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...
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, 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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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]:

\[
\text{estimated blood loss (mL of RBC)} = \text{Blood volume (mL)} \times \left( \frac{Hct_{\text{preop}} - Hct_{\text{postop}}}{Hct_{\text{preop}}} \right) + \text{RBC transfusion volume (mL)}.
\]

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]:

\[
\text{blood volume (mL)} = \text{Weight (kg)} \times \text{estimated blood volume (mL/kg)}.
\]

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 reconvalescence 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 (1.26-1.67)     | 1.41 (1.10-1.85) | 0.316   |
| BMI at operation (kg/m²)       | 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 (cm³)              | 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   |     |
| Patient 24                   | External genital edema | I | |
| Patient 24                   | 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  |     |
| 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 (0-0.95)              | 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 |

\(^1\)Median of all Numerical Rating Scale scores within 24 h.
Comparison 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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