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Morbidity and mortality from a propensity score-matched, prospective cohort study of laparoscopic versus open total gastrectomy for gastric cancer: data from a nationwide web-based database

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Abstract

Background Controversy persists regarding the technical feasibility of laparoscopic total gastrectomy (LTG), and to our knowledge, no prospective study with a sample size sufficient to investigate its safety has been reported. We aimed to compare the postoperative morbidity and mortality rates in patients undergoing LTG and open total gastrectomy (OTG) for gastric cancer in prospectively enrolled cohort using nationwide web-based registry.

Methods From August 2014 to July 2015, consecutive patients undergoing LTG or OTG (925 and 1569 patients, respectively) at the participating institutions were enrolled prospectively into the National Clinical Database registration system. We constructed propensity score (PS) models separately in four facility yearly case-volume groups, and evaluated the postoperative morbidity and mortality in PS-matched 1024 patients undergoing LTG or OTG.

Results The incidence of overall morbidity were 84 (16.4%) in the OTG and 54 (10.3%) in the LTG groups ($p=0.01$).The incidence of anastomotic leakage and pancreatic fistula grade B or above were not significantly different between the two groups (LTG 5.3% vs. OTG 6.1%, $p=0.59$, LTG 2.7% vs. OTG 3.7%, $p=0.38$, respectively). There were also no significant differences in the 30-day and in-hospital mortality rates between the two groups (LTG 0.2% vs. OTG 0.4%, $p=0.56$; LTG 0.4% vs. OTG 0.4%, $p=1.00$, respectively).

Conclusion The results from our nationally representative data analysis showed that LTG could be a safe procedure to treat gastric cancer compared to OTG. The indication for LTG should be considered carefully in a clinical setting.

Keywords National Clinical Database registration system · Prospective cohort study · Laparoscopic total gastrectomy

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Abbreviations

NCD National Clinical Database
LTG Laparoscopic total gastrectomy
OTG Open total gastrectomy
PS Propensity Score

Since the first report of laparoscopic gastrectomy with lymph node dissection for gastric cancer in 1991, laparoscopic distal gastrectomy (LDG) has become widely accepted by surgeons as an option of common practice [1, 2]. So far, many retrospective studies have demonstrated the benefits from its minimal invasiveness including shorter hospital stay, less bleeding, and accelerated recovery [3, 4]. Furthermore, recent phase III studies have shown that LDG is comparable to open gastrectomy in terms of the surgical outcomes [5–7]. On the other hand, laparoscopic total gastrectomy (LTG) for gastric cancer has not been regarded as a common procedure because reconstruction and lymph node dissection around the spleen, which is required in LTG, are more technically complicated and difficult. Although some retrospective studies have demonstrated the safety of LTG compared to open total gastrectomy (OTG), the small sample sizes of these studies have prohibited us from making firm conclusions about the non-inferiority of LTG to OTG [8–11]. In addition, to our knowledge, no phase III randomized control trials (RCTs) have evaluated the surgical outcomes of LTG against OTG. Therefore, whether the surgical outcomes of LTG are comparable to those of OTG in our current practice still remains as an important clinical question for gastrointestinal surgeons.

To evaluate and improve the quality of surgeries, a nationwide surgical case registration system, the National Clinical Database (NCD), was initiated in 2011 in Japan [12, 13]. Presently, 1,200,000 patients who underwent surgery per year are registered from 4105 institutions. This system has covered more than 90% of general surgery procedures in all of Japan. Using the registry platform, we conducted a prospective data collection of prespecified variables that we saw as the determinants for selecting LTG over OTG, to enhance our propensity score model. The aim of this study was to evaluate the surgical outcomes and safety of LTG compared to OTG.

Methods

Data collection

NCD is a nationwide registry platform in association with the board certification system for surgery in Japan. The present study was a prospective observational cohort study using this NCD registration system. To extract representative patients from all over Japan, target institutions were selected via stratified random sampling. The locations of all institutions were distributed proportionally throughout Japan, and institution locations in each area were selected randomly. First, as shown in Fig. 1, Japan was divided into ten regions, and all municipalities were classified into three urban/rural levels: metropolitan areas (population ≥ 1 million; black circles in Fig. 1) [14], larger cities (≥ 100,000), and small cities (< 100,000). Second, we randomly sampled the facilities in each group stratified by hospital volume (number of surgical cases per year), hospital type (university hospital, specialized hospital, and "others"), and location (10 regions and three urban levels), so as to reflect the distribution of these factors in Japan as a whole. One hundred seventy-nine institutions were selected from this procedure, of which 169 ultimately agreed to participate in the study.

From August 2014 to July 2015, consecutive patients of the participating institutions who underwent LTG and OTG were enrolled prospectively.

Propensity Score (PS) modeling

Expecting a difference in the baseline preoperative characteristics between the patients undergoing LTG and OTG, we planned a PS matching analysis for confounding adjustment. To model the optimal PS, our study team consisting of surgeons who were experts of endoscopic surgery, clinical epidemiologists, and biostatisticians identified the preoperative information related to the decision making by the surgeon as to whether open surgery or laparoscopic surgery would be performed. As a result, covariates for PS estimation included patient's age, sex, body mass index (BMI), American Society of Anesthesiologist (ASA) physical status, comorbidity,

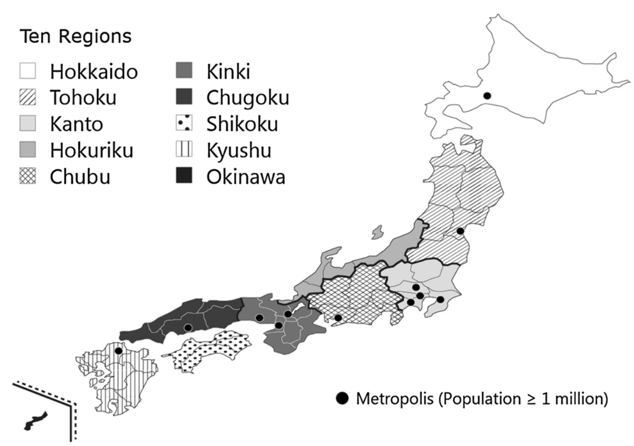

Fig. 1 Ten geographical regions of Japan and twelve metropolitan areas. To select representative hospital from all over Japan, the stratified random sampling was performed. Adjusting for hospital volume, types and location, the prospective cohort was developed in the present study

tumor depth (T), node metastasis (N), and distant metastasis (M) as clinical diagnostic factors according to 7th edition of the American Joint Committee on Cancer TNM classification, histological type on biopsy, the history of preoperative treatment, and surgical factors including the presence of concomitant cholecystectomy/splenectomy, reconstruction approach. As not all data components were collected routinely in the NCD system, we added them as survey variables collected for the purposes of conducting this study.

During the 1-year period from August 2014 to July 2015, we identified 2494 patients undergoing total gastrectomy within our system who met the study enrollment criteria: 1569 undergoing OTG and 925 undergoing LTG. After PS matching, 512 patients each in the LTG and OTG groups were included in the final analyses.

Endpoints

The primary endpoints were postoperative morbidity and mortality. Secondary endpoints included length of operative time, amount of blood loss, the number of harvested lymph node, incidence of switches to open surgery from LTG, re-operation and re-admission, and length of postoperative hospital stay.

Statistical analysis

We tabulated the proportion of patients with the baseline characteristic variables listed above for those undergoing OTG versus LTG, using means and medians for continuous variables and proportions for categorical variables. After excluding a small portion of patients who had missing baseline characteristic factors, we modeled the PS for being treated laparoscopically using multivariable logistic regression models from the variables as listed previously, separately in 4 different yearly case-volume facility groups of <10, 10–19, 20–29, and 30 and above. This was done as we suspected a different familiarity with procedure, and to balance the proportion of patients treated at different volume groups in the matched cohort. We conducted a greedy nearest neighbor matching within the volume groups with a caliper of 0.2 standard deviation of the logit (PS) at a 1:1 ratio without replacement, using macro by Coca-Perraillon [15], and combined the matched cases into one cohort. We assessed the difference in the distribution of the confounding factors before and after PS matching using standardized differences estimated using the macro by Yang and Dalton [16].

In the matched cohort, we compared the occurrences of the study endpoints between those undergoing LTG and OTG. Pearson's χ^2 test or Fisher's exact test was used as appropriate for the comparison of categorical variables, and Wilcoxon rank sum test was used for comparing continuous variables. All statistical tests were two-sided, and p values less than 0.05 were considered significant. All analyses were conducted using SAS 9.4 (SAS Institute Inc., Cary, NC).

Results

Patient characteristics

Patient baseline characteristics of each treatment group are shown in Table 1. The OTG group included a higher proportion of high-risk patients with an ASA physical status of 3 or above, or those with an emergent surgical indication. In addition, there were a considerably greater number of patients with advanced clinical staging in the OTG group, with more than half of the patients having $\geq$ T3 invasion, and lymph node metastasis. Preoperative chemotherapy and combined resection of other organs, such as the spleen and gallbladder, was much more common in OTG patients. Preoperative endoscopic resection was more common in the LTG group. There were no substantial differences in age, BMI, or histological findings of the biopsy specimen between the two groups. LTG was more frequently performed at high-volume hospitals rather than low-volume hospitals.

We excluded a small number of patients with unknown TNM classification or with missing baseline variables, and modeled the PS in 2390 patients. The four propensity models had *c*-statics ranging from 0.84 to 0.86 showing good discrimination between the two treatment groups. After combining the matched cases into one cohort, all baseline variables included in the model were well balanced within the standardized difference below 0.1 (Table 1).

Morbidity and mortality

A comparison of primary endpoints between the two procedure groups is shown in Table 2. The overall morbidity was observed in 84 (16.4%) cases in the OTG and 54 (10.5%) cases in the LTG groups ($p=0.01$). The incidence of anastomotic leakage was not significantly different between the two groups (OTG 6.1% vs. LTG 5.3%, $p=0.59$). The incidence of pancreatic fistula grade B or above was also not significantly different between the two groups (OTG 3.7% vs. LTG 2.7%, $p=0.38$). There were no significant differences between the two groups regarding surgical site infection, intraabdominal abscess, wound dehiscence, mechanical bowel obstruction, pneumonia, pulmonary embolism, and sepsis.

With respect to mortality, there were no significant differences in the 30-day and in-hospital mortality rates between the two groups (OTG 0.4% vs. LTG 0.2%, $p=0.56$; OTG 0.4% vs. LTG 0.4%, $p=1.00$, respectively).

Table 1 Baseline characteristics before and after propensity score matching

		All patients ($n=2494$)					Propensity-matched patients ($n=1024$)				
		OTG ($n=1569$)	%	LTG ($n=925$)	%	Standardized difference	OTG ($n=512$)	%	LTG ($n=512$)	%	Standardized difference
Age	< 65	445	28.4	282	30.5	0.06	145	28.3	147	28.7	0.03
	65–75	623	39.7	370	40.0		204	39.8	209	40.8	
	75 <	501	31.9	273	29.5		163	31.8	156	30.5	
Sex	Male	1182	75.3	684	73.9	0.03	378	73.8	383	74.8	−0.02
	Female	387	24.7	241	26.1		134	26.2	129	25.2	
ASA-PS	1,2	1367	87.1	864	93.4	−0.21	467	91.2	467	91.2	0
	3,4,5	202	12.9	61	6.6		45	8.8	45	8.8	
BMI	<18.5	215	13.7	110	11.9	0.08	56	10.9	60	11.7	0.03
	18.5=<BMI<25	1058	67.4	617	66.7		351	68.6	349	68.2	
	BMI=>25	291	18.5	196	21.2		105	20.5	103	20.1	
Weight loss 10%<		131	8.3	22	2.4	−0.27	15	2.9	18	3.5	0.03
Comorbidities	DM with insulin	44	2.8	29	3.1	0.02	18	3.5	19	3.7	0.01
	Respiratory	29	1.8	9	1.0	−0.07	5	1.0	5	1.0	0
	COPD	113	7.2	45	4.9	−0.1	30	5.9	29	5.7	−0.01
	Hypertension	590	37.6	339	36.6	−0.02	199	38.9	192	37.5	−0.03
	Angina	23	1.5	6	0.6	−0.08	6	1.2	5	1.0	−0.02
	Dialysis	11	0.7	5	0.5	−0.02	3	0.6	2	0.4	−0.03
	Steroid	15	1.0	11	1.2	0.02	5	1.0	5	1.0	0
	Bleeding disorder	69	4.4	39	4.2	−0.01	21	4.1	23	4.5	0.02
Emergency		29	1.8	0	0.0	−0.19	0	0.0	0	0.0	0
Concomitant surgery	Cholecystectomy	185	11.8	17	1.8	−0.46	73	14.3	74	14.5	0.01
	Splenectomy	423	27.0	90	9.7	−0.4	18	3.5	15	2.9	−0.03
Preoperative chemotherapy		171	10.9	41	4.4	−0.24	41	8.0	38	7.4	−0.02
Clinical T	Tis	0	0.0	2	0.2	1.15					0.05
	1a	52	3.3	115	12.4		43	8.4	47	9.2	
	1b	155	9.9	409	44.2		126	24.6	126	24.6	
	2	229	14.6	154	16.6		117	22.9	116	22.7	
	3	535	34.1	133	14.4		126	24.6	125	24.4	
	4a	534	34.0	96	10.4		96	18.8	92	18.0	
	4b	52	3.3	6	0.6		4	0.8	6	1.2	
	X	12	0.8	10	1.1						

Table 1 (continued)

		All patients (*n* = 2494)					Propensity-matched patients (*n* = 1024)				
		OTG (*n* = 1569)	%	LTG (*n* = 925)	%	Standardized difference	OTG (*n* = 512)	%	LTG (*n* = 512)	%	Standardized difference
Clinical N	N0	662	42.2	714	77.2	0.77	329	64.3	328	64.1	0.03
	N1	400	25.5	112	12.1		91	17.8	96	18.8	
	≥ N2	486	31.0	93	10.1		92	18.0	88	17.2	
	NX	21	1.3	6	0.6						
Clinical M	0	1461	93.1	901	97.4	0.34	477	93.2	481	93.9	0.04
	1	108	6.9	24	2.6		27	5.3	23	4.5	
Clinical stage	0	0	0.0	2	0.2	1.18					0.17
	IA	185	11.8	505	54.6		156	30.5	165	32.2	
	IB	155	9.9	141	15.2		93	18.2	99	19.3	
	IIA	260	16.6	83	9.0		79	15.4	75	14.6	
	IIB	311	19.8	63	6.8		79	15.4	57	11.1	
	IIIA	248	15.8	49	5.3		35	6.8	47	9.2	
	IIIB	191	12.2	34	3.7		35	6.8	34	6.6	
	IIIC	85	5.4	12	1.3		8	1.6	12	2.3	
	IV	108	6.9	24	2.6		27	5.3	23	4.5	
	X	26	1.7	12	1.3						
Histological findings of biopsy specimen	Well	730	46.5	474	51.2	0.18	259	50.6	259	50.6	0.04
	Poor	574	36.6	305	33.0		183	35.7	60	11.7	
	Mixed type	206	13.1	117	12.6		58	11.3	178	34.8	
	Others	59	3.8	29	3.1		12	2.3	15	2.9	
Reconstruction	R–Y	1504	95.9	855	92.4	0.10	487	95.1	483	94.3	0.03
	Other	65	4.1	70	7.6		25	4.9	29	5.7	
Yearly volume	< 10	210	13.4	87	9.4		57	11.3	57	11.3	
	10–19	523	33.3	258	27.9		159	31.5	159	31.5	
	20–29	463	29.5	273	29.5		145	28.8	145	28.8	
	30 and above	373	23.8	307	33.2		151	30.0	151	30.0	

OTG open total gastrectomy, *LTG* laparoscopic total gastrectomy, *ASA-PS* American Society of Anesthesiologists physical status

Table 2 Morbidity, mortality, and surgical outcomes

OTG ($n = 512$)		(%)	LTG ($n = 512$)	(%)	p value
Overall postoperative morbidity	84	16.4	54	10.3	0.01
Superficial SSI	13	2.5	7	1.4	0.18
Deep SSI	2	0.4	3	0.6	1.00
Intraabdominal abscess	24	4.7	20	3.9	0.54
Anastomotic leakage	31	6.1	27	5.3	0.59
Pancreatic fistula (Grade B,C)	19	3.7	14	2.7	0.38
Wound dehiscence	1	0.2	0	0.0	1.00
Mechanical bowel obstruction	2	0.4	7	1.4	0.18
Pneumonia	16	3.1	12	2.3	0.44
Pulmonary embolism	2	0.4	1	0.2	1.00
Sepsis	18	3.5	11	2.1	0.18
Mortality within 30 days	2	0.4	1	0.2	0.56
In-hospital mortality	2	0.4	2	0.4	1.00
Re-admission within 30 days	21	4.1	12	2.3	0.11
Re-operation within 30 days	15	2.9	22	4.3	0.24
Operating time (min), median (percentile range 10–90)	254 (178–369)		352 (255–517)		< 0.001
Blood loss (ml), median (percentile range 10–90)	342 (100–961)		80 (10–460)		< 0.001
The number of harvested lymph node, median (percentile range 10–90)	39 (11–71)		41 (15–69)		0.03
Length of postoperative stay (days), median (percentile range 10–90)	14 (9–35)		13 (8–31)		0.002

OTG open total gastrectomy, *LTG* laparoscopic total gastrectomy, *SSI* surgical site infection

Secondary endpoints

The LTG groups had significantly longer operating times (median, 352 vs. 254 min, $p < 0.001$) and significantly lower blood loss (median blood loss, 80 vs. 342 ml, $p < 0.001$) than the OTG group. A total of 7 (1.4%) patients in the LTG group needed to switch to open surgery caused by intraoperative accident. There was no significant difference in the incidence of reoperations within 30 days after initial operation between the two groups (OTG 2.9% vs. LTG 4.3%, $p = 0.24$). With regard to reoperations due to anastomotic leakage or drainage, there was also no significant difference between the two groups (OTG 2.0% vs. LTG 2.9%, $p = 0.31$). The number of harvested lymph node in the LTG group was slightly larger than that in the OTG group (median number, 39 vs. 37, $p = 0.03$).

The LTG group had significantly shorter postoperative stay than the OTG group (median, 13 vs. 14 days, $p = 0.002$). There was no significant difference in the incidence of re-admission within 30 days after initial discharge between the two groups (OTG 4.1% vs. LTG 2.3%, $p = 0.11$).

Discussion

In the present study, based on the data from a Japanese nationwide web-based database, we assessed the feasibility of LTG for gastric cancer with regard to the surgical outcomes. The overall morbidity and 30-day mortality rates in propensity score-matched LTG and OTG groups were 10.5, 0.2% and 16.4, 0.4%, respectively. We also have demonstrated the minimal invasiveness of LTG through the evaluations of secondary endpoints. These results from our nationwide database, which is most likely representative of the Japanese healthcare provision, support the usefulness of LTG for the treatment of gastric cancer.

There were several unique characteristics to our study design. First, as the data registered in the NCD are used for the surgical board certification in Japan, we believe the data registration to be highly accurate and with near-complete coverage of all the procedures performed at the facilities. Second, in addition to the variables routinely recorded in the current NCD system, we prospectively collected some additional variables for this particular research, i.e., variables associated with surgeon's decision making for the allocation of open or laparoscopic surgery, such as preoperative TNM stage. Third, stratified random sampling was performed based on hospital capacity and regional/metropolitan level to recruit patients who are representative of Japan as a whole. The study design enabled us to compare LTG and OTG using a PS that has good clinical persuasiveness. In this cohort, LTG was more likely to be performed for patients with earlier stage lesions including T1 and N0 lesions compared to those undergoing OTG. This suggests that the indication of LTG for gastric cancer is being considered carefully by Japanese surgeons at this moment.

Consequently, our matched population included predominantly early-stage cancer patients, and our results are mainly applicable to these patients.

Many studies have previously shown postoperative morbidity and mortality rates of gastrectomy for gastric cancer [8–11, 17, 18]. They found morbidity and mortality rates for open gastrectomy to be at 17.4–24.5% and 0.6–0.8%, respectively, with examples of independent risk factors including age, combined resection, BMI, and operation time [19–22]. Among these reports, however, few have mentioned these rates for total gastrectomy alone. In a recent study for developing a risk model for total gastrectomy using NCD data, the ASA score was one of the most important variables affecting morbidity and mortality [12]. In our study, even after baseline variables such as age, combined resection with spleen for lymph node dissection, BMI, and ASA included in the model were balanced, morbidity and mortality rates in LTG were favorable compared to that in OTG. Furthermore, re-admission and re-operation rates did not differ between the LTG and OTG groups. We believe that when collectively evaluated, these data support the safety, feasibility, and minimal invasiveness of LTG for gastric cancer compared to OTG.

Among the postoperative morbidities in total gastrectomy, anastomotic leakage is one of the main causes of operative or in-hospital mortality. Esophagojejunostomy in LTG is technically demanding, and previous retrospective studies have shown that the incidence of anastomotic leakage in LTG was high ranging from 0 to 7.4% [8–10, 17, 23]. A national survey conducted by the Japan Society of Endoscopic Surgery also showed the incidence of anastomotic leakage to be 6.1% [3]. In our study, the incidence of anastomotic leakage in LTG was 5.3% and that in OTG was 6.1%. While the assessment of different types of esophagojejunostomy was outside the scope of our study, recent development in the anastomotic procedure, both in regard to surgical techniques and surgical instruments which enable protection of deep organs in the cavity, may have played a role in lowering the incidence of postoperative morbidities in LTG cases [23–26]. Development of useful devices or establishment of standard techniques in anastomosis might lead to the expansion of the indication of LTG and shortening of its operation time in the near future.

The present study had several limitations. First, because the study was not an RCT, the comparisons of outcome incidences between the two groups may be confounded by the differences in the baseline characteristics of the patients. We tried to minimize the effect of confounding by carefully constructing the PS from variables that our study team predetermined to affect the choice of the surgical approach and by using a matching method for balancing the factors. However, residual confounding unmeasured factors may remain. Second, our dataset might include some heterogeneity in the surgical techniques used in the procedure. No data were collected on the details of the surgical techniques including the use of energy devices, the type of staplers for anastomosis, and 2 or 3 dimensional visions of laparoscopy, which may influence the results of the study to a certain degree. Lastly, data on patients' long-term outcomes could not be obtained in the current study. More studies are needed to evaluate the comparative safety and effectiveness of the LTG vs. OTG on long-term clinical outcomes.

Conclusions

The results from our comprehensive nationally representative data analysis showed that LTG could be a safe procedure for gastric cancer compared to OTG. The indication for LTG should be evaluated thoroughly in the clinical setting.

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Compliance with ethical standards

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References

1. Kitano S, Iso Y, Moriyama M et al (1994) Laparoscopy-assisted Billroth I gastrectomy. Surg Laparosc Endosc 4:146–148
2. Japanese Gastric Cancer Association (2017) Japanese gastric cancer treatment guidelines 2014 (ver. 4).Gastric Cancer 20(1):1–19. https://doi.org/10.1007/s10120-016-0622-4
3. Etoh T, Inomata M, Shiraishi N et al (2013) Minimally invasive approaches for gastric cancer-Japanese experiences. J Surg Oncol 107:282–288
4. Memon MA, Khan S, Yunus RM et al (2008) Meta-analysis of laparoscopic and open distal gastrectomy for gastric carcinoma. Surg Endosc 22(8):1781–1789
5. Katai H, Mizusawa J, Katayama H et al (2016) Short-term surgical outcomes from a phase III study of laparoscopy-assisted versus open distal gastrectomy with nodal dissection for clinical stage IA/IB gastric cancer: Japan Clinical Oncology Group Study JCOG0912. Gastric Cancer. https://doi.org/10.1007/s10120-016-0646-9
6. Kim W, Kim HH, Han SU et al (2016) Decreased morbidity of laparoscopic distal gastrectomy compared with open distal

gastrectomy for stage I gastric cancer: short-term outcomes from a multicenter randomized controlled trial (KLASS01). Ann Surg 263(1):28–35
7. Hu Y, Huang C, Sun Y et al (2016) Morbidity and mortality of laparoscopic versus open D2 distal gastrectomy for advanced gastric cancer: a randomized controlled trial. J Clin Oncol 34(12):1350–1357
8. Sakuramoto S, Kikuchi S, Futawatari N et al (2009) Laparoscopy-assisted pancreas- and spleen-preserving total gastrectomy for gastric cancer as compared with open total gastrectomy. Surg Endosc 23:2416–2423
9. Jeong O, Jung MR, Kim GY et al (2013) Comparison of short-term surgical outcomes between laparoscopic and open total gastrectomy for gastric carcinoma: case control study using propensity score matching method. J Am Coll Surg 216:184–191
10. Lee MS, Lee JH, Park DJ et al (2013) Comparison of short- and long-term outcomes of laparoscopic assisted total gastrectomy and open total gastrectomy in gastric cancer patients. Surg Endosc 27:2598–2605
11. Xiong JJ, Nunes QM, Huang Wei et al (2013) Laparoscopic vs open total gastrectomy for gastric cancer: a meta-analysis. World J Gastroenterol 19(44):8114–8132
12. Watanabe M, Miyata H, Gotoh M et al (2014) Total gastrectomy risk model: data from 20,011 Japanese patients in a nationwide internet-based database. Ann Surg 260(6):1034–1039
13. Kurita N, Miyata H, Gotoh M et al (2015) Risk model for distal gastrectomy when treating gastric cancer on the basis of data from 33,917 Japanese patients collected using a nationwide web-based data entry system. Ann Surg 262(2):295–303
14. Hiki N, Honda M, Etoh T et al (2017) Higher incidence of pancreatic fistula in laparoscopic gastrectomy. Real-world evidence from a nationwide prospective cohort study. Gastric Cancer. http://doi.org/10.1007/s10120-017-0764-z
15. Coca-Perraillon M (2007) Local and Global Optimal Propensity Score Matching. SAS Global Forum 2007 Paper, pp 185–2007
16. Yang DDJ (2012) A unified approach to measuring the effect size between two groups using SAS. @ SAS Global Forum paper pp 335–2012
17. Lee JH, Ahn SH, Park DJ et al (2012) Laparoscopic total gastrectomy with D2 lymphadenectomy for advanced gastric cancer. World. J Surg 36(10):2394–2399
18. Haverkamp L, Weijs TJ, van der Sluis PC et al. (2013) Laparoscopic total gastrectomy versus open total gastrectomy for cancer: a systematic review and meta-analysis. Surg Endosc 27(5):1509–1520
19. Kim MC, Kim W, Kim HH et al. (2008) Risk factors associated with complication following laparoscopy-assisted gastrectomy for gastric cancer: a large-scale Korean multicenter study. Ann Surg Oncol 15(10):2692–2700
20. Kodera Y, Sasako M, Yamamoto S et al (2005) Identification of risk factors for the development of complications following extended and superextended lymphadenectomies for gastric cancer. Br J Surg 92(9):1103–1109
21. Park DJ, Lee HJ, Kim HH et al (2005) Predictors of operative morbidity and mortality in gastric cancer surgery. Br J Surg 92(9):1099–1102
22. Katai H, Yoshimura K, Fukagawa T et al (2005) Risk factors for pancreas-related abscess after total gastrectomy. Gastric Cancer 8(3):137–141
23. Okabe H, Obama K, Tanaka E et al (2009) Intracorporeal esophagojejunal anastomosis after laparoscopic total gastrectomy for patients with gastric cancer. Surg Endosc 23:2167–2171
24. Uyama I, Sugioka A, Fujita J et al. (1999) Laparoscopic total gastrectomy with distal pancreatosplenectomy and D2 lymphadenectomy for advanced gastric cancer. Gastric Cancer 2(4):230–234
25. Kunisaki C, Makino H, Oshima T et al. (2011) Application of the transorally inserted anvil (OrVil) after laparoscopy-assisted total gastrectomy. Surg Endosc 25(4):1300–1305
26. Nunobe S, Hiki N, Tanimura S et al (2011) Three-step esophagojejunal anastomosis with atraumatic anvil insertion technique after laparoscopic total gastrectomy. J Gastrointest Surg 15(9):1520–1525