

World Journal of *Gastroenterology*

World J Gastroenterol 2019 October 7; 25(37): 5578-5731



**MINIREVIEWS**

- 5578** Pathogenesis and clinical management of *Helicobacter pylori* gastric infection
de Brito BB, da Silva FAF, Soares AS, Pereira VA, Santos MLC, Sampaio MM, Neves PHM, de Melo FF

ORIGINAL ARTICLE**Basic Study**

- 5590** Oncogenic ADAM28 induces gemcitabine resistance and predicts a poor prognosis in pancreatic cancer
Wei L, Wen JY, Chen J, Ma XK, Wu DH, Chen ZH, Huang JL

Case Control Study

- 5604** Correlation of plasma miR-21 and miR-93 with radiotherapy and chemotherapy efficacy and prognosis in patients with esophageal squamous cell carcinoma
Wang WT, Guo CQ, Cui GH, Zhao S

Retrospective Cohort Study

- 5619** Accuracy of an administrative database for pancreatic cancer by international classification of disease 10th codes: A retrospective large-cohort study
Hwang YJ, Park SM, Ahn S, Lee JC, Park YS, Kim N

- 5630** Post-transplant infection improves outcome of hepatocellular carcinoma patients after orthotopic liver transplantation
Chao JS, Zhao SL, Ou-yang SW, Qian YB, Liu AQ, Tang HM, Zhong L, Peng ZH, Xu JM, Sun HC

Retrospective Study

- 5641** Short-term efficacy of robotic and laparoscopic spleen-preserving splenic hilar lymphadenectomy via Huang's three-step maneuver for advanced upper gastric cancer: Results from a propensity score-matched study
Wang JB, Liu ZY, Chen QY, Zhong Q, Xie JW, Lin JX, Lu J, Cao LL, Lin M, Tu RH, Huang ZN, Lin JL, Zheng HL, Que SJ, Zheng CH, Huang CM, Li P
- 5655** Estimating survival benefit of adjuvant therapy based on a Bayesian network prediction model in curatively resected advanced gallbladder adenocarcinoma
Geng ZM, Cai ZQ, Zhang Z, Tang ZH, Xue F, Chen C, Zhang D, Li Q, Zhang R, Li WZ, Wang L, Si SB
- 5667** Soluble mannose receptor as a predictor of prognosis of hepatitis B virus-related acute-on-chronic liver failure
Li TP, Guan SH, Wang Q, Chen LW, Yang K, Zhang H

Observational Study

- 5676** Nonalcoholic fatty liver disease in patients with inflammatory bowel disease: Beyond the natural history
Magri S, Paduano D, Chicco F, Cingolani A, Farris C, Delogu G, Tumbarello F, Lai M, Melis A, Casula L, Fantini MC, Usai P

Prospective Study

- 5687** Long-term outcomes of hepatocellular carcinoma that underwent chemoembolization for bridging or downstaging
Affonso BB, Galastri FL, da Motta Leal Filho JM, Nasser F, Falsarella PM, Cavalcante RN, de Almeida MD, Felga GEG, Valle LGM, Wolosker N

META-ANALYSIS

- 5702** Is there an association between *Helicobacter pylori* infection and irritable bowel syndrome? A meta-analysis
Ng QX, Foo NX, Loke W, Koh YQ, Seah VJM, Soh AYS, Yeo WS
- 5711** Is total laparoscopic pancreaticoduodenectomy superior to open procedure? A meta-analysis
Zhang H, Lan X, Peng B, Li B

ABOUT COVER

Editorial board member of *World Journal of Gastroenterology*, Mortada HF El-Shabrawi, MD, FAASLD, Professor, Department of Pediatrics, Faculty of Medicine, Cairo University, Cairo 11559, Egypt

AIMS AND SCOPE

The primary aim of *World Journal of Gastroenterology* (WJG, *World J Gastroenterol*) is to provide scholars and readers from various fields of gastroenterology and hepatology with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJG mainly publishes articles reporting research results and findings obtained in the field of gastroenterology and hepatology and covering a wide range of topics including gastroenterology, hepatology, gastrointestinal endoscopy, gastrointestinal surgery, gastrointestinal oncology, and pediatric gastroenterology.

INDEXING/ABSTRACTING

The WJG is now indexed in Current Contents®/Clinical Medicine, Science Citation Index Expanded (also known as SciSearch®), Journal Citation Reports®, Index Medicus, MEDLINE, PubMed, PubMed Central, and Scopus. The 2019 edition of Journal Citation Report® cites the 2018 impact factor for WJG as 3.411 (5-year impact factor: 3.579), ranking WJG as 35th among 84 journals in gastroenterology and hepatology (quartile in category Q2). CiteScore (2018): 3.43.

RESPONSIBLE EDITORS FOR THIS ISSUE

Responsible Electronic Editor: *Yu-Jie Ma*

Proofing Production Department Director: *Yun-Xiaojuan Wu*

NAME OF JOURNAL

World Journal of Gastroenterology

ISSN

ISSN 1007-9327 (print) ISSN 2219-2840 (online)

LAUNCH DATE

October 1, 1995

FREQUENCY

Weekly

EDITORS-IN-CHIEF

Subrata Ghosh, Andrzej S Tarnawski

EDITORIAL BOARD MEMBERS

<http://www.wjgnet.com/1007-9327/editorialboard.htm>

EDITORIAL OFFICE

Ze-Mao Gong, Director

PUBLICATION DATE

October 7, 2019

COPYRIGHT

© 2019 Baishideng Publishing Group Inc

INSTRUCTIONS TO AUTHORS

<https://www.wjgnet.com/bpg/gerinfo/204>

GUIDELINES FOR ETHICS DOCUMENTS

<https://www.wjgnet.com/bpg/GerInfo/287>

GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH

<https://www.wjgnet.com/bpg/gerinfo/240>

PUBLICATION MISCONDUCT

<https://www.wjgnet.com/bpg/gerinfo/208>

ARTICLE PROCESSING CHARGE

<https://www.wjgnet.com/bpg/gerinfo/242>

STEPS FOR SUBMITTING MANUSCRIPTS

<https://www.wjgnet.com/bpg/GerInfo/239>

ONLINE SUBMISSION

<https://www.f6publishing.com>



Retrospective Study

Short-term efficacy of robotic and laparoscopic spleen-preserving splenic hilar lymphadenectomy *via* Huang's three-step maneuver for advanced upper gastric cancer: Results from a propensity score-matched study

Jia-Bin Wang, Zhi-Yu Liu, Qi-Yue Chen, Qing Zhong, Jian-Wei Xie, Jian-Xian Lin, Jun Lu, Long-Long Cao, Mi Lin, Ru-Hong Tu, Ze-Ning Huang, Ju-Li Lin, Hua-Long Zheng, Si-Jin Que, Chao-Hui Zheng, Chang-Ming Huang, Ping Li

ORCID number: Jia-Bin Wang (0000-0002-2023-0183); Zhi-Yu Liu (0000-0002-2207-2932); Qi-Yue Chen (0000-0001-6391-4043); Qing Zhong (0000-0002-8214-9129); Jian-Wei Xie (0000-0001-9000-5638); Jian-Xian Lin (0000-0002-5006-4454); Jun Lu (0000-0002-8459-4867); Long-Long Cao (0000-0003-3144-3050); Mi Lin (0000-0001-7299-6159); Ru-Hong Tu (0000-0002-7491-3879); Ze-Ning Huang (0000-0001-7284-3689); Juli Lin (0000-0002-6518-9372); Hua-Long Zheng (0000-0002-2749-0113); Si-Jin Que (0000-0002-4156-0659); Chao-Hui Zheng (0000-0003-0157-5167); Chang-Ming Huang (0000-0002-0019-885X); Ping Li (0000-0002-9418-9339).

Author contributions: Liu ZY wrote most of the manuscript and designed the study; Liu ZY, Wang JB, Zheng CH, and Chen QY collected the data and performed the statistical analysis; Chen QY, Zhong Q, Wang JB, Li P, and Zheng HL prepared the final edition version of the manuscript and designed the tables and figures; Xie JW and Lin JX provided technical support and assisted in analyzing the results; Lu J and Wang JB helped draft the manuscript; Huang ZN, Lin JL, Cao LL, Lin M, Tu RH, and Huang CM reviewed the pathological specimens; all authors read and approved the final manuscript.

Jia-Bin Wang, Zhi-Yu Liu, Qi-Yue Chen, Qing Zhong, Jian-Wei Xie, Jian-Xian Lin, Jun Lu, Long-Long Cao, Mi Lin, Ru-Hong Tu, Ze-Ning Huang, Ju-Li Lin, Hua-Long Zheng, Si-Jin Que, Chao-Hui Zheng, Chang-Ming Huang, Ping Li, Department of Gastric Surgery, Fujian Medical University Union Hospital, Fuzhou 350001, Fujian Province, China

Jia-Bin Wang, Zhi-Yu Liu, Qi-Yue Chen, Qing Zhong, Jian-Wei Xie, Jian-Xian Lin, Jun Lu, Long-Long Cao, Mi Lin, Ru-Hong Tu, Ze-Ning Huang, Ju-Li Lin, Hua-Long Zheng, Si-Jin Que, Chao-Hui Zheng, Chang-Ming Huang, Ping Li, Department of General Surgery, Fujian Medical University Union Hospital, Fuzhou 350001, Fujian Province, China

Jia-Bin Wang, Jian-Xian Lin, Jun Lu, Chao-Hui Zheng, Chang-Ming Huang, Ping Li, Key Laboratory of Ministry of Education of Gastrointestinal Cancer, Fujian Medical University, Fuzhou 350001, Fujian Province, China

Corresponding author: Ping Li, MD, PhD, Doctor, Professor, Department of Gastric Surgery, Fujian Medical University Union Hospital, No. 29, Xinquan Road, Fuzhou 350001, Fujian Province, China. pingli811002@163.com

Telephone: +86-591-83363366

Fax: +86-591-83363366

Abstract

BACKGROUND

Robotic surgery has been considered to be significantly better than laparoscopic surgery for complicated procedures.

AIM

To explore the short-term effect of robotic and laparoscopic spleen-preserving splenic hilar lymphadenectomy (SPSHL) for advanced gastric cancer (GC) by Huang's three-step maneuver.

METHODS

A total of 643 patients who underwent SPSHL were recruited from April 2012 to July 2017, including 35 patients who underwent robotic SPSHL (RSPSHL) and 608 who underwent laparoscopic SPSHL (LSPSHL). One-to-four propensity score

Supported by the Scientific and Technological Innovation Joint Capital Projects of Fujian Province, China, No. 2016Y9031; the Construction Project of Fujian Province Minimally Invasive Medical Center, No. [2017]171; the Second-batch Special Support Funds for Fujian Province Innovation and Entrepreneurship Talents, No. 2016B013; Science and Technology Innovation Joint Fund Project of Fujian Province, No. 2017Y9004; and the Special Fund for Clinical Research of the Wu Jieping Medical Foundation, No. 320.6750.17511.

Institutional review board

statement: This retrospective study was approved by the Ethics Committee of Fujian Medical University Union Hospital.

Informed consent statement:

Patients were not required to give informed consent to the study because the analysis used anonymous clinical data that were obtained after each patient agreed to treatment by written consent.

Conflict-of-interest statement: We have no financial relationships to disclose.

Data sharing statement: No additional data are available.

Open-Access: This article is an open-access article which was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

Manuscript source: Unsolicited manuscript

Received: May 24, 2019

Peer-review started: May 24, 2019

First decision: June 16, 2019

Revised: July 12, 2019

Accepted: August 7, 2019

Article in press: August 7, 2019

Published online: October 7, 2019

P-Reviewer: Fiori E, Tanabe S

S-Editor: Ma RY

L-Editor: Wang TQ

E-Editor: Zhou BX

matching was used to analyze the differences in clinical data between patients who underwent robotic SPSHL and those who underwent laparoscopic SPSHL.

RESULTS

In all, 175 patients were matched, including 35 patients who underwent RSPSHL and 140 who underwent LSPSHL. After matching, there were no significant differences detected in the baseline characteristics between the two groups. Significant differences in total operative time, estimated blood loss (EBL), splenic hilar blood loss (SHBL), splenic hilar dissection time (SHDT), and splenic trunk dissection time were evident between these groups ($P < 0.05$). Furthermore, no significant differences were observed between the two groups in the overall noncompliance rate of lymph node (LN) dissection (62.9% vs 60% , $P = 0.757$), number of retrieved No. 10 LNs (3.1 ± 1.4 vs 3.3 ± 2.5 , $P = 0.650$), total number of examined LNs (37.8 ± 13.1 vs 40.6 ± 13.6 , $P = 0.274$), and postoperative complications (14.3% vs 17.9% , $P = 0.616$). A stratified analysis that divided the patients receiving RSPSHL into an early group (EG) and a late group (LG) revealed that the LG experienced obvious improvements in SHDT and length of stay compared with the EG ($P < 0.05$). Logistic regression showed that robotic surgery was a significantly protective factor against both SHBL and SHDT ($P < 0.05$).

CONCLUSION

RSPSHL is safe and feasible, especially after overcoming the early learning curve, as this procedure results in a radical curative effect equivalent to that of LSPSHL.

Key words: Advanced gastric cancer; Robotic surgery; Laparoscopic surgery; Dissection of splenic hilar lymph node; Propensity score matching; Huang's three-step maneuver

©The Author(s) 2019. Published by Baishideng Publishing Group Inc. All rights reserved.

Core tip: The safety and oncologic efficacy of spleen-preserving splenic hilar lymphadenectomy (SPSHL) are being evaluated, but the data are limited, especially for robotic surgery. What's more, few previous studies have compared robotic SPSHL (RSPSHL) with laparoscopic SPSHL (LSPSHL) for gastric cancer. Huang's three-step maneuver constitutes a set of effective surgical procedures for the SPSHL, which was proposed previously by our department. Thus, we offer a single-institution investigation on the comparative safety, feasibility, and oncologic efficacy of robotic vs laparoscopic SPSHL. It is worth noting that this is the first study that compared RSPSHL and LSPSHL using Huang's three-step maneuver for advanced gastric cancer.

Citation: Wang JB, Liu ZY, Chen QY, Zhong Q, Xie JW, Lin JX, Lu J, Cao LL, Lin M, Tu RH, Huang ZN, Lin JL, Zheng HL, Que SJ, Zheng CH, Huang CM, Li P. Short-term efficacy of robotic and laparoscopic spleen-preserving splenic hilar lymphadenectomy via Huang's three-step maneuver for advanced upper gastric cancer: Results from a propensity score-matched study. *World J Gastroenterol* 2019; 25(37): 5641-5654

URL: <https://www.wjnet.com/1007-9327/full/v25/i37/5641.htm>

DOI: <https://dx.doi.org/10.3748/wjg.v25.i37.5641>

INTRODUCTION

Since 1991, when Kitano^[1] first reported the application of laparoscopic radical gastrectomy in early gastric cancer (GC), minimally invasive surgery has increasingly been used to treat GC. In subsequent years, many scholars have consistently confirmed that laparoscopic gastrectomy is a viable option for the treatment of GC. For D2 lymph node (LN) dissection in patients with advanced upper GC, some surgeons with extensive experience in laparoscopic surgery recommend spleen-preserving splenic hilar lymphadenectomy (SPSHL), which is the most challenging part of surgery for GC^[2-4].

For successful surgical intervention in the splenic hilar area, our department proposed Huang's three-step maneuver in 2012. Huang's three-step maneuver



divided this complicated surgical procedure into the dissection of LNs in the inferior pole region of the spleen (first step), the dissection of LNs in the region of the splenic artery trunk (second step), and the dissection of LNs in the superior pole region of the spleen (third step). Huang's three-step maneuver constitutes a set of effective surgical procedures for SPSHL. Compared with traditional surgical methods, Huang's three-step maneuver has better short-term surgical outcomes^[5-7]. However, the splenic hilar region has a complicated and variable anatomy. Due to the characteristics of the splenic hilar region of interest, surgeons, especially novices, often find it difficult to maneuver in the narrow space during surgery, and thus the broad application of this procedure is limited.

Since 2003, when robotic distal gastrectomy was first reported^[8], its safety and feasibility have been repeatedly confirmed. Due to its flexibility, the extensive range of motion beyond the human body, and the clear field of vision compared with traditional laparoscopy, robotic surgery has been considered in some preliminary studies to be significantly better than laparoscopic surgery for complicated procedures^[8,9]. However, the safety and efficacy of robotic SPSHL (RSPSHL) in patients with advanced upper GC have rarely been reported. Therefore, this study aimed to retrospectively analyze the clinical and pathological data of patients with advanced upper GC in our department to compare the short-term effects of RSPSHL and laparoscopic SPSHL (LSPSHL) using propensity score matching.

MATERIALS AND METHODS

Patients

From April 2012 to July 2017, we retrospectively analyzed the clinicopathological data of 643 patients who underwent SPSHL for GC at the Department of Gastric Surgery of Fujian Medical University Union Hospital. These patients were all treated by the same group of surgeons. The exclusion criteria (Supplemental Figure 1) were as follows: (1) Non-total gastrectomy; (2) Non-D2 radical surgery; (3) Non-No. 10 LN dissection; (4) American Society of Anesthesiologists (ASA) class IV; (5) cT1 or cT4b; (6) cTNM stage IV; and (7) incomplete data. Age, sex, body mass index (BMI), ASA class, cT, and cN were used as the matching factors. The two groups were matched by one-to-four propensity score matching. Finally, 175 patients were enrolled, including 35 who underwent RSPSHL and 140 who underwent LSPSHL. This retrospective study was approved by the Ethics Committee of Fujian Medical University Union Hospital. All patients signed informed consent forms before surgery. The clinical procedure in our department is described below. First, nasal feeding is performed through a nasal jejunal tube. If no abnormal conditions are present, an oral fluid and soft diet are provided in a stepwise manner. The drain tube is then removed based on the patient's condition.

Methods

All patients underwent routine preoperative examinations, including upper gastrointestinal endoscopy and upper gastrointestinal imaging, to assess the tumor location. In addition to chest radiography, total abdominal computed tomography (CT), abdominal ultrasonography, positron emission tomography (PET)-CT, and bone scans were performed as needed to assess the preoperative clinical stage. Patients with upper GC, defined as a tumor located in the upper or middle region of the stomach, cardia, or gastroesophageal junction, received confirmation of the preoperative diagnosis of tumor invasion into or beyond the muscle layers. These patients were eligible for spleen-preserving total gastrectomy. The extent of LN dissection was based on the Japanese Gastric Cancer Treatment Guidelines in 2010^[10]. Preoperative comorbidity was assessed using the Charlson score. pTNM staging was performed using the 2010 edition of the 7th edition of the Union for International Cancer Control (UICC) staging system. All robotic gastrectomies were performed with the Da Vinci surgical system. Each patient was given detailed information about the instruments, sizes of the incisions, oncological risks, and the cost of the operation for both the robotic and laparoscopic approaches. The decision to receive laparoscopic *vs* robotic treatment was made by the patient after an informed discussion about both approaches because of the additional expenses for robotic surgery^[11]. A portion of the fee for laparoscopic surgery was covered by medical insurance, but the extra charges associated with robotic surgery were not included in the medical insurance coverage.

Procedure

Operative procedures considered Huang's three-step maneuver were the same as previously described^[5-7,12,13] and included the following three steps: the dissection of

the LNs in the inferior pole region of the spleen; the dissection of the LNs in the region of the trunk of the splenic artery (SpA); and the dissection of the LNs in the superior pole region of the spleen. The first step begins with the separation of the gastrosplenic ligament using an ultrasonic scalpel and ends with the dissection of the lymphatic tissue along the vessels distally up to the splenic hilar region. The second step involves using the ultrasonic scalpel to denude the trunk of the SpA along the latent anatomic space on its surface toward the splenic hilar area until the fork of the splenic lobar arteries is reached. The third step begins with the dissection of the fork of the splenic lobar arteries and ends with the division of the last short gastric vessel (SGV). This procedure was used in both RSPSHLs and LSPSHLs. Furthermore, the method of RSPSHL was similar to that of LSPSHL. A previous report^[12] provided the details of the laparoscopic procedure. Each step starts with the initial transection of the tissues and ends with dividing the tissues in the subsequent step of the maneuver using an ultrasonic scalpel. The photographs show the relevant steps of RSPSHL (Supplemental Figure 2A and B).

Definitions

The total operative time consisted of the docking time and operation time (OR time) during robotic surgery. OR time was defined as the time between the trocar insertion and the closure of the abdomen, but the extra time required to incorporate the robotic system was not included. Estimated blood loss (EBL) was determined by calculating the amount of gauze and the amount of blood in the aspirator. Splenic hilar dissection time (SHDT) began when the gastrosplenic ligament was cut and ended when the last SGV was divided. Splenic hilar blood loss (SHBL) during the SHDT was determined by calculating the amount of gauze used and the amount of blood in the aspirator. The amount of extra fluid pooled around the spleen after Huang's three-step maneuver was completed was not included in the SHBL calculation. Two types of SpA were found, namely, the concentrated type and the distributed type. The concentrated type was present when the SpA divides into its terminal branches less than 2 cm from the splenic hilum. If the distance is equal to or greater than 2 cm, the artery was considered the distributed type. Vascular injury was defined as bleeding caused by intraoperative vascular injury that required a titanium clip for clamping or electrocoagulation^[6,14]. Each individual case parameter was evaluated routinely after surgery as soon as possible. Noncompliance was defined as patients with more than one empty LN station, as described in the protocol of D2 LN dissection from the Japanese GC Association^[10]. Complications were graded according to the Clavien-Dindo classification. According to the references^[15,16], the patients in the robotic cohort were divided into an "early group" (EG) if surgery occurred before January 2017 ($n = 20$) and a "late group" (LG) if surgery occurred after January 2017 ($n = 15$).

Statistical analysis

Propensity score matching was performed using R software (3.4.2, the statistical packages MatchIt and Foreign, <http://www.r-project.org>). All data were statistically analyzed using the SPSS 20.0 (SPSS Inc. Chicago, IL, United States). Continuous variables were analyzed using the Student's *t*-test or Mann-Whitney *U* test, and categorical variables were analyzed using the χ^2 test or Fisher's exact test. The SHDT and the times for the first, second, and third steps of the maneuver were analyzed by binary class comparison using the medians as the cut-off values. Logistic regression analysis was performed to evaluate the effects of robotic surgery on the intraoperative and postoperative parameters. Two-sided $P < 0.05$ indicated a significant difference.

RESULTS

Clinical and pathological data of the two groups before and after matching

Before matching, significant differences in ASA, cT, and pTNM were evident between the two groups of patients ($P < 0.05$). The clinical data of the patients in the RSPSHL ($n = 35$) and LSPSHL ($n = 140$) groups were similar when matched for age, sex, BMI, ASA, cT, and cN ($P > 0.05$) (Table 1).

Operative outcomes after matching

No conversion to open surgery occurred in the LSPSHL group, and no conversion to open or laparoscopic surgery occurred in the RSPSHL group. After matching, the total OR time was significantly longer in the RSPSHL group than in the LSPSHL group, while the EBL, SHDT, SHBL, and time for the second step were lower in the RSPSHL group than in the LSPSHL group ($P < 0.05$). The two groups were similar in terms of OR time, first step time, third step time, splenic injury, vascular injury, and anatomy

Table 1 General clinical and pathological data of patients

	All patients					Propensity score matching				
Variable	RSPSHL		LSPSHL		P-value	RSPSHL		LSPSHL		P-value
	(n = 35)	%	(n = 608)	%		(n = 35)	%	(n = 140)	%	
Age, yr ¹	55.3 ± 10.4		56.9 ± 10.6		0.424	55.3 ± 10.4		55.1 ± 11.5		0.925
Sex					0.345					0.615
Female	6	17.1	156	25.7		6	17.1	17	12.1	
Male	29	82.9	452	74.3		29	82.9	123	87.9	
BMI, kg/m ^{2[1]}	23.0 ± 2.7		22.2 ± 3.0		0.152	23.0 ± 2.7		23.1 ± 3.0		0.858
ASA score					0.014					0.944
I	4	11.4	186	30.6		4	11.4	19	13.6	
II	28	80.0	401	65.9		28	80.0	109	77.8	
III	3	8.6	21	3.5		3	8.6	12	8.6	
cT classification					0.037					0.211
T2	10	28.6	100	16.4		10	28.6	22	15.7	
T3	15	42.9	207	34.1		15	42.9	69	49.3	
T4a	10	28.6	301	49.5		10	28.6	49	35.0	
cN classification					0.483					0.541
N0	13	37.1	212	34.8		13	37.1	57	40.7	
N1	14	40.0	187	30.6		14	40.0	39	27.9	
N2	4	11.4	122	20.0		4	11.4	21	15.0	
N3	4	11.4	89	14.6		4	11.4	23	16.4	
cTNM stage					0.094					0.137
IB	2	5.7	55	9.0		2	5.7	13	9.3	
IIA	7	20.0	106	17.4		7	20.0	18	12.9	
IIB	13	37.1	104	17.1		13	37.1	31	22.1	
IIIA	7	20.0	137	22.5		7	20.0	22	15.7	
IIIB	3	8.6	109	17.9		3	8.6	29	20.7	
IIIC	3	8.6	97	16.0		3	8.6	27	19.3	
Depth of invasion					0.201					0.617
pT1a	5	14.3	31	5.1		5	14.3	10	7.1	
pT1b	4	11.4	52	8.6		4	11.4	24	17.1	
pT2	2	5.7	55	9		2	5.7	10	7.1	
pT3	16	45.7	283	46.5		16	45.7	57	40.7	
pT4a	8	22.9	187	30.8		8	22.9	39	27.9	
Metastatic LNs					0.308					0.649
N0	16	45.7	194	31.9		16	45.7	54	38.6	
N1	6	17.1	174	28.7		6	17.1	20	14.3	
N2	6	17.1	120	19.7		6	17.1	23	16.4	
N3	7	20.0	120	19.7		7	20.0	43	30.7	
pTNM stage					0.038					0.102
IA	7	20.0	44	7.2		7	20.0	29	20.7	
IB	3	8.6	45	7.4		3	8.6	8	5.7	
IIA	6	17.1	91	15.0		6	17.1	23	16.4	
IIB	6	17.1	93	15.3		6	17.1	16	11.4	
IIIA	6	17.1	122	20.1		6	17.1	8	5.7	
IIIB	2	5.7	149	24.5		2	5.7	31	22.1	
IIIC	5	14.3	64	10.5		5	14.3	25	17.9	
Charlson score					0.467					0.132
0	25	71.5	439	72.2		25	71.5	90	64.3	
1	6	17.1	129	21.2		6	17.1	43	30.7	
≥2	4	11.4	40	6.6		4	11.4	7	5.0	
Primary site					0.458					0.335

Upper	21	60.0	402	66.1	21	60.0	96	68.6
Middle	14	40.0	206	33.9	14	40.0	44	31.4

¹Values are expressed as the mean \pm SD. RSPSHL: Robotic spleen-preserving splenic hilar lymphadenectomy; LSPSHL: Laparoscopic spleen-preserving splenic hilar lymphadenectomy; BMI: Body mass index; ASA: American Society of Anesthesiologists; LN: Lymph node.

(*e.g.*, SGVs, the PGA, and the terminal branches of the SpA) ($P > 0.05$). The No. 10 LN metastasis rate was 10.9% (19/175), and the rates were similar between the RSPSHL (11.4%, 4/35) and LSPSHL (10.7%, 15/140) groups ($P = 0.855$) (Table 2). The overall noncompliance rates for patients undergoing RSPSHL and LSPSHL were 62.9% (22/35) and 60% (84/140), respectively ($P = 0.757$). Subgroup analysis by clinical stage or BMI revealed no significant differences in the noncompliance rates of LN dissection between the two groups ($P > 0.05$) (Table 3).

Short-term outcomes and postoperative complications

Significant differences were evident in the times to liquid diet intake and nasogastric tube removal, which were shorter in the RSPSHL group than in the LSPSHL group ($P < 0.05$). However, the times to ambulation, flatus passage, soft diet intake, and drain removal, and the length of stay (LOS) were similar between the groups ($P > 0.05$) (Table 4). No significant differences were evident in the overall postoperative complications or in grades I-II and III-IV complications between the two groups. Surgical complications (including intraperitoneal hemorrhage and infection) in both groups were resolved with conservative treatments. No deaths occurred in the hospital or within 30 d after surgery.

Impact of number of surgical cases on short-term operative outcomes

The SHDT, first step time, second step time, and LOS were longer in the EG than in the LG ($P < 0.05$). However, the OR time, EBL, third step time, SHBL, number of retrieved No. 10 LNs, total number of retrieved LNs, and postoperative complications were similar between the groups ($P > 0.05$) (Supplemental Table 1).

Comparison of difference between the first and second steps among patients

Table 5 shows that the first step time was longer than the second step time for both RSPSHL (8.4 ± 3.5 vs 6.7 ± 2.6 , $P = 0.024$) and EG (10.0 ± 3.4 vs 7.5 ± 2.6 , $P = 0.013$). In the LG, the first step time was similar to the second step time (6.3 ± 2.3 vs 5.8 ± 2.2 , $P = 0.548$).

Cost difference

As Figure 1 shows, cost analyses of the inpatient cases revealed that RSPSHL had a higher mean total cost than LSPSHL before matching (\$14727.9 vs \$11026.2, $P < 0.001$) and after matching (\$15445.2 vs \$10397.2, $P < 0.001$). However, no difference was observed in the mean total cost between the EG and LG (\$15445.2 vs \$13771.6, $P = 0.102$).

Sensitivity analysis of robotic surgery

The unadjusted logistic analysis showed that robotic surgery was a positive factor affecting shorter SHDT and second step time and less SHBL. When robotic surgery was adjusted for age, sex, BMI, ASA, cT and cN stages, and several anatomical factors, such as the PGA, SGVs, splenic upper or lower pole arteries, and the terminal branches of the SpA, we found that the effects of robotic surgery were protective factors resulting in a shorter SHDT and less SHBL, both before and after the adjustments ($P < 0.05$) (Figure 2A and B).

DISCUSSION

In 2008, Hyung *et al.*^[17] first reported LSPSHL and confirmed that laparoscopic spleen-preserving surgery is safe and feasible^[5,18-22]. However, traditional laparoscopic surgery is still associated with multiple shortcomings, including a restricted range of motion, amplified physiologic tremors, two-dimensional visualization, and inflexible instruments. These shortcomings have deterred novice surgeons from performing complicated operations, such as LSPSHL^[23]. Due to its high stability and precision, the robotic system can overcome the technical limitations of conventional laparoscopic surgery and therefore has great potential for use in complicated surgeries^[8,24].

The initial purpose of robotic or laparoscopic surgery was adherence to minimally invasive principles. For postoperative outcomes, a meta-analysis^[25] performed in 2012

Table 2 Operative outcomes after propensity score matching

Variable	RSPSHL (n = 35)	%	LSPSHL (n = 140)	%	P-value
Total operative time, min ¹	221.3 ± 40.3		189.1 ± 43.8		<0.001
Docking time, min ²	30 (26-34)		-		
OR time, min ¹	186.0 ± 35.3		189.1 ± 43.8		0.698
EBL, mL ¹	13.7 ± 4.3		62.4 ± 29.3		<0.001
SHDT, min ¹	20.4 ± 4.5		24.1 ± 8.9		0.018
First step, min ¹	8.4 ± 3.5		8.7 ± 4.0		0.685
Second step, min ¹	6.7 ± 2.6		9.8 ± 5.6		0.002
Third step, min ¹	5.2 ± 2.1		5.6 ± 3.0		0.458
SHBL, mL ¹	2.2 ± 1.9		10.0 ± 4.5		<0.001
No. of SGVs ¹	3.5 ± 1.2		3.6 ± 1.1		0.637
No. of PGAs (yes)	22	62.9	81	57.9	0.591
No. of SUPAs (yes)	4	11.4	20	14.3	0.870
No. of SLPAs (yes)	1	2.9	7	5	0.928
Terminal branches of SpA					0.754
Concentrated type	23	65.7	88	62.9	
Distributed type	12	34.3	52	37.1	
Splenic injury	3	8.6	19	13.6	0.608
Vascular injury	7	20	17	12.1	0.350
No.10 metastatic LN	4	11.4	15	10.7	0.855
No.10 retrieved LN ¹	3.1 ± 1.4		3.3 ± 2.5		0.650
Total retrieved LNs ¹	37.8 ± 13.1		40.6 ± 13.6		0.274

¹Values are the mean ± SD.²Values are medians (IQR). Operative total time = Docking time + operation time. RSPSHL: Robotic spleen-preserving splenic hilar lymphadenectomy; LSPSHL: Laparoscopic spleen-preserving splenic hilar lymphadenectomy; OR time: Operation time; EBL: Estimated blood loss; SHDT: Splenic hilar dissection time; SHBL: Splenic hilar blood loss; SGV: Short gastric vessel; PGA: Post-gastric artery; SUPA: Splenic upper pole artery; SLPA: Splenic lower pole artery; SpA: Splenic artery.

of robotic versus laparoscopic gastrectomy for GC showed no differences in the incidence of postoperative complications or the LOS between robotic and laparoscopic surgery. However, robotic surgery and laparoscopy could both reduce the risk of postoperative complications and shorten patients' LOS compared with open surgery^[24,26]. Our study also found that RSPSHL is safe. RSPSHL has a postoperative recovery similar to that of LSPSHL, and the related intraoperative and postoperative occurrences of complications were not increased compared with LSPSHL. In the field of GC treatment, the Da Vinci surgical system is expected to overcome the disadvantages of traditional laparoscopic gastrectomy. Most surgeons who recommend laparoscopic gastrectomy have confirmed that robotic gastrectomy (RG) is safe and feasible^[27-29]. In 2015, Suda *et al*^[27] demonstrated that the morbidity (overall complication) rate of RG was approximately one-fifth that of laparoscopic gastrectomy and that the incidence of postoperative pancreatic fistula was reduced by RG. RG showed significantly better short-term postoperative outcomes. Moreover, a multi-institutional prospective single-arm study conducted in Japan in 2018 also confirmed that the morbidity rate (Clavien-Dindo grade ≥ IIIa) within 30 d after surgery was significantly lower in the RG group than in the laparoscopic gastrectomy group (RG *vs* laparoscopic gastrectomy = 2.45% *vs* 6.4%, *P* = 0.0018)^[30]. Through a cost analysis, we determined that the average total cost of robotic surgery was higher than that of laparoscopic surgery. The results are consistent with those reported by Keller *et al*^[31]. Despite the high economic burden of robotic surgery^[32,33], these results suggested that RG would likely exhibit improved cost-effectiveness if the surgical cost per procedure was reduced to approximately the same amount as that for laparoscopic gastrectomy^[30]. Consequently, we believe that the application of RG will increase with the decreasing of cost of robotic systems and the government's policy regarding gradual expansion of the range of the medical insurance system.

RSPSHL resulted in a shorter SHDT and less SHBL than LSPSHL. Logistic analysis showed that robotic surgery was a protective factor for a shorter SHDT and less SHBL. We believe that the microscopic images from the robotic system are more vivid and allow easier identification of the spatial relationship between the tissue of the

Table 3 Noncompliance rate of nodal dissection between robotic spleen-preserving splenic hilar lymphadenectomy and laparoscopic spleen-preserving splenic hilar lymphadenectomy

Variable	RSPSHL		LSPSHL		P-value
	Compliant	Noncompliant	Compliant	Noncompliant	
cT classification					
cT2	3	7	6	16	0.791
cT3	6	9	31	39	0.761
cT4	4	6	19	29	0.741
cN classification					
cN0	4	9	22	36	0.868
cN1	6	8	15	23	0.825
cN2	2	2	11	10	0.647
cN3	1	3	8	15	0.848
cTNM stage					
I	1	1	5	8	1.000
II	9	16	18	31	0.950
III	3	5	33	45	0.909
BMI, kg/m ²					
< 25	11	14	38	68	0.449
≥ 25	2	8	18	16	0.139
Total	13	22	56	84	0.757

RSPSHL: Robotic spleen-preserving splenic hilar lymphadenectomy; LSPSHL: Laparoscopic spleen-preserving splenic hilar lymphadenectomy; BMI: Body mass index.

splenic hilar region and the operating instruments than the laparoscopic view^[2]. Successful performance of this maneuver in laparoscopy requires close cooperation among the surgeon, assistant, and camera operator. However, if the assistant cannot generate good coordinates while pulling the spleen, intraoperative complications such as splenic envelope laceration can easily occur. Huang's three-step robotic maneuver uses a multi-arm robotic system with which the surgeon can complete the main pull alone and greatly minimize pulling by the assistant compared with that needed for traditional laparoscopic surgery. Additionally, the mechanical arm can more stably and reliably pull the adipose connective tissue. Both the surgeon and the assistant can avoid errors based on the advantages of this system. The advantages of this system, including the high flexibility of the operative instruments and the elimination of natural hand trembling, result in less intraoperative damage. The stratified analysis showed that with an increasing number of surgical cases and techniques, the LG exhibited significant improvements in SHDT and length of stay compared with the EG. Notably, although shorter SHDT and less SHBL were significantly different between robotic surgery and laparoscopic surgery, it seems that the difference does not exist in the clinical setting.

We believe that Huang's three-step maneuver using the robotic system can help surgeons maintain fluent surgical thinking and body-motor memory, thus improving the response speed of novice surgeons. Even as a novice, the operator can operate freely. The three-step maneuver can reduce the impact of the complex anatomy of the splenic hilar area on the performance of the surgeon. The literature^[16,34,35] indicates that the robotic surgery learning curve is shorter than that for laparoscopic surgery. We also propose that learning robotic surgery will be substantially easier for surgeons who already have some basic experience with laparoscopic surgery. A learning curve for Huang's three-step robotic maneuver also exists, and patients' intraoperative outcomes will significantly improve if surgeons complete this learning curve.

With the application of robotic surgery for GC, minimally invasive advantages have gradually been acknowledged. However, a primary concern of most scholars is whether RSPSHL can achieve equal or better perioperative and postoperative outcomes than laparoscopic or open surgery. The number of retrieved LNs is an important factor in evaluating the efficacy of surgical techniques. After retrospectively analyzing 36 robotic procedures and 65 laparoscopic procedures, Yoon *et al*^[36] found that the total number of retrieved LNs in robotic total gastrectomy (39.4 ± 13.4 vs 42.8

Table 4 Short-term operative outcomes and postoperative complications according to the Clavien–Dindo classification

Variable	RSPSHL (n = 35)	%	LSPSHL (n = 140)	%	P-value
Time to ambulation, d ¹	2.4 ± 0.9		2.1 ± 1.0		0.107
Flatus passage, d ¹	3.2 ± 0.9		3.5 ± 1.3		0.199
Liquid diet, d ¹	4.8 ± 1.1		5.4 ± 1.7		0.049
Soft diet, d ¹	7.0 ± 2.4		7.5 ± 1.5		0.125
Drain removal, d ¹	9.2 ± 2.1		9.6 ± 2.0		0.296
Nasojunal tube removal, d ¹	3.9 ± 1.6		4.8 ± 2.5		0.044
LOS, d ¹	14.7 ± 13.4		14.4 ± 11.5		0.894
Overall complications	5	14.3	25	17.9	0.616
Grade I–II	3	8.6	17	12.1	0.632
Anastomotic fistula	2	5.7	3	2.1	
Digestive hemorrhage	-		1	0.7	
Lymphatic fistula	-		6	4.3	
Intestinal obstruction	-		1	0.7	
Intraperitoneal infection	1	2.9	4	2.9	
Wound infection	-		1	0.7	
Fat liquefaction	-		1	0.7	
Grade III–IV	2	5.7	8	5.7	1
Anastomotic fistula	-		1	0.7	
Digestive hemorrhage	1	2.9	3	2.1	
Lymphatic fistula	-		2	1.4	
Intestinal obstruction	-		1	0.7	
Intraperitoneal infection	1	2.9	1	0.7	
30-day mortality	0		0		
In-hospital mortality	0		0		

¹Values are the mean ± SD. The most severe complication was noted in the cases in which more than one complication occurred in a patient. RSPSHL: Robotic spleen-preserving splenic hilar lymphadenectomy; LSPSHL: Laparoscopic spleen-preserving splenic hilar lymphadenectomy; LOS: Length of stay.

± 12.7) was similar to that in laparoscopic total gastrectomy ($P = 0.209$). Obama *et al*^[37] retrospectively analyzed 313 robotic procedures and 524 laparoscopic procedures and found similar outcomes regarding the total number of retrieved LNs between robotic and laparoscopic surgery. In our study, no significant differences between RSPSHL and LSPSHL were observed regarding the total number of retrieved LNs or the number of retrieved No. 10 LNs. This result is consistent with the results of the study by Kazutaka Obama. Moreover, this article introduces noncompliance as an objective measure of LN dissection in robotic surgery and laparoscopy^[38–40]. To our knowledge, it is the first study that compares oncological outcomes between RSPSHL and LSPSHL through the LN noncompliance rate. Our study showed that the overall noncompliance rates were similar between the two groups. Further subgroup analysis revealed that the noncompliance rate was also similar after stratification by clinical stage and BMI. However, this conclusion requires more prospective data for validation. SPSHL is usually performed along the particularly intricate and variable vessels in the splenic hilar area. Due to the well-spaced depth of the field and the clear and vivid view provided by the robotic system, robotic surgery can easily identify the anatomy of the splenic hilar vessels and LNs. High-definition three-dimensional magnification imaging can better show small anatomical structures and can be used to more clearly visualize the splenic vasculature^[41]. This method can reduce the difficulty of LN dissection and bleeding. The seven degrees of directional freedom of the mechanical wrist in the robotic system allow complex dissections in the narrow space of the splenic hilum, which greatly improves the flexibility of the operation and makes the procedure easier and more convenient than common laparoscopic surgery^[2,42]. Moreover, we stress that the robotic system is substantially easier to use and more accurate than laparoscopy in terms of LN exposure, discrimination, and collection in practice. Therefore, robotic surgery has similar outcomes as laparoscopic surgery when the complex process of SPSHL is performed, and robotic surgery is considered as effective as laparoscopy^[43,44].

Table 5 Time difference between the first and second steps among robotic spleen-preserving splenic hilar lymphadenectomy patients

Variable	First step time (min) ¹	Second step time (min) ¹	P-value
Total RSPSHL (<i>n</i> = 35)	8.4 ± 3.5	6.7 ± 2.6	0.024
EG (<i>n</i> = 20)	10.0 ± 3.4	7.5 ± 2.6	0.013
LG (<i>n</i> = 15)	6.3 ± 2.3	5.8 ± 2.2	0.548

¹Values are the mean ± SD. EG: Early group; LG: Late group; RSPSHL: Robotic spleen-preserving splenic hilar lymphadenectomy.

Our study also had several limitations. First, this study was a retrospective study from a single center, and large-sample, prospective, multicenter data are required to validate our findings. Second, the number of robotic cases was very small in this study. Third, we did not address the long-term outcomes of Huang's three-step robotic maneuver because robotic surgery was implemented relatively recently at our center. Despite these shortcomings, this is the first study in an Eastern population to identify the differences between RSPSHL and LSPSHL using propensity-matched scores to reduce the selection bias.

In conclusion, this study shows that robotic surgery using Huang's three-step maneuver can be performed to complete SPSHL. The safety of robotic surgery is equivalent to that of laparoscopy, especially after overcoming the early learning curve. Therefore, this procedure is worth promoting to most surgeons and patients. However, its long-term outcomes require further confirmation.

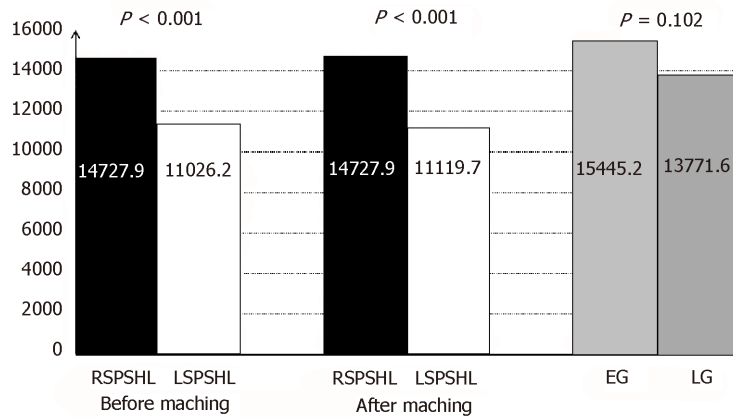


Figure 1 Cost analysis between different groups and subgroups. RSPSHL: Robotic spleen-preserving splenic hilar lymphadenectomy; LSPSHL: Laparoscopic spleen-preserving splenic hilar lymphadenectomy; EG: Early group; LG: Late group.

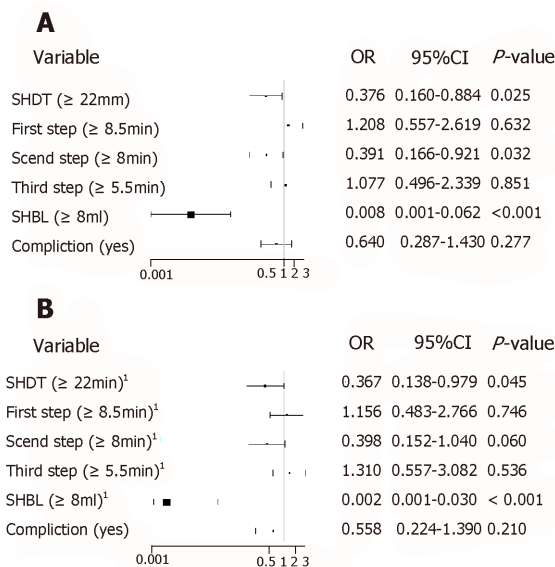


Figure 2 Unadjusted (A) and adjusted (B) regression models of robotic surgery via Huang's three-step maneuver and complications.¹Adjusted for: age, sex, body mass index, American Society of Anesthesiologists class, cT, cN, post-gastric artery, short gastric vessels, splenic upper pole artery, splenic lower pole artery, and the terminal branches of the splenic artery. BMI: Body mass index; ASA: American Society of Anesthesiologists; SGV: Short gastric vessel; PGA: Post-gastric artery; SUPA: Splenic upper pole artery; SLPA: Splenic lower pole artery; SpA: Splenic artery; SHDT: Splenic hilar dissection time; SHBL: Splenic hilar blood loss.

ARTICLE HIGHLIGHTS

Research background

Due to its high stability and precision, the robotic system can overcome the technical limitations of conventional laparoscopic surgery and therefore has great potential for use in complicated surgeries.

Research motivation

Robotic surgery has been considered to be significantly better than laparoscopic surgery for complicated procedures.

Research objectives

The aim of this study was to explore the short-term effect of robotic and laparoscopic spleen-preserving splenic hilar lymphadenectomy (SPSHL) for advanced gastric cancer by Huang's three-step maneuver.

Research methods

A total of 643 patients who underwent SPSHL were recruited from April 2012 to July 2017, including 35 patients who underwent robotic SPSHL (RSPSHL) and 608 who underwent laparoscopic SPSHL (LSPSHL). One-to-four propensity score matching was used to analyze the differences in clinical data between groups.

Research results

In all, 175 patients were matched, including 35 patients who underwent RSPSHL and 140 who underwent LSPSHL. After matching, there were no significant differences detected in the baseline characteristics between the two groups. Significant differences in total operative time, estimated blood loss (EBL), splenic hilar blood loss (SHBL), splenic hilar dissection time (SHDT), and splenic trunk dissection time were evident between these groups ($P < 0.05$). Furthermore, no significant differences were observed between the two groups in the overall noncompliance rate of lymph node (LN) dissection (62.9% *vs* 60%, $P = 0.757$), number of retrieved No. 10 LNs (3.1 ± 1.4 *vs* 3.3 ± 2.5 , $P = 0.650$), total number of examined LNs (37.8 ± 13.1 *vs* 40.6 ± 13.6 , $P = 0.274$), and postoperative complications (14.3% *vs* 17.9%, $P = 0.616$). A stratified analysis that divided the patients receiving RSPSHL into an early group (EG) and a late group (LG) revealed that the LG experienced obvious improvements in SHDT and length of stay compared with the EG ($P < 0.05$). Logistic regression showed that robotic surgery was a significantly protective factor against both SHBL and SHDT ($P < 0.05$).

Research conclusions

The safety of robotic surgery is equivalent to that of laparoscopy, especially after overcoming the early learning curve. Therefore, this procedure is worth promoting to most surgeons and patients. However, its long-term outcomes require further confirmation.

Research perspectives

We hope to perform a multi-center prospective study on the long-term outcomes of Huang's three-step robotic maneuver in order to provide a high-level scientific theoretical basis and clinical experience.

ACKNOWLEDGEMENTS

The authors thank all the medical staff who contributed to the maintenance of the medical record database.

REFERENCES

- 1 Kitano S, Iso Y, Moriyama M, Sugimachi K. Laparoscopy-assisted Billroth I gastrectomy. *Surg Laparosc Endosc* 1994; 4: 146-148 [PMID: 8180768 DOI: 10.1007/BF00590967]
- 2 Son T, Lee JH, Kim YM, Kim HI, Noh SH, Hyung WJ. Robotic spleen-preserving total gastrectomy for gastric cancer: comparison with conventional laparoscopic procedure. *Surg Endosc* 2014; 28: 2606-2615 [PMID: 24695982 DOI: 10.1007/s00464-014-3511-0]
- 3 Son SY, Shin DJ, Park YS, Oo AM, Jung DH, Lee CM, Ahn SH, Park DJ, Kim HH. Spleen-preserving lymphadenectomy versus splenectomy in laparoscopic total gastrectomy for advanced gastric cancer. *Surg Oncol* 2017; 26: 207-211 [PMID: 28577727 DOI: 10.1016/j.suronc.2017.04.002]
- 4 Huang CM, Chen T, Lin JX, Chen QY, Zheng CH, Li P, Xie JW, Wang JB, Lu J, Cao LL, Lin M, Tu RH. The effects of laparoscopic spleen-preserving splenic hilar lymphadenectomy on the surgical outcome of proximal gastric cancer: a propensity score-matched, case-control study. *Surg Endosc* 2017; 31: 1383-1392 [PMID: 27450211 DOI: 10.1007/s00464-016-5126-0]
- 5 Huang CM, Zhang JR, Zheng CH, Li P, Xie JW, Wang JB, Lin JX, Lu J, Chen QY. A 346 case analysis for laparoscopic spleen-preserving no.10 lymph node dissection for proximal gastric cancer: a single center study. *PLoS One* 2014; 9: e108480 [PMID: 25264673 DOI: 10.1371/journal.pone.0108480]
- 6 Huang CM, Huang ZN, Zheng CH, Li P, Xie JW, Wang JB, Lin JX, Jun L, Chen QY, Cao LL, Lin M, Tu RH. Huang's three-step maneuver shortens the learning curve of laparoscopic spleen-preserving splenic hilar lymphadenectomy. *Surg Oncol* 2017; 26: 389-394 [PMID: 29113657 DOI: 10.1016/j.suronc.2017.07.010]
- 7 Huang ZN, Huang CM, Zheng CH, Li P, Xie JW, Wang JB, Lin JX, Lu J, Chen QY, Cao LL, Lin M, Tu RH. Learning Curve of the Application of Huang Three-Step Maneuver in a Laparoscopic Spleen-Preserving Splenic Hilar Lymphadenectomy for Advanced Gastric Cancer. *Medicine (Baltimore)* 2016; 95: e3252 [PMID: 27043698 DOI: 10.1097/MD.0000000000003252]
- 8 Hashizume M, Sugimachi K. Robot-assisted gastric surgery. *Surg Clin North Am* 2003; 83: 1429-1444 [PMID: 14712877 DOI: 10.1016/S0039-6109(03)00158-0]
- 9 Patriti A, Ceccarelli G, Bellochi R, Bartoli A, Spaziani A, Di Zitti L, Casciola L. Robot-assisted laparoscopic total and partial gastric resection with D2 lymph node dissection for adenocarcinoma. *Surg Endosc* 2008; 22: 2753-2760 [PMID: 18813994 DOI: 10.1007/s00464-008-0129-0]
- 10 Japanese Gastric Cancer Association. Japanese gastric cancer treatment guidelines 2010 (ver. 3). *Gastric Cancer* 2011; 14: 113-123 [PMID: 21573742 DOI: 10.1007/s10120-011-0042-4]

- 11 **Lu J**, Zheng HL, Li P, Xie JW, Wang JB, Lin JX, Chen QY, Cao LL, Lin M, Tu RH, Huang ZN, Huang CM, Zheng CH. A Propensity Score-Matched Comparison of Robotic Versus Laparoscopic Gastrectomy for Gastric Cancer: Oncological, Cost, and Surgical Stress Analysis. *J Gastrointest Surg* 2018; **22**: 1152-1162 [PMID: [29736669](#) DOI: [10.1007/s11605-018-3785-y](#)]
- 12 **Huang CM**, Chen QY, Lin JX, Zheng CH, Li P, Xie JW. Huang's three-step maneuver for laparoscopic spleen-preserving No. 10 lymph node dissection for advanced proximal gastric cancer. *Chin J Cancer Res* 2014; **26**: 208-210 [PMID: [24826062](#) DOI: [10.3978/j.issn.1000-9604.2014.04.05](#)]
- 13 **Huang CM**, Chen QY, Lin JX, Zheng CH, Li P, Xie JW, Wang JB, Lu J, Yang XT. Laparoscopic spleen-preserving no. 10 lymph node dissection for advanced proximal gastric cancer using a left approach. *Ann Surg Oncol* 2014; **21**: 2051 [PMID: [24590432](#) DOI: [10.1245/s10434-014-3492-1](#)]
- 14 **Zheng CH**, Xu M, Huang CM, Li P, Xie JW, Wang JB, Lin JX, Lu J, Chen QY, Cao LL, Lin M. Anatomy and influence of the splenic artery in laparoscopic spleen-preserving splenic lymphadenectomy. *World J Gastroenterol* 2015; **21**: 8389-8397 [PMID: [26217091](#) DOI: [10.3748/wjg.v21.i27.8389](#)]
- 15 **Tsung A**, Geller DA, Sukato DC, Sabbaghian S, Tohme S, Steel J, Marsh W, Reddy SK, Bartlett DL. Robotic versus laparoscopic hepatectomy: a matched comparison. *Ann Surg* 2014; **259**: 549-555 [PMID: [24045442](#) DOI: [10.1097/SLA.0000000000000250](#)]
- 16 **Kang BH**, Xuan Y, Hur H, Ahn CW, Cho YK, Han SU. Comparison of Surgical Outcomes between Robotic and Laparoscopic Gastrectomy for Gastric Cancer: The Learning Curve of Robotic Surgery. *J Gastric Cancer* 2012; **12**: 156-163 [PMID: [23094227](#) DOI: [10.5230/jgc.2012.12.3.156](#)]
- 17 **Hyung WJ**, Lim JS, Song J, Choi SH, Noh SH. Laparoscopic spleen-preserving splenic hilar lymph node dissection during total gastrectomy for gastric cancer. *J Am Coll Surg* 2008; **207**: e6-11 [PMID: [18656040](#) DOI: [10.1016/j.jamcollsurg.2008.04.027](#)]
- 18 **Li P**, Huang CM, Zheng CH, Xie JW, Wang JB, Lin JX. [Laparoscopic spleen-preserving splenic hilar lymph node dissection for proximal gastric cancer]. *Zhonghua Wai Ke Za Zhi* 2011; **49**: 795-798 [PMID: [22177432](#) DOI: [10.4240/wjgs.v8.i6.402](#)]
- 19 **Shin SH**, Jung H, Choi SH, An JY, Choi MG, Noh JH, Sohn TS, Bae JM, Kim S. Clinical significance of splenic hilar lymph node metastasis in proximal gastric cancer. *Ann Surg Oncol* 2009; **16**: 1304-1309 [PMID: [19241107](#) DOI: [10.1245/s10434-009-0389-5](#)]
- 20 **Sakuramoto S**, Kikuchi S, Futawatari N, Katada N, Moriya H, Hirai K, Yamashita K, Watanabe M. Laparoscopy-assisted pancreas- and spleen-preserving total gastrectomy for gastric cancer as compared with open total gastrectomy. *Surg Endosc* 2009; **23**: 2416-2423 [PMID: [19266232](#) DOI: [10.1007/s00464-009-0371-0](#)]
- 21 **Kosuga T**, Ichikawa D, Okamoto K, Komatsu S, Shiozaki A, Fujiwara H, Otsuji E. Survival benefits from splenic hilar lymph node dissection by splenectomy in gastric cancer patients: relative comparison of the benefits in subgroups of patients. *Gastric Cancer* 2011; **14**: 172-177 [PMID: [21331530](#) DOI: [10.1007/s10120-011-0028-2](#)]
- 22 **Chikara K**, Hiroshi S, Masato N, Hirotochi A, Goro M, Hidetaka O. Indications for pancreaticosplenectomy in advanced gastric cancer. *Hepatogastroenterology* 2001; **48**: 908-912 [PMID: [11462954](#)]
- 23 **Baik SH**, Kwon HY, Kim JS, Hur H, Sohn SK, Cho CH, Kim H. Robotic versus laparoscopic low anterior resection of rectal cancer: short-term outcome of a prospective comparative study. *Ann Surg Oncol* 2009; **16**: 1480-1487 [PMID: [19290486](#) DOI: [10.1245/s10434-009-0435-3](#)]
- 24 **Ballantyne GH**. Telerobotic gastrointestinal surgery: phase 2--safety and efficacy. *Surg Endosc* 2007; **21**: 1054-1062 [PMID: [17287918](#) DOI: [10.1007/s00464-006-9130-7](#)]
- 25 **Xiong B**, Ma L, Zhang C. Robotic versus laparoscopic gastrectomy for gastric cancer: a meta-analysis of short outcomes. *Surg Oncol* 2012; **21**: 274-280 [PMID: [22789391](#) DOI: [10.1016/j.suronc.2012.05.004](#)]
- 26 **Lee JH**, Nam BH, Ryu KW, Ryu SY, Kim YW, Park YK, Kim S. Comparison of the long-term results of patients who underwent laparoscopy versus open distal gastrectomy. *Surg Endosc* 2016; **30**: 430-436 [PMID: [25875090](#) DOI: [10.1007/s00464-015-4215-9](#)]
- 27 **Suda K**, Man-I M, Ishida Y, Kawamura Y, Satoh S, Uyama I. Potential advantages of robotic radical gastrectomy for gastric adenocarcinoma in comparison with conventional laparoscopic approach: a single institutional retrospective comparative cohort study. *Surg Endosc* 2015; **29**: 673-685 [PMID: [25030478](#) DOI: [10.1007/s00464-014-3718-0](#)]
- 28 **Shinohara T**, Satoh S, Kanaya S, Ishida Y, Taniguchi K, Isogaki J, Inaba K, Yanaga K, Uyama I. Laparoscopic versus open D2 gastrectomy for advanced gastric cancer: a retrospective cohort study. *Surg Endosc* 2013; **27**: 286-294 [PMID: [22733201](#) DOI: [10.1007/s00464-012-2442-x](#)]
- 29 **Isogaki J**, Haruta S, Man-I M, Suda K, Kawamura Y, Yoshimura F, Kawabata T, Inaba K, Ishikawa K, Ishida Y, Taniguchi K, Sato S, Kanaya S, Uyama I. Robot-assisted surgery for gastric cancer: experience at our institute. *Pathobiology* 2011; **78**: 328-333 [PMID: [22104204](#) DOI: [10.1159/000330172](#)]
- 30 **Uyama I**, Suda K, Nakauchi M, Kinoshita T, Noshiro H, Takiguchi S, Ehara K, Obama K, Kuwabara S, Okabe H, Terashima M. Clinical advantages of robotic gastrectomy for clinical stage I/II gastric cancer: a multi-institutional prospective single-arm study. *Gastric Cancer* 2019; **22**: 377-385 [PMID: [30506394](#) DOI: [10.1007/s10120-018-00906-8](#)]
- 31 **Keller DS**, Senagore AJ, Lawrence JK, Champagne BJ, Delaney CP. Comparative effectiveness of laparoscopic versus robot-assisted colorectal resection. *Surg Endosc* 2014; **28**: 212-221 [PMID: [23996335](#) DOI: [10.1007/s00464-013-3163-5](#)]
- 32 **Kim HI**, Han SU, Yang HK, Kim YW, Lee HJ, Ryu KW, Park JM, An JY, Kim MC, Park S, Song KY, Oh SJ, Kong SH, Suh BJ, Yang DH, Ha TK, Kim YN, Hyung WJ. Multicenter Prospective Comparative Study of Robotic Versus Laparoscopic Gastrectomy for Gastric Adenocarcinoma. *Ann Surg* 2016; **263**: 103-109 [PMID: [26020107](#) DOI: [10.1097/SLA.0000000000001249](#)]
- 33 **Park JY**, Jo MJ, Nam BH, Kim Y, Eom BW, Yoon HM, Ryu KW, Kim YW, Lee JH. Surgical stress after robot-assisted distal gastrectomy and its economic implications. *Br J Surg* 2012; **99**: 1554-1561 [PMID: [23027072](#) DOI: [10.1002/bjs.8887](#)]
- 34 **Park EJ**, Kim CW, Cho MS, Kim DW, Min BS, Baik SH, Lee KY, Kim NK. Is the learning curve of robotic low anterior resection shorter than laparoscopic low anterior resection for rectal cancer?: a comparative analysis of clinicopathologic outcomes between robotic and laparoscopic surgeries. *Medicine (Baltimore)* 2014; **93**: e109 [PMID: [25437022](#) DOI: [10.1097/MD.0000000000000109](#)]
- 35 **Park SS**, Kim MC, Park MS, Hyung WJ. Rapid adaptation of robotic gastrectomy for gastric cancer by experienced laparoscopic surgeons. *Surg Endosc* 2012; **26**: 60-67 [PMID: [21789643](#) DOI: [10.1007/s00464-011-1828-5](#)]
- 36 **Yoon HM**, Kim YW, Lee JH, Ryu KW, Eom BW, Park JY, Choi JJ, Kim CG, Lee JY, Cho SJ, Rho JY.

- Robot-assisted total gastrectomy is comparable with laparoscopically assisted total gastrectomy for early gastric cancer. *Surg Endosc* 2012; **26**: 1377-1381 [PMID: [22083338](#) DOI: [10.1007/s00464-011-2043-0](#)]
- 37 **Obama K**, Kim YM, Kang DR, Son T, Kim HI, Noh SH, Hyung WJ. Long-term oncologic outcomes of robotic gastrectomy for gastric cancer compared with laparoscopic gastrectomy. *Gastric Cancer* 2018; **21**: 285-295 [PMID: [28639136](#) DOI: [10.1007/s10120-017-0740-7](#)]
- 38 **Lee JH**, Kim YW, Ryu KW, Lee JR, Kim CG, Choi IJ, Kook MC, Nam BH, Bae JM. A phase-II clinical trial of laparoscopy-assisted distal gastrectomy with D2 lymph node dissection for gastric cancer patients. *Ann Surg Oncol* 2007; **14**: 3148-3153 [PMID: [17705092](#) DOI: [10.1245/s10434-007-9446-0](#)]
- 39 **Park YK**, Yoon HM, Kim YW, Park JY, Ryu KW, Lee YJ, Jeong O, Yoon KY, Lee JH, Lee SE, Yu W, Jeong SH, Kim T, Kim S, Nam BH; COACT group. Laparoscopy-assisted versus Open D2 Distal Gastrectomy for Advanced Gastric Cancer: Results From a Randomized Phase II Multicenter Clinical Trial (COACT 1001). *Ann Surg* 2018; **267**: 638-645 [PMID: [28187041](#) DOI: [10.1097/SLA.0000000000002168](#)]
- 40 **Japanese Gastric Cancer Association**. Japanese Classification of Gastric Carcinoma - 2nd English Edition -. *Gastric Cancer* 1998; **1**: 10-24 [PMID: [11957040](#) DOI: [10.1007/s101209800016](#)]
- 41 **Coratti A**, Annecchiario M, Di Marino M, Gentile E, Coratti F, Giulianotti PC. Robot-assisted gastrectomy for gastric cancer: current status and technical considerations. *World J Surg* 2013; **37**: 2771-2781 [PMID: [23674257](#) DOI: [10.1007/s00268-013-2100-z](#)]
- 42 **Hanly EJ**, Talamini MA. Robotic abdominal surgery. *Am J Surg* 2004; **188**: 19S-26S [PMID: [15476648](#) DOI: [10.1016/j.amjsurg.2004.08.020](#)]
- 43 **Hyun MH**, Lee CH, Kwon YJ, Cho SI, Jang YJ, Kim DH, Kim JH, Park SH, Mok YJ, Park SS. Robot versus laparoscopic gastrectomy for cancer by an experienced surgeon: comparisons of surgery, complications, and surgical stress. *Ann Surg Oncol* 2013; **20**: 1258-1265 [PMID: [23080320](#) DOI: [10.1245/s10434-012-2679-6](#)]
- 44 **Kim MC**, Heo GU, Jung GJ. Robotic gastrectomy for gastric cancer: surgical techniques and clinical merits. *Surg Endosc* 2010; **24**: 610-615 [PMID: [19688399](#) DOI: [10.1007/s00464-009-0618-9](#)]



Published By Baishideng Publishing Group Inc
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA
Telephone: +1-925-2238242
E-mail: bpgoffice@wjgnet.com
Help Desk: <http://www.f6publishing.com/helpdesk>
<http://www.wjgnet.com>

