Surg Endosc (2017) 31:2651–2660
DOI 10.1007/s00464-016-5279-x

Effect of comorbidities on postoperative complications in patients with gastric cancer after laparoscopy-assisted total gastrectomy: results from an 8-year experience at a large-scale single center

Jia-Bin Wang[1] · Chao-Hui Zheng[1] · Ping Li[1] · Jian-Wei Xie[1] · Jian-Xian Lin[1] · Jun Lu[1] · Qi-Yue Chen[1] · Long-Long Cao[1] · Mi Lin[1] · Chang-Ming Huang[1]

Received: 10 September 2016 / Accepted: 4 October 2016 / Published online: 14 October 2016
© Springer Science+Business Media New York 2016

Abstract
Background Comorbidity is a predictor of postoperative complications in gastrectomy. However, it remains unclear which comorbidities are predictors of postoperative complications in gastric cancer patients who have undergone laparoscopy-assisted total gastrectomy (LATG). The purpose of this study was to evaluate the effect of comorbidities on the surgical outcomes of patients with gastric cancer after LATG.
Methods We retrospectively collected data on 1657 gastric cancer patients who underwent LATG between January 2008 and December 2015. We investigated the incidences, types, and risk factors for postoperative complications after LATG. Patients were enrolled in analysis to evaluate the effects of comorbidities on postoperative complications.
Results The number of postoperative complications was associated with the number of comorbidities in the gastric cancer patients according to the operative period. Of the 1657 patients included in this study, 714 (43.1 %) had one or more comorbidities. Postoperative complications occurred in 283 patients (17.1 %), and 6 patients (0.4 %) died during hospitalization. With an increasing number of comorbidities, the incidence of local and systemic complications also increased. Univariate and multivariate analyses revealed that comorbidity was a predictive risk factor for local complications (OR 1.204, 1.014–1.431) and systemic complications (OR 1.237, 1.039–1.474). Diabetes mellitus, anemia, pulmonary disease, and renal dysfunction were found to be associated with postoperative complications, including abdominal bleeding, anastomotic leakage, and pneumonia.
Conclusions Our study has revealed that comorbidities could be a predictive risk factor for postoperative complications after LATG. Surgeons should carefully assess patients with full perioperative attention to some specific types of comorbidities.

Keywords Gastric cancer · Laparoscopy · Gastrectomy · Complications

The use of laparoscopy-assisted total gastrectomy (LATG) is not yet widespread, although laparoscopic techniques have been used to perform gastrectomy for gastric cancer since 1994 [1]. Many gastric surgeons have the preconceived notion that LATG is technically difficult and associated some severe complications, such as anastomotic leakage and anastomotic bleeding. Postoperative complications negatively affect patient quality of life and can even be life-threatening. Identification of risk factors for postoperative complications might help to reduce such complications.

Comorbidity has also been identified as a predictive risk factor for postoperative complications. With improvements in individuals' qualities of life and increased life expectancy, the proportions of older or obese patients diagnosed with gastric cancer have increased over the past several decades. This has resulted in a larger number of patients living with comorbid diseases, including hypertension, heart disease, and diabetes mellitus. More than half of cancer patients have comorbid conditions, and this figure increases to more than 60 % among patients aged 70 years [2, 3]. This increased number of patients with

✉ Chang-Ming Huang
hcmlr2002@163.com

[1] Department of Gastric Surgery, Fujian Medical University Union Hospital, No. 29 Xinquan Road, Fuzhou 350001, Fujian Province, China

comorbidities has raised concern regarding the influences of these comorbidities on postoperative complications following gastric cancer surgery.

It is important to understand the effects of different types of comorbidities on surgical outcome in patients who underwent LATG, because precise preoperative assessment of patients with comorbidities enables tailored surgery and proper perioperative management to reduce the postoperative complications and mortality. This study aimed to evaluate the effect of comorbidities on the occurrence of postoperative complications in gastric cancer patients after LATG with D2 lymph node dissection based on an established database after overcoming the LATG learning curve.

Materials and methods

Patients

This study was a retrospective analysis of a database of 1657 primary gastric cancer patients treated with LATG at the Department of Gastric Surgery of Fujian Medical University Union Hospital, Fuzhou, China, between January 2008 and December 2015. The patient demographics, underlying diseases, clinicopathological findings, surgery data, and data on preoperative and postoperative monitoring were recorded in a clinical data system for gastric cancer surgery. Staging was performed according to the 7th edition of the UICC TNM classification. [4].

The inclusion criteria were as follows: histologically confirmed carcinoma of the stomach, and no evidence of invasion of tumors into adjacent organs (pancreas, spleen, liver, and transverse colon), para-aortic lymph node enlargement, or distant metastasis, as demonstrated by abdominal computed tomography (CT) and/or abdominal ultrasound and posteroanterior chest radiographs. The exclusion criteria were as follows: intraoperative evidence of peritoneal dissemination, invasion of adjacent organs, or distant metastasis; conversion to open laparotomy; total gastrectomy for remnant gastric cancer; total gastrectomy for palliative operation; receipt of preoperative chemotherapy; and incomplete pathological data. Written informed consent was obtained from all patients prior to performing surgery. The Ethics Committee of Fujian Medical University Union Hospital approved this retrospective study and supervised the procedures, and all of the patients included in this study gave their consent. In principle, D2 lymph node dissection was adopted for cT2–T4a disease, whereas modified D2 lymph node dissection was used for cT1 cancer, according to the guidelines of the Japanese Research Society for Gastric Cancer [1], as reported in detail in our previous study [5–7]. In this study, D2 lymph node dissection during LATG was performed with spleen preservation. All operations were performed by one surgeon (Prof. Chang-Ming Huang) who has considerable experience with performing laparoscopic gastrectomy (LG); this surgeon performed over 500 gastric cancer surgeries each year and was considered to have mastered LG (defined as treatment of over 50 cases) before the study period.

Definitions

All gastric cancer patients underwent preoperative venous blood analysis [including hemoglobin (HB) and serum biochemical assays], electrocardiography, pulmonary function testing, etc. The results of these examinations were retrieved from the patients' electronic medical records. As abdominal obesity may occur more frequently in Asians than in non-Asians, the International Obesity Task Force has recommended a BMI cutoff of 25.0 kg/m^2 for obesity in Asians [8]. Elderly was defined as 70 years of age or older, in line with previous studies demonstrating that an age of greater than 70 years is an independent predictor of increased rates of postoperative complications and in-hospital mortality and a longer hospital stay [9]. Patients who had a history of receiving medical treatments for a disease were considered to have a comorbid condition. Anemia was defined as a serum HB concentration of less than 9.0 g/dl [10, 11], and hypoalbuminemia was defined as a serum albumin concentration of less than 3.0 g/dl. Complications occurring in association with a surgical technique performed near the operative field, such as the wound or intra-abdominal cavity, were considered local complications, whereas those not associated with the operative field were considered systemic complications. Postoperative mortality was defined as death of a patient in the hospital due to complications. Patients were observed for 30 days following surgery, and short-term surgical outcomes, including the operative time, estimated blood loss (EBL), postoperative complications, number of dissected lymph nodes, and clinicopathological characteristics, were recorded in a clinical database system. The cutoff value of operative time, blood loss, and total size is according to the average value.

Statistical analysis

The statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 18.0 for Windows (SPSS Inc., Chicago, IL, USA). Continuous data were reported as the mean ± SD and coded as categorical data. Correlations of complications with comorbidities or operative quantity were assessed by Spearman correlation analysis. Postoperative complications after LATG were analyzed by ANOVA. In univariate analysis,

the risk factors for postoperative complication and the incidence of postoperative complication according to comorbidities were analyzed by the Chi-square test or Fisher's exact test. Multivariate analysis was performed using binary logistic multiple regression tests using dummy variables. P value of <0.05 was considered statistically significant.

Results

Complications associated with comorbidities and operative quantity

The numbers of complications and comorbidities and the operative quantities were 11/33/62, 20/52/116, 12/85/159, 22/88/210, 47/121/278, 43/86/238, 54/94/247, and 74/182/347 for each year from 2008 to 2015, respectively (Fig. 1). The number of complications tended to change as the number of comorbidities and operative quantity changed according to the operative period. In addition, Spearman correlation analysis revealed that the number of complications was correlated with the number of comorbidities ($r = 0.090$, $P = 0.014$), as well as with the operative quantity ($r = 0.094$, $P < 0.001$).

Clinicopathological characteristics of the patients

Of the 1657 gastric cancer patients included in this study, 714 (43.1 %) had one or more comorbidities; the most common comorbidity was hypertension, which was present in 388 patients (23.4 %) (Table 1). The mean patient age was 62.09 ± 10.90 years, and the average BMI was 22.13 ± 3.01 kg/m^2. Modified D2 lymph node dissection was performed for 159 patients (9.6 %), and D2 lymph node dissection was performed for 1498 patients (90.4 %). The average surgery time was 192.39 ± 52.46 min. The average blood loss was 83.21 ± 126.53 ml, and the average number of dissected lymph nodes was 36.08 ± 14.41.

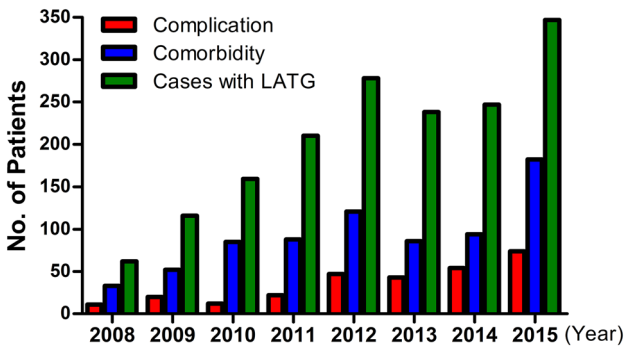

Fig. 1 Complications, comorbidities, and operative quantity during 2008–2015

Postoperative morbidity and mortality

Table 2 shows the observed morbidities for all of the gastric cancer patients. Postoperative complications occurred in 283 patients (17.1 %). Local complications were observed in 175 patients (10.5 %), and systemic complications were detected in 161 (9.7 %). With an increasing number of comorbidities, the overall incidence of local and systemic complications significantly increased ($P < 0.05$). Among the local complications, the incidences of abdominal bleeding, anastomotic leakage, and abdominal infection were significantly increased along with an increased number of comorbidities ($P < 0.05$). Further, among the systemic complications, only the incidence of pneumonia was elevated along with an increased number of comorbidities ($P < 0.05$). Six patients (0.4 %) died following surgery before the 30th postoperative day. The following causes of death were noted: anastomotic leakage and pancreatic fistula (1 patient); anastomotic leakage, pneumonia, and cerebral infarction (1 patient); severe abdominal infection and pneumonia (1 patient); splenic infarction, pancreatic fistula, and abdominal bleeding (1 patient); Ileus (1 patient), and disseminated intravascular coagulation (DIC) (1 patient). However, the incidence of postoperative mortality did not differ between the groups ($P > 0.05$).

Predictive factors for postoperative complications

Table 3 shows the results of univariate analyses of the possible risk factors for the development of complications. The following five factors were associated with an increased risk of overall complications: number of comorbidities, age, BMI, EBL, and operative time, which were also associated with local and systemic complications. Multivariate analysis revealed that the number of comorbidities, age, BMI, EBL, and operative time were independent risk factors for total complications. Further, the no. of comorbidities was an independent predictive risk factor for the occurrence of local and systemic complications. In addition, the BMI and EBL were independent predictive risk factors for the development local complications, while age and operative time were independent predictive risk factors for the development of systemic complications (Table 4).

Because the presence of comorbidities was found to be an independent predictive factor, we further investigated the impact of each type of comorbidities on the development of postoperative complications (Table 5). Multivariate binary logistic regression analyses revealed that diabetes mellitus and renal dysfunction were significantly associated with local complications ($P < 0.05$), while diabetes mellitus, pulmonary disease, and anemia were

Table 1 Comorbidity index in patients with LATG

Comorbidity	No. of patients ($n = 1657$) (%)
Types of comorbidity	741 (44.7)
Hypertension	388 (23.4)
Diabetic mellitus	166 (10.1)
Heart disease (coronary atherosclerotic heart disease, arrhythmia, etc.)	84 (5.1)
Pulmonary disease (COPD, asthma, pneumonia, etc.)	104 (6.3)
CNS disease (cerebrovascular disease, neurodegenerative disease, etc.)	25 (1.5)
Liver disease (cirrhosis, hepatitis, etc.)	49 (3.0)
Renal disease (CKD, nephritis, etc.)	14 (0.8)
Anemia	236 (14.2)
Hypoalbuminemia	109 (6.6)
Hyperthyroidism	6 (0.4)
No. of comorbidities	
0	916 (55.3)
1	429 (25.9)
2	217 (13.1)
≥3	95 (5.7)

COPD chronic obstructive pulmonary disease, *CKD* chronic kidney disease

Table 2 Postoperative complications after LATG

Outcomes	No. of patients ($N = 1647$)	No. of comorbidities				*P*
		0	1	2	≥3	
Local complications	175	78	52	30	15	0.016
Wound infection	30	15	11	2	2	0.433
Chylous leak	32	14	12	4	2	0.474
Anastomotic bleeding	10	3	5	1	1	0.282
Abdominal bleeding	17	6	3	6	2	0.026
Duodenal stump fistula	6	3	3	0	0	0.472
Anastomotic leakage	37	13	10	9	5	0.015
Pancreatic fistula	6	2	3	1	0	0.516
Ileus	21	11	3	5	2	0.316
Abdominal infection	45	21	8	13	3	0.014
System complications	161	73	43	22	23	<0.001
Pneumonia	136	63	35	19	19	<0.001
Arrhythmia	4	1	1	1	1	0.296
Transient liver enzyme abnormalities	7	3	3	0	1	0.424
Urinary tract infection	12	6	2	2	2	0.377
Sepsis	6	3	2	0	1	0.531
Catheter-related infection	3	1	2	0	0	0.430
DIC	4	2	1	1	0	0.877
Cardiac failure	2	1	1	0	0	0.841
Thrombus disease	3	0	1	1	1	0.084
Mortality	6	2	1	2	1	0.277

significantly associated with systemic complications ($P < 0.05$). Further, we assessed which specific comorbidities had effects on the 10 major complications. A total of 166 patients with diabetes mellitus were at high risk of complications, including anastomotic bleeding, abdominal bleeding, anastomotic leakage, and pneumonia. In addition, 236 patients with anemia were at high risk of abdominal bleeding, anastomotic leakage, and pneumonia, and 104

Table 3 Univariate analysis of risk factors for postoperative complication

Variable	No. of patients ($N = 1657$)	Total complication		Local complication		System complication	
		$N = 283$	P	$N = 175$	P	$N = 161$	P
Gender			0.857		0.547		0.961
Male	1289	219		133		125	
Female	368	64		42		36	
Age (years)			<0.001		0.034		<0.001
<70	1236	180		119		96	
≥70	421	103		56		65	
BMI (kg/m^2)			<0.001		<0.001		0.046
<25	1397	218		129		127	
≥25	260	65		46		34	
No. of comorbidities			<0.001		0.016		<0.001
0	916	127		78		73	
1	429	82		52		43	
2	217	42		30		22	
≥3	95	32		15		23	
Operative time (min)			0.001		0.033		0.004
≤192	949	138		87		75	
>192	708	145		88		86	
EBL (ml)			0.002		0.006		0.018
≤82	1144	173		105		98	
>82	513	110		70		63	
Tumor size (mm)			0.878		0.654		0.118
<53	930	160		101		81	
≥53	727	123		74		80	
Lymphadenectomy			0.394		0.549		0.473
Modified D2	159	31		19		18	
D2	1498	252		156		143	
No. of resected LNs			0.577		0.733		0.302
<15	29	5		4		2	
15–30	549	103		62		64	
31–45	723	114		70		64	
>45	356	61		39		31	
Tumor location			0.351		0.098		0.531
Upper	692	114		69		68	
Middle	558	90		57		44	
≥2 areas	407	79		49		49	
T stage			0.231		0.069		0.473
T1	211	45		33		18	
T2	171	30		16		21	
T3	563	85		52		49	
T4a	712	123		74		73	
N stage			0.743		0.762		0.170
N0	482	76		51		36	
N1	242	46		30		23	
N2	289	50		28		35	
N3	644	111		66		67	
TNM stage			0.433		0.094		0.504
Ia	178	38		28		15	

Table 3 continued

Variable	No. of patients ($N = 1657$)	Total complication		Local complication		System complication	
		$N = 283$	P	$N = 175$	P	$N = 161$	P
Ib	120	17		11		10	
IIa	191	26		12		18	
IIb	176	28		22		11	
IIIa	199	34		17		24	
IIIb	306	59		35		35	
IIIc	487	81		50		48	
Smocking			0.739		0.388		0.831
Yes	482	80		46		48	
No	1175	203		129		113	
Drinking			0.557		0.269		0.616
Yes	119	18		9		10	
No	1538	265		166		151	

Table 4 Multivariate analysis of risk factors for postoperative complication

Variables	Total complication			Local complication			System complication		
	OR	95 %CI	P	OR	95 %CI	P	OR	95 %CI	P
Age (≥70 vs. <70 years)	1.648	1.229–2.211	0.001	1.250	0.868–1.801	0.231	1.874	1.305–2.691	0.001
BMI (≥25 vs. <25 kg/m^2)	1.665	1.205–2.301	0.002	1.966	1.355–2.851	<0.001	1.363	0.901–2.061	0.142
No. of comorbidities (1, 2, ≥3 vs. 0)	1.237	1.074–1.425	0.003	1.204	1.014–1.431	0.024	1.237	1.039–1.474	0.017
Operating time (>192 vs. ≤192 min)	1.382	1.052–1.814	0.020	1.253	0.900–1.745	0.182	1.493	1.058–2.107	0.023
EBL (>82 vs. ≤82 ml)	1.366	1.229–2.211	0.030	1.423	1.013–1.999	0.042	1.304	0.915–1.856	0.143

Table 5 Impact of each type of comorbidity on postoperative complication using multivariate analysis

Variables	Local complication			System complication		
	OR	95 %CI	P	OR	95 %CI	P
Hypertension	1.077	0.737–1.574	0.700	1.140	0.775–1.645	0.506
Diabetic mellitus	1.946	1.236–3.065	0.004	1.730	1.077–2.781	0.023
Heart disease	0.824	0.391–1.738	0.611	1.097	0.549–2.192	0.794
Pulmonary disease	0.850	0.430–1.682	0.641	1.941	1.123–3.354	0.017
CNS disease	0.602	1.133–2.715	0.509	2.087	0.744–5.854	0.162
Liver disease	1.859	0.887–3.894	0.101	0.999	0.383–2.609	0.999
Renal dysfunction	4.292	1.361–13.530	0.013	0.607	0.076–4.861	0.638
Anemia	1.337	0.866–2.063	0.190	1.687	1.099–2.589	0.018
Hypoalbuminemia	1.136	0.611–2.112	0.686	1.015	0.541–1.903	0.963
Hyperthyroidism	1.471	0.163–13.530	0.731	1.583	0.175–14.326	0.683

patients with pulmonary disease were at high risk of pneumonia. Moreover, this analysis showed that renal dysfunction was associated with anastomotic leakage and abdominal infection (Table 6). Finally, a slight association between hyperthyroidism and ileus was detected; however, the rate of this comorbidity was very low. No correlations were detected between the remainder of the comorbidities and the major complications.

Discussion

The size of the geriatric population will continue to increase dramatically over the next decade, and the number of elderly patients with gastric cancer will correspondingly increase. Moreover, in China, dietary changes favoring western eating habits appear to have resulted in an increased rate of obesity. Patients with a high BMI or old

Table 6 Incidence of postoperative complication according to comorbidities

Comorbidity	No. of cases ($n = 1657$)	Local complication									
		Wound infection ($n = 32$)	Chylous leak ($n = 30$)	Anastomotic bleeding ($n = 10$)	Abdominal bleeding ($n = 17$)	Duodenal stump fistula ($n = 6$)	Anastomotic leakage ($n = 37$)	Pancreatic fistula ($n = 6$)	Ileus ($n = 21$)	Abdominal infection ($n = 45$)	Pneumonia ($n = 136$)
Hypertension	388	4 (1.0)	10 (2.6)	1 (0.3)	5 (1.2)	2 (0.5)	13 (3.4)	1 (0.3)	5 (1.3)	13 (3.4)	40 (10.3)
Diabetic mellitus	166	4 (2.4)	6 (3.6)	4* (2.4)	5* (3.0)	0 (0)	6 (3.6)	1 (0.6)	3 (1.8)	9* (5.4)	24* (14.5)
Heart disease	84	0 (0)	1 (1.2)	1 (1.2)	1 (1.2)	1 (1.2)	3 (3.6)	0 (0)	1 (1.2)	3 (3.6)	8 (9.5)
Pulmonary disease	104	2 (1.9)	2 (1.9)	0 (0)	1 (1.0)	0 (0)	3 (2.9)	2 (1.9)	2 (1.9)	2 (1.9)	16* (15.4)
CNS disease	25	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (4.0)	0 (0)	1 (4.0)	0 (0)	4 (16.0)
Liver disease	49	2 (4.1)	1 (2.0)	1 (2.0)	0 (0)	0 (0)	1 (2.0)	0 (0)	4* (8.2)	2 (4.1)	5 (10.2)
Renal disease	14	0 (0)	1 (7.1)	1* (7.1)	0 (0)	0 (0)	2* (14.3)	0 (0)	2 (14.3)	2* (14.3)	1 (7.1)
Anemia	236	6 (2.5)	4 (1.7)	2 (0.8)	7* (3.0)	0 (0)	11* (4.7)	1 (0.4)	0 (0)	9 (3.8)	28* (11.9)
Hypoalbuminemia	109	4 (3.7)	3 (2.8)	0 (0)	2 (1.8)	0 (0)	4 (3.7)	0 (0)	1 (0.9)	4 (3.7)	11 (10.1)
Hyperthyroidism	6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1* (16.7)	0 (0)	1 (16.7)

Values in parentheses are percentages, which depict the proportion of patients who developed the respective complication in the presence of the respective comorbidity

* $P < 0.05$: chance of developing a complication in the presence of the respective comorbidity versus the chance of developing a complication in the absence of comorbidity

age have increased incidences of comorbidities, including hypertension, heart disease, and renal disease. Thus, the increasing number of patients with comorbidities has raised concern regarding the influences of these comorbidities on surgery outcomes following cancer surgery. The knowledge of the effects of comorbidities is important for minimizing the incidence of postoperative complications. However, few studies have examined the impacts of comorbidities on early postoperative outcome after laparoscopic surgical resection for the treatment of gastric cancer. In two previous studies, Korean surgeons have demonstrated that the presence of comorbidities influences the rate of surgical complications in gastric cancer patients after LADG [12, 13]. However, LATG is more difficult to perform than LADG, which need more extended lymphadenectomy and esophagojejunostomy. LATG also has its specific complications, such as anastomotic leakage, anastomotic bleeding, and duodenal stump fistula. It remains unclear which comorbidities are predictors of these complications. Inokuchi et al. [14] reported that comorbidity is a predictor of postoperative complications in LAG, However, only 14.7 % of the patients in their study underwent LATG, and 14.6 % received D2 lymph node dissection. The surgical procedure used to treat gastric cancer patients is quite different from that used in our study. To date, no studies examining the impacts of comorbidities on postoperative complications in patients who have undergone LATG with D2 lymph node dissection have been conducted. Thus, the primary objective of our study was to identify the comorbidities associated with postoperative complications in patients treated with LATG. Identification of these specific comorbidities might facilitate the improvement of treatment strategies for gastric cancer.

The morbidity rate for laparoscopic surgery has been recently reported to vary from 11.0 to 25.3 % [15–17]. In this study, postoperative complications occurred in 283 patients (17.1 %). The anastomotic leakage and abdominal infection were the most frequent local complications observed, in contrast to previous reports [12, 13]. However, pneumonia was only systemic complication affected by the presence of comorbidities. In our study, we found that the presence of diabetes mellitus resulted in the highest risks of most types of complications. However, Hwang et al. [18] reported that diabetes mellitus is not associated with postoperative complications after gastrectomy. Some surgeons have suggested that strict preoperative diabetic control by diabetologists for approximately 2 weeks in patients with severe diabetes mellitus might result in a favorable postoperative course [14]. At our hospital, the preoperative blood sugar levels were maintained at normal levels in the gastric cancer patients with diabetes mellitus, but the period of management for most patients with diabetes mellitus was less than 1 week. The preoperative HbA1c levels in some of the patients with diabetes mellitus were even above normal. This may be the reason that the presence of diabetes mellitus resulted in the highest risks of most types of complications. Increased focus should be placed on the sufficient preoperative preparation of patients with diabetes mellitus in the future. COPD is the main cause of pulmonary disease, which is a risk factor for postoperative pulmonary complications after non-thoracic surgery [19]. Preoperative breathing exercises might have contributed to the low incidence of pulmonary complications. However, most of our patients were instructed to perform breathing exercises outside of the hospital due to the high patient volume and rapid bed turnover in our hospital. It was difficult to monitor each patient's condition, and some patients did not cooperate with the doctor's advice. For these patients, more rigorous preoperative preparation should be arranged during hospitalization. In addition, several studies have reported that the use of pneumoperitoneum during laparoscopic surgery causes an increase in intra-abdominal cavity pressure and carbon dioxide absorption from the peritoneal cavity, leading to pulmonary complications in patients with pulmonary functional impairment [20]. Therefore, the use of low-pressure pneumoperitoneum may be preferable for patients with a pulmonary comorbidity. Cancer-related anemia commonly occurs in AGC patients, which is typically multifactorial and could contribute to chronic blood loss, malnutrition, and abnormalities in the immune response, as well as in metabolite homeostasis. Some studies have indicated that perioperative anemia in malignancy has been associated with increased rates of morbidity and mortality [21]. In our study, we defined anemia as HB < 9.0 g/dl. Preoperative anemia increased the risks of 3 primary complications, including abdominal bleeding, anastomotic leakage and pneumonia. Transfusion is an effective treatment method for anemia, and it has been shown to reduce the rate of anemia-related postoperative complications. However, transfusion itself has some adverse effects, including pulmonary complications, graft versus host disease, and transmission of infectious diseases. Ansari et al. [22] proposed that using the HB level as an indicator for transfusion could reduce blood utilization. At our hospital, patients were transfused according to their statuses, including their vital signs and evidence of bleeding, not according to their HB levels. Approximately 60 % of preoperative patients with HB < 9.0 g/dl received blood transfusion. The mean volume of blood transfused was 873.83 ± 553.66 ml. The abdominal bleeding and anastomotic leakage may have been due to the poor preoperative nutritional statuses of the patients with an HB level of <9.0 g/dl. It is difficult to improve patient's condition in a short perioperative period. In addition, the high volume of

blood transfused may have promoted the development of postoperative pneumonia. We will ensure that blood transfusions are performed for patients with HB <9.0 g/dl to reduce the volume of blood transfused later in the preoperative period. Another important comorbidity is renal disease. The incidence of renal disease, and that of chronic kidney disease (CKD) in particular, is increasing as the population worldwide is aging [23]. Renal dysfunction remains a major risk factor because it is related not only to metabolic and coagulopathic disorders secondary to uremia and anuria but also to other comorbidities. Immune response deficiency is common in patients with CKD, and humoral immune defense is often compromised. Matsumoto et al. [24] recommended that surgeons should minimize operative blood loss and the surgery duration to reduce postoperative complications despite their efforts in intensive preoperative management. Thus, we suggest that limited surgery should be considered for patients with renal disease.

In conclusion, the results of our study suggest that patient comorbidities could be a predictive risk factor for surgical complications after LATG. Surgeons should carefully assess patients with full perioperative attention to some specific types of comorbidities. However, some shortcomings of this study need to be noted. The results were based on a retrospective analysis of the clinical data at a large-scale single institution. There are not universal and cannot be applicable for all hospitals and surgeons. A large multicenter data will be necessary to collect, which evaluate the effect of comorbidities on the surgical outcomes in patients after LATG.

Acknowledgments The authors are thankful to Fujian Medical University Union Hospital for her management of our gastric cancer patient database.

Funding This study was funded by the National Key Clinical Specialty Discipline Construction program of China (No. [2012]649) and the Key Projects of Science and Technology Plan of Fujian Province (No. 2014Y0025).

Compliance with ethical standards

Disclosures Drs. Jia-Bin Wang, Chao-Hui Zheng, Ping Li, Jian-Wei Xie, Jian-Xian Lin, Jun Lu, Qi-Yue Chen, Long-Long Cao, Mi Lin, and Chang-Ming Huang have no conflicts of interest or financial ties to disclose.

References

1. Kitano S, Iso Y, Moriyama M, Sugimachi K (1994) Laparoscopy-assisted Billroth I gastrectomy. Surg Laparosc Endosc 4:146–148
2. Oohara T, Johjima Y, Yamamoto O, Tohma H, Kondo Y (1984) Gastric cancer in patients above 70 years of age. World J Surg 8:315–320
3. Takeda J, Tanaka T, Koufuji K, Kodama I, Tsuji Y, Kakegawa T (1994) Gastric cancer surgery in patients aged at least 80 years old. Hepatogastroenterology 41:516–520
4. Sobin LH, Compton CC (2010) TNM seventh edition: what's new, what's changed: communication from the international union against cancer and the american joint committee on cancer. Cancer 116:5336–5339
5. Wang JB, Huang CM, Zheng CH, Li P, Xian JW, Lin JX (2012) Laparoscopic spleen-preserving No. 10 lymph node dissection for advanced proximal gastric cancer in left approach: a new operation procedure. World J Surg Oncol 10:241
6. Chen RF, Huang CM, Chen QY, Zheng CH, Li P, Xie JW, Wang JB, Lin JX, Lu J, Cao LL, Lin M (2015) Why the proximal splenic artery approach is the ideal approach for laparoscopic suprapancreatic lymph node dissection in advanced gastric cancer? A large-scale vascular-anatomical-based study. Med (Baltimore) 94:e832
7. Huang CM, Chen QY, Lin JX, Zheng CH, Li P, Xie JW (2014) Huang's three-step maneuver for laparoscopic spleen-preserving No. 10 lymph node dissection for advanced proximal gastric cancer. Chin J Cancer Res 26:208–210
8. Consultation WHOE (2004) Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet 363:157–163
9. Polanczyk CA, Marcantonio E, Goldman L, Rohde LE, Orav J, Mangione CM, Lee TH (2001) Impact of age on perioperative complications and length of stay in patients undergoing noncardiac surgery. Ann Intern Med 134:637–643
10. Carless PA, Henry DA, Carson JL, Hebert PP, McClelland B, Ker K (2010) Transfusion thresholds and other strategies for guiding allogeneic red blood cell transfusion. Cochrane Database Syst Rev. doi:10.1002/14651858.CD002042.pub2
11. Hare GM, Baker JE, Pavenski K (2011) Assessment and treatment of preoperative anemia: continuing professional development. Can J Anaesth 58:569–581
12. Kim W, Song KY, Lee HJ, Han SU, Hyung WJ, Cho GS (2008) The impact of comorbidity on surgical outcomes in laparoscopy-assisted distal gastrectomy: a retrospective analysis of multicenter results. Ann Surg 248:793–799
13. Choi YS, Park DJ, Lee HJ, Kim HH, Yang HK, Lee KU (2011) Laparoscopy-assisted distal gastrectomy for gastric cancer patients with comorbid diseases: is it contraindicated for patients with systemic comorbidity? Surg Laparosc Endosc Percutaneous Tech 21:33–36
14. Inokuchi M, Kato K, Sugita H, Otsuki S, Kojima K (2014) Impact of comorbidities on postoperative complications in patients undergoing laparoscopy-assisted gastrectomy for gastric cancer. BMC Surg 14:97
15. Lee JH, Park do J, Kim HH, Lee HJ, Yang HK (2012) Comparison of complications after laparoscopy-assisted distal gastrectomy and open distal gastrectomy for gastric cancer using the Clavien–Dindo classification. Surg Endosc 26:1287–1295
16. Miki Y, Tokunaga M, Tanizawa Y, Bando E, Kawamura T, Terashima M (2014) Perioperative risk assessment for gastrectomy by surgical Apgar score. Ann Surg Oncol 21:2601–2607
17. Jeong O, Ryu SY, Choi WY, Piao Z, Park YK (2014) Risk factors and learning curve associated with postoperative morbidity of laparoscopic total gastrectomy for gastric carcinoma. Ann Surg Oncol 21:2994–3001
18. Hwang SH, Park DJ, Jee YS, Kim HH, Lee HJ, Yang HK, Lee KU (2009) Risk factors for operative complications in elderly patients during laparoscopy-assisted gastrectomy. J Am Coll Surg 208:186–192
19. McAlister FA, Bertsch K, Man J, Bradley J, Jacka M (2005) Incidence of and risk factors for pulmonary complications after nonthoracic surgery. Am J Respir Crit Care Med 171:514–517

20. Hsieh CH (2003) Laparoscopic cholecystectomy for patients with chronic obstructive pulmonary disease. J Laparoendosc Adv Surg Tech A 13:5–9
21. Leichtle SW, Mouawad NJ, Lampman R, Singal B, Cleary RK (2011) Does preoperative anemia adversely affect colon and rectal surgery outcomes? J Am Coll Surg 212:187–194
22. Ansari S, Szallasi A (2012) Blood management by transfusion triggers: when less is more. Blood Transfus 10:28–33
23. Imai E, Horio M, Iseki K, Yamagata K, Watanabe T, Hara S, Ura N, Kiyohara Y, Hirakata H, Moriyama T, Ando Y, Nitta K, Inaguma D, Narita I, Iso H, Wakai K, Yasuda Y, Tsukamoto Y, Ito S, Makino H, Hishida A, Matsuo S (2007) Prevalence of chronic kidney disease (CKD) in the Japanese general population predicted by the MDRD equation modified by a Japanese coefficient. Clin Exp Nephrol 11:156–163
24. Matsumoto S, Takayama T, Wakatsuki K, Tanaka T, Migita K, Nakajima Y (2014) Short-term and long-term outcomes after gastrectomy for gastric cancer in patients with chronic kidney disease. World J Surg 38:1453–1460