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Surgical outcomes of laparoscopic distal gastrectomy compared to open distal gastrectomy: A retrospective cohort study based on a nationwide registry database in Japan

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Abstract
To clarify the safety profile of laparoscopic distal gastrectomy (LDG) for gastric cancer patients, the short-term outcome of LDG was compared to that of open distal gastrectomy (ODG) by propensity score matching using data from the Japanese National Clinical Database (NCD). We conducted a retrospective cohort study of patients undergoing distal gastrectomy between January 2012 and December 2013. Using the data for 70,346 patients registered in the NCD, incidences of mortality and morbidity were compared between LDG patients and ODG patients in the propensity score matched stage I patients (ODG: n = 14,386, LDG: n = 14,386) and stage II-IV patients (ODG: n = 3738, LDG: n = 3738), respectively. There was no significant difference in mortality rates between LDG and ODG at all stages. Operating time was significantly longer in LDG compared to ODG, whereas blood loss and incidences of superficial surgical site infection (SSI), deep SSI, and wound dehiscence were significantly higher in ODG at all stages. Interestingly, pancreatic fistula was found significantly more often in LDG (1%) compared to ODG (0.8%) (P = .01) in stage I patients; however, it was not different in stage II-IV patients.
The length of postoperative stay was significantly longer in patients undergoing ODG compared to LDG at all stages. LDG in general practice might be a feasible therapeutic option in patients with both advanced gastric cancer and those with early gastric cancer in Japan.

**KEYWORDS**

gastric cancer, laparoscopic surgery, national clinical database, open gastrectomy, propensity score matching

1 | INTRODUCTION

The incidence of gastric cancer (GC) is decreasing, but it still remains the second leading cause of death worldwide. In Japan, according to the national cancer registry, 40%-50% of GC patients are detected at an early stage, and they are mostly treated by minimally invasive surgery including endoscopic mucosal resection and laparoscopic surgery.

Laparoscopic distal gastrectomy (LDG) was initially reported in 1991 and has recently become prevalent. Its short-term outcomes have been clarified by randomized controlled trials (RCT), and operative procedures have been recommended at level B in the Japanese GC cancer treatment guidelines. However, the results of RCT may not necessarily represent the effectiveness of the procedure in general practice; the patients enrolled in the clinical trials are mostly in good condition as trials tend to have eligibility criteria that prohibit the enrollment of high-risk patients such as the elderly and patients with severe comorbidities. Moreover, the hospitals participating in the RCT are mostly high-volume centers, and the qualities of treatment and care do not necessarily represent those of the routine care provided at community hospitals. This is especially true in the field of laparoscopic surgery, which requires special training to acquire proficiency in high-quality techniques. It is obvious to postulate that there should be differences in treatment outcomes between high-volume centers and hospitals in general and between doctors with and without board certification by special academic societies. In the past decade, LDG has been carried out in general practice, and the number carried out in 2013 increased 6-fold compared to that of 2001, without any evaluation or quality control that would be warranted from the concerns described above. It is only recently that we have begun to pay close attention to the quality and outcomes of these procedures, which are being conducted at institutions all over Japan.

To solve the problems mentioned above, analysis using large, truly trustable, and real-time data is necessary. The Japanese National Clinical Database (NCD) is a nationwide web-based data entry system started in 2011 that is based on the National Surgical Quality Improvement Program of the American College of Surgeons. The NCD is the largest clinical database in Japan, covering more than 90% of the general clinical practice data relating to surgery and surveying the operative risks and complications of approximately 1.2 million cases from 4105 institutions per year. It was founded in April 2010 by the Japan Surgical Society and other societies. According to the annual report of the NCD in 2013, the total number of 115 nominated gastrointestinal operations carried out from January 2011 to December 2012 was 949,824. The procedures were done on the esophagus (1.7%), gastroduodenal area (15.0%), small intestine and colon (35.4%), anorectal area (9.6%), liver (5.2%), gall bladder (23.8%), pancreas (3.1%), and others (5.5%). Now, the NCD data are regarded as the most reliable baseline data reflecting general practice. The enrolled cases are linked with the board certification system for surgeons, and enrollment is also mandatory for teaching hospitals.

The present study, the largest cohort study to date, was conducted to clarify the present situation of LDG in general practice and also to confirm that LDG is conducted safely in patients with advanced GC and in those with early GC in Japan.

2 | MATERIALS AND METHODS

2.1 | Study design and cohort development

This study was a retrospective cohort study enrolling patients registered in the NCD gastrointestinal surgery registry as undergoing distal gastrectomy during the enrollment period between January 2012 and December 2013 and the study was conducted as a collaborative study with Japanese Gastric Cancer Association, Japan Society for Endoscopic Surgery, the Japanese Society of Gastroenterological Surgery and NCD. We divided the cohort into patients with stage I and those with stages II–IV GC and analyzed them separately as treatments between these two groups are distinct. All procedures were conducted in accordance with the ethical standards of the respective committees on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later versions. The study was approved by the Institutional Review Board of Gifu University.

2.2 | Outcomes and identification of confounding factors

Because many confounding factors were expected when comparing conventional open distal gastrectomy (ODG) against LDG for the incidences of perioperative events, we held a consensus meeting that included members such as laparoscopy surgeons, gastroenterology...
surgeons, and clinical epidemiologists to determine the study outcomes and the confounding variables. We defined the primary endpoints as 30-day postoperative death and surgical death (deaths within 30 days after surgery or those occurring while hospitalized, respectively). Secondary endpoints included occurrences of reoperation, readmission, and operative complications, and operating time, blood loss, and length of postoperative stay. Confounding factors included patients’ age, gender, American Society of Anesthesiologists performance status (ASA-PS) score, and body mass index (BMI); preoperative conditions including weight loss of greater than 10% within the past 6 months, smoking status, emergency ambulance to the hospital, presence of habitual alcohol intake, and patient activities of daily living; presence of comorbidities including insulin-dependent diabetes mellitus, respiratory disease, chronic obstructive pulmonary disease, hypertension, angina, hemodialysis, congestive heart failure, history of cerebrovascular accident, long-term use of steroids, and bleeding disorder; surgical tumor node metastasis (TNM) classifications, presence of concurrent cholecystectomy, whether the surgery was emergent, and the presence of preoperative chemotherapy. We also considered as potential confounders of the present study laboratory abnormalities that were identified as being strongly associated with perioperative mortality in past studies.

2.3 | Propensity score matching and statistical analysis

A statistical analyst conducted propensity score modeling and matching while being blinded to the outcome. The propensity score was estimated by logistic regression models predicting the exposure of undergoing laparoscopic surgery against undergoing ODG from the above-described confounding variables, but built separately in the two cohorts for stage IA+IB cases and stage II-IV cases. After propensity score estimation, each patient undergoing laparoscopy was matched to a patient undergoing open surgery using the macro, a SAS software program made public, by Marcelo Coca-Perraillon, through a greedy matching algorithm without replacement with a matching caliper of 0.2 standard deviation of logit of the propensity score. We assessed the balance of the matched cohort by calculating the standardized difference between the two groups using the macro devised by Yang and Dalton. We estimated the occurrences of primary and secondary outcomes in the matched cohort and compared them between the two surgical approach groups using Fisher’s exact test for the outcomes with an expected cell count less than 5 or Pearson’s chi-squared test for others for binary variables and the Wilcoxon rank-sum test for continuous variables. Comparisons were all two-sided, and P-values less than .05 were considered significant. All analyses were conducted using SAS 9.4 statistical software (SAS Institute, Cary, NC, USA).

3 | RESULTS

3.1 | Patient characteristics

We initially enrolled 70,346 patients in the NCD database who underwent distal gastrectomy during the study period. After

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**FIGURE 1** Flowchart of the participants enrolled as undergoing distal gastrectomy in the National Clinical Database. LDG, laparoscopic distal gastrectomy; ODG, open distal gastrectomy.
excluding cases of non-cancers (n = 544), cases with concurrent surgical procedures other than cholecystectomy (n = 658), and those of surgical stage 0 or undefined (n = 2396), we were left with 40 875 patients with stage IA or IB cancer and 26 095 patients with stage II-IV cancer. A flowchart of the enrollment and exclusion of cases is depicted in Figure 1.

Background characteristics of the surgical stage I patients are shown in Table 1. Information on pre-matching of patients is tabulated on the left side, whereas that of the propensity-matched patients is tabulated on the right. Among the total of 40 875 patients, 17 240 underwent open surgery and 23 635 underwent laparoscopic surgery. Patients undergoing open surgery were more likely to be older, have poorer ASA-PS, and have more comorbidities, including insulin-dependent diabetes mellitus and respiratory disease, compared to those undergoing laparoscopic surgery. Moreover, the ODG patients comprised a higher percentage of stage IB patients than the LDG patients, suggesting that higher-risk patients tended to undergo open surgery. After propensity score matching, these discrepancies in patient background disappeared (standardized difference 0.05 or less) (open surgery: n = 14 386, laparoscopic surgery: n = 14 386) as shown in Table 1.

Characteristics of patients with surgical stage II-IV cancers (all patients: n = 26 095, ODG: n = 22 291, LDG: n = 3804) are shown in Table 2. Open surgeries were more likely to be conducted on patients with poorer ASA-PS, with higher frequency of bodyweight loss above 10%, poorer activities of daily living, and more respiratory disease. The percentage of patients with surgical stage II cancer was much higher in the LDG group than in the ODG group. Surprisingly, 5.8% of patients undergoing laparoscopic surgery had stage IV GC. After propensity score matching, we had 3738 patients each undergoing LDG and ODG, with the standardized difference at 0.05 or less for propensity score matching, we had 3738 patients each undergoing laparoscopic surgery. Patients undergoing open surgery had stage IV GC. After propensity score matching, these discrepancies in patient background disappeared (standardized difference 0.05 or less) (open surgery: n = 14 386, laparoscopic surgery: n = 14 386) as shown in Table 1.

3.2 Mortality and complications in stage I GC patients

Mortality and complications for propensity-matched patients with stage I GC (n = 28 772) are shown in Table 3. We observed no significant difference in either 30-day or in-hospital mortality: 33 (0.2%) and 31 (0.2%) deaths within 30 days after ODG and LDG (P = .90) and 76 (0.5%) and 55 (0.4%) patients with in-hospital mortality after ODG and LDG (P = .08), respectively. In addition, there were no significant differences in the incidences of reoperation and readmission after surgery. Mean and median operating times were significantly longer in LDG (mean: 295 minutes, median: 287 minutes) compared to ODG (mean: 218 minutes, median: 209 minutes), whereas blood loss was significantly higher in ODG (mean: 264.5 mL, median: 185 mL) compared to LDG (mean: 105.8 mL, median: 50 mL). Length of postoperative stay was significantly longer in ODG (median: 15 days, 10th-90th percentile: 10-31 days) compared to LDG (median: 12 days, 10th-90th percentile: 8-24 days) (P < .001).

Incidences of superficial SSI, deep SSI, and wound dehiscence were significantly higher in ODG compared to LDG as expected. The frequency of superficial SSI was 266 (1.8%) for ODG and 149 (1%) for LDG (P < .001). Deep SSI occurred in 89 (0.6%) of the ODG patients and in 55 (0.4%) of the LDG patients (P < .01). Moreover, the incidence of wound dehiscence in ODG was 59 (0.4%), whereas it was 27 (0.2%) in LDG (P < .001). Very interestingly, the incidence of pancreatic fistula was significantly higher in LDG (145: 1%) compared to ODG (116: 0.8%) (P = .01). There was no significant difference in the incidence of anastomotic leakage between ODG (1.8%) and LDG (1.9%).

3.3 Mortality and complications in stage II-IV advanced GC patients

Surgical outcomes in stage II-IV propensity-matched patients (n = 7476) are shown in Table 4. We found no significant differences in mortality within 30 days and in-hospital mortality between ODG and LDG. In addition, interestingly, there were also no statistically significant differences in other complications or in the incidences of reoperation and readmission after surgery. As shown for stage I patients, operating time in LDG (mean: 304.8 minutes, median: 296 minutes) was longer compared to ODG (mean: 230.4 minutes, median: 222 minutes) (P < .001), whereas blood loss was significantly higher in ODG (mean: 317.5 mL, median: 240 mL) compared to LDG (mean: 131.5 mL, median: 50 mL) (P < .001). Postoperative stay was significantly longer in ODG (median: 15 days, 10th-90th percentile: 10-35 days) compared to LDG (median: 13 days, 10th-90th percentile: 8-29 days) (P < .001).

4 DISCUSSION

We made three major findings in the present study. First, during the study period, LDG was commonly carried out in patients with stage I GC, whereas open surgery was more common in more advanced cases; indeed, 85% or more of the stage II-IV GC patients underwent ODG. Second, younger patients or those with lower ASA-PS tended to be selected for a laparoscopic approach. Finally, after adjusting for confounding factors, neither the incidence of mortality nor that of morbidity was significantly higher for laparoscopic surgery than for the conventional open approach.

This was the first and largest-scale survey to focus on the spread of laparoscopic surgery for patients with GC in Japan, so these findings should prove valuable and useful for surgeons in their daily practice. The current penetration of laparoscopic surgery has been limited to stage I GC, with a certain degree of safety ensured from the perspectives of mortality and morbidity. Although the conventional open approach was more common for stage II-IV cancer during the study period, the proportion of patients undergoing laparoscopic surgery will likely increase rapidly in the near future under the revised Japanese treatment guidelines established in May 2014 because the laparoscopic approach has been certified as a
standard procedure for clinical stage I cancer. However, the oncological safety of laparoscopic surgery remains to be confirmed by phase III randomized trials; therefore, we will focus on the long-term outcomes of on-going clinical trials. Indeed, some reliable observational studies have reported the non-inferiority of the oncological outcomes of LDG compared with ODG. We believe that this shift toward laparoscopic surgery will persist for some time, given the benefits associated with less-invasive surgery. Given the

| TABLE 1 | Baseline characteristics before and after propensity score matching in stage IA/IB patients |
|---------|-----------------------------------------------------------------------------------------|
|         | All patients (n = 40 875) | Propensity-matched patients (n = 28 772) |
|         | ODG (n = 17 240) | LDG (n = 23 635) | Standardized difference | ODG (n = 14 386) | LDG (n = 14 386) | Standardized difference |
| Age (y) | | | | | | |
| Median [IQR] | 71 [63-78] | 68 [61-75] | −0.27 | 69.1 (11.0) | 68.5 (11.2) | −0.05 |
| <65 | 4981 | 28.9 | 9060 | 38.3 | 0.25 | 4536 | 31.5 | 4563 | 31.7 | 0.01 |
| 65-75 | 5786 | 33.6 | 8186 | 34.6 | 0.04 | 4970 | 34.5 | 4988 | 34.7 |
| 75< | 6473 | 37.5 | 6389 | 27.0 | 0.27 | 4880 | 33.9 | 4835 | 33.6 |
| Gender | | | | | | |
| Male | 11 794 | 68.4 | 15 424 | 65.3 | 0.07 | 9770 | 67.9 | 9794 | 68.1 | 0.00 |
| Female | 5446 | 31.6 | 8211 | 34.7 | 0.06 | 4616 | 32.1 | 4592 | 31.9 |
| ASA-PS | | | | | | |
| ≤2 | 15 373 | 89.2 | 22 231 | 94.1 | −0.18 | 13 202 | 91.8 | 13 189 | 91.7 | 0.00 |
| ≥3 | 1867 | 10.8 | 1404 | 5.9 | 0.29 | 1184 | 8.2 | 1197 | 8.3 |
| BMI (kg/m²) | | | | | | |
| Mean (SD) | 22.6 (3.4) | 22.6 (3.2) | 0.00 | 22.7 (3.4) | 22.7 (3.3) | 0.00 |
| Weight loss 10%< | 366 | 2.1 | 284 | 1.2 | −0.07 | 238 | 1.7 | 232 | 1.6 | 0.00 |
| Smoking | 3387 | 19.6 | 4982 | 21.1 | 0.04 | 2941 | 20.4 | 2926 | 20.3 | 0.00 |
| Habitual alcohol intake | 4519 | 26.2 | 7107 | 30.1 | 0.09 | 4013 | 27.9 | 4010 | 27.9 | 0.00 |
| Comorbidities | | | | | | |
| Diabetes mellitus | 562 | 3.3 | 560 | 2.4 | −0.05 | 413 | 2.9 | 402 | 2.8 | 0.00 |
| Respiratory | 320 | 1.9 | 235 | 1.0 | −0.07 | 197 | 1.4 | 201 | 1.4 | 0.00 |
| COPD | 648 | 3.8 | 786 | 3.3 | −0.02 | 524 | 3.6 | 522 | 3.6 | 0.00 |
| Hypertension | 6779 | 39.3 | 8147 | 34.5 | −0.10 | 5496 | 38.2 | 5480 | 38.1 | 0.00 |
| Ischemic heart disease | 270 | 1.6 | 264 | 1.1 | −0.04 | 204 | 1.4 | 194 | 1.3 | −0.01 |
| Dialysis | 241 | 1.4 | 137 | 0.6 | −0.08 | 129 | 0.9 | 125 | 0.9 | 0.00 |
| Cerebrovascular event | 348 | 2.0 | 254 | 1.1 | −0.08 | 219 | 1.5 | 217 | 1.5 | 0.00 |
| Use of steroid | 155 | 0.9 | 180 | 0.8 | −0.02 | 117 | 0.8 | 125 | 0.9 | 0.01 |
| Bleeding disorder | 701 | 4.1 | 593 | 2.5 | −0.09 | 483 | 3.4 | 485 | 3.4 | 0.00 |
| Surgical T | | | | | | |
| 1a | 5256 | 30.5 | 9263 | 39.2 | 0.37 | 4846 | 33.7 | 4916 | 34.2 | 0.01 |
| 1b | 8307 | 48.2 | 12 340 | 52.2 | 0.37 | 7480 | 52.0 | 7458 | 51.8 |
| 2 | 3677 | 21.3 | 2032 | 8.6 | 0.25 | 2060 | 14.3 | 2012 | 14.0 |
| Surgical N | | | | | | |
| N0 | 16 073 | 93.2 | 22 557 | 95.4 | 0.18 | 13 498 | 93.8 | 13 482 | 93.7 | 0.01 |
| N1 | 1167 | 6.8 | 1078 | 4.6 | 0.25 | 888 | 6.2 | 904 | 6.3 |
| Surgical stage | | | | | | |
| IA | 12 396 | 71.9 | 20 525 | 86.8 | 0.18 | 11 438 | 79.5 | 11 470 | 79.7 | 0.01 |
| IB | 4844 | 28.1 | 3110 | 13.2 | 0.38 | 2948 | 20.5 | 2916 | 20.3 |
| Preoperative chemotherapy | 139 | 0.8 | 98 | 0.4 | −0.05 | 83 | 0.6 | 87 | 0.6 | 0.00 |
| Cholecystectomy | 2709 | 15.7 | 1799 | 7.6 | −0.25 | 1774 | 12.3 | 1732 | 12.0 | −0.01 |
| Emergency surgery | 124 | 0.7 | 68 | 0.3 | −0.06 | 53 | 0.4 | 64 | 0.4 | 0.01 |

ASA-PS, American Society of Anesthesiologists physical status; BMI, body mass index; COPD, chronic obstructive pulmonary disease; IQR, interquartile range; LDG, laparoscopic distal gastrectomy; ODG, open distal gastrectomy; SD, standard deviation.
situation described above, the present analysis was planned to confirm the safety of LDG in general practice in stage IA (T1N0) or IB (T1N1, T2N0) cancer, as defined in JCOG070319 and JCOG0912,13 and to explore the feasibility of LDG for stage II-IV cancer by a complete enumeration survey using the Japanese NCD registration system.

Apart from the TNM stage, there were some clinical factors associated with a surgeon’s decision to select open or laparoscopic surgery for a given patient. In the present study, younger patients and those with better ASA-PS tended to be treated by the laparoscopic approach, whereas a greater proportion of the patients with severe comorbidities received open surgery rather than laparoscopy, including those with diabetes mellitus, respiratory disease, hemodialysis, a history of cardiovascular events, and coagulation disorder. These trends were considered to reflect Japanese surgical practice.

Given these differences in patients’ characteristics, a number of confounding factors should be adjusted for when comparing surgical outcomes between laparoscopic and open surgery. After adjusting for confounding factors by precise propensity score matching, we ultimately noted no significant difference in the mortality of patients with stage I versus those with stage II-IV cancer. Regarding morbidities, the incidences of SSI and pneumonia were common in ODG. Laparotomy with a long wound was likely to cause a SSI, which is consistent with the results of previous reports.15,20,21 In addition, difficulty of expectoration and rehabilitation after open surgery might be associated with postoperative pneumonia, which tended to be more frequent in the ODG group than in the LDG group. However, the greatest difficulty associated with LDG is the lack of tactile sensation experienced by the surgeon when manipulating the forceps. Although utmost caution should be paid to prevent organ injury as a result of the inappropriate use of forceps in LDG, the high incidence of pancreatic fistulas in LDG may be because of the assistant applying greater force than is actually required to displace the pancreas to expand the operative field and to the surgeon inflicting thermal injury on the pancreas by using energy devices.22 In addition, very interestingly, the rate of grade B or C pancreatic fistula was significantly higher in LDG (1.0%) than in ODG (0.8%) in stage I patients, whereas it was not markedly different between the two approaches in patients with stage II-IV locally advanced cancer (ODG: 1.4%, LDG 1.5%). These are novel findings that have not been shown by other clinical research. The precise reason for the difference in outcomes between the different approaches in stage I cancer is unclear; however, pancreas injury during suprapancreatic lymph node dissection (mostly D1+ dissection) or compression of the pancreas by energy devices or forceps may be more frequent with LDG than with ODG. In stage II-IV GC, more aggressive dissection at the D2 level in ODG increased the rate of pancreatic fistula, thereby reducing the statistical difference compared to LDG.

Significant differences in the incidence of morbidities were evident between the two procedures in this study, but the point estimation
was small from the clinicians’ perspective. We should therefore be careful when interpreting this small $P$-value in analyses using such a large-scale dataset. Furthermore, we found that the length of hospitalization after surgery was shortened with LDG from 2.4 to 2.8 in-hospital days compared with ODG. Taken together, the present findings suggest that the surgical safety and low invasiveness of LDG were mostly proven as already shown by considerable established evidence. However, as seen in Table 4, the merit of the laparoscopic approach in stages II to IV gastric cancer could not be shown. Expected lower invasiveness of LDG was not shown by the present analysis and, moreover, the cost of using LDG devices can be more expensive than that of ODG even if the hospital stay is short.

This analysis did not overcome all the uncertainties associated with the details of the surgical procedures, such as the degree of lymphadenectomy, methods or technique of reconstruction, or types of energy devices used. In addition, the NCD system did not include any variables related to nutrition, quality of life, or oncological outcomes. We should therefore pay careful attention to the results of ongoing clinical trials. Furthermore, we need to consider whether our results can be safely extrapolated to patients with GC.

**FIGURE 2** Propensity score distribution in the whole cohort and in the matched cohort

(A) Before matching in Stage I cohort

(B) Before matching in Stage II–IV cohort

Density

- Laparoscopic surgery
- Open

Density

- Laparoscopic surgery
- Open

Density

- Laparoscopic surgery
- Open

Density

- Laparoscopic surgery
- Open

Density

- Laparoscopic surgery
- Open
| TABLE 3  Baseline characteristics before and after propensity score matching stage II to IV patients |
|---------------------------------------------------------------|
| **All patients (n = 26,095)** | **Propensity-matched patients (n = 7,476)** |
|----------------------------------|----------------------------------|
| **ODG (n = 22,291)** | **LDG (n = 3,804)** | **Standardized difference** | **ODG (n = 3,738)** | **LDG (n = 3,738)** | **Standardized difference** |
| **Age (y)** | | | | | | |
| Median (IQR) | 73 (65-80) | 71 (62-78) | -0.19 | 70 (63-78) | 71 (62-78) | 0.01 |
| <65 | 5436 | 24.4 | 1235 | 32.5 | 0.19 | 1219 | 32.6 | 1217 | 32.6 | 0.01 |
| 65-75 | 7207 | 32.3 | 1197 | 31.5 | | 1164 | 31.1 | 1174 | 31.4 | |
| 75< | 9648 | 43.3 | 1372 | 36.1 | | 1355 | 36.2 | 1347 | 36.0 | |
| **Gender** | | | | | | | |
| Male | 15,031 | 67.4 | 2491 | 65.5 | 0.04 | 2444 | 65.4 | 2450 | 65.5 | 0.00 |
| Female | 7260 | 32.6 | 1313 | 34.5 | | 1294 | 34.6 | 1288 | 34.5 | |
| **ASA-PS** | | | | | | | |
| 1,2 | 19,174 | 86.0 | 3449 | 90.7 | -0.15 | 3395 | 90.8 | 3395 | 90.8 | 0.00 |
| 3,4,5 | 3117 | 14.0 | 355 | 9.3 | | 343 | 9.2 | 343 | 9.2 | |
| **BMI (kg/m²)** | | | | | | | |
| Mean (SD) | 21.7 (3.4) | 22.2 (3.4) | 0.15 | 22.2 (3.3) | 22.2 (3.4) | 0.00 |
| **Weight loss 10%<** | | | | | | | |
| Smoking | 4610 | 20.7 | 758 | 19.9 | -0.24 | 670 | 17.9 | 744 | 19.9 | 0.05 |
| Habitual alcohol intake | 5157 | 23.1 | 1023 | 26.9 | 0.09 | 994 | 26.6 | 1010 | 27.0 | 0.01 |
| **Comorbidities** | | | | | | | |
| Diabetes mellitus | 699 | 3.1 | 108 | 2.8 | -0.02 | 90 | 2.4 | 107 | 2.9 | 0.03 |
| Respiratory | 646 | 2.9 | 69 | 1.8 | -0.07 | 55 | 1.5 | 65 | 1.7 | 0.02 |
| COPD | 987 | 4.4 | 142 | 3.7 | -0.04 | 115 | 3.1 | 138 | 3.7 | 0.03 |
| Hypertension | 8098 | 36.3 | 1393 | 36.6 | 0.01 | 1344 | 36.0 | 1371 | 36.7 | 0.02 |
| Ischemic heart disease | 350 | 1.6 | 64 | 1.7 | 0.01 | 68 | 1.8 | 64 | 1.7 | -0.01 |
| Dialysis | 160 | 0.7 | 17 | 0.4 | -0.04 | 14 | 0.4 | 16 | 0.4 | 0.01 |
| Cerebrovascular event | 574 | 2.6 | 66 | 1.7 | -0.06 | 60 | 1.6 | 64 | 1.7 | 0.01 |
| Use of steroid | 139 | 0.6 | 37 | 1.0 | 0.04 | 33 | 0.9 | 34 | 0.9 | 0.00 |
| **Bleeding disorder** | | | | | | | |
| T1a | 27 | 0.1 | 17 | 0.4 | 0.49 | 13 | 0.3 | 14 | 0.4 | 0.01 |
| T1b | 148 | 0.7 | 64 | 1.7 | 0.02 | 62 | 1.7 | 62 | 1.7 | |
| T2 | 2303 | 10.3 | 809 | 21.3 | | 785 | 21.0 | 799 | 21.4 | |
| T3 | 9347 | 41.9 | 1865 | 49.0 | | 1864 | 49.9 | 1841 | 49.3 | |
| T4a | 9016 | 40.4 | 990 | 26.0 | | 955 | 25.5 | 964 | 25.8 | |
| T4b | 1421 | 6.4 | 59 | 1.6 | | 59 | 1.6 | 58 | 1.6 | |
| Tx | 29 | 0.1 | 0 | 0.0 | | | | | | |
| **Surgical T** | | | | | | | |
| **Surgical N** | | | | | | | |
| M0 | 18,915 | 84.9 | 3585 | 94.2 | 0.34 | 3544 | 94.8 | 3538 | 94.6 | 0.01 |
| M1 | 3376 | 15.1 | 219 | 5.8 | | 194 | 5.2 | 200 | 5.4 | |

(Continues)
worldwide. Also, the generalizability of our results to the population outside the PS matched cohorts (ie those with dominant propensity for either LDG or ODG) is unwarranted. There might be disadvantageous conditions related to the incidence of complications in Western countries, such as patients with a higher body mass index and the greater proportion of patients who present at an advanced stage.23–25 The surgical outcomes of the present survey have been gradually established and refined since 1991, when Kitano et al2 first reported LDG in patients with GC in Japan. Therefore, surgeons should continue to carefully consider the appropriate indications for laparoscopic surgery for GC.

In conclusion, we confirmed the surgical safety of LDG, which has similar incidences of mortality and morbidity to ODG, using the NCD registry system. In this first and complete enumeration survey from a Japanese national database, we confirmed that LDG is being conducted safely in Japan in stage I GC patients in general practice.

### TABLE 3  (Continued)

| Surgical stage | All patients (n = 26 095) | Propensity-matched patients (n = 7476) |
|----------------|---------------------------|--------------------------------------|
|                | ODG (n = 22 291)          | LDG (n = 3804)                       | Standardized difference | ODG (n = 3738) | LDG (n = 3738) | Standardized difference |
|                | %                         | %                                    |                         | %             | %             |                         |
| IIA            | 4358                      | 19.6                                 | 1363                    | 35.8          | 0.53          | 1370                    | 36.7                      | 1347                      | 36.0 | 0.03 |
| IIB            | 4380                      | 19.6                                 | 984                     | 25.9          | 4.71          | 950                     | 25.4                      | 971                        | 26.0 | .03 |
| IIIA           | 3517                      | 15.8                                 | 553                     | 14.5          | 0.75          | 569                     | 15.2                      | 545                        | 14.6 | .06 |
| IIIB           | 3657                      | 16.4                                 | 428                     | 11.3          | 3.08          | 411                     | 11.0                      | 423                        | 11.3 | .00 |
| IIIC           | 3003                      | 13.5                                 | 257                     | 6.8           | 1.43          | 244                     | 6.5                       | 252                        | 6.7  | .04 |
| IV             | 3376                      | 15.1                                 | 219                     | 5.8           | 0.75          | 194                     | 5.2                       | 200                        | 5.4  | .00 |
| Preoperative chemotherapy | 1091                      | 4.9                                 | 132                     | 3.5           | −0.07         | 105                     | 2.8                       | 129                        | 3.5  | .04 |
| Cholecystectomy | 3745                      | 16.8                                 | 307                     | 8.1           | −0.27         | 356                     | 9.5                       | 303                        | 8.1  | −0.05 |
| Emergency surgery | 351                       | 1.6                                 | 17                      | 0.4           | −0.11         | 12                      | 0.3                       | 16                         | 0.4  | .02 |

ASA-PS, American Society of Anesthesiologists physical status; BMI, body mass index; COPD, chronic obstructive pulmonary disease; IQR, interquartile range; LDG, laparoscopic distal gastrectomy; ODG, open distal gastrectomy; SD, standard deviation.

### TABLE 4  Surgical outcomes in stage II to IV patients

|                          | ODG (n = 3738) (%) | LDG (n = 3738) (%) | P-value |
|--------------------------|--------------------|--------------------|---------|
| Operating time (min)     |                    |                    |         |
| Median [percentile 10-90]| 222 [139-330]      | 296 [195-427]      | <.001   |
| Blood loss (mL)          |                    |                    |         |
| Median [percentile 10-90]| 240 [57-635]       | 50 [1-308]         | <.001   |
| Mortality                |                    |                    |         |
| Within 30 days           | 11                 | 22                 | 0.6%    | .08     |
| In-hospital              | 33                 | 37                 | 1%      | .72     |
| Readmission within 30 days | 78              | 93                 | 2.5%    | .28     |
| Reoperation              | 106                | 113                | 3%      | .68     |
| Complications            |                    |                    |         |
| Superficial SSI          | 70                 | 62                 | 1.7%    | .54     |
| Deep SSI                 | 21                 | 18                 | 0.5%    | .75     |
| Intra-abdominal abscess  | 109                | 97                 | 2.6%    | .43     |
| Leakage                  | 82                 | 81                 | 2.2%    | 1.00    |
| Pancreatic fistula (grade B,C) | 53        | 55                 | 1.5%    | .92     |
| Wound dehiscence         | 18                 | 10                 | 0.3%    | .18     |
| Pneumonia                | 74                 | 55                 | 1.5%    | .11     |
| Pulmonary embolism       | 8                  | 2                  | 0.1%    | .11     |
| Sepsis                   | 16                 | 17                 | 0.5%    | 1.00    |
| Length of postoperative stay |                |                    |         |
| Median [percentile 10-90]| 15 [10-35]         | 13 [8-29]          | <.001   |

P-values derived from Wilcoxon rank-sum test for continuous variables and Fisher’s exact test for binary variables.

LDG, laparoscopic distal gastrectomy; ODG, open distal gastrectomy; SSI, surgical site infection.
as suggested by the Japanese guidelines for GC treatment. LDG may represent a new therapeutic option for patients with stage II-IV disease as well as stage I GC patients.

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DISCLOSURE

Ethical statement: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (in institutional and national) and in compliance with the Helsinki Declaration of 1964 and later versions. Both hospitals disclose information to the patients. Participating patients were excluded only when they specified that they were unwilling to participate.

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