

# Surgery of the spleen

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## Abstract

A normally functioning spleen is critical in providing adequate immune protection and in regulating blood homeostasis. Whereas primary disorders of the spleen can attenuate these important functions, absence of the spleen, most commonly as a result of surgical excision, carries the grave and lifetime risk of devastating systemic sepsis. With some historical exceptions, splenic surgery has classically involved removal of the entire organ at open surgery, either following traumatic injury or to supplement the medical management of haematological disorders. Performed primarily for this latter indication, laparoscopy has emerged over the last two decades as the strongly favoured approach for elective splenectomy, with very large splenic size being one of the few remaining reasons for a planned open approach. Even in skilled hands, laparoscopic splenectomy can prove technically demanding, where careful patient selection and recognition of major complications including haemorrhage, portal system thrombosis and pancreatic injury, requires considerable experience. Whether performed under emergency or elective circumstances and undertaken as an open or laparoscopic procedure, an optimal surgical outcome depends on the successful collaboration between surgeon, anaesthetist, haematologist and radiologist in the preoperative and postoperative phases. Finally, it is paramount that in patients undergoing splenectomy, sufficient attention is given to providing effective lifelong prophylaxis against post-splenectomy infection.

**Keywords** Haematology; laparoscopy; sepsis; splenectomy; trauma

## Introduction

With its name derived from the Greek, 'splḗn', and Latin, 'lien', the spleen was characterized classically by Hippocrates according to humorism. This identified the spleen as responsible for the production of yellow bile and, in parallel with the element of fire, corresponded to the choleric, or easily angered, of the four temperaments. Following on from these ancient classifications, the spleen has become recognized as an organ with critical roles in immune function and red blood cell regulation and accordingly is functionally conserved in virtually all vertebrates.

Disorders of the spleen resulting in functional attenuation are rare and result in hyposplenism, most commonly as a consequence of sickle cell disease, coeliac disease or long-term use of corticosteroid. The term asplenicism is reserved for those conditions where splenic activity is absent, and can be functional or

follow splenectomy. Elective surgery to remove the spleen is most often performed for haematological disease, where combined multidisciplinary care by surgical, anaesthetic and haematological specialists in the preoperative and postoperative phases ensures comprehensive and safe management in these complex patients. However, emergency splenectomy is still undertaken following iatrogenic or traumatic injury, although advances in imaging and interventional radiological techniques have identified an important role for non-operative management.

In the asplenic patient, a critical concern is the appropriate prophylactic management of sepsis. Timely vaccination, combined with antibiotic therapy, reduces the incidence of post-splenectomy infection which can otherwise rapidly progress to multiorgan failure and death. However, despite the presence of antimicrobial guidelines for the routine management of post-splenectomy patients, a significant number of patients remain without adequate sepsis prophylaxis.

## Indications for splenectomy

### Elective splenectomy

Elective splenectomy is routinely performed laparoscopically if anatomically and technically feasible<sup>1–3</sup> and is most frequently undertaken for benign haematological disorders including idiopathic thrombocytopenic purpura, itself accounting for 50–80% of elective laparoscopic splenectomies, and haemolytic anaemia.<sup>1,2,4</sup> Less frequently, splenectomy for oncological purposes is performed in the context of primary or, more rarely, metastatic tumours of the spleen or the very occasional staging of specific haematological malignancies including lymphoma. En-bloc removal of the spleen may alternatively form part of a resection for malignancy involving the tail of the pancreas.<sup>5</sup>

### Emergency splenectomy

Emergency splenectomy is typically performed using conventional open surgical approaches in the context of trauma or iatrogenic injury to the spleen. Whereas some series have suggested that such splenic injuries constitute the principal indication for splenectomy,<sup>6</sup> there exists considerable variation, with other centres reporting that only approximately 16% of spleens were removed for trauma. The spleen is the most commonly injured organ in the abdomen despite the classical description of protection by the lower ribs and costal margin.<sup>7</sup> Although principally associated with road traffic accidents, falls and sporting injuries, spontaneous rupture of the spleen can also occur where the spleen is enlarged as a result of haematological or infectious pathology, such as Epstein–Barr virus infection or malaria, or where there is excessive anti-coagulation.

Iatrogenic injuries to the spleen at laparotomy are not uncommon and occur in approximately 1% of colorectal resections requiring splenectomy in around 85% of cases. Other than after splenic flexure mobilization, unplanned splenectomy was most frequently performed during anti-reflux surgery, left nephrectomy and aortic surgery, particularly where there had been previous surgery or in the obese. One study reported that approximately 40% of all splenectomies were carried out for inadvertent operative injury. Traction injuries to the lower pole of the spleen following excessive manoeuvring during colonoscopy have also been reported, although these instances are rare.

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A specific danger under these circumstances is that bleeding can be occult and recognized late after haemodynamic deterioration.

Whether iatrogenic or traumatic, injuries to the spleen have been characterized according to the extent of injury<sup>7</sup> (Table 1). Injury grading is anatomical and based on radiological assessment by CT or operative findings and not systematically correlated with clinical outcome. Nevertheless, mortality from traumatic grade V injuries was significantly greater (at approximately 23%) compared to the lesser grades of injury, which varied from 6.9 to 9.4%, and each grade was significantly predictive of length of hospital stay.<sup>7</sup> Despite these predictive shortcomings, characterizing the extent of injury and assessing the clinical status of the patient provides important information regarding surgical care. This is because in patients who are haemodynamically stable with low-grade injuries, successful splenic conservation by non-operative management is both achievable and favourable when compared with open splenectomy in terms of overall morbidity and without the lifelong need for post-splenectomy prophylaxis. Under these circumstances, it is the authors' practice that these patients are carefully observed over 72 hours in a high-dependency ward setting, the period within which most failures of non-operative management occur, and urgent laparotomy undertaken where there is any physiological deterioration.<sup>8</sup> It has been reported that approximately 10% of patients selected for non-operative management will progress to surgery.<sup>8</sup> Indeed, failure of non-operative management is associated with high grade splenic injury and in centres where trauma workload is low.

The success of non-operative management is critically dependent on careful appraisal of CT imaging and attention to any alteration in haemodynamic behaviour, since an

underestimation of physiological instability or injury severity have been implicated in approximately 40% of failed non-operative cases. As a consequence of comparatively lower grades of splenic injury and perhaps an increased desire to avoid splenectomy, non-operative management is highly favoured in the paediatric setting and successful in over 90% of injuries in children.<sup>9</sup> By contrast, some investigators have suggested that in patients greater than 55–60 years of age, higher grade injuries and failure of non-operative management are more likely and contribute to the greater overall mortality of around 10% observed in this age-group, compared with 5% in younger patients. These data support the notion that in the elderly, surgery might be contemplated early, even in the presence of low grade splenic injuries, while patients remain physiologically well. Of those treated without surgery, careful observation only is required following discharge from high-dependency care, with follow-up CT imaging identified as of little clinical value.

Techniques involving interventional radiology are an adjunct to spleen-conserving management following traumatic injury. Recent work has identified a potential role for CT angiography and embolization, suggesting selective use in stable patients with evidence of radiologically active haemorrhage and/or pseudoaneurysm and appropriately severe splenic injury. While some authors have suggested that embolization might improve the success of non-operative management in these patients,<sup>10</sup> others have shown no difference.<sup>11</sup> One small retrospective study has even proposed the use of embolization in patients with high-grade injuries who are haemodynamically unstable, whereas the broad consensus is that these patients should always be managed surgically.<sup>8</sup> At present, selection criteria for arterial embolization in patients with splenic injury are poorly defined in non-randomized studies with small patient numbers, where comparative failure rates requiring splenectomy, post-embolectomy sequelae and longer-term outcome require to be clarified.

**American Association for surgery of trauma organ injury scale for spleen<sup>7</sup>**

Grade	Injury description
I	Haematoma Subcapsular, < 10% surface area
	Laceration Capsular tear, <1 cm parenchymal depth
II	Haematoma Subcapsular, 10–50% surface area; intraparenchymal, <5 cm in diameter
	Laceration 1–3 cm parenchymal depth, which does not involve a trabecular vessel
III	Haematoma Subcapsular, >50% surface area or expanding; ruptured subcapsular or parenchymal haematoma; intraparenchymal haematoma >5 cm or expanding
	Laceration >3 cm parenchymal depth, or involving trabecular vessels
IV	Laceration Laceration involving segmental or hilar vessels producing major devascularization (>25% of spleen)
V	Haematoma Completely shattered spleen
	Laceration Hilar vascular injury which devascularizes spleen

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**Open splenectomy**

**Indications**

The principal indication for open splenectomy is splenic trauma in the haemodynamically unstable patient, regardless of the severity of injury or planned non-operative management. Alternatively, patients with an iatrogenic splenic injury during abdominal surgery unresponsive to conservative methods including fibrin glue, oxidized regenerated cellulose sheets or fibrinogen/thrombin-impregnated patches should undergo splenectomy. Traditional conservative techniques including omental patches, absorbable mesh bags and spleen conserving resection are rarely undertaken. Open splenectomy may also be undertaken as a primary elective procedure in patients with massive splenomegaly not amenable to a laparoscopic approach.<sup>2,12</sup>

**Surgical technique**

Following administration of oxygen therapy, fluid resuscitation, antibiotic prophylaxis, with available cross-matched red cells and coagulation factors, adequate exposure is gained through an upper midline or left subcostal incision. In controlling haemorrhage, priority should be given to dividing the lienorenal ligament to facilitate medial and anterior splenic mobilization,

**Table 1**

allowing the hilar vessels to be identified and controlled. Care should be taken to secure the short gastric vessels during division of the gastrosplenic ligament. Where open elective splenectomy is undertaken for splenomegaly, the splenic artery can be approached and ligated in continuity first, allowing the spleen to shrink in size, rendering the remainder of the mobilization safer.<sup>13</sup> Following splenectomy, meticulous attention should be paid to haemostasis in the splenic bed, but there is little data to support routine subphrenic drainage.<sup>2</sup>

### Laparoscopic splenectomy

The technique and preliminary outcomes of laparoscopic splenectomy were initially published by several groups in the early 1990s.<sup>14</sup> The principle of laparoscopic splenectomy was based on the appreciation that an intact spleen was not required for pathological analysis in most cases and the perception that wound-related morbidity might be reduced. Since that period, several large studies have provided convergent evidence that in the vast majority of elective circumstances, laparoscopic splenectomy was strongly favourable compared with a conventional open approach in terms of reduction in postoperative discomfort, fewer wound or respiratory complications, a shorter hospital stay, less blood loss and a equivalent operating time.<sup>2,3</sup> Moreover, other data supports equivalent longer term outcomes for open and laparoscopic splenectomy when undertaken for haematological disease.<sup>15</sup> However, collaboration with the referring haematologist in the preoperative and postoperative phases to ensure platelet count, coagulation and DVT prophylaxis are sufficiently addressed is essential. Finally, quality-of-life outcome measures are improved with a laparoscopic approach compared with open splenectomy.

### Indications

In general terms, laparoscopic splenectomy represents an elective procedure where the short and longer term complications, principally the lifelong risk of severe post-splenectomy sepsis, are outweighed by the benefits of the specific indication for surgery, most often to assist in the medical management of haematological disease.<sup>2</sup> However, there are certain limitations to laparoscopic splenectomy. Laparoscopic splenectomy is associated with greater morbidity and longer operating times when the long axis of the spleen is greater than 15cm compared with spleens of a normal size.<sup>12</sup> For this reason, if the spleen is palpable on clinical examination the authors suggest that operative planning benefits from CT to clarify suitability for laparoscopic resection.<sup>1,2</sup> This is particularly important in light of evidence suggesting that in spleens greater than 20cm in maximal diameter, surgery should be performed as a primary open procedure.<sup>6</sup> Indeed, spleens which are super-massive in size, exceeding approximately 27 cm in longitudinal axis, are highly likely to require conversion to open surgery.<sup>2</sup> Interestingly, there is preliminary evidence that in massive and super-massive splenomegaly, preoperative splenic artery embolization might reduce the incidence of laparoscopic conversion to open surgery, although this needs to be corroborated.<sup>16</sup>

Although routine imaging is not usually recommended, cross-sectional radiological assessment should be performed when there is a clinical suspicion of portal hypertension, since venous shunts might occur through the splenic vasculature and may

preclude safe laparoscopic resection. Nevertheless, laparoscopic splenectomy has been performed successfully in patients with liver cirrhosis. Preoperative CT can also identify other anatomical features which might render laparoscopic resection more challenging including hilar lymphadenopathy, peri-splenic inflammation or splenic infarcts.<sup>2</sup> Splenic artery aneurysms are a rare but potentially life threatening and may be detected by preoperative CT (Figure 1). Management of significant aneurysms (>2 cm or enlarging) is by splenectomy and resection or more recently by endovascular occlusion.<sup>17</sup>

### Surgical technique

The favoured approach in laparoscopic splenectomy now employs the hanging spleen technique first described by Delaitre in 1995.<sup>18</sup> The patient is positioned in the right lateral decubitus position and the operating table broken to lengthen the distance between the left costal margin and iliac crest. The authors suggest a four-port arrangement and use of a 30° 10 mm laparoscope.<sup>1</sup> Dissection is commenced laterally from the inferior pole, dividing the lieno-renal ligament and continued to the superior polar attachment of the gastro-splenic ligament. Once satisfactorily circumferentially mobilized, control of the hilar pedicle is achieved through use of a linear cutting stapler device<sup>1,2,13</sup> (Figure 2). The spleen is then placed in a retrieval bag and hand-morcellated to assist in removal. After re-insufflation, meticulous attention to haemostasis should be conducted, although drainage is not usually indicated unless there are concerns regarding partial pancreatic transection or injury.<sup>2</sup> Hand-assisted laparoscopic splenectomy is particularly useful where there is splenomegaly or massive splenomegaly, allowing controlled manipulation of the spleen for safe dissection and easier extraction of the specimen.<sup>1,2</sup> Indeed, when used in splenomegaly, this technique is associated with a lower chance of conversion to open surgery, reduction in morbidity and a shorter hospital stay than with the fully laparoscopic approach.

### Complications

Although the overall incidence of any complication from splenectomy can exceed 50%, it is greatest in those patients



**Figure 1** Large aneurysm of the splenic artery.



**Figure 2** Control of the hilar pedicle.

undergoing open splenectomy, particularly in the context of iatrogenic or traumatic injury. In addition to general risks associated with surgery, such as respiratory complications, subphrenic abscess, haemorrhage, wound problems and visceral injury, there also exist complications specific to splenectomy, such as conversion from laparoscopic to open splenectomy, thrombotic phenomena, the sequelae of pancreatic injury, missed accessory spleens or splenosis and overwhelming post-splenectomy infection.

### Conversion to open surgery

When elective laparoscopic splenectomy is undertaken, conversion to open surgery for all reasons occurs in up to 20% of patients.<sup>2</sup> The most common reason for conversion is bleeding, accounting for around 80% of conversions, followed by difficulties with adhesions or inadvertent injury to the diaphragm or pancreas. However, the overall incidence of bleeding complications during laparoscopic splenectomy is low, occurring in approximately 3% of cases. Although laparoscopic splenectomy is associated with a lower risk of bleeding than open surgery,<sup>2</sup> when patients who were converted to open from laparoscopic splenectomy for bleeding are taken into account, the incidence of haemorrhagic complications is marginally greater at 4.8% than with open surgery, particularly where the surgeon is inexperienced. As expected, the likelihood of conversion to open surgery as a consequence of bleeding is reported to be considerably greater in those with splenomegaly.<sup>1,2</sup> While a learning curve exists in laparoscopic surgery, the number of cases required to become proficient in splenectomy is poorly defined and outcomes including conversion to open surgery are equivalent when trainees are supervised by experienced surgeons performing laparoscopic splenectomy.

### Pancreatic injury

Pancreatic injury during splenectomy can result in serious morbidity and should be considered in patients with abdominal pain, fever and hyperamylasaemia. Since injuries are often occult, CT is considered by the authors to be mandatory under these circumstances, where the cardinal radiological features include oedema of the pancreatic tail, peri-pancreatic fluid collection, subphrenic abscess, pseudocyst or pancreatic fistula.

Clearly some of these are late sequelae of pancreatic damage and highlight that most instances are not recognized intraoperatively. Although reported to occur in some 16% of open procedures, laparoscopic splenectomy is associated with a comparatively lower risk of pancreatic injury, in the order of 2%. While higher rates comparable to open surgery have been reported when asymptomatic hyperamylasaemia is also incorporated into the definition of pancreatic damage, the significance of this and any relationship to true parenchymal injury is unclear.

Understanding the intimate anatomical relationship of the tail of the pancreas to the spleen is crucial in reducing the risk of inadvertent damage. Under laparoscopic conditions, pancreatic injury is thought to be more likely where there is poor haemostasis or splenomegaly, where accurate division of the hilar vessels might be compromised.

### Missed accessory spleens and splenosis

Accessory splenic tissue is reported to be present in around 15% of patients with 70% of accessory spleens located around the splenic hilum.<sup>1</sup> Following initial concerns that laparoscopy might increase the rate of missed accessory splenic tissue, several studies now agree that the detection rate for accessory spleens is equivalent in open and laparoscopic surgery. Nevertheless, in order to improve detection, some authors have suggested routine imaging prior to laparoscopy, particularly in the era of high definition CT. Detection rates of 100% have been reported, regardless of the size of the accessory spleen, although other series have suggested considerably lower sensitivity in the region of 60% for CT, compared to 93% for laparoscopy. Therefore, the role of routine imaging prior to splenectomy to detect accessory spleens remains unclear.

Splenosis is the implantation of autologous splenic tissue within the peritoneal cavity. Although sometimes deliberate, where there is a desire to maintain some functional splenic activity following splenectomy, accidental splenosis is a complication typically occurring where the splenic capsule is torn during dissection. While reported to occur in up to 17% of open procedures, presumably mostly performed for trauma, there is little data on the incidence of splenosis following laparoscopic splenectomy. However, one study has reported that in an *in vivo* rodent model of laparoscopic splenectomy, the presence of a pneumoperitoneum made inadvertent splenic implantation during splenectomy more likely than with open surgery or laparoscopy without insufflation. Whether the experimental conditions can be translated into laparoscopic splenectomy in humans remains uncertain.

The importance of overlooking accessory splenic tissue or inadvertent splenosis at surgery is that when splenectomy is undertaken for haematological pathology, recurrence might be related to the persistence of such splenic tissue.<sup>1,2</sup> Since accessory splenic tissue is identified readily with laparoscopic and open techniques, long-term outcomes for laparoscopic splenectomy for benign haematological conditions are comparable to open surgery.<sup>15</sup> Given that detection rate for accessory spleens at surgery can exceed 90%, current guidelines suggest a judicious search intraoperatively is obligatory.<sup>2</sup> Furthermore, vigilant hand-morcellation of the spleen in the retrieval bag is critical during extraction to minimize the risk of intra-peritoneal or wound site splenosis.

### Portal and systemic venous thrombosis

In addition to the well-recognized increased incidence of lower limb venous thrombo-embolic disease associated with surgery in general, the risk of portal and splenic venous thrombosis (PSVT) is specifically increased following splenectomy.<sup>4</sup> Untreated, PSVT has the potential to generate life-threatening conditions including portal hypertension and intestinal venous infarction, but timely diagnosis can be hampered by vague clinical features.<sup>2</sup> The overall incidence of PSVT is reported to be approximately 3%, although alternative series using Doppler ultrasound 1 week post-operatively identified PSVT in around 20% of patients after laparoscopic splenectomy. Nevertheless, the overall incidence appears to be similar between open and laparoscopic procedures in most studies, typically occurring around 2 weeks following surgery and is best identified using CT where other complications can be excluded.<sup>1–3,19</sup>

While certain haematological disorders associated with a prothrombotic tendency are thought to contribute to a greater incidence of PSVT, correlation with increasing splenic size has also been reported.<sup>1,2</sup> This latter phenomenon is postulated to occur as a result of enlargement of the splenic vein and the resultant stump following resection, which might promote clot propagation. Although prophylaxis against PSVT remains controversial and the definition of high-risk groups unclear, guidelines suggest that once identified, immediate therapeutic low-molecular weight heparin followed by 3–6 months of warfarin therapy is required to achieve satisfactory clot resolution.<sup>1,2</sup>

### Overwhelming post-splenectomy infection

Following splenectomy, patients are more prone to developing severe sepsis, termed overwhelming post-splenectomy infection (OPSI), typically by encapsulated organisms normally isolated by the spleen. While the reported incidence is approximately 3% and most infections occur within the first 2 years, approximately one-third occur more than 5 years post-splenectomy and overall mortality can exceed 50%.<sup>2</sup> Nevertheless, the risk of OPSI is lifelong and thought to be 50-fold greater than in non-splenectomized patients with cases sometimes identified several decades following splenectomy.<sup>20</sup> The most commonly implicated organism is *Streptococcus pneumoniae*, identified in 50–90% of cases, with *Haemophilus influenzae* type B and *Nisseria meningitides* accounting for the majority of remaining cases.

As a result of the permanent risk of life-threatening sepsis, splenectomized individuals are recommended to undertake vaccine and antibiotic prophylaxis against infection. Current guidelines vary widely by country, but in general for elective surgery vaccination against pneumococcus, *Haemophilus influenzae* type B and meningococcus should be undertaken a minimum of 2 weeks prior to splenectomy and within the first 2 months following emergency splenectomy.<sup>2,20,21</sup> There is no current consensus on the duration of antibiotic prophylaxis following splenectomy but recent reports agree that penicillin or macrolide therapy should be undertaken immediately following splenectomy, the period when the risk of sepsis is greatest.<sup>2,20</sup> In the UK, lifelong antibiotic prophylaxis is recommended,<sup>21</sup> whereas in other countries long-term treatment is suggested in high-risk patients such as those with previous post-splenectomy sepsis or where splenectomy was undertaken for haematological disease resulting in impaired immunity.<sup>20</sup> Despite these efforts, a large majority of patients appear to

remain unaware of their susceptibility to infection, with important implications for antibiotic prophylaxis compliance. Furthermore, not all patients receive appropriate immunization, either as a result of poor vaccine response and inadequate re-vaccination or where vaccination is inadvertently omitted.<sup>20</sup>

### Conclusions

Laparoscopic splenectomy has emerged as the procedure of choice across almost all outcome measures for the majority of indications. Although there are few contraindications to laparoscopic splenectomy, careful patient selection is still paramount to minimize the potentially lethal risks associated with the procedure. However, an appreciation of the surgical anatomy and technical proficiency must be supplemented with a careful understanding of the operative pitfalls, occult presentation of complications, threat of severe sepsis and the absolute requirement for multidisciplinary care by an experienced team including surgeons, anaesthetists, interventional radiologists, haematologists and microbiologists. Despite the clear advantage of laparoscopy and a requirement for expert training for splenectomy, open surgery still has an important role in elective and emergency circumstances. ◆

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