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Laparoscopic Splenectomy for the Elderly Liver Cirrhotic Patients With Hypersplenism

A Retrospective Comparable Study

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Abstract: A growing body of evidence has supported the benefits of laparoscopic splenectomy (LS) for hypersplenism due to liver cirrhosis. With the increased proportion of elderly persons worldwide, it is necessary to investigate the risks and benefits of LS in elderly liver cirrhotic patients.

From September 2003 to March 2012, LS and open splenectomy (OS) were performed for 21 (Group 1) and 19 (Group 3) patients, respectively, all of whom were 65 years of age and older; in addition, 39 patients who were <65 years old were treated with LS and referred to as Group 2. Data (i.e., demographic characteristics and preoperative, intraoperative, and postoperative information) were retrospectively collected. Between-group comparisons were performed for the above-mentioned data.

Compared with the patients in Group 3, the patients in Group 1 required longer operative times, fewer transfusions, less intensive care, a shorter postoperative course, and a shorter time to the first oral intake, and they had less blood loss and fewer postoperative short-term complications. During the follow-up period, compared with the preoperative status, significant changes in hemoglobin, leukocyte, platelet, and albumin levels were observed in all groups, whereas changes in the total BILirubin (BIL), aspartate aminotransferase (AST), and alanine aminotransferase (ALT) levels were inconspicuous.

Patients >65 years of age with hypersplenism caused by liver cirrhosis can safely undergo LS.

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Abbreviations: AASLD = American Association for Study Regarding Liver Diseases, ALT = alanine aminotransferase, ASA = American Society of Anesthesiologists, AST = aspartate aminotransferase, BIL = total bilirubin, BMI = body mass index, CT = computed tomography, EEVL = emergency endoscopic variceal ligation, ICU = intensive care unit, INR = International Normalized Ratio, ITP = immune thrombocytopenia, LS = laparoscopic splenectomy, MELD = model for end-stage liver disease, OS = open splenectomy, OSS = Operative Severity Score, POD = postoperative days, POM = postoperative months, POSSUM = PS and OSS for the Enumeration of Mortality and Morbidity, PS = physiological score, PSVT = portal or splenic vein thrombosis.

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INTRODUCTION

Liver cirrhosis is defined as the histological development of regenerative nodules surrounded by fibrous bands in response to chronic liver injury, such as alcoholic liver disease and hepatitis B and C.[1] It has been reported that the prevalence of liver cirrhosis was 0.15% in the USA,[2] with a similar level in European countries and an even higher level in most Asian and African countries.[1] Hypersplenism with the presence of leucopenia and/or thrombocytopenia associated with splenomegaly is a common complication in patients with portal hypertension caused by liver cirrhosis.[3,4]

Splenectomy, an alternative surgical intervention for these patients, has been determined to decrease portal pressure[5,6] and improve thrombocytopenia,[7] as well as liver function.[8–10] Since it was first reported by Delaitre in 1991,[11] laparoscopic splenectomy (LS) has demonstrated distinct advantages compared with open splenectomy (OS), including shorter hospital stays, less blood loss, reduced costs, and better cosmetic outcomes; since then, it has been recommended as the standard procedure for benign hematological diseases, particularly for chronic immune thrombocytopenia (ITP).[12] Recently, a number of studies have clarified the feasiBILity, safety, and effectiveness of LS for hypersplenism caused by liver cirrhosis, suggesting that patients will benefit more in terms of short- and long-term surgical outcomes compared with OS.[10,13–15] However, few studies auditing the potential advantages of laparoscopic splenectomy for hypersplenism secondary to liver cirrhosis have focused on age as a factor affecting outcomes.

As the geriatric population increases worldwide, surgery in elderly populations should garner more attention because it will be an inevitable challenge for surgeons. It is not difficult to understand that elderly patients often suffer from cardiovascular, pulmonary, renal, endocrine, or metabolic diseases, which may be significantly associated with postoperative complications. Thus, it is important to analyze the risks and benefits of surgery in elderly patients. Therefore, we performed the present study of LS in elderly patients with hypersplenism secondary to liver cirrhosis.

MATERIALS AND METHODS

From September 2003 to March 2012, at the Department of Pancreatic Surgery in West China Hospital, Sichuan University of China, 145 splenectomies were performed for patients with hypersplenism secondary to liver cirrhosis, with an LS/OS ratio of 0.71. LS and OS were performed for 21 (Group 1) and 19 (Group 3) patients, respectively, with hypersplenism secondary to liver cirrhosis, all of whom were 65 years of age and older; in addition, 39 patients <65 years of age, with hypersplenism due to liver cirrhosis, were treated with LS and included as Group 2. The decision whether to perform LS or OS was based on the discretion of the surgeon, the willingness of the patients, and the intraoperative situation. All patients in the study provided written informed consent. The study was approved by the Ethics Committee of West China Hospital, Sichuan University, China. The ethics committee also approved the retrospective analysis of existing patient data without the need for additional informed consent for the current study because we received written consent for the scientific research from all patients at the time of surgery.

The patient diagnoses were based on their medical histories (e.g., hepatitis B or C, schistosoma infection, and alcohol abuse), blood tests (thrombocytopenia, leucopenia or/and anemia), and computed tomography (CT) scans (i.e., an enlarged spleen, and abnormal hepatic shape, size, and edges with/without gastroesophageal varices), and the diagnoses were confirmed through postoperative pathological examinations (using a 4-point scale [F0-F4: F0, no fibrosis; F1, portal fibrosis without septa; F2, portal fibrosis and few septa; F3, numerous septa without cirrhosis; and F4, cirrhosis]), according to the METAVIR scoring system.[16] Indications for both LS and OS were as follows: (1) patients suffering from mucosal bleeding, anemia requiring transfusions, or/and infections with a platelet count of $<30 \times 10^9$/L, with/without a white blood count $<3 \times 10^9$/L; (2) patients with severe (size 3 or 4) esophageal varices, or who previously underwent treatment for esophageal varices bleeding through band ligation. The process of LS and OS for hypersplenism secondary to liver cirrhosis was detailed in our previous study.[17]

All patients received preoperative CT scans to measure the craniocaudal splenic length. A preoperative endoscopic examination was performed for each patient to classify the severity of the varices, based on the guidelines of the AASLD (the American Association for Study Regarding Liver Diseases).[18] The blood samples including hemoglobin, leukocyte, platelet, total BILirubin (BIL), aspartate aminotransferase (AST), alanine aminotransferase (ALT), and albumin assays were routinely examined a day before surgery and on postoperative days (POD) 1, 3, and 5. The Charlson Comorbidity Index,[19] Karnofsky score,[20] Physiological score (PS), and Operative Severity Score (OSS) for the Enumeration of Mortality and Morbidity (POSSUM)[21] were calculated. After the operation, B-ultrasound examinations were performed, and the amylase concentration in the fluid drainage was monitored daily until POD 7 to detect thrombus (if thrombus was detected with B-ultrasound, a CT scan was used to make a definite diagnosis) and pancreatic leakage. Upon discharge, all patients were reminded to have their blood samples re-examined at postoperative months (POM) 1, 3, and 6. B-ultrasound examinations were also performed to monitor postoperative portal or splenic vein thrombosis (PSVT) once a month for 3 months. Postoperative esophageal variceal bleeding events were recorded, and emergency endoscopic variceal ligation (EEVL) was performed as soon as possible.

The following data were retrospectively collected from the patients' medical records and individual telephones: demographic characteristics, preoperative information (i.e., body mass index [BMI], Child-Pugh class, MELD [Model for end-stage liver disease] score, INR [International Normalized Ratio], hemoglobin, platelet, and leukocyte levels, AST, BIL, ALT and albumin levels, ASA [American Society of Anesthesiologists] classification, splenic size, incidence of gastroesophageal varices, diagnoses, co-morbidities, Charlson, Karnofsky, and physiological scores), intraoperative information (i.e., the conversion rate, operative time, accessory spleen, transfusion rate, estimated blood loss, additional operation and the operative severity score [OSS]), and postoperative information (ICU [intensive care unit], utilization, postoperative stays, time until the first diet, histologic fibrosis stage, short- and long-term complications, readmission rate within 30 days, mortality rate, and hematological parameters involving routine blood and liver function). Postoperative complications were classified into 3 groups based on the Clavien–Dindo classification of surgical complications: no complications, mild complications ([1] any deviation from the normal postoperative course without the requirement for pharmacologic treatment or surgical, endoscopic, or radiologic interventions; [2] complications requiring pharmacologic treatment with drugs), and severe complications ([1] complications needing surgical, endoscopic, or radiologic interventions; [2] life-threatening complications requiring intensive care unit management, and [3] death).[22]

STATISTICAL ANALYSIS

Continuous quantitative data were presented as the mean ± standard deviation or as the median (quartile), whereas categorical data were expressed as the number of cases and percentage. Statistical analyses, which were performed using SPSS 16.0 (SPSS, Chicago, IL) for Windows, consisted of Student's *t* test, the nonparametric Mann–Whitney *U* test, the chi-squared test, and the Fisher exact test, with significance set at P value <0.05. Afterward, univariate and multivariate logistic regression analyses with the forward stepwise method and likelihood ratio were used to determine the predictors of postoperative short-term complications for the patients in Group 1.

RESULTS

Detailed demographics and preoperative information for the 3 groups are listed in Table 1. The LS procedures were performed on 21 patients >65 years of age and 39 patients <65 years of age, whereas 19 patients >65 years received traditional open splenectomy. Comparing Group 1 with Group 2 and Group 3, the distribution of gender, Child-Pugh class and disease types, preoperative hemoglobin, platelet and leukocyte levels, INR and craniocaudal splenic length were similar, as were the incidence and severity of gastroesophageal varices. Group 1 and Group 3 showed no significant difference in terms of BMI and preoperative co-morbidities, whereas comparing Group 1 with Group 2, the results indicated otherwise. No significant between-group differences were observed in terms of the Charlson score distribution, whereas more patients in Group 1 had lower Karnofsky scores compared with those in Group 2 ($P<0.05$), the physiological score demonstrated the same result.

A description of the intraoperative details is provided in Table 2. Except for 1 (5.3%) and 2 patients (5.1%) in Group 1 and Group 2, respectively, all candidates in the 2 groups

TABLE 1. Demographic and Preoperative Information

Variables	Group 1	Group 2	Group 3	P^a Value	P^b Value
Cases	21	39	19		
Gender (M/F)	8/13	20/19	11/8	NS	NS
Age (y)	67.1 ± 2.0	39.7 ± 7.6	67.7 ± 2.9	/	NS
BMI (kg/m^2)	19.7 ± 0.5	20.4 ± 1.1	19.5 ± 0.6	<0.05	NS
Child-Pugh class				NS	NS
A	8	18	8		
B	7	13	7		
C	1	1	1		
MELD score	10.9 ± 0.8	10.3 ± 1.6	11.2 ± 2.3	NS	NS
INR	1.03 ± 0.06	1.06 ± 0.11	1.02 ± 0.13	NS	NS
HGB (g/L)	109.0 (91.0–120.5)	115.0 (92.0–129.0)	115.0 (94.0–133.0)	NS	NS
Platelet (×10^9/L)	39.0 (27.5–43.5)	32.0 (27.0–46.0)	36.0 (30.0–50.0)	NS	NS
WBC (×10^9/L)	2.0 (1.7–2.4)	2.2 (1.8–3.1)	2.4 (1.7–3.3)	NS	NS
Total bilirubin (μmol/L)	20.6 (14.5–24.4)	22.6 (17.3–31.0)	17.3 (15.9–22.9)	NS	NS
ALT (IU/L)	34.0 (26.5–50.5)	34.0 (25.0–46.0)	34.0 (23.0–41.0)	NS	NS
AST (IU/L)	32.0 (25.0–54.5)	31.0 (21.0–48.0)	38.0 (26.0–47.0)	NS	NS
Albumin (g/L)	37.4 (34.9–40.3)	38.9 (34.9–40.9)	39.6 (33.5–42.1)	NS	NS
ASA classification				NS	NS
II	3 (14.3%)	10 (25.6%)	2 (10.5%)		
III	17 (80.9%)	27 (69.3%)	16 (84.2%)		
IV	1 (4.8%)	2 (5.1%)	1 (5.3%)		
Spleen size (cm)	21.0 (20.0–25.0)	20.0 (19.0–26.0)	22.0 (22.0–26.0)		
Incidence of gastroesophageal varices	9 (42.9%)	21 (53.8%)	9 (47.4%)	NS	NS
Mild	3	6	2		
Severe	6	15	7		
Diagnoses					
Posthepatitis cirrhosis	18	36	13		
Alcoholic cirrhosis	2	1	2		
Schistosomiasis cirrhosis	1	2	4		
Comorbidities					
Hypertension	2	1	2		
Pulmonary tuberculosis	2	2	0		
Chronic bronchitis	2	1	1		
Diabetes	2	0	5		
Rheumatic disease	0	0	2		
Gastric cancer	1	0	0		
Gallbladder stone/polypus	5	6	3		
Chronic renal insufficiency	0	1	0		
Chronic superficial gastritis	2	4	1		
Total events	16	15	14		
Charlson score				NS	NS
1	5	14	4		
2	6	4	2		
≥3	10	21	13		
Karnofsky score (range 0–100%)				<0.05	NS
0–59%	1	0	0		
60–79%	6	0	3		
80–100%	14	39	16		
PS in POSSUM	21.0 (19.0–25.5)	18.0 (17.0–20.0)	22.0 (19.5–27.5)	<0.05	NS
Indications for splenectomy					
Lower platelet counts	15	24	12		
Severe esophageal varices	6	15	7		

Child-Pugh class and MELD (model for end-stage liver disease) score: only calculated for patients with F4 cirrhosis.

Incidence of gastroesophageal varices: the severity of the varices was classified based on the guidelines of the AASLD (the American Association for Study Regarding Liver Diseases).

Lower platelet counts: a platelet count $<30 \times 10^9$/L with/without a white blood count $<3 \times 10^9$/L.

ALT = alanine aminotransferase, ASA = American Society of Anesthesiologists, AST = aspartate aminatransferase, HGB = hemoglobin, INR = International Normalized Ratio; MELD = model for end-stage liver disease; NS = no significance; PS in POSSUM = the physiological score in Physiological score (PS) and Operative Severity Score (OSS) for the Enumeration of Mortality and Morbidity (POSSUM), WBC = white blood cell.

P^a value = comparison between Group 1 and Group 2.

P^b value = comparison between Group 1 and Group 3.

TABLE 2. Intraoperative Information

Variables	Group 1 (n = 21)	Group 2 (n = 39)	Group 3 (n = 19)	P^a Value	P^b Value
Conversion rate	1 (5.3%)	2 (5.1%)	/	NS	/
Operative time (min)	210.0 (150.0–265.0)	230.0 (190.0–260.0)	180.0 (120.0–190.0)	NS	<0.05
Accessory spleen	1 (5.3%)	3 (7.7%)	2 (10.5%)	NS	NS
Transfusion rate	3 (14.3%)	4 (10.3%)	8 (42.1%)	NS	<0.05
EBL (mL)	150.0 (125.0–205.0)	170.0 (90.0–200.0)	350.0 (300.0–600.0)	NS	<0.001
Additional operation					
Liver biopsy	21 (100%)	39 (100%)	19 (100%)	/	/
Cholecystectomy	5 (23.8%)	6 (15.4%)	3 (15.8%)	/	/
OSS in POSSUM	7.0 (7.0–7.0)	7.0 (7.0–7.0)	7.0 (7.0–9.0)	NS	<0.05

EBL = estimated blood loss, NS = no significance, OSS in POSSUM = the operative severity score (OSS) in Physiological score (PS) and Operative Severity Score (OSS) for the Enumeration of Mortality and Morbidity (POSSUM).
P^a value = comparison between Group 1 and Group 2.
P^b value = comparison between Group 1 and Group 3.

underwent successful LS. The emergency conversion to traditional open splenectomy primarily resulted from bleeding from the splenic pedicel beyond the surgeons' control through laparoscopic instruments in the relatively limited intra-abdominal room. Compared to Group 3, the operative time for Group 1 was longer, and the patients in Group 1 required fewer blood transfusions and suffered less blood loss, whereas when comparing Group 1 with Group 2, in terms of the operative time, transfusion rate, and estimated blood loss, the results indicated no significant difference. Liver biopsies were routinely performed for all patients for postoperative pathological examinations. Co-cholecystectomy was performed in 5, 6, and 3 patients separately in the 3 groups based on their preoperative diagnoses. The operative severity score (OSS) was calculated using 6 factors, namely, the operative severity, procedures, blood loss, peritoneal soiling, presence of malignancy, and mode of surgery.[21] The scores were quite comparable in Group 1 and Group 2, whereas a significant difference was detected when comparing the Group 1 score with that of Group 3 ($P<0.05$).

The postoperative details are provided in Table 3. Compared with Group 3, fewer patients in Group 1 required intensive care (3 [14.3%] vs 8 [42.1%], $P<0.05$). Moreover, the postoperative stays were shorter (7.0 days [median, 6.0–8.5 days] vs 10.0 days [median, 9.0–12.0 days], $P<0.001$), as was the interval between the splenectomy and the first oral intake (2.0 days [median, 1.5–3.0 days] vs 4.0 days [median, 3.0–5.0 days], $P<0.001$). The pathological results of the liver biopsies showed that all histological fibrosis stages belonged to F3 (numerous septa without cirrhosis) or F4 (cirrhosis). A lower overall short-term complication rate was detected when comparing Group 1 with Group 3 (7 [33.3%] vs 14 [73.7%], $P<0.05$). All patients suffering from short-term complications were cured through conservative treatments, except for 1 case of splenic fossa collection in Group 3 and 1 case of pleural effusion in Group 1 that required B-ultrasound-guided percutaneous drainage, and 2 postoperative bleeding cases in Groups 1 and 2 that required emergency laparotomies and blood transfusions. Long-term postoperative portal or splenic vein thrombosis was detected in 5 cases. Two patients (1 in Group 1 and 1 in Group 2) experienced variceal bleeding 9 and 18 months after splenectomy, respectively, and both patients received emergency endoscopic variceal ligation (EEVL) to avoid life-threatening ongoing bleeding. A single patient in Group 1 had to be readmitted to the hospital within 30 days after the LS because of the invasion and metastasis of his gastric cancer, which led to his death 5 months after the LS, resulting in a 6-month mortality of 4.8%, which seemingly had nothing to do with the LS.

The changes in the hematological and liver function parameters before and after splenectomy are listed in Table 4. The preoperative hemoglobin levels were nearly within normal limits for all patients, with relatively lower POD 1, POD 3, and POD 5 hemoglobin levels; however, the progressive increase in the hemoglobin levels during the follow-up resulted in normal ranges for all patients in the 3 groups 6 months postsplenectomy. Compared with the preoperative conditions, significantly higher but normal levels of POM 1, 3, 6 leukocytes were observed in the 3 groups. Compared with the preoperative risk and low platelet levels, the platelet counts at POM 1, 3, and 6 reached significantly higher but normal ranges in the 3 groups. In terms of the liver function changes before and after splenectomy, no significant difference was detected in terms of BIL, AST, and ALT in all of the groups, whereas the albumin levels of first decreased significantly on the first postoperative day and then gradually increased to the significantly normal range in the sixth postoperative month compared to the preoperative status.

Table 5 shows correlations between the related variables and the incidence of overall short-term surgical complications in Group 1, which were examined by univariate analysis. The Charlson score, Karnofsky, and the physiological scores were found to have a predictive value for better outcomes for elderly liver cirrhotic patients treated with LS. However, in the multivariate logistic regression analysis, no significant independent predictors were confirmed.

DISCUSSION

Improvements in the results of laparoscopic splenectomy have led to growing acceptance of this approach as a potentially alternative therapy for patients with hypersplenism secondary to liver cirrhosis. To the best of our knowledge, to date, few studies investigating LS for hypersplenism due to liver cirrhosis have been conducted, particularly in elderly population, who require surgical attention. Therefore, the purpose of the present study was to evaluate the risks and benefits of LS for the elderly. To make the comparisons between the groups more homogeneous, Group 3 was included as a control.

TABLE 3. Postoperative Information

Variables	Group 1 (n = 21)		Group 2 (n = 39)		Group 3 (n = 19)		P^a Value	P^b Value
ICU utilization	3 (14.3%)		5 (12.8%)		8 (42.1%)		NS	<0.05
Postoperative stay (days)	7.0 (6.0–8.5)		8.0 (7.0–10.0)		10.0 (9.0–12.0)		NS	<0.001
Oral intake (days)	2.0 (1.5–3.0)		2.0 (2.0–2.0)		4.0 (3.0–5.0)		NS	<0.001
Histologic fibrosis stage							NS	NS
F3	5		7		3			
F4	16		32		16			
Short-term complications								
No complication	14		27		5			
Mild complications								
	Pulmonary infection	1	Splenic fossa collection	1	Splenic fossa collection	1		
	Pancreatic leakage	2	Pleural effusion	1	Pleural effusion	1		
	Portal thrombosis	2	Pulmonary infection	2	Pulmonary infection	5		
			Pancreatic leakage	4	Incision infection	3		
			Portal thrombosis	3	Pancreatic leakage	2		
					Portal thrombosis	1		
Severe complications								
	Pleural effusion	1	Postoperative bleeding	1	Splenic fossa collection	1		
	Postoperative bleeding	1						
Total	7 (33.3%)		12 (30.8%)		14 (73.7%)		NS	<0.05
Long-term complications								
No complication	19		35		18			
Mild complications								
	PSVT	1	PSVT	3	PSVT	1		
Severe complications								
	Variceal bleeding	1	Variceal bleeding	1				
Total	2 (9.5%)		4 (10.3%)		1 (5.3%)		NS	NS
Readmission within 30 days	1		0		0		/	/
Mortality								
In-hospital	0		0		0		/	/
6-months	1		0		0		/	/
Total	1 (4.8%)		0		0		/	/

Short-term complications and long-term complications were classified into 3 groups (no, mild, and severe) based on the Clavien–Dindo classification of surgical complications.

ICU = intensive care unit, NS = no significance.

P^a value = comparison between Group 1 and Group 2.

P^b value = comparison between Group 1 and Group 3.

It is well accepted that the elderly are more likely to have comorbidities, such as hypertension, diabetes, rheumatic diseases, and so on; therefore, these patients were considered to poorly tolerate abdominal surgery because of their high postoperative morbidity.[23] Laparoscopic surgery, a minimally invasive procedure, has been determined to have favorable impacts on postoperative complications and recovery. Recently, many studies have compared open and laparoscopic procedures in elderly patients with colorectal cancer; these studies have revealed that the latter procedure would lead to a lower rate of postoperative complications (31.3–51.3% vs 10.1–23.5%, open vs laparoscopic procedures).[24–27] Studies comparing open and laparoscopic splenectomy for hypersplenism caused by liver cirrhosis, without addressing patient age, have shown that the rate of postoperative complications varies from 14.1% to 41.7% versus from 8.8% to 28.0% (OS vs LS).[15,17,28] When comparing Group 1 with Group 3 in the present study, the results showed a significantly lower rate of postoperative short-term complications for patients in Group 1 (primarily involving pulmonary and incision infections), whereas the rate was similar between Groups 1 and 2. Although the research objects and purposes are different, a common conclusion can be reached: patients undergoing laparoscopic procedures suffer from fewer postoperative complications compared with those undergoing open procedures, which is an important consideration for older adults.

It has been reported that the incidence of portal splenic vein thrombosis (PSVT) in liver cirrhotic patients treated with splenectomy varied from 2% to 55%.[29–33] In the present study, during the follow-up period, 5 patients were diagnosed with PSVT. No significant difference in the occurrence of PSVT was detected between LS and OS (6.7% vs 5.3%), which aligned with the results of some previous studies[34–36] but conflicted with others.[37] In addition, older and younger patients suffered from PSVT at a similar rate after LS, suggesting that age is not a risk factor for PSVT. In the present study, there was no significant difference in the occurrence of PSVT at the early or delayed stage; however, LS seemed to increase the risk of developing PSVT (early stage: 8.3% vs 5.3%, LS vs OS; delayed stage: 6.7% vs 5.3%, LS vs OS). The surgical technique

TABLE 4. Changes of Hematological and Liver Function Parameters Before and After Splenectomy

	Pre	POD 1	POD 3	POD 5	POM 1	POM 3	POM 6
HGB[a] (g/L)							
Group 1 (n = 21)	109.0 (91.0–120.5)	102.0 (89.5–119.0)	99.0 (87.0–112.5)	103.0 (92.5–113)	122.0 (110.0–126.5)*	126.0 (115.0–131.5)*	129.0 (121.5–135.0)*
Group 2 (n = 39)	115.0 (92.0–129.0)	113.0 (100.0–121.0)	110.0 (93.0–121.0)	108.0 (95.0–122.0)	123.0 (100.0–132.0)	131.0 (112.0–137.0)*	138.0 (126.0–145.0)*
Group 3 (n = 19)	115.0 (94.0–133.0)	102.0 (92.0–125.0)	102.0 (89.0–127.0)	111.0 (90.0–122.0)	112 (98.0–130.0)	124.0 (100.0–132.0)	130.0 (97.0–134.0)
Platelet ($\times 10^9$/L)							
Group 1 (n = 21)	39.0 (27.5–43.5)	65.0 (52.0–77.5)*	112.0 (84.0–147.0)*	190.0 (114.0–250.5)*	227.0 (187.0–338.0)*	251.0 (166.0–296.0)*	225.0 (146.5–270.0)*
Group 2 (n = 39)	32.0 (27.0–46.0)	62.0 (40.0–84.0)*	116.0 (68.0–174.0)*	189.0 (143.0–332.0)*	278.0 (191.0–343.0)*	227.0 (137.0–313.0)*	209.0 (131.0–231.0)*
Group 3 (n = 19)	36.0 (30.0–50.0)	61.0 (43.0–84.0)*	125.0 (88.0–138.0)*	242.0 (156.0–276.0)*	267.0 (176.0–406.0)*	234.0 (198.0–314.0)*	221.0 (198.0–290.0)*
WBC[b] ($\times 10^9$/L)							
Group 1 (n = 21)	2.0 (1.7–2.4)	11.1 (8.2–12.2)*	10.4 (8.0–13.6)*	9.6 (6.7–10.0)*	6.7 (5.4–8.3)*	6.5 (5.7–7.0)*	5.9 (5.6–7.0)*
Group 2 (n = 39)	2.2 (1.8–3.1)	11.9 (9.4–15.1)*	10.5 (8.6–14.2)*	7.6 (6.8–10.5)*	6.9 (6.0–8.0)*	6.8 (5.5–7.9)*	6.3 (5.3–7.9)*
Group 3 (n = 19)	2.4 (1.7–3.3)	13.1 (9.8–14.2)*	12.0 (8.8–15.2)*	8.7 (7.2–10.0)*	7.0 (6.0–8.0)*	6.1 (6.0–8.0)*	7.0 (5.9–7.7)*
Total bilirubin (μmol/L)							
Group 1 (n = 21)	20.6 (14.5–24.4)	21.0 (15.3–33.3)	22.0 (14.6–23.4)	21.0 (14.4–26.8)	19.8 (14.5–25.0)	19.0 (15.7–24.5)	21.0 (14.3–24.5)
Group 2 (n = 39)	22.6 (17.3–31.0)	23.0 (14.5–31.0)	20.0 (12.6–29.2)	20.0 (12.0–32.9)	19.5 (15.1–29.0)	20.5 (16.0–28.0)	19.0 (14.0–24.0)
Group 3 (n = 19)	17.3 (15.9–22.9)	17.3 (14.0–26.0)	26.7 (16.5–32.0)	19.8 (16.5–26.8)	19.3 (12.0–21.4)	20.0 (14.0–32.0)	16.0 (11.4–19.9)
ALT[c] (IU/L)							
Group 1 (n = 21)	34.0 (26.5–50.5)	34.0 (28.5–53.5)	38.0 (26.5–57.5)	30.0 (21.0–42.5)	28.0 (18.0–33.0)	24.0 (20.0–34.0)	26.0 (19.0–40.0)
Group 2 (n = 39)	34.0 (25.0–46.0)	32.0 (27.0–61.0)	33.0 (23.0–51.0)	33.0 (24.0–54.0)	35.0 (26.0–53.0)	33.0 (22.0–44.0)	32.0 (22.0–44.0)
Group 3 (n = 19)	34.0 (23.0–41.0)	37.0 (27.0–47.0)	32.0 (24.0–47.0)	31.0 (18.0–45.0)	28.0 (21.0–39.0)	32.0 (22.0–42.0)	24.0 (19.0–29.0)
AST[d] (IU/L)							
Group 1 (n = 21)	32.0 (25.0–54.5)	34.0 (28.5–53.5)	38.0 (26.5–57.5)	30.0 (21.0–42.5)	28.0 (18.0–33.0)	24.0 (20.0–34.0)	26.0 (19.0–40.0)
Group 2 (n = 39)	31.0 (21.0–48.0)	37.0 (33.0–52.0)	39.0 (30.0–53.0)	35.0 (26.0–55.0)	34.0 (27.0–54.0)	34.0 (22.0–51.0)	33.0 (21.0–54.0)
Group 3 (n = 19)	38.0 (26.0–47.0)	41.0 (31.5–47.0)	37.0 (32.0–70.0)	30.0 (21.0–51.0)	39.0 (26.0–47.0)	36.0 (27.0–44.0)	31.0 (23.0–43.0)
Albumin (g/L)							
Group 1 (n = 21)	37.4 (34.9–40.3)	32.0 (29.8–35.0)*	31.6 (28.0–33.8)*	33.0 (30.7–35.5)*	36.5 (34.6–39.5)	39.0 (37.0–41.0)	40.0 (38.3–43.9)*
Group 2 (n = 39)	38.9 (34.9–40.9)	30.7 (27.7–34.7)*	32.3 (29.6–36.9)*	35.0 (32.0–38.1)*	39.0 (35.0–41.0)	40.0 (37.0–42.0)	41.0 (39.0–44.0)*
Group 3 (n = 19)	39.6 (33.5–42.1)	27.7 (26.0–32.6)*	34.5 (32.8–36.4)*	33.4 (31.5–38.0)*	38.0 (35.0–41.0)	39.0 (37.4–41.7)	41.0 (39.5–43.0)*

ALT[c] = alanine aminotransferase; AST[d] = aspartate aminatransferase; HGB[a] = hemoglobin; WBC[b] = white blood cell.
*Compared with preoperative status within the group, $P < 0.05$.

TABLE 5. Univariate Analysis of Short-Term Complications for the Elderly Treated With LS

		Group 1 (n = 21)		
Variables	**All Patients**	**With Complications**	**Without Complications**	***P* Value**
Gender				NS
Male	8	4	4	
Female	13	3	10	
Hospital stay (days)		7.0 (6.0–11.0)	7.0 (6.0–8.0)	NS
Duration of surgery (min)	230.0 (150.0–260.0)	200.0 (145.0–270.0)	NS	
Conversion				NS
Yes	1	1	0	
No	20	6	14	
Blood transfusion				NS
Yes	3	2	1	
No	18	5	13	
Splenic length (cm)		20.0 (18.0–21.0)	22.0 (20.8–25.0)	NS
Accessory spleen				NS
Yes	1	1	0	
No	20	6	14	
EBL (mL)		150.0 (145.0–210.0)	150.0 (117.5–210.0)	NS
Charlson score		4.0 (3.0–4.0)	2.0 (1.0–2.3)	<0.001
Karnofsky score	70.0 (60.0–70.0)	85.0 (80.0–90.0)	<0.001	
PS in POSSUM	28.0 (24.0–30.0)	20.0 (19.0–21.0)	<0.05	
OSS in POSSUM	7.0 (7.0–7.0)	7.0 (7.0–7.0)	NS	
ASA classification				NS
II	3	0	3	
III	17	6	11	
IV	1	1	0	
Preoperative platelet count	36.0 (27.0–58.0)	39.0 (27.0–43.3)	NS	
Preoperative leucocyte count	2.0 (1.6–5.0)	2.0 (1.7–2.4)	NS	

ASA = American Society of Anesthesiologists, EBL = estimated blood loss, NS = no significance, OSS in POSSUM = the operative severity score (OSS) in Physiological score (PS) and Operative Severity Score (OSS) for the Enumeration of Mortality and Morbidity (POSSUM), PS in POSSUM = the physiological score in Physiological score (PS) and Operative Severity Score (OSS) for the Enumeration of Mortality and Morbidity (POSSUM).

itself may explain the higher incidence of PSVT after LS compared with OS. During LS, pneumoperitoneum may decrease portal vein flow and induce stasis,[38,39] whereas splenic hilar vessels transected by endoscopic stapler may result in venous stasis at the very end of the stump. Because of the mild and nonspecific symptoms, including fever, abdominal pain, diarrhea, and vomiting,[40–42] with more than half asymptomatic,[34] it appears to be difficult to make an early clinical diagnosis of potentially fatal complications. Therefore, a monthly B-ultrasound examination for at least 3 months after splenectomy was performed. After the complication was detected, early anticoagulation therapy was recommended, according to the practice guidelines.[43]

The present study also showed the dynamic changes in hematological and liver function parameters until 6 months after splenectomy. As reported in many studies, normal ranges of platelet and leukocyte counts was achieved after splenectomy, and no significant difference was observed between the 3 groups, suggesting that, in addition to less intraoperative blood loss, fewer transfusions, fewer short-term complications, lower ICU utilization, faster recovery, shorter hospital stays, and better cosmetic results, the elderly, compared with the youth, acquired the same benefits from LS in terms of hematological responses.

In terms of improvements in liver function after splenectomy, the results differ according to a variety of studies. Shimada et al[44] have reported that LS could significantly improve the Child-Pugh scores of liver cirrhotic patients through inhibition of cytokine mediators from the pathological spleen. Cai et al[17] have reported that the ALT, AST, and BIL levels decreased 2 weeks after splenectomy, without any statistical significance. No obvious changes in ALT, AST, and albumin levels were observed after splenectomy in the Imura study.[6] The related findings of a decrease in BILirubin, and an increase in protein production have been reported in other studies.[5,45] In the present study, no significant changes in the ALT, AST, and BIL levels were observed after splenectomy among the 3 groups during the 6-month follow-up period, except for a marked increase in the albumin level at POM 6. Different conclusions may be attributed to patient selection bias, in addition to a diverse preoperative status.

Various studies have indicated that cardiopulmonary diseases may reduce the tolerance for pneumoperitoneum,[46] which is required for a sufficient operative view.[47] This method was also reported to generate adverse pathophysiological changes, including hypercapnia, reduced venous return, increased peak airway pressure, decreased pulmonary compliance,[48,49] and elevated ALT levels,[50] all of which are potential dangers for the elderly. Fortunately, in the present study, no patients had to be converted due to pneumoperitoneum intolerance, even among the elderly.

Although LS may provide a good start for elderly liver cirrhotic patients, it is necessary to explore the underlying predictors of postoperative complications. In this study, in addition to the clinical and laboratory data, the objective indices, including the Charlson score, Karnofsky score, PS in POSSUM, and OSS in POSSUM, were also used for the univariate analysis. The results indicated that the Charlson score, Karnofsky score, and PS in POSSUM differed significantly between patients with and without complications. However, in the multiple logistic regression analysis, no independent predictors were found, which may result from the small sample size. It is not surprising that the open splenectomy group did not do as well in terms of postoperative complications. Even so, complications resulting from laparoscopic surgeries should not be neglected. Based on our study, the Charlson score, Karnofsky score, and PS in POSSUM should be considered when treating an elderly population with LS.

Additionally, advanced laparoscopic instruments and a professional team of surgeons, anesthesiologists and nursing staff contribute significantly to successful LS in the elderly patients with hypersplenism secondary to liver cirrhosis.

Admittedly, our study is retrospective in nature and nonrandomized, and the sample size is small. Thus, the results could have been affected by some potential biases. However, the preoperative information among the 3 groups was comparable (Table 1), which could balance the potential biases to some extent. Therefore, a large-volume, prospective, and randomized study is necessary for further study.

In summary, although elderly patients have a higher rate of preoperative comorbidities, the results of this study indicate that laparoscopic splenectomy provides clear benefits to them. Thus, LS for hypersplenism caused by liver cirrhosis should extend to the elderly population. Furthermore, when selecting elderly candidates, the Charlson score, Karnofsky score, and PS in POSSUM should be considered to determine whether elderly patients are healthier than their peers.

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