# Minimally invasive splenectomy: an update and review

Gary Gamme, MD*
Daniel W. Birch, MD, MSc†
Shahzeer Karmali, BSc, MD†

From the * Faculty of Medicine, University of Calgary, Calgary, and the †Centre for the Advancement of Minimally Invasive Surgery (CAMIS), Department of Surgery, University of Alberta, Edmonton, Alta.

Accepted for publication
Oct. 9, 2012

**Correspondence to:**
S. Karmali
10240 Kingsway Ave., Rm. 405 CSC
Edmonton AB T5H 3V9
shahzeer@ualberta.ca

DOI: 10.1503/cjs.014312

Laparoscopic splenectomy (LS) has become an established standard of care in the management of surgical diseases of the spleen. The present article is an update and review of current procedures and controversies regarding minimally invasive splenectomy. We review the indications and contraindications for LS as well as preoperative considerations. An individual assessment of the procedures and outcomes of multiport laparoscopic splenectomy, hand-assisted laparoscopic splenectomy, robotic splenectomy, natural orifice transluminal endoscopic splenectomy and single-port splenectomy is included. Furthermore, this review examines postoperative considerations after LS, including the postoperative course of uncomplicated patients, postoperative portal vein thrombosis, infections and malignancy.

La splénectomie laparoscopique (SL) est devenue la norme de soins établie pour la prise en charge des maladies de la rate justiciables d'une chirurgie. Le présent article fournit une mise à jour et une synthèse des interventions et des controverses actuelles entourant la splénectomie minimalement effractive. Nous passons en revue les indications et contre-indications de la SL, de même que les considérations préopératoires. Nous incluons une analyse individuelle des interventions et des résultats de la SL multiport, de la SL manuellement assistée, de la splénectomie robotisée, de la splénectomie endoscopique transluminale par voie naturelle et de la splénectomie par simple incision. De plus, cette synthèse explore les considérations postopératoires suivant la SL, y compris l'évolution postopératoire des cas non compliqués, la thrombose de la veine porte postopératoire, les infections et les cancers.

Minimally invasive splenectomy has become an established standard of care in general surgery. Minimally invasive splenectomy was first reported in 1991 by Delaitre and Maignien,[1] who performed laparoscopic splenectomy (LS) in 1 patient. Subsequent literature has shown that minimally invasive splenectomy improves patient morbidity, reduces length of stay in hospital, reduces perioperative pain and provides enhanced cosmesis.[2–6] The breadth of minimally invasive splenectomy procedures now includes hand-assisted LS (HALS), natural orifice transluminal endoscopic surgery (NOTES), robot-assisted splenectomy and single-port access (SPA) splenectomy.[7–15]

Currently, minimally invasive splenectomy is successfully performed for a variety of conditions, including idiopathic thrombocytopenic purpura, hereditary spherocytosis, autoimmune hemolytic anemia, thrombocytopenic purpura, Hodgkin and non-Hodgkin lymphoma, chronic lymphocytic leukemia, hemangiomas, idiopathic myelofibrosis, myelodysplastic syndrome, hairy cell leukemia, splenic abscess or cyst, and tuberculosis.[7,11,16,17] Other indications may include blunt trauma.[18]

Contraindications to performing LS include uncorrected coagulopathies and severe portal hypertension from liver cirrhosis.[6,11] It has also been shown that increasing spleen size has a direct correlation with conversion to open splenectomy (OS).[6,17,19] In a study by Targarona and colleagues,[17] as many as 77% of patients with spleens weighing up to 3200 g underwent successful LS. However, in patients with spleens weighing between 3200 and 3600 g, rates of conversion to OS exceed 75%.[17] Hand-assisted splenectomy may be the better option for massively enlarged spleens owing to the technical difficulty of manipulating the spleen during the procedure and avoiding bleeding due to

 

capsular tears and parenchymal injury.[19,20] Morbid obesity (body mass index [BMI] > 35) is not a contraindication to LS. Although blood loss may be greater and duration of surgery may be longer, particularly in patients with a BMI greater than 40, there is no evidence to suggest significantly different perioperative and postoperative differences for morbidly obese patients undergoing LS.[21]

## Methods

### Search strategy

We searched PubMed, Ovid and Google Scholar using the keywords "splenectomy," "minimally invasive" and "spleen."

### Selection criteria

The search was limited to clinical trials, meta-analyses, practice guidelines, randomized controlled trials (RCTs), reviews, studies involving humans and studies publislhed in English. A total of 39 articles were chosen (Table 1).

## Preoperative planning

Regardless of the minimally invasive procedure of choice, every splenectomy patient must undergo a thorough preoperative assessment. This should include a physical exam, adequate size measurements of the spleen obtained using ultrasonography, blood counts and workup for coagulopathy as well as obtaining informed consent. It is preferable to immunize the patient against *Hemophilus influenza*, *pneumoccocus* and *meningiococcus* at least 2 weeks before the surgery. Subcutaneous heparin injections and compression stockings should be used as deep vein thrombosis prophylaxis. A Foley catheter and a nasogastric tube can also be used,[2,3,7,11] but are typically not necessary.

There has been debate over whether imaging for accessory spleens is necessary.[11,16,22,25] However, the sensitivity and specificity of computed tomography (CT) for detecting accessory spleens is 60% and 95.6%, respectively, whereas that of laparoscopic detection is 93.3% and 100%, respectively. Perioperative CT for the detection and localization of accessory spleens may not be necessary.[22,23]

## Operative procedures and outcomes

### Multiport laparoscopic splenectomy

The patient is positioned in the right lateral decubitus position, with the table flexed and the kidney bar raised to facilitate exposure of the spleen. A reverse Trendelenburg position may allow greater exposure of the left upper quadrant. Incisions are made for three 5 mm trocars and one 12 mm trocar. Pneumoperitoneum up to 12 mm Hg is standard. Trocar placement should reflect patient anatomy, correcting for spleen size and splenic attachments. At this time there should be an examination for accessory spleens.[5–7,16,21–23,30]

Access to the splenic vessels can be gained by dividing the gastrosplenic ligament to gain entry into the lesser sac. Care should be taken when dividing short gastric vessels and the gastrosplenic ligament along the greater curvature of the stomach. Once the gastrosplenic ligament has been divided, the hilar vessels should be visible. A vascular stapler may be used to separate the artery and vein if the goal is to divide the artery before the vein. Another approach may be to mobilize all attachments before approaching the hilum and using a vascular loaded stapler to take the artery and vein together. The splenophrenic and splenorenal ligaments are relatively avascular so they can be divided along their attachments to free the spleen. Once completely free, the spleen can be placed into an endoscopic retrieval bag and morcelated with a forceps. The dissection area is then reinspected for bleeding or any damage to adjacent structures.[5–7,16,25,30,31]

In a consensus statement, the European Association for Endoscopic Surgery (EAES) identifies multiport LS as the gold standard of treatment for surgical diseases involving normal to moderately enlarged spleens.[11] A meta-analysis by Winslow and Brunt[12] found that despite its longer duration, LS was associated with a shorter postoperative stay in hospital, lower complication rates and fewer pulmonary, wound and infectious complications. Systematic reviews by Kojouri and colleagues[13] and Mikhael and colleagues[14] specific to patients with idiopathic thrombocytopenic purpura also show the superiority of LS over OS. Laparoscopic splenectomy had significantly lower mortality and complication rates.

Other studies have compared LS to OS.[2,3,5–7,11,16] Most authors report lower operative blood loss with LS. Postoperative splenectomy complications, such as pneumonia and atelectasis, were less frequent with LS than OS. Postoperative patient recovery times were also shorter with LS, and less analgesia was required for patients who had LS than those who had OS. Finally, patients who had LS returned to regular activities more quickly and had better cosmetic results than patients who had OS.

Laparoscopic splenectomy is a powerful tool in the hands of an experienced surgeon. However, there is no consensus on the optimal amount of training to determine when a surgeon can be considered proficient in different laparoscopic procedures.[11,22]

### Hand-assisted laparoscopic splenectomy

Patient positioning for HALS is similar to that for multiport LS. The patient is in a right lateral decubitus position and may require reverse Trendelenburg positioning, depending on the anatomy. Usually in cases of splenomegaly, the procedure is started fully laparoscopically and converted to HALS as the procedure continues. In a

primary HALS, a subxiphoid midline, left or right upper quadrant, Pfannestiel or McBurney incision can be introduced for a hand port, which can be used to inflate the abdomen and visualize subsequent trocar placements. The location of the hand port will be determined by the size and orientation of the spleen. The incision size is usually 7 cm and is determined by glove size. A hand-assisted device is installed, and 2 further incisions are made after the abdomen is inflated to 15 mm Hg, one for a 10 mm trocar and another for a 5 mm trocar parallel to the splenic margin. The spleen is then fully mobilized by dissecting its circumferential attachments beginning with the splenocolic ligament. After division of the splenorenal and gastrosplenic ligaments, the hilum is then manually manipulated and stapled with an endovascular stapler. Splenophrenic attachments are divided last, and the spleen is placed into a retrieval bag placed over the surgeon's hand and introduced into the abdomen. Once the spleen is within the bag, it is morcelated as necessary and pulled out through the port site.[7,11,25,26,30]

Hand-assisted laparoscopic splenectomy has been shown to facilitate the surgical management of massive splenomegaly, allowing a traumatic manipulation of enlarged spleens. In 1 RCT comparing HALS to OS, median splenic weight for the HALS group was 1200 g, with no conversions.[26] Moreover, spleens weighing considerably more than 3000 g have been safely removed using HALS.[7,17,19,20,26]

**Table 1. Characteristics and quality of studies on minimally invasive splenectomy**

| Approach; study | Level of evidence | Indication | Procedures | Sample size | Sample age | Type | Class |
|---|---|---|---|---|---|---|---|
| **Multiport LS** | | | | | | | |
| Delaitre and Maignien[1] | 4 | ITP | LS | 1 | Adult | Case report | Prospective |
| Brunt et al.[2] | 3b | Diverse | LS, OS | 46 | — | Retrospective cohort | Retrospective |
| Carroll et al.[3] | 4 | ITP, Hodgkin lymphoma | LS | 3 | Adult | Prospective case series | Prospective |
| Delaitre et al.[4] | 4 | ITP | LS | 1 | Adult | Case report | Prospective |
| Kercher et al.[5] | 3b | Splenomegaly diverse hematologic | LS | 49 | All | Prospective cohort, case–control | Prospective |
| Park et al.[6] | 3b | Diverse hematologic | LS, OS | 210 | All | Prospective case–control | Prospective |
| Winslow and Brunt[12] | 2a | Diverse | OS, LS | 2940 | All | Systematic review | Retrospective |
| Kojouri et al.[13] | 2a | ITP | OS, LS | 2623 | All | Systematic review | Retrospective |
| Mikhael et al.[14] | 2a | ITP mainly | LS | 1223 | All | Systematic review | Retrospective |
| Watson et al.[16] | 3b | ITP | LS, OS | 60 | Adult | Case–control | LS prospective, OS, retrospective |
| Basso et al.[18] | 3b | Splenic trauma | LS | 10 | Adult | Prospective cohort | Prospective |
| Targarona et al.[19] | 3b | Splenomegaly | LS, OS | 186 | Adult | Case series | Retrospective |
| Weiss et al.[21] | 4 | Diverse hematologic, pregnancy, obesity, malignancy, splenomegaly | LS | 77 obesity | Adult | Prospective cohort, case–control | Prospective |
| Altaf et al.[22] | 3b | ITP, accessory spleen | LS | 7 | Adult | Prospective cohort | Prospective |
| Quah et al.[23] | 3b | Diverse hematologic | LS | 58 | Adult | Prospective cohort | Prospective |
| Kinjo et al.[24] | 3b | Diverse hematologic cirrhosis | OS, LS | 70 | Adult | Retrospective cohort | Retrospective |
| **HALS** | | | | | | | |
| Hellman et al.[20] | 3b | Splenomegaly | HALS | 7 | Adult | Prospective cohort, case–control | Prospective |
| Swanson et al.[25] | 3b | Diverse | HALS, OS | 217 | Adult | Prospective cohort | Prospective |
| Barbaros et al.[26] | 2b | Splenomegaly, diverse hematologic | HALS, OS | 27 | Adult | RCT | Prospective |
| **Robotic splenectomy** | | | | | | | |
| Giulianotti et al.[8] | 2b | Diverse hematologic | Robot-assisted laparoscopic splenectomy | 24 | Adult | Prospective cohort | Prospective |
| Maeso et al.[27] | 2c | Diverse splenic and nonsplenic | Robot-assisted laparoscopy, laparoscopic | 2177 | All | Systematic review | Retrospective |
| **NOTES splenectomy** | | | | | | | |
| Targarona et al.[9] | 5 | Polycystic tumour of the spleen | NOTES | 1 | Adult | Case report | Prospective |
| **SPA splenectomy** | | | | | | | |
| Targarona et al.[28] | 4 | Diverse hematologic | SPA splenectomy | 17 | Adult | Systematic review | Retrospective |
| **Complications/infections** | | | | | | | |
| Waghorn[29] | 4 | Overwhelming postsplenectomy infection | — | 77 | All | Case series | Retrospective |

HALS = hand-assisted laparoscopic splenectomy; ITP = immune thrombocytopenic purpura; LS = laparoscopic splenectomy; NOTES = natural orifice transluminal endoscopic surgery; OS = open splenectomy; RCT = randomized controlled trial; SPA = single-port access.

Compared with OS, HALS has been shown to lead to shorter incisions overall, less postoperative pain and reduced hospital stay. Compared with LS, HALS has been associated with fewer conversions to OS and may have fewer postoperative complications.[7,11,20,26]

### *Robotic splenectomy*

For robotic splenectomy, the patient is positioned in the right lateral decubitus position with a reverse Trendelenburg inclination. Laparoscopic port sites are similar to those described previously. A pneumoperitoneum of 12 mm Hg is maintained. Ultrasonic dissection of the splenic ligaments is undertaken, and hilar vessels are typically controlled using an endovascular stapler. An enlarged supraumbilical or subumbilical incision may be used to remove the spleen contained in a durable extraction sac.[8,32]

The literature comparing robotic splenectomy and conventional LS in terms of conversion rate, drain removal, food intake, hospital stay and complication rates failed to find any significant differences.[27,32] Duration of surgery and procedural cost, however, were significantly different; the duration of robotic splenectomy was longer and the associated costs were higher. At the present time, robotic splenectomy does not provide any clear clinical benefit in terms of patient outcome.[8,32] There may be a role for robotic splenectomies as a training procedure to allow surgeons to acquire more experience, improve their technique and increase their comfort level for more complex cases. One study cited the possible usefulness of robotic splenectomy in managing technically more challenging splenectomies.[8]

Until there is further equipment development in robotic splenectomy to shorten the duration of surgery and reduce operating costs, conventional LS will remain the gold standard.[32]

### *Natural orifice transluminal endoscopic surgery*

Natural orifice transluminal endoscopic surgery was first described in the early 1990s and has since played an evolving role in minimally invasive procedures. It has promised better cosmesis, shorter hospital stays and less pain postoperatively.[28] The advantage is best seen when extracting whole spleens owing to pathologic necessity. The only report of a NOTES splenectomy in humans was that of Targarona and colleagues,[9] who performed the procedure transvaginally. It was a hybrid approach using laparoscopic NOTES-assisted splenectomy.

It had been previously determined that vaginal access for NOTES procedures in the abdomen is a viable route owing to its easy accessibility and relative ease in decontamination.[9,28] The report described the advantage of placing the patient in a right lateral decubitus position with the left leg in a stirrup to allow access to the genitalia.[9] The procedure allowed transvaginal visualization of the spleen, dissection of splenic attachments and stapling of the splenic hilum, and spleen extraction minimizing parietal wall trauma was safely carried out with standard laparoscopic instrumentation.[9] Endoscopic instrumentation designed for this approach may greatly reduce the duration of surgery and improve the operative technique and logistics. For now, further analysis is required to determine long-term clinical, esthetic and functional advantages.[10]

### *Single-port access splenectomy*

In SPA splenectomy, the patient is placed in the right lateral decubitus position with the table flexed to provide reverse Trendelenburg positioning to better access the left hypochondrium.[12,28,33] In thin patients with normal-sized livers, a transumbilical approach may be used. In a patient with splenomegaly, a 2 cm left-sided incision is made at the level of the umbilicus in the midclavicular line. Two techniques have been described. One option is to use multiple trocars, introducing trocars one at a time after pneumoperitoneum is achieved via a Veress needle. Another option is to insufflate the abdomen to achieve pneumoperitoneum and introduce a multiport device.[28] The remainder of the procedure is very similar to multiport LS. After an initial search for accessory spleens, splenic ligaments are dissected and then the hilar structures are transected. An endobag is then introduced into the abdomen, and the spleen is removed either intact or morcelated, through the umbilicus.

There are greater challenges when working through a single port. Problems with triangulation, clashing of instruments and lack of space have all been reported. There is a need for standardization of the SPA splenectomy technique as well as better patient selection criteria for SPA splenectomy. That being said, the literature does point to the fact that early experiences with SPA splenectomy have led to better patient cosmesis, shorter hospital stay, fewer complications in the postoperative period and better pain control than conventional LS.[12,28,33] Single-site umbilical LS has been described in children and has been shown to have excellent cosmetic advantages compared with conventional LS. From the child's perspective, these are scars that last a lifetime.[34] There has yet to be large-scale prospective randomized studies directly comparing standard multiport LS with SPA splenectomy, differences between instruments and differences between surgical SPA techniques in terms of patient outcomes.[28]

## POSTOPERATIVE CARE AND COMPLICATIONS

### *Typical postoperative management*

In uncomplicated patients, oral intake and fluids are commenced and progressed as tolerated. Typically, nonsteroidal anti-inflammatory drugs are used for analgesia if

there are no hematologic contraindications. The most common complications are pancreatitis, postoperative hemorrhage and lung atelectasis.[35] Deep vein thrombosis prophylaxis is also used if there are no hematologic contraindications. Typically the median length of stay in hospital is 2 days, with 20% of patients being discharged the next day. Several studies have described using abdominal Doppler ultrasonography in the postoperative period to identify portal vein thrombosis (PVT).[7,24,36] Rates of PVT range from 0% to 52%, depending on whether reported cases are asymptomatic or symptomatic, as do the rates of underlying risk factors, which may include various hematologic disorders (e.g., low white blood cell count, preoperative portal vein diameter).[7,24,36] Portal vein thrombosis responds to anticoagulation therapy.[7,24,36]

Hematologic manifestations of asplenism include granulocystosis initially giving way to lymphocytosis and monocytosis. Thrombocytosis is expected with levels remaining elevated for more than a year. Antiplatelet agents, such as acetylsalicylic acid, may be used for anticoagulation and are typically reserved for patients with platelet counts greater than 1000 ($\times 10^9$/L).[37]

### *Infections and malignancy*

Overwhelming postsplenectomy infection has been reported in up to 0.5% of patients, with a mortality of up to 50%. There is debate as to whether patients require lifelong antibiotic prophylaxis. Patients are currently advised to present to the emergency department early or use antibiotic prophylaxis at the earliest signs of fever or infection. Some suggest antibiotic prophylaxis for 2 years, followed by individual assessment of further risk.[29,38,39]

Clinical studies in humans have shown no increase in the number of patients with cancer who have undergone splenectomy posttrauma. The literature is inconclusive on whether patients undergoing splenectomy for other reasons truly have an increased risk for cancer due to their asplenism.[36]

## Conclusion

Minimally invasive splenectomy has progressed to become an established general surgery procedure. With superior patient outcomes than OS, LS has become the gold standard procedure for spleen removal; HALS is a well-accepted option for cases of severe splenomegaly. Patients have improved outcomes in this setting compared with OS. Further development of minimally invasive splenectomy has given rise to robotic splenectomy; however, there is no consensus on improved patient outcomes. There may be a role for further development of robotic splenectomy in patients with technically challenging anatomy and for training purposes. Laparoscopic NOTES-assisted splenectomy may also be a useful option when attempting to minimize abdominal wall trauma. Further trials and analyses are required to verify its effectiveness. Single-port access splenectomy is the most recent of the advancements in minimally invasive splenectomy. It has a clear benefit in terms of enhanced cosmesis and has already been implemented in the pediatric population. Many agree that there needs to be further analysis into the standardization of the procedure to best evaluate patient outcomes. Postoperative risks include portal vein thrombosis and overwhelming infection.

**Competing interests:** None declared for G. Gamme. D.W. Birch declares having been paid consultant fees by Johson & Johnson/Ethicon Endo-Surgery, Covidien, Bard, Baxter and Olympus. S. Karmali declares having received consultant and speaker fees from Ethicon and Covidien.

**Contributors:** All authors designed the review, analyzed the data, reviewed the article and approved its publication. G. Gamme and S. Karmali acquired the data. G. Gamme wrote the article.

## References

1. Delaitre B, Maignien B. [Splenectomy by the laparoscopic approach. Report of a case] [Article in French]. *Presse Med* 1991;20:2263.
2. Brunt LM, Langer JC, Quasebarth MA, et al. Comparative analysis of laparoscopic versus open splenectomy. *Am J Surg* 1996;172:596-9.
3. Carroll BJ, Phillips EH, Semel CJ, et al. Laparoscopic splenectomy. *Surg Endosc* 1992;6:183-5.
4. Delaitre B, Maignien B, Icard P. Laparoscopic splenectomy. *Br J Surg* 1992;79:1334.
5. Kercher KW, Matthews BD, Walsh RM, et al. Laparoscopic splenectomy for massive splenomegaly. *Am J Surg* 2002;183:192-6.
6. Park A, Marcaccio M, Sternbach M, et al. Laparoscopic vs open splenectomy. *Arch Surg* 1999;134:1263-9.
7. Feldman LS. Laparoscopic splenectomy: standardized approach. *World J Surg* 2011;35:1487-95.
8. Giulianotti PC, Buchs NC, Addeo P, et al. Robot-assisted partial and total splenectomy. *Int J Med Robot* 2011;7:482-8.
9. Targarona EM, Gomez C, Rovira R, et al. NOTES-assisted transvaginal splenectomy: the next step in the minimally invasive approach to the spleen. *Surg Innov* 2009;16:218-22.
10. Moris DN, Bramis KJ, Mantonakis EI, et al. Surgery via natural orifices in human beings: yesterday, today, tomorrow. *Am J Surg* 2012;204:93-102.
11. Habermalz B, Sauerland S, Decker G, et al. Laparoscopic splenectomy: the clinical practice guidelines of the European Association for Endoscopic Surgery (EAES). *Surg Endosc* 2008;22:821-48.
12. Winslow ER, Brunt LM. Perioperative outcomes of laparoscopic versus open splenectomy: a meta-analysis with an emphasis on complications. *Surgery* 2003;134:647-53.
13. Kojouri K, Vesely SK, Terrell DR, et al. Splenectomy for adult patients with idiopathic thrombocytopenic purpura: a systematic review to assess long-term platelet count responses, prediction of response, and surgical complications. *Blood* 2004;104:2623-34.

14. Mikhael J, Northridge K, Lindquist K, et al. Short-term and long-term failure of laparoscopic splenectomy in adult immune thrombocytopenic purpura patients: a systematic review. *Am J Hematol* 2009;84:743-8.

15. Moreno Sanz C, Noguera Aguilar JF, Herrero Bogajo ML, et al. Single-incision laparoscopic surgery. *Cir Esp* 2010;88:12-7.

16. Watson DI, Coventry BJ, Chin T, et al. Laparoscopic versus open splenectomy for immune thrombocytopenic purpura. *Surgery* 1997; 121:18-22.

17. Targarona EM, Balague C, Trias M. Is the laparoscopic approach reasonable in cases of splenomegaly? *Semin Laparosc Surg* 2004;11:185-90.

18. Basso N, Silecchia G, Raparelli L, et al. Laparoscopic splenectomy for severe blunt trauma: initial experience of ten consecutive cases with a fast hemostatic technique. *J Laparoendosc Adv Surg Tech A* 2003;13:109-12.

19. Targarona EM, Espert JJ, Cerdan G, et al. Effect of spleen size on splenectomy outcome: a comparison of open and laparoscopic surgery. *Surg Endosc* 1999;13:559-62.

20. Hellman P, Arvidsson D, Rastad J. HandPort-assisted laparoscopic splenectomy in massive splenomegaly. *Surg Endosc* 2000;14:1177-9.

21. Weiss CA III, Kavic SM, Adrales GL, et al. Laparoscopic splenectomy: What barriers remain? *Surg Innov* 2005;12:23-9.

22. Altaf AM, Sawatzky M, Ellsmere J, et al. Laparoscopic accessory splenectomy: the value of perioperative localization studies. *Surg Endosc* 2009;23:2675-9.

23. Quah C, Ayiomamitis GD, Shah A, et al. Computed tomography to detect accessory spleens before laparoscopic splenectomy: Is it necessary? *Surg Endosc* 2011;25:261-5.

24. Kinjo N, Kawanaka H, Akahoshi T, et al. Risk factors for portal venous thrombosis after splenectomy in patients with cirrhosis and portal hypertension. *Br J Surg* 2010;97:910-6.

25. Swanson TW, Meneghetti A, Sampath S, et al. Hand-assisted laparoscopic splenectomy versus open splenectomy for massive splenomegaly: 20-year experience at a Canadian centre. *Can J Surg* 2011;54:189-93.

26. Barbaros U, Dinççag A, Sümer A, et al. Prospective randomized comparison of clinical results between hand-assisted laparoscopic and open splenectomies. *Surg Endosc* 2010;24:25-32.

27. Maeso S, Reza M, Mayol JA, et al. Efficacy of the DaVinci Surgical System in abdominal surgery compared with that of laparoscopy: a systematic review and meta-analysis. *Ann Surg* 2010;252:254-62.

28. Targarona EM, Lima MB, Balague C, et al. Single- port splenectomy: current update and controversies. *J Minim Access Surg* 2011;7:61-4.

29. Waghorn DJ. Overwhelming infection in asplenic patients: current best practice preventive measures are not being followed. *J Clin Pathol* 2001;54:214-8.

30. Almond BA, Diehl KM. Splenectomy. In: Minter RM, Doherty GM, editors. *Current procedures: surgery*. New York: McGraw Hill; 2010. p. 146-8.

31. Dagash H, Chowdhury M, Pierro A. When can I be proficient in laparoscopic surgery? A systematic review of the evidence. *J Pediatr Surg* 2003;38:720-4.

32. Gelmini R, Franzoni C, Spaziani A, et al. Laparoscopic splenectomy: conventional versus robotic approach. A comparative study. *J Laparoendosc Adv Surg Tech A* 2011;21:393-8.

33. Romanelli JR, Earle DB. Single-port laparoscopic surgery: an overview. *Surg Endosc* 2009;23:1419-27.

34. Bruzoni M, Dutta S. Single-site umbilical laparoscopic splenectomy. *Semin Pediatr Surg* 2011;20:212-8.

35. Doherty GM. Spleen. In: *Current: diagnosis and treatment*. New York: McGraw Hill; 2010. pp. 610-614.

36. Cadili A, de Gara C. Complications of splenectomy. *Am J Med* 2008;121:371-5.

37. William BM, William BM, Corazza GR. Hyposplenism: a comprehensive review. Part 1: basic concepts and causes. *Hematology* 2007;12: 1-13.

38. Davies JM, Lewis MPN, Wimperis J, et al. Review of guidelines for the prevention and treatment of infection in patients with an absent or dysfunctional spleen: prepared on behalf of the British Committee for Standards in Haematology by a Working Party of the Haemato-Oncology Task Force. *Br J Haematol* 2011;155:308-17.

39. Spelman D, Buttery J, Daley A, et al. Guidelines for the prevention of sepsis in asplenic and hyposplenic patients. *Intern Med J* 2008; 38:349-56.