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RETROSPECTIVE STUDY

Perioperative advantages of modified laparoscopic *vs* open splenectomy and azygoportal disconnection

Guo-Qing Jiang, Ping Chen, Jian-Jun Qian, Jie Yao, Xiao-Dong Wang, Sheng-Jie Jin, Dou-Sheng Bai

Guo-Qing Jiang, Ping Chen, Jian-Jun Qian, Jie Yao, Xiao-Dong Wang, Sheng-Jie Jin, Dou-Sheng Bai, Department of Hepatobiliary Surgery, Clinical Medical College of Yangzhou University, Yangzhou 225001, Jiangsu Province, China
Author contributions: Jiang GQ and Chen P contributed equally to this work; Jiang GQ, Chen P, and Bai DS designed the research; Bai DS, Chen P, Qian JJ, Yao J, and Jin SJ performed the research; Jiang GQ and Wang XD analyzed the data; and Jiang GQ and Chen P wrote the manuscript.
Correspondence to: Dou-Sheng Bai, MD, Department of Hepatobiliary Surgery, Clinical Medical College of Yangzhou University, 98 West Nantong Rd, Yangzhou 225001, Jiangsu Province, China. bdsno1@hotmail.com
Telephone: +86-514-87373272 Fax: +86-514-87990188
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Abstract

AIM: To investigate perioperative outcomes in patients undergoing modified laparoscopic splenectomy or open splenectomy and azygoportal disconnection for portal hypertension.

METHODS: This study included 44 patients who underwent modified laparoscopic splenectomy and azygoportal disconnection (MLSD) and 71 who underwent open procedures for portal hypertension. Blood samples were collected before surgery and on days 1, 3, and 7 after surgery. Markers of liver and renal function, C-reactive protein (CRP), interleukin-6 (IL-6), and procalcitonin (PCT) were measured, and perioperative variables were compared between the two groups.

RESULTS: The modified laparoscopic group showed significantly better and faster recovery, better liver and renal function, and fewer complications than the open group. CRP, IL-6, and PCT concentrations on postoperative days 1, 3, and 7 were significantly lower in the modified laparoscopic group than in the open group.

CONCLUSION: MLSD was associated with lower inflammatory immune responses, less impairment of liver and renal function, and faster and better recovery.

Core tip: Minimal surgical trauma is an important goal to both surgeons and patients. A novel technique, in which massively enlarged spleens are removed from the abdominal cavity with an electromechanical morcellator through an existing 12-mm port, was first developed by our surgical team for laparoscopic splenectomy and azygoportal disconnection, and greatly reduces surgical trauma for cirrhotic patients with bleeding portal hypertension and secondary hypersplenism. This technique resulted in minimal postoperative pain and scarring, faster and better postoperative recovery, and lower inflammatory immune responses.

INTRODUCTION

Surgical trauma results in the activation of systemic immunologic and inflammatory responses; a process called surgical stress. Acute inflammatory responses are initiated by direct tissue trauma caused by incisions, dissections, organ manipulation, and vascular compromise[1-4]. The minimally invasive nature of laparoscopic surgery is thought to generate weaker systemic immune and inflam-

matory responses than traditional open surgery. These weaker responses are likely caused by the minimal manipulation of organs, as well as smaller surgical incisions.

Modified laparoscopic splenectomy and azygoportal disconnection (MLSD), which was first developed by our surgical team, is a novel technique in which massively enlarged spleens are removed from the abdominal cavity with an electromechanical morcellator through an existing 12-mm port[5]. Although resulting in less surgical trauma than open procedures, little is known about the exact pathophysiologic mechanisms that occur during MLSD. Other types of laparoscopic surgical techniques have shown immunologic advantages over traditional open surgery[1,3,6], with lower concentrations of interleukin-6 (IL-6) and C-reactive protein (CRP) induced by laparoscopic than by open surgical procedures[7-10]. Laparoscopic splenectomy and azygoportal disconnection (LSD) has become increasingly popular for the treatment of cirrhotic patients with bleeding portal hypertension and secondary hypersplenism. However, the immunologic effects of LSD, and especially MLSD, have not yet been well clarified. To our knowledge, this report is the first to compare the immunologic effects of MLSD *vs* open splenectomy and azygoportal disconnection (OSD). We therefore compared systemic inflammatory indices and perioperative outcomes in patients undergoing MLSD or OSD for portal hypertension, focusing specifically on the immunologic markers IL-6, the main indicator of surgical trauma[11]; CRP, as an important acute phase reactant produced by the liver; and procalcitonin (PCT), a pro-peptide of calcitonin produced by the thyroid gland and an early and specific biologic marker of infection.

MATERIALS AND METHODS

Patients
All cirrhotic patients who underwent LSD or MLSD for bleeding portal hypertension and secondary hypersplenism at the Clinical Medical College of Yangzhou University in China from January 2010 and May 2013 were eligible for inclusion. Data on these patients were retrospectively entered into a database. Of the 115 cirrhotic patients with bleeding portal hypertension and secondary hypersplenism, 44 elected to undergo MLSD and 71 chose OSD.

This study was not a randomized trial. During the pre-operation discussion, all patients were informed that MLSD is a minimally invasive procedure, but still in the experimental stage compared with the more typical OSD. Procedures were selected by individual patients, who provided written informed consent. This study was approved by the Ethics Committee of the Clinical Medical College of Yangzhou University.

Data collected included patient gender, age, etiology of cirrhosis, Acute Physiology and Chronic Health Evaluation (APACHE) II score, Child-Pugh class, longitudinal diameter of the spleen, operation time, estimated intraoperative blood loss, and volume of intraoperative blood transfusion. Other factors analyzed included Visual Analogue Scale (VAS) pain score on the first day after surgery, time to first oral intake, first passage of flatus, and off-bed activity, postoperative hospital stay, perioperative complications, number of days of postoperative body temperature > 38.0 ℃, and incidence of non-fever and normal white blood cell (WBC) counts on postoperative days 1, 3, and 7. Blood analysis included WBC count, hemoglobin (Hb) concentration, platelet (PLT) count; and concentrations of aspartate transaminase (AST), alanine aminotransferase (ALT), blood urea nitrogen (BUN), creatinine (CER), CRP, IL-6, and PCT determined preoperatively and 1, 3, and 7 d after surgery.

VAS pain score was evaluated by direct interview using a questionnaire that rated pain intensity on a scale of 0-10[12-14], with 0 representing no pain and 10 representing very severe pain.

Surgical procedures
MLSD: After induction and intubation, patients received general anesthesia and were placed in the supine and parted-legs position. A pneumoperitoneum of 13 mm Hg was obtained with a Veress needle. A five-port method (Figure 1A) was used, including one 5-mm, three 10-mm, and one 12-mm port. The splenic artery was dissociated and clipped with a hem-o-lok, and the ligaments surrounding the spleen were divided with a LigaSure vessel-sealing device (Covidien, Boulder, CO, United States). The splenic artery and vein were transected en bloc through the 12-mm port using a linear laparoscopic vascular stapler (EndoGIA). During laparoscopic azygoportal disconnection, all paraesophageal venous collaterals were divided by the LigaSure vessel-sealing device, from back to front, from below to above, and from left to right.

The spleen was removed from the abdominal cavity through the 12-mm port using an electromechanical morcellator (TSCS, Hangzhou, China), consisting of a motor-driven cutting tube and large claw forceps. The spleen was grasped by these forceps through the cutting tube and extracted by rolling the tube (Figure 1B), allowing a cylindrical spleen sample (Figure 1C) to be cut and removed from the tube using a mild pulling force. These steps were repeated until the entire spleen was removed. The entire upper quadrant was irrigated and carefully inspected for residual tissue and bleeding.

OSD: OSD was performed through either a midline laparotomy or a left subcostal incision using traditional methods. Splenectomy was performed before azygoportal disconnection.

Statistical analysis
Data are presented as the mean ± SD, median (range), or number (%). Group means were compared using Student's *t*-test or the Mann-Whitney *U* test, as appropriate, and χ^2 tests were used to compare percentages. A *P* val-
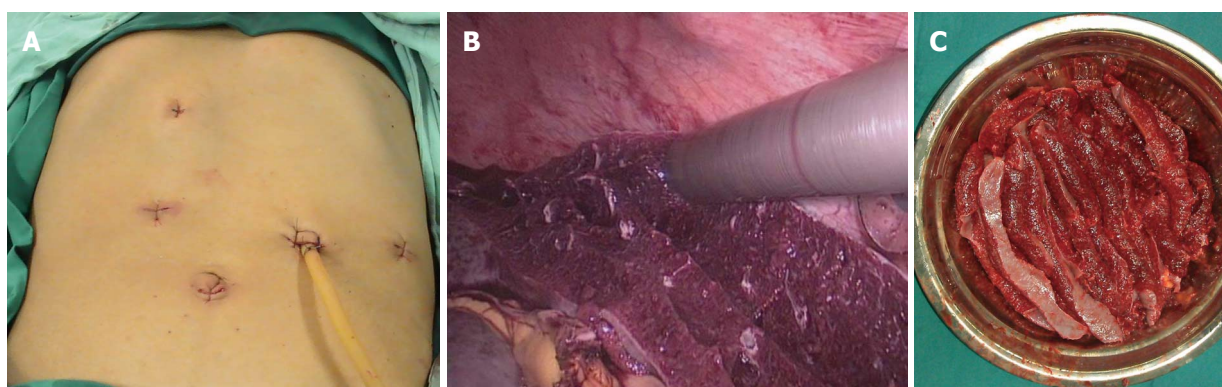
Figure 1 Five-port position for modified laparoscopic splenectomy and azygoportal disconnection using an electromechanical morcellator. A: Five-port position; B: Electromechanical morcellator portraying the spleen tissue; C: Cylindrical splenic tissue.

Table 1 Baseline demographic and clinical characteristics of the modified laparoscopic splenectomy and azygoportal disconnection and open splenectomy and azygoportal disconnection groups

Variable	MLSD (n = 44)	OSD (n = 71)	P value
Gender, M/F, n	27/17	41/30	0.701
Age, mean ± SD, yr	54.98 ± 10.41	52.46 ± 10.33	0.209
Etiology, n			
HBV cirrhosis	23	46	0.183
HCV cirrhosis	3	5	0.963
Schistosome cirrhosis	6	9	0.882
Alcoholic cirrhosis	3	4	0.796
Autoimmunity liver cirrhosis	9	7	0.111
APACHE Ⅱ score, mean ± SD	3.32 ± 2.27	3.49 ± 2.57	0.712
Child-Pugh classification, A/B, n	29/15	39/32	0.244
Longitudinal diameter of spleen, mean ± SD, mm	179.45 ± 27.88	185.44 ± 33.24	0.321
WBC, mean ± SD, 10^9/L	2.89 ± 1.65	3.07 ± 1.85	0.596
Hb , mean ± SD, g/dL	104.16 ± 26.95	95.34 ± 28.14	1.000
PLT, mean ± SD, 10^9/L	40.32 ± 7.74	38.24 ± 9.18	0.214
TBIL, mean ± SD, μmol/L	19.21 ± 9.76	20.88 ± 12.66	0.454
AST, mean ± SD, U/L	34.93 ± 21.26	35.89 ± 15.08	0.779
ALT, mean ± SD, U/L	31.14 ± 23.91	29.41 ± 15.28	0.637
BUN, mean ± SD, mmol/L	5.93 ± 2.25	5.38 ± 1.95	0.168
CER, mean ± SD, μmol/L	72.32 ± 17.63	71.15 ± 19.81	0.748

ALT: Alanine aminotransferase; AST: Aspartate transaminase; BUN: Urea nitrogen; CER: Creatinine; Hb: Hemoglobin; HBV: Hepatitis B virus; HCV: Hepatitis C virus; MLSD: Modified laparoscopic splenectomy and azygoportal disconnection; OSD: Open splenectomy and azygoportal disconnection; PLT: Platelet; WBC: White blood cell.

ue < 0.05 was considered significant. SPSS 13.0 software (SPSS, Chicago, IL, United States) was used for statistical analysis.

RESULTS

Of 115 cirrhotic patients with bleeding portal hypertension and secondary hypersplenism, 44 underwent MLSD and 71 underwent OSD. There were no significant differences between groups in terms of patient gender, age, etiology of cirrhosis, APACHE Ⅱ score, Child-Pugh class, longitudinal spleen diameter, preoperative WBC counts, or preoperative Hb, PLT, TBIL, AST, ALT, BUN, and CER concentrations (Table 1).

Operation

The median operation time was significantly longer for the MLSD than for the OSD group (P < 0.0001; Table 2). Median intraoperative estimated blood loss was significantly lower for MLSD than for OSD (P < 0.0001), as was median intraoperative volume of blood transfused (P < 0.05) (Table 2).

Recovery after surgery

The mean ± SD VAS pain score on the first day after surgery was significantly lower in the MLSD than the OSD group (P < 0.0001; Table 2). Mean times to first oral intake, first flatus, and off-bed activity were significantly shorter in the MLSD than the OSD group (all P < 0.001), as was median hospital stay (P < 0.0001) (Table 2).

Complications

Seven of the 44 patients (15.91%) in the MLSD group and 26 of 71 (36.62%) in the OSD group experienced

Table 2 Intraoperative and postoperative characteristics of the modified laparoscopic splenectomy and azygoportal disconnection and open splenectomy and azygoportal disconnection groups

Variable	MLSD (*n* = 44)	OSD (*n* = 71)	*P* value
Operation time, median (range), min	210 (140-390)	180 (110-300)	< 0.0001
Estimated blood loss, median (range), mL	150 (50-800)	300 (50-1200)	< 0.0001
Blood transfused, median (range), mL	0 (0-400)	0 (0-700)	0.024
VAS pain score on the first day, mean ± SD	2.50 ± 0.85	5.06 ± 1.08	< 0.0001
Time to first oral intake, mean ± SD, d	1.52 ± 0.63	2.76 ± 0.62	< 0.0001
Time to first flatus, mean ± SD, d	2.36 ± 0.97	3.18 ± 1.00	0.0004
Time to off-bed activity, mean ± SD, d	2.59 ± 0.69	5.96 ± 0.93	< 0.0001
Postoperative hospital stay, median (range), d	10 (7-18)	15 (7-28)	< 0.0001
Perioperative complications, *n*	7	26	0.017
Incision complications	0	9	0.035
Incision hernia	0	1	
Superficial SSI	0	5	
Deep SSI	0	3	
Pneumonia	0	3	0.436
Organ space SSI	0	2	0.697
Emergency operation for bleeding	0	3	0.436
Pancreatic fistula	2	1	0.672
Asymptomatic portal vein thrombosis	5	8	1.000

MLSD: Modified laparoscopic splenectomy and azygoportal disconnection; OSD: Open splenectomy and azygoportal disconnection; VAS: Visual analog scale; SSI: Surgical site infection.

Table 3 Postoperative fever and white blood cell counts of the modified laparoscopic splenectomy and azygoportal disconnection and open splenectomy and azygoportal disconnection groups

Variable	MLSD (*n* = 44)	OSD (*n* = 71)	*P* value
Postoperative fever, mean ± SD, d	4.09 ± 3.16	6.89 ± 3.55	< 0.0001
No fever, *n*	7	2	0.029
WBC 0 d, mean ± SD, 10^9/L	2.89 ± 1.65	3.07 ± 1.85	0.596
WBC 1 d, median (range), 10^9/L	11.45 (5.2-17.4)	16.9 (6.1-33.90)	< 0.0001
WBC 3 d, mean ± SD, 10^9/L	11.63 ± 3.29	13.72 ± 4.67	0.011
WBC 7 d, median (range), 10^9/L	8.4 (5-23.1)	9.5 (4.9-38)	0.035
Normal WBC, 1 d, *n*	15	3	< 0.0001
Normal WBC, 3 d, *n*	14	10	0.023
Normal WBC, 7 d, *n*	36	39	0.003

MLSD: Modified laparoscopic splenectomy and azygoportal disconnection; OSD: Open splenectomy and azygoportal disconnection; Postoperative fever, the number of days of postoperative body temperature > 38.0 ℃; WBC: White blood cell count; day 0: Day of admission; day 1: Postoperative day 1; day 3: Postoperative day 3; day 7: Postoperative day 7.

postoperative complications ($P < 0.05$). The seven complications in the MSLD group included two patients with pancreatic fistulae and five with asymptomatic portal vein thrombosis. In the OSD group, one patient had a pancreatic fistula, eight had asymptomatic portal vein thrombosis, nine had incision complications [including five with superficial surgical site infections (SSI), three with deep SSI, and one with an incision hernia], three had pneumonia, two had organ space SSI, and three required emergency laparotomy for bleeding. All complications were successfully managed. The incision complication rate was significantly lower in the MLSD than in the OSD group (0% *vs* 12.68%, $P < 0.05$). Emergency laparotomy operation for bleeding was not necessary following MLSD (Table 2).

Body temperature and white blood cell counts
Before surgery, none of the patients in either group had fever. The mean ± SD number of days of postoperative body temperature > 38.0 ℃ was significantly lower after MLSD than after OSD ($P < 0.0001$; Table 3). Seven patients in the MLSD and two in the OSD group did not have fever postoperatively, making the rate significantly higher in the MLSD than in the OSD group (15.91% *vs*

2.82%, $P < 0.05$; Table 3). Although WBC count at admission was similar in both the MLSD and OSD groups ($P > 0.05$ each), median WBC counts on postoperative days 1 ($P < 0.0001$), 3 ($P < 0.05$), and 7 ($P < 0.05$) were significantly lower after MLSD than after OSD (Table 3). The percentage of patients with normal WBC counts on postoperative days 1 (34.09% *vs* 4.22%, $P < 0.0001$), 3 (31.82% *vs* 14.08%, $P < 0.05$), and 7 (81.82% *vs* 54.93%, $P < 0.01$) were all significantly higher after MLSD than after OSD (Table 3).

Postoperative liver and renal function
Preoperative AST and ALT concentrations were similar in the two groups (Table 1). Although AST concentrations were similar on postoperative day 1 ($P > 0.05$), mean AST on postoperative days 3 ($P < 0.05$) and 7 ($P < 0.001$) were significantly lower after MLSD than after OSD (Table 4). Moreover, although ALT concentrations on postoperative days 1 and 3 were similar in the two groups, ALT was significantly lower after MLSD than after OSD on day 7 ($P < 0.01$) (Table 4).

Preoperative BUN and CER concentrations were similar in the two groups (Table 1). Although mean BUN was significantly lower after MLSD than after OSD on postoperative day 1 ($P < 0.05$), BUN concentrations were similar in the two groups on postoperative days 3 and 7 (Table 4). Similarly, mean CER was significantly lower after MLSD than after OSD on day 1 ($P < 0.05$), but was similar in the two groups on postoperative days 3 and 7 (Table 4).

CRP, IL-6, and PCT
Median CRP concentrations were similar preoperatively in the MLSD and OSD groups, but were significantly lower in the MLSD group on postoperative days 1 ($P <$

Table 4 Postoperative liver and renal functions of the modified laparoscopic splenectomy and azygoportal disconnection and open splenectomy and azygoportal disconnection groups

Variable	MLSD (*n* = 44)	OSD (*n* = 71)	*P* value
AST 1 d, mean ± SD, U/L	57.32 ± 27.89	87.14 ± 135.13	0.152
AST 3 d, mean ± SD, U/L	33.84 ± 22.16	50.86 ± 43.83	0.018
AST 7 d, mean ± SD, U/L	25.66 ± 11.28	33.63 ± 16.32	0.005
ALT 1 d, mean ± SD, U/L	40.14 ± 18.81	61.66 ± 105.43	0.183
ALT 3 d, mean ± SD, U/L	31.93 ± 25.21	46.93 ± 56.60	0.100
ALT 7 d, mean ± SD, U/L	21.14 ± 12.63	29.68 ± 17.36	0.003
BUN 1 d, mean ± SD, mmol/L	5.52 ± 1.76	6.54 ± 2.33	0.014
BUN 3 d, mean ± SD, mmol/L	6.63 ± 2.20	7.33 ± 2.85	0.171
BUN 7 d, mean ± SD, mmol/L	4.76 ± 2.02	5.52 ± 2.21	0.069
CER 1 d, mean ± SD, μmol/L	75.27 ± 16.22	84.99 ± 20.92	0.010
CER 3 d, mean ± SD, μmol/L	59.75 ± 16.64	66.04 ± 19.08	0.074
CER 7 d, mean ± SD, μmol/L	60.88 ± 13.92	60.83 ± 16.17	0.986

ALT: Alanine aminotransferase; AST: Aspartate transaminase; BUN: Blood urea nitrogen; CER: Creatinine; MLSD: Modified laparoscopic splenectomy and azygoportal disconnection; OSD: Open splenectomy and azygoportal disconnection; day 1: Postoperative day 1; day 3: Postoperative day 3; day 7: Postoperative day 7.

Table 5 Perioperative C-reactive protein, interleukin-6, and procalcitonin concentrations of the modified laparoscopic splenectomy and azygoportal disconnection and open splenectomy and azygoportal disconnection groups

Variable	MLSD (*n* = 44)	OSD (*n* = 71)	*P* value
CRP day 0, median (range), mg/L	1.03 (0.02-49.21)	0.96 (0.03-13.32)	0.715
CRP day 1, mean ± SD, mg/L	28.39 ± 16.30	36.86 ± 12.86	0.002
CRP day 3, mean ± SD, mg/L	92.64 ± 53.16	114.06 ± 44.37	0.022
CRP day 7, mean ± SD, mg/L	41.14 ± 27.61	52.49 ± 29.70	0.043
IL-6 day 0, mean ± SD, pg/mL	6.14 ± 5.61	6.60 ± 7.26	0.715
IL-6 day 1, mean ± SD, pg/mL	8.09 ± 6.97	11.78 ± 9.18	0.024
IL-6 day 3, mean ± SD, pg/mL	7.65 ± 6.95	10.84 ± 8.42	0.037
IL-6 day 7, mean ± SD, pg/mL	6.58 ± 5.66	9.83 ± 8.26	0.024
PCT day 0, mean ± SD, ng/mL	0.45 ± 0.25	0.47 ± 0.27	0.722
PCT 1 d, median (range), ng/mL	0.97 (0.36-3.2)	1.96 (0.54-10.08)	< 0.0001
PCT 3 d, median (range), ng/mL	0.795 (0.3-2.67)	1.45 (0.6-4.88)	< 0.0001
PCT 7 d, median (range), ng/mL	0.5 (0.28-4.01)	0.77 (0.38-5.87)	< 0.0001

CRP: C-reactive protein; IL-6: Interleukin-6; MLSD: Modified laparoscopic splenectomy and azygoportal disconnection; OSD: Open splenectomy and azygoportal disconnection; PCT: Procalcitonin; day 0: Day of admission; day 1: Postoperative day 1; day 3: Postoperative day 3; day 7: Postoperative day 7.

0.001), 3 (*P* < 0.05), and 7 (*P* < 0.05) (Table 5). Similarly, IL-6 concentrations did not differ preoperatively, but were significantly lower in the MLSD group on postoperative days 1, 3, and 7 (*P* < 0.05 each) (Table 5). Additionally, PCT concentrations were similar in the two groups preoperatively, but were significantly lower in the MLSD than in the OSD group on postoperative days 1, 3, and 7 (*P* < 0.0001 each) (Table 5).

DISCUSSION

LSD has become more frequently used at some institutions to treat portal hypertension and has been shown to be superior to OSD in reducing postoperative pain severity, time to first flatus, and the duration of hospital stay and convalescence[15,16]. We developed an even less invasive technique, MLSD, for portal hypertension, extending the advantages of LSD to patients likely to most benefit from it (namely cirrhotic patients with bleeding portal hypertension and hypersplenism). This study compared both subjective and objective parameters, including measures of surgical trauma, convalescence, and burden on the immune system, in patients undergoing MLSD and OSD. To our knowledge, this is the first retrospective clinical study comparing these techniques in patients with portal hypertension.

None of the patients included in this study had a liver transplant or TIPS. In China, there is a shortage of donor livers, whereas TIPS is usually used to treat portal hypertension, especially as a bridge to transplantation. Although TIPS can reduce portal pressure to prevent recurrent gastroesophageal variceal bleeding, it cannot be used to treat secondary hypersplenism. Furthermore, TIPS has been associated with portosystemic encephalopathy.

Traditional LSD utilizes several methods to remove massively enlarged spleens, including the creation of an enlarged incision to morcellate and remove the spleen enveloped in a cumbersome intracorporeal bag or hand-assisted laparoscopy to remove the spleen through a hand-assisted incision[15-21]. During MLSD, a massively enlarged spleen is removed through the existing 12 mm port using an electromechanical morcellator. Therefore, MLSD appears to involve less surgical trauma than LSD. Moreover, to avoid damage to organs or tissues when using the electromechanical morcellator to cut the spleen, the patient is placed in the reverse Trendelenburg position, the dissected spleen is placed in the left subphrenic space, and a splenic retractor or forceps is used to lift the upper pole of the spleen to maintain it in an ideal location.

Although the operation time of LSD was longer than that of OSD, LSD was associated with lower estimated blood loss and a lower volume of blood transfused[15]. We observed similar outcomes when comparing MLSD with OSD. Only one patient in the MLSD group required a blood transfusion. These advantages of MLSD and LSD are due to their good operational view and exposure, as well as the use of a LigaSure vessel-sealing device, which is efficient in dividing the splenogastric ligament and esophagogastric varices.

We also found that convalescence was more rapid after MLSD than after OSD. VAS pain score on the first postoperative day was significantly lower, and times to first oral intake, passage of flatus, and off-bed activity,

as well as postoperative hospital stay, were significantly shorter in the MLSD than the OSD group. Similarly, LSD resulted in faster recovery than OSD, as shown by a reduced time to first flatus and postoperative hospital stay[15,16].

MLSD also showed other benefits, including fewer numbers of days of postoperative body temperature > 38.0 ℃; a lower rate of no fever postoperatively; lower WBC counts on postoperative days 1, 3, and 7; and higher rates of normal WBC counts on postoperative days 1, 3, and 7. In contrast, a previous study found no significant differences in WBC count on postoperative day 7 between patients undergoing LSD and OSD[16]. These findings suggest that MLSD results in weaker inflammatory responses and better recovery than OSD.

The absence of incision complications in patients undergoing LSD may be due to the small sizes of the incisions, and earlier ambulation after surgery may result from decreased postoperative pain, but the postoperative rates of total and incision-associated complications did not differ significantly in patients undergoing LSD and OSD[16]. The incisions resulting from MLSD were less invasive than those resulting from LSD, with no incision complications after MLSD. However, we found that the postoperative rates of total and incision-associated complications differed in our MLSD and OSD groups. The difference between studies was likely due to the smaller sample size in the previous study, which included 24 patients in the LSD and 30 in the OSD group[16].

The earlier study found that ALT and AST concentrations on postoperative day 7 were significantly lower in the LSD than in the OSD group[16]. Our findings were similar, except that AST concentrations on postoperative day 3 were significantly lower in the MLSD than in the OSD group. We also found that BUN and CER concentrations on postoperative day 1 were lower in the MLSD group, providing further evidence for the benefits of MLSD. These findings also suggest a difference in the rate of recovery from surgical trauma to the liver and kidneys.

The immune response to surgical trauma involves a complex cascade of many types of mediators and immune cells. IL-6 is thought to play a pivotal role in the pathogenesis of surgical trauma, with increased IL-6 concentrations found to correlate with the magnitude of surgical trauma[22,23], as well as contributing to fever[24]. CRP is an acute phase molecule produced in the liver during tissue injury, whereas PCT is a pro-peptide of calcitonin produced by the thyroid gland and a highly specific marker of clinically relevant bacterial infections and sepsis[25,26].

Systemic stress responses are lower after laparoscopic than after conventional open surgery[4,27], with differences in cytokine concentrations and cell-mediated immune responses observed both in animal experiments and clinical trials[28-30]. Laparoscopic techniques have been shown to have an immunologic advantage over traditional open surgery[1,3,6], with lower concentrations of IL-6 and CRP induced during laparoscopic than during open general and urinary surgery[7-10,24]. These differences may be due to CO_2 pneumoperitoneum; CO_2 insufflation has a protective function during laparoscopic procedures, with CO_2 acidification of the peritoneal cavity attenuating overall inflammatory response and suppressing peritoneal macrophages, which are cells that initiate inflammatory responses during surgery[31,32].

We observed similar findings, in that the concentrations of IL-6, CRP, and PCT on postoperative days 1, 3, and 7 were all lower after MLSD than after OSD. These objective measurements showed that MLSD resulted in improved immunologic function compared with OSD. Because liver function in these patients is usually very poor, postoperative immune dysfunction is an important aspect of treatment for patients with liver cirrhosis, bleeding portal hypertension, and hypersplenism. IL-6, CRP, and PCT may be better markers of immune recovery than WBC count in patients with liver cirrhosis, since patients with leukocytopenia due to hypersplenism frequently have WBC counts below the lower limit of the normal range.

Despite longer operation times, MLSD resulted in better and faster recovery, less liver and renal dysfunction, less fever, and less stimulation of host immunity than OSD. These findings may be due to: (1) the smaller size of the incision used to remove the enlarged spleen; (2) the reduced estimated blood loss during surgery; (3) CO2 pneumoperitoneum; and/or (4) fewer postoperative complications.

In conclusion, this study indicated that MLSD had numerous advantages over OSD and is technically feasible and safe. MLSD consisted of a combination of LSD and a novel technique with an electromechanical morcellator. MLSD was associated with minimal postoperative pain and scarring, faster and better postoperative recovery, and lower inflammatory immune responses than OSD. MLSD can therefore extend the advantages of LSD to patients with portal hypertension. It represents a promising and minimally-invasive treatment that may become the gold standard of surgical procedures for liver cirrhosis patients with bleeding portal hypertension and hypersplenism.

COMMENTS

Background
Although many types of laparoscopic surgery have shown immunologic benefits, the effects of modified laparoscopic splenectomy and azygoportal disconnection (MLSD) for portal hypertension have not been investigated thoroughly.

Research frontiers
Systemic stress responses are lower after laparoscopic than after conventional open surgery, with differences in cytokine concentrations and cell-mediated immune responses observed both in animal experiments and clinical trials. Laparoscopic techniques have been shown to have an immunologic advantage

over traditional open surgery, with lower concentrations of interleukin-6 (IL-6) and C-reactive protein induced during laparoscopic than during open general and urinary surgery.

Innovations and breakthroughs

The authors developed an even less invasive technique, MLSD. During the procedure, an electromechanical morcellator allows for easy extraction of the entire massive splenic tissue through the existing 12 mm port without the cumbersome intracorporeal bag, enlarged incision, or hand-assisted incision used in traditional laparoscopic splenectomy and azygoportal disconnection (LSD). Therefore, MLSD appears to involve less surgical trauma than LSD.

Applications

MLSD is technically feasible, safe, and resulted in better and faster recovery, less liver and renal dysfunction, less fever, and less stimulation of host immunity than open splenectomy and azygoportal disconnection. MLSD represents a promising and minimally-invasive treatment for liver cirrhosis patients with bleeding portal hypertension and hypersplenism.

Terminology

Surgical trauma, a process also called surgical stress, activates systemic immunologic and inflammatory responses, which are characterized by (1) release of the pro-inflammatory cytokines tumor necrosis factor α, interleukin (IL)-1, and IL-6; (2) neutrophil activation and microvascular adherence; and (3) uncontrolled polymorphonuclear and macrophage oxidative burst.

Peer review

The authors investigated the perioperative advantages of modified laparoscopic *vs* open splenectomy and azygoportal disconnection. The paper and the results are interesting. The manuscript is original and may be useful to clinicians.

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