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World J Gastrointest Surg 2021 September 27; 13(9): 885-1109



REVIEW

- 885 Neoadjuvant treatment: A window of opportunity for nutritional prehabilitation in patients with pancreatic ductal adenocarcinoma
Trestini I, Cintoni M, Rinninella E, Grassi F, Paiella S, Salvia R, Bria E, Pozzo C, Alfieri S, Gasbarrini A, Tortora G, Milella M, Mele MC
- 904 Current trends in three-dimensional visualization and real-time navigation as well as robot-assisted technologies in hepatobiliary surgery
Wang Y, Cao D, Chen SL, Li YM, Zheng YW, Ohkohchi N
- 923 How can probiotic improve irritable bowel syndrome symptoms?
Benjak Horvat I, Gobin I, Kresović A, Hauser G

MINIREVIEWS

- 941 Role of minimally invasive techniques in gastrointestinal surgery: Current status and future perspectives
Ye SP, Zhu WQ, Huang ZX, Liu DN, Wen XQ, Li TY
- 953 Trends of rapamycin in survival benefits of liver transplantation for hepatocellular carcinoma
Zhao Y, Liu Y, Zhou L, Du GS, He Q
- 967 Finding the seed of recurrence: Hepatocellular carcinoma circulating tumor cells and their potential to drive the surgical treatment
Carissimi F, Barbaglia MN, Salmi L, Ciulli C, Roccamatysi L, Cordaro G, Mallela VR, Minisini R, Leone BE, Donadon M, Torzilli G, Pirisi M, Romano F, Famularo S

ORIGINAL ARTICLE**Retrospective Cohort Study**

- 979 Comparison of perioperative outcomes between laparoscopic and open partial splenectomy in children and adolescents
Makansi M, Hutter M, Theilen TM, Fiegel HC, Rolle U, Gfroerer S
- 988 Suture ligation for submucosal hemostasis during hand-sewn side-to-side duodeno-ileostomy in simultaneous pancreas and kidney transplantation
Wang H, Fu YX, Song WL, Mo CB, Feng G, Zhao J, Pei GH, Shi XF, Wang Z, Cao Y, Nian YQ, Shen ZY

Retrospective Study

- 1000 Evaluating the benefit of adjuvant chemotherapy in patients with ypT0-1 rectal cancer treated with preoperative chemoradiotherapy
Jeon YW, Park IJ, Kim JE, Park JH, Lim SB, Kim CW, Yoon YS, Lee JL, Yu CS, Kim JC
- 1012 Optimal postoperative surveillance strategies for stage III colorectal cancer
Park MY, Park IJ, Ryu HS, Jung J, Kim M, Lim SB, Yu CS, Kim JC

- 1025 Carbohydrate antigen 19-9 as a novel prognostic biomarker in distal cholangiocarcinoma

Jiang T, Lyu SC, Zhou L, Wang J, Li H, He Q, Lang R

Observational Study

- 1039 Novel suturing technique, based on physical principles, achieves a breaking point double that obtained by conventional techniques

Pérez Lara FJ, Zubizarreta Jimenez R, Moya Donoso FJ, Hernández Gonzalez JM, Prieto-Puga Arjona T, Marín Moya R, Pitarch Martínez M

Prospective Study

- 1050 Quality of life after colorectal surgery: A prospective study of patients compared with their spouses

Aylaz G, Akyol C, Kocaay AF, Gökmen D, Yavuzarslan AB, Erkek AB, Kuzu MA

SYSTEMATIC REVIEWS

- 1063 Literature review of the outcome of and methods used to improve transperineal repair of rectocele

Fathy M, Elfallal AH, Emile SH

META-ANALYSIS

- 1079 Perioperative steroid administration reduces overall complications in patients undergoing liver resection: A meta-analysis

Hai HH, Aw P, Teng TZJ, Shelat VG

CASE REPORT

- 1095 Three colonic cancers, two sites of complete occlusion, one patient: A case report

Bergeron E, Maniere T, Do XV, Bensoussan M, De Broux E

- 1102 Fluorescence *in situ* hybridization-based confirmation of acute graft-vs-host disease diagnosis following liver transplantation: A case report

Xiao JJ, Ma JY, Liao J, Wu D, Lv C, Li HY, Zuo S, Zhu HT, Gu HJ

ABOUT COVER

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The primary aim of *World Journal of Gastrointestinal Surgery* (*WJGS, World J Gastrointest Surg*) is to provide scholars and readers from various fields of gastrointestinal surgery with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJGS mainly publishes articles reporting research results and findings obtained in the field of gastrointestinal surgery and covering a wide range of topics including biliary tract surgical procedures, biliopancreatic diversion, colectomy, esophagectomy, esophagostomy, pancreas transplantation, and pancreatectomy, etc.

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Retrospective Cohort Study

Comparison of perioperative outcomes between laparoscopic and open partial splenectomy in children and adolescents

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Abstract

BACKGROUND

In order to avoid consequences of total splenectomy, partial splenectomy (PS) is increasingly reported. The purpose of this study was to compare perioperative outcomes of laparoscopic PS (LPS) and open PS (OPS) in children and adolescents.

AIM

To compare perioperative outcomes of patients with LPS and OPS.

METHODS

After institutional review board approval, a total of 26 patients that underwent LPS or OPS between January 2008 and July 2018 were identified from the database of our tertiary referral center. In total, 10 patients had LPS, and 16 patients underwent OPS. Blood loss was calculated by Mercuriali's formula. Pain scores, analgesic requirements and complications were assessed. The Wilcoxon rank sum test was used for comparison. To compare categorical variables, Fisher's exact test was applied.

RESULTS

LPS was performed in 10 patients; 16 patients had OPS. Demographics (except for body mass index and duration of follow-up), indicating primary disease, preoperative spleen size and postoperative spleen volume, perioperative hematological parameters, postoperative pain scores, analgesic requirements, adverse events according to the Clavien-Dindo classification and the comprehensive complication index, median time from operation to initiation of feeds, median time from operation to full feeds, median time from operation to mobilization and

statement: The study protocols were reviewed and approved by the Ethics Committee of the University Hospital Frankfurt (339/18).

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 informed consent.

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Makansi M, Hutter M and Drs. Gfroerer S, Fiegel HC, Theilen TM and Rolle U have no conflicts of interest or financial ties to disclose in relation to this manuscript.

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median length of hospital stay did not differ between LPS and OPS. Median (range) operative time (min) was longer in LPS compared to the OPS group [185 (135-298) vs 144 (112-270), respectively; $P = 0.048$]. Calculated perioperative blood loss (mL of red blood cell count) was higher in the LPS group compared to OPS [87 (-45-777) vs -37 (-114-553), respectively; $P = 0.039$].

CONCLUSION

This is the first study that compared outcomes of LPS and OPS. Both operative approaches had comparable perioperative outcomes. LPS appears to be a viable alternative to OPS.

Key Words: Laparoscopic vs open; Laparoscopy; Partial splenectomy; Perioperative outcome; Children; Adolescents

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Core Tip: In this retrospective study, perioperative outcomes of children and adolescents that underwent laparoscopic or open partial splenectomy were analyzed. Postoperative outcomes including initiation of feeds and mobilization, adverse events assessed according to the Clavien-Dindo classification and the comprehensive complication index, postoperative pain scores and analgesic requirements were similar between both groups. Operative time and intraoperative blood loss were higher in the laparoscopic group. Results indicate that laparoscopic partial splenectomy is a safe alternative to open partial splenectomy. Future research needs to focus on a larger patient cohort and a prospective study design.

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INTRODUCTION

The urge to implement minimally invasive approaches for traditionally open surgical procedures has occupied all surgical specialties for several decades[1], especially for an open procedure that inevitably requires a large abdominal incision such as a partial splenectomy (PS) in patients with splenomegaly. A reduction of transabdominal invasiveness appears desirable. Frequent reasoning advocating a minimally invasive approach in PS comprises a better cosmesis, less pain and less complications (*i.e.* adhesions)[2,3]. However, data comprising both techniques are rare[4]. Laparoscopic PS (LPS) has first been described by Poulin *et al*[5] in 1995. Several benefits resulting from a minimal invasive approach of this procedure have been described[6,7]. However, to date there are no data available stating which approach can be regarded as superior over the other. The aim of this study was to review perioperative outcomes of children and adolescent patients that had undergone either laparoscopic or open PS (OPS) and to compare their outcomes.

MATERIALS AND METHODS

Study design

In this retrospective study, we analyzed a series of 26 consecutive patients who underwent either LPS or OPS between January 2008 and July 2018 at the University Hospital Frankfurt. Patients who experienced an unplanned conversion to the open approach were allocated to the laparoscopic group. The study protocols were reviewed and approved by the Ethics Committee of the University Hospital Frankfurt (339/18). Analysis of clinical data included demographics, spleen characteristics,

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operative and hematological variables, postoperative outcomes and postoperative adverse events. Demographics included gender, age at operation, weight and height of the patient, the body mass index at operation, the indicating primary disease and the duration of follow-up. Spleen characteristics included the longitudinal diameter of the spleen prior to operation measured by ultrasound and the postoperative residual spleen volume. Operative parameters included operative time and the frequency of a simultaneous cholecystectomy. The operative time included the time for simultaneous cholecystectomy. The procedures were classified into primary or secondary operation. Primary operation indicated that the patient underwent a PS for the first time, whereas secondary operation indicated that the patient was operated a second time (redo PS).

Outcome measures

Postoperative outcome variables included time from operation to initiation of feeds (day on which feeding was initiated orally), time from operation to full feeds (day on which the parenteral nutrition was ceased), time from operation to mobilization of the patients and length of the postoperative hospital stay. The length of hospital stay did not include the day of operation but did include the day of discharge. For evaluation of individual postoperative adverse events we applied the Clavien-Dindo classification [8]. The Clavien-Dindo classification consists of seven grades (I, II, IIIa, IIIb, IVa, IVb, V). We categorized into minor morbidity (Clavien-Dindo grade I and II) and major morbidity (Clavien-Dindo grade III-V). Minor morbidity displayed non-invasive treatment including the need of red blood cell transfusions. Major morbidity comprised the need of surgical, endoscopic or radiological intervention. Additionally, we calculated the comprehensive complication index [9]. This index reflects the overall postoperative morbidity and its severity, ranging from 0 (no complication) to 100 (death). To calculate the comprehensive complication index we used the calculator available online (<http://www.assessurgery.com>).

For assessment of the perioperative blood loss we used the Mercuriali's formula [10]: estimated blood loss [mL of red blood cell count (RBC)] = Blood volume (mL) × [hematocrit (Hct)_{preop} - Hct_{postop}] + RBC transfusion volume (mL).

The formula uses the difference between the preoperative hematocrit (Hct_{preop}) and the hematocrit of the fifth postoperative day (Hct_{postop}). A negative value of the estimated blood loss (mL of RBC) occurs when the volume of perioperatively transfused RBC exceeds the RBC loss.

Patient blood volume can be calculated through the Nadler formula [11]: blood volume (mL) = Weight (kg) × estimated blood volume (mL/kg).

For the different age groups and sexes, we used the following blood volumes per kilogram body weight: children < 10 years 75 mL/kg, males between 10-19 years 70 mL/kg and females between 10-19 years 65 mL/kg.

Furthermore, we analyzed how many patients received RBC, fresh frozen plasma and thrombocyte concentrate intra- and postoperatively. Transfusions of blood products were counted from operation to discharge of the patient.

Postoperative pain was assessed by a numerical rating scale ranging from 0 (no pain at all) to 10 (worst possible pain) [12,13]. The clinical pain scores were measured repeatedly daily by healthcare professionals. For a nuanced assessment of the patients' postoperative analgesic requirements, we categorized the pain medication into opioids and non-opioids and calculated the cumulative doses during the hospital stay. Three patients in the open group were excluded from pain assessment due to peridural anesthesia treatment.

Statistical analysis

Continuous data were presented as median with range. For comparison, the Wilcoxon rank sum test was used. Pain assessment was measured longitudinally in F1-LD-F1 design, and the Wald-Test was used. Furthermore, we applied Fisher's exact test to compare categorical variables. Testing was based on a 5% significance level. We used statistical software R version 3.4.0 for analysis [R Foundation for Statistical Computing, Vienna, Austria (www.R-project.org)].

The statistical methods of this study were reviewed by Mr. Hutter M, biomedical statistician from the Department of Pediatric Surgery and Pediatric Urology, University Hospital Frankfurt.

RESULTS

Baseline characteristics

A total of 26 patients underwent a PS. The patient cohort consisted of 16 patients with OPS and 10 patients with LPS. OPS were performed by Gfroerer S, Theilen TM and Fiegel HC. Gfroerer S and Theilen TM performed LPS.

Table 1 compares the demographic data of both groups. Patients with LPS had a higher body mass index at time of operation [median (range), 21.3 (14.9-25.7) *vs* 16.6 (12.7-24.2) kg/m², *P* = 0.036] and a shorter follow-up period [median (range), 4.1 (2.1-5.2) *vs* 6.6 (4.4-11.4) years, *P* < 0.001]. The mean age was 13.1 (7.7-20.3) and 10.7 (5.0-18.2), respectively, for the LPS and OPS group. **Table 2** displays the pre- and postoperative spleen characteristics of the laparoscopic group in comparison to the open group. Spleen characteristics did not differ in both groups.

Table 3 shows the operative variables. The operative time was higher in the LPS cohort compared to the OPS cohort [median (range), 185 (135-298) *vs* 144 (112-270) min, *P* = 0.048]. There were 1/10 (10%) conversions to laparotomy in the LPS group.

Treatment outcomes

Table 4 compares postoperative outcomes in the LPS *vs* the OPS group. Both postoperative convalescence variables during hospital stay and scores of adverse events were comparable between both groups.

Table 5 lists all individual postoperative adverse events recorded within hospital stay. Neither post-splenectomy sepsis nor death occurred perioperatively.

Table 6 shows the hematological variables. The estimated blood loss was higher in the LPS group [median (range), 87 (-45-777) *vs* -37 (-114-553) mL, *P* = 0.039]. Individual frequency of perioperative blood product transfusions (RBC, fresh frozen plasma or thrombocyte concentrate) did not differ between groups.

Table 7 displays the results of the pain assessment and pain management in both groups. There was no difference between LPS and OPS groups.

DISCUSSION

This is a retrospective analysis comparing perioperative outcomes of children and adolescents that underwent either LPS or OPS. To the best of our knowledge, this is the only study comparing both operative approaches to date.

In our study postoperative time from operation to initiation of feeds and to full feeds, time from operation until patient's mobilization, postoperative adverse events, pain assessment and analgesic requirements did not differ between LPS and OPS. Operative time in the LPS group was longer, and the estimated blood loss was higher reflecting the technical challenges of the minimally invasive surgery. In both groups, only intraoperative (not postoperative) transfusions of blood products were performed.

We assessed adverse events using the Clavien-Dindo classification and by calculating the comprehensive complication index. Both scores did not reveal differences between the LPS and OPS group.

Laparoscopic handling of the spleen was noticeably more difficult in spleens measuring ≥ 25 cm in cranio-caudal diameter due to the restricted view. As a reflection of our early learning curve, a patient's spleen sized > 25 cm led to a conversion to open splenectomy. This case taught us the need to consider a timely intraoperative laparoscopic multiple dissection of a large spleen in order to facilitate a controlled removal of the splenic parenchyma from the abdominal cavity without conversion to open surgery. The conversion rate in a larger cohort reported by Liu and Fan[14] was 3.6%.

There are a number of studies that examine the feasibility and safety of the LPS for different indications, such as splenic benign lesions[15,16], traumata that require emergency surgery[17] or patients with hereditary spherocytosis[16]. All these studies come to the result that LPS is safe and feasible; however, none of the studies compared perioperative outcomes of both approaches.

Our study has several limitations. One limitation is that our study was restricted to children and adolescents. The median age of all patients in our cohort was 11.9 years. Generally, there is very little data available on children and young adults undergoing PS. Costi *et al*[18] carried out a systematic review of 2130 published cases of PS published between 1960 and December 2017. Patient average age was 18.4 years. Because older patients undergoing a PS were suffering from severe comorbidities like portal hypertension (patient mean age 27.6 years) or neoplastic lesions such as

Table 1 Demographic data for 26 patients undergoing laparoscopic partial splenectomy or open partial splenectomy

	Laparoscopic, n = 10	Open, n = 16	P value
Gender (male:female)	2:8	7:9	0.399
Age at operation (yr)	13.1 (7.7-20.3)	10.7 (5.0-18.2)	0.220
Weight at operation (kg)	50.5 (25.0-70.0)	32.6 (18.0-70.0)	0.120
Height at operation (m)	1.54 (1.28-1.67)	1.41 (1.10-1.85)	0.316
BMI at operation (kg/m ²)	21.30 (14.92-25.71)	16.58 (12.71-24.22)	0.036
Indicating primary disease			0.292
Hereditary spherocytosis (%)	9 (90)	14 (88)	
DiGeorge syndrome (%)	0 (0)	2 (13)	
Splenic cyst (%)	1 (10)	0 (0)	
Duration of follow-up (yr)	4.1 (2.1-5.2)	6.6 (4.4-11.4)	< 0.001

Data are median (range) or frequency (%). BMI: Body mass index.

Table 2 Spleen characteristics

	Laparoscopic, n = 10	Open, n = 16	P value
Preoperative longitudinal spleen diameter (cm)	15.8 (12.2-29.0)	14.0 (9.9-28.9)	0.523
Postoperative spleen volume (cm ³)	24 (16-48)	31 (11-210)	0.244
Total splenectomy leaving the accessory spleen (%)	2 (20)	0 (0)	0.138
Splenic US visibility in follow-up sonography (%)	4 (57) – n = 7	11 (79) – n = 14	0.354

Data are median (range) or frequency (%). US: Ultrasonography.

Table 3 Operative variables

	Laparoscopic, n = 10	Open, n = 16	P value
Operative time (min)	185 (135-298)	144 (112-270)	0.048
Simultaneous cholecystectomy (%)	6 (60)	13 (81)	0.369
Primary (first PS) operation (%)	10 (100)	15 (94)	1
Secondary (redo PS) operation	0	1 (6)	
Conversion to open (%)	1 (10)		

Data are median (range) or frequency (%). PS: Partial splenectomy.

metastases (patient mean age 40 years) results from this study cannot easily be transferred to younger age groups. Further, patients in the review by Costi *et al*[18] undergoing a PS due to hematological issues represented 48% of all indications; 42% of the patients underwent the procedure due to nonhematological and nontraumatic condition and 9% as a result of a trauma. In contrast, 90% (LPS group) and 88% (OPS group) of our patients underwent PS due to hypersplenism caused by hereditary spherocytosis. No patient in our study underwent PS resulting from an acute trauma. All patients were electively admitted to hospital. The elective process guaranteed the presence of a senior surgeon with a long-term surgical experience.

According to the findings of our study when comparing both approaches, LPS and OPS are both feasible and safe procedures despite differences in operative time and intraoperative blood loss. LPS is a technically demanding minimally invasive procedure, resulting in a longer operative time compared to the open approach.

Table 4 Postoperative outcomes

	Laparoscopic, n = 10	Open, n = 16	P value
Time from OP to initiation of feeds (h)	37 (4-62)	28 (16-63)	0.580
Time from OP to full feeds (d)	3.5 (2.0-7.0)	4.0 (3.0-6.0)	0.313
Time from OP to mobilization (h)	46 (22-92)	47 (19-98)	0.812
Length of postoperative hospital stay (d)	5 (3-8)	5 (3-8)	0.602
Morbidity (Clavien-Dindo grade I-V) (%)	3 (30)	9 (56)	0.248
Minor morbidity (Clavien-Dindo grade I-II) (%)	3 (30)	8 (50)	0.428
Major morbidity (Clavien-Dindo grade III-V) (%)	0 (0)	2 (13)	0.508
Comprehensive complication index	0 (0-24.20)	8.66 (0-39.70)	0.387

Data are median (range) or frequency (%). OP: Operation.

Table 5 Individual profile of postoperative adverse events graded according to Clavien-Dindo and with calculated comprehensive complication index

	Postoperative adverse events	Clavien-Dindo grade	CCI
Laparoscopic			
Patient 17	Urticaria	II	20.9
Patient 18	Pruritus	II	20.9
Patient 24	Pleural effusion	I	
	External genital edema	I	
	Blood transfusion	II	24.2
Open			
Patient 1	Lid edema	I	8.7
Patient 3	Urticaria	II	20.9
Patient 4	Pleural effusion	I	8.7
Patient 6	Pleural effusion	I	8.7
Patient 7	Wound dehiscence	I	8.7
Patient 9	Exanthema	II	20.9
Patient 11	Urine retention, bladder catheterization	IIIa	26.2
Patient 13	Wound infection	II	
	Redo partial splenectomy	IIIb	39.7
Patient 20	Pleural effusion	I	8.7

CCI: Comprehensive complication index.

The small size of our retrospective case series does not enable us to draw representative conclusions. However, our analysis allows us to view the laparoscopic operation as a viable alternative compared to the open approach and warrants future research comprising prospective multicentric study designs.

CONCLUSION

This is the first study that compared outcomes of LPS and OPS. LPS is a viable alternative to the open operation with a broadly similar perioperative outcome providing superior cosmesis of the ventral abdominal wall. However, a longer

Table 6 Perioperative hematological variables

	Laparoscopic, n = 10	Open, n = 16	P value
Latest hematocrit prior to operation (%)	31.6 (18.7-33.4)	28.1 (24.1-35.7)	0.633
Latest hemoglobin prior to operation (g/L)	114 (65-122)	97 (78-133)	0.221
Lowest hematocrit postoperative (%)	28.0 (26.0-31.0)	30.0 (23.0-35.0)	0.131
Lowest hemoglobin postoperative (g/L)	93 (79-104)	99 (67-126)	0.118
Estimated blood loss (mL of RBC)	87 (-45-777)	-37 (-114-553)	0.039
Patients receiving intra- or postoperative RBC (%)	2 (20)	1 (6)	0.538
Patients receiving intra- or postoperative FFP and TC (%)	0 (0)	2 (13)	0.508

Data are median (range) or frequency (%). RBC: Red blood cell count; FFP: Fresh frozen plasma; TC: Thrombocyte concentrate.

Table 7 Pain assessment and analgesics

	Laparoscopic, n = 10	Open, n = 13	P value
Pain assessment ¹ (0-10 NRS)			0.152 ²
Day 1	4 (2-6)	4 (2-9)	
Day 2	2 (0-4)	4 (1-7)	
Day 3	1.0 (0-2.5)	2.0 (1.0-4.0)	
Day 4	0 (0-1)	1 (0-2)	
Day 5	0 (0-3)	0 (0-5)	
Day 6	0 (0-4)	0 (0-0)	
Day 7	0 (0-0)	0 (0-0)	
Non-opioids – cumulative doses (mg/kg body weight)			
Day 1	33.5 (10.0-48.4)	37.7 (19.2-50.0)	
Day 2	35.3 (10.0-60.5)	31.6 (10.0-68.2)	
Day 3	22.5 (0-37.0)	30.3 (9.3-54.6)	
Day 4	5.0 (0-36.3)	18.2 (0-39.9)	
Day 5	0 (0-36.3)	0 (0-18.8)	
Day 6	0 (0-65.3)	0 (0-0)	
Day 7	0 (0-36.3)	0 (0-0)	
Overall dose	113.0 (20.1-308.0)	134.8 (50.5-172.7)	0.232
Opioids – cumulative doses (mg/kg body weight)			
Day 1	0.44 (0-0.69)	0.32 (0-0.51)	
Day 2	0.42 (0-0.93)	0.28 (0-0.55)	
Day 3	0.25 (0-0.71)	0.09 (0-0.55)	
Day 4	0.08 (0-0.65)	0 (0-0.31)	
Day 5	0 (0-0.53)	0 (0-0.08)	
Day 6	0 (0-0.31)	0 (0-0)	
Day 7	0 (0-0.26)	0 (0-0)	
Overall dose	1.06 (0.09-3.58)	0.72 (0-1.75)	0.343

¹Median of all Numerical Rating Scale scores within 24 h.

²Comparison whether the pain scores of each day differed between the groups over time. Data are median (range) or frequency (%). Three patients in the open group were excluded from comparison due to peridural anesthesia treatment. NRS: Numerical Rating Scale.

operative time and higher intraoperative blood loss necessitates further laparoscopic refinement to adequately balance the superior cosmesis of the minimally invasive approach.

ARTICLE HIGHLIGHTS

Research background

Partial splenectomy for the treatment of hypersplenism is increasingly reported. To date no data stating which approach can be regarded as superior over the other are available.

Research motivation

The purpose of this study was to compare perioperative outcomes of laparoscopic partial splenectomy (LPS) and open partial splenectomy (OPS) in children and adolescents.

Research objectives

The objective of this study was to analyze and compare LPS and OPS with perioperative outcome parameters.

Research methods

We retrospectively reviewed all patients ($n = 26$) that underwent LPS ($n = 10$) or OPS ($n = 16$) between January 2008 and July 2018. Clinical data including demographics, spleen characteristics, operative and hematological variables, postoperative outcomes including pain scores and analgesic requirements as well as postoperative adverse events were analyzed.

Research results

Perioperative hematological parameters, postoperative pain scores, analgesic requirements, adverse events according to the Clavien-Dindo classification and the comprehensive complication index, median time from operation to initiation of feeds, median time from operation to full feeds, median time from operation to mobilization and median length of hospital stay did not differ between LPS and OPS. Median operative time was longer in LPS compared to the OPS group. Calculated perioperative blood loss (mL of red blood cells) was higher in the LPS group compared to OPS.

Research conclusions

This is the first study that compared outcomes of LPS and OPS. LPS appears to be a viable alternative to the open operation with a broadly similar perioperative outcome providing superior cosmesis of the ventral abdominal wall.

Research perspectives

Our study results warrant a prospective multicentric clinical trial to compare outcomes in a larger group.

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