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Evaluation of Hem-o-lok clips in controlling the splenic pedicle in laparoscopic splenectomy in children

Mahmoud Mohamed Eid[1*], Khalid Mohammad Elshimy[2], Akram Mohamed Elbatarny[2] and Mohamed Fathy Metwally[3]

Abstract

Background Splenectomy is an established therapeutic intervention for benign haematological disorders (BHD) in children. Laparoscopic splenectomy (LS) has become accepted as the preferred alternative to the open procedure. The aim of this study was to evaluate the Hem-o-lok clips in controlling the splenic hilum during laparoscopic splenectomy in children as regards feasibility, safety, operative time, cost, and perioperative complications.

Methods This study included 27 cases with BHD, from April 2020 to December 2021, who underwent LS. In all patients, the Hem-o-lok clips were used to control the splenic pedicle. Operative time, intraoperative complications, need for conversion, and splenic extraction were reported. Postoperative course, complications, and hospital stay were also recorded. Patients were followed up for 3 months for development of complications and for evaluation of cosmetic appearance.

Results The mean operative time, excluding splenic extraction, was 67.04 min. There were 3 intraoperative minor bleeding incidents, all not related to Hem-o-lok application, and they were successfully controlled, with no need for conversion. The mean hospital stay was 1.3 days. We used one cartridge for each case (cost; 686 LE, US $28).

Conclusions The Hem-o-lok clips are feasible, safe, and cost effective in controlling the splenic hilum during LS in children with benign haematological diseases.

Keywords Hem-o-lok clips, Splenic pedicle, Laparoscopic splenectomy, Children

Background

Splenectomy is an established therapeutic intervention for benign haematological disorders (BHD) in children. Laparoscopic splenectomy (LS) has become accepted as the preferred alternative to the open procedure. First described in 1991, this technique became more popular after the introduction of newer instruments that made dissection easier, shortened operative time, and decreased blood loss [1].

The secure control of the splenic hilum is the most critical step in LS. Multiple haemostatic devices are available for control of the vascular pedicle including platinum clips, endostaplers, ligatures, Hem-o-lok plastic clips, and energy vessel sealing devices. Several studies have examined the efficacy, safety, and cost of these devices in different situations [2].

The Hem-o-lok clip was introduced in 1999. This clip has gained popularity among laparoscopic urologists, primarily for closure of the renal hilum during minimally invasive nephrectomy, effecting appropriate results.

*Correspondence:
Mahmoud Mohamed Eid
3ed2318@gmail.com
[1] Faculty of Medicine, Tanta University, Tanta, Egypt
[2] Paediatric Surgery, Faculty of Medicine, Tanta University, Tanta, Egypt
[3] General and Pediatric Surgery, Faculty of Medicine, Tanta University, Tanta, Egypt

Many others have also adopted the Hem-o-lok for a variety of laparoscopic procedures in recent years. This non-absorbable polymer-locking clip is inert, non-conductive, and compatible with computed tomography (CT) scan and magnetic resonance imaging (MRI). The lok engagement feature and the presence of teeth in the jaws provide good security. Loading of the applier with the clip is easy, and a flexible mechanism virtually prevents clips from falling out of the applier [3].

The aim of this study was to evaluate the use of Hem-o-lok clips in controlling the splenic hilum during LS in child as regards feasibility, safety, operative time, cost, and perioperative complications.

Patients and methods

This prospective study was carried out on 27 patients, who presented to our University Hospitals with BHD indicated for splenectomy during the period from April 2020 to December 2021. The study included children less than 18 years old with benign haematological conditions indicated for splenectomy. We excluded children with previous open upper abdominal surgery, severe cardiac or respiratory diseases, malignant splenomegaly, parasitic or nonparasitic cysts, ruptured spleen, patients with portal hypertension, and children with massive splenomegaly. The latter were defined as those whose spleens are enlarged more than 3 fingers below the umbilicus.

Vaccination against encapsulated organisms (*Streptococcus pneumoniae*, *Neisseria meningitidis*, and *Haemophilus influenzae* type B) was given 2 weeks before the operation. The preoperative HB level was corrected to a minimum of 9 gm/dl and platelet count to a minimum of 50,000/cmm.

Operative details

General anaesthesia with endotracheal intubation was used in all cases. Nasogastric tube and a urinary catheter were routinely inserted. Prophylactic IV antibiotics were given 30 min before the procedure. Patients were placed in the supine position with a flank cushion placed under the left side. The patient is fixed in that position using broad adhesive tape or fixing belts. By tilting the table to the left, we could introduce the initial trocars in the neutral position, and then the table was returned to the neutral horizontal position and finally raising the head of the table up. A mixture of lignocaine (3–5 mg/kg) and bupivacaine (1–2 mg/kg) was used to infiltrate trocar and other wound sites. We used four trocars as shown in Fig. 1. Insufflation of the abdomen was performed at 10–15 mm Hg pressure with a flow rate 2–5 L depending on the age of the patient.

Fig. 1 Trocar sites

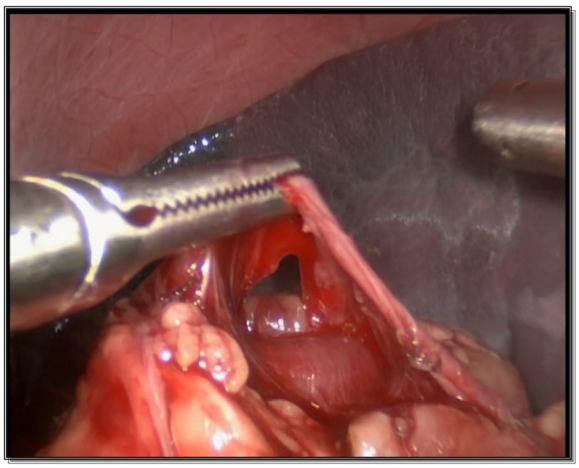

Fig. 2 Selective dissection of the artery

Technique

After laparoscopic exploration of abdomen and splenic area looking for splenules, we start by division of the splenocolic ligament, followed by the gastrosplenic ligament using a vessel sealing facility (harmonic or LigaSure™). Now, the anterior layer of the lienorenal ligament is dissected just above the pancreas to reach the hilum. The splenic hilum is dissected, starting with the splenic artery which is controlled first using double Hem-o lok clips (large sized) proximally and one clip distally and then divided with scissors (Figs. 2, 3 and 4). The splenic vein is then dissected and controlled in a similar manner (Figs. 5, 6 and 7). Dissection of the vessels is done cautiously using a combination of Maryland forceps, vessel sealing device, and monopolar hook diathermy. It should be noted that complete skeletonization of the vessels is necessary to apply the Hem-o-lok properly, and that applicator closure should be done under vision. The posterior layer of the lienorenal ligament and the lienophrenic ligament is

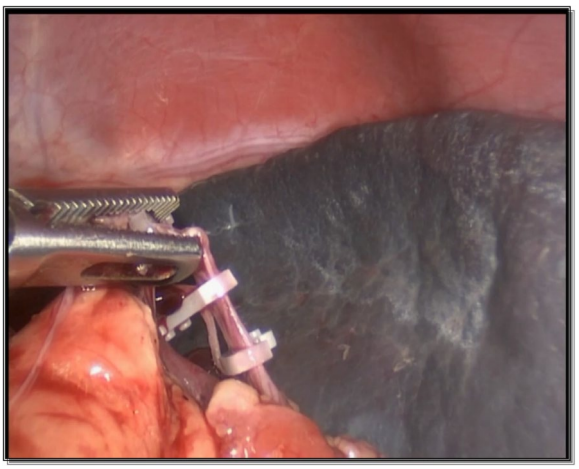

Fig. 3 Control of the artery with Hem-o-lock clips

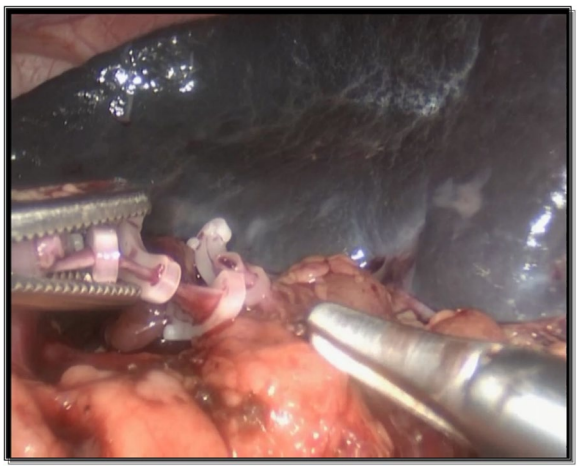

Fig. 6 Control of the vein with Hem-o-lock clips

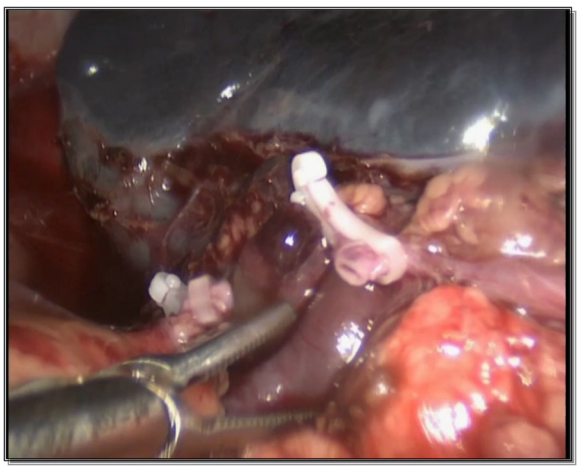

Fig. 4 The artery was cut between 2 clips proximal and 1 clip distal using scissor

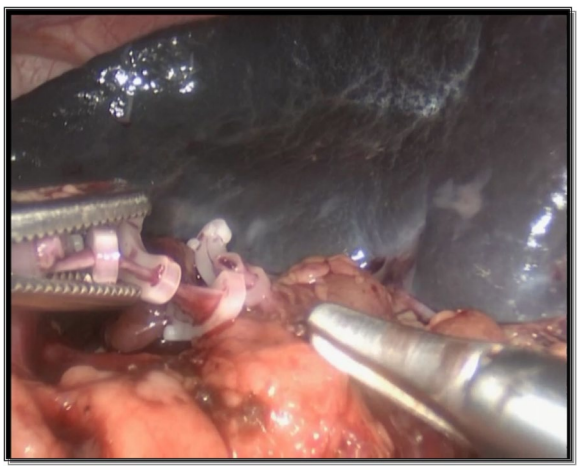

Fig. 7 The vein was dissected between 2 clips proximal and 1 clip distal (hilum after complete devascularization of spleen)

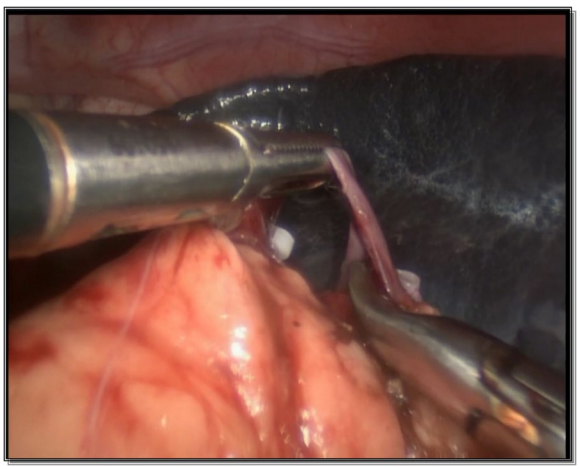

Fig. 5 Selective dissection of the vein

then divided. After complete separation of the spleen, the splenic bed is immersed with saline which is then sucked. The spleen will then be extracted either through a home-made endo bag through the umbilical wound or a Pfannenstiel incision depending on its size. A Nelaton drain (optional) was put in the splenic bed and brought out through the right working port. The abdomen is deflated, and the ports are removed. Wounds are closed, and the NG tube is removed. Then, the spleen or the splenic pieces were sent for histopathology.

Postoperative

All the patients were nursed in Fowler position with meticulous follow-up of the vital signs specially pulse rate. IV antibiotics were continued during hospital stay and then continued orally for 1 week. Proper

post-operative analgesics were given in a ladder step manner as required starting with IV paracetamol and adding NSAIDs when needed. Oral feeding was initiated 6–8 h postoperatively in patients whose spleens were extracted by an endo bag or after regaining of peristalsis in cases who had a Pfannenstiel incision. Complete blood count (CBC) was obtained 6 h postoperatively to check for haemoglobin and platelet levels. Foley's catheter was removed when there was no need for blood transfusion, as confirmed by the CBC. The drain (if present) was removed after 24–48 h. Patients were discharged after a minimum of 24 h and scheduled for follow-up in the outpatient clinic. Patients were followed up for a minimum of 3 months. US was repeated at the 1-week visit for any collection. Patients continued follow-up at the paediatric haematology unit for their original haematologic disease.

Statistical analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Shapiro–Wilk test and histograms were used to evaluate the normality of the distribution of data. Quantitative parametric data were presented as mean and standard deviation (SD). Quantitative nonparametric data were presented as median and interquartile range (IQR). Qualitative variables were presented as frequency and percentage (%). A two-tailed P-value < 0.05 was considered statistically significant.

Results

This study included 27 children who underwent LS for BHD. Their age ranged from 4 to 18 years with a mean of 7.44 ± 3.25 years. Twelve were males (44.4%), and 15 were females (55.6%). The diagnosis was thalassemia in 13 patients, spherocytosis in 6 patients, AIHA in 4 patients, ITP in 3 patients, and sickle-cell disease in 1 patient.

By preoperative ultrasound, splenic span ranged from 10 to 18.5 cm with a mean of 13.5 cm. GB stones were detected in 3 cases (11.1%); 1 case had AIHA, 1 case had thalassemia major, and 1 case had spherocytosis. Those 3 cases underwent simultaneous laparoscopic splenectomy and cholecystectomy. By US, a splenule was detected in 1 case, and it measured 20 mm × 20 mm. The operative time for cases of splenectomy, counted until complete de-vascularization and separation of the spleen (excluding extraction time), ranged from 40 to 85 min with a mean of (67.04 ± 14.02). In cases of combined laparoscopic splenectomy and cholecystectomy, we started by cholecystectomy first, and the operative time ranged from 85 to 95 min. Minor to moderate intraoperative bleeding occurred in 3 cases: 1 from the short gastric vessels and 2 from small pancreatic branches. All cases were controlled laparoscopically without conversion. Based on surgeon discernment, a drain was inserted in 24 cases (88.9%), while 3 cases (11.1%) had no drain as the field was dry and safe. Drain placement was mainly a surgeon decision. All cases have been completed laparoscopically without conversion.

Postoperative feeding was tried after 6–8 h in all cases who had their spleen extracted in a bag (16 cases; 59.3%) and all of them tolerated. Patients who had their spleen extracted via a Pfannenstiel incision (11 cases; 40.7%) started oral feeding after regaining peristalsis or passing flatus, and 8 of them tolerated feeding. Three cases suffered vomiting 1–2 times and were managed by IV ondansetron (0.1 mg/kg) with resumption of oral feeding. Drain was removed after 24 h in 22 (81.5%) patients while the 2 other drains removed after 48 h.

The mean hospital stay was 1.3 days (1–2 days). We used only 1 Hem-o-lok cartridge for each patient to control the splenic hilum with a cost of (US $28) (686 LE), while the cost of the homemade endo bag was (US $4.5) (110 LE). On the other hand, we used a commercial endo bag in 1 case, and it costs US $62 (1519 LE).

There was a significant positive correlation between the type of splenic extraction and the period of hospital stay. Cases with the spleen extracted via a Pfannenstiel incision had a longer stay. There was also a positive correlation between the splenic size and the method of extraction. In the 16 cases, who had their spleen extracted via endo bag (homemade or commercial), the average splenic span was 13 cm (10–16 cm), while in the 11 cases, who had their spleen extracted via a Pfannenstiel incision, the average splenic size was 14 cm (13–18.5 cm).

Discussion

The secure control of the splenic hilum is the most critical step in LS. In our study, we used the Hem-o-lok clips to control the hilum in all cases. After dissection of the splenic hilum, the splenic artery is controlled first using Hem-o lok clips with double clips proximally and a single clip distally. It is then divided using scissors. This is followed by controlling the splenic vein in a similar manner. This was exactly described by Adetokunbo Fadipe et al. (2022), Haffenden et al. (2021), Ali Aminian et al. (2012), and Murat Derebey et al. (2020). Selective control of the splenic hilum starting by the artery and then the vein revives the traditional concept of splenic autotransfusion [4–7].

On the other hand, Khiralla et al. (2016) used only the LigaSure™ for controlling the splenic vessels [8].

In our study, the splenic span as measured by preoperative ultrasonography ranged from 10 to 18.5 cm with an average of 13 cm. This is consistent with many other similar studies. Adetokunbo Fadipe et al. (2022) reported that the mean splenic size was 13.4 cm and 12–14.4 cm [4]. Cetin Ali Karadag et al. (2015) reported that 39 of

their patients had splenic lengths exceeding the suggested upper limit of normal according to Rosenberg's study [9].

We had 3 (11.1%) cases of minor to moderate intraoperative bleeding, one from the short gastric vessels and 2 from small pancreatic branches during dissection of the hilum. All were not related to the use of the Hem-o-lok clips, and all were controlled laparoscopically without the need to convert. Ali Aminian et al. (2012) reported they had a bleeding in 1 case (2%) due to tearing of splenic vessels [6]. Haffenden et al. (2021) reported that they had no intraoperative bleeding [7]. Adetokunbo Fadipe et al. (2022) reported that there were no cases of significant intraoperative bleeding [4]. Mohammad Gharieb et al. (2016) reported that 1 case had an injury to the splenic vein, and 4 cases had an injury of the short gastric vessels [8].

So, the rate of bleeding in our study is comparable to the rate in other studies using our technique or other methods for hilar control. It must be noted that for proper application of the Hem-o-lok clips, a segment of both the artery and vein must be skeletonized to allow for application of the clips with safe distance to cut between them. Dissection of the hilum should be done carefully and meticulously.

The mean operative time for splenectomy only (excluding extraction time) ranged from 40 to 85 min with a mean of 67.04 ± 14.02. Adetokunbo Fadipe et al. (2022) reported that the operative duration for LS only was 178 min (156–185 min), and they used Hem-o-lok for hilum control in all cases [4]. Mohammad Gharieb et al. (2016) reported the mean operative time was 85 min for ITP patients and 120 min for thalassemia and spherocytosis, and the LigaSure™ was the only device used in hilar control in their study [8]. Mohamed E. Hassan et al. (2014) reported the operative time ranged from 150 to 210 min, and they used a linear endoscopic vascular stapler for hilar control [10]. Cetin Ali Karadag et al. (2015) reported that the mean operative time for their first 25 cases was 154.6 min, whereas the mean operative time for their last 25 cases was 115.5 min. They did not specify the time needed for extraction, and they used the LigaSure™ for hilar control [9]. So, it is clear that using this method for vascular control does not increase the operative time.

We had no conversion to open splenectomy (OS) in our cases. Adetokunbo Fadipe et al. (2022) reported that there were no conversions to OS [4]. Murat Derebey et al. (2020) reported that conversion was performed in 1 (5.3%) patient in the Hem-o-lok group due to bleeding from the splenic hilum during the dissection [5]. Cetin Ali Karadag et al. (2015) mentioned that 5 (21.5%) of the laparoscopic splenectomies required conversion to an open procedure [9]. Mohammad Gharieb et al. (2016) had 2 cases that were converted to conventional splenectomy due to bleeding [8]. It is also clear that using the Hem-o-lok for hilar control does not increase the rate of conversion to OS.

GB stones were detected only in 3 cases (13.6%). The 3 cases underwent simultaneous laparoscopic splenectomy and cholecystectomy. In Adetokunbo Fadipe et al. (2022) study, 6 out of the 20 cases (33%) underwent concomitant laparoscopic cholecystectomy and splenectomy [4]. Cetin Ali Karadag et al. (2015) mentioned that 5 patients (10%) underwent concomitant cholecystectomy and splenectomy [9].

In cases of combined laparoscopic splenectomy and cholecystectomy, we always start by cholecystectomy first, and this was exactly reported by Faisal G. Qureshi et al. (2005) [11].

We extracted the spleen in a homemade retrieval bag in 15 cases (40.7%), in a commercial endo bag in 1 case (3.7%), and via a Pfannenstiel incision in 11 cases (55.6%). The spleen was fragmented in the bag after extending the umbilical port incision in the midline. Khiralla et al. (2016) reported that they used the retrieval endo bag in 20 patients, while they extracted the spleen via a Pfannenstiel incision in 40 cases [8]. Adetokunbo Fadipe et al. (2022) reported that they used the endo bag for all cases [4]. Using an endo bag avoids the use of another incision, although hidden, with its tissue trauma, pain, and added operative time, promoting ileus and potential complications. So, we opt to extract only very large spleens through a Pfannenstiel incision. The homemade endo bag is less costly but more difficult to manipulate than the commercial endo bag.

In our study, postoperative feeding was tried after 6–8 h in all cases who had their spleen extracted in a bag (16 cases) and all of them tolerated. Patients who had their spleen extracted via a Pfannenstiel incision (11 cases) started oral feeding after regaining peristalsis or passing flatus and all of them tolerated except 3 cases who had vomiting that was medically managed with success. Mohamed E. Hassan et al. (2014) reported that postoperatively, oral feeding was resumed within 6 to 8 h as they extracted all the spleens by an endo bag [10]. Early feeding, especially in children, alleviates their postoperative discomfort and anxiety and could shorten hospital stay as well.

Twenty-four of our patients had an intraperitoneal drain postoperatively; in 22 of them, it was removed after 24 h, and 2 drains were removed after 48 h. Mohamed E. Hassan et al. (2014) inserted a drain in cases of massive splenomegaly which was removed within 24 h [10]. Mohammad Gharieb et al. (2016) mentioned that they put a drain in all cases that was removed on the 2nd day as they discharged all the cases on the 3rd day [8].

Table 1 comparison between the most important variables of the already published case series including our study

	Hilar control	Intra operative bleeding	Mean operative time	conversion	Gall bladder stones	Splenic extraction	Abdominal drain	Mean hospital stay	Post operative complications
Our study	Hem-O-lok	3 cases (11%)	67.04 ± 14.02 min	no	3 cases (13.6%)	16 cases (endo bag) 11 cases (Pfannenstiel)	22 cases	1.3 days	No
Fadipe et al. [4]	Hem-O-lok	No	178 min	no	6 cases (33%)	All cases (endo bag)		2 days	1 case (post operative pain)
Haffenden et al. [7]	Hem-O-lok	No		no		All cases (endo bag)		2 days	no
Aminian and Khorgami,[6]	Hem-O-lok	1 case (2%)							
Derebey et al. [5]	Hem-O-lok	1 case (5.3%)	116.7 min	1 case (5.3%)	3 cases (7.1%)	14 (En-bloc) 26 (morselation) 2 (laparotomy)		5.6 days	3 (port site infection)
Khirallah et al. [8]	Ligasure TM	5 cases (8.3%)	85 min (ITP) 120 min (thalassemia)	2 cases (3.3%)		20 cases (endo bag) 40 cases (Pfannenstiel)	All cases	3 days	5 cases (subphrenic collection)
Hassan and Al Ali [10]	Endo vascular stapler	1 case (8%)	180 min	1 case (8%)		(endo bag)	In massive splenomegaly	1.5 days	
Qureshi et al. [11]	Hem-O-lok/ endo vascular stapler/ both		201 min	12 cases (15%)	(33%) of cases	(endo bag)		2.4 days	1 case (pneumothorax)
Karadag et al. [9]	Ligasure TM	2 cases (8.6%)	130 min	5 cases (21.5%)	5 cases from spherocytosis (10%)	(endo bag)		3.36 days	

In our study, we had no major complications in the postoperative period, specifically no bleeding or failure of the Hem-o-lok clips. Haffenden et al. (2021) reported no incidences of post-operative haemorrhage or surgical complications [7]. Mohammad Gharieb et al. (2016) mentioned that they had 5 cases of subphrenic collections; 2 cases required ultrasound-guided drain, and the other 3 cases were treated conservatively and recovered [8]. The absence of postoperative haemorrhage or clip failure emphasises the safety of using the Hem-o-lok clips for controlling the splenic hilum.

In our study, the mean hospital stay was 1.3 days range (1–2 days). The main cause for delaying hospital discharge was the delay in tolerating full oral feeding in cases who had a Pfannenstiel incision. There was a significant positive correlation between the type of splenic extraction and the period of hospital stay (*P*-value 0.004). Cases with spleen extracted via a Pfannenstiel incision had a longer stay. Mohamed E. Hassan et al. (2014) mentioned that the mean hospital stay was 36 h in the LS group, extracting all spleens by an endo bag, starting oral feeding after a mean 7.5 h, and removing all drains after 24 h [10]. Haffenden et al. (2021) and Adetokunbo Fadipe et al. (2022) reported that the mean postoperative length of stay was 2 days (2–3 days). Both of them used the endo bag as a method of splenic extraction [4, 7].

In this study, we opted to early postoperative feeding and found that it is tolerated by all cases who had their spleens extracted by an endo bag. This helped to shorten the hospital stay. We also removed the nasogastric tube in all cases at the end of the operation which gives great comfort to our patients.

As regard the cost of the operation, we used 1 cartridge of Hem-o-lok clips/patient which costs US $28 = 686 LE, and the cost of the homemade endo bag was with a cost of US $4.5 = 110 LE. On the other hand, we used a commercial endo bag in 1 case, and it cost US $62 (1519 LE). Murat Derebey et al. (2020) also supported our results regarding the cost, as they reported that the mean cost of surgical instruments used to divide the splenic hilum was significantly lower for the Hem-o-lok group (US $22–$44) than Tri-Staple group (US $126–$253) with an average of US $34.1 vs US $165.4 [5].

Our study had some limitations including small sample size, and it is not a comparative study Table 1.

Conclusion

The Hem-o-lok clips are feasible and safe in controlling the splenic hilum during laparoscopic splenectomy in children with BHDs. The operative time, operative, and postoperative complications are comparable to other studies using other methods of hilar control. Their use is associated with marked cost reduction specifically when compared to staplers. Splenic extraction using an endo bag helps early feeding and shortens the hospital stay. However, comparative studies including a larger number of cases are needed to support these results.

Abbreviations

BHD	Benign haematological disorders
LS	Laparoscopic splenectomy
OS	Open splenectomy

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Authors' contributions

ME, principal investigator, study design, participated in surgery, collection of data, data analysis, and writing the draft and final version of the manuscript. KE and AE approved study design, participated in surgery and follow-up of the patients, and reviewed and approved the final version of the manuscript. MM, senior supervisor, study design, and review the draft and final version of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Tanta University Hospital. Ethics committee reference number is (33762/3/20). Approval of the research ethics committee and written consent was obtained from the parents of all participants in the study. Privacy of all patient data was guaranteed.

Consent for publication

The parents provided written consent, and the ethics committee approved this procedure as it suits this research project.

Competing interests

The authors declare that they have no competing interests.

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