Stage I gastric cancer patients with muscle-layer invasion who underwent curative gastrectomy. **f** Disease-specific survival by age group in Stage I gastric cancer patients with muscle-layer invasion who underwent curative gastrectomy

affect long-term survival in elderly patients with Stage I gastric cancer. We grouped by the average annual number of quartiles and compared the 4 groups and the 1st and 4th quartiles, but the results were almost the same in terms of OS and DSS (data not shown).

An analysis that used the Japan Surgical Society's Nationwide Internet-based Database and a risk model to evaluate perioperative mortality in gastric cancer patients also found that age and sex were important factors in outcomes [5, 6]. Furthermore, results from the analyses using the National

**Table 8** Long-term outcomes of 1-year, 3-year, and 5-year overall survival and disease-specific survival rates in the patients with Stage I gastric cancer by tumor depth of invasion

| Class of age (years old) | Depth[a] | 1-Year OS (%) | 1-Year DSS (%) | 3-Year OS (%) | 3-Year DSS (%) | 5-Year OS (%) | 5-Year DSS (%) |
|---|---|---|---|---|---|---|---|
| Total | M | 98.6 | 99.9 | 95.9 | 99.7 | 93.0 | 99.4 |
| | SM | 98.0 | 99.7 | 93.8 | 98.8 | 89.4 | 98.0 |
| | MP | 97.1 | 99.6 | 91.6 | 97.8 | 86.5 | 96.3 |
| ≤74 | M | 99.1 | 99.9 | 97.3 | 99.8 | 95.4 | 99.6 |
| | SM | 98.7 | 99.8 | 95.8 | 99.1 | 92.7 | 98.5 |
| | MP | 98.1 | 99.8 | 94.4 | 98.2 | 90.8 | 97.0 |
| 75–79 | M | 96.7 | 99.8 | 91.3 | 99.3 | 85.2 | 98.8 |
| | SM | 96.3 | 99.6 | 88.8 | 98.0 | 80.5 | 96.6 |
| | MP | 94.8 | 99.3 | 86.0 | 97.1 | 78.4 | 94.7 |
| 80–84 | M | 95.1 | 99.4 | 88.2 | 98.8 | 77.5 | 98.3 |
| | SM | 95.5 | 99.4 | 85.7 | 97.7 | 74.5 | 95.9 |
| | MP | 94.9 | 99.4 | 83.4 | 95.9 | 70.9 | 93.2 |
| 85–89 | M | 93.8 | 100.0 | 80.5 | 99.1 | 60.7 | 99.1 |
| | SM | 91.7 | 98.7 | 75.8 | 95.9 | 61.3 | 94.3 |
| | MP | 89.5 | 99.3 | 69.1 | 91.9 | 51.3 | 87.1 |
| ≥90 | M | 90.3 | 100.0 | 70.2 | 100.0 | 42.5 | 100.0 |
| | SM | 83.1 | 97.8 | 66.7 | 90.1 | 59.2 | 90.1 |
| | MP | 85.6 | 100.0 | 55.9 | 95.2 | 36.1 | 87.9 |

*OS* overall survival, *DSS* disease-specific survival

[a]Depth: *M* mucosa, *SM* submucosa, *MP* muscles

Clinical Database have shown that the perioperative mortality rate associated with total gastrectomy procedures was 2.3%, which is higher than the perioperative mortality rate associated with distal gastrectomy procedures (1.1%) [5, 6]. However, this database included all stages of gastric cancer surgical cases and revealed only short-term outcomes without survival data after surgery for gastric cancer. In other reports for elderly gastric cancer patients, the patient selection was biased, and the number of patients was limited [7–9]. The present data were specific for elderly patients with Stage I gastric cancer, which allowed us to analyze various factors associated with short- and long-term outcomes for various age groups.

Treatments for early gastric cancer are broadly divided into the following two categories: endoscopic treatment (localized treatment) and surgery, which consists of systemic lymph node dissection. Both treatment options have good clinical outcomes. In the current Japanese Gastric Cancer Treatment Guidelines, the indication of endoscopic treatment for early-stage gastric cancer is dictated by comparing 5-year DSS rates and low rates of lymph node metastasis in early-stage patients who receive endoscopic treatment [10]. However, comorbidities are common in elderly patients with early gastric cancer who are more likely to die from diseases other than gastric cancer. Thus, the current standard treatment, which is informed by disease-specific prognosis, may not always apply to elderly patients. For gastric cancer Stage I, the standard treatment is undoubtedly curative surgical resection except in early cases, which may warrant endoscopic resection. However, the average life expectancy of the oldest patients is rather short, so considering this matter and the increased risk associated with surgical treatment of older patients, surgical resection as the best way to care for these patients is controversial. Actually, endoscopic treatment for early gastric cancer is dictated strictly by comparing 5-year DSS rates and rates of lymph node metastasis. Only patients with minimal lymph node metastasis are indicated for endoscopic treatment. Even though there have been efforts to expand endoscopic treatment in gastric cancer beyond this narrow indication, cancers predicted to involve lymph node metastasis are still not treated by endoscopic resection. Therefore, gastrectomy with lymph node resection is the standard surgery for patients who are not indicated for endoscopic treatment.

The latest Japanese Gastric Cancer Treatment Guidelines have proposed a new category that accounts for the degree of cure following endoscopic treatment with consideration for aging gastric cancer patients (i.e., eCura-C2) [10]. Thus, there is now an option that omits additional surgery with lymph node dissection following endoscopic treatment. Choosing this option requires consideration for the patient's overall general state and informing the patient of the risks of

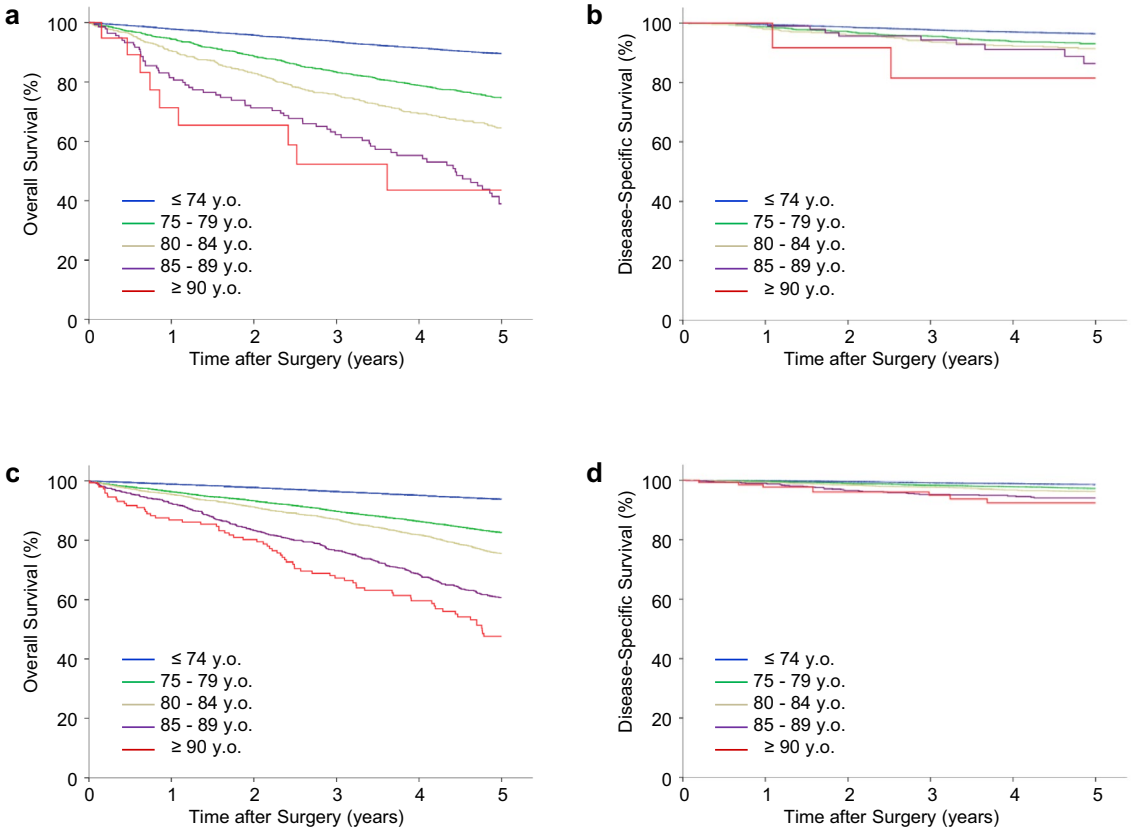



**Fig. 4** **a** Overall survival by age group in Stage I gastric cancer patients who underwent curative total gastrectomy. **b** Disease-specific survival by age group in Stage I gastric cancer patients who underwent curative total gastrectomy. **c** Overall survival by age group in Stage I gastric cancer patients who underwent curative non-total gastrectomy. **d** Disease-specific survival by age group in Stage I gastric cancer patients who underwent curative non-total gastrectomy

**Table 9** Long-term outcomes of 1-year, 3-year, and 5-year overall survival and disease-specific survival rates in the patients with Stage I gastric cancer by surgical procedure

| Class of age (years old) | Procedure | 1-Year OS (%) | 1-Year DSS (%) | 3-Year OS (%) | 3-Year DSS (%) | 5-Year OS (%) | 5-Year DSS (%) |
|---|---|---|---|---|---|---|---|
| Total | Total | 96.7 | 99.3 | 90.7 | 97.1 | 85.5 | 95.6 |
| | Non-total | 98.2 | 99.8 | 94.5 | 98.9 | 90.7 | 98.2 |
| ≤ 74 | Total | 97.8 | 99.5 | 93.5 | 97.7 | 89.6 | 96.4 |
| | Non-total | 98.9 | 99.9 | 96.4 | 99.2 | 93.8 | 98.6 |
| 75–79 | Total | 94.4 | 98.7 | 83.4 | 95.6 | 74.7 | 93.1 |
| | Non-total | 96.3 | 99.6 | 89.9 | 98.3 | 82.6 | 97.3 |
| 80–84 | Total | 90.5 | 98.0 | 75.6 | 93.7 | 64.5 | 91.4 |
| | Non-total | 95.4 | 99.4 | 87.0 | 97.7 | 75.5 | 96.2 |
| 85–89 | Total | 81.4 | 100.0 | 62.2 | 94.3 | 38.9 | 86.4 |
| | Non-total | 92.4 | 99.0 | 76.5 | 95.2 | 60.7 | 94.1 |
| ≥ 90 | Total | 71.3 | 100.0 | 52.3 | 81.5 | 43.6 | 81.5 |
| | Non-total | 86.8 | 97.7 | 67.3 | 94.9 | 47.6 | 92.4 |

*OS* overall survival, *DSS* disease-specific survival

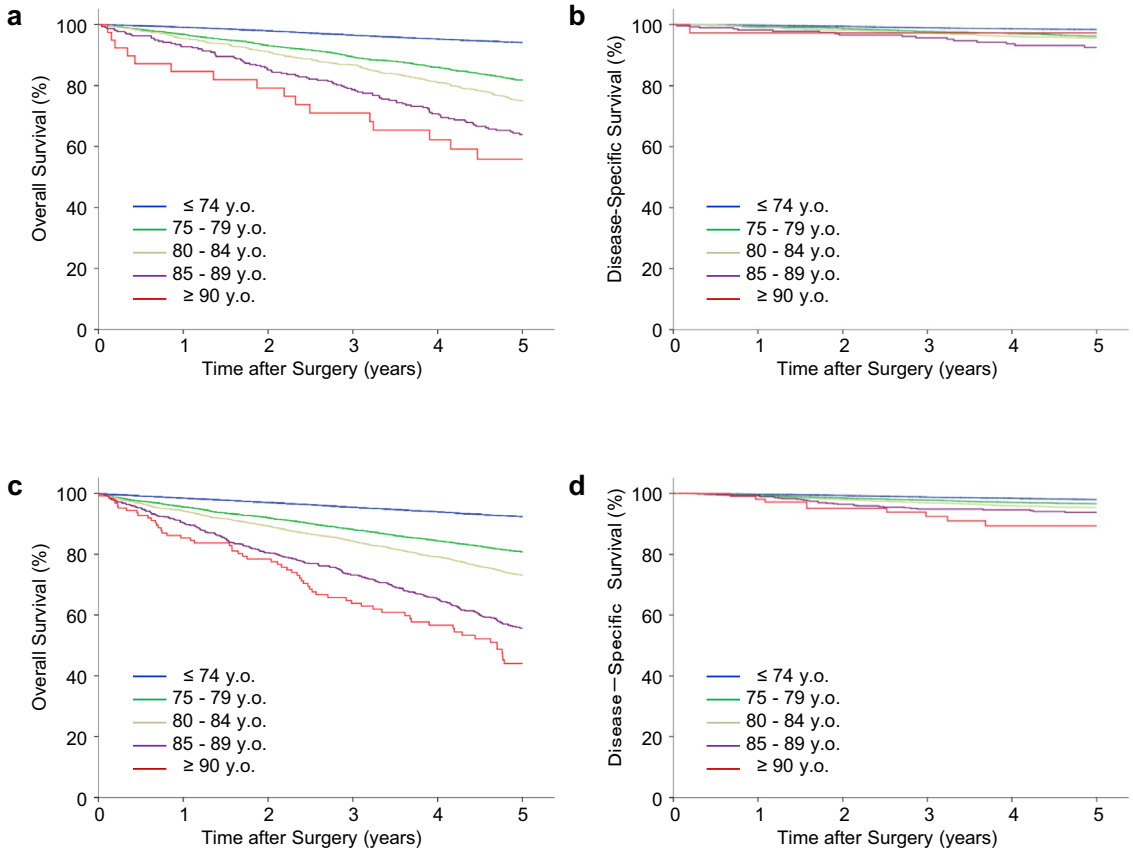



**Fig. 5** **a** Overall survival by age group in Stage I gastric cancer patients who underwent curative gastrectomy at a high-volume center. **b** Disease-specific survival by age group in Stage I gastric cancer patients who underwent curative gastrectomy at a high-volume center. **c** Overall survival by age group in Stage I gastric cancer patients who underwent curative gastrectomy at a non-high-volume center. **d** Disease-specific survival by age group in Stage I gastric cancer patients who underwent curative gastrectomy at a non-high-volume center

**Table 10** Long-term outcomes of 1-year, 3-year, and 5-year overall survival and disease-specific survival rates in the patients with Stage I gastric cancer by hospital volume

| Class of age (years old) | Hospital volume | 1-Year OS (%) | 1-Year DSS (%) | 3-Year OS (%) | 3-Year DSS (%) | 5-Year OS (%) | 5-Year DSS (%) |
|---|---|---|---|---|---|---|---|
| Total | HVC | 98.6 | 99.7 | 95.0 | 98.7 | 91.3 | 98.0 |
| | Non-HVC | 97.6 | 99.7 | 93.2 | 98.5 | 88.8 | 97.6 |
| ≤74 | HVC | 99.1 | 99.8 | 96.5 | 99.0 | 94.1 | 98.4 |
| | Non-HVC | 98.4 | 99.8 | 95.5 | 98.8 | 92.4 | 98.0 |
| 75–79 | HVC | 96.8 | 99.4 | 89.3 | 97.8 | 81.8 | 96.3 |
| | Non-HVC | 95.6 | 99.5 | 88.2 | 97.8 | 80.8 | 96.6 |
| 80–84 | HVC | 95.4 | 99.0 | 86.8 | 97.3 | 75.0 | 95.7 |
| | Non-HVC | 94.2 | 99.2 | 84.3 | 97.0 | 73.1 | 95.4 |
| 85–89 | HVC | 92.8 | 98.2 | 78.7 | 95.7 | 64.0 | 92.5 |
| | Non-HVC | 90.3 | 99.4 | 73.1 | 94.9 | 55.6 | 93.8 |
| ≥90 | HVC | 84.6 | 97.3 | 71.0 | 97.3 | 55.8 | 97.3 |
| | Non-HVC | 85.4 | 98.1 | 63.9 | 92.5 | 44.0 | 89.4 |

*OS* overall survival, *DSS* disease-specific survival, *HVC* high-volume center, *non-HVC* non-high-volume center

lymph node metastasis. The references on this topic discuss histological analysis of resected specimens from the endoscopic resection and assessment of the likelihood of lymph node metastasis, which enables the ability to inform patients of the risk of metastasis. Considering the findings of this study and patients who have been informed about the risk of lymph node metastasis and have consented to endoscopic treatment, the indications of local treatment, including endoscopic treatment and partial gastrectomy, may be extended to the elderly who have a somewhat higher likelihood of death caused by other diseases. Considering transition risk and death risk caused by other diseases in the elderly who were cleared this time, it is necessary to consider ER adaptation [11].

Selection bias was a limitation in this study because the cohort consisted of surgical patients for whom the surgeon decided the surgical indication according to performance status. Another limitation of this study was the retrospective study design and reliance on nationwide survey data, which included patients lost to follow-up. Early postoperative mortality also may have been somewhat underestimated, although it seems that it was actually small. The number of cases with insufficient lymph node dissection (D0) increases with age, and Stage migration may have resulted in poor prognosis. However, despite being limited to the cases (94.5% of the total) where dissection of D1 or more was performed, the value of DSS is almost the same and the influence seems to be minimal (data not shown). Furthermore, the effects of patient background, including comorbidities such as cardiovascular disease, on short- and long-term postoperative outcomes, were not examined in detail. HVC is the average annual registration of more than 100 cases in Japan, but it is unclear whether it is a statistically valid cut-off line and it may not be applicable in the West. The effects of accurate hospital volume may be derived from studies that include patient background and the rate of complications in the short term after surgery.

Despite these limitations, the overall conclusions on mortality outcomes assessed in this study are likely to be sufficient for investigating the trends in postoperative outcomes for elderly Stage I gastric cancer patients.

## Conclusion

Among elderly patients with Stage I gastric cancer, postoperative early mortality was high, and deaths due to other diseases were frequently observed. Thus, for elderly patients, it may be appropriate to reconsider the balance between the invasiveness of the treatment and the prognosis.

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## Compliance with ethical standards

**Conflict of interest** We declare that we have no conflicts of interests to disclose in relation to the conduct/publication of this study.

**Human rights statement** All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later versions.

**Informed consent** Informed consent or its substitute was obtained from all patients included in this study.

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