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REVIEW ARTICLE

A prediction model for potential intraoperative laparoscopic hemostasis in spleen-preserving No. 10 lymphadenectomy for proximal gastric cancer

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Scoring system

Summary To identify the risk factors for intraoperative laparoscopic hemostasis during laparoscopic spleen-preserving splenic hilar lymph node dissection (LSPSD) for proximal gastric cancer (GC) and to develop and validate a model to estimate the risk of intraoperative laparoscopic hemostasis.

Between January 2011 and December 2014, we prospectively collected and retrospectively analyzed the medical records of 398 patients with proximal GC who underwent LSPSD. The data were split 75/25, with one group used for model development and the other for validation testing.

Of the 398 patients enrolled in this study, 174 (43.7%) required laparoscopic hemostasis treatment. A multivariate analysis determined that the risk factors for the model group were gender, preoperative N stage, and terminal branches of the splenic artery (SpA), and each factor contributed 1 point to the risk score. The intraoperative laparoscopic hemostasis rates

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were 11.5%, 33.6%, 58.5%, and 73.5% for the low-, intermediate-, high-, and extremely high-risk categories, respectively ($p < 0.001$). Blood loss volume (BLV) and operative time (in min) for LSPSD increased significantly ($p < 0.001$) as the risk increased. The area under the receiver operating characteristic curve for the intraoperative laparoscopic hemostasis score was 0.700. The observed and predicted incidence rates were parallel for intraoperative laparoscopic hemostasis in the validation set.

This simple, efficient scoring system using the factors for gender, preoperative N stage, and terminal SpA branches can accurately predict the risk of intraoperative laparoscopic hemostasis during LSPSD to improve surgical safety.

1. Background

For advanced proximal gastric cancer (GC), the No. 10 lymph node (LN) is a crucial link in lymphatic drainage. The 14th edition of the Japanese GC treatment guidelines indicates that a D2 lymphadenectomy is the standard procedure for advanced GC, and the No. 10 LN should be dissected to treat advanced proximal GC. In recent years, as the concept of preserving viscera function and the use of minimally invasive technology have been accepted by more clinicians, laparoscopic spleen-preserving splenic hilar lymph node dissection (LSPSD) has become a valuable treatment option, and its use has gradually increased. In our preliminary study and the related literature, the procedure indicates favorable, safe, and feasible short-term outcomes.[1] However, the No. 10 LN is located in a narrow but deep space. Because it covers more fascial tissue, adequately exposing the splenic hilar area is difficult. In addition, splenic vessels are rich in this area, and their branches are complex. Therefore, when performing LSPSD, we must often perform laparoscopic hemostasis because vascular injury occurs frequently during surgery.[2,3] Laparoscopic hemostasis is difficult because its frequency can affect the operation and extend this already lengthy surgery, subsequently reducing the surgeon's confidence. In recent years, laparoscopic hemostasis has gained value among increasing clinicians. To our knowledge, no studies have identified the risk factors for intraoperative laparoscopic hemostasis during LSPSD for proximal GC. The present study identified these risk factors and used them to develop a scoring system for predicting intraoperative laparoscopic hemostasis.

2. Materials and methods

2.1. Materials

This study retrospectively analyzed a prospectively collected database of proximal GC patients treated with LSPSD in the Department of Gastric Surgery of Fujian Medical University Union Hospital, Fuzhou, China, between January 2011 and December 2014. The inclusion criteria were (1) histologically confirmed primary adenocarcinoma in the upper- or middle-third stomach; (2) no evidence of tumors invading the adjacent organs (pancreas, spleen, liver, or transverse colon), enlargement or integration of the para-aortic or No. 10 LNs, or distant metastasis demonstrated by preoperative abdominal computed tomography (CT), abdominal ultrasound or endoscopic ultrasound; and (3) a total gastrectomy plus D2 lymphadenectomy with curative R0 resection based on postoperative pathological diagnosis. The exclusion criteria were patients with T4b tumors, incomplete clinicopathological data, intraoperative evidence of peritoneal dissemination or distant metastasis, or gastric stump carcinoma. In total, 398 patients (302 men and 96 women) were included, with a mean age of 60.76 ± 10.58 years. The preoperative size, location, T stage (with or without serosal invasion) and N stage (with or without lymph node metastasis) of the neoplasm were assessed in all patients by an upper digestive endoscopy with biopsy, chest X-ray, total abdominal ultrasound, and abdominopelvic CT scan. Preoperative comorbidities were described per the American Society of Anesthesiologists' classification system.[4] CT scans and multislice-spiral CT angiography were performed to preoperatively assess the splenic vascular anatomy. Blood loss volume (BLV; mL) of the splenic LNs was estimated by the number of the gauze blocks and the trip attraction of the aspirator. A piece of two-by-two gauze is equivalent to 4 mL of blood, and patients required a blood transfusion if the total blood loss was greater than 800 mL during the operation (No patients required a blood transfusion during the operation in this study.) The patient demographics, underlying diseases, clinicopathology, surgery, and preoperative and postoperative monitoring data were recorded in a clinical data system for GC surgery. The surgical resection type (i.e., distal subtotal gastrectomy, proximal subtotal gastrectomy, or total gastrectomy) and extent of the LN dissection were selected based on the Japanese GC treatment guidelines.[5] The resected specimens were examined histopathologically and staged as per the 7th edition of the Union for International Cancer Control (UICC) tumor node metastasis (TNM) classification.[6] Data were randomly divided into two subsets using SPSS version 18.0 (SPSS, Chicago, IL, USA) to create a 75/25 split, with one subset divided into either the no vascular injury group (NVIG) or laparoscopic hemostasis group (LPHG). One subset was used for model development and the other for validation testing.

The Research Ethical Committee at the authors' institution reviewed the research proposal. All procedures were performed after obtaining written informed consent from the patients after explaining the surgical and oncological risks.

2.2. Definition of laparoscopic hemostasis and the pattern of terminal branches of the SpA

Laparoscopic hemostasis is a vascular injury requiring compression with laparoscopic instruments or gauze, clipping with an absorbed or titanium clip, or laparoscopic ligation during LSPSD without conversion to open laparotomy or splenectomy.

Based on a previous study,[7] terminal branches are usually defined by the distance between the artery's furcation to the splenic hilar region, including the distributed and concentrated SpA types. The concentrated-type SpA always divides into its terminal branches within 2 cm from the splenic hilum. The splenic hilum artery trunk (SpAT) is long, while the splenic lobar arteries (SLAs) are short and centralized. Conversely, the distributed-type SpA generally divides into its terminal branches more than 2 cm from the splenic hilum. Its branches are long and smaller in caliber, always accompanying the splenic pole artery (SPoA).

2.3. Follow-up

Postoperative follow-ups were performed by trained investigators through mailings, telephone calls, home visits or outpatient services. Most patients routinely underwent physical examinations, laboratory tests (including CA19-9, CA72-4, and CEA levels), chest radiography, abdominal US or CT, and annual endoscopic examinations. Overall survival (OS) was calculated from the day of surgery until death or until the final follow-up date in June 2016, whichever occurred first.

2.4. Statistical analysis

Continuous data are reported as the mean $\pm$ SD, and the differences between the groups were analyzed using t-tests. Categorical data are presented as proportions and percentages and were analyzed using the chi-square test or Fisher's exact test. The variables in the model reaching $p < 0.05$ in the univariate analysis were subsequently included in a multivariate binary logistic regression model. Those variables that remained significant in the multivariate analysis were used to construct a scoring system to classify patients into groups based on their risk for laparoscopic hemostasis. The multivariate analysis results were expressed as odds ratios (ORs) with corresponding 95% confidence intervals (95% CIs). A goodness-of-fit test was conducted to assess how well the model discriminated between patients who did and did not experience laparoscopic hemostasis. Receiver operating characteristic (ROC) and area under the curve (AUC) analyses were used to determine the adequacy of the prediction model. Values of 0.7 and higher were considered clinically useful.[8] The model was internally validated using the validation set. The model calibration, or the degree to which the observed outcomes were similar to those predicted by the model across patients, was examined by comparing the observed averages with the predicted averages within each subgroup arranged in increasing order of patient risk. Values of $p < 0.05$ were considered statistically significant. The statistical analyses were performed using SPSS version 18.0 (SPSS, Chicago, IL, USA).

3. Results

3.1. Clinicopathological characteristics of the patients in the model development group (MDG) and validation testing group (VTG)

The 299 patients in the MDG included 226 men and 73 women with a mean age of 60.94 $\pm$ 10.36 years. The patients' average body mass index (BMI) was 21.98 $\pm$ 2.71 kg/m^2. The MDG patients' preoperative information was similar to that of the VTG patients, which was comparable (Table 1).

Table 2 summarizes the patients' intraoperative and postoperative clinicopathological characteristics. We found that the number of metastasizing LNs, blood loss volume (BLV) of the splenic LNs and number of vascular clamps used for the splenic hila were significantly greater in the LPHG than in the NVIG. Additionally, the operation time (in min) for the No. 10 LN dissection was significantly longer in the LPHG.

Postoperative complications were observed in 49 patients (16.4%). Complications in the LPHG were similar to those in the NVIG ($p = 0.073$). However, abdominal chyle leakage was significantly greater in the LPHG than in the NVIG ($p = 0.004$) (Table 3).

3.2. Incidence rates of intraoperative vascular injury requiring laparoscopic hemostasis and columns of vascular injury

Of the 398 patients, 174 (43.7%) suffered a vascular injury requiring laparoscopic hemostasis. Those requiring laparoscopic hemostasis had the highest incidence of short gastric vascular injury (Table 4).

3.3. Univariate and multivariate analyses associated with intraoperative laparoscopic hemostasis

Table 5 shows the results of the univariate and multivariate analyses of the possible risk factors for laparoscopic hemostasis. Five factors were associated with an increased risk of laparoscopic hemostasis, including age ($p = 0.032$), gender ($p < 0.001$), preoperative N stage ($p < 0.001$), preoperative albumin ($p = 0.029$), and terminal SpA branches ($p = 0.003$). A multivariate analysis identified gender (OR $=$ 2.983, $p < 0.001$), preoperative N stage (OR $=$ 3.417, $p < 0.001$), and terminal SpA branches (OR $=$ 2.206, $p = 0.003$) as adverse risk factors for laparoscopic hemostasis.

Table 1 Comparison of preoperative information for the LPHG and NVIG.

Variables	MDG				VTG	p
	LPHG%	NVIG%		Total%	Total %	
	n = 136	n = 163	P	n = 299	n = 99	
Age (years)	62.30 ± 8.17	59.80 ± 11.79	0.032	60.94 ± 10.36	60.23 ± 11.24	0.78
Gender			0.001			0.812
Male	115	111		226	76	
Female	21	52		73	23	
BMI (kg/m^2)	22.08 ± 3.00	21.90 ± 2.44	0.557	21.98 ± 2.71	22.23 ± 2.53	0.856
Longitudinal location			0.378			0.054
Upper	54	74		128	45	
Middle	73	83		156	54	
Multiple lesions	9	6		15	0	
Cross-sectional location			0.67			0.273
Greater curvature	13	15		28	7	
Lesser curvature	101	111		212	73	
Anterior wall	5	11		16	9	
Backwall	14	20		34	10	
Complete cycle	3	6		9	0	
Tumour size (cm)	5.62 ± 2.91	5.20 ± 2.76	0.206	5.39 ± 2.83	5.33 ± 2.54	0.621
Preoperative T stage			0.821			0.776
With serosal invasion	40	46		86	27	
Without serosal invasion	96	117		213	72	
Preoperative N stage			<0.001			0.162
N0	50	104		154	59	
N+	86	59		145	40	
Accompanying diseases			0.178			0.537
Yes	42	39		81	30	
No	94	124		218	69	
Previous upper abdominal surgery			0.822			1
Yes	3	3		6	1	
No	133	160		293	98	
Preoperative Charlson score			0.573			0.685
0	96	123		219	71	
1–2	38	37		75	26	
≥3	2	3		5	2	
ASA score			0.826			0.836
1	91	110		201	70	
2	39	48		87	26	
3	6	5		11	3	
Preoperative (ALB)	38.98 ± 4.44	40.07 ± 4.09	0.029	39.58 ± 4.28	40.16 ± 4.45	0.495
Preoperative (HB)	123.88 ± 24.27	124.64 ± 21.96	0.777	124.29 ± 23.00	127.71 ± 24.85	0.334
Terminal branches of the SpA			0.003			0.433
Concentrated type	82	124		206	64	
Distributed type	54	39		93	35	
Neoadjuvant chemotherapy			0.183			0.124
Yes	13	9		22	3	
No	123	154		277	96	

BMI: body mass index; SpA: splenic artery; MDG: model development group; VDG: validation testing group; LPHG: laparoscopic hemostasis group; NVIG: no vascular injury group; ASA: American Society of Anesthesiologists; ALB: albumin; HB: hemoglobin.

3.4. Laparoscopic hemostasis scoring system

Despite the differences in regression coefficients for laparoscopic hemostasis, which ranged from 0.791 to 1.229, for simplicity, 1 point was assigned for each risk factor. The resulting gender, preoperative N stage, and terminal SpA branch (GNT) scores were obtained for laparoscopic hemostasis. Because there were 3 risk factors, the following four risk groups were established: low risk (0 points, i.e., no risk factors); intermediate risk (1 point, i.e., one risk factor); high risk (2 points, i.e., two risk factors); and extremely high risk (3 points, i.e., three risk factors). The patients were distributed according to the scoring system as follows: low risk, 8.7%; intermediate risk, 38.8%;

Table 2 Comparison of intraoperative and postoperative information for the LPHG and NVIG.

Variables	LPHG%	NVIG%	p-value
	n = 136	n = 163	
No. of positive LNs	9.32 ± 11.90	6.09 ± 8.96	0.009
No. of retrieved LNs	42.19 ± 14.20	42.94 ± 15.69	0.67
No. of positive No. 10 LNs	0.18 ± 0.64	0.21 ± 0.77	0.75
No. of retrieved No. 10 LNs	2.44 ± 1.96	2.76 ± 2.29	0.203
No. 10 LNs metastasis			0.614
No	122	149	
Yes	14	14	
BLV(mL) of splenic LNs	28.13 ± 19.28	12.77 ± 10.23	<0.001
Operation time (min) for No. 10 LNs	25.41 ± 8.55	20.85 ± 7.95	<0.001
No. of vascular clamps used for the splenic hilus	11.46 ± 3.65	8.89 ± 2.42	<0.001
Spleen adhesion	45	57	0.733
Branch points of SpA			0.967
Division above the pancreas	130	155	
Division along pancreas	4	5	
Division between the hilar and pancreatic tail	2	3	
Type of SpA			0.657
Single branch SpA	7	9	
2-branched SpA	116	135	
3-branched SpA	12	19	
Multiple-branched SpA	1	0	
Polar artery of the spleen			
No.of SUPA	28	44	0.197
No.of SLPA	13	22	0.292
No.of SGA			0.44
<4	59	78	
≧4	77	85	
No.of PGA			0.184
0	37	56	
1	99	107	
Histology			0.711
Differentiated	78	90	
Undifferentiated	58	73	
Day of first flatus, d	4.35 ± 1.41	3.95 ± 1.00	0.005
Day of first fluid diet, d	4.98 ± 2.19	4.76 ± 1.87	0.357
Day of first semifluid diet, d	8.70 ± 4.68	8.41 ± 4.37	0.582
Postoperative hospital stay, d	13.09 ± 6.78	12.81 ± 6.82	0.722

BLV: blood loss volume; SpA: splenic artery; SUPA: splenic upper polar artery; SLPA: splenic lower polar artery; SGA: short gastric artery; PGA: posterior gastric artery; LPHG: laparoscopic hemostasis group; NVIG: no vascular injury group; LN: lymph node.

high risk, 41.1%; and extremely high risk, 11.4%. The laparoscopic hemostasis incidence rates among patients in the low-, intermediate-, high-, and extremely high-risk categories were 11.5%, 33.6%, 58.5%, and 73.5%, respectively. The relative risks of laparoscopic hemostasis in the intermediate-, high-, and extremely high-risk groups compared with the low-risk group were 3.45 (95% CI, 0.973–12.233, $p = 0.055$); 10.824 (95% CI, 3.084–37.985, $p < 0.001$); and 21.296 (95% CI, 5.127–88.465, $p < 0.001$), respectively (Table 6). With the increased risk, both the BLV and operation time (in min) for No. 10 LN dissection increased significantly ($p < 0.001$) (Figs. 1–3).

3.5. Survival analysis

The median follow-up period was 33 months (range, 18–66). The OS did not significantly differ between the LPHG and NVIG ($P = 0.165$) (Fig. 4). The OS for patients in the low-risk category was significantly higher than that for patients in the high-risk ($p = 0.012$) and extremely high-risk groups ($p = 0.021$) (Fig. 5).

3.6. Discrimination

The area under the ROC curve was 0.700 for the simplified GNT score for laparoscopic hemostasis (Fig. 6). The observed versus predicted incidence rates in the validation set were compared to evaluate the performance of the model. The ratio of expected to observed risk for laparoscopic hemostasis was 1.19 ($x^2 = 1.09$, $P = 0.296$), indicating good calibration. The ratios of expected to observed risks for the low-, intermediate-, high-, and extremely high-risk categories in the validation set were 1.15, 1.41, 1.02, and 1.6, respectively. No statistically significant differences

Table 3 Comparison of postoperative complications for the LPHG and NVIG.

Variables	LPHG% n = 136	NVIG% n = 163	p-value
General complications	28 (9.4)	21 (7)	0.073
Pulmonary infection	14 (4.7)	8 (2.7)	0.076
Wound infection	3 (1)	5 (1.7)	0.646
Lymphatic fistula	11 (3.7)	2 (0.67)	0.004
Anastomotic fistula	2 (0.67)	3 (1)	0.804
Intraperitoneal infection	8 (2.7)	5 (1.7)	0.235
Sepsis	2 (0.67)	0 (0)	0.12
Inflammatory intestinal obstruction	4 (1.4)	4 (1.4)	0.795
Anastomotic bleeding	2 (0.67)	1 (0.33)	0.459
Clavien-Dindo classification			0.102
II	14 (4.7)	16 (5.4)	
IIIA	9 (3.0)	2 (0.67)	
IIIB	1 (0.33)	2 (0.67)	
IV	4 (1.4)	1 (0.33)	

LPHG: laparoscopic hemostasis group; NVIG: no vascular injury group.

were found among the groups (Fig. 7). Table 7 shows the performance characteristics of the validation set scores.

4. Discussion

With the increasing application of laparoscopic GC radical surgery and advancements in surgical instruments, laparoscopy for GC is becoming increasingly widespread.[9,10] Many surgeons with strong knowledge of laparoscopic technology and various laparoscopic techniques have performed laparoscopic D2 LN dissection. Laparoscopic amplification and the superior effects of ultrasonic scalpels for cutting and hemostasis allow surgeons to clearly visualize the perigastric fascia, intrafascial space, vasculature, nerves and other structures. The splenic vessels and their branches can therefore be safely exposed, and the meticulous procedure required for a No. 10 lymphadenectomy can be performed smoothly and efficiently. More clinicians are accepting the concept of LSPSD. Hyung et al published the first report on using LSPSD to treat proximal GC in 2008. A mean of 2.7 (range, 1—5) LNs per patient was found for the splenic hilar, and the effect of dissection was the same as that of open surgery.[11] However, few reports have identified the intraoperative complications during LSPSD. Bleeding and organ ischemia caused by vascular injury are the most common intraoperative complications. Intraoperative vascular injury requires laparoscopic hemostatic compression with laparoscopic instruments or gauze, clipping with an absorbed or titanium clip, or laparoscopic ligation during LSPSD, without requiring a splenectomy.[2] Therefore, exploring the risk factors of laparoscopic

Table 4 Vascular injury columns.

	vascular injury (N = 174) %
SGV	130 (32.6)
PGV	33 (8.3)
LGEV	29 (7.3)
SLV	10 (2.5)
SGV,PGV	11 (2.8)
LGEV,SGV	7 (1.8)
SGV,SLV	3 (0.75)
LGEV,PGV	1 (0.25)
LGEV,SGV,SLV	3 (0.75)

SGV: short gastric vessel; PGV: posterior gastric vessel; LGEV: left gastroepiploic vessel; SLV, splenic lobar vessel.

Table 5 Multivariate analysis associated with intraoperative laparoscopic hemostasis during LSPSD.

Variables	B	OR	95%CI	p-value	score
Gender	1.093	2.983	1.623—5.484	<0.001	1
Male					
Female					
Preoperative N stage	1.229	3.417	2.075—5.627	<0.001	1
N0					
N+					
Terminal branches of the SpA	0.791	2.206	1.298—3.751	0.003	1
Concentrated type					
Distributed type					

LSPSD: laparoscopic spleen-preserving splenic hilar lymph node dissection; SpA: splenic artery.

Table 6 GNT scoring system for intraoperative laparoscopic hemostasis during LSPSD.

Risk group	score	No. patients (n = 299%)	No. patients (n %)	OR	95%CI	p-value
Low	0	26 (8.7)	3 (11.5)	1	/	/
Intermediate	1	116 (38.8)	39 (33.6)	3.45	0.973–12.233	0.055
High	2	123 (41.1)	72 (58.5)	10.824	3.084–37.985	<0.001
Extremely high	3	34 (11.4)	25 (73.5)	21.296	5.127–88.465	<0.001

GNT: Gender, preoperative N stage, Terminal branches of the SpA; LSPSD: laparoscopic spleen-preserving splenic hilar lymph node dissection.

hemostasis and taking appropriate measures to reduce these risks is crucial. To our knowledge, no reports have identified the risk factors for intraoperative laparoscopic hemostasis during LSPSD for GC. This study is the largest retrospective study to identify the risk factors for intraoperative laparoscopic hemostasis during LSPSD. Our results showed that the rate of laparoscopic hemostasis was 43.7% and that gender, preoperative N stage, and terminal SpA branches are preoperative adverse risk factors. Preoperative patients and disease characteristic data are routinely available and can simply and effectively predict the risk of intraoperative laparoscopic hemostasis, which might have implications for selecting risk-adapted interventions to improve surgical safety. Surgical skill is strongly related to splenic hilar bleeding; thus, we believe that laparoscopic splenic hilar lymph node dissection should be performed by a physician who is highly experienced in laparoscopic surgery. Therefore, our study was performed by the same team that performed more than 2000 cases of laparoscopic gastric cancer surgery to reduce the result bias.

One interesting result of the present study was that the risk factors differed between male and female patients. Generally, abdominal operations are more difficult in men because of greater visceral obesity and reduced abdominal distension due to greater muscle mass.[12] Our study also

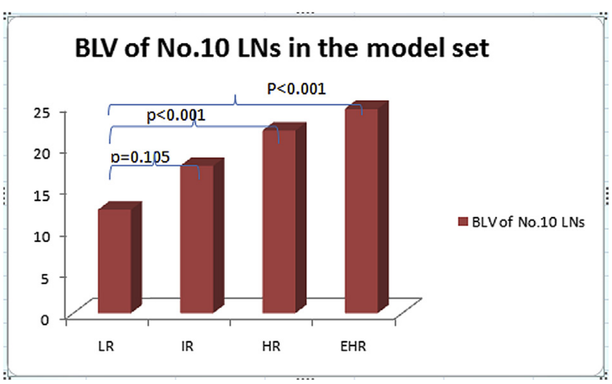

Figure 1 Association between BLV (mL) of the No. 10 LNs and the model set score (BLV: blood loss volume, LN: lymph node, LR: low-risk group, IR: intermediate risk group, HR: high-risk group, EHR: extremely high-risk group.)

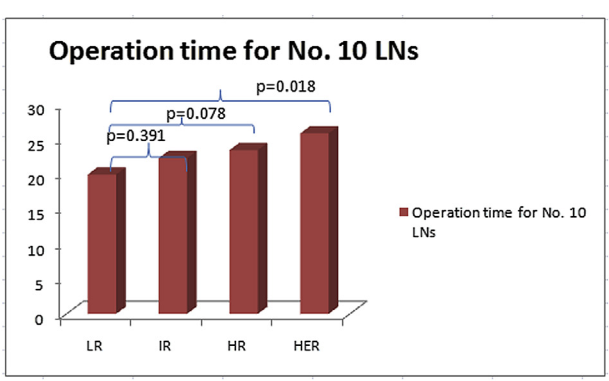

Figure 2 Association between the operation time (in min) for No. 10 LNs and score (LN: lymph node, LR: low-risk group, IR: intermediate risk group, HR: high-risk group, EHR: extremely high-risk group).

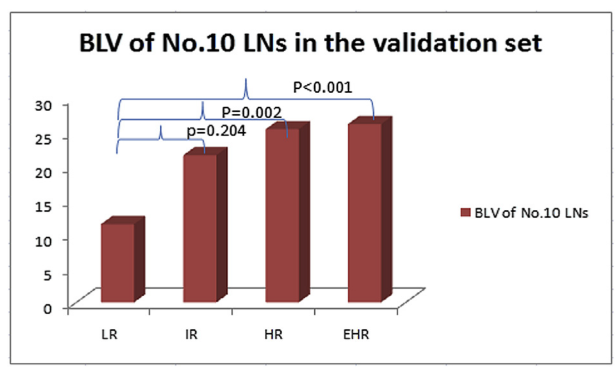

Figure 3 Association between BLV (mL) of No. 10 LNs and validation set score (BLV: blood loss volume, LN: lymph node, LR: low-risk group, IR: intermediate risk group, HR: high-risk group, EHR: extremely high-risk group).

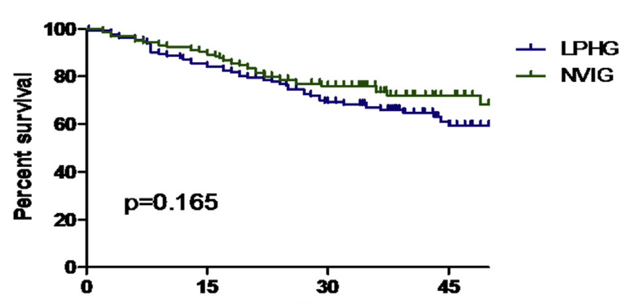

Figure 4 Overall survival of patients with LPHG and NVIG. No differences were statistically significant (P = 0.165) (LPHG: laparoscopic hemostasis group, NVIG: no vascular injury group).

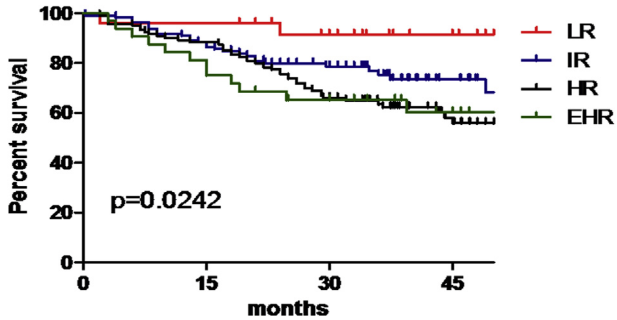

Figure 5 Overall survival of patients among the LR, IR, HR, and EHR groups (P = 0.0242) (LR: low-risk group, IR: intermediate risk group, HR: high-risk group, EHR: extremely high-risk group).

found that preoperative N+ stage was closely related to vascular injury. Patients with preoperative N+ stages generally have more LN metastases, and LNs are more difficult to dissect. Therefore, vascular injury is more likely to occur during surgery. In addition, our previous study showed that the splenic artery's complexity often influences both surgery duration and postoperative effects.[13] We suspect that three-dimensional (3D) CT reconstruction can be used preoperatively to detect the splenic vessel distribution, which can inform the surgeon of vasculature variations during surgery, thereby avoiding unnecessary injury and bleeding and thus ensuring the patient's safety during surgery. The results of this study indicate that distributed-type SpA terminal branches are adverse risk factors for intraoperative laparoscopic hemostasis during LSPSD in preoperative 3D-CT reconstruction. When the terminal SpA branches are of the concentrated type, the line of the splenic artery is shorter with a thicker diameter than that of the distributed-type SpA terminal branches,[7,14] which is advantageous for LN dissection and can shorten the operating time.

In predicting the risk of intraoperative complications from LSPSD, the results of our previous study showed that

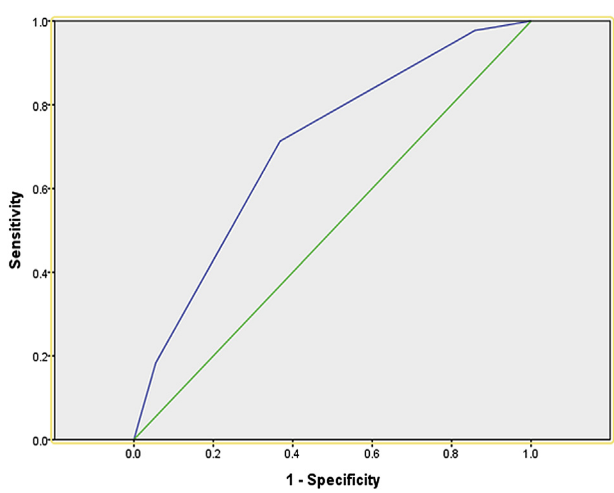

Figure 6 Receiver operating characteristic curves for predicting intraoperative laparoscopic hemostasis during LSPSD in the development sets.

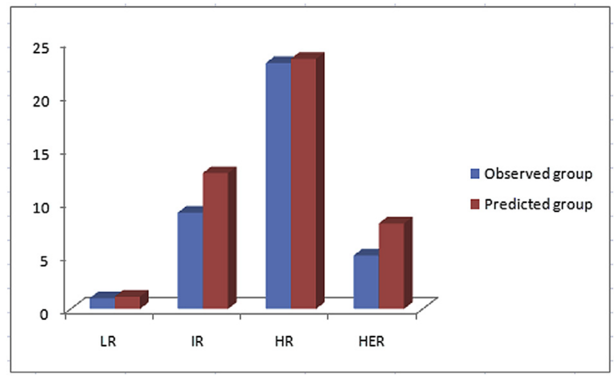

Figure 7 Observed and predicted incidence rates for intraoperative laparoscopic hemostasis during LSPSD in the validation set (LR: low-risk group, IR: intermediate risk group, HR: high-risk group, EHR: extremely high-risk group).

BMI, tumor location, and No. 10 LN metastases were significantly associated with increased rates of major perioperative complications.[2] The GNT scoring system classified patients into four categories: low, intermediate, high, and extremely high risk. The scoring system identified the extremely high-risk group, which had a statistically significant 6.4-fold greater risk of intraoperative laparoscopic hemostasis than did the low-risk group. The intraoperative laparoscopic hemostasis rates were 58.5% and 73.5% for the high- and extremely high-risk categories. The BLV of the No. 10 LNs in the low-risk category was significantly higher than that of the high-risk and extremely high-risk groups in both the model and validation sets. In addition, the OS for patients in the low-risk category was significantly higher than that for patients in the high-risk and extremely high-risk groups. Based on these results, we propose that the increased BLV for the No. 10 LNs was significantly associated with the poorer OS. Jiang et al[15] obtained similar results, revealing that intraoperative blood loss was independent of prognostic factors for the OS of GC patients with grade III complications (P = 0.003). Results from a retrospective study at Memorial Sloan-Kettering Cancer Center revealed that increased intraoperative blood loss was an independent prognostic factor for tumor recurrence and death.[16] Greater BLV can cause decreased immunity and resistance, thus increasing the risk of death. The GNT scoring system is essential for accurately assessing patient outcomes based on preoperative findings and is extremely useful in discussing patient-specific risks during the informed consent process. In addition, the GNT scoring system may have implications for selecting risk-adapted interventions to reduce the risk of vascular injury and improve surgical safety. For example, for these patients, sufficient blood products must be prepared preoperatively, and signs and symptoms of vascular injury and hemostasis must be closely monitored during the operation and examined by laboratory tests and imaging examinations postoperatively. Preoperative patient and disease characteristic data are routinely available and can simply and efficiently predict the risk of intraoperative laparoscopic hemostasis during LSPSD.

This study had some shortcomings. First, the results were based on clinical data from an Eastern country at a

Table 7 Performance characteristics of the score in the validation set score (N = 99).

Risk score	Persons, n	N	Per cent	Sensitivity, %	Specificity, %	Positive predictive value, %	Negative predictive value, %
0	10	1	10	100	0	10	/
1	38	9	23.68	97.4	14.8	26.19	94.83
2	40	23	57.5	73.7	62.3	72.56	64.88
3	11	5	45.45	60.5	72.7	64.38	68.84
Total	99	38	38.38				

single institution. Eastern countries have higher GC morbidity and more advanced-stage GC patients than Western countries. Moreover, the average BMIs in Eastern ethnicities are lower than those in Western countries. Therefore, a prospective multicenter study with a large population would help validate this scoring system using samples from both Eastern and Western countries. Second, some patients may have experienced intraoperative laparoscopic hemostasis more than once, which may have biased the results. Third, the hemostatic grades differed. These different grades could not be included in one category, and we could not divide these various hemostatic types into some categories or select a higher grade (clip or ligation).

5. Conclusion

This simple and efficient scoring system using gender, preoperative N stage, and terminal SpA branches can be used to accurately predict the risk of intraoperative laparoscopic hemostasis during LSPSD to improve surgical safety.

Declarations

Author contributions

CQ wrote and designed the main manuscript. HZ and CQ collected the data and performed the statistical analyses. ZC, LP and LZ did the final edits and designed the tables and figures. HZ, XJ, LJ, and ZQ participated in the technical support and the analysis of the results. HZ and WJ helped draft the manuscript. HZ, LJ, CL, LM, TR and HC reviewed all the pathological specimens. All authors read and approved the final manuscript.

Ethics approval and consent to participate

The ethics committee of Fu Jian Medical University Union hospital approved this retrospective study. Written consent was provided by patients for the information to be stored in the hospital database and used for this research.

Data and material availability statement

The data that support this study's findings are available from the corresponding author upon reasonable request.

Consent for publication

Written consent was given by the patients and their relatives to use their information in a research study and publish it.

Conflict of interest

The authors declare that they have no competing interests. The authors report no relevant financial disclosures related to this current work.

Author disclosures

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Appendix A. Supplementary data

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