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# Evaluation of Laparoscopic Splenectomy in Children and Adolescents

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ORIGINAL ARTICLE

# Evaluation of Laparoscopic Splenectomy in Children and Adolescents

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Abstract

*Objectives:* ***Currently, it is unknown whether laparoscopic splenectomy is successful and safe for all individuals. Although laparoscopic splenectomy is an evolving technique, its techniques are developing rapidly.***

*Aim:* ***To evaluate laparoscopic splenectomy in children and adolescents regarding the safety, efficacy, intraoperative difficulties, and postoperative primary outcomes.***

*Patients and methods :* ***This was a prospective study conducted at general and pediatric surgery departments, Al-Azhar University Hospitals' and submitted for patients with laparoscopic splenectomy in the period from May 2023 to February 2024.***

*Results:* ***Thirty patients were included in our study. With a broad age span from 4 to 18 years (mean age of 12.90±4.82 years), the mean of Operative time (mins) was 122.50±19.51; 29 patients had intraoperative mild bleeding (96.7 %) about 155.83±106.11 (ml), Blood transfusion was indicated in one patient packed RBCS (3.3%) and indicated for conversion to open; Regarding postoperative complications, five patients developed fever (16.7%); 3 patients developed ileus (10.0%), and two patients developed infection of the surgical incision (6.7%), The range of hospitalization was 2 to 4 days with mean 2.97±0.61; while 26 patients (86.7%) were highly satisfied by operation (score 5) and four patients (13.3%) were somewhat satisfied (score 4).***

*Conclusion:* ***The outcomes of this study demonstrated that laparoscopic splenectomy is a safe, feasible, and efficient technique. The advantages included fast recovery, a short hospital stay, a low risk of complications, and excellent cosmetic results. Careful patient selection is important for the laparoscopic approach to achieve maximum benefits.***

*Keywords:* Splenomegaly; Laparoscopic splenectomy; pediatrics; safety

## 1. Introduction

Splenectomy is carried out with the intention of curing disease when the disease only affects the spleen or when it plays a significant role in the pathophysiology that is underlying. In the majority of cases, it was done to successfully alleviate the symptoms of diseases in patients who are resistant to medical care.[1] Indications for splenectomy can be divided into 3 major categories: Hematologic disorders, Splenic lesions, and Trauma. [2]

In healthy people, elective open splenectomy is a generally worldwide applied treatment that requires hospitalization for about 3 to 7 days, with considerable postoperative painkillers, and 2 to 6 weeks for complete recovery. However, thrombocytopenia and/or neutropenia are commonly associated disorders in individuals who need splenectomy, which makes therapy during and after surgery more difficult. Currently, it is unknown whether laparoscopic splenectomy is successful and safe for all of these individuals. Although laparoscopic splenectomy is an evolving technique, and their techniques are developing rapidly. [3]

Our purpose in this study is to evaluate laparoscopic splenectomy in children and adolescents regarding the safety, efficacy, intraoperative difficulties, and postoperative primary outcomes.

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## 2. Patients and methods

This was a prospective study conducted at general and pediatric surgery departments at Al-Azhar University Hospitals and submitted for pediatric patients with laparoscopic splenectomy in the period from May 2023 to February 2024. All patients had a thorough medical history and physical examination, as well as routine full preoperative laboratory testing (Complete blood count, Coagulation profile, Liver function tests, Renal function tests) and radiological studies for the underlying disease. Pelviabdominal ultrasound has been done for all patients to assess the spleen long axis, a CT scan was done for selected patients upon demand, and other specific investigations were done according to the underlying disease.

Patients eligible for the study who have the following criteria: age of less than 18 years old, either male or female genders. Patients with hematological diseases (Hereditary spherocytosis, ITP, Beta thalassemia, Sickle cell anemia), patients with splenic cysts >5cm, or patients with splenic tumors as long as splenic size not more than three times the normal size for age in all conditions

Patients with splenic cysts <5cm, patients with traumatic splenic lesions, patients with portal hypertension, patients with previous upper abdominal operations, and patients with splenic size more than three times the normal size for age were excluded from the study.

All patients had triple vaccinations (Hemophilus influenza, Pneumococcus pneumonia, and Meningococcus): 15 days prior to scheduled surgery.

Laparoscopic splenectomy technique:

Under endotracheal general anesthesia, after sterilization and draping, patients were placed in the right lateral decubitus position with a flexed operating table with the left side up and a flank cushion placed under the right side. Four trocars were used (Figure 1:A); the first port, 10 mm, was introduced through the umbilicus; this port was used for a 30° telescope to pass through. The second trocar of 5 mm was introduced at the midline midway between the xiphoid process and umbilicus for instruments (left working). The third trocar, 5 mm, was introduced at the midline subxiphoid for assistance and liver retraction. The fourth trocar, 10 mm, was introduced at the midclavicular line with level positioning according to the lower end of the spleen; this port was used for instruments (right working).

The first step was diagnostic laparoscopy for accessory spleen (Figure 1B). Initially, the splenocolic ligament was divided with the energy device, allowing the splenic flexure to fall away from the spleen (Figure 1C). The surgeon divided the inferior portion of the gastrosplenic ligament, divided the short gastric arteries, and opened the lesser sac while operating in a cephalad direction (Figure 1:D). Because the most superior short gastric vessels were usually particularly short, caution must be used to prevent harm to the diaphragm or stomach.

The presence of auxiliary spleens was examined in the lesser sac. The division of the splenophrenic ligament allowed for complete upper pole mobilization. This is the time to approach the hilum, and a decision must be made to either staple across all the vessels or divide each individually with an energy device. If a stapler was utilized, it was easiest to divide the splenorenal ligament to allow easy access to the entire hilum. The artery was controlled first (Figure 2:A), with bluish discoloration of the spleen denoting ischemia (Figure 2:B), followed by the vein (Figure 2:C); this might allow for the concept of autotransfusion. The spleen could then be extracted through a Pfannenstiel incision or inserted into an endo retrieval bag and morcellated within the sac with ringed forceps until the sac can be removed, depending on its size. The same was done for splenic cysts (Figure 2:D).

Following the full splenic extraction, saline irrigation was applied to the splenic bed and good hemostasis was ensured, drain was inserted into splenic bed. Then all port sites and abdominal wounds were closed.

Intraoperative parameters measured included operative times, intraoperative difficulties, organ injury, bleeding, and conversion to open splenectomy.

Postoperative follow-up for early complications during hospitalization was carried out; a complete blood count was done on days 0, 1, and 7 to assess hemoglobin and platelet levels. Clinical evaluation was done, including measurements of body temperature, presence of vomiting, and auscultation for intestinal sounds to monitor ileus. Drains were observed regarding the amount, color, and content, in addition to abdominal ultrasound to follow up on splenic bed hematoma or subphrenic collection.

During postoperative outpatient clinic visits, patients were followed up by; complete blood count, clinical assessment, and evaluate the wound condition for infections or any other complications. Also, abdominal ultrasonography was done to exclude portal vein thrombosis, and patient satisfaction score was taken from patients or caregivers.

Calculated Sample Size = (30)

Population size 32, population proportion 50%, Confidence level 95%, Margin of Error 5%.

Statistical analysis:

The statistical software for social sciences, version 23.0 (SPSS Inc., Chicago, Illinois, USA), was used to analyze the recorded data. When the

distribution of the quantitative data was parametric (normal), it was shown as mean± standard deviation and ranges; for non-parametric (non-normally distributed) variables, it was shown as median with inter-quartile range (IQR). Quantitative variables were also shown as percentages and numbers. Using the Shapiro-Wilk and Kolmogorov-Smirnov tests, data were examined for normality.

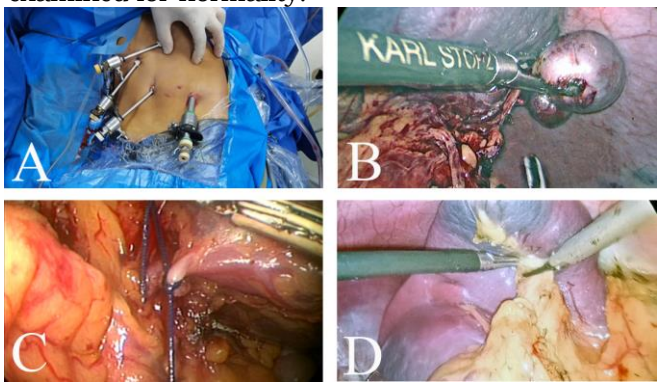


Figure 1. A. Port placement. B. Accessory splenule. C. Splenocolic ligament division. D. Suturing of short gastric vessels and division.

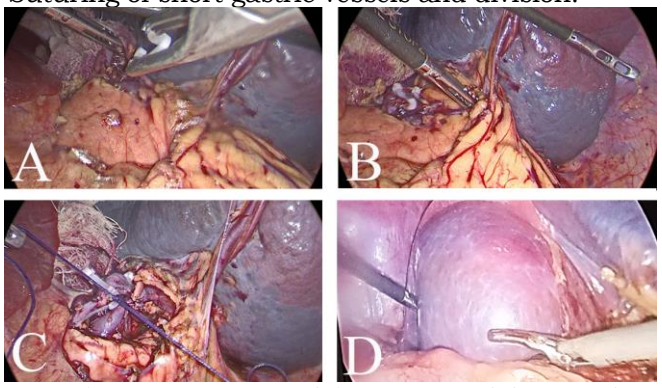


Figure 2: A. Applying Hem-o-lok on the splenic artery. B. Bluish discoloration of the spleen, indicating ischemia. C. Suturing of the splenic vein. D. Splenic cyst.

## 3. Results

Thirty patients were included in our study. with a wide age group ranging from 4 to 18 years, (mean age of 12.90±4.82 years). As regards sex distribution, there was female predominance with 17 females with a percentage 56.7% and 13 males with a percentage 43.3% (Table 1).

*Table 1. Demographic distribution among study group.*

| DEMOGRAPHIC | TOTAL (N=30) |
|---|---|
| AGE "YEARS" | |
| RANGE | 4-18 |
| MEAN±SD | 12.90±4.82 |
| GENDER | |
| FEMALE | 17 (56.7%) |
| MALE | 13 (43.3%) |

There were 14 patients (46.7%) with Thalassemia, 12 patients (40.0%) with Hereditary Spherocytosis, 2 patients (6.7%) with Sickle Cell Disease, one patient (3.3%) with ITP and one patient (3.3%) with Splenic cyst; while, U/S Spleen long axis (cm), it was Ranged 10.5-17.8 with mean and Mean±SD 15.02±1.72 (Table 2).

*Table 2. Clinical data distribution among study group.*

| CLINICAL DATA | TOTAL (N=30) |
|---|---|
| UNDERLYING DISEASE | |
| THALASSEMIA | 14 (46.7%) |
| HEREDITARY SPHEROCYTOSIS | 12 (40.0%) |
| SICKLE CELL DISEASE | 2 (6.7%) |
| ITP | 1 (3.3%) |
| SPLENIC CYST | 1 (3.3%) |
| U/S SPLEEN LONG AXIS (CM) | |
| RANGE | 10.5-17.8 |
| MEAN±SD | 15.02±1.72 |
| GALL BLADDER | |
| GALL BLADDER STONES | 2 (6.7%) |
| NORMAL | 26 (86.7%) |
| PREVIOUSLY REMOVED | 2 (6.7%) |
| CT SCAN FINDINGS | |
| CYST | 1 (3.3%) |

Regarding intraoperative data (Table 3), the mean of Operative time (mins) was 122.50±19.51; 29 patients had intraoperative mild bleeding (96.7 %) about 155.83±106.11 (ml), Blood transfusion was indicated in one patient packed RBCS 1 (3.3%) and indicated for conversion to open; as for the Route, 6 patients were done by Endobag 6 (20.0%) and 24 patients were done by Pfannenstiel incision (80.0%); Also, two patients have intraoperative complications, one patient (3.3%) had backflow bleeding and one patient (3.3%) had minor pancreatic tail injury without affection of pancreatic function.

*Table 3. Intraoperative data distribution among study group.*

| INTRAOPERATIVE DATA | TOTAL (N=30) |
|---|---|
| OPERATIVE TIME (MINS) | |
| RANGE | 90-160 |
| MEAN±SD | 122.50±19.51 |
| BLEEDING | |
| NIL | 6 (20.0%) |
| YES | 24 (80.0%) |
| BLEEDING (ML) | |
| RANGE | 40-500 |
| MEAN±SD | 155.83±106.11 |
| ROUTE | |
| ENDOBAG | 6 (20.0%) |
| PFANNENSTIEL INCISION | 24 (80.0%) |
| BLOOD TRANSFUSION | |
| 1 PACKED RBCS | 1 (3.3%) |
| NO | 29 (96.7%) |
| COMPLICATIONS | |
| BACKFLOW BLEEDING | 1 (3.3%) |
| PANCREATIC TAIL INJURY | 1 (3.3%) |
| NO | 28 (93.3%) |
| CONVERSION TO OPEN | |
| NO | 29 (96.7%) |
| YES | 1 (3.3%) |

During the follow-up period all patients had a significant improvement of hemoglobin concentration at post-operative day 7 in comparison with pre-operative level, with p-value ($p<0.05$); while there is no statistically significant difference between pre-operative and post-operative day 1 (Table 4).

*Table 4. Comparison between Pre-operative and Post-operative according to their Hgb.*

| HGB. | RANGE | MEAN±SD | PAIRED SAMPLE T-TEST | | |
|---|---|---|---|---|---|
| | | | MD±SD | t-test | p-value |
| PRE-OPERATIVE | 10.2-12.5 | 11.18±0.67 | | | |
| POST DAY 1 | 8.9-11.9 | 10.72±0.70 | 0.46±0.07 | 1.051 | 0.682 |
| POST DAY 7 | 11.9-13.2 | 12.62±0.47 | 1.44±0.46 | 2.182 | 0.023* |

***P-VALUE <0.001 IS HIGHLY SIGNIFICANT*

The one ITP patient showed statistically significant improvement of mean of PLT at post-operative day 1 and post-operative day 7 in comparison with pre-operative platelets count, with p-value (p=0.007 and p<0.001) respectively (Table 5).

Table 5: Comparison between Pre-operative and Post-operative according to their PLT in one case of ITP.

| PLT | RANGE | MEAN±SD | PAIRED SAMPLE T-TEST | | |
|---|---|---|---|---|---|
| | | | MD±SD | t-test | p-value |
| PRE-OPERATIVE | 80-80 | 80.0±0.0 | | | |
| POST DAY 1 | 120-120 | 120.0±0.0 | 40.0±0.0 | 2.682 | 0.007* |
| POST DAY 7 | 240-240 | 240.0±0.0 | 160.0±0.0 | 3.556 | <0.001** |

***P-VALUE <0.001 IS HIGHLY SIGNIFICANT*

Regarding feeding tolerance, 23 patients tolerated feeding on day 1 (76.7%), 4 patients tolerated feeding on day 2 (13.3%), and 3 patients tolerated feeding on day 3 (10.0%)(Table 6).

*Table 6. Post-Operative distribution among study group.*

| POST-OPERATIVE | TOTAL (N=30) |
|---|---|
| FEEDING TOLERANCE | |
| DAY 1 | 23 (76.7%) |
| DAY 2 | 4 (13.3%) |
| DAY 3 | 3 (10.0%) |

Regarding postoperative complications, 5 patients developed fever (16.7%); 3 patients developed ileus (10.0%), and 2 patients developed wound infection (6.7%), all patients completely improved with conservative and medical treatments. (Table 7)

*Table 7. Post-operative Complications distribution among study group.*

| POST-OPERATIVE COMPLICATIONS | NO. | % |
|---|---|---|
| FEVER | 5 | 16.7% |
| ILEUS | 3 | 10.0% |
| WOUND INFECTION | 2 | 6.7% |
| HEMORRHAGE | 0 | 0.0% |
| SUBPHRENIC ABSCESS | 0 | 0.0% |
| PANCREATITIS | 0 | 0.0% |
| OPSI | 0 | 0.0% |
| VASCULAR SPLENIC THROMBOSIS | 0 | 0.0% |
| PNEUMONIA | 0 | 0.0% |
| PORT-SITE HERNIA | 0 | 0.0% |
| INCISIONAL HERNIA | 0 | 0.0% |

The range of hospital stay was 2 to 4 days with mean 2.97±0.61; while 26 patients (86.7%) were highly satisfied by operation (score 5) and 4 patients (13.3%) were somewhat satisfied (score 4) (Table 8).

*Table 8. Hospital Stay (Days), Patient Satisfaction Score and Patient Satisfaction Score distribution among study group.*

| | TOTAL (N=30) |
|---|---|
| HOSPITAL STAY (DAYS) | |
| RANGE | 2-4 |
| MEAN±SD | 2.97±0.61 |
| PATIENT SATISFACTION SCORE | |
| HIGHLY SATISFIED SCORE 5 | 26 (86.7%) |
| SOMEWHAT SATISFIED SCORE 4 | 4 (13.3%) |
| NEITHER SATISFIED OR NOT SCORE 3 | 0 |
| SOMEWHAT DISSATISFIED SCORE 2 | 0 |
| VERY DISSATISFIED SCORE 1 | 0 |

## 4. Discussion

Laparoscopy has become more common in pediatric and general surgery over the past few decades as an established technique of splenectomy for individuals with benign hematological disorders. When compared to the conventional open method, it offers numerous benefits, including a shorter hospital stay, improved outcomes, and improved cosmetic results following surgery. [4]

When it comes to LS, intraoperative bleeding is the main cause of concern. The chance of bleeding during a splenectomy is influenced by numerous factors. A complicated blood supply, fragile parenchyma, and a challenging perisplenic dissection characterize the spleen. The severe bleeding makes it more difficult to identify important structures, which in turn complicates the dissection. The main cause of open approach conversion is uncontrollably leaking blood from capsular tears or hilar vessels. [5]

The most common primary disease included in this study was Thalassemia in 14 patients (46.7%), Hereditary Spherocytosis in 12 patients (40.0%), Sickle Cell Disease in 2 patients (6.7%), ITP in one patient (3.3%) and Splenic cyst in one patient (3.3%). This can be explained by our country being a Mediterranean country with a prevalence of thalassemia. The main indication of splenectomy in thalassemic children is hypersplenism, although only seven thalassemic patients were referred from the hematological clinic for splenectomy suffering from hypersplenism. The main reason for splenectomy in the rest of the seven other children was increased frequency of blood transfusion (>200-220 ml of packed RBCs/kg/year) and failure of iron chelating regimes. All of them needed a blood transfusion in longer intervals post-splenectomy. Thalassemia came first as the most frequent primary disease in Eid et al.,[6] study as 13 patients (48.2%) were diagnosed with thalassemia, while the other indications were spherocytosis, AIHA, ITP, and sickle-cell disease. The main indication of Laparoscopic splenectomy in Fadipe et al.,[7] was Hereditary spherocytosis with a percentage of 60%, in addition to 6 cases with Sickle cell anemia and only two cases with

Beta thalassemia and Splenic haem angiomatosis.

On studying splenic span by preoperative ultrasound, we found that it ranged from 10.5-17.8 cm with mean and mean ± SD 15.02±1.72 cm. This aligns with multiple other related research. Eid et al.,[6] reported a range of 10 to 18.5 cm for splenic span with a mean of 13.5 cm. Fadipe et al.,[7] mentioned that the mean splenic span was 13.4 cm and 12–14.4 cm. It should be highlighted that the absolute splenic span is not a predictor of operational feasibility or difficulty; rather, it is the relationship between the splenic span and the patient's abdomen size. We discovered that spleens extending below the umbilicus are difficult to operate laparoscopically, regardless of size.

Operative time was counted until full mobilization of the spleen, including splenic hilum control. It took from 90 to 160 minutes with a mean of 122.50±19.51 minutes. The wide range of operative time can be explained by different splenic spans among the cases; the larger the splenic span, the more time needed. The operation time on average was 176 (166 to 188) minutes and 178 min [156–185] in Zhang et al.[8] and Fadipe et al.[7] respectively, while it was 154.9 + 68.2 in Shelby et al. [9]. Our study's reduced mean operative time could be attributed to the global rise in the learning curve and the steady advancement of laparoscopic techniques.

The most common reason for converting a laparoscopic splenectomy to an open procedure is bleeding. About one-fifth of laparoscopic splenectomies performed worldwide are converted to open approach .[10] In our study, we achieved a 3.33 % (1/30) rate of conversion to an open approach mainly because of bleeding from capsular injury before hilar vessel control and short gastric vessel injury that obscured laparoscopic vision. Shin et al.[11] reported that the conversion rate for LS in their study was 14% (3 out of 22) and 35% (9 out of 26) for moderate and massive splenomegaly, respectively.

In our study, intraoperative blood loss ranged from 40 to 500 ml with a mean of 155.83±106.11 ml. There were only 2 cases with intraoperative bleeding of about 300 ml, which was controlled laparoscopically and not needing blood transfusion, and 1 case of about 500 ml, which converted to open splenectomy. Lasheen et al.[12] showed the intraoperative blood loss in the staple-less group 141.5±44.6 ml and in the stapler group 131.5±58.0 ml.

In our study, the mean length of hospitalization was 2.97±0.61 days. In Fadipe et al[7], the median length of stay was 2 days [2–3]. Shelby et al[9], length of stay, 3.2 days, median (2.5–4.2 days).

In our study, postoperative complications were fever, ileus, and wound infection. 5 cases (16.7%) had low-grade fever and well controlled by antipyretics, and 3 cases (10%) developed ileus and managed conservatively till recovery and also 2 cases (6.7%) had wound infection which well responded to frequent dressing and topical antibiotics, without incidence of lung atelectasis or subphrenic collection. In the Fadipe et al.[7] study, in one case, postoperative ileus developed, while in another, laparotomy was necessary to address unexplainable postoperative pain. In contrast to that study done by Khirallah et al.[13] who performed their study on 70 cases with benign splenic diseases, 9 of them developed lung atelectasis, and 7 of them developed subphrenic collection during the period of follow-up.

In our study, we measured patient satisfaction scores by a Likert scale ranging from 1 to 5, with 5 being the highest score of satisfaction. The majority of cases (26 cases) scored 5 points "Highly satisfied," and only 4 cases scored 4 points "Satisfied". This reflects the high satisfaction of all patients regarding the improvement of condition, less need for blood transfusion, patient care, and good cosmetic results. Edwin et al.[14] reported patient satisfaction was excellent in nine and intermediate in two cases; it was poor in one case due to postoperative pain.

Limitation: The study's limitations included its non-controlled design, limited sample size, and brief follow-up duration. To confirm these results and derive more significant, universally applicable inferences, larger patient populations and longer follow-up periods would be needed for additional randomized controlled trials.

### *4. Conclusion*

The findings of this study demonstrated that laparoscopic splenectomy is a safe, feasible, efficient technique. The advantages included fast recovery, short hospital stay, low risk of complications, and excellent cosmetic results. Careful patient selection is important for laparoscopic approach to achieve maximum benefits.

## Disclosure

The authors have no financial interest to declare in relation to the content of this article.

## Authorship

All authors have a substantial contribution to the article

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## Conflicts of interest

There are no conflicts of interest.

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