Single Incision Pediatric Endosurgical (SIPES) Splenectomy

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23.1 Indications for Laparoscopic Approach to Splenectomy

The need for splenic surgery in children is limited. Most of the causative diseases are blood disorders that are otherwise insufficiently treatable. Removal of the spleen is therefore indicated in selected patients with hereditary spherocytosis, autohemolytic anemia, thalassemia and sickle cell disease because in each case the spleen is associated with specific factors that promote excessive hemolysis. The massive size of the organ in thalassemia or hereditary spherocytosis is an additional indication for its removal.

Other indications are variable:

- Accessory spleen (about 75% located near the splenic hilum)
- Wandering spleen (lack of ligamentous attachment to the diaphragm, colon, and retroperitoneum; children may present with episodic pain and abdominal mass from torsion and infarction of spleen)
- Splenogonadal fusion (congenital fusion between a portion of the spleen and a gonad or other mesonephric derivative; most patients are males)
- Splenic cyst (congenital, infectious (parasites) or traumatic; uni- or multilocular)
- Splenic abscess
- Functional abnormalities (hypersplenism, hyposplenism)
- Others (rare; tumors (leukemia, lymphoma), Gaucher's disease, splenosis)

Since the studies of Stylianos et al. splenectomies in trauma cases are rather very rare [1, 2]. The rate is well below 10% in children [3].

Ermolov et al. and Huang et al. [4, 5] describe laparoscopic splenectomy as a safe feasible operation in selected patients with spleen injury. The operation is described as possible in patients with spleen laceration >3 cm of parenchymal depth with moderate continuing bleeding or expanding hematoma and contraindicated in patients with hemodynamic instability and high bleeding rate (>500 mL/h on serial ultrasound examinations).

In an emergency situation one should certainly always consider the personal experience. If there is any doubt, the classic splenectomy is certainly the safer option.

In the hands of an experienced surgeon elective cases of splenectomy in children should nowadays certainly be performed laparoscopically, as the overview in the upper abdomen is usually better and the operative trauma compared to the open splenectomy is significantly reduced [6].

In our clinic, laparoscopic splenectomy is performed as standard via a single incision access via the umbilicus. If intraoperative necessary we place an additional trocar for holding purposes. The procedure is more demanding than a standard laparoscopy. But in our experience it is just as safe and offers the advantage of better cosmetics. In case of any emergency, a classic, open splenectomy is always possible without the need of repositioning.

23.2 Preoperative Workup and Considerations

The spleen is the dominant site for the production of IgM antibodies required for opsonizing encapsulated pathogens.

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Thus, whenever elective splenectomy is considered, patients should undergo appropriately timed preoperative immunization against Streptococcus pneumoniae (pneumococcus), Neisseria meningitidis (meningococcus), and Haemophilus influenzae type b.

In a recently published contemporary national cohort study (inclusion criterion was splenectomy at age 18 years or prior) the prevalence of postsplenectomy sepsis was 7% (1.8 events per 100 person-years). Although most presented during the first year after splenectomy, many (62%) sepsis events occurred later, suggesting that postsplenectomy immunologic dysfunction persists beyond 1 year. The immunologic consequences of asplenia must continue to be acknowledged, as postsplenectomy sepsis remains a serious concern [7].

Therefore, vaccination recommendations for asplenic patients should always be adapted according to current studies and published literature. For orientation it is recommended that the vaccination should be administered 2 weeks before the elective splenectomy.

Without prior vaccination, a vaccination interval of 1–2 weeks after splenectomy is recommended [8, 9].

The further preoperative procedure is usually patient-specific based on the underlying disease and should always be determined by the treating pediatric surgeon with the treating hematologist or oncologist and infectologist. Children with hemolytic disorders require gallbladder ultrasonography to evaluate for gallstones and possible simultaneous cholecystectomy. Otherwise, coagulation should be checked preoperatively, and packed red blood cells should be crossed because, under certain circumstances, significant bleeding may occur intraoperatively. Since it can make the surgical procedure easier, the colon should be decompressed with either an enema or a laxative on the day before surgery, which often aids in visualization during the OR.

23.3 Anesthetic Considerations

On the OR day the patient should be kept NPO per standard protocol. SIPES Splenectomy is typically performed under general endotracheal anesthesia. As splenectomy requires a preparation and ligation of large vessels, resulting in a corresponding risk of bleeding, anesthesia should be performed by an experienced pediatric anesthesiologist. Severe intraoperative bleeding is rare, but having blood available is advisable due to the complex nature of the procedure. At least two peripheral intravenous catheters should be available. In addition, many anesthetists favor intraoperative arterial blood pressure measurement for safe, invasive blood pressure measurement. Hypothermia should be avoided. A nasogastric tube can be of an advantage when there is an important intra-abdominal extension of the spleen or when the upper bowel is distended.

A urinary catheter is surgically not required per se once the bladder was emptied preoperatively. However, many anesthesiologists prefer a transurethral bladder catheter for intraoperative circulatory monitoring.

A perioperative antibiotic prophylaxis can be done according to general recommendations.

23.4 Operative Technique

23.4.1 Equipment

Single Site Access Platform

- 5 mm 30° laparoscope
- 5 mm Maryland dissector
- 5 mm atraumatic grasper
- 5 mm laparoscopic sealer/divider
- 5 mm Metzenbaum scissors
- 5 mm flexible retractor
- 10 mm endobag (for small spleens), 15 mm endobag (for large spleens)
- 5 mm or 10 mm endoscopic stapler (if required)
- 5 mm or 10 mm endoscopic clips (if required)

23.4.2 Positioning

The patient is placed in a semilateral position with a 45° tilt of the left side. The table is flexed 20–30° and elevated in a 30° anti-Trendelenburg position. Instead of flexing one could also use a small roll under the left flank to increase the distance between the left iliac crest and the 12th rib. Both arms are extended sideways (Fig. 23.1) or fixed in an overhead position. The patient should be secured by tape to the bed to allow for safe positioning and rotating to both sides during the procedure if necessary. Older children can also be positioned and stored on a vacuum mattress. Surgeon and assistant stand at the right foot of the patient at the end of the bed, the monitor is at the left head end of the bed in-line with the spleen and the surgeon. The scrub nurse is positioned on the right side of the surgeon. The abdomen is prepped and draped from the nipples to the symphysis.

23.4.3 Trocar Placement

The single site access platform is placed with the table rotated to the patient's left to approach a supine position (trocar placement position). The umbilical port site is injected with local anesthesia (for instance 0.25% bupivacaine) at the beginning. The umbilical skin incision is made lengthwise

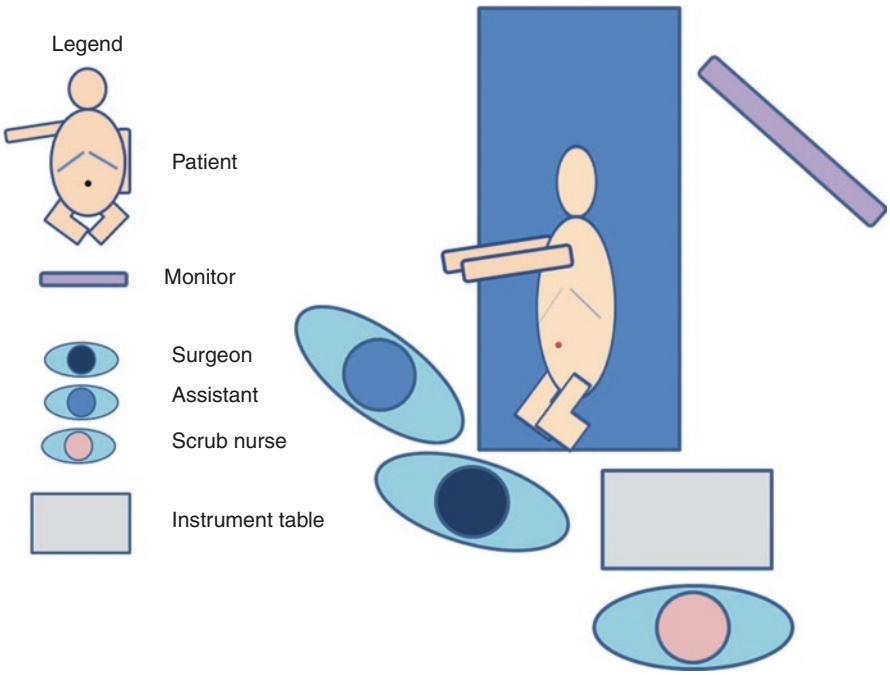


Fig. 23.1 Positioning of patient, surgeons and monitors

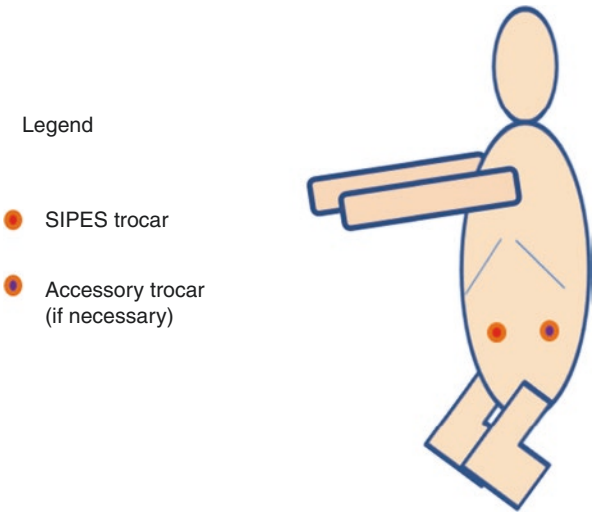


Fig. 23.2 Positioning of the trocars

(about 3 cm). A small umbilical fascial defect is usually present, allowing introduction of an Overholt clamp that can guide the fascial incision, which should be about 5 cm. In smaller children it is important to avoid injury to the umbilical vessels, as they still might bleed. After introducing the single site access platform three 5 mm trocars and one 10 mm trocar are inserted via this device (Fig. 23.2). The capnoperitoneum is insufflated using a pressure of 12 mmHg and a flow of 10 l/min. During the procedure, the insufflation pressure can be increased temporarily to provide more sufficient working space.

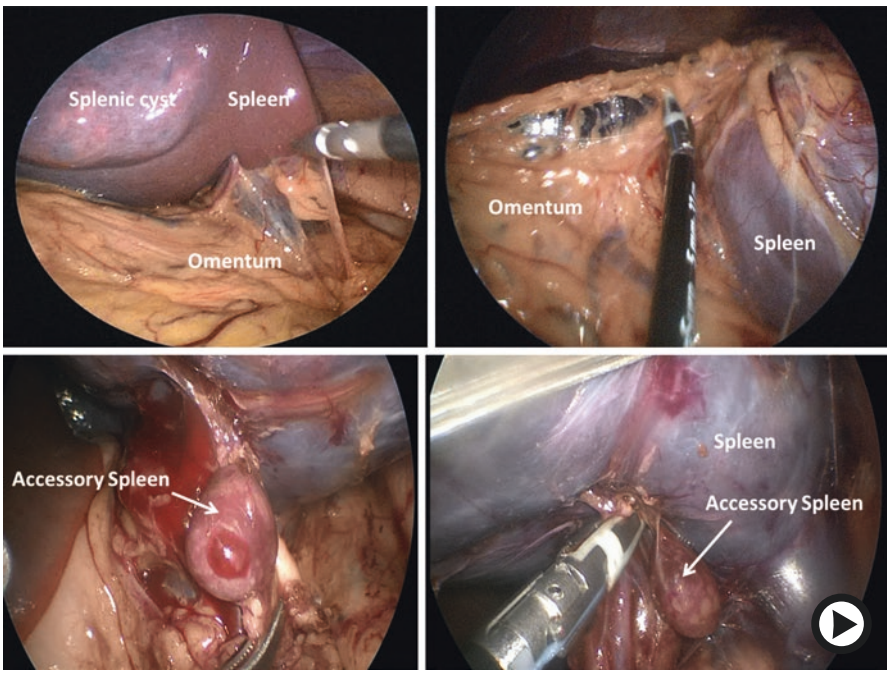
The table is then rotated to the right to achieve a lateral left position (OR position). This helps the viscera to fall away from the operative field, leaving the spleen "hanging" in the left upper quadrant. The spleen is usually positioned anterior to the costodiaphragmatic recess, lateral to the greater curvature of the stomach, adjacent to the tail of the pancreas, anterior to the left kidney, and superior or posterior to the splenic flexure of the colon.

Under Vision, if necessary during the procedure, an additional 3 or 5 mm trocar is placed in the left upper abdominal. This would allow the introduction of an additional retractor system. Instead of a regular laparoscopic retractor we sometimes use a 2 mm percutaneous grasper as a retractor.

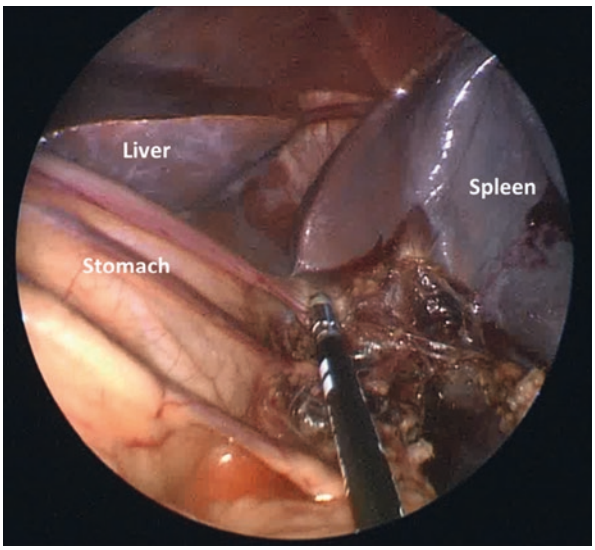
23.4.4 Operative Milestones

The right-handed surgeon primarily holds a blunt grasper with the left hand and a laparoscopic sealer/divider in the right hand. The first assistant uses primarily a blunt grasper or flexible retractor to elevate the spleen and provide traction on the various ligaments together with the surgeon with the left hand and the camera with his right hand.

As the first step in most cases omental attachments to the caudal aspect of the spleen are divided using the sealer device. The surgeon should also evaluate for already visible accessory spleens which could already be removed (Milestone 23.1). After that, it is recommended to divide ligamentous attachments of the spleen. The gastrosplenic ligament at the lower pole of the spleen is usually the ligament to start with. They are divided with the sealer device and additional downward retraction of the colon all the way up to the splenic hilum. This allows the colon to fall away.



Milestone 23.1 Omental attachments to the caudal aspect of the spleen are divided using the sealer device. The surgeon should also evaluate for already visible accessory spleens which could already be removed (Video 23.1 Splenectomy). (▶ https://doi.org/10.1007/000-2vh)



Milestone 23.2 Exposure of the gastrosplenic ligament, which contains the short gastric vessels, and vessels division and sealing from inferior to superior with the sealer device

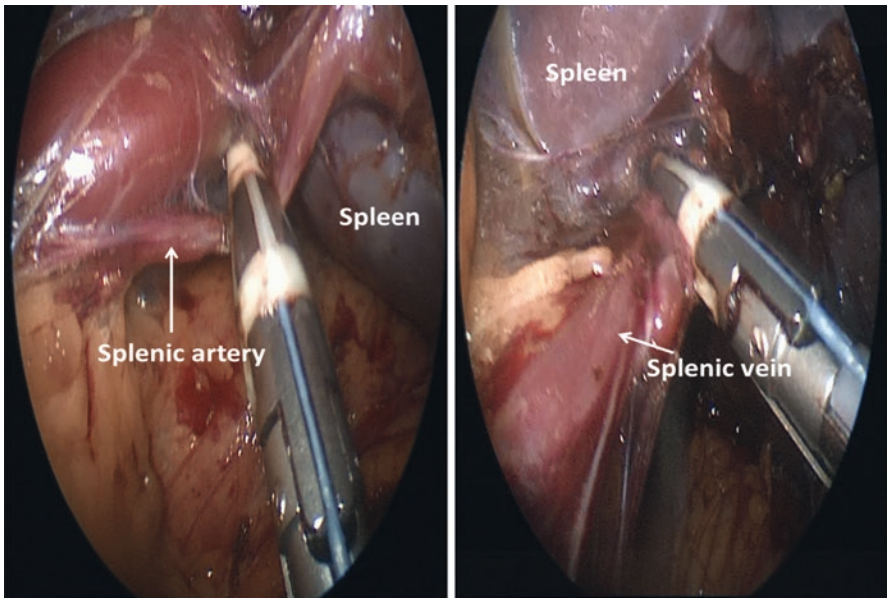
After that the assistant retracts the stomach to the right to expose the gastrosplenic ligament, which contains the short gastric vessels, and these vessels are also divided from inferior to superior with the sealer device (Milestone 23.2). The lesser sac should be inspected for the further presence of accessory spleens. At the uppermost portion of the splenogastric ligament the spleen and stomach are very close and the sealer must be placed very close to the spleen in order to avoid gastric injury. At this point the assistant may elevate the upper pole and the diaphragmatic attachments (splenophrenic ligament) may be divided. Take care to avoid injury to the diaphragm.

Now the hilum preparation begins. At this point one must decide whether to divide the hilum with individual vessel division (clips, endoscopic sealer, tie) or with a stapling device.

For individual vessel division in some cases it might be helpful to keep the splenorenal ligament, which extends from the left kidney to the hilum of the spleen, and the lateral splenic attachments intact to allow the spleen to "hang."

The splenic artery arises from the celiac trunk and travels along the superior edge of the pancreas, where it branches to form the short gastric, left gastroepiploic, and terminal splenic branches. The splenic vein is usually lying caudal from the artery. It forms in the splenorenal ligament and runs inferior to the artery and posterior to the pancreas. It joins the superior mesenteric vein behind the head of the pancreas to form the portal vein. The vessels are prepared close to the hilum and they are gradually ligated and divided with the sealer device near to the hilum (Milestone 23.3). For this purpose, clips or ligatures can also be used. However, the latter are difficult to place in SIPES technique. Thereafter, the remaining splenic adhesions are released.

If there is enough distance to the pancreas (at least 1 cm in our experience), the vessels can sometimes be stapled in total using a 10 mm laparoscopic vascular stapler system. For this procedure it is recommended to release the splenorenal ligament and the lateral splenic attachments initially so that the spleen can be fully mobilized prior placing the stapler. Care must be taken to make sure that the tail of the pancreas is not included in the stapler firing. One application



Milestone 23.3 Vessel preparation close to the hilum and gradually ligation with the sealer device near to the hilum

of the vascular load stapler is usually adequate for ligation and division of the vessels in the hilum.

After the spleen is completely free it may be placed high in the left upper quadrant against the anterior abdominal wall and a retrieval bag is placed through the 10 mm Port within single site access platform. It is positioned under the spleen and opened and the spleen is gently dropped into the open bag. The drawstring should be pulled to separate the top of the bag from the ring and the bag will be closed.

One could now remove the cap of the single site access platform in order to deliver the neck of the bag through the umbilicus while the wound retractor still remains in place. Quite often the spleen is far a way to huge for direct complete bag removal. Careful morcellation of the spleen using large clamps, sponge sticks or the surgeon's fingers within the bag may help in this case.

The cap of the platform is replaced and completion laparoscopy is performed to ensure adequate hemostasis and to exclude any remaining accessory spleen. Leaving a surgical drain in the operations area is usually not required.

If concomitant cholecystectomy is required it could be performed via the same umbilical access after rotating the operating table to the patient's left to approach a supine position.

Otherwise the single site access platform is removed and the fascia at umbilical site is closed with 2–0 polyglactin 910 suture in running suture technique or any other technique. The skin is closed for instance with intracutaneus running suture poliglecaprone 25. Remaining local anesthesia is injected at the umbilicus. Finally we place a vacuum dressing, as this seems to lower the rate of umbilical site infections after laparoscopic surgery [10].

23.5 Postoperative Care

Intensive care monitoring is usually not required postoperatively. Postoperative cardiac and pulse oximetry monitoring over 24 h on the floor is usually sufficient and recommended to watch for the development of tachycardia (potential postoperative bleeding).

The nasogastric tube and urinary catheter are removed at the end of the procedure. Pain control is achieved by in-house standard.

A clear liquids diet is instituted upon arrival to the floor with advancement to a regular diet as tolerated. Maintenance intravenous fluids are weaned as the fluid intake advances. Children with sickle-cell-disease are maintained postoperatively on intravenous fluids at a slightly greater then maintenance dosage and are carefully monitored to avoid hypoxemia.

Most children can be discharged from the hospital after full mobilization.

Surgery related postoperative complications are rare and may include umbilical wound healing problem in most cases of complication.

Splenectomy increases the risk of thrombosis, especially in the portal vein system [11, 12].

The risk of thrombosis is highest immediately after splenectomy. In childhood, thrombotic complications are less common than in adults. The need for antithrombotic prophylaxis for instance with acetylsalicylic acid is always discussed and should be decided individually according to the latest international guidelines.

The increased susceptibility to infection after splenectomy in the young patient emphasizes the need for close

supervision postoperatively. The length of postoperative antibiotic prophylaxis (usually with penicillin V or amoxicillin) is determined individually according to age. One should always follow the latest international guidelines [13–15].

In order to be prepared for an emergency situation, all our patients receive a medical emergency card "asplenia" (www.aplenia-net.org).

23.6 Pearls/Tips & Tricks

1. Position the child accurately so that the left side is elevated and use gravity to assist with the dissection.
2. The splenic artery and vein are identified beyond the tail of the pancreas. The splenic vein is usually lying caudal the artery. Vessels can be dissected using many different devices (sealer device, clips, vascular load of staples or even ligatures).
3. It is usually recommended to keep the splenorenal ligament and the lateral attachments intact until completing dissection of the medial aspect of the spleen (hilum, short gastrics). Only in the cases of using stapling devices it is recommended to release the splenorenal ligament and the lateral splenic attachments initially so that the spleen can be fully mobilized prior placing the stapler.
4. The most difficult aspect in short gastric preparation is the uppermost level where the spleen and stomach are very close. Place the sealer very close to the spleen in order to avoid gastric injury.
5. Look for accessory spleens during the procedure in the lesser sac next to the splenic hilum and on the omentum.
6. Be aware of patients with sickle-cell-disease. Children should be maintained postoperatively on intravenous fluids at a slightly greater then maintenance dosage and should be carefully monitored to avoid hypoxemia.
7. Do not hesitate to convert from laparoscopy to laparotomy in unclear situations or any case of emergency.

23.7 Pitfalls & Ways to Avoid

1. The operation is overall not too difficult. However, it can end in a disaster if the surgeon does not know the anatomy. There is a close relationship between spleen and stomach (short gastric vessels), splenic hilum and pancreatic tail, as well as the lower spleen pole and the left colic flexure. One must be aware of this anatomy in order to avoid a stomach injury or pancreatic (tail) injury or fistula.
2. Cases of incidental left nephrectomy instead of splenectomy are described in literature and yellow press. A safe identification of the left kidney and delineation to the spleen is essential before splenectomy.
3. The sealer device may reach high temperatures which easily could cause perforation to adjacent tissue like colon if this tissue is incidentally touched.
4. The jaw of the sealer system may stick to the vessel wall after it has been sealed and transected. A cautious rocking movement will separate the jaws of the sealer from the vessel wall (Video 23.1). If there will be bleeding immediate reclosure and additional sealing on both sides may stop the bleeding in most cases. If bleeding continues, temporary gastric wall compression against the bleeding vessel is another possibility to stop the bleeding.
5. If surgeons use a stapling device for hilum division the tail of the pancreas may be included. Identify the pancreatic tail securely and estimate the distance to the spleen before firing the device. Do not hesitate to change the device to sealer or clips.
6. Take care to avoid injury to the diaphragm. If a hole is made in the diaphragm, a figure-eight suture may be placed and a catheter may be inserted into the chest. While aspirating the pneumothorax the suture can be tied during withdrawal of the catheter.

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