Surg Endosc (2008) 22:821–848
DOI 10.1007/s00464-007-9735-5

CONSENSUS STATEMENT

Laparoscopic splenectomy: the clinical practice guidelines of the European Association for Endoscopic Surgery (EAES)

B. Habermalz · S. Sauerland · G. Decker · B. Delaitre · J.-F. Gigot · E. Leandros · K. Lechner · M. Rhodes · G. Silecchia · A. Szold · E. Targarona · P. Torelli · E. Neugebauer

Received: 19 November 2007 / Accepted: 23 November 2007 / Published online: 22 February 2008

Abstract
Background Although laparoscopic splenectomy (LS) has become the standard approach for most splenectomy cases, some areas still remain controversial. To date, the indications that preclude laparoscopic splenectomy are not clearly defined. In view of this, the European Association for Endoscopic Surgery (EAES) has developed clinical practice guidelines for LS.
Methods An international expert panel was invited to appraise the current literature and to develop evidence-based recommendations. A consensus development conference using a nominal group process convened in May 2007. Its recommendations were presented at the annual EAES congress in Athens, Greece, on 5 July 2007 for discussion and further input. After a further Delphi process between the experts, the final recommendations were agreed upon.
Results Laparoscopic splenectomy is indicated for most benign and malignant hematologic diseases independently of the patient's age and body weight. Preoperative investigation is recommended for obtaining information on spleen size and volume as well as the presence of accessory splenic tissue. Preoperative vaccination against meningococcal, pneumococcal, and *Haemophilus influenzae* type *B* infections is recommended in elective cases. Perioperative anticoagulant prophylaxis with subcutaneous heparin should be administered to all patients and prolonged anticoagulant prophylaxis to high-risk patients. The choice of approach (supine [anterior], semilateral or lateral) is left to the surgeon's preference and concomitant conditions.

B. Habermalz · S. Sauerland · E. Neugebauer (✉)
Institute for Research in Operative Medicine,
University Witten/Herdecke, Witten/HerdeckeIFOM,
Ostmerheimer Straße 200, 51109 Köln,
Germany
e-mail: edmund.neugebauer@uni-wh.de

G. Decker
Department of Visceral and Thoracic Surgery,
Clinique Ste.Thérèse, Luxemburg, Luxemburg

B. Delaitre
Departement de Chirurgie, Hopital Cochin, Paris, France

J.-F. Gigot
Department of Abdominal Surgery and Transplantation,
St. Luc University Hospital, Louvain Medical School,
Brussels, Belgium

E. Leandros
First Department of Propaedeutic Surgery, Hippocrateion
Hospital, Athens, Greece

K. Lechner
Division of Haematology and Haemostaseology,
Medical University, Vienna, Austria

M. Rhodes
Department of Surgery, Norfolk and Norwich University
Hospital, Norwich, UK

G. Silecchia
Department of General Surgery "Paride Stefani," Policlinico
Umberto I, University La Sapienza, Rome, Italy

A. Szold
Department of Surgery B, Tel Aviv Sourasky Medical Center,
Tel Aviv, Israel

E. Targarona
Department of General and Digestive Surgery, Hospital Sant
Pau, Barcelona, Spain

P. Torelli
Department of Miniinvasive Surgery, Sanremo Hospital,
Sanremo, Italy

In cases of massive splenomegaly, the hand-assisted technique should be considered to avoid conversion to open surgery and to reduce complication rates. The expert panel still considered portal hypertension and major medical comorbidities as contraindications to LS.

Conclusion Despite a lack of level 1 evidence, LS is a safe and advantageous procedure in experienced hands that has displaced open surgery for almost all indications. To support the clinical evidence, further randomized controlled trials on different issues are mandatory.

Keywords Guidelines · ITP–Laparoscopic · Laparoscopy · Minimally invasive surgery · Splenectomy

Splenectomy is performed either as causal or symptomatic therapy for numerous indications. Patients with benign hematologic disorders especially can benefit from this procedure [1–3]. Formerly, open splenectomy represented the traditional therapy for normalizing platelet levels or for staging the extent of malignant disease. Since the first description of laparoscopic splenectomy (LS) in 1991 [4], it has been adopted as the standard technique for most indications for splenectomy throughout the world.

Most of reported data reflect good overall acceptance of the laparoscopic method, but they also show some disadvantages, such as longer operating times or limitations of this technique in cases of splenomegaly. These differences in difficult cases are less marked in more recent reports, probably due to technical improvements and growing experience of the staff performing LS. Although widespread clinical consensus exists for many aspects of LS, there is still uncertainty about some issues, especially the contraindications to LS. The European Association for Endoscopic Surgery (EAES) therefore perceived the need to hold a Consensus Development Conference (CDC) on LS and hence provide clinical practice guidelines.

Methods

The EAES scientific committee commissioned the planning group in Cologne to undertake a preliminary literature review. An expert panel constituted for a CDC in May 2007 consisted of nine surgeons, one hematologist, and three research scientists. Criteria for the selection of experts included clinical and scientific expertise and geographic location. It was decided that detailed indications for splenectomy and splenic trauma [5] were outside the remit of these guidelines.

A literature search via PubMed and the Cochrane Library was undertaken using the subject heading "splenectomy" in combination with the term "laparosc*" Additional searches were performed using the added terms "partial" "splenic cyst*" "splenic abscess" "pregnan*" "obes*" and "access*." The reference lists of the original literature also were screened. A total of 202 relevant publications were included in the literature review.

Studies were assigned the following levels of evidence (LoE) as defined in the grading scheme developed by the Centre for Evidence-Based Medicine in Oxford (http://www.cebm.jr2.ox.ac.uk): randomized controlled trials (RCTs, LoE 1), nonrandomized controlled clinical trials (CCTs, LoE 2), case series with nonconcurrent (i.e., historical) control groups (LoE 3), and simple case series (LoE 4). Only one RCT on splenectomy was found [6]. If comparison groups differed in important baseline characteristics (e.g., spleen size), the study was downgraded. Case reports were drawn into closer consideration only if they contributed to special aspects or contained implications on new procedures at that time. Lower-level studies were accepted for analysis only if higher-evel studies contained important flaws or were small in number or size.

The grade of recommendation (GoR) for each consensus statement was based on the quality of the scientific evidence and the views of the expert panel. The grades of recommendation are as follows: A (high-quality evidence [e.g,. RCTs] with consistent results and a positive risk-benefit ratio), B (medium-quality evidence [e.g., CCTs] or contradictory results of higher-quality studies), C (low-quality evidence [e.g., case series] or contradictory results of higher-quality studies including good clinical practice aspects in the case of lacking or low-quality evidence).

After the literature review and circulation of a questionnaire among the expert panel, provisional guidelines were drawn up and key questions highlighted for the CDC in Cologne. The provisional guidelines were sent to all members of the panel before the consensus meeting. At the CDC, the nominal group process was used to get a consensus. In one instance, consensus could not be obtained, and it is indicated as a minority statement in the guidelines. The statements were reformulated after the consensus meeting and sent out to the members of the expert panel for final approval. At the 15th annual congress of the EAES in Athens, Greece on 5 July 2007, the consensus statements were presented for further discussion and input, after which final guidelines were produced.

Recommendations

Choice of approach: laparoscopic versus open splenectomy

> The laparoscopic approach is preferable to the open approach for most indications because it reduces complications and shortens recovery (GoR B).

Although only one randomized controlled trial [6] has compared open splenectomy (OS) with LS, a widespread and common consensus maintains that the laparoscopic approach is superior to the open technique for almost all diseases requiring splenectomy (Table 1). Therefore, LS is considered the standard approach for most indications. Some limitations remain for patients with splenic trauma, splenomegaly, and serious medical comorbidity.

Laparoscopic splenectomy may be associated with longer operating times than OS. Although the duration of LS reported by different authors varies widely, there is a trend toward shorter operating times, which may be attributed to various technical improvements and a learning curve (LoE 3b) [7, 8]. Recent publications show no significant differences in operating times between LS and OS for normal-sized or moderately enlarged spleens (Table 1). Some studies have shown that operating time is directly correlated with spleen size [9], reporting a conversion rate of 100% for spleens with a longitudinal diameter larger than 27 cm. The issue of massive splenomegaly as a potential contraindication is discussed later.

Most authors report that intraoperative blood loss is less with LS. The rate of intraoperative complications appears to be similar regardless of approach. Postoperative complications after splenectomy include pulmonary complications such as pneumonia and atelectasis as well as intraabdominal and wound infections. The rates for those complications are reported to be lower with LS [9]. Especially in cases of autoimmune hematologic disorders, undetected accessory spleens could be the cause of disease recurrence. Some authors state that LS carries the risk of missing accessory spleens, but most data show detection rates comparable with those in OS [10–12].

Postoperative recovery is quicker after LS (LoE 3b) [7], and there is lower usage of postoperative analgesics. The time until return to normal activity (i.e., driving, work) is significantly shorter after LS (LoE 3b) [13]. Better cosmetic outcomes are achieved with LS.

For idiopathic thrombocytopenic purpura (ITP), the most common indication for elective splenectomy, the outcome is measured by the postsurgical platelet count. Studies have shown no significant difference between LS and OS (LoE 3b) [8, 14, 15]. Velanovich [16] reported on quality of life after laparoscopic surgery and found that laparoscopic surgery leads to faster improvements in general health, physical functioning, and bodily pain (LoE 3b).

Most authors agree that LS is an advanced laparoscopic procedure that, in the hands of an experienced surgeon, is a safe approach to splenectomy. They admit the existence of a learning curve, and many have reported that they have reached the limits of feasibility with the consequence of conversion mainly during the first laparoscopic approaches. The perception of a need for training to perform advanced laparoscopic surgery was shown by Rattner et al. [17] in an assessment of surgical residents' opinion (LoE 5). Some authors define the learning curve as a decrease in operating time [18–20], a decrease in conversion rate [20, 21], or a decrease in complication rate [22] that can be achieved after a minimum of 10 (LoE 4) [20] or 20 (LoE 4) [18] patients. Others have shown by comparing 25 cases of LS managed by experienced surgeons and the same number of LS cases managed by trainees under direct supervision of an experienced surgeon that there were no statistically significant outcome differences in terms of operative time, blood loss, intraoperative complications, need for transfusion, conversion rate, length of hospital stay, or postoperative complications (LoE 3b) [23]. A review by Dagash et al. [24] showed that no agreement exists concerning the number of operations a surgeon must perform to become "proficient" in different laparoscopic procedures (LoE 2a).

The costs of surgery include operating room costs, hospital costs, and societal costs (e.g., caused by lost workdays). Although operating room costs are higher with LS than with OS because of more expensive technical equipment, the use of disposable items, and maybe longer operating times, the total hospital charges are not significantly higher with LS (LoE 3b) [14, 25]. Total hospital charges may be even lower with LS due to a significantly shorter hospital stay (LoE 3b) [26]. Other authors have found that costs are related to age, spleen size, and major complications, but not to operative technique (LoE 3b) [7]. A thorough cost-effectiveness analysis still is needed.

Splenectomy for benign and malignant disorders

> Laparoscopic surgery is recommended for both benign and malignant disease (GoR B). In cases of splenomegaly, surgery may be more difficult and accompanied by more complications, thus requiring significant experience (GoR B).

Indications for LS are the same as for OS. Splenectomy can be applied to prevent the increased elimination of the blood's corpuscular elements and to relieve symptoms caused by an enlarged spleen, possibly including

Table 1 Studies comparing laparoscopic (LS) and open (OS) splenectomy in adults with normal-sized spleens[a]

Author, year, LoE	Indication, sample size	Group size	Spleen size[b,c]	Operative time (min)[c]	Blood loss (ml)[c]	Complications (%)	Accessory spleens (%)	Conversions (%)	Hospital stay (d)[c]	Return to oral diet (d)[c]
Sampath et al., 2007, 3b, [10]	ITP, $n = 105$	OS (54)	12 cm	103	NA	17	12	–	10	NA
		LS (51)	11 cm	156*		31	12	14	3*	
Kucuk et al., 2005, 3b, [187]	Diverse benign disease, $n = 60$	OS (38)	212 ± 156 g	81 ± 31	188 ± 94	16	5	–	5.1 ± 2.3	NA
		LS (30)	187 ± 132 g	148 ± 64*	216 ± 129	13	13	7	2.8 ± 1.2*	
Vecchio et al., 2005, 2b, [188]	ITP, $n = 40$	OS (20)	NA	NA	92 ± 8	0	NA	–	NA	NA
		LS (20)			46 ± 10*	0		0		
Berends et al., 2004, 3b, [11]	ITP, $n = 81$	OS (31)	11.4 cm (8–15)	103 (60–170)	725	26	13	–	8.9 (5–27)	NA
		LS (50)	11.9 cm (8–14)	159 (90–240)*	615	14*	12	22	5.5 (1–18)*	
Tanoue et al., 2002, 3b, [12]	ITP, $n = 90$	OS (41)	122 ± 65	100 ± 35	511 ± 375	46	12	–	20.1 ± 12.5	3.8 ± 1.9
		LS (49)	125 ± 123	198 ± 93*	187 ± 243*	11	11	0	9.6 ± 3.2*	1.3 ± 0.5*
Franciosi et al., 2000, 3b, [19]	Diverse benign disease, $n = 48$	OS (28)	382 ± 230 g	114 ± 24	215 ± 113	17	14	–	8.1 ± 1.5	3.0 ± 0.9
		LS (20)	365 ± 262 g	165 ± 41*	151 ± 69	10	10	5	4.1 ± 1.1*	1.5 ± 0.4*
Marassi et al., 1999, 3b, [156]	ITP, $n = 29$	OS (15)	181 g	90 (70–125)	223 (50–550)	13	93	–	8.7 (5–15)	2.8 (2–5)
		LS (14)	203 g	146 (105–245)	239 (50–700)	7	80	7	5.0 (3–7)*	2.0 (1–3)*
Glasgow & Mulvihill 1999, 3b, [26]	Not reported, $n = 31$	OS (11)	176 g (55–374)	162 (120–240)	462 (75–1000)	18	NA	–	6.3 ± 1.3	4.2 ± 1.0
		LS (20)	278 g (100–1400)	186 (120–275)	418 (75–1800)	5		10	2.6 ± 1.8*	1.7 ± 0.9*
Lozano-Salazar et al., 1998, 3b, [8]	ITP, $n = 49$	OS (27)	11 cm (8–15)[d]	162 ± 42	11%[e]	37	11	–	6 (3–44)	NA
		LS (22)	10 cm (7–15)[d]	270 ± 60*	9%[e]	27	9	18	4 (2–11)*	
Park et al., 1999, 3b, [189]	Diverse hematologic, $n = 210$	OS (63)	284 g (55–1250)	77	381 (10–2900)	35	5	–	9.2 (3–31)[d]	NA
		LS (147)	265 g (70–144)	145*	162 (5–1400)*	10	15	3	2.4 (1–17)[d]	
Shimomatsuya & Horiuchi, 1999, 3b, [190]	ITP, $n = 34$	OS (20)	NA	126 ± 52	321 ± 264	15	29	–	15.2 ± 5.8	NA
		LS (14)		203 ± 83*	560 ± 659	21	20	0	8.9 ± 2.9*	
Targarona et al., 1999, 3b, [126]	Diverse hematologic, $n = 109$	OS (43)	182 ± 80	102 ± 18	20%	25	NA	–	8 ± 3	NA
		LS (66)	180 ± 9	143 ± 50	17%	11		Excluded	3.7 ± 2.4*	
Baccarani et al. 1998, 3b, [191]	Hodgkin's lymphoma, $n = 55$	OS (40)	184 (70–480)	144 (80–240)	NA	NA	NA	–	6.7 (4–13)	3.2 (2–4)
		LS (15)	204 (100–410)	202 (120–360)*				0	4.4 (2–7)*	1.9 (1–3)*
Yuan et al., 1998, 3b, [192]	ITP or β-thalassemia, $n = 52$	OS (22)	10.0 ± 2.5 cm	114 ± 51	211 ± 124	23	18	–	6.8 ± 1.5	2.2 ± 0.9
		LS (30)	9.6 ± 2.0 cm	190 ± 79*	164 ± 110	10	17	3	4.1 ± 1.5*	0.6 ± 0.3*

Table 1 continued

Author, year, LoE	Indication, sample size	Group size	Spleen size[b,c]	Operative time (min)[c]	Blood loss (ml)[c]	Complications (%)	Accessory spleens (%)	Conversions (%)	Hospital stay (d)[c]	Return to oral diet (d)[c]
Diaz et al., 1997, 3b, [193]	Diverse hematologic, $n = 30$	OS (15)	492 ± 445 g	116 ± 64[d]	359 ± 318	40	20	–	8.8 ± 6.8	NA
		LS (15)	305 ± 247 g	196 ± 71[d,f,*]	385 ± 168	20	20	0	2.3 ± 1.5*	
Delaitre & Pitre, 1997, 3b, [194]	ITP and hemolytic anemia, $n = 56$	OS (28)	NA	127	$n = 13$	32	18	–	8.6	NA
		LS (28)		183	$n = 11$	11	11	11	5.1*	
Brunt et al., 1996, 3b, [195]	NA, $n = 46$	OS (20)	NA	134 ± 43	376 ± 500	30	5	–	5.8 ± 2.9	4.1 ± 3.0
		LS (26)		202 ± 55*	222 ± 280	23	12	0	2.5 ± 1.2*	1.4 ± 0.6*
Friedman et al., 1996, 3b, [155]	ITP, $n = 49$	OS (18)	167 ± 98 g	103 ± 45	285 ± 196	6	11	–	6.9 ± 3.0	3.2 ± 0.7
		LS (29)	184 ± 156 g	122 ± 54	203 ± 155	7	21	Excluded	2.9 ± 1.3*	1.2 ± 0.5*
Watson et al., 1997, 3b, [153]	ITP, $n = 60$	OS (47)	NA	87 (50–165)	13%[e]	19	15	–	10 (5–55)	NA
		LS (13)		88 (48–140)	0%[e]	0	6	0	2.1 (1–3)*	
Rhodes et al., 1995, 3b, [196]	Diverse hematologic, $n = 35$	OS (11)	255 g (94–5040)[d]	75 (40–130)[d]	NA	27	NA	–	7 (4–21)[d]	NA
		LS (24)	218 g (101–1538)[d]	120 (80–245)[d,*]		8		8	3 (2–7)[d,*]	
Schlinkert & Mann, 1995, 3b, [197]	ITP, $n = 21$	OS (14)	NA	68	NA	21	14	–	5	2.6
		LS (7)		154*		0	0	0	2.1*	0.7*
Yee et al., 1995, 3b, [198]	Benign hematologic, $n = 50$	OS (25)	157 ± 85 g	156 ± 30	273 ± 56	12	24	–	6.7 ± 2.5	4.3 ± 1.5
		LS (25)	148 ± 125 g	198 ± 60*	319 ± 89	8	4	16	5.1 ± 3.0	2.1 ± 1.5*

[a] Data is ordered according to level of evidence (LoE) and year of publication

[b] Data on spleen size is shown either as weight (in grams) or largest diameter (in cm). Only studies comparing spleens of similar size were included

[c] Data are means (± standard deviations) or means (range), unless indicated otherwise

[d] Data are medians with ranges

[e] Data are number of patients who required blood transfusion

[f] Including concomitant procedures

*$p < 0.05$, p-value is indicated only if data are available

abdominal distension, pain, and fullness or early satiety, or it may be used for staging purposes in cases of malignant diseases, although the latter has largely been replaced by other diagnostic means.

In cases of benign hematologic diseases, ITP is the most common indication and the cause for surgery in 50% to 80% of the patients treated by laparoscopic splenectomy [27, 28]. Laparoscopic splenectomy can be considered the method of choice for cases of refractory symptomatic thrombocytopenia after medical therapy, when toxic doses of steroids are required to achieve remission, or for relapse of thrombocytopenic purpura after the initial response to steroid therapy [14, 29]. Spleens in patients with ITP are normal sized or slightly enlarged, so these patients benefit from all the advantages of minimally invasive surgery.

Studies have shown that splenectomy is safe (LoE 2b) [27] and highly effective in terms of complete or partial remission. Its results are even superior to those for medical treatment due to high rates of complete remission in the absence of side effects related to medical therapy (LoE 3b) [1, 29, 30]. Other types of thrombocytopenic purpura (e.g., thrombotic or HIV-related; LoE 4) [7] also may be treated by splenectomy. Splenectomy also is indicated for hemolytic anemia including hereditary spherocytosis, major and intermediate thalassemia with secondary hypersplenism or severe anemia, and refractory autoimmune hemolytic anemia.

All surgeons in the panel strongly supported the laparoscopic approach, accepting the fact that only one randomized controlled trial had been conducted [6]. The hematologist in the panel expressed reservations about the overall superiority of laparoscopic surgery due to this lack of evidence.

> During laparoscopic splenectomy for autoimmune hematologic disorders (autoimmune thrombocytopenia, autoimmune hemolytic anemia), a routine search for accessory splenic tissue is recommended to avoid disease recurrence (GoR C).

The need for preoperative imaging to evaluate the existence of accessory spleens is not clear. In 2004, Napoli et al. [31] published a study of 22 patients who underwent multidetector row CT preoperatively. They found that CT correctly predicted the number and sites of accessory spleens, with a sensitivity of 100% (LoE 3b), compared with intraoperative findings.

Earlier studies presented lower rates or detection by CT. In a study of 58 ITP patients treated with LS, preoperative spiral CT, abdominal ultrasound examination, and in one patient scintigraphy were performed. The presence of accessory spleens was shown in three patients by CT but in none by US. One accessory spleen was first detected by CT, then confirmed by scintigraphy. Intraoperatively, three additional accessory spleens were found, and three other patients presenting postoperative signs of persistent splenic tissue were submitted to scintigraphy, which showed accessory spleens that had not been found either pre- or intraoperatively, giving an overall sensitivity of 43% for preoperative imaging (LoE 3b) [32].

After an initial study on accessory spleen detection (LoE 3b) [33], Gigot et al. [34] found that the results of preoperative localization studies have improved significantly since the development of high-resolution CT technologies. They reported a current detection rate of 100% by preoperative spiral CT irrespective of accessory spleen size. Meanwhile, they perform routine preoperative imaging at their institution.

A thorough search for accessory spleens during the LS surgical process provides detection rates similar to those for OS and therefore is obligatory [32, 33, 35, 36]. The highest detection rates can be achieved in combination with preoperative imaging [14].

Recently, Barbaros et al. [37] reported the use of a handheld gamma probe for intraoperative detection of accessory spleens during initial surgery and compared the results with preoperative CT and intraoperative findings (LoE 4) [37]. They found that the handheld gamma probe had a sensitivity of 100% for detecting accessory spleens in 2 of 17 patients, one of which had not been detected previously by CT. The existence of two accessory spleens indicated by preoperative CT scan could not be confirmed during surgery by exploration and gamma probe, nor did postoperative scintigraphy confirm any persistent splenic tissue. The authors concluded that the handheld gamma probe may be an adjuvant method for detecting accessory spleens.

These data suggest that with the technical advances of CT imaging, the preoperative detection rate and the localization of accessory spleens will increase. Nevertheless, a thorough search for splenic tissue during surgery is obligatory.

> For malignant hematologic diseases requiring splenectomy, laparoscopic surgery is recommended (GoR B). In cases of massive splenomegaly, the procedure may be more technically demanding but nevertheless feasible in experienced hands (GoR C).
>
> If the spleen is to be retrieved *in toto* for histopathologic evaluation or if tumor spillage is to be avoided, the hand-assisted laparoscopic splenectomy (HALS) port or alternatively an additional incision can be used for specimen retrieval (GoR C).

Malignant diseases involving the spleen may require splenectomy for therapeutic or diagnostic reasons [38]. Indications include hematologic malignancies such as myeloproliferative disorders (i.e., myelofibrosis),

lymphoproliferative diseases such as chronic lymphocytic leukemia with massive splenomegaly, autoimmune thrombocytopenia or autoimmune hemolytic anemia, hairy cell leukemia, and splenic lymphoma with villous lymphocytes, among others (LoE 4) [9, 39]. Because hematologic malignancies often result in splenomegaly [40, 41], the recommendations for splenomegaly apply (Table 2).

In cases of splenectomy for diagnostic or staging purposes, removal of the intact organ for pathologic examination may be necessary. This requires an additional incision of 8 to 10 cm [42], or alternatively, when HALS is performed, the spleen can be removed via the hand port device without an accessory incision [38] (Table 3).

Malignancies of primary splenic origin are very rare, comprising mostly lymphangiosarcomas, malignant vascular tumors such as hemangiosarcoma or malignant lymphoma [43]. Most splenic tumors are metastases (e.g., of malignant melanoma or ovarian cancer) [44].

Silecchia et al. [45] showed in a comparison of 24 patients with malignant disease and 52 patients with benign disease that LS in the former group was associated with longer operating times, partly because of concomitant procedures, larger spleen size, a higher conversion rate, and fewer intraoperative complications, but the difference did not reach statistical significance. They concluded that LS should be the preferred approach for splenectomy even for patients with malignant disease and splenomegaly (LoE 3b).

In 2004, Walsh et al. [46] compared the operative outcome of standard LS and HALS for 73 patients who had lymphoproliferative disease (LPD) with those for 86 patients who had ITP. They found that although patients presenting with LPD had significantly longer operating times, greater blood loss, and a longer hospital stay, there was no difference in morbidity. They stated that LS can be performed safely for patients with LPD, and that if HALS is used judiciously, the conversion and morbidity rates are low. In the case of organ removal for histopathologic evaluation, the spleen was divided inside the bag into pieces about 3 cm in size, which was regarded sufficient by their pathologist (LoE 3b).

Other authors state that LS for splenic malignancy can be performed using the same surgical techniques and considerations, but should allow an additional incision for removal of the intact specimen for histopathologic evaluation (LoE 4) [38, 43]. The clinical response of patients without hematologic disturbances is satisfactory [15].

For splenic vascular tumors, whose character is difficult to predict preoperatively, the use of the HALS technique offers the additional advantage of palpation and thus detection of further malignant lesions (e.g., in regional lymph nodes, pancreas, or stomach) (LoE 4) [43].

To avoid tumor spillage and port-site metastasis, meticulous care has to be taken during preparation and removal of the specimen. Placement of the spleen in a thick bag for morcellation or retrieval *in toto* is obligatory.

> For the removal of accessory spleens or splenosis, the laparoscopic approach is technically safe and feasible (GoR C).

Recurrence of the initial disease, mainly in ITP, can be due to remaining splenic tissue. This may be in the form of accessory spleens missed during the initial surgery or splenic implants that have developed as splenosis after splenic capsule injury and cell spillage during surgery. If remaining splenic tissue is detected, laparoscopic removal is a safe and feasible technique (LoE 4) [16, 32, 37, 47]. The choice of approach (i.e., lateral or semilateral) may be made according to the location of the accessory spleen or spleens.

> For partial splenectomy, the laparoscopic approach is feasible but rarely indicated for adults (GoR C).

The first reports of laparoscopic partial splenectomy appeared in 1994 [48]. Because the early and late complications of splenectomy (e.g., overwhelming postsplenectomy infection or thrombosis of the portal or splenic vein) are potentially life threatening, the development of spleen-sparing techniques has been pressed ahead [49]. Indications include nonparasitic cysts, benign tumors [49], splenomegaly of unknown origin [48, 49], and single metastasis [48]. Although new magnetic resonance imaging (MRI) techniques have improved the diagnosis and evaluation of focal splenic lesions [50], preoperative differentiation sometimes remains difficult. For a series of 38 patients who underwent laparoscopic partial splenectomy for different indications, Uranues et al. [48] described their technique of resecting spleen parts that involved first sealing the corresponding vessels with ultrasonic shears or LigaSure™, Valleylab (Boulder, CO) then applying slow and atraumatic compression to the parenchyma with a grasper, with special care taken not to tear the capsule. The part of the spleen to be resected was cut by using multiple applications of an endostapler. The raw edge then was sealed using fibrin and collagen fleece. No perioperative mortality occurred in this series. Three patients received packed erythrocytes, and two procedures required conversion to open surgery because of bleeding. These authors concluded that partial splenectomy can be performed quickly and safely as a laparoscopic procedure (LoE 4).

Some authors have reported that because of the spleen's segmental blood supply, resection of parts of the organ after segmental devascularization using electrocautery or ultrasonic scissors is feasible and safe (LoE 4) [49, 51, 52]. The resection surface may be sealed using the argon beamer and fibrin glue (LoE 4) [49].

If surgery for a splenic cyst is indicated, the laparoscopic approach is recommended for adults (GoR C).

Splenic cysts can be of parasitic or nonparasitic origin. Depending on whether the cyst wall has an epithelial lining, they can be subdivided into primary (i.e., true) or secondary splenic cyst (i.e., pseudocyst). Nonparasitic splenic cysts account for about 75% (range, 50–80%) of cystic spleen lesions and are mostly pseudocysts because of prior trauma to the abdomen [53–55]. Primary nonparasitic cysts are regarded as congenital [56].

Most cysts are asymptomatic. If symptoms evolve, they are vague and appear when the cyst has reached a certain size.The symptoms include abdominal pain, fullness, nausea, vomiting, flatulence and diarrhea, and irritation of the left diaphragm followed by cough or pneumonia. Occasionally, cysts present by hemorrhage, infection, or rupture [57].

The indication for surgical treatment of nonparasitic cysts in adults is not clearly defined, and because of small patient numbers in published studies, the evidence is controversial. Some authors state that cysts with a diameter exceeding 5 cm and any symptomatic or complicated cysts should be treated by spleen-preserving resection (e.g., partial splenectomy, cystectomy, or cyst decapsulation) [56].

Whereas splenectomy historically was the treatment of choice for splenic cysts, currently, spleen-conserving techniques are promoted. These procedures carry the risk of cyst recurrence, especially in cases of primary cysts with epithelial lining. The definite character of a cyst and whether the cyst wall has an epithelial lining can be determined only by pathology, so some authors advocate the intraoperative frozen section to determine further surgical strategies [56].

In a small study of 15 patients, Mertens et al. [56] found that postoperative complications occurred only with open surgery and not after laparoscopic treatment. They propose laparoscopic partial splenectomy for primary cysts or, alternatively, a laparoscopic decapsulation with destruction of the remaining cyst wall, although the risk of recurrence is not clear.

Czauderna et al. [58] reported that in a study of 50 children with nonparasitic splenic cysts, laparoscopic removal of the cyst was associated with a higher rate of complications and recurrence than open surgery.

For splenic abscess, LS is feasible but technically more difficult, depending on the degree of surrounding inflammation with vascular adhesions and fibrous attachments. The evidence on this issue is very scarce, but findings of one study have shown the laparoscopic approach to be a safe and effective treatment [59].

Splenic artery aneurysms, the most common visceral artery aneurysms, have a prevalence of 0.04% to 0.1%, which is increased up to 20% for patients with portal hypertension and cirrhosis. Most aneurysms are located at a bifurcation in a middle or distal segment of the splenic artery and present as multiple aneurysms in 20% of the cases [60].

Treatment is indicated if aneurysms become symptomatic and cause symptoms such as abdominal pain or back pain, in women of childbearing age, in the presence of portal hypertension, before liver transplantation, if the diameter exceeds 2 cm [61, 62] or 2.5 cm, and in the case of pseudoaneurysms regardless of size [60]. Asymptomatic aneurysms that show tendencies to enlargement also should be treated.

Spleen-preserving techniques such as endovascular splenic arterial interventions can be applied in most cases of splenic arterial aneurysms. However, surgical intervention by either laparoscopic exclusion of the aneurysm or (partial) splenectomy is necessary if other interventional techniques are not applicable.

Laparoscopic splenectomy in splenomegaly

Splenomegaly should be defined in metric terms by preoperative imaging.
From a surgical perspective, splenomegaly is defined by a maximum splenic diameter exceeding 15 cm (No GoR). A maximum splenic diameter exceeding 20 cm should be considered as indicating a massive splenomegaly (No GoR).

Management of splenomegaly is controversial. Although the presence of splenomegaly has long been considered a relative or absolute contraindication for LS, later reports indicate that laparoscopic management is feasible and should be attempted for spleens of almost any size (LoE 3b [63, 64]) (Table 4). The healthy spleen in adults measures approximately 11 × 7 × 4 cm and weighs 100 to 250 g (wet spleen weight). The literature presents no unanimous use of the terms "splenomegaly" or "massive splenomegaly," and some authors use terms such as "giant," "supermassive," and "supramassive" for very large organs. For the purposes of these guidelines, splenomegaly is defined as a long axis exceeding 15 cm, and massive splenomegaly as a long axis exceeding 20 cm. These definitions were unanimously agreed upon by the panel.

A definition by weight does not seem appropriate because the weight can be obtained only postoperatively and has no predictive value for the choice of surgical approach. Additionally, in a study of 58 porcine spleens, Walsh et al. [65] found that the morcellated weight of the spleen, as described by most authors when presenting their results, by far underestimates the weight of the intact

specimen. A categorization of spleen size by morcellated weight is difficult and inaccurate. Therefore, the size of the spleen should be evaluated in terms of centimeters before surgery. Some authors consider the spleen longitudinal diameter to be a reasonably predictive parameter [9, 39]. However, because of the spleen's shape, the term "maximum diameter" seems more appropriate.

Ultrasonic measurement can provide reliable information [39, 66–69]. Computed tomography also can be used, although it is more cost intensive and does not provide significant advantages for the determination of splenic size. Although new MRI techniques offer very good results in the detection and characterization of pathologic spleen conditions [50], it does not play a significant role in the preoperative evaluation of splenic size because of higher costs and lower availability in certain countries.

> For splenomegaly (but not massive splenomegaly), LS still is safe and preferable to OS in experienced hands (GoR B)

Most studies of LS in splenomegaly have shown that LS is associated with longer operative times, increased blood loss, more perioperative complications, a longer hospital stay, and higher conversion rates (LoE 2b) [70] than LS for normal-sized spleens. One study of 142 patients found no statistically significant differences for perioperative complications and length of hospital stay (LoE 3b) [64]. Still, strong evidence suggests that LS is superior to open splenectomy for this group of patients (Table 2).

> In case of massive splenomegaly (diameter, >20 cm), hand-assisted laparoscopic or open splenectomy should be considered (GoR C) because the larger the spleen, the more likely the need for open surgery.

For spleens larger than a certain size, LS becomes more technically challenging. While some authors set the boundary at more than 600 g [63, 71–73], most regard more than 1,000 g as more relevant [22, 74–77]. Disagreement also exists about the use of preoperative imaging to establish splenic size. Some authors set the boundary at a longitudinal diameter greater than 15 cm [39, 78, 79], whereas others use a boundary of 16 cm [73], 17 cm [63, 72], or 20 cm [42, 80].

Sometimes the term "giant spleen" or "supermassive splenomegaly" (>22 cm or >1,600 g [63, 64, 72, 73]) has been used to describe even larger spleens. Laparoscopic resection in the setting of massive splenomegaly is challenging because of the limited abdominal working space and the difficulty of intraabdominal manipulation and retrieval of the large organ.

Some authors have found that all spleens with a longitudinal diameter exceeding 27 cm (LoE 3b) [40] or 30 cm [81] have required conversion to open splenectomy when the purely laparoscopic approach was attempted and thus have suggested the use of HALS (see later). Others have suggested HALS for all spleens with a width exceeding 19 cm and a length greater than 22 cm [64, 72] or 23 cm [28, 38]. Operative difficulty, as measured by operation time, blood loss, and conversion rate, becomes greater as splenic weight and size increase. Studies show poorer operative results with spleens weighing more than 500 g (LoE 3b [41]) or 1,000 g (LoE 3b) [39]. In a series of 60 patients, Terrosu et al. [82] found a shorter operative time for LS used to manage spleens of normal size compared with LS for spleens as large as 2,000 g, but detected no further statistically significant differences. They defined the limitation for LS at a spleen weight of 2,000 g or a size of 23 cm (LoE 3b). One group suggested the open approach for all spleens with an estimated weight exceeding 1,000 g or a longitudinal diameter exceeding 20 cm (LoE 3b) [39].

Hand-assisted laparoscopic splenectomy

> Hand-assisted laparoscopic splenectomy (HALS) is a valid approach (GoR B). It should be considered to avoid conversion to open surgery (GoR B).
> For massive splenomegaly, HALS is recommended as a primary procedure because it shortens operative time and minimizes intraoperative blood loss (GoR B).

Hand-assisted laparoscopic splenectomy is a modification of LS. For this approach, most authors prefer the patient to be positioned in a semilateral or 45° right lateral decubitus position on the operating table [73]. An additional incision 7 to 8 cm long is made, large enough to allow the surgeon's hand and forearm to pass. It may be located in the upper midline or the right upper abdomen [72, 76, 83, 84], or alternatively at the McBurney or Pfannenstiel site [85]. The location of the incision site can be varied depending on the size of the spleen. At the chosen site, a hand port device can be used that allows the surgeon to insert the nondominant hand into the abdomen while maintaining pneumoperitoneum.

Some authors report performing the procedure without the hand port device by inserting a hand through the additional incision [86] and tightening the skin around the wrist with a towel clamp [87]. The inserted hand allows for tactile feedback and can assist in the surgical process during dissection, retraction, and placement of the enlarged spleen into the retrieval bag. Furthermore, unexpected situations such as hemorrhage or adhesions can be controlled. The spleen then can be removed via the additional incision, often without morcellation. Possible disadvantages include

Table 2 Comparison studies on OS versus LS in adults with splenomegaly[a]

Author, year, LoE	Indication, sample size	Group sizes	Spleen size[b,c]	Operative time (min)[c]	Blood loss (ml)	Complications (%)	Accessory spleens	Conversions (%)	Hospital stay (d)[c]	Return to oral diet (d)[c]
Konstadoulakis et al., 2006, 1b, [6]	β-thalassemia, $n = 28$	OS (14)	631 ± 353 g[d]	135 ± 23[d]	14%[e]	14	NA	–	6.5 ± 1.2[d]	NA
		LS (14)	685 ± 274 g[d]	188 ± 42[d,*]	64%[e]	21		21	5.0 ± 2.4[d,*]	
Watanabe et al., 2007, 3b, [199]	Hypersplenism, $n = 53$	OS (28)	460 ± 200 g	205 ± 60	750 ± 600[c]	36	NA	–	NA	NA
		LS (25)	525 ± 300 g	173 ± 53	359 ± 280[c,*]	28		16[f]		
Boddy et al., 2006, 3b, [39]	Diverse hematologic, $n = 29$	OS (18)	2448 g (1025–6000)[d]	45 (25–85)[d]	65 (0–1635)[d]	11	NA	–	7 (5–44)[d]	NA
		LS (11)	2000 g (1000–3530)[d]	90 (45–255)[d,*]	800 (20–5120)[d,*]	18		55	6 (2–8)[d]	
Owera et al., 2006, 3b, [200]	Diverse hematologic, $n = 28$	OS (13)	1100 g (1000–3800)[d]	90 (70–120)[d]	NA	31	NA	–	10 (6–20)[d]	3 (2–5)[d]
		LS (15)	1300 g (1000–3600)[d]	175 (120–270)[d,*]		13		7	3 (2–40)[d,*]	1 (1–3)[d,*]
Donini et al., 1999, 3b, [7]	Diverse hematologic, $n = 100$	OS (56)	732 ± 1112 g	133 ± 42	347 ± 511[c]	23	9%	–	7.2 ± 2.1	3.6 ± 0.8
		LS (44)	773 ± 1184 g	130 ± 62	295 ± 279[c,*]	7	9%	2*	5.1 ± 2.7*	1.7 ± 0.8*
Glasgow & Mulvihill 1999, 3b, [26]	Not reported, $n = 31$	OS (11)	176 (55–374)[e]	162 (120–240)[e]	462 (75–1000)[c]	18	NA	–	6.3 ± 1.3	4.2 ± 1.0
		LS (20)	278 (100–1400)[e]	186 (120–275)[e]	418 (75–1800)[c]	5		10	2.6 ± 1.8	1.7 ± 0.9
Targarona et al., 1999, 3b, [126]	Diverse hematologic, $n = 36$	OS (18)	642 ± 160	103 ± 60	33%[e]	40	NA		12 ± 6	NA
		LS (18)	670 ± 184	179 ± 77*	22%[e]	27		Excluded	5 ± 2*	
Targarona et al., 1999, 3b, [126]	Diverse hematologic, $n = 41$	OS (20)	2713 ± 1097 g	111 ± 19	40%[e]	55	NA	–	12 ± 5	NA
		LS (21)	1762 ± 1150 g	176 ± 56*	33%[e]	27		Excluded	6 ± 3*	

[a] Data is ordered according to level of evidence (LoE) and year of publication

[b] Data on spleen size is shown either as weight (in grams) or largest diameter (in cm)

[c] Data are means (± standard deviations) or means (range), unless indicated otherwise

[d] Data are medians with ranges

[e] Data are number of patients who required blood transfusion

[f] Conversions from laparoscopic to a hand-assisted or open approach were taken together

* $p < 0.05$, p-value is indicated only if data are available

Table 3 Studies comparing laparoscopic splenectomy between in malignant versus benign disease

Author, year, LoE	Sample size	Group sizes	Spleen size[a,b]	Operative time (min)[b]	Blood loss (ml)	Complications (%)	Accessory spleens (%)	Conversions (%)[e]	Hospital stay (d)[b]	Return to oral diet (d)[b]
Casaccia et al., 2006, 3b, [201]	$n = 379$	Malign. $n = 144$	1844 ± 1185 g*	151 ± 52	35%[d]	18	10	13	6.1 ± 2.2*	NA
		Benign $n = 235$	676 ± 522 g	134 ± 55*	25%[d]	22	7	4	4.9 ± 2.7	
Silecchia 2006, 3b, [45, 201]	$n = 76$	Malign. $n = 24$	18.1 ± 5.8 cm	151 ± 34	8.30%[d]	12.5	NA	8.3	5.9 (3–10)	2
		Benign $n = 52$	13.7 ± 3.2 g cm	138 ± 43.5	3.80%[d]	5.7		3.8	5.5 (2–11)	2
Walsh 2004, 3b, [46, 201]	$n = 159$	Malign. $n = 73$	680 g (65–3500)[c]	148[c]	200[c]	8	12	15	3[c]	NA
		Benign $n = 86$	162 g (33–493)[c,*]	126[c,*]	100[c,*]	8	13	1*	2[c]	
Knauer et al., 2003, 3b, [27]	$n = 131$	Malign. $n = 30$	1295 ± 859 g	190 ± 43	1060 ± 1293[b]	20	NA	40	6.3 ± 5.7	3.8 ± 2.9
		Benign $n = 101$	191 ± 176 g	139 ± 42	382 ± 593[b]	10		6	3.5 ± 5	1.5 ± 0.8
Berman et al. 1999, 3b, [41]	$n = 53$	Malign. $n = 22$	930 g (32–1352)[c]	203 (150–300)[c]	600 (150–4100)[c]	32	NA	41	4 (3–24)[c]	NA
		Benign $n = 31$	164 g (190–3500)[c,*]	155 (109–265)[c,*]	125 (50–3000)[c,*]	9		3*	2 (1–11)[c,*]	
Schlachta et al., 1999, 3b, [40]	$n = 64$	Malign. $n = 14$	17.0 cm[c,*]	239 ± 73[c,*]	100[c]	18	NA	21	3[c]	NA
		Benign $n = 50$	11.0 cm[c]	180 ± 61[c]	165[c]	11		6	3[c]	
Targarona et al., 1999; LoE 3b, [126]	$n = 105$	Malign. $n = 28$	1441 ± 1000 g*	170 ± 59	32%[d]	25	NA	14	5 ± 2.4	NA
		Benign $n = 77$	331 ± 458 g	150 ± 50	20%[d]	14		5	4 ± 2.3	
Decker et al., 1998, LoE 3b, [66]	$n = 35$	Malign. $n = 13$	1420 ± 850 g	235 ± 67	NA	15	NA	23	4.5[c]	NA
		Benign $n = 22$	160 ± 387 g	173 ± 67		22		0	5.0[c]	

[a] Data on spleen size is shown either as weight (g) or largest diameter (cm)

[b] Data are means (± standard deviations) or means (range), unless indicated otherwise

[c] Data are medians (with ranges)

[d] Data are number of patients who required blood transfusion

[e] Conversions from laparoscopic only to open approach were recorded

* $p < 0.05$, p-value is indicated only if data are available

Table 4 LS in splenomegaly versus normal-sized spleens

Author, year, LoE	Patients/splenomegaly	Spleen size[a,b]	Operative time (min)[b]	Blood loss (ml)[b]	Hospital stay (d)[b]	Conversion rate (%)	Complications (%)	Use of HALS/ accessory incision (%)
Pugliese et al., 2006, 3b, [70]	$n = 45$, <15 cm	13 cm (9–15)[c] 110 g (90–400)[c]	110 (70–135)[c]	55 (20–80)[c]	4,4 (2–39)[c]	0	4,4	NA
	$n = 30$, >15 cm	19 cm (16–30)[c,*] 680 g (400–2500)[c,*]	135 (95–170)[c,*]	105 (45–250)[c,*]	9 (4–18)[c]	6.7	20	NA
Heniford et al., 2001, 3b, [64]	$n = 82$, <150 (morcellated weight)	118 g (48–140)	127 (60–225)	123 (10–1000)	2,4 (1–7)	2.4	6,1	NA
	$n = 60$, >500g*	983 g (500–4750)	172 (90–369)*	173 (25–1500)*	2,7 (1–17)	3.3	8,3	16.7 (>22 cm/1600 g)
Terrosu et al., 1998, 3b, [202]	$n = 27$	175 g (90–410)	117 (42–200)	228 (0–1100)	5 (2–18)	3.7	8	0
	$n = 8$, >500 g	1762 g (500–3680)	197 (110–300)	393 (100–800)	6 (4–12)	0	12,5	75 (Pfannenstiel)
Terrosu et al., 2002, 3b, [82]	$n = 40$	166 ± 83 g 7–14 cm	110 ± 52	219 ± 232	4,6 ± 2,6	5	5	
	$n = 20$, >500 g	2200 ± 1280 g 14–42 cn	163 ± 56	569 ± 393	5,6 ± 2,5	20 (includ. all >2000 g)	20 (mortality) = 5%	75 (Pfannenstiel)
Targarona et al., 1998, 3b, [22]	Group I, <400 g $n = 52$	177 ± 90 g[$]	146 ± 49	16%[d]	4 ± 3	3.9	11.5	18
	Group II, 400–1000 g $n = 9$	638 ± 163g***	184 ± 103	33%[d]	5 ± 2	0	22.7	22
	Group III, >1000 g $n = 13$	1616 ± 651 g	190 ± 69	30%[d]	6 ± 4	23.1		100

[a] Data on spleen size is shown as weight (g) and/or largest diameter (cm) p-value is indicated only if data are available

[b] Data are means (± standard deviations) or means (range), unless indicated otherwise

[c] Data are medians (with ranges)

[d] Data are number of patients who required blood transfusion

[e] Conversions from laparoscopic only to open approach were recorded

p-value is indicated only if data are available, HALS = hand-assisted laparoscopic splenectomy

[$] $p < 0.01$ versus Group II and III

* $p < 0.05$; *** $p < 0.01$ versus Group III

Table 5 Comparison between HALS and pure LS

Author, year, LoE	Patients	Spleen size[a,b]	Operative time (min)[b]	Blood loss (ml)[b]	Hospital stay (d)[b]	Conversion rate (%)	Complications (%)	HALS size/location
Rosen et al., 2002, 3b, [76]	$n = 14$ HALS	1516 g	177	602	5,4	7	35.7	7 cm upper midline
	(>22 cm)							
	$n = 31$	1031 g*	186	376	4,2	23	19.4	
	LS							
Ailawadi et al, 2002, 3b, [87]	$n = 22$ HALS	1394 g (570–1937)[c]	161 (130–191)[c]	325 (150–1000)[c]	3 (2.75–5)[c]	13.6	18	6–8 cm upper midline
	(>500g)							
	$n = 19$	740 g (550–1320)[c]	212 (171–253)[c,*]	550 (262–1725)[c]	4,5 (2–7)[c]	36.8	32	
	LS							
Wang et al., 2007, 3b, [90]	$n = 20$	1346 g (750–4800)	141 (95–280)	86 (30–350)	7,4 (5–9)	0	0	7–8 cm upper midline or right subcostal region
	HALS							
	$n = 16$	1185 g (720–3900)	195 (110–320)*	138 (60–550)*	5.3 (3–13)*	25*	2	
	LS							
Kaban et al., 2004, 4, [71]	$n = 54$ HALS	1017 ± 614	138 ± 64	218 ± 224	4.8 ± 2.7	3	24 mortality 5%	~7 cm upper midline
Meijer et al., 1999, 4, [85]	$n = 22$ HALS	NA	89 (45–120)[c]	230 (30–600)[c]	3.9	4,5	4.5 (=death)	7–8 cm McBurney/ Pfannenstiel
Borazzo et al., 2003, 4, [84]	$n = 16$ HALS	2008 g (543–4090)	240 (165–360)	425 (100–1800)[c]	3.3 (2–7)	0	6.25	7.5 cm upper midline, right upper abdomen
Backus et al., 2000, 4, [73]	$n = 8$ HALS	24–28 cm	153	135	2	0	0	6–8 cm upper midline
Hellman et al., 2000, 4, [83]	$n = 7$ HALS	3500–5800 g	133 (110–155)	500[d]	7 (5–13)	14.3	28.6 no mortality	7.5 (6.5–8.5) cm/upper midline, right upper abdomen

p-value is indicated only if data are available

[a] Data on spleen size is shown as weight (g) or largest diameter (cm)

[b] Data are means (± standard deviation) or means (range), unless indicated otherwise

[c] Data are medians (with ranges)

[d] Only patients that have not been converted to open surgery ($n = 5$)

* $p < 0.05$

Table 6 Comparison studies on OS versus LS in pediatric patients[a]

Author, year, LoE	Indication, sample size	Group sizes	Age[b] (a)	Spleen (g)[b]/ splenom egaly (%)	Operative time (min)[c]	Blood loss (ml)[c]	Complications (%)	Accessory spleens (%)	Conversions (%)	Hospital stay (d)[c]
31Qureshi et al., 2005, 3b, [165]	Diverse, $n = 140$	OS (59)	10.9 ± 0.6	509 ± 110 g	122 ± 8[e]	76 ± 14	0	10	–	4.1 ± 0.3
		LS (81)	11.9 ± 0.5	308 ± 45	201 ± 10[e,*]	61 ± 8	1	15	15[f]	2.4 ± 0.1*
Minkes, 2000 et al., 3b, [167]	Diverse, $n = 52$	OS (8)	11.8 (2–17)	47%	NA	50[d]	13	12	–	4.0 ± 1
		LS (35)	9.4 (1–17)	31%		50[d]	15	29	2.9[f]	1.8 ± 1*
Rescorla et al., 1998, 3b, [168]	Diverse, $n = 82$	OS (32)	6.9	NA	83[e]	49	NA	25	–	2.5 ± 1.43
		LS (50)	7.8		115[e,*]	54	6	18	0	1.4 ± 0.97*
Curran et al., 1998, 3b, [177]	Diverse benign, $n = 14$	OS (7)	8.9 (5–13)	NA	86 (50–115)	34	NA	NA	–	4[d]
		LS (7)	8.7 (2–13)		147 (115–190)	41*	NA		0	2[d,*]
Farah et al., 1997, 3b, [169]	Diverse benign, $n = 36$	OS (20)	9.7	NA	84 (42–174)[e]	78	30	25	–	4.9 (3–9)
		LS (16)	10.3		138 (96–180)[e,*]	74	63	0	6,25	3.6 (2–7)*
Waldhausen & Tapper, 1997, 3b, [178]	Diverse, $n = 20$	OS (10)	8.3 (4–17)	276 g	90	34	0	20	–	3.3 (2.8–5.0)[d]
		LS (10)	10.3 (4–17)	276 g	211*	99	0	20	0	2.6 (1.8–3.8)[d]
Esposito et al., 1997, 3b, [183]	Diverse, $n = 16$	OS (8)	6.4 (4–11)	400–1400	100 (50–155)[e]	NA	13	NA	NA	4.7 (3–9)
		LS (8)			170 (125–240)[e]		0			3 (2–5)
Hicks et al., 1996, 3b, [170]	Diverse, $n = 21$	OS (10)	8.0 (NA)	NA	112	86	60	NA	–	5.3
		LS (11)	9.8 (2–119)		147	32	27		9.1	3.6
Janu et al., 1996, 3b, [171]	Diverse, $n = 61$	OS (47)	1–15	NA	81 (33–145)[e]	NA	26	NA	–	3.6 (2–8)
		LS (14)			187 (151–235)[e,*]		14		7.1	2.7 (1–6)
Yoshida et al., 1995, 3b, [172]	HS/ITP, $n = 19$	OS (11)	8.5 ± 2.7	145 ± 15	101 ± 8	73 ± 11	0	NA	–	10.4 ± 0.5
		LS (8)	8.8 ± 3.8	182 ± 22a	226 ± 24[e,*]	100 ± 39	0	50	25	6.8 ± 0.6*

LoE Level of evidence; NA, not available; HS, hereditary spherocytosis; ITP, idiopathic thrombocytopenic purpura

[a] Data is ordered according to level of evidence (LoE) and year of publication

[b] Data on spleen size is shown as weight (g) or largest diameter (cm)

[c] Data are means (± standard deviation) or means (range), unless indicated otherwise

[d] Data are medians (with ranges)

[e] Incl. concomitant procedures

[f] Conversion due to splenomegaly

*$p < 0.05$, p-value is indicated only if data are available

Table 7 Topics of LS that should be investigated by clinical trials

HALS vs open surgery in very large spleens
True incidence and clinical importance of portal (and/or splenic) vein thrombosis after LS
Choice of patient positioning: comparison of anterior, semilateral and lateral approaches for LS
Substances and duration of antibiotic prophylaxis for the prevention of postsplenectomy infection
Clinical interest of accessory spleens
Feasibility of LS in portal hypertension if surgery is inevitable
Means of pre-operative imaging for detection of accessory spleens
Advanced bipolar and ultrasonic coagulation devices for occlusion of the hilar vessels

HALS, hand-assisted laparoscopic splenectomy

the space taken up by the surgeon's hand or forearm that can hamper certain maneuvers and hand fatigue, reported by 21% of the surgeons [88, 89].

Many studies have shown that HALS in cases of splenomegaly results in shorter operating times, lower conversion rates, and fewer perioperative complications (i.e., bleeding of hilar structures or parenchyma) than with the purely laparoscopic approach (LoE 3b [41, 76, 87, 90, 91], LoE 4 [84, 92], Table 5). In a series of 56 patients with splenomegaly, Targarona et al. [91] showed a significantly shorter hospital stay in the HALS group than in the purely laparoscopic group due to fewer complications (LoE 3b). Although an additional incision is required, thereby causing more trauma to the abdominal wall, HALS maintains the benefits of classic laparoscopic surgery such as short hospital stay, early resumption of an oral diet, and less postoperative pain compared with OS (LoE 3b) [63, 72, 86].

In a study of 26 patients who underwent HALS with the hand port device located in a low transverse abdominal incision, Maartense et al. [92] showed that the operating times were comparable with those for the purely laparoscopic approach, and that the morbidity rates were comparable with those for purely laparoscopic and open surgery. But they noted the development of wound-related complications in four cases (13%), including incisional hernias at the hand port site in two cases (7.7%) (LoE 4).

Some authors suggest the use of HALS for any spleen with a longitudinal diameter exceeding 22 cm (LoE 3b [72, 76]), but not for normal-sized spleens (LoE 4 [88, 89, 91, 92]). In very rare cases of splenectomy, in combination with simultaneous procedures such as kidney transplantation, the HALS technique may allow for surgery via the hand port incision (LoE 4 [93].

Limits of the laparoscopic approach

> Portal hypertension from liver cirrhosis still should be considered a contraindication to LS (GoR C).

Although some data exist to show that LS can be performed safely and successfully for patients with liver cirrhosis, the panelists still considered portal hypertension a contraindication to the laparoscopic approach (LoE 3b [38, 79]; LoE 5 [83]).

Portal hypertension with gastric varices increases the risk of intraoperative hemorrhage (LoE 4) [94]. In 2005, Cobb et al. [95] studied 50 patients with liver cirrhosis who underwent different laparoscopic procedures in their institution. They found that the procedures were technically more challenging due to the frequent coexistence of portal hypertension, varices, and thrombocytopenia. In eight cases of LS, they found a mean operative time of 192 min, a mean estimated blood loss of 193 ml, and a mean hospital stay of 3.5 days. They concluded that besides the higher risk of bleeding, basic and advanced laparoscopic procedures are safe for patients with mild to moderate (Child-Pugh classification A and B) cirrhosis of the liver (LoE 4).

Hashizume et al. [96] reported on a series of 73 patients with portal hypertension who underwent laparoscopic splenectomy in 2002. They observed a conversion rate of 4.1% due to bleeding, a mean operative time of 210 ± 102 min, and an estimated blood loss of 375 ± 352 ml. In conclusion, they considered the laparoscopic approach not only to be a safe and well-tolerated procedure, but the procedure of choice (LoE 4).

In 2005, Ohta et al. [94] published an analysis of risk factors for massive intraoperative bleeding (>800 ml) during LS. In the multivariate analysis, portal hypertension and Child class were independent risk factors, whereas univariate analysis showed that significant risk factors are liver cirrhosis, portal hypertension, splenomegaly, Child class, and preoperative platelet count. These authors stated that careful attention to intraoperative bleeding during laparoscopic splenectomy is necessary (LoE 4).

> With the advent of increased laparoscopic surgery for morbid obesity (body mass index [BMI] > 35), morbid obesity is not a contraindication to laparoscopic splenectomy (GoR C).
> Laparoscopic splenectomy is an attractive approach because the potential benefits are greater for obese patients (GoR C).

Morbid obesity may lead to technical difficulties during surgery due to reduced intraabdominal working space and worse visualization. Weiss et al. [97] reported an increased

blood loss, but no further significant differences in operative time, length of stay, or complication rates related to BMI. Nevertheless, the laparoscopic approach should be chosen whenever possible because obese patients especially profit from lower complication (e.g. wound infection) rates related to the laparoscopic approach (LoE 3b) [97]. In contrast to this, Delaitre et al. [20] reported a significantly higher conversion rate (37.9%) for obese patients.

To evaluate the impact of morbid obesity on outcome for LS, Weiss et al. analyzed the data for 112 patients classified into groups by BMI before they underwent LS. These authors reported statistically significant longer operative times for the group with a BMI greater than 40. The complication and conversion rates also were higher, but this difference did not reach statistical significance. None of the aforementioned differences could be shown between the groups with a BMI less than 30 and those with a BMI of 30 to 40. Intraoperative blood loss was similar in all three groups (LoE 3b) [98].

> In the absence of major comorbidities, advanced age is not a contraindication to LS (GoR B).

The patient's age itself is not a hindrance to LS, but success of surgery is strongly dependent on coexisting clinical features resulting in a worse American Society of Anesthesiology (ASA) score (e.g., cardiovascular diseases (LoE 2b) [81]. After LS performed for elderly patients (age, >65 years), who usually present with higher ASA scores, a significantly longer hospital stay and a greater number of complications could be noted (LoE 2b) [81, 99].

> It generally is recommended that surgery be postponed during pregnancy (GoR C), although successful LS for pregnant women has been reported.

Pregnancy has long been considered a contraindication to laparoscopy, and no large series exist to provide evidence. Some case reports have shown that laparoscopic procedures can be performed safely during pregnancy. The need for urgent splenectomy during pregnancy is rare, indications, for example, can include hemolytic crisis in hereditary spherocytosis (LoE 4) [97]. Some authors propose that LS may be preferred to OS because the advantages of the minimally invasive approach and the lower preterm labor rates are especially beneficial for both the patient and the fetus [100, 101].

If possible, surgery should be scheduled for the second trimester of pregnancy because the risk of fetal loss then is lower. Additionally, the gravid uterus has not yet reached a size that could lead to technical difficulties such as impaired intraabdominal working space (LoE 5) [102]. It is suggested that to establish pneumoperitoneum and further introduction of the laparoscope, the Hasson technique is safer (the needle for insufflation is placed under direct visualization via a small incision) than the blind insertion of the Veress needle and helps to avoid injury to the uterus [97].

Preoperative imaging

> All adults scheduled for splenectomy should be investigated preoperatively by ultrasound to clarify spleen size and volume (GoR B). Thin-slice spiral CT should be used if additional information about anatomy and the presence of accessory spleens is needed or if malignancy is suspected (GoR C).

For patients with benign hematologic diseases, ultrasonography is an adequate technique for evaluating anatomic features such as spleen size, vascular conditions, and concomitant diseases (e.g., gallstones) [35]. For autoimmune or hemolytic disease, thin-slice spiral CT may be used to detect accessory spleens. For patients with malignant hematologic diseases, CT scan provides accurate information on splenic size and volume as well as possible lymphadenopathy at the splenic hilum and perisplenic inflammation or splenic infarction, which may cause severe intraoperative complications [38].

Preoperative management

> For autoimmune thrombocytopenia, when the platelet count is less than 20×10^9/l, treatment by preoperative administration of steroids and/or immunoglobulins and possibly by intraoperative platelet transfusion for therapy-resistant patients should be used (GoR C).
>
> A platelet count lower than 20×10^9/l does not preclude LS, although patients with a low count have a higher complication rate (GoR C).
>
> As a minority statement, a preoperative platelet count exceeding 50×10^9/l is considered to be relevant by the hematologist.

In case of low platelet counts, the risk of severe intraoperative bleeding is high. Treatment with prednisone (1 mg/kg/day, beginning 5 to 7 days before surgery) is recommended to achieve preoperative counts exceeding 50×10^9/l. A failure of the thrombocyte count to reach this level is not considered a contraindication to surgery because prolonged steroid therapy has not proved to offer better results.

In 2003, Keidar et al. [103] reported a study of LS for 12 patients with severe refractory thrombocytopenia ($<20 \times 10^9$/l). They found that LS for patients with very low platelet counts is feasible but carries a higher

complication rate (33%) and a longer hospital stay (average, 5.5 days) than for patients with higher preoperative platelet counts. There are no comparable data on open surgery for patients with very low platelet counts. The morbidity rate seems to correlate with the degree of thrombocytopenia, so special efforts should be made to elevate the platelet count preoperatively (e.g., by the administration of steroids) or platelet transfusions in selected cases during surgery after division of the splenic pedicle [LoE 4]). Immunoglobulins may be an effective but costly alternative and are related to more unwanted side affects. Immunoglobulin G (e.g., 400 mg/kg/day) may be administered for 3 to 5 days at least 1 week before surgery to raise the platelet count to a mean value of 50 [104] or 80×10^9/l [105]. In cases of anemia, preoperative transfusions of packed erythrocytes to raise hemoglobin to levels exceeding 10 g/dl are advisable.

> Vaccination against meningococcal, pneumococcal, and *H. influenzae* type *B* infections at least 15 days prior to surgery in elective cases (GoR C) is recommended.

The risk of overwhelming postsplenectomy infection in the form of life-threatening sepsis is a well-documented major long-term risk for splenectomized patients. It is caused mainly by infection with encapsulated organisms usually eliminated by the spleen. The risk of infection is highest within the first 2 years after splenectomy, but one-third of all infections occur more than 5 years after splenectomy, and patients are at lifelong risk. Although the overall incidence is low (3.2%), the mortality rate in the case of infection is extremely high (40–50%). Patients with thalassemia major and sickle-cell anemia are at the highest risk (LoE 2a) [106]. Vaccination against *Streptococcus pneumoniae*, *H. influenzae* type *B*, and *Neisseria meningitidis* infections at least 15 days prior to surgery, or in case of emergency, within 30 days after surgery is recommended (LoE 4) [107, 108].

> Antibiotic prophylaxis should be applied immediately before surgery in the operating room (GoR C).
> The patient must be advised that after splenectomy, the risk for infection is increased lifelong.

Antibiotic prophylaxis is based on cefazolin (alternatively clindamycin) injection immediately before surgery and continued by postoperative intravenous amoxicillin (alternatively, erythromycin) administration. A prophylaxis with oral penicillin V (alternatively erythromycin in cases of allergic reaction to penicillin) administration should be offered for at least 2 years for adults and 5 years for children [107]. Some authors recommend a lifelong prophylaxis, with amoxicillin at hand for the patient to take immediately at the onset of any flu-like symptoms (LoE 4 [108]).

> Routine preoperative splenic artery embolization is not recommended because it is accompanied by severe pain and ischemic complications (GoR C).

The technique of preoperative splenic artery embolization has been described in detail and promoted by Poulin et al. [109, 110] (LoE 4). These authors applied the technique the day before surgery to decrease splenic size, thereby improving maneuverability especially of large and very large spleens, and to diminish bleeding complications, which are a major factor for conversion to open surgery.

Most other authors have found that this technique is associated with severe pain for the patient as well as embolic and ischemic complications involving other organs (i.e., the tail of the pancreas with consecutive pancreatitis because these two organs share a common blood supply) (LoE 4) [68]. Others have reported preoperative artery embolization using "painless contour emboli" only a few hours before surgery for two cases with no occurrence of pain (LoE 4) [68, 111, 112] or for patients under general anesthesia in the operating room directly before surgery (LoE 3b) [113]. In case of massively enlarged spleens, preoperative splenic artery embolization may be of use in preventing major intraoperative bleeding (LoE 4) [109–111].

In 2007, Naoum et al. [113] compared 18 patients who underwent intraoperative splenic artery embolization (SAE) and LS with 18 patients who underwent surgery without SAE and could show that blood loss was significantly less in the former group, especially for spleens larger than 18 cm. However, there were no differences in postoperative complications or recovery, return of bowel function, or length of hospital stay. These authors concluded that the combined treatment of SAE and LS may be advantageous for patients who represent concerns about bleeding complications or blood transfusion (e.g., patients with severe thrombocytopenia, Jehovah's Witnesses, or morbidly obese patients likely to present technical challenges) (LoE 3b).

Technical aspects of laparoscopic splenectomy

> Laparoscopic splenectomy may be performed using a lateral, semilateral, or supine approach depending on surgeon preference, spleen size, patient characteristics, and need of concomitant procedures (GoR B).

The anterior or "supine" position was applied mostly in the early years of LS [4, 104, 105]. This position allows for good access to the omental pouch and excellent visualization of the splenic hilum [104, 114]. Difficulties arise in exposing and dissecting the ligamental structures as well as the dorsal vessels and the splenic hilum, with its close relationship to the tail of the pancreas [105].

The anterior (or supine) position is indicated in case concurrent procedures need to be performed (e.g. cholecystectomy, lymph node biopsies, or biopsies of other organs) [9]. Then the table may be tilted to achieve a semilateral position (see later), which facilitates the process of splenectomy [115]. This position for concomitant procedures also can be achieved by putting the patient in a semilateral position and then tilting the table to the patient's left so that a supine position is reached. Some authors state that this approach may be advantageous in case of very large spleens. The splenic artery may be ligated early, thereby diminishing the risk of severe hemorrhage (LoE 4 [9]).

With the hemi- (or semi-) lateral approach, described initially as the so-called "hanging spleen technique" by Delaitre et al. [116] (LoE 4), the patient is positioned on the table with the left side elevated by use of positioning devices (e.g., beanbag, foam wedges) up to a 40° to 45° angle from the table surface [117]. With this approach, the patient's positioning can be adjusted to surgical requirements by tilting the table so that a fully supine or fully lateral positioning is obtained. Some authors prefer a hemilateral position at the beginning of the procedure for access to the lower sac and division of the short gastric vessels [117]. The table then can be tilted to a more lateral position in which the spleen and other organs (stomach, intestine) fall medially by gravity. This allows for easier access to the posterior face of the spleen and the perisplenic ligaments (LoE 3b) [105, 117]. Then dissection and ligation of the vessels at the splenic hilum are facilitated while the tail of the pancreas is spared. This approach seems to offer the most advantages because the patient's position can be adjusted to the requirements during surgery. The hemilateral approach is preferred by most authors for the majority of indications [118].

With the fully lateral approach, the patient is positioned at a 90° angle to the operating table. The spleen and viscera fall medially due to gravity, facilitating the dissection of the ligaments and hilar structures. Thus, this approach allows for safe vascular control [119–121]. Visualization for the tail of the pancreas is good, so the risk of pancreatic injury is minimized [122]. Some authors have reported a statistically significant reduction in operating time, number of trocars needed, transfusion requirements, and length of hospital stay (LoE 3b) [120]. The conversion rate also was lower in one study when the lateral approach was used (LoE 3b) [114]. Others have recommended the lateral approach for patients with splenomegaly (LoE 3b) [105].

> Ultrasonic shears, advanced bipolar devices, and surgical stapling devices all facilitate vascular control in LS, and their use is recommended to reduce blood loss and shorten operating time (GoR B).

Bleeding is the main complication and cause for conversion during LS. Use of the endovascular stapler is reported to shorten and facilitate hilar dissection compared with the former techniques of ligation or clipping (LoE 4) [121, 123]. Recently, electrothermal bipolar vessel sealer (LigaSure™) or ultrasonic coagulating shears (Ultracision Harmonic Scalpel™, Ethicon Endosurgical, Cincinnati, OH) have been used for dissection of smaller polar vessels and the small gastric vessels (LoE 4) [124], vessel-containing tissue (LoE 4) [39, 125, 126], or even the greater hilar vessels (LoE4) [127]. Romano et al. [128, 129] reported the safe use of LigaSure™ for hilar vessels with a diameter up to 7 mm in patients with normal-sized to slightly enlarged spleens as well as lower blood loss, shorter operative time, and even lower costs than with other techniques (LoE 2b).

Yüney et al. [124] performed LS for 10 patients with ITP using LigaSure™ for hilar vessel sealing. The mean blood loss was 60 ml, and the average operating time was 93 min, without any conversions or complications in the postoperative period (LoE 4). Gelmini et al. [130] reported the performance of 63 laparoscopic splenectomies using LigaSure™ as the only means of achieving hemostasis, with a conversion rate of 7.9%, an average blood loss of 65 ml (range, 0–100 ml), and an average operating time of 120 min (including 17 concomitant procedures). These authors concluded that the use of the LigaSure™ vessel sealing system during LS with a semilateral approach is safe and effective, reduces blood loss and operating time, and is a valid and cheap alternative to the use of endostaplers (LoE 4).

Recently, Targarona et al. [131] conducted a prospective randomized comparison of conventional electrosurgery, bipolar computer-controlled electrosurgery, and ultrasonic dissection during laparoscopic left colectomy. They showed a significant reduction in intraoperative blood loss and operating time with the use of ultrasonic coagulating shears (UCS) or computer-based bipolar energy devices and no significant difference in total costs (LoE 1b). It seems tenable to reference these data because the character of the vessels treated is similar.

In an experimental study on pig arteries, Harold et al. [132] evaluated the bursting pressure of arteries sealed with electrothermal bipolar vessel sealer (LigaSure™), UCS, titanium laparoscopic clips, and plastic laparoscopic clips. They compared three different artery sizes (2–3 mm, 4–5 mm, and 6–7 mm) and found that clips achieve substantial bursting pressures for all sizes of vessels. Whereas LigaSure showed similar results with vessels up to 5 mm in size, the bursting pressure with vessels 6 to 7 mm in diameter was lower, but still well above physiologic systolic pressure. Only for small vessels up to 3 mm did UCS show effectiveness. The authors concluded that

electrothermal bipolar vessel sealer can be used confidently for vessels up to 7 mm in diameter, whereas the use of UCS should be limited to small vessels (LoE 5). In contradiction to this, Schaarschmidt et al. [127] in 2002 reported the successful use of UCS as only means of vessel occlusion for vessels up to 10 mm in diameter in pediatric patients, even for the hilar vessels (LoE 4).

Diamantis et al. [133] conducted a study to investigate the mid- and long-term healing process after the use of electrothermal bipolar vessel sealer (LigaSure™), UCS (Ultracision Harmonic Scalpel™), and monopolar and bipolar electrocautery. They also compared the efficacy and safety of these methods in an animal model with vessel diameters less than 1 mm. In this study, LigaSure™ was shown to be the safest and most efficient method of coagulation with the mildest side effects in terms of thermal injury and inflammatory response (LoE 5). Although an increasing number of reports describe the safe control of the hilar vessels using bipolar or ultrasonic devices, the results did not lead to a recommendation by the expert panel.

For retrieval of the intact spleen and/or morcellation, the use of a strong bag is recommended to avoid spillage of splenic tissue (GoR B).

With LS, the removal of the spleen from the abdominal cavity is a technical challenge and can be a time-consuming procedure, especially in case of large and very large organs. Sometimes the procedure leads to additional incisions or even conversion to open surgery. The organ must be morcellated for removal. Meticulous care must be taken to avoid capsular tear and cell spillage. An undetected implantation of splenic cells may be the cause of splenosis and can be responsible for recurrence in both benign and malignant diseases. Therefore, the process of morcellation must be accomplished within a bag.

Some authors have reported tearing of the bag during morcellation [14], so use of a strong bag and blunt instruments for morcellation (e.g., fingers, ring forceps.) is recommended. The fragments then can be removed by suction, forceps, or both [77]. For insertion of the bag into the abdominal cavity, a 15-mm trocar is needed. Specific features of the bags limit their use. Some materials such as polyurethane are reportedly vulnerable to perforation during morcellation, whereas bags made from ripcord nylon are more resistant to injury. Some bags available for laparoscopic procedures fail to accommodate very large spleens (e.g., those exceeding 15 cm in cross diameter) [77]. One group reported the use of a liposucker, which removed the enbagged spleen while leaving a rim of splenic tissue attached to the capsule for histopathologic evaluation, allowing retrieval by forceps without enlargement of the trocar incision [134].

Usually, the pieces of the spleen obtained after morcellation and piecemeal extraction are sufficient for histopathologic evaluation, especially in cases of ITP. For suspected metastases or single manifestation of lymphoma [135], staging purposes, or splenic malignancy, the spleen should be retrieved *in toto* (LoE 4) [135].

Routine use of drainage is not recommended unless indicated by specific circumstances (e.g., injury to the pancreas) (GoR C).

The placement of a drain after splenectomy is mainly dependent on the surgeon's preference, and there are no valid data on this issue. In a retrospective multicenter study by Delaitre et al. [20] that included 209 patients with ITP, the morbidity rate was higher for the group in which a drain had been used (13.7%) than for the group without drainage (5%), although the difference was not statistically significant (LoE 3b).

Intra- and postoperative complications

In case of severe bleeding, the threshold for conversion to open surgery should be low (GoR A).
With autoimmune disease, gentle manipulation of the spleen is important to avoid capsular rupture and splenosis (GoR C).

Intraoperative hemorrhage, one of the main complications, may be a cause for conversion. It is mainly due to laceration of the hilar or short gastric vessels, the splenic capsule, and/or parenchyma, and may be increased by the underlying disease. One group reported the use of a grasper device to facilitate handling of the spleen during pure LS to avoid capsular tears and bleeding [118].

Intraoperative injury to adjacent organs and structures, especially injury to the pancreas, as well as gastric or diaphragmatic damage can occur. Chand et al. [136] reported an incidence of 15% for pancreatic injury, characterized by isolated hyperamylasemia (minor complication), peripancreatic fluid collections, pancreatic abscess, amylase-rich drain fluid, and/or atypical postoperative pain. A drain was placed only in the case of suspected injury to the pancreas. Patients with splenomegaly had a significantly higher risk of sustaining a major pancreatic complication, which may have been due to technical difficulties in the placement of multiple staples across the hilum. These authors did not find a correlation between the incidence of pancreatic injury and the learning curve of the staff. They suggested that early use of a hand-assisted technique may help to minimize the risk of pancreatic injury in cases of splenomegaly. They recommended a routine check of amylase levels on postoperative

day 1 to alert the surgeon and change postoperative management if necessary (LoE 4).

Further complications after splenectomy may include postoperative bleeding, subphrenic collections or abscess, deep vein thrombosis, thrombosis of the splenoportal axis, pneumonia and atelectasis, pancreatitis, ileus, abdominal wall infections, abdominal wall hematomas and abdominal wall hernias, among others [137, 138]. The incidence of these complications is significantly higher after conversion (LoE 3b) [20, 137]. Treatment of those complications should be according to general clinical standards.

Perioperative anticoagulant prophylaxis with subcutaneous heparin should be applied for all patients (GoR C).
Patients at high risk for portal and/or splenic vein thrombosis (PSVT) should receive anticoagulant prophylaxis for 4 weeks (GoR C).
In case of symptomatic PSVT, heparin administration should be continued at a higher dosage (GoR B).
For patients presenting with unspecific abdominal symptoms, the diagnosis of PSVT must be considered and investigated early.

Portal or splenic vein thrombosis is a potentially life-threatening complication that can occur within months after surgery [139, 140]. It can lead to intestinal infarction and portal hypertension. The reported rate of PSVT ranges from 0.7% [141] to 14% [142] after splenectomy and can reach 80% among high-risk patients [143]. To date, the role of the surgical approach (LS or OS) is not clear. Whereas some studies have shown no influence of surgical technique on the incidence of PSVT (LoE 3b [144, 145]), others have reported a significantly higher incidence of PSVT after LS (LoE 3b) [146, 147].

High-risk factors for the development of PSVT are the presence of myeloproliferative disorders associated with hypercoagulopathy, hemolytic anemia, hypersplenism or hematologic malignancy and splenomegaly (LoE 3b) [147]. A large organ is associated with a greater diameter of the splenic vein and the later stump that allows for the formation of thrombi and serves as the origin for thromboembolic incidents. The incidence of PSVT seems to correlate directly with splenic size [139, 140, 143, 147, 148]. The rate of PSVT occurrence may be influenced by numerous other factors such as technical details (early ligation of the splenic artery, use of the endoscopic vascular stapler, distal or proximal ligation of the splenic vein, pneumoperitoneum) or hematologic changes (postoperative elevation of the platelet count), but their role in the formation of thrombi remains unknown.

Symptoms often are only vague and include diffuse abdominal pain, nausea, fever, ileus, diarrhea, and decreased appetite, among others [139, 143, 145, 149]. Difficulties in establishing the diagnosis often delay adequate treatment for some weeks [143, 145, 148, 150]. Diagnosis can be obtained by color Doppler ultrasonography or contrast-enhanced CT [143]. Magnetic resonance tomography (MRI) also may detect PSVT with sufficient accuracy [151]. The superiority of CT imaging over ultrasonography for the detection of PSVT has not yet been proved by valid data. The rate for thrombosis detected by ultrasonography may be low as it is highly dependent on the performer's skills. Also, the vision may be limited (e.g., in case of morbid obesity or bowel distension during the first days after surgery) [150–152]. The use of CT with intravenous contrast not only establishes the diagnosis of PSVT, but also can exclude other intraabdominal complications [145].

After diagnosis, immediate anticoagulant therapy with intravenous heparin and later oral warfarin therapy at hospital discharge or therapeutic doses of low-molecular-weight heparin offer good results (>90% recanalization if treated immediately) [143]. Systemic thrombolytic therapy with streptokinase or alteplase is an alternative [153], although rarely used. The current standard of warfarin therapy aims at maintaining an international normalized ratio (INR) of between 2 and 3 up to 6 months, whereas Ikeda et al. [146] recommended an INR of between 1.5 and 2.0 for about 3 months.

The selection of patients in need of therapy is not clearly defined. Although most authors advocate immediate anticoagulative treatment for any patient with symptomatic PSVT, there is some evidence that the need for anticoagulant therapy depends on the site and extent of PSVT rather than the mere existence of a thrombus [147]. In this context, a thrombus site within the intrahepatic portal vein is considered less severe than a thrombus within the superior mesenteric vein, which must be treated immediately [146, 147]. The question whether small asymptomatic thrombi as detected by CT should receive therapeutic doses of heparin is unresolved.

Patients presenting with one or more of the aforementioned risk factors need very careful surveillance with regard to possible symptoms of PSVT. Routine postoperative anticoagulation prophylaxis and routine frequent imaging are advisable even after hospital discharge, especially for patients presenting with myeloproliferative disease or hemolytic anemia and splenomegaly [152]. Although the impact of thrombocytosis on the incidence of PSVT is not yet clear, long-term antiplatelet therapy (i.e., acetylsalicylic acid) for high-risk patients has been recommended by some authors [140, 145].

Prophylactic administration of subcutaneous heparin remains controversial. Some authors have found that for high-risk patients, this prophylaxis was insufficient to prevent PSVT [149, 152], and have recommended a

combination of heparin, antiplatelet agents, and oral warfarin after hospital discharge (LoE 4 [145]).

Long-term outcome of LS

Over the long term, LS is effective in resolving hematologic diseases mainly in cases of thrombocytopenia (GoR B). However, there are no definitive preoperative predictive factors of a positive outcome.

There is no clear definition of positive response after splenectomy. Whereas some authors consider a platelet count exceeding 50×10^9/l as relevant, others define the threshold as greater than 150×10^9/l.

Some studies were able to show that long-term results are similar after LS and OS (LoE 3b [15, 154–157], LoE 4 [158–162]). The role of different clinical variables as predictors for the response after splenectomy is controversial. Some authors found in a study of patients with ITP that no preoperative predictive factors exist (LoE3b [157]), although in some studies, univariate analysis has suggested that certain conditions (e.g., age, previous response to steroids, disease duration, site of platelet sequestration) are significant in predicting surgical outcome. However, none of the preoperative characteristics mentioned in single studies consistently predicted response to splenectomy (LoE 3a [2], LoE 3b [163]).

Ojima et al. [154] conducted a study of 32 patients with ITP over a median follow-up period of 8.3 years and reported that long-term outcome could be predicted by platelet levels on postoperative day 7. The age at surgery, the time between diagnosis and splenectomy, and the prior response to corticosteroid therapy were not predictive factors of outcome. Seven patients (21.9%) had no satisfactory response to splenectomy. None of these patients showed the presence of accessory spleens in abdominal CT images 1 month after surgery (LoE 3b).

Katkhouda et al. [29] studied LS for 52 patients with ITP and found age (age older or younger than 40 years) to be the most significant predictive factor for success or failure of the operation according to multivariate analysis. Other significant predictors according to univariate analysis were preoperative response to corticosteroids and platelet count at discharge. Pace et al. [158] observed that in 3 of 9 patients who showed unsatisfactory response to LS, accessory splenic tissue was found in a denaturated red blood cell scan (33.3%). They therefore concluded that a careful laparoscopic dissection results in an acceptable remission rate. Although in a study of ITP patients, younger age, a good response to corticosteroids, and a short interval between onset of the disease and time of surgery showed better remission rates [164], the success of splenectomy cannot be predicted preoperatively.

Special aspects of LS for children

If splenectomy is indicated for children, the laparoscopic approach should be preferred (GoR B). However, surgery should be postponed until the child is 6 years of age or older if possible (GoR C).
In children, the ratio between spleen size and the size of the abdominal cavity may cause technical problems, so the threshold for conversion should be low (GoR C).

For children, LS has shown the same advantages over OS as for adults, such as similar or less blood loss, a similar or lower complication rate, a shorter hospital stay, and better cosmesis (LoE 3b [165–172], LoE 4 [173–176]). Less postoperative pain and earlier return to normal activities are especially important for pediatric patients (LoE 3b) [165, 170, 177, 178]. As with adults, the long-term outcome for patients with ITP showed that this procedure is effective and that no differences exist between the open and laparoscopic approaches (LoE 3b) [179].

Indications for splenectomy in children include hematologic disorders such as hereditary spherocytosis, ITP, sickle-cell anemia, and beta-thalassemia. The most common indication is hereditary spherocytosis, followed by ITP resistant to therapy [129, 165, 177]. Among children with acute ITP, 80% to 90% experience spontaneous recovery with or without therapy. A chronic course persisting for more than 6 months is seen in the remaining 10% to 20%, but the probability of complete remission over time reaches 80%. This has led to the assumption that splenectomy in children with ITP should be avoided or deferred for as long as possible [180]. Existing guidelines do not recommend splenectomy for children with less than 1 year of persisting chronic disease, bleeding symptoms, and low platelet counts ($< 10 \times 10^9$/l) [181], or those who are less than 12 months from the initial diagnosis unless there are major problems [182].

Significant differences in LS between pediatric patients (age, <17 years) and adults can be noted in terms of lower blood loss and a lower ASA score (Table 6).

Some groups have pointed out the superiority of LS in case concomitant procedures must be performed because no accessory incision is required, whereas with OS, either an enlargement of the left subcostal or a midline incision is inevitable (LoE 3b) [165, 168, 183]. Some authors state that trocar placement in smaller children or children with an enlarged spleen must be more inferior than in adults to allow increased working space in the small abdominal cavity [173].

The LS procedure is feasible even for very young children. Standard 5-mm instruments are adequate for most pediatric splenectomies. For smaller patients, even 3-mm instruments may be used. A 12-mm port is needed for the endoscopic linear stapler and for organ retrieval [184].

For children, measurement of the splenic size by pure metric data is irrelevant because it must be put in relation to body size. "Massive" splenomegaly is defined as a spleen larger than four times normal for age [72]. Nevertheless, some data show that the conversion rate seems to be correlated with splenic size, and that spleens weighing more than 500 g are associated with a higher risk of conversion to open surgery (LoE 3b) [165, 172]. In 1997, one group reported major problems placing organs weighing more than 700 g inside the bag and concluded that LS should be limited to spleens weighing less than 700 g and cases in which a concomitant procedure is indicated, and that in all other cases, OS is preferable (LoE 3b) [178].

Some authors state that HALS, additional incisions for specimen retrieval, and preoperative splenic artery embolization do not appear to be useful in children (LoE 4) [185] In a study of 15 children undergoing LS, Romano et al. [129] used ultrasonic shears for dissection of the hilar vessels instead of an endovascular stapler, as did Schaarschmidt et al. [127] Both authors reported that using ultrasonic shears for dissection of the splenic hilum and hilar vessels was safe and resulted in significantly shorter operative times and less blood loss (LoE 3b, LoE 4). Hicks et al. [170] noted that with LS, the costs were not higher than with OS because they used clips or electrocautery for hemostasis with no occurrence of bleeding complications (LoE 3b). In 1995, Yoshida et al. [172] stated that the hilar vessels in children can be clipped and divided safely without the need to use an endostapler.

> Children undergoing elective splenectomy, including children younger than 2 years, should be vaccinated against *S. pneumoniae*, *N. meningitides*, and *H. influenzae* type B infection prior to surgery (GoR B).

Most commonly, postsplenectomy infection presents as pulmonary infection, and the incidence of a serious infection is low. Nevertheless, if serious infection occurs, the rate of mortality is high (up to 50%). In 1999, Jugenburg et al. [186] conducted a study about the morbidity and mortality due to postsplenectomy sepsis. Infection occurred 4 days to 9.7 years after surgery. These authors showed that the risk was highest within 2 years after surgery (77% of serious infections), but remained present throughout life. The risk for children ages 0 to 5 years was the greatest. Comparing the incidence of serious infection between immunized and nonimmunized patients, a lower risk could be shown if immunization was performed before surgery rather than afterwards. A reimmunization every 5 to 10 years also was recommended (LoE 3b).

Some authors have recommended daily penicillin for patients younger than 5 years. Others have recommended proceeding with this prophylactic treatment up to the age of 10 years [184]. Due to a lack of evidence, no recommendations concerning the antibiotic prophylaxis can be made.

Discussion

Splenectomy is one of the few examples in surgery demonstrating acceptance of the laparoscopic technique despite the paucity of high-level evidence. Given the clear superiority of the laparoscopic approach, this may seem acceptable from a clinical point of view. However, from a scientific perspective, the rapid spread of LS remains controversial, although this debate currently is probably irrelevant because LS has become the gold standard in the majority of cases.

Currently, a randomized trial comparing open and laparoscopic splenectomy appears ethically justifiable only for patients with very large spleens or specific comorbidities (e.g., liver cirrhosis). In addition, the expert panel identified several future research topics (Table 7). It also was noted that a registry for LS would provide valuable information.

The guidelines rely on the available literature and the view of a European expert panel. As such, it is not possible to give firm recommendations on all aspects of LS. The expert panel was multidisciplinary, made up of nine surgeons, one hematologist, and three research scientists. It identified a paucity of literature on the pediatric patient as well as other areas for which data are lacking. A unanimous consensus was reached on all statements except that establishing the platelet count at which it is safe to offer surgery. Disagreement on this matter reflects the scarce evidence on this topic. A large volume of low-level evidence exists to support the widespread use of LS for most patients. Areas of controversy still exist, and these should encourage further research.

References

1. Gadenstatter M, Lamprecht B, Klingler A, Wetscher GJ, Greil R, Schmid T (2002) Splenectomy versus medical treatment for idiopathic thrombocytopenic purpura. Am J Surg 184:606–610
2. Kojouri K, Vesely SK, Terrell DR, George JN (2004) 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 104:2623–2634
3. Baccarani U, Terrosu G, Donini A, Zaja F, Bresadola F, Baccarani M (1999) Splenectomy in hematology: current practice and new perspectives. Haematologica 84:431–436

4. Delaitre B, Maignien B (1991) Splenectomy by the laparoscopic approach: report of a case. Presse Med 20:2263
5. Sauerland S, Agresta F, Bergamaschi R, Borzellino G, Budzynski A, Champault G, Fingerhut A, Isla A, Johansson M, Lundorff P, Navez B, Saad S, Neugebauer EA (2006) Laparoscopy for abdominal emergencies: evidence-based guidelines of the European Association for Endoscopic Surgery. Surg Endosc 20:14–29
6. Konstadoulakis MM, Lagoudianakis E, Antonakis PT, Albanopoulos K, Gomatos I, Stamou KM, Leandros E, Manouras A (2006) Laparoscopic versus open splenectomy in patients with beta thalassemia major. J Laparoendosc Adv Surg Tech A 16:5–8
7. Donini A, Baccarani U, Terrosu G, Corno V, Ermacora A, Pasqualucci A, Bresadola F (1999) Laparoscopic vs open splenectomy in the management of hematologic diseases. Surg Endosc 13:1220–1225
8. Lozano-Salazar RR, Herrera MF, Vargas-Vorackova F, Lopez-Karpovitch X (1998) Laparoscopic versus open splenectomy for immune thrombocytopenic purpura. Am J Surg 176:366–369
9. Casaccia M, Torelli P, Squarcia S, Sormani MP, Savelli A, Troilo B, Santori G, Valente U (2006) Laparoscopic splenectomy for hematologic diseases: a preliminary analysis performed on the Italian Registry of Laparoscopic Surgery of the Spleen (IRLSS). Surg Endosc 20:1214–1220
10. Sampath S, Meneghetti AT, MacFarlane JK, Nguyen NH, Benny WB, Panton ON (2007) An 18-year review of open and laparoscopic splenectomy for idiopathic thrombocytopenic purpura. Am J Surg 193:580–584
11. Berends FJ, Schep N, Cuesta MA, Bonjer HJ, Kappers-Klunne MC, Huijgens P, Kazemier G (2004) Hematological long-term results of laparoscopic splenectomy for patients with idiopathic thrombocytopenic purpura: a case-control study. Surg Endosc 18:766–770
12. Tanoue K, Okita K, Akahoshi T, Konishi K, Gotoh N, Tsutsumi N, Tomikawa M, Hashizume M (2002) Laparoscopic splenectomy for hematologic diseases. Surgery 131:S318–S323
13. Phillips EH, Carroll BJ, Fallas MJ (1994) Laparoscopic splenectomy. Surg Endosc 8:931–933
14. Cordera F, Long KH, Nagorney DM, McMurtry EK, Schleck C, Ilstrup D, Donohue JH (2003) Open versus laparoscopic splenectomy for idiopathic thrombocytopenic purpura: clinical and economic analysis. Surgery 134:45–52
15. Trias M, Targarona EM, Espert JJ, Cerdan G, Bombuy E, Vidal O, Artigas V (2000) Impact of hematological diagnosis on early and late outcome after laparoscopic splenectomy: an analysis of 111 cases. Surg Endosc 14:556–560
16. Velanovich V (2000) Laparoscopic vs open surgery: a preliminary comparison of quality-of-life outcomes. Surg Endosc 14:16–21
17. Rattner DW, Apelgren KN, Eubanks WS (2001) The need for training opportunities in advanced laparoscopic surgery. Surg Endosc 15:1066–1070
18. Peters MB Jr, Camacho D, Ojeda H, Reichenbach DJ, Knauer EM, Yahanda AM, Cooper SE, Sweeney JF (2004) Defining the learning curve for laparoscopic splenectomy for immune thrombocytopenia purpura. Am J Surg 188:522–525
19. Franciosi C, Caprotti R, Romano F, Porta G, Real G, Colombo G, Uggeri F (2000) Laparoscopic versus open splenectomy: a comparative study. Surg Laparosc Endosc Percutan Tech 10:291–295
20. Delaitre B, Blezel E, Samama G, Barrat C, Gossot D, Bresler L, Meyer C, Heyd B, Collet D, Champault G (2002) Laparoscopic splenectomy for idiopathic thrombocytopenic purpura. Surg Laparosc Endosc Percutan Tech 12:412–419
21. Rege RV, Joehl RJ (1999) A learning curve for laparoscopic splenectomy at an academic institution. J Surg Res 81:27–32
22. Targarona EM, Espert JJ, Balague C, Piulachs J, Artigas V, Trias M (1998) Splenomegaly should not be considered a contraindication for laparoscopic splenectomy. Ann Surg 228:35–39
23. Pace DE, Chiasson PM, Schlachta CM, Mamazza J, Poulin EC (2002) Laparoscopic splenectomy: does the training of minimally invasive surgical fellows affect outcomes? Surg Endosc 16:954–956
24. Dagash H, Chowdhury M, Pierro A (2003) When can I be proficient in laparoscopic surgery? A systematic review of the evidence. J Pediatr Surg 38:720–724
25. Smith CD, Meyer TA, Goretsky MJ, Hyams D, Luchette FA, Fegelman EJ, Nussbaum MS (1996) Laparoscopic splenectomy by the lateral approach: a safe and effective alternative to open splenectomy for hematologic diseases. Surgery 120:789–794
26. Glasgow RE, Mulvihill SJ (1999) Laparoscopic splenectomy. World J Surg 23:384–388
27. Knauer EM, Ailawadi G, Yahanda A, Obermeyer RJ, Millie MP, Ojeda H, Mulholland MW, Colletti L, Sweeney JF (2003) 101 laparoscopic splenectomies for the treatment of benign and malignant hematologic disorders. Am J Surg 186:500–504
28. Walsh RM, Heniford BT, Brody F, Ponsky J (2001) The ascendance of laparoscopic splenectomy. Am Surg 67:48–53
29. Katkhouda N, Grant SW, Mavor E, Friedlander MH, Lord RV, Achanta K, Essani R, Mason R (2001) Predictors of response after laparoscopic splenectomy for immune thrombocytopenic purpura. Surg Endosc 15:484–488
30. Khan LR, Nixon SJ (2007) Laparoscopic splenectomy is a better treatment for adult ITP than steroids—it should be used earlier in patient management: conclusions of a ten-year follow-up study. Surgeon 5:3–4, 6–8
31. Napoli A, Catalano C, Silecchia G, Fabiano P, Fraioli F, Pediconi F, Venditti F, Basso N, Passariello R (2004) Laparoscopic splenectomy: multidetector row CT for preoperative evaluation. Radiology 232:361–367
32. Stanek A, Stefaniak T, Makarewicz W, Kaska L, Podgorczyk H, Hellman A, Lachinski A (2005) Accessory spleens: preoperative diagnostics limitations and operational strategy in laparoscopic approach to splenectomy in idiopathic thrombocytopenic purpura patients. Langenbecks Arch Surg 390:47–51
33. Gigot JF, Jamar F, Ferrant A, van Beers BE, Lengele B, Pauwels S, Pringot J, Kestens PJ, Gianello P, Detry R (1998) Inadequate detection of accessory spleens and splenosis with laparoscopic splenectomy: a shortcoming of the laparoscopic approach in hematologic diseases. Surg Endosc 12:101–106
34. Gigot JF, Mabrut JY, Matairie S, Jamar F, Ferrant A, van Beers BE, Gianello P (2002) Failures following laparoscopic splenectomy and their management with special reference to accessory spleens and splenosis. Prob Gen Surg 19:80–94
35. Katkhouda N, Manhas S, Umbach TW, Kaiser AM (2001) Laparoscopic splenectomy. J Laparoendosc Adv Surg Tech A 11:383–390
36. Velanovich V, Shurafa M (2000) Laparoscopic excision of accessory spleen. Am J Surg 180:62–64
37. Barbaros U, Dinccag A, Erbil Y, Mercan S, Sanli Y, Adalet I, Kucukkaya R (2007) Handheld gamma probe used to detect accessory spleens during initial laparoscopic splenectomies. Surg Endosc 21:115–119
38. Heniford BT, Matthews BD, Answini GA, Walsh RM (2000) Laparoscopic splenectomy for malignant diseases. Semin Laparosc Surg 7:93–100
39. Boddy AP, Mahon D, Rhodes M (2006) Does open surgery continue to have a role in elective splenectomy? Surg Endosc 20:1094–1098
40. Schlachta CM, Poulin EC, Mamazza J (1999) Laparoscopic splenectomy for hematologic malignancies. Surg Endosc 13:865–868

41. Berman RS, Yahanda AM, Mansfield PF, Hemmila MR, Sweeney JF, Porter GA, Kumparatana M, Leroux B, Pollock RE, Feig BW (1999) Laparoscopic splenectomy in patients with hematologic malignancies. Am J Surg 178:530–536
42. Cavaliere D, Torelli P, Panaro F, Casaccia M, Ghinolfi D, Santori G, Rossi E, Bacigalupo A, Valente U (2004) Outcome of laparoscopic splenectomy for malignant hematologic diseases. Tumori 90:229–232
43. Yano H, Imasato M, Monden T, Okamoto S (2003) Hand-assisted laparoscopic splenectomy for splenic vascular tumors: report of two cases. Surg Laparosc Endosc Percutan Tech 13:286–289
44. Klinger PJ, Smith SL, Abendstein BJ, Hinder RA (1998) Hand-assisted laparoscopic splenectomy for isolated splenic metastasis from an ovarian carcinoma: a case report with review of the literature. Surg Laparosc Endosc 8:49–54
45. Silecchia G, Boru CE, Fantini A, Raparelli L, Greco F, Rizzello M, Pecchia A, Fabiano P, Basso N (2006) Laparoscopic splenectomy in the management of benign and malignant hematologic diseases. JSLS 10:199–205
46. Walsh RM, Brody F, Brown N (2004) Laparoscopic splenectomy for lymphoproliferative disease. Surg Endosc 18:272–275
47. Targarona EM, Espert JJ, Piulachs J, Lacy AM, Bosch F, Trias M (1999) Laparoscopic removal of accessory spleens after splenectomy for relapsing autoimmune thrombocytopenic purpura. Eur J Surg 165:1199–1200
48. Uranues S, Grossman D, Ludwig L, Bergamaschi R (2007) Laparoscopic partial splenectomy. Surg Endosc 21:57–60
49. Breitenstein S, Scholz T, Schafer M, Decurtins M, Clavien PA (2007) Laparoscopic partial splenectomy. J Am Coll Surg 204:179–181
50. Elsayes KM, Narra VR, Mukundan G, Lewis JS Jr., Menias CO, Heiken JP (2005) MR imaging of the spleen: spectrum of abnormalities. Radiographics 25:967–982
51. Soares RL Jr, Balder DA, Migliori SJ, Amaral JF (1998) Laparoscopic complete excision of a splenic epidermoid cyst. J Laparoendosc Adv Surg Tech A 8:237–240
52. Kaiwa Y, Kurokawa Y, Namiki K, Matsumoto H, Satomi S (2000) Laparoscopic partial splenectomies for true splenic cysts: a report of two cases. Surg Endosc 14:865
53. Wu JM, Lai IR, Yuan RH, Yu SC (2004) Laparoscopic splenectomy for idiopathic thrombocytopenic purpura. Am J Surg 187:720–723
54. de Melo VA, Alves Junior A, Andrade LC, Aragao JF, Rosa JE (1995) Splenic cyst: review of the literature and report of 2 cases. Rev Hosp Clin Fac Med Sao Paulo 50:289–293
55. Cala Z, Cvitanovic B, Perko Z, Velnic D, Rasic Z (1996) Laparoscopic treatment of nonparasitic cysts of spleen and liver. J Laparoendosc Surg 6:387–391
56. Mertens J, Penninckx F, DeWever I, Topal B (2007) Long-term outcome after surgical treatment of nonparasitic splenic cysts. Surg Endosc 21:206–208
57. Macheras A, Misiakos EP, Liakakos T, Mpistarakis D, Fotiadis C, Karatzas G (2005) Nonparasitic splenic cysts: a report of three cases. World J Gastroenterol 11:6884–6887
58. Czauderna P, Vajda P, Schaarschmidt K, Kalman A, Jainsch M, Engelis A, Lewicki K, Verebely T, Koltai J, Petersons A, et al. (2006) Nonparasitic splenic cysts in children: a multicentric study. Eur J Pediatr Surg 16:415–419
59. Carbonell AM, Kercher KW, Matthews BD, Joels CS, Sing RF, Heniford BT (2004) Laparoscopic splenectomy for splenic abscess. Surg Laparosc Endosc Percutan Tech 14:289–291
60. Madoff DC, Denys A, Wallace MJ, Murthy R, Gupta S, Pillsbury EP, Ahrar K, Bessoud B, Hicks ME (2005) Splenic arterial interventions: anatomy, indications, technical considerations, and potential complications. Radiographics 25(Suppl 1):S191–S211
61. Berceli SA (2005) Hepatic and splenic artery aneurysms. Semin Vasc Surg 18:196–201
62. Hashizume M, Ohta M, Ueno K, Okadome K, Sugimachi K (1993) Laparoscopic ligation of splenic artery aneurysm. Surgery 113:352–354
63. Grahn SW, Alvarez J III, Kirkwood K (2006) Trends in laparoscopic splenectomy for massive splenomegaly. Arch Surg 141:755–762
64. Heniford BT, Park A, Walsh RM, Kercher KW, Matthews BD, Frenette G, Sing RF (2001) Laparoscopic splenectomy in patients with normal-sized spleens versus splenomegaly: does size matter? Am Surg 67:854–858
65. Walsh RM, Chand B, Brodsky J, Heniford BT (2003) Determination of intact splenic weight based on morcellated weight. Surg Endosc 17:1266–1268
66. Decker G, Millat B, Guillon F, Atger J, Linon M (1998) Laparoscopic splenectomy for benign and malignant hematologic diseases: 35 consecutive cases. World J Surg 22:62–68
67. Katkhouda N, Hurwitz MB, Rivera RT, Chandra M, Waldrep DJ, Gugenheim J, Mouiel J (1998) Laparoscopic splenectomy: outcome and efficacy in 103 consecutive patients. Ann Surg 228:568–578
68. Poulin EC, Thibault C, Mamazza J (1995) Laparoscopic splenectomy. Surg Endosc 9:172–177
69. Yetter EM, Acosta KB, Olson MC, Blundell K (2003) Estimating splenic volume: sonographic measurements correlated with helical CT determination. AJR Am J Roentgenol 181:1615–1620
70. Pugliese R, Sansonna F, Scandroglio I, Maggioni D, Ferrari GC, Di Lernia S, Costanzi A, Grillo G, Cimbanassi S, Chiara O (2006) Laparoscopic splenectomy: a retrospective review of 75 cases. Int Surg 91:82–86
71. Kaban GK, Czerniach DR, Cohen R, Novitsky YW, Yood SM, Perugini RA, Kelly JJ, Litwin DE (2004) Hand-assisted laparoscopic splenectomy in the setting of splenomegaly. Surg Endosc 18:1340–1343
72. Kercher KW, Matthews BD, Walsh RM, Sing RF, Backus CL, Heniford BT (2002) Laparoscopic splenectomy for massive splenomegaly. Am J Surg 183:192–196
73. Backus CL, Walsh RM, Matthews BD, Sing RF, Heniford BT (2000) Hand-assisted laparoscopic splenectomy. Surg Technol Int IX:95–100
74. Smith L, Luna G, Merg AR, McNevin MS, Moore MR, Bax TW (2004) Laparoscopic splenectomy for treatment of splenomegaly. Am J Surg 187:618–620
75. Patel AG, Parker JE, Wallwork B, Kau KB, Donaldson N, Rhodes MR, O'Rourke N, Nathanson L, Fielding G (2003) Massive splenomegaly is associated with significant morbidity after laparoscopic splenectomy. Ann Surg 238:235–240
76. Rosen M, Brody F, Walsh RM, Ponsky J (2002) Hand-assisted laparoscopic splenectomy vs conventional laparoscopic splenectomy in cases of splenomegaly. Arch Surg 137:1348–1352
77. Zacharoulis D, O'Boyle C, Royston CM, Sedman PC (2006) Splenic retrieval after laparoscopic splenectomy: a new bag. J Laparoendosc Adv Surg Tech A 16:128–132
78. Brodsky JA, Brody FJ, Walsh RM, Malm JA, Ponsky JL (2002) Laparoscopic splenectomy. Surg Endosc 16:851–854
79. Khoursheed M, Al-Sayegh F, Al-Bader I, Kanawati N, Maroof R, Asfar S, Dashti H (2004) Laparoscopic splenectomy for hematological disorders. Med Princ Pract 13:122–125
80. Casaccia M, Torelli P, Cavaliere D, Santori G, Panaro F, Valente U (2005) Minimal-access splenectomy: a viable alternative to laparoscopic splenectomy in massive splenomegaly. JSLS 9:411–414

81. Park AE, Birgisson G, Mastrangelo MJ, Marcaccio MJ, Witzke DB (2000) Laparoscopic splenectomy: outcomes and lessons learned from over 200 cases. Surgery 128:660–667
82. Terrosu G, Baccarani U, Bresadola V, Sistu MA, Uzzau A, Bresadola F (2002) The impact of splenic weight on laparoscopic splenectomy for splenomegaly. Surg Endosc 16:103–107
83. Hellman P, Arvidsson D, Rastad J (2000) HandPort-assisted laparoscopic splenectomy in massive splenomegaly. Surg Endosc 14:1177–1179
84. Borrazzo EC, Daly JM, Morrisey KP, Fischer E, Belmont M, Hogle NJ, Fowler DL (2003) Hand-assisted laparoscopic splenectomy for giant spleens. Surg Endosc 17:918–920
85. Meijer DW, Gossot D, Jakimowicz JJ, De Wit LT, Bannenberg JJ, Gouma DJ (1999) Splenectomy revised: manually assisted splenectomy with the dexterity device—a feasibility study in 22 patients. J Laparoendosc Adv Surg Tech A 9:507–510
86. Kusminsky RE, Boland JP, Tiley EH, Deluca JA (1995) Hand-assisted laparoscopic splenectomy. Surg Laparosc Endosc 5:463–467
87. Ailawadi G, Yahanda A, Dimick JB, Bedi A, Mulholland MW, Colletti L, Sweeney JF (2002) Hand-assisted laparoscopic splenectomy in patients with splenomegaly or prior upper abdominal operation. Surgery 132:689–696
88. Targarona EM, Gracia E, Rodriguez M, Cerdan G, Balague C, Garriga J, Trias M (2003) Hand-assisted laparoscopic surgery. Arch Surg 138:133–141
89. Litwin DE, Darzi A, Jakimowicz J, Kelly JJ, Arvidsson D, Hansen P, Callery MP, Denis R, Fowler DL, Medich DS, et al. (2000) Hand-assisted laparoscopic surgery (HALS) with the HandPort system: initial experience with 68 patients. Ann Surg 231:715–723
90. Wang KX, Hu SY, Zhang GY, Chen B, Zhang HF (2007) Hand-assisted laparoscopic splenectomy for splenomegaly: a comparative study with conventional laparoscopic splenectomy. Chin Med J (Engl) 120:41–45
91. Targarona EM, Balague C, Cerdan G, Espert JJ, Lacy AM, Visa J, Trias M (2002) Hand-assisted laparoscopic splenectomy (HALS) in cases of splenomegaly: a comparison analysis with conventional laparoscopic splenectomy. Surg Endosc 16:426–430
92. Maartense S, Bemelman WA, Gerritsen van der Hoop A, Meijer DW, Gouma DJ (2004) Hand-assisted laparoscopic surgery (HALS): a report of 150 procedures. Surg Endosc 18:397–401
93. Tojimbara T, Nakajima I, Kimikawa M, Sato S, Kawase T, Nanmoku K, Kai K, Kato Y, Tsuda S, Fuchinoue S, et al. (2003) Hand-assisted laparoscopic splenectomy in ABO-incompatible kidney transplant recipients: a single skin incision technique. Transplant Proc 35:321–322
94. Ohta M, Nishizaki T, Matsumoto T, Shimabukuro R, Sasaki A, Shibata K, Matsusaka T, Kitano S (2005) Analysis of risk factors for massive intraoperative bleeding during laparoscopic splenectomy. J Hepatobiliary Pancreat Surg 12:433–437
95. Cobb WS, Heniford BT, Burns JM, Carbonell AM, Matthews BD, Kercher KW (2005) Cirrhosis is not a contraindication to laparoscopic surgery. Surg Endosc 19:418–423
96. Hashizume M, Tomikawa M, Akahoshi T, Tanoue K, Gotoh N, Konishi K, Okita K, Tsutsumi N, Shimabukuro R, Yamaguchi S, et al. (2002) Laparoscopic splenectomy for portal hypertension. Hepatogastroenterology 49:847–852
97. Weiss CA III, Kavic SM, Adrales GL, Park AE (2005) Laparoscopic splenectomy: what barriers remain? Surg Innov 12:23–29
98. Dominguez EP, Choi YU, Scott BG, Yahanda AM, Graviss EA, Sweeney JF (2007) Impact of morbid obesity on outcome of laparoscopic splenectomy. Surg Endosc 21:422–426
99. Kavic SM, Segan RD, Park AE (2005) Laparoscopic splenectomy in the elderly: a morbid procedure? Surg Endosc 19:1561–1564
100. Curet MJ, Allen D, Josloff RK, Pitcher DE, Curet LB, Miscall BG, Zucker KA (1996) Laparoscopy during pregnancy. Arch Surg 131:546–551
101. Holthausen UH, Mettler L, Troidl H (1999) Pregnancy: a contraindication? World J Surg 23:856–862
102. Allran CF Jr, Weiss CA III, Park AE (2002) Urgent laparoscopic splenectomy in a morbidly obese pregnant woman: case report and literature review. J Laparoendosc Adv Surg Tech A 12:445–447
103. Keidar A, Sagi B, Szold A (2003) Laparoscopic splenectomy for immune thrombocytopenic purpura in patients with severe refractory thrombocytopenia. Pathophysiol Haemost Thromb 33:116–119
104. Kuriansky J, Ben Chaim M, Rosin D, Haik J, Zmora O, Saavedra P, Shabtai M, Ayalon A (1998) Posterolateral approach: an alternative strategy in laparoscopic splenectomy. Surg Endosc 12:898–900
105. Tan M, Zheng CX, Wu ZM, Chen GT, Chen LH, Zhao ZX (2003) Laparoscopic splenectomy: the latest technical evaluation. World J Gastroenterol 9:1086–1089
106. Bisharat N, Omari H, Lavi I, Raz R (2001) Risk of infection and death among postsplenectomy patients. J Infect 43:182–186
107. Legrand A, Bignon A, Borel M, Zerbib P, Langlois J, Chambon JP, Lebuffe G, Vallet B (2005) Perioperative management of asplenic patients. Ann Fr Anesth Reanim 24:807–813
108. (1996) Guidelines for the prevention and treatment of infection in patients with an absent or dysfunctional spleen. Working Party of the British Committee for Standards in Haematology Clinical Haematology Task Force. BMJ 312:430–434
109. Poulin E, Thibault C, Mamazza J, Girotti M, Cote G, Renaud A (1993) Laparoscopic splenectomy: clinical experience and the role of preoperative splenic artery embolization. Surg Laparosc Endosc 3:445–450
110. Poulin EC, Mamazza J, Schlachta CM (1998) Splenic artery embolization before laparoscopic splenectomy: an update. Surg Endosc 12:870–875
111. Iwase K, Higaki J, Mikata S, Tanaka Y, Yoshikawa M, Hori S, Osuga K, Kosugi S, Tamaki T, Kamiike W (1999) Laparoscopically assisted splenectomy following preoperative splenic artery embolization using contour emboli for myelofibrosis with massive splenomegaly. Surg Laparosc Endosc Percutan Tech 9:197–202
112. Totte E, Van Hee R, Kloeck I, Hendrickx L, Zachee P, Bracke P, Hermans P (1998) Laparoscopic splenectomy after arterial embolisation. Hepatogastroenterology 45:773–776
113. Naoum JJ, Silberfein EJ, Zhou W, Sweeney JF, Albo D, Brunicardi FC, Kougias P, El Sayed HF, Lin PH (2007) Concomitant intraoperative splenic artery embolization and laparoscopic splenectomy versus laparoscopic splenectomy: comparison of treatment outcome. Am J Surg 193:713–718
114. Trias M, Targarona EM, Balague C (1996) Laparoscopic splenectomy: an evolving technique: a comparison between anterior and lateral approaches. Surg Endosc 10:389–392
115. Trias M, Targarona EM, Moral A, Prados M (1994) Laparoscopic splenectomy: technical aspects and preliminary results. Endosc Surg Allied Technol 2:288–292
116. Delaitre B, Bonnichon P, Barthes T, Dousset B (1995) Laparoscopic splenectomy: the "hanging spleen technique" in a series of nineteen cases. Ann Chir 49:471–476
117. Dexter SP, Martin IG, Alao D, Norfolk DR, McMahon MJ (1996) Laparoscopic splenectomy: the suspended pedicle technique. Surg Endosc 10:393–396

118. Bedirli A, Sozuer EM, Saglam A, Sakrak O, Guler I, Kucuk C, Aritas Y (2003) Grasper-assisted versus traditional laparoscopic splenectomy in the management of hematologic disorders. J Laparoendosc Adv Surg Tech A 13:359–363
119. Park A, Gagner M, Pomp A (1997) The lateral approach to laparoscopic splenectomy. Am J Surg 173:126–130
120. Gossot D (1998) Laparoscopic splenectomy: value of the posterior approach. Ann Chir 52:940–945
121. Szold A, Sagi B, Merhav H, Klausner JM (1998) Optimizing laparoscopic splenectomy: technical details and experience in 59 patients. Surg Endosc 12:1078–1081
122. Nageli J, Lange J (1997) Indications, technique, and outcome of laparoscopic splenectomy. Ther Umsch 54:510–514
123. Miles WF, Greig JD, Wilson RG, Nixon SJ (1996) Technique of laparoscopic splenectomy with a powered vascular linear stapler. Br J Surg 83:1212–1214
124. Yüney E, Hobek A, Keskin M, Yilmaz O, Kamali S, Oktay C, Bender O (2005) Laparoscopic splenectomy and LigaSure. Surg Laparosc Endosc Percutan Tech 15:212–215
125. Rothenberg SS (1996) Laparoscopic splenectomy using the harmonic scalpel. J Laparoendosc Surg 6(Suppl 1):S61–63
126. Targarona EM, Espert JJ, Cerdan G, Balague C, Piulachs J, Sugranes G, Artigas V, Trias M (1999) Effect of spleen size on splenectomy outcome: a comparison of open and laparoscopic surgery. Surg Endosc 13:559–562
127. Schaarschmidt K, Kolberg-Schwerdt A, Lempe M, Saxena A (2002) Ultrasonic shear coagulation of main hilar vessels: a 4-year experience of 23 pediatric laparoscopic splenectomies without staples. J Pediatr Surg 37:614–616
128. Romano F, Caprotti R, Franciosi C, De Fina S, Colombo G, Uggeri F (2002) Laparoscopic splenectomy using Ligasure: preliminary experience. Surg Endosc 16:1608–1611
129. Romano F, Caprotti R, Franciosi C, De Fina S, Colombo G, Sartori P, Uggeri F (2003) The use of LigaSure during pediatric laparoscopic splenectomy: a preliminary report. Pediatr Surg Int 19:721–724
130. Gelmini R, Romano F, Quaranta N, Caprotti R, Tazzioli G, Colombo G, Saviano M, Uggeri F (2006) Sutureless and stapleless laparoscopic splenectomy using radiofrequency: LigaSure device. Surg Endosc 20:991–994
131. Targarona EM, Balague C, Marin J, Neto RB, Martinez C, Garriga J, Trias M (2005) Energy sources for laparoscopic colectomy: a prospective randomized comparison of conventional electrosurgery, bipolar computer-controlled electrosurgery, and ultrasonic dissection: operative outcome and costs analysis. Surg Innov 12:339–344
132. Harold KL, Pollinger H, Matthews BD, Kercher KW, Sing RF, Heniford BT (2003) Comparison of ultrasonic energy, bipolar thermal energy, and vascular clips for the hemostasis of small-, medium-, and large-sized arteries. Surg Endosc 17:1228–1230
133. Diamantis T, Kontos M, Arvelakis A, Syroukis S, Koronarchis D, Papalois A, Agapitos E, Bastounis E, Lazaris AC (2006) Comparison of monopolar electrocoagulation, bipolar electrocoagulation, Ultracision, and Ligasure. Surg Today 36:908–913
134. Lai PB, Leung KL, Ho WS, Yiu RY, Leung BC, Lau WY (2000) The use of liposucker for spleen retrieval after laparoscopic splenectomy. Surg Laparosc Endosc Percutan Tech 10:39–40
135. Seelig MH, Senninger N, Kocher T (2004) Laparoscopic splenectomy: first experiences with a 3-trocar-technique and the "hanging-spleen-maneuver". Zentralbl Chir 129:387–390
136. Chand B, Walsh RM, Ponsky J, Brody F (2001) Pancreatic complications following laparoscopic splenectomy. Surg Endosc 15:1273–1276
137. Pomp A, Gagner M, Salky B, Caraccio A, Nahouraii R, Reiner M, Herron D (2005) Laparoscopic splenectomy: a selected retrospective review. Surg Laparosc Endosc Percutan Tech 15:139–143
138. Rosin D, Brasesco O, Rosenthal RJ (2001) Laparoscopic splenectomy: new techniques and indications. Chirurg 72:368–377
139. Svensson M, Wiren M, Kimby E, Hagglund H (2006) Portal vein thrombosis is a common complication following splenectomy in patients with malignant haematological diseases. Eur J Haematol 77:203–209
140. Pietrabissa A, Moretto C, Antonelli G, Morelli L, Marciano E, Mosca F (2004) Thrombosis in the portal venous system after elective laparoscopic splenectomy. Surg Endosc 18:1140–1143
141. Rattner DW, Ellman L, Warshaw AL (1993) Portal vein thrombosis after elective splenectomy: an underappreciated, potentially lethal syndrome. Arch Surg 128:565–570
142. Harris W, Marcaccio M (2005) Incidence of portal vein thrombosis after laparoscopic splenectomy. Can J Surg 48:352–354
143. Romano F, Caprotti R, Conti M, Piacentini MG, Uggeri F, Motta V, Pogliani EM (2006) Thrombosis of the splenoportal axis after splenectomy. Langenbecks Arch Surg 391:483–488
144. Winslow ER, Brunt LM (2003) Perioperative outcomes of laparoscopic versus open splenectomy: a meta-analysis with an emphasis on complications. Surgery 134:647–655
145. Winslow ER, Brunt LM, Drebin JA, Soper NJ, Klingensmith ME (2002) Portal vein thrombosis after splenectomy. Am J Surg 184:631–636
146. Ikeda M, Sekimoto M, Takiguchi S, Kubota M, Ikenaga M, Yamamoto H, Fujiwara Y, Ohue M, Yasuda T, Imamura H, et al. (2005) High incidence of thrombosis of the portal venous system after laparoscopic splenectomy: a prospective study with contrast-enhanced CT scan. Ann Surg 241:208–216
147. Ikeda M, Sekimoto M, Takiguchi S, Yasui M, Danno K, Fujie Y, Kitani K, Seki Y, Hata T, Shingai T, et al. (2007) Total splenic vein thrombosis after laparoscopic splenectomy: a possible candidate for treatment. Am J Surg 193:21–25
148. Fujita F, Lyass S, Otsuka K, Giordano L, Rosenbaum DL, Khalili TM, Phillips EH (2003) Portal vein thrombosis following splenectomy: identification of risk factors. Am Surg 69:951–956
149. van't Riet M, Burger JW, van Muiswinkel JM, Kazemier G, Schipperus MR, Bonjer HJ (2000) Diagnosis and treatment of portal vein thrombosis following splenectomy. Br J Surg 87:1229–1233
150. Petit P, Bret PM, Atri M, Hreno A, Casola G, Gianfelice D (1994) Splenic vein thrombosis after splenectomy: frequency and role of imaging. Radiology 190:65–68
151. Loring LA, Panicek DM, Karpeh MS (1998) Portal system thrombosis after splenectomy for neoplasm or chronic hematologic disorder: is routine surveillance imaging necessary? J Comput Assist Tomogr 22:856–860
152. Chaffanjon PC, Brichon PY, Ranchoup Y, Gressin R, Sotto JJ (1998) Portal vein thrombosis following splenectomy for hematologic disease: prospective study with Doppler color flow imaging. World J Surg 22:1082–1086
153. Watson DI, Coventry BJ, Chin T, Gill PG, Malycha P (1997) Laparoscopic versus open splenectomy for immune thrombocytopenic purpura. Surgery 121:18–22
154. Ojima H, Kato T, Araki K, Okamura K, Manda R, Hirayama I, Hosouchi Y, Nishida Y, Kuwano H (2006) Factors predicting long-term responses to splenectomy in patients with idiopathic thrombocytopenic purpura. World J Surg 30:553–559
155. Friedman RL, Fallas MJ, Carroll BJ, Hiatt JR, Phillips EH (1996) Laparoscopic splenectomy for ITP: the gold standard. Surg Endosc 10:991–995
156. Marassi A, Vignali A, Zuliani W, Biguzzi E, Bergamo C, Gianotti L, Di Carlo V (1999) Splenectomy for idiopathic

thrombocytopenic purpura: comparison of laparoscopic and conventional surgery. Surg Endosc 13:17–20
157. Tsereteli Z, Smith CD, Branum GD, Galloway JR, Amerson RJ, Chakaraborty H, Hunter JG (2001) Are the favorable outcomes of splenectomy predictable inpatients with idiopathic thrombocytopenic purpura (ITP)? Surg Endosc 15:1386–1389
158. Pace DE, Chiasson PM, Schlachta CM, Mamazza J, Poulin EC (2003) Laparoscopic splenectomy for idiopathic thrombocytopenic purpura (ITP). Surg Endosc 17:95–98
159. Winde G, Schmid KW, Lugering N, Fischer R, Brandt B, Berns T, Bunte H (1996) Results and prognostic factors of splenectomy in idiopathic thrombocytopenic purpura. J Am Coll Surg 183:565–574
160. Harold KL, Schlinkert RT, Mann DK, Reeder CB, Noel P, Fitch TR, Braich TA, Camoriano JK (1999) Long-term results of laparoscopic splenectomy for immune thrombocytopenic purpura. Mayo Clin Proc 74:37–39
161. Bresler L, Guerci A, Brunaud L, Ayav A, Sebbag H, Tortuyaux JM, Lederlin P, Boissel P (2002) Laparoscopic splenectomy for idiopathic thrombocytopenic purpura: outcome and long-term results. World J Surg 26:111–114
162. Balague C, Targarona EM, Cerdan G, Novell J, Montero O, Bendahan G, Garcia A, Pey A, Vela S, Diaz M, et al. (2004) Long-term outcome after laparoscopic splenectomy related to hematologic diagnosis. Surg Endosc 18:1283–1287
163. Balague C, Vela S, Targarona EM, Gich IJ, Muniz E, D'Ambra A, Pey A, Monllau V, Ascaso E, Martinez C, et al. (2006) Predictive factors for successful laparoscopic splenectomy in immune thrombocytopenic purpura: study of clinical and laboratory data. Surg Endosc 20:1208–1213
164. Kwon HC, Moon CH, Cho YR, Kim MC, Kim KH, Han JY, Lee YH, Oh SY, Kim SH, Kim JS, et al. (2005) Prognostic factors of response to laparoscopic splenectomy in patients with idiopathic thrombocytopenic purpura. J Korean Med Sci 20:417–420
165. Qureshi FG, Ergun O, Sandulache VC, Nadler EP, Ford HR, Hackam DJ, Kane TD (2005) Laparoscopic splenectomy in children. JSLS 9:389–392
166. Park A, Heniford BT, Hebra A, Fitzgerald P (2000) Pediatric laparoscopic splenectomy. Surg Endosc 14:527–531
167. Minkes RK, Lagzdins M, Langer JC (2000) Laparoscopic versus open splenectomy in children. J Pediatr Surg 35:699–701
168. Rescorla FJ, Breitfeld PP, West KW, Williams D, Engum SA, Grosfeld JL (1998) A case controlled comparison of open and laparoscopic splenectomy in children. Surgery 124:670–676
169. Farah RA, Rogers ZR, Thompson WR, Hicks BA, Guzzetta PC, Buchanan GR (1997) Comparison of laparoscopic and open splenectomy in children with hematologic disorders. J Pediatr 131:41–46
170. Hicks BA, Thompson WR, Rogers ZR, Guzzetta PC (1996) Laparoscopic splenectomy in childhood hematologic disorders. J Laparoendosc Surg 6(Suppl 1):S31–S34
171. Janu PG, Rogers DA, Lobe TE (1996) A comparison of laparoscopic and traditional open splenectomy in childhood. J Pediatr Surg 31:109–114
172. Yoshida K, Yamazaki Y, Mizuno R, Yamadera H, Hara A, Yoshizawa J, Kanai M (1995) Laparoscopic splenectomy in children: preliminary results and comparison with the open technique. Surg Endosc 9:1279–1282
173. Cusick RA, Waldhausen JH (2001) The learning curve associated with pediatric laparoscopic splenectomy. Am J Surg 181:393–397
174. Mattioli G, Pini Prato A, Cheli M, Esposito C, Garzi A, LiVoti G, Mastroianni L, Porreca A, Riccipetitoni G, Scalisi F, et al. (2007) Italian multicentric survey on laparoscopic spleen surgery in the pediatric population. Surg Endosc 21:527–531
175. Danielson PD, Shaul DB, Phillips JD, Stein JE, Anderson KD (2000) Technical advances in pediatric laparoscopy have had a beneficial impact on splenectomy. J Pediatr Surg 35:1578–1581
176. Rescorla FJ, Engum SA, West KW, Tres Scherer LR III, Rouse TM, Grosfeld JL (2002) Laparoscopic splenectomy has become the gold standard in children. Am Surg 68:297–302
177. Curran TJ, Foley MI, Swanstrom LL, Campbell TJ (1998) Laparoscopy improves outcomes for pediatric splenectomy. J Pediatr Surg 33:1498–1500
178. Waldhausen JH, Tapper D (1997) Is pediatric laparoscopic splenectomy safe and cost effective? Arch Surg 132:822–824
179. Mantadakis E, Buchanan GR (2000) Elective splenectomy in children with idiopathic thrombocytopenic purpura. J Pediatr Hematol Oncol 22:148–153
180. Gadner H (2001) Management of immune thrombocytopenic purpura in children. Rev Clin Exp Hematol 5:201–222
181. George JN, Woolf SH, Raskob GE, Wasser JS, Aledort LM, Ballem PJ, Blanchette VS, Bussel JB, Cines DB, Kelton JG, et al. (1996) Idiopathic thrombocytopenic purpura: a practice guideline developed by explicit methods for the American Society of Hematology. Blood 88:3–40
182. Eden OB, Lilleyman JS (1992) Guidelines for management of idiopathic thrombocytopenic purpura. The British Paediatric Haematology Group. Arch Dis Child 67:1056–1058
183. Esposito C, Corcione F, Garipoli V, Ascione G (1997) Pediatric laparoscopic splenectomy: are there real advantages in comparison with the traditional open approach? Pediatr Surg Int 12:509–510
184. Rothenberg SS (1998) Laparoscopic splenectomy in children. Semin Laparosc Surg 5:19–24
185. Rescorla FJ (2002) Laparoscopic splenectomy. Semin Pediatr Surg 11:226–232
186. Jugenburg M, Haddock G, Freedman MH, Ford-Jones L, Ein SH (1999) The morbidity and mortality of pediatric splenectomy: does prophylaxis make a difference? J Pediatr Surg 34:1064–1067
187. Kucuk C, Sozuer E, Ok E, Altuntas F, Yilmaz Z (2005) Laparoscopic versus open splenectomy in the management of benign and malign hematologic diseases: a ten-year single-center experience. J Laparoendosc Adv Surg Tech A 15:135–139
188. Vecchio R, Cacciola E, Lipari G, Privitera V, Polino C, Cacciola R (2005) Laparoscopic splenectomy reduces the need for platelet transfusion in patients with idiopathic thrombocytopenic purpura. JSLS 9:415–418
189. Park A, Marcaccio M, Sternbach M, Witzke D, Fitzgerald P (1999) Laparoscopic vs open splenectomy. Arch Surg 134:1263–1269
190. Shimomatsuya T, Horiuchi T (1999) Laparoscopic splenectomy for treatment of patients with idiopathic thrombocytopenic purpura: comparison with open splenectomy. Surg Endosc 13:563–566
191. Baccarani U, Carroll BJ, Hiatt JR, Donini A, Terrosu G, Decker R, Chandra M, Bresadola F, Phillips EH (1998) Comparison of laparoscopic and open staging in Hodgkin disease. Arch Surg 133:517–522
192. Yuan RH, Chen SB, Lee WJ, Yu SC (1998) Advantages of laparoscopic splenectomy for splenomegaly due to hematologic diseases. J Formos Med Assoc 97:485–489
193. Diaz J, Eisenstat M, Chung R (1997) A case-controlled study of laparoscopic splenectomy. Am J Surg 173:348–350
194. Delaitre B, Pitre J (1997) Laparoscopic splenectomy versus open splenectomy: a comparative study. Hepatogastroenterology 44:45–49
195. Brunt LM, Langer JC, Quasebarth MA, Whitman ED (1996) Comparative analysis of laparoscopic versus open splenectomy. Am J Surg 172:596–601

196. Rhodes M, Rudd M, O'Rourke N, Nathanson L, Fielding G (1995) Laparoscopic splenectomy and lymph node biopsy for hematologic disorders. Ann Surg 222:43–46
197. Schlinkert RT, Mann D (1995) Laparoscopic splenectomy offers advantages in selected patients with immune thrombocytopenic purpura. Am J Surg 170:624–627
198. Yee LF, Carvajal SH, de Lorimier AA, Mulvihill SJ (1995) Laparoscopic splenectomy: the initial experience at University of California, San Francisco. Arch Surg 130:874–879
199. Watanabe Y, Horiuchi A, Yoshida M, Yamamoto Y, Sugishita H, Kumagi T, Hiasa Y, Kawachi K (2007) Significance of laparoscopic splenectomy in patients with hypersplenism. World J Surg 31:549–555
200. Owera A, Hamade AM, Bani Hani OI, Ammori BJ (2006) Laparoscopic versus open splenectomy for massive splenomegaly: a comparative study. J Laparoendosc Adv Surg Tech A 16:241–246
201. Casaccia M, Torelli P, Squarcia S, Sormani MP, Savelli A, Troilo BM, Santori G, Valente U, Basso N, Silecchia G, et al. (2006) The Italian Registry of Laparoscopic Surgery of the Spleen (IRLSS): a retrospective review of 379 patients undergoing laparoscopic splenectomy. Chir Ital 58:697–707
202. Terrosu G, Donini A, Baccarani U, Vianello V, Anania G, Zala F, Pasqualucci A, Bresadola F (1998) Laparoscopic versus open splenectomy in the management of splenomegaly: our preliminary experience. Surgery 124:839–843