Minimal access surgery in children: Implementation of an innovating technique
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Implementation of laparoscopic splenectomy in children and the incidence of portal vein thrombosis diagnosed by ultrasonography

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Abstract

When performing laparoscopic splenectomy (LS), Virchow’s Triad is challenged as pneumoperitoneum reduces blood flow in the portal vein. This might lead to Portal Vein Thrombosis (PVT) which is a serious complication because of the risk of portal hypertension and esophageal varices. When implementing a new surgical technique, such as LS, different factors might contribute to a potential different outcome compared with the known used technique (i.e. open splenectomy). To define specific elements in the implementation of LS we focused primarily on the complication of portal vein thrombosis (PVT). So far, no large series of pediatric laparoscopic splenectomized patients with systematically postoperative ultrasound are available.

The aim of this study is to evaluate if symptomatic or asymptomatic PVT, as diagnosed with ultrasonography (US), occurs more often in children after the introduction and implementation of LS compared to open splenectomy.

Methods. A retrospective cohort of 76 splenectomized patients for benign hematological disease were analyzed, 24 after open splenectomy (OS) and 52 after LS.

Results. In six of the OS and 40 after LS a postoperative US was made. In two patients after LS a PVT was seen on US. Both patients were symptomatic and also underwent a laparoscopic cholecystectomy. The length of stay in the hospital was significantly shorter for LS (median 4.5 days, range 2-12) compared to OS (median 7 days, range 5-12), (p = 0.00). Median operation time of OS was 65 min (range 35 – 130 min) and of LS 170 min (range 85- 275 min) (p = 0.00). There was no difference in postoperative complications.

Conclusion.
The risk of developing a PVT after laparoscopic splenectomy seems low and thus LS is not contraindicated in patients with benign hematological disease. When combining LS and laparoscopic cholecystectomy prophylactic heparin might be considered.
Introduction

With the development of minimally invasive instruments, laparoscopic splenectomy (LS) for various benign hematological disorders became feasible. Benefits of LS are improved cosmesis, less pain and shorter length of hospital stay. Adult comparative studies showed that fewer complications occur in LS than in open OS i.e. fewer pulmonary-, wound - and infectious complications. Nowadays, LS is considered the standard technique for splenectomy.

After the first report of LS in adults in 1991, the first results in children were published two years later. Several studies described advantages of LS in children similar to those in adults, i.e. shorter length of stay, time to full feed and duration of postoperative analgesia.

The introduction of a new surgical approach involves various factors that can lead to an outcome that differs from the standard approach. One of these is the learning curve. LS has a learning curve as an advanced laparoscopic procedure. Both adult- and pediatric literature describe the effect of experience on outcome parameters such as conversion rate, length of stay, rate of complications and operating time.

Portal vein thrombosis (PVT) is a serious complications following splenectomy. The reported incidence range from 6.3 to 10% in adults and 6% in children. PVT may cause intestinal infarction and portal hypertension. This latter can lead to esophageal varices in 90-95% and gastric varices in 35-40% of the patients. Furthermore, the risk of bleeding during adolescence is more then 50% if PVT occurs during childhood. The mortality from gastrointestinal bleeding secondary to variceal rupture is 2-5%.

PVT after LS in pediatric patients is reported in several case-reports, mainly including symptomatic patients only. Asymptomatic PVT has also been reported, both after OS and LS and has the same potential threats (i.e. portal hypertension). This indicates the importance of analysing the presence of PVT by abdominal ultrasonography in all post-splenectomy patients.

Factors influencing thrombus formation, like in PVT, are represented as Virchow’s Triad: changes in vessel wall, stasis of blood flow and hypercoagulability. Most patients who develop PVT after a splenectomy are known with a haematological disease and thus have altered blood composition. The minimal access approach of LS does not change the manipulation of the vessel nor the blood composition in comparison with OP. However, pneumoperitoneum does alter the blood flow and stasis in the portal vein. When starting the implementation of LS as a surgical novelty, the time to operate will be prolonged, and thus the duration of pneumoperitoneum. Only a few – mostly retrospective- studies are performed in which the incidence of PVT after splenectomy using ultrasonography (US) is described.
In a study including 16 children who underwent OS, in three of them a symptomatic PVT and in one child an asymptomatic PVT were diagnosed using US \(^\text{15}\). In a study in 60 adults, systematically US was done after open splenectomy to study the portal venous flow. Three cases of asymptomatic PVT were detected besides one symptomatic PVT \(^\text{16}\). So far, no large series of paediatric postoperative LS patients are described in which US is used to diagnose the presence of asymptomatic PVT.

The aim of our study is to evaluate a) the occurrence of PVT after LS compared to OS in a paediatric cohort and b) whether the learning curve and/or duration of pneumoperitoneum of LS may influences the incidence. Primairy endpoint is the occurrence of symptomatic and asymptomatic PVT, investigated by US after OS and LS for a benign haematological disorder in a paediatric cohort. Further endpoints are conversion rate, other complications and operating time.

**Patients and methods**

**Cohort:**

A total of 76 consecutive paediatric patients, age under 19 years at the time of surgery, who underwent OS or LS for a benign haematological disorder in the department of Paediatric Surgery from 1985 to June 2012 were included in this study. Exclusion criteria were trauma related splenic surgery, partial splenectomies and malignancies.

Data were collected for demographics (age and sex), underlying pathology, operating time, type of surgery, complications, length of stay and conversion. In the first week after surgery the highest platelet count were noted. Thrombocytosis was defined as platelet count > 450x10⁹/L for more then 3 days.

All children received pre-operative immunization and antibiotic prophylaxis pre-and postoperatively.

**Abdominal ultrasonography (US):**

From 2010, in all paediatric patients, US was performed within 6 weeks after discharge to evaluate the possible existence of asymptomatic PVT. (\(n=9\) LS patients; median time 2.2 weeks post-splenectomy). Furthermore, abdominal US was performed if there was a clinical suspicion of PVT.

Patients who underwent their splenectomy before 2010 were included in the retrospective part of the study, only if written informed consent was obtained. US was performed by the same experienced paediatric radiologist (RRvR). In total, 37 patients were included in this retrospective part of the study (median time 7.6 yrs post-splenectomy).
Surgical techniques

Open splenectomy (OS)
In the open procedure, a left subcostal or transverse incision was placed with the patient in supine position. The spleen was freed from the ligaments and vascular control was obtained. After dissection of the vasa brevia the splenic pedicle vessels were clamped, ligated and divided (and the specimen could be taken out through the wound.)

Laparoscopic splenectomy (LS)
This procedure was carried out with the patient in hanging spleen position. Insufflation to 12-14 mm Hg was used depending on weight and age. After placing 4 trocarts the spleen was mobilized by freeing all the ligaments with electrocautery or harmonic scalpel devices. After that the vascular pedicle was taken down with a vascular endostapler. With a harmonic scalpel device the vasa breviae were dissected so that the spleen was completely mobilized. Removal was carried out by using an endobag or by enlarging the incision of a trocart. When an endobag was introduced it was done directly through a 10 mm opening of a trocart. The spleen was scooped to be covered completely in the bag. The bag was tightened and opened outside the abdomen and the spleen was removed in pieces. No morcelation was done to prevent damaging the bag and thus avoiding splenosis. When enlarging an incision it was done at the most appropriate trocart site depending on the size of the spleen and abdomen of the patient.

Learning Curve
Any change in operation time, complication or conversion rate was analyzed in subgroups of 10 patients. A possible trend could identify a learning curve.

Statistical analysis
Analysis was done of the two separate groups: the OS group and the LS group. The data were collected and analyzed with SPSS 19.0 software using a paired t-test. A p-value of < 0.05 was considered statistically significant.

Results

PATIENTS
A total of 76 patients were included in this study with a median age of 8.8 years (range 2.5 – 18.2 years). Demographic characteristics and indication of splenectomy are described in table 1. Indications for splenectomy were spherocytosis (n=47), sickle cell disease (n=10), chronic ITP (n=12), B-thalassemia (n= 5) and metabolic disorder (n= 2). OS was performed in 24 patients and LS in 52.
Chapter 7

Median operation time of OS was 65 min (range 35 – 130 min) which was significantly shorter than of LS (median 170 min; range 85- 275 min) (p = 0.00). (Table 2) In contrast, The length of stay in the hospital was significantly shorter after LS (median 4.5 days, range 2-12) compared with OS (median 7 days, range 5-12), (p = 0.00).

For the subgroup of five patients who underwent a laparoscopic splenectomy and cholecystectomy (LC), the median operation time was 225 min (range 185-324), which is not significantly longer than LS only (p=0.106).

The postoperative platelet count after LS+LC (median 1231x10^9) was significantly higher (P =0.000) than after LS (median 521x10^9) or OS (median 520x10^9) only. All LS +LC patients had a postoperative thrombocytosis.

In the OS group, 14 of the 24 children (58%) and in the LS group 20 of the 52 children (38%) had thrombocytosis.

Table 3 summarizes the median operating time of the procedure, the postoperative complications and conversions in the first 10 patients (median 209 min) compared to the following subcohorts of 10 patients, showing no significant decrease of operating time in relation to the experience of the surgeons.

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Table 1, demographic characteristics and indication of splenectomy of the study population, SCD: sickle cell disease, MD: metabolic disorder

<table>
<thead>
<tr>
<th></th>
<th>OS n=24</th>
<th>LS n=52</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years) (median and range)</td>
<td>7.1 ( range 2.5-12.2)</td>
<td>9.3 ( range 3.4-18.2)</td>
</tr>
<tr>
<td>Male/female (n)</td>
<td>16/8</td>
<td>23/28</td>
</tr>
<tr>
<td>Indication</td>
<td>Spherocytosis 19</td>
<td>Spherocytosis 28</td>
</tr>
<tr>
<td></td>
<td>SCD 1</td>
<td>SCD 9</td>
</tr>
<tr>
<td></td>
<td>ITP 2</td>
<td>ITP 10</td>
</tr>
<tr>
<td></td>
<td>MD 2</td>
<td>β-Thalassemia 5</td>
</tr>
</tbody>
</table>

Table 2, outcomes of OS study group vs LS study group and separate LS+LC group. OS=open splenectomy, LP=laparoscopic splenectomy, LC= laparoscopic cholecystectomy.

<table>
<thead>
<tr>
<th></th>
<th>OS</th>
<th>LS</th>
<th>LS+LC</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>24</td>
<td>47</td>
<td>5</td>
</tr>
<tr>
<td>OR time min (median and range)</td>
<td>65(35-130)</td>
<td>170(85-375)</td>
<td>225(185-324)</td>
</tr>
<tr>
<td>LOS days (median and range)</td>
<td>7( 5-12)</td>
<td>4.5 (2-12)</td>
<td></td>
</tr>
<tr>
<td>Conversions</td>
<td>0</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Complications</td>
<td>3</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Platelet count (x109)</td>
<td>520 (180-1390)</td>
<td>521(153-1386)</td>
<td>1231(720-1994)</td>
</tr>
<tr>
<td>median and range</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PVT by US</td>
<td>0/6</td>
<td>0/38</td>
<td>2</td>
</tr>
</tbody>
</table>
Of the 52 LS procedures, 33 (63%) were performed mainly by three staff surgeons with experience in minimal invasive surgery, 11 (21%) by fellows and 8 (15%) by three other staff surgeons.

Of the 24 OS 16 (66%) were mainly operated by three staff surgeons, 2 by fellows, three by residents and the other 3 by three other staff surgeons.

**Conversion rate**

Six of the 52 LS (10%) had to be converted into an OS. Three conversions in the first half of the series had to be done for bleeding. Of the three conversions in the second half, one was due to technical reasons (equipment failure), one was for severe adhesions caused by peri-splenitis, and one was for bleeding (in LS with concomitant laparoscopic cholecystectomy).

**Complications**

Post-operative complications were seen in 3 of the 24 patients (pneumonia, septicaemia, allergic reaction on antibiotics) in the OS group and in four of the 47 patients (atelectasis, pneumonia, subcutaneous hematoma one intra-abdominal bleeding) in the LS group.

**Portal Venous Thrombosis**

Abdominal US was performed in 6 of the 24 patients after OS and in 40 of the 52 patients after LS (Fig 1). In OS the median interval between surgery and US was 13.2 yrs (range 6-24 yrs) and in LS the median interval was 2.5 yrs (range 5 days-13.6 yrs). The groups without and with ultrasound differed in median age of 6.7 years when no US and 9.0 years when US was made.

There were two cases with PVT which were treated with low molecular weight heparin for a period of three months. Both patients were diagnosed with spherocytosis and in both the splenectomy was combined with cholecystectomy for gall stone disease. In one patient because of the amount of adhesions in the region of the gallbladder the operating time was one of the longest in our series (324 min). The postoperative platelets increased up to 1.231 $10^9$. The other patient had perisplenic adhesions due to an earlier splenic

**Table 3**, median time to operate in LS, complications and conversion per 10 operations.

<table>
<thead>
<tr>
<th>Patient number</th>
<th>Median operating time</th>
<th>Complication</th>
<th>Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>209</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>10-20</td>
<td>160</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>20-30</td>
<td>188</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>30-40</td>
<td>210</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>40-47</td>
<td>193</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
rupture. Because of uncontrollable bleeding at the vasa brevia conversion took place. At the first postoperative day an abdominal US showed no PVT. After recovery the patient was discharged at day six postoperative with a platelet count of 1500 $10^9$. Two weeks later he presented with abdominal pain and abdominal US showed PVT.

**Discussion**

In this study, the total incidence of PVT after splenectomy for benign haematological diseases was 2.6% (2/76) , 3.8% (2/52) when focusing on the LS group and 4.3% (2/46) when US is made. This paediatric cohort is the largest, so far in the literature, analyzing the occurrence of PVT after LS and OS, assessed by abdominal US.

A significantly longer operating time but significantly shorter length of stay was seen in the LS subgroup compared with the OS subgroup. In both children with PVT a LS combined with LC was performed. Although there was a significant difference in postoperative platelet count there is debate whether this is a causative factor in postoperative PVT. Postoperative elevated platelet count can raise after splenectomy because of loss of splenic function in removal of senescent platelets. But their role in formation of thrombi is unknown. It seems that the quality and function of the platelets is more important than quantitative platelet count only. Unfortunately, the total number of children in the OS group was too small to perform statistical analysis. It is thus difficult to recommend a postoperative strategy here but when prolonged asymptomatic thrombocytosis above 1000x$10^9$ occurs low molecular heparine might be considered.

Data about the incidence and the risk factors of PVT postsplenectomy in pediatric patients are scarce. As in our study, in two case reports PVT occurred after additional laparoscopic cholecystectomy. Theoretically the long duration of the surgical procedure caused by the additional laparoscopic cholecystectomy might be a risk factor. From colonic surgery there are data that operation time that exceeds 270 min is significantly associated with more complications. Furthermore, pneumoperitoneum in laparoscopy may reduce blood flow in the portal vein. So the prolonged operation time in the patients with postoperative PVT might have influenced the blood flow resulting in PVT. The duration of this operation in the female patient due to the adhesions at the gallbladder was 324 minutes and one might ask if conversion after 2.5 or 3 hours would have been justified. The operation in the male patient took 185 minutes to finish. It is remarkable that in our male patient no PVT was diagnosed at US at the first postoperative day but after three weeks when abdominal pain occurred and a subsequent ultrasound did show a PVT.

The mechanism is not understood, maybe it is due to the prolonged pneumoperitoneum or the manipulation of the ligamentum hepatoduodenale and the liver. Or perhaps due to a combination of the significant higher postoperative platelet count, in comparison to LS
only, with these factors. Nevertheless it might be recommendable studying the effect of peri-operative heparine in a prospective placebo controlled multicenter study, in children with a presumed higher risk, eg the combination of LS and LC or LS only with a long expected pneumoperitoneum (after splenic rupture or very large spleen).

Concerning our late postoperative US we might have missed some asymptomatic PVT. This could indicate that after long follow-up no radiological signs of PVT are present either, and thus lack clinical relevance. Also we realize that in this study not all the splenectomized patients were examined by ultrasound (6/24 in OS and 40/51 in LS, see flowsheet figure 1). Also the difference in time of postoperative ultrasound after LS or OS is a flaw in our study design.

When comparing groups subcohorts of 10 patients there is no decrease in time to operate thus no learning curve could not be detected. Also there was no trend in decrease of complications or conversion in time that could identify a learning curve.

Our data show a significantly shorter length of stay in favor of the laparoscopic procedure (table 2) but a significantly longer operating time. Also a part of the control group, 16 out of 24, was operated in the past before the concept of fast track surgery was introduced with the LS in 1995. Thus the shorter length of stay could be achieved by the introduction of fast track surgery or the implementation of LS.
Conclusion

This study emphasizes that LS takes more time than OS to perform and is associated with a low incidence of PVT. Although this is the largest cohort of paediatric laparoscopic splenectomized patients who underwent routine US to detect a symptomatic or asymptomatic PVT, the findings do not allow the conclusion that the incidence of PVT is higher than after OS. PVT was associated with long operation time due to concomitant laparoscopic cholecystectomy. Therefore implementing LS is safe in patients with benign haematological diseases. When combining LS with laparoscopic cholecystectomy, prophylactic low molecular heparin might be considered which should be studied in the future by means of a multicenter RCT.

Acknowledgement

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References


