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Comparative treatment and literature review for laparoscopic splenectomy alone versus preoperative splenic artery embolization splenectomy

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Abstract
Background Although laparoscopic splenectomy has been gradually regarded as an acceptable therapeutic approach for patients with massive splenomegaly, intraoperative blood loss remains an important complication. In an effort to evaluate the most effective and safe treatment of splenomegaly, we compared three methods of surgery for treating splenomegaly, including open splenectomy, laparoscopic splenectomy, and a combination of preoperative splenic artery embolization plus laparoscopic splenectomy.
Methods From January 2006 to August 2011, 79 patients underwent splenectomy in our hospital. Of them, 20 patients underwent a combined treatment of preoperative splenic artery embolization and laparoscopic splenectomy (group 1), 30 patients had laparoscopic splenectomy alone (group 2), and 29 patients underwent open splenectomy (group 3). Patients' demographics, perioperative data, clinical outcome, and hematological changes were analyzed.
Results Preoperative splenic artery embolization plus laparoscopic splenectomy was successfully performed in all patients in group 1. One patient in group 2 required an intraoperative conversion to traditional open splenectomy because of severe blood loss. Compared with group 2, significantly shorter operating time, less intraoperative blood loss, and shorter postoperative hospital stay were noted in group 1. No marked significant differences in postoperative complications of either group were observed. Compared with group 3, group 1 had less intraoperative blood loss, shorter postoperative stay, and fewer complications. No significant differences were found in operating time. There was a marked increase in platelet count and white blood count in both groups during the follow-up period.
Conclusions Preoperative splenic artery embolization with laparoscopic splenectomy reduced the operating time and decreased intraoperative blood loss when compared with laparoscopic splenectomy alone or open splenectomy. Splenic artery embolization is a useful intraoperative adjunctive procedure for patients with splenomegaly because of the benefit of perioperative outcomes.

Keywords Laparoscopic splenectomy · Splenic artery embolization · Splenomegaly

Since the first series of laparoscopic splenectomy (LS) was reported by Cuschieri et al. in 1992 [1], the procedure has been gradually regarded as an acceptable therapeutic approach by surgeons for the management of a normal-sized or moderately enlarged spleen [2]. Recently, with rapid advancement in surgical techniques and instruments, LS is becoming feasible for use in patients with splenomegaly [3, 4]. Nevertheless, the peculiar vascularity of the massive spleen makes it difficult to remove and susceptible to the feared complication of hemorrhage [5]. For splenomegaly, there are reports of high conversion rates and high perioperative transfusion rates [3].

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A few reports in the literature have proposed that preoperative splenic artery embolization (SAE) [6] reduces the danger of perioperative bleeding [7], operative time, intraoperative blood loss, and the need for transfusion while it improves preoperative hematological parameters [8, 9]. Although the indication for preoperative embolization before LS is still controversial because of unresolved problems, including postembolic pain, and complications such as pancreatitis, atelectasis, and microcoil migration [6, 10], preoperative splenic artery embolization has been recommended before LS, especially for splenomegaly [6, 10, 11].

Massive splenomegaly was defined as a spleen more than 20 cm long [12]. There are few reports in the literature that describe the operational procedure compared with the LS procedure alone or with open splenectomy (OS) for massive splenomegaly. In this study, we compared the three types of surgery methods, including preoperative SAE plus LS, LS alone, and OS, for patients with massive splenomegaly via perioperative details and clinical outcomes.

Materials and methods

Patients

From October 2009 to January 2011, 20 patients who transferred to our department were diagnosed with massive splenomegaly and underwent preoperative SAE combined with LS. The medical indications for splenectomy in treating splenomegaly were based on two criteria: (1) a platelet count less than 30×10^9/L or a white blood count less than 3×10^9/L; and (2) esophageal varices of size III or IV and the patient under treatment for esophageal variceal bleeding previously via band ligation. Those who underwent preoperative SAE plus LS were considered group 1. For comparison, we selected another 30 cases who underwent LS from October 2009 to January 2011 (group 2) and 29 patients who underwent OS from January 2006 to August 2011 (group 3) as control groups by matching each paired subject for gender, age, and operative procedure during the same period. Other data such as the spleen's size, perioperative variables, and clinical outcomes were retrospectively reviewed and compared among the three groups. Abdominal ultrasonography was intervened 1 month postoperatively to exclude portal vein thrombosis.

Splenic artery embolization (SAE) procedure

The risk and potential benefits of SAE were explained to all patients and informed consent was obtained. Preoperative SAE was performed on the same day as the LS using a method previously described [2, 13]. In brief, patients were placed on a radiopaque table in a supine position. A variety of catheters, mainly a 2.5-Fr microcatheter, sometimes a 5-Fr catheter, were inserted into the right femoral artery with the patient under local anesthesia. The catheter tip, placed in the splenic artery, was advanced to the splenic hilum distal to the left gastroepiploic artery to preserve distal pancreatic branches of the splenic artery. At this level, 250–400-μm superabsorbent polymer microsphere (SAP-MS), sodium acrylate, and vinyl alcohol copolymer [14, 15] were carefully injected, and a digital subtraction angiogram was performed to verify the complete obliteration of splenic blood flow. The total amount of SAP-MS used in each patient was 90–170 mg in splenomegaly cases. Almost complete reduction of splenic blood flow was observed after completion of embolization in all cases. Approximately 3.8 h later these patients were transported to the operating room.

Laparoscopic splenectomy

Laparoscopic splenectomy was performed as previously described [16, 17]. While under general anesthesia, the patient was placed in the right semidecubitus position and the area between the iliac crest and the left costal margin was exposed. Intra-abdominal access was established with placement of a 10-mm trocar between the umbilicus and the left costal margin. CO_2 at 14 mmHg was insufflated into the abdominal cavity and a 10-mm 30° endoscope was inserted to inspect the abdomen. A 12-mm trocar was placed in the left anterior axillary line, below the costal margin. Two 5-mm trocars were then placed in the upper midline or to the left of midline along the costal margin. The procedure began with division of the splenocolic attachments and the opening of the gastrocolic ligament in order to enter the lesser sac. LigaSure vessel-sealing equipment or harmonic shears was used to divide the splenogastric ligament (including short gastric vessels) and the splenorenal ligament. With the spleen mobilized, the tail of the pancreas was clearly identified. The splenic hilum was dissected cautiously, and the splenic artery and vein were transected en bloc with the application of a linear laparoscopic vascular stapler (EndoGIA; AutoSuture, Norwalk, CT, USA, or Endolinear Cutter; Ethicon Endo-Surgery, Cincinnati, OH). After dividing the remaining splenodiaphragmatic attachments with the LigaSure vessel-sealing equipment or harmonic shears, splenectomy was completed. A large specimen bag was used to contain the spleen, which was then morcellated and removed.

Open splenectomy

Open splenectomy was performed as previously described [18].

Changes in preoperative splenic volume

Informed consent had been obtained from all patients with respect to the clinical procedure. Splenic length was determined in all patients twice either by computed tomography (CT) or X-ray, as described previously [18] before SAE and just before starting the procedure (a median of 3.8 h after completion of SAE).

Hematological changes during follow-up

All patients in both groups were followed up at 1, 3, and 6 months. The follow-up period ranged from 6 to 20 months (mean = 13 months). A clinical examination was completed at each visit. The hematological results were reviewed in our study.

Statistical analysis

Numerical data are expressed as mean ± standard deviation and compared using the nonparametric Mann–Whitney U test, Student's t test, χ^2 test, or Fisher's exact test as appropriate. All statistical analyses were performed using SPSS v16.0 (SPSS, Inc., Chicago, IL), and $p < 0.05$ were considered statistically significant.

Results

Clinical features

We enrolled 20 patients who underwent SAE with LS and 30 patients who underwent LS in our study. We also included another 29 patients who underwent OS as a control group. Patient demographics are listed in Table 1. No statistical differences among the three groups were found in regard to demographics, including age, gender contribution, and Child-Pugh score. Indication for treatment of splenectomy in these patient groups is listed in Table 1. Briefly, the most common indication for LS in both groups was cirrhosis (including post-hepatitis and alcohol cirrhosis), followed by Mediterranean disease.

Splenic artery embolization was successfully performed in all patients in group 1. An intravenous injection of narcotics (15 mg of pentazocine) was given during angiography in all 20 patients because of pain during injection of the contrast material before embolization. No drugs were administered between completion of SAE and transportation to the operating room. Six patients (30 %) complained of pain before operation.

Perioperative outcomes

Perioperative details are given in Table 2. The median interval between SAE and LS was 3.8 h. Technical success was 100 % in group 1. One patient in group 2 required conversion because of severe blood loss (800 ml). Compared with group 2, patients in group 1 had shorter operating time and less intraoperative blood loss ($p < 0.05$). There was no statistical difference in the transfusion rate. Compared with group 3, patients in group 1 had less intraoperative blood loss and a lower transfusion rate.

Postoperative outcomes

Postoperative details are given in Table 3. The median hospital stay in groups 1, 2, and 3 was 7.2, 8.6, and

Table 1 Demographic information and associated comorbidities of patient groups

Variable	Group 1	Group 2	Group 3	*P* value[a]	*P* value[b]
Patient No.	20	30	29		
Age (years)	43.1 ± 12.8	44.4 ± 16.5	44.5 ± 13.0	0.762	0.708
Gender				NS	NS
Male	11	14	16		
Female	9	16	13		
Child-Pugh class				NS	NS
A	18	27	23		
B	2	3	6		
C	0	0	0		
Diagnosis					
Post-hepatitis cirrhosis	8	17	24		
Alcoholic cirrhosis	1	2	4		
Mediterranean disease	4	7	0		
Hereditary spherocytosis	3	1	0		
ITP	0	1	0		
Lymphoma	4	2	1		

[a] Comparison between group 1 and group 2

[b] Comparison between group 1 and group 3

ITP immune thrombocytopenia

Table 2 Intraoperative details

Variable	Group 1	Group 2	Group 3	*P* value[a]	*P* value[b]
Conversion	0	1	–		
Operating time (min)	166.3 ± 29.3	209.2 ± 50.9	177.6 ± 69.5	0.001	0.495
EBL (ml)	47.0 ± 27.6	119.2 ± 24.2	223.8 ± 209.2	0.027	0.000
% Patients who received RBC transfusion (units)	10 %	30 %	51.7 %	NS	
Spleen length (cm)	31.3 ± 6.0	30.0 ± 5.9	21.5 ± 4.9	NS	0.000
Time interval between SAE and LS	3.8 ± 1.1	–	–	–	–
Change of spleen volume after spleen artery embolization					
Decrease	16	–	–		
No change	4	–	–		
Increase	0	–	–		
Additional operation					
Liver biopsy	9	19	24		
APD	0	1	6		
LC	4	2	0		

[a] Comparison between group 1 and group 2

[b] Comparison between group 1 and group 3

EBL estimated blood loss; *RBC* red blood cells; *APD* azygoportal devascularization; *LC* laparoscopic cholecystectomy; *NS* not significant

Table 3 Postoperative details

Variable	Group 1	Group 2	Group 3	*P* value[a]	*P* value[b]
Postoperative stay (days)	7.2 ± 1.4	8.6 ± 2.0	10.4 ± 4.5	0.012	0.003
Complication					
Pleural effusion	0	0	2		
Pancreatic leakage	1	1	1		
Pulmonary infection	0	2	2		
Postoperative bleeding	0	0	2		
Portal of splenic vein thrombosis	2	0	0		
Incision infection	0	0	3		
Total	3 (15 %)	3 (10 %)	10 (34.5 %)	NS	

[a] Comparison between group 1 and group 2

[b] Comparison between group 1 and group 3

10.4 days, respectively. One patient of each group experienced slight pancreatic leakage. They were drained until the laboratory analysis of the drainage tube was normal. Postoperative pancreatitis was not found in any case. Two patients in group 3 suffered pleural effusion and were treated with drainage and antibiotic therapy. There were no episodes of postoperative bleeding in groups 1 and 2, while two patients in group 3 had postoperative bleeding. Three patients in group 3 had incisional infections. All five aforementioned group 3 patients underwent conservative treatment and were cured by 1 week after surgery. The portal of splenic vein thrombosis was identified in two group 1 patients 1 month after surgery. They did not complain of any discomfort. Low-molecular-weight heparin was used to prevent thrombopoiesis, and a regular color Doppler ultrasound was performed 3 months after LS. Two patients in group 2 and two patients in group 3 had pulmonary infection. They were treated by combining medicines with enhanced nutrients. The signs and symptoms disappeared after 12 days.

Changes in preoperative splenic length

In group 1, 16 patients had a gradual decrease in splenic length just before LS compared with that before SAE. Figure 1 shows the change of splenic edge before and after SAE. Only four patients were noted to have a nearly constant spleen length during this time. The median spleen length in group 1 before SAE was 31.1 cm, while just before LS it decreased significantly to 27.6 cm ($p = 0.046$)

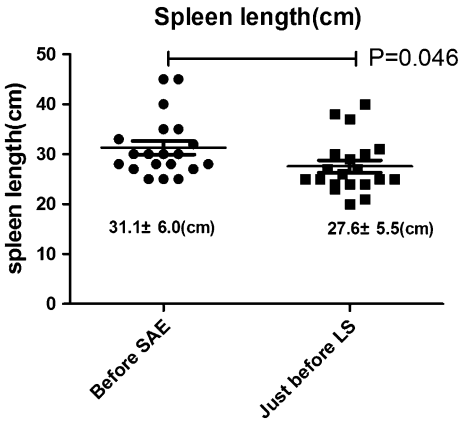

Fig. 1 Change of splenic edge after SAE

(Table 3). All spleen capsules were darker than before SAE. During the operation, a softer spleen could be palpated, and the incidence of bleeding was reduced significantly.

Hematological changes during follow-up

Hematological changes were reviewed 1, 3, and 6 months after LS (Table 4) There was marked improvement in platelet and white blood cell count in the two groups during the follow-up. No differences were found in hemoglobin.

Discussion

Although the clinical benefit of preoperative SAE with LS has been shown in many studies [19–23], to the best of our knowledge, our study is the first in which SAE with LS, LS alone, and OS for treating patients with massive splenomegaly were compared. Massive splenomegaly was defined as a spleen length exceeding 20 cm [12].

Surgical splenectomy has been performed since the 1950 s for splenomegaly and hypersplenism caused by portal hypertension [23]. Severe portal hypertension, complicated by gastrointestinal hemorrhage justifying portal decompression [24], has become one of the principal indications for splenectomy. The perception of LS as a less invasive surgical procedure is the main reason why it has become the gold standard for the removal of the spleen among surgeons with advanced laparoscopic skills. However, the risk of intraoperative blood loss or hemorrhagic complications associated with LS in patients with portal hypertension because of the peculiar vascularity of the spleen has been recognized in many reports [25, 26], and the conversion rate for uncontrolled bleeding is as high as 9 % [6, 7]. In a hopeful report, Poulin et al. [6] suggested that surgeons can reduce the incidence of intraoperative bleeding in two ways: by gaining more experience with laparoscopic surgery and by performing preoperative splenic artery embolization.

Disrupting splenic artery flow in the management of splenic disorders is not a novel therapeutic concept [27]. Maddison first performed a partial splenic embolization as a nonoperative treatment for hypersplenism in 1973 [28]. However, this technique was soon abandoned because of its complications of abscesses and splenic rupture. Recently, SAE has been taken into consideration in the surgical management of splenic diseases because of its ability to reduce the risk of operative blood loss [29]. Fujitani et al. [8] reported that preoperative SAE can be performed as an adjunct to high-risk splenectomy. In a

Table 4 Hematological changes in patients with preoperative SAE plus LS

	Time	LS + SAE	LS	OS	*P* value[a]	*P* value[b]
HGB (g/L)	Preoperation	100.8 ± 19.7	97.3 ± 26.3	105.3 ± 23.5	0.618	0.485
	After surgery					
	1 month	105.4 ± 13.9	98.8 ± 13.9	120.2 ± 15.9	0.108	0.001
	3 months	121.3 ± 11.3	118.9 ± 19.8	120.2 ± 12.2	0.630	0.752
	6 months	127.6 ± 10.0	125.2 ± 18.2	123.9 ± 16.2	0.606	0.379
WBC ($\times 10^9$/L)	Preoperation	3.0 ± 1.3	2.8 ± 1.8	3.1 ± 1.6	0.634	0.841
	After surgery					
	1 month	9.7 ± 4.1	9.6 ± 4.9	7.9 ± 4.2	0.939	0.146
	3 months	6.9 ± 2.4	7.3 ± 2.8	7.3 ± 3.4	0.622	0.659
	6 months	5.7 ± 2.5	6.6 ± 2.1	7.6 ± 4.4	0.174	0.090
PLT ($\times 10^9$/L)	Preoperation	50.6 ± 44.2	46.9 ± 38.8	41.3 ± 17.6	0.758	0.311
	After surgery					
	1 month	249.3 ± 190.4	227.6 ± 125.2	268.0 ± 90.1	0.629	0.647
	3 months	228.7 ± 84.5	210.9 ± 94.5	230.3 ± 50.8	0.500	0.935
	6 months	219.2 ± 82.9	211.9 ± 98.9	251.4 ± 70.9	0.787	0.151

similar study, Poulin [6] revealed that intraoperative blood loss was better controlled during LS if preoperative SAE was performed more completely. Meanwhile, he emphasized the role of preoperative SAE when the spleen was greater than 20 cm in size. Naoum et al. [27] showed that there was reduced blood loss and a lower conversion rate to open surgery in patients who had preoperative SAE. The benefit of preoperative SAE for better control of intraoperative blood loss during a LS procedure has been confirmed in our study. During the LS procedure, a softer and smaller spleen reduced the incidence of bleeding, especially following laparoscopic division of the splenic hilum [30]. Patients who underwent the combined treatment of SAE plus LS had less intraoperative blood loss than those patients who underwent LS alone. Because we were fortunate enough to avoid any episodes of intraoperative blood loss in our limited series, none of our procedures were converted to open surgery in group 1 compared with one conversion in group 2.

We listed in Table 5 the operative times of SAE plus LS reported in the literature. The median operative time of the SAE plus LS group in our study was 166 min, significantly less than LS alone group. We have demonstrated that the addition of SAE to LS decreased the operative time, and this has been proved in Reso's study [3].

It is not clear whether there is an optimal interval between completion of SAE and the start of laparoscopic splenectomy. A few studies in the literature described a staged-treatment approach to preoperative SAE followed many hours later by laparoscopic splenectomy, ranging from 2 h to 1 day [2, 6, 23]. In these studies, a change in splenic volume between the duration of SAE and LS was observed. Two opposing mechanisms for the change in splenic volume can be hypothesized: decrease of the splenic volume caused by the delay in blood flow and increase of the splenic volume caused by secondary tissue reaction following embolization [23]. We compared the interval between the completion of the preoperative SAE and the beginning of the laparoscopic procedure of previous studies and summarized them in Table 6. Iwase [23] demonstrated that the prolonged time interval between embolization and surgery resulted in a decrease in splenic

Table 5 Summary of perioperative outcomes from previous studies

Authors (year)	Case no.	Median age (years)	Operating time (min)	Estimated blood loss (ml)	Blood transfusion	Conversion rate
Poulin [6]	10	30.7	195	483.5	0	1/10
Poulin [10]	26	NM	195 (size <20 cm)	250 (size <20 cm)	10/26	4/26
Iwase [2]	2	42	221	451	0	0
Iwase [15]	16	52.9	161	290	NM	0
Takahashi [5]	5	13.2	211	9	NM	0
Naoum [27]	18	22	175	25	1/18 (5 %)	0
Reso [3]	19	47	130	200	4/19 (21 %)	0
Current study	20	43.1	166.3	47	2/20 (10 %)	0

NM = not mentioned

Table 6 Comparison of outcomes of SAE and LS from previous studies

Authors (year)	Case no.	Time interval between SAE and LS	Change of PLT just before LS compared with the completion of SAE	Change of PV just before LS compared with the completion of SAE	Complaint of postembolic pain
Poulin [6]	10	1 day	NM	NM	6 (60 %)
Poulin [10]	26	NM	NM	NM	12 (46 %)
Iwase [2]	2	2 h	NM	NM	0
Iwase [15]	16	2–4 h	Slightly elevate in 8 of 9 ITP patients	3 of 5 ITP patients decrease, 3 of 3 splenomegaly patients increase	1 (6.25 %)
Takahashi [5]	5	1 day	NM	NM	5 (100 %)
Naoum [27]	18	Concomitant	–	–	–
Reso [3]	19	3 h	NM	NM	NM
Current study	20	3.8 h	–	16 decrease, 4 without change	6 (30 %)

NM not mentioned

volume in 60 % of their patients with ITP. However, in cases of splenomegaly, the splenic volume increased after embolization. In the study by Yamashita et al. [31], a 10 % reduction in splenic length after balloon occlusion of the splenic artery was observed. These results were similar to those of Fujitani [8]. Our data showed that it is effective to prolong the period between distal embolization and surgery to reduce splenic volume in cases of splenomegaly. The decreased splenic length may improve the surgical view and intraoperative exposure and facilitate laparoscopic dissection during the splenectomy procedure [27].

Iwase et al. [23] revealed that the platelet count increased slightly 2–4 h after completion of embolization. They attributed this to the reduction of splenic function. Secondary hypercoagulopathy and consumption of platelets caused by SAE was documented as negligible.

Postembolic pain is a significant abdominal discomfort after SAE. The pain following artery embolization can be categorized roughly into two mechanisms: postembolic pain occurring immediately after embolization and pain caused by tissue infarction that occurs in the delayed phase [23]. Poulin et al. [6] reported that during the day between SAE and LS, 6 of 10 patients (60 %) suffered severe pain that necessitated narcotic analgesia. In the series described by Takahashi [5], all of their patients experienced postembolic pain but not to a degree that was unmanageable by intravascular narcotics. Iwase et al. [23] reported that the interval between SAE and LS was 2–4 h, and of their 17 patients, there was only 1 patient who received 15 mg pentazocine IV for pain. Nevertheless, Naoum et al. [27] reported a novel treatment strategy of concomitant intraoperative SAE and LS. They believed it had several advantages over the traditional staged-treatment strategy, i.e., patients had only one general anesthetic session for both planned procedures, thus reducing potential mental stress or procedure-related anxiety and maybe avoiding postembolic pain [23, 32].

Reso et al. [33] showed that in 19 patients with massive splenomegaly (median splenic length = 23 cm and weight = 1,740 g), LAS or HALS with preoperative SAE is safe and has a lower conversion rate to an open procedure. This study quoted only three portal vein thrombosis (PVT) complications postoperatively, adding that routine postoperative imaging surveillance is important for follow-up.

Because the splenectomy was performed after SAE in our series, we focus on the results of the first cause. Surgery was performed about 3.8 h after SAE and no patients reported pain requiring drugs between completion of embolization and arrival in the operating room.

In our study, there was improvement in platelet count in our patients (Fig. 2). This result is similar to that of Amin [34]. We also observed a positive response (platelet count remained more than 100×10^9/L) in 90 % of the patients

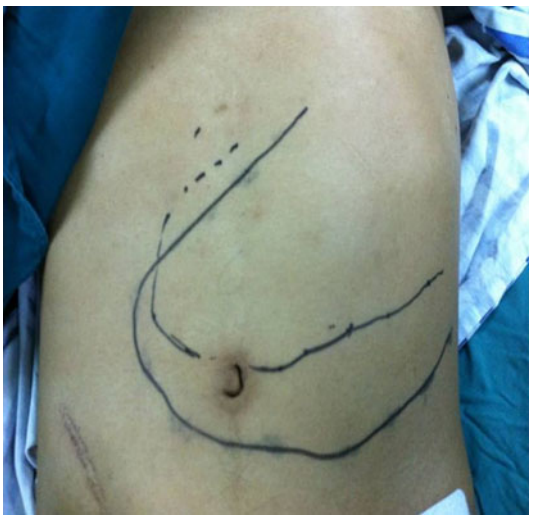

Fig. 2 Change of splenic length after SAE

compared with 94 % positive response observed by Letoquart et al. [35]. We previously reported on a comparative study of open versus laparoscopic splenectomy for massive splenomegaly where we observed the safety and efficacy of LS with a 0.03 % conversion rate to the open approach [36]. The current study focused on SAE along with LS which might be useful because it is less invasive, entails a shorter hospital stay, and has a lower postoperative complication rate. In our previous report there were three postoperative complications in LS patients for a rate of 9.1 % compared to ten complications for open splenectomy for a rate of 34.5 % and eight complications for ITP patients for a rate of 16.7 %. We observed better outcomes in our current sandwich therapy for massive splenomegaly in regard to postoperative complications [37] (Table 3).

The indication for preoperative embolization before laparoscopic splenectomy still is obfuscated by unresolved problems and complications [5]. The placement of embolic agents or coils must be distal to the greater pancreatic artery to preserve the blood supply to the pancreas and alert pancreatic necrosis and pancreatitis [27]. Migration of coils or embolic material to the arterial beds other than the spleen may result in severe procedure-related complications and tissue necrosis, especially in the pancreas and retroperitoneum [10, 37]. We perform distal embolization through selective catheterization from the distal to the greater pancreatic artery using 250–400-μm SAP-MS. In our study, we were able to achieve technical success in all patients who underwent SAE with no procedure-related complications. With improvement in the technique of SAE, prolongation is possible to decrease spleen volume resulting in far less postembolic pain.

Previous studies reported an incidence of PVT after splenectomy of 0–30 % [32, 38–40]. In our study, PVT

occurred in two patients (10 %) without any symptoms or signs. We prescribed low-molecular-weight heparin to prevent thrombopoiesis and a regular color Doppler ultrasound was performed 3 months after LS. Maalouf et al. [41] reported that anticoagulation is the treatment of choice and allows recanalization of the portal system in the majority of cases if the patient has no underlying risk factors. Anticoagulation treatment facilitated recanalization of the portal vein and this could be verified by Doppler ultrasound at follow-up.

Tran et al. [42] studied the timing of Doppler imaging in 40 patients. He observed that the rate of PSVT (symptomatic portal or splenic vein thrombosis) after LS in the first postoperative week was 8/40 (20 %). They also observed that in most of the cases PSVT developed on 7th postoperative day. If asymptomatic PSVT has not developed by this time, it is unlikely to develop by 1 month, and subsequent ultrasound screening at 1 month is not required.

Some reports indicated that during LS, the surgeon can ligate the distal splenic artery before dissection or the splenectomy in order to get the same outcome as with SAE in most cases. However, according to our experience, ligation of the distal splenic artery during the procedure proved to be very difficult, especially when the spleen length was greater than 20 cm. The separation of spleen and lateral organs as well as varicose veins increased bleeding.

Our study has some drawbacks. Randomization was not used, which may lead to potential treatment bias. Furthermore, the retrospective study design may result in possible patient selection bias. Finally, the decision of whether to perform SAE was made using mainly the surgeon's and the patient's subjective judgment rather than being based on established objective criteria. Even so, we believe our research confirms the benefit of shorter operating time and decreased intraoperative blood loss in patients undergoing SAE plus LS. Our study is valuable information to add to the literature.

In conclusion, the outcomes of our study suggest that the use of a combination of preoperative SAE and LS has the potential to reduce intraoperative blood loss, conversion to open surgery, and the need for transfusion without increasing postoperative morbidity and mortality. Our study reveals the efficacy and safety of preoperative SAE along with LS treatment for massive splenomegaly, and it is convenient, less invasive, and probably could be the first choice of intervention for massive splenomegaly.

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