Calculating the learning curve for laparoscopic splenectomy

Ahmed Kamal, *MD****; Hamed Abo Steit,*** *MRCS, MD****;***
Haitham Elmaleh, *MRCS,MD****; Ahmed Elnabil,*** *MRCS, MD*

Department of General surgery, Ain Shams University, Cairo, Egypt.

Background & objectives: *Laparoscopic splenectomy had become the golden standard for elective splenectomy, as it is feasible, safe and provides many advantages to the patients in comparison to open splenectomy. However, a learning curve exists for mastering the procedure and defining will be helpful in designing a training program for laparoscopic splenectomy.*

Methods: *57 patients underwent elective laparoscopic splenectomy for different indications in our hospital between August 2011 and September 2013. Patients' data whether preoperative, operative or postoperative were collected, subdivided in 10 cases groups and certain outcome measures were statistically analyzed to identify the learning curve.*

Results: *Laparoscopic splenectomy was done for all patients. The mean operative times in the 3rd, 4th, 5th and 6th groups were significantly shorter than the 1st and 2nd groups. There was a trend toward decreased blood loss in the latter groups (3rd, 4th, 5th and 6th), and the differences between them and the first two groups were statistically significant. There was a trend of high postoperative complications and conversion rate in the first group in relation to the other groups, but a statistically significant difference between groups couldn't be found. Similarly, there was a trend towards decreased period of ileus with the consecutive groups; but a statistically significant difference couldn't be shown. A statistically significant difference in hospital stay was found between the consecutive groups. The results showed that the outcome measures were seen to improve with the advancement of the experience with a plateau reached after 20-30 cases of laparoscopic splenectomy.*

Conclusion: *Laparoscopic splenectomy can be done safely by experienced laparoscopic surgeons. A learning curve for mastering the procedure is 20-30 cases, after which the outcome parameters nearly reaches a plateau.*

Introduction:

Splenectomy is performed either as causal or symptomatic therapy for numerous indications. Formerly, open splenectomy represented the traditional for patients with different indications of splenectomy.[1] The first successful laparoscopic splenectomy was reported by Delaitre and Maignien in 1991,[2] and since then, the procedure had been adopted as the standard technique for most indications for splenectomy throughout the world, specially normal sized spleen.[3] The wide acceptance of laparoscopic splenectomy is based on the benefits it offers compared to open splenectomy, which include decreased analgesia use, earlier initiation of oral diet, decreased length of stay, and fewer complications, together with comparable clinical outcomes.[4] Moreover, the growing experience and the advances in equipment had made this approach feasible in situations that were thought to be contraindications in the past.[3]

These advantages are dependent, however, on the surgeon's experience and ability to perform the procedure expeditiously and without complication. As described with other laparoscopic techniques, there is a learning curve as new procedures are introduced.[5]

Some authors define the learning curve as a decrease in operating time, a decrease in conversion rate, or a decrease in complication

rate that can be achieved after a certain number of cases.[6,7,8,9]

Surgeons, who are seeking to undertake this procedure, should be aware that it is considered an advanced laparoscopic procedure and is associated with a significant learning curve that has yet to be defined. This is also important in the planning of structured training programs for laparoscopic splenectomy in any educational hospital.

In this study, we are trying to define the learning curve for laparoscopic splenectomy in our hospital in order to define those who can be granted the privilege of independently performing the procedure and who to structure the training for it in our training program.

Patients and methods:

The study was carried out in Ain Shams University hospitals during the period between August 2011 and September 2013. Patients who were referred to our surgical team with indications of splenectomy during that period were prepared for elective laparoscopic splenectomy. Each of the patients was operated on by an experienced surgeon who was just starting to practice laparoscopic splenectomy (all cases were done by the same team).

Preoperative preparation of all patients included vaccinations with polyvalent pneumococcal, polyvalent meningococcal, and Haemophilus influenza type B conjugate vaccines, and preoperative antibiotics. Other preoperative measures were individualized according to each patient condition. Transfusion of blood products, such as platelets, packed red blood cells, or gamma globulin, was performed according to the plane of the referring hematologist, or anesthesiologist. Routine preoperative ultrasound to determine splenic size. An informed consent was obtained from the patients before operation.

The procedure is performed with the patient under general anesthesia with endotracheal entubation. A nasogastric tube is inserted to decompress the stomach and a Foley's catheter is inserted to the bladder. The patient is put in the supine position with legs apart and a 20° head-up tilt (reversed Trendelenburg position). The surgeon operates in the ''French'' position (between the patient's legs) with the camera assistant on his left and the second assistant to the right. A 12 mm port is inserted at the level of the umbilicus using the open technique and carbon dioxide pneumoperitoneum is induced. Thorough exploration of the abdomen, pelvis, and omentum for accessory spleens using a 30° angled scope is carried out at first. Then, 3 more trocars are inserted under direct vision as shown in **Figure (1)**. In cases of larger spleens, port positions and size were altered according to the size of the spleen.

The table is then tilted 30° to the right. The stomach is retracted medially through the left 5-mm trocar to expose the spleen after the omentum has been displaced inferiorly. Then the phrenicocolic and the splenocolic ligaments are incised near the lower pole using the Ligasure through the right 12-mm port. The lower pole of the spleen is gently lifted with a closed instrument without grasping which is introduced through a 5-mm port to expose the splenic hilum and the tail of the pancreas. A window above the tail of the pancreas is created to permit the application of a stapling device and to control all hilar vessels. We used an Endo-GIA with a vascular (white) cartridge to transect the hilum. After control of the hilar vessels, the short gastric vessels are then divided using the Ligasure. After that, proper hemostasis is ensured. The specimen is then inserted into a plastic bag, and the spleen is morcellated using a long forceps and the bag is extracted through enlarging of the port sites. After reestablishing of pneumoperitoneum, fast reexploration is done to ensure proper hemostasis. A redivac is advanced through the left trocar site and placed in the left subphrenic space. The operation is completed by closure of all trocar ports.

Postoperatively, the patients are observed for vital data, return of bowel functions and wound complications. The patients were discharged after return of normal bowel functions, drain removed and any

complication ruled out.

Perioperative parameters were assessed, including patient age and sex, surgical indication for splenectomy, American society of Anesthesiology (ASA) score, other comorbidities, size of the longitudinal access of the spleen, preoperative hemoglobin and platelet count and body mass index. Operative data were assessed including operative time in minutes, presence of technical difficulty, estimated blood loss, requirement for blood product transfusion, spleen specimen weight and the need for conversion to open splenectomy. Postoperative data was assessed including period of ileus, time to oral intake, length of hospital stay, the need for reoperation and postoperative morbidity or mortality.

Calculation of the learning curve:

To define the learning curve, the cases were divided into sequential groups of 10 cases and the parameters used for calculation of the learning curve (operative time, estimated intraoperative blood loss, the need for conversion to open splenectomy, postoperative complications or mortality, period of ileus and hospital stay) were recorded and evaluated for statistical significance. The groups were compared using the independent sample t-test for continuous variables and chi-square test for categorical variables. All calculations were done using SPSS version 21 statistical software.

Results:

This study included 57 patients. The indication for splenectomy was thrombocytopenia in all patients. The cause of thrombocytopenia was ITP in 36 (63.2%) patients, spherocytosis in 13 (22.8%) patients, chronic lymphocytic leukemia (CLL) in 5 (8.8%) patients and lymphoma in 3 (5.3%) patients as shown in **Table (1)**.

The study group consisted of 23 (40.4%) males and 34 (59.6%) females. The mean age of the patients was 27.5 ± 8.7 years with range from 16-52 years. The mean longitudinal splenic dimension was 14 ± 4.9 cm with range from 12 to 19 cm. The preoperative data are shown in **Table (2)**.

Laparoscopic splenectomy was done for all patients. The operation was successfully completed laparoscopically (no conversion) in 52 patients (91.2%). The conversion was done in 5 cases (8.8%) due to bleeding which couldn't be controlled. The mean operative time was 106.5 ±25.9 minutes. The mean estimated intraoperative blood loss was 276.5 ±175.7 ml. Operative data are shown in **Table (3)**.

The mean period until passage of flatus was 2 ±1.3 days. The patients resumed oral food intake in 3.1 ±1.6 days and were discharged from the hospital in 4.3 ±1.4 days. 6 patients (10.5%) had post-operative complications in their hospital stay, 4 (7.2%) had wound infection (the midline incision) which was treated by dressing and antibiotics, and 2 (3.5%) had prolonged ileus which was managed conservatively (all were converted cases). No mortality was recorded intra or post operatively. The postoperative data are shown in **Tables (4,5)**.

We divided the cases for 10 case groups (5 (10) cases and 1 (7) cases groups). Then we analyzed the preoperative parameters (age, sex, surgical indication for splenectomy, ASA score, other comorbidities, size of the longitudinal access of the spleen and body mass index) to make sure that they don't affect the outcome measures. The analysis showed that there is no significant difference between the groups regarding preoperative parameters.

Then the outcome measures (operative time, estimated intraoperative blood loss, the need for conversion to open splenectomy, postoperative complications, period of ileus and hospital stay) were calculated for each of the groups and evaluated for statistical significance. Summary of outcome measures in each group is shown in **Table (6)**.

When we analyzed these parameters. We found that the mean operative times in the 3rd, 4th, 5th and 6th groups were significantly shorter than the 1st and 2nd groups, with a clear trend towards decrease operative time with each group. Operative time started to reach a plateau in the final 27 patients, which was between 40-45minutes faster than that

seen in the first 20 patients.

There was a trend toward decreased blood loss in the latter groups (3rd, 4th, 5th and 6th), and the differences between them and the 1st 2 groups were statistically significant.

Although that there was a trend of high postoperative complications and conversion rate in the 1st group in relation to the other groups, a statistically significant difference between groups couldn't be found in our trial. Similarly, although there was a trend towards decreased period of ileus with the consecutive groups, a statistically significant difference couldn't be shown.

Regarding the hospital stay, a statistically significant difference was found between the consecutive groups.

These results showed that the outcome measures were seen to improve with the advancement of the experience with a plateau reached after 20-30 cases of laparoscopic splenectomy.

Discussion:

Since its introduction, laparoscopic splenectomy had become the golden standard for elective splenectomy, as it is feasible, safe and provides many advantages to the patients in comparison to open splenectomy, and the growing experience and the advances in equipment had made it feasible in situations that were thought to be contraindications in the past.[3,4]

Mastering this procedure to achieve its benefits requires advanced laparoscopic surgical skills and overcoming the learning curve associated with the procedure.[10] The learning curve for advanced laparoscopic procedures has been described in the literature (eg, Nissen fundoplication,[11] colon resection,[12] Roux-en-Y gastric bypass[13] and splenectomy[14]). Our study was undertaken to define the learning curve for laparoscopic splenectomy in our institution. We assumed that achieving the learning curve will be manifested by a plateau in certain outcome measures (operative time, estimated intraoperative blood loss, the need for conversion to open splenectomy, postoperative complications, period of ileus and hospital stay).

We first performed an analysis of preoperative parameters to eliminate any bias in the study, as it is well known that these factors (indication, splenic size, dense adhesions and portal hypertension) affect the outcome measures.[3,5,6,7,8]

Operative times were significantly reduced with increasing experience. We found that the mean operative times in the 3rd, 4th, 5th and 6th groups were significantly shorter than the 1st and 2nd groups, with a clear trend towards a decrease in operative time with each group. Operative time started to reach a plateau in the final 27 patients, which was between 40-45minutes faster than that seen in the first 20 patients. As we didn't modify the technique or instruments, this improvement is mostly due to increased familiarity with the operation and the ability to provide better exposure and to dissect more expeditiously. Others have also reported a similar decrease in operative times, although with smaller numbers.[15]

There was a trend toward decreased blood loss in the latter groups (3rd, 4th, 5th and 6th), and the differences between them and the 1st 2 groups were statistically significant. Blood loss decreased with time primarily because of improved technical ability to accomplish the operation.

Complications in this study were few and were mostly spaced out over the entire series of patients. Although that there was a trend of high postoperative complications and conversion rate in the 1st group in relation to the other groups, a statistically significant difference between groups couldn't be found in our study.

Similarly, although there was a trend towards decreased period of ileus with the consecutive groups, a statistically significant difference couldn't be shown. Regarding the hospital stay, a statistically significant difference was found between the consecutive groups.

As noted, outcomes improved rapidly with the first 20–30 patients. The learning curve flattens and outcome parameters become more consistent after the first 30 patients. This

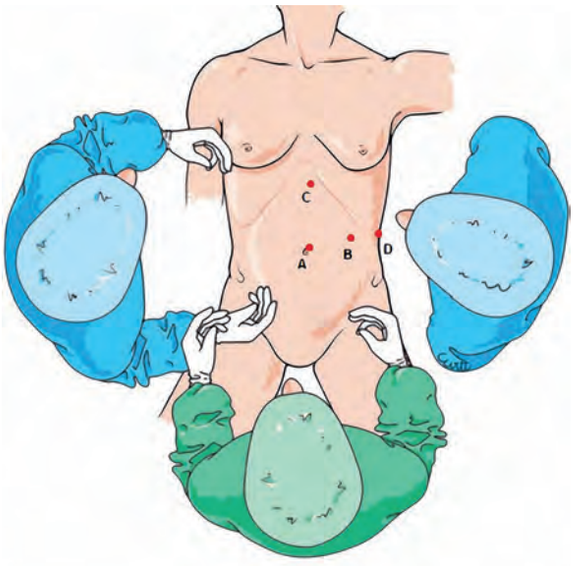

Figure (1): A diagram showing surgical team position and port position A: 12 mm port at umbilicus, B: 12 mm port at midclaviular line just above umbilical level, C: 5 mm port below xiphisternum, D: 5 mm port at anterior axillary line below costal margin.

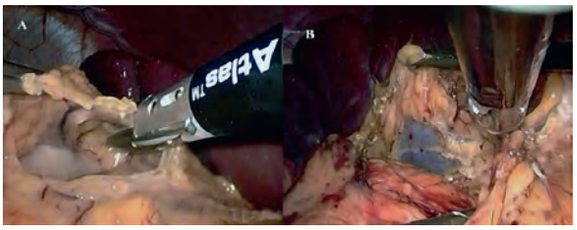

Figure (2): An intraoperative picture showing: A: dissection of gastrosplenic ligament, B: dissection of the inferior splenic attachments.

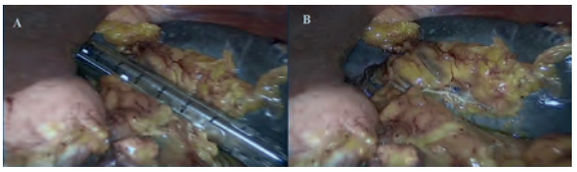

Figure (3): An intraoperative picture showing: A: application of the EndoGIA to the hilum, B: after transection of the hilum.

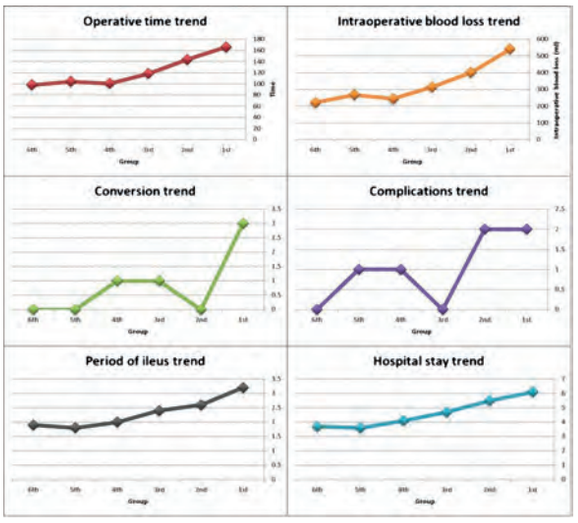

Figure (4):Graphic representation of different outcome measures trend.

Table (1): Showing the indication of splenectomy in the study group.

Indication	Frequency	Percent
ITP	36	63.2
Spherocytosis	13	22.8
CLL	5	8.8
Lymphoma	3	5.3
Total	57	100.0

Table (2): Preoperative data.

Variable	Age	BMI	Splenic longitudinal axis length (cm)	Preoperative Hb	Preoperative platelet Count (x103)
Mean	27.5	25	14	12	61.8
Std. Deviation	8.7	1.6	4.9	2.2	7.5
Minimum	16	20	12	10	47
Maximum	52	31	19	16	82

Table (3): Showing operative data.

Variable	Operative time (minutes)	Intraoperative blood loss (ml)	Specimen weight (gms)
Mean	106.5	276.5	526.2
Std. deviation	25.9	175.7	232.9
Minimum	79	80	280
Maximum	173	590	1300

Tables (4, 5): Showing postoperative data.

Type of complication	Frequency	Percent
None	51	89.5
Wound infection	4	7.2
Prolonged Ileus	2	3.5
Total	57	100

Variable	Period of ileus (days)	Full oral intake (days)	Hospital stay (days)
Mean	2	3.1	4.3
Std. Deviation	1.3	1.6	1.4
Minimum	1	2	3
Maximum	5	6	8

Table (6): Showing outcome parameters for each group.

Group	No.	Operative time	Intraoperative blood loss (ml)	Conversion	Complications	Period of ileus (days)	Hospital stay (days)
1st	10	166.2 ± 17.1	541.7 ± 103.9	3	2	3.2 ± 2.2	6.1 ± 1.7
2nd	10	143.8 ± 11.7	401.2 ± 175.6	0	2	2.6 ± 1.6	5.5 ± 1.8
3rd	10	118.5 ± 22.4	314.1 ± 136.4	1	0	2.4 ± 1.8	4.7 ± 1.2
4th	10	100.6 ± 10.1	244.5 ± 165.2	1	1	2 ± 1.1	4.1 ± 2.3
5th	10	104.1 ± 13.9	268.3 ± 87.3	0	1	1.8 ± 1.5	3.6 ± 1.4
6th	7	98.2 ± 21.5	221.9 ± 142.91	0	0	1.9 ± 1.6	3.7 ± 1.1

is consistent with many studies that stated that the learning curve for the procedure is 20 cases[8,14] or 20-25.[6]

Interestingly, the significant improvement in operative time did not correspond with a significant improvement some of the other

outcomes measures including conversion to open splenectomy, postoperative complications, period of ileus. One explanation for this may be the small statistical power when comparing the sequential groups of 10 patients. Another possible explanation for this finding may be that laparoscopic splenectomy can be safely performed early in the learning curve by surgeons who possess advanced laparoscopic skills. This trend was reported previously in the literature.[8]

Conclusion :

Laparoscopic splenectomy can be done safely by experienced laparoscopic surgeons. A learning curve for mastering the procedure is 20-30 cases, after which the outcome parameters nearly reach a plateau.

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