Splenic injury: diagnosis and management

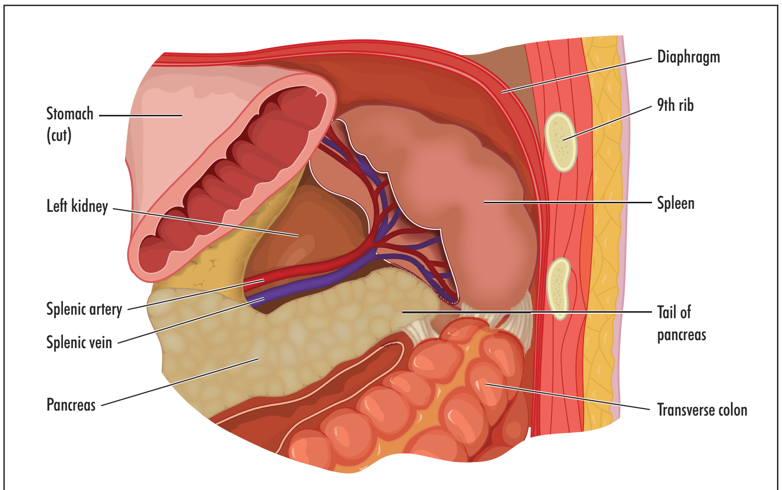
Better understanding of the dual functionality of the spleen has led to a conservative approach to splenic trauma. With accurate assessment and vigilant clinical examination up to two thirds of splenic injuries can be managed expectantly; when surgery is unavoidable, splenic preserving techniques may be used to maintain function.

Splenic injury following blunt abdominal trauma is relatively common, but the organ is also prone to iatrogenic injury from both operative and non-operative causes. The dual functionality of the spleen, combining both haematological and immunological function, and increasing awareness of the role it plays in preventing infection has led to an increased use of splenic preservation techniques. The role of expectant management in abdominal trauma and the increasing use and accuracy of radiological imaging and interventional radiology have also fostered a non-operative approach to splenic injury.

Anatomy

The spleen lies in a relatively protected location beneath the left cupola of the diaphragm against the ninth, tenth and eleventh ribs (*Figure 1*). It is covered by a fibrous capsule and has two main attachments: the lienorenal ligament (which is relatively bloodless) and the gastrosplenic ligament (containing the short gastric vessels (vasa brevia) and the left gastroepiploic branches of the splenic artery and vein). The spleen receives its blood supply from the splenic artery and the short gastric vessels; collateral flow via the left gastroepiploic artery may limit necrosis following ligation (or embolization) of the splenic artery. The splenic artery usually divides into its terminal branches outside the organ, and these vessels supply small transverse segments of spleen (*Figure 1*) (Dixon et al, 1980). It is the presence of these segmental end arteries that makes partial splenectomy feasible.

Figure 1. Anatomical illustration of relationships of the spleen with ligaments in situ.



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Physiology

The spleen has both a haematological and immunological function. The spleen is involved in the maturation of red cells and extraction of abnormal cells via phagocytosis (Mebius and Kraal, 2005). In adults, splenic haematopoiesis is only seen in myeloproliferative disorders and leads to the production of abnormal red cell forms – immature, multinucleated or megakaryoblasts (O'Malley et al, 2005). The filtering and destructive capabilities of the spleen are increased in splenomegaly and this tends to result in anaemia and cytopenias (hypersplenism).

The spleen makes an important contribution to both humoral and cell-mediated immunity; most of the white cells contained within it derive from bone marrow. The white pulp contains efferent lymphatics only: antigen is presented by dendritic cells to plasma cells within germinal centres with resultant antibody production (notably IgM) by plasma cells. Within the red pulp monocytes mature into tissue macrophages and, as a result of the local production of powerful opsonins (molecules that either act as a binding enhancer for phagocytosis or activate the complement system), the spleen has a critical immune function against encapsulated bacteria, which are relatively resistant to phagocytosis without these adjuncts.

Mechanisms of injury

Traumatic injuries are far more prevalent than iatrogenic injuries and tend to be more significant. However, both mechanisms can present a challenge to the clinician and management depends upon their grade of injury and stability of the patient. Classically, a ruptured spleen leads to haemoperitoneum and hypotensive shock, but some injuries present some hours or even weeks later. In these situations the patient develops either a subcapsular haematoma or a post-traumatic pseudocyst (at a later stage), which can secondarily rupture into the peritoneal cavity.

Traumatic

The spleen is injured in approximately 0.17–1.3% of all traumatic injuries presenting to hospital (Garber et al, 2000; Brady et al, 2007; Hildebrand et al, 2014). Splenic trauma predominantly affect young men; 70% of all injuries occur in males with a median age of 30 years (Garber et al, 2000; Brady et al, 2007). The most common mechanism of injury is road traffic collisions (with mortality rates of up to 38%), although it can be seen following falls onto protruding objects (e.g. a bicycle handlebar) (Brady et al, 2007). Patients with splenomegaly may sustain significant injury following relatively trivial trauma. Penetrating injuries are much less common except in military situations or in areas of endemic urban violence, accounting for 5–14% of all cases (Garber et al, 2000; Brady et al, 2007). Isolated splenic injury is uncommon following major trauma (6.2% of cases) and concurrent injury to the thorax (37.7–77%), head (46.5–59%) and liver (31%) are frequently reported (Garber et al, 2000; Brady et al, 2007). Concurrent diaphragmatic injury may occur with both blunt and penetrating splenic injury, although this may be difficult to detect at the time of presentation as many injuries are small and enlarge over time.

Iatrogenic

Iatrogenic splenic injury can occur through one of three main mechanisms: during splenic biopsy, during colonoscopy or during operative intervention to the upper abdomen. Although the incidence of iatrogenic injury is not fully known, with many minor injuries being asymptomatic, it is thought to be low.

Biopsy

Splenic biopsy is a viable alternative to elective splenectomy in providing tissue for a histological diagnosis, with significantly less associated operative morbidity. Radiologically-guided splenic biopsy is performed in a similar manner to renal and hepatic biopsies with comparable sensitivity (87%) and complication rates (2.2%), mostly from bleeding and pain (McInnes et al, 2011). Operative intervention has not been reported for the management of post-biopsy complications.

Colonoscopy

Splenic injury during colonoscopy can result from direct trauma or excessive traction on the spleno-colic ligament. Although the incidence of injury is low (0.00005–0.017%), the resultant trauma is associated with a high morbidity (Singla et al, 2012). A review found 102 reported cases of splenic injury following colonoscopy in the literature; of these 73 (72%) underwent operative intervention, with 70 requiring splenectomy (96%) (Singla et al, 2012). Thus a high degree of clinical suspicion should be maintained in patients with abdominal pain following colonoscopy.

Intraoperative

Splenic injury can complicate both open and laparoscopic intervention and tends to occur when an omental adhesion is avulsed from the surface of the organ; over-enthusiastic use of a retractor during open operations is another occurrence. Most injuries tend to respond to splenic preserving techniques (see below) rather than formal splenectomy.

Assessment

Patients with splenic trauma require both clinical and radiological assessment to reveal extent of injury. Clinical examination should focus on whether the patient is stable enough to allow urgent computed tomography, or requires resuscitative laparotomy.

History and examination

Key points from the history should include the mechanism of injury and any risk factors for splenomegaly or operative intervention (e.g. bleeding diathesis or cardiovascular comorbidities). Patients should be assessed in accordance with advanced trauma life support protocols. Clinical signs associated with splenic trauma are notoriously unreliable, but tenderness and bruising to the left upper quadrant (combined with rib fractures) or penetrating injury should raise the index of suspicion (Burch and Moore, 2006; Hildebrand et al, 2014). Significant trauma to the left lower chest (fractures of one of more lower ribs (7–12) or patients with pleuritic chest pain) has been associated with splenic injury in 43% of patients presenting to a level 1 trauma centre (Schneir and Holmes, 2001).

Investigations

The use of investigation is highly dependent on the overall stability of the patient; those whom are deemed too unstable to undergo investigation are best served with resuscitative laparotomy (Williamson et al, 2013). A full blood count and clotting screen can provide an estimation of blood loss and may show signs of pre-existing haematological disease or hypersplenism. Computed tomography is the investigation of choice in abdominal trauma (*Figure 2*), with an accuracy of up to 98% (Wallis et al, 2010); it will highlight the extent of splenic and concomitant injury, and may guide management (*Table 1*) (Moore et al, 1995; Murken et al, 2012). Focused assessment with sonography in trauma (FAST) scans can provide information about the extent of injury and the presence of free peritoneal fluid (98% sensitivity); however, they are highly user dependent as up to 25% of splenic injuries may be missed (Hildebrand et al, 2014). Extravasation can be seen in up to 32% of cases during angiography, and these vascular injuries may be amenable to subsequent embolization (Haan et al, 2004; Dasgupta et al, 2010).

Management

The key decision in managing patients with splenic injuries is their overall cardiovascular stability and requirement for blood and fluid resuscitation. Patients who are unstable require immediate resuscitative laparotomy and those who are stable should be managed expectantly. Overall mortality associated with splenic trauma ranges from 2.1–9.2% (Garber et al, 2000; Hildebrand et al, 2014).

Non-operative management

The use of expectant management for splenic trauma is increasing; minor injuries are routinely managed conservatively, and there has been a shift to non-operative management in more complex splenic injury (Hildebrand et al, 2014). Currently two thirds of patients can be managed conservatively with success rates of 90% (Renzulli et al, 2010; Clancy et al, 2012). The main complication of conservative management is one of failure; patients who require more than two units of blood or show signs of ongoing bleeding should be considered for operative exploration or embolization (Rose et al, 2000). Complications following conservative management also include abscess formation (2.3%), infarction (50% for grade IV injuries and 66% for grade V injuries) and death (4%) (Cocanour et al, 1998; Clancy et al, 2012). Both older patients and those with high grade injury are thought to be at an increased likelihood of failure of conservative management.

Figure 2. Computed tomography scan of a 27-year-old man involved in a road traffic collision showing a grade III laceration. Note major disruption to the lower pole and further lacerations to the superior pole. The patient was managed conservatively.

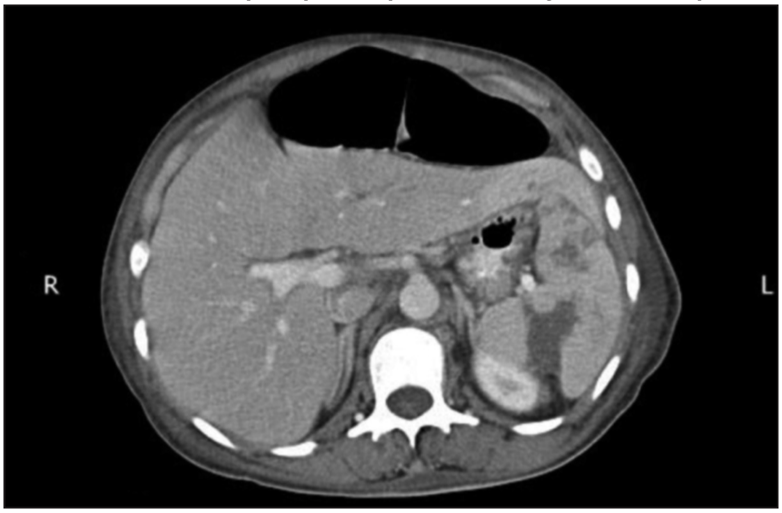

Table 1. American Association for the Surgery of Trauma (AAST) organ injury scales for spleen

AAST grade	Laceration: characteristics of injury	Haematoma: characteristics of injury
I	Capsular tear, non-bleeding, <1 cm parenchymal depth	Subcapsular, non-expanding, <10% surface area
II	Capsular tear, active bleeding, 1–3 cm parenchymal depth, not involving a trabecular vessel	Subcapsular, non-expanding, 10–50% surface area; intraparenchymal, non-expanding, <5 cm in diameter
III	>3 cm parenchymal depth or involving trabecular vessels	Subcapsular, >50% surface area or expanding; ruptured subcapsular haematoma with active bleeding; intraparenchymal, >5 cm or expanding
IV	Laceration involving segmental or hilar vessels producing major devascularization (>25% of spleen)	Ruptured intraparenchymal haematoma with active bleeding
V	Completely shattered spleen	Hilar vascular injury that devascularizes spleen

Advance one grade for multiple injuries up to level III (Moore et al, 1995). Minor injuries = grade I–II, major injuries = III–V

Embolization therapy

Embolization is being increasingly used as an adjunct to non-operative management in all grades of splenic injury. Approximately 7% of patients managed expectantly are suitable for endovascular intervention (Renzulli et al, 2010), with success rates of up to 95% (Haan et al, 2004; Dasgupta et al, 2010; Wallis et al, 2010). No clear selection criteria exist for which patients should undergo embolization, although those with the presence of active splenic bleeding (contrast blush on computed tomography), a haemoperitoneum, a high grade splenic injury or a non-bleeding vascular injury (i.e. pseudoaneurysm) may benefit from intervention (Wallis et al, 2010). Embolization can decrease the rate of blood loss for splenic laceration and may prevent the morbidity and mortality associated with operation, although it cannot evacuate perisplenic haematoma (Sclafani et al, 1995).

The decision about which type of embolization to perform – peripheral splenic artery branch embolization or main splenic artery embolization – is controversial, although a shattered spleen with multiple areas of contrast extravasation is better treated with proximal embolization (Dasgupta et al, 2010; Lopera, 2010). The benefits of preserving splenic function must be balanced against the risk of delayed haemorrhage. Splenic perfusion should be maintained following embolization, to a greater or lesser extent, by collateral supply from the pancreatic, gastroduodenal and gastric arteries. Complications include abscess formation (3.8–7%), infarction (10–43%) and fluid collections (43%); splenic atrophy, fever and pleural effusions are uncommon (Dasgupta et al, 2010; Lopera, 2010; Renzulli et al, 2010).

Operative

The priority in the management of a patient with a ruptured spleen is to restore the circulating blood volume: splenectomy is the simplest definitive management and is performed in 97% of cases (Renzulli et al, 2010). The extent of injury and condition of the patient influences whether splenic salvage (splenic repair (splenorrhaphy) or

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partial splenectomy) may be considered (Cooper and Williamson, 1984; Burch and Moore, 2006). Splenic salvage is often attempted more vigorously in paediatric patients, as they are at greater risk of overwhelming post-splenectomy infection.

Splenectomy

Abdominal access is via an upper midline or left subcostal laparotomy incision, which allows assessment of the viscera and packing of any bleeding points. The spleen is mobilized and delivered by dividing the lienorenal ligament and short gastric vessels. Prompt delivery of the spleen is mandated when the spleen is bleeding profusely, and digital dissection is often required. The splenic artery and then the splenic vein are subsequently ligated and divided. Care must be taken to avoid injury to the greater curve of the stomach, pancreatic tail and left colic flexure. Undue tension on the spleen should be resisted to minimize tearing the splenic capsule. Dissection can be facilitated by rotating the spleen anticlockwise and by tilting the operating table to the right or by placing the patient in the reverse Trendelenberg position (to expose the plane between the spleen and pancreas) (Burch and Moore, 2006). It is customary to place a drain to the splenic bed and to leave a nasogastric tube in place at the end of the operation to prevent acute gastric dilatation.

Splenic preserving techniques

Recognition of the immunological importance of the spleen has revived interest in splenic preserving techniques and autotransplantation. Unless the spleen is clearly injured beyond repair, it should be carefully inspected to see if it can be salvaged. Minor splenic lacerations and capsular tears can usually be controlled with local pressure combined with electrocautery or a haemostatic agent (such as gelatin sponge, fibrin glue, thrombin and microfibrillar collagen) (Kram et al, 1990; Hildebrand et al, 2014). Suture repair (splenorrhaphy) with a blunt tipped heavy monofilament suture, with or without adjuncts (including Teflon buttresses, a tongue of omentum or a topical haemostatic agent), can be used for more extensive injuries (Cooper and Williamson, 1984) (*Figure 3*).

Decreasing the splenic arterial blood supply, either by ligation or embolization, can increase the likelihood of splenic salvage techniques (Sclafani et al, 1995; Dasgupta et al, 2010). Traumatic injuries that affect only a portion of the spleen (usually inferior or superior half) may be suitable for partial splenectomy. This technique is possible because of the segmental nature of the splenic blood supply – the relevant peripheral splenic arterial supply is ligated and the damaged segment excised. Interrupted mattress sutures should be placed along the raw edge of the spleen to cause parenchymal compression and haemostasis (Burch and Moore, 2006).

Autotransplantation

Postsplenectomy sepsis is markedly reduced in traumatic situations compared to the elective setting, potentially as a result of seeding of splenic cells within the peritoneal cavity (Zoli et al, 1994). Attempts have been made to retain some immunological function following splenectomy by implanting ‘nests’ of splenic tissue within an omental pocket or artificial mesh.

Postoperative complications

Patients can develop left-sided subphrenic collections (even with a drain in situ) following splenectomy, secondary to oozing from the raw surface of the splenic bed. Symptomatic collections can cause pain, fever, leukocytosis and a left pleural effusion; they can be aspirated under radiological guidance. Other complications include acute gastric dilatation, left basal collapse (which should respond to physical therapy with or without antibiotics) and, uncommonly, a gastric or pancreatic fistula (which may close spontaneously with satisfactory drainage) (Ellison and Fabri, 1983).

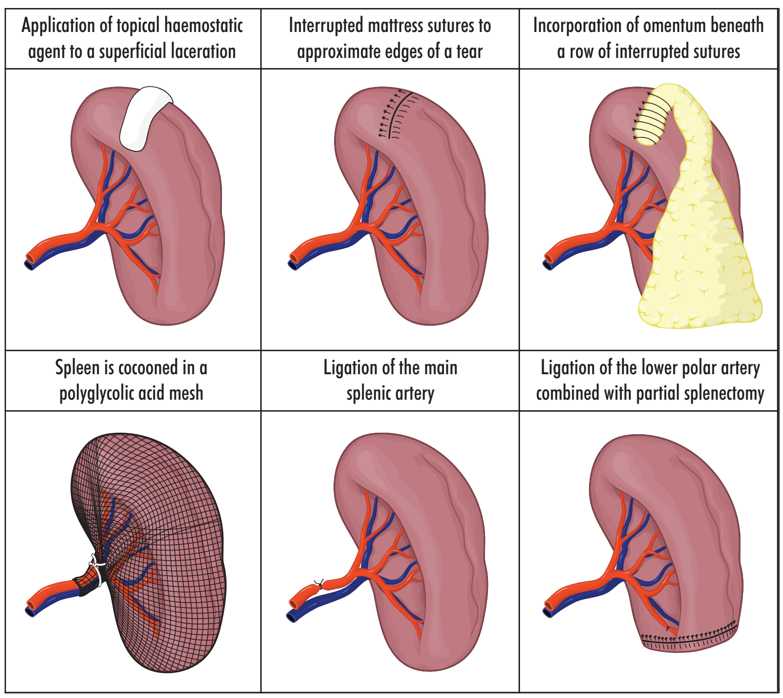
Effects following splenectomy

The resultant asplenia following splenectomy has both a haematological and immunological effect; the most significant is the lifelong risk of overwhelming post splenectomy infection.

Haematological effects

Following splenectomy, defective red cells can be seen within the circulation, including target and burr cells, surface craters and pits and a variety of red cell inclusions: Howell–Jolly bodies (nuclear remnants), Heinz bodies

Figure 3. Schematic showing some techniques of splenic conservation.

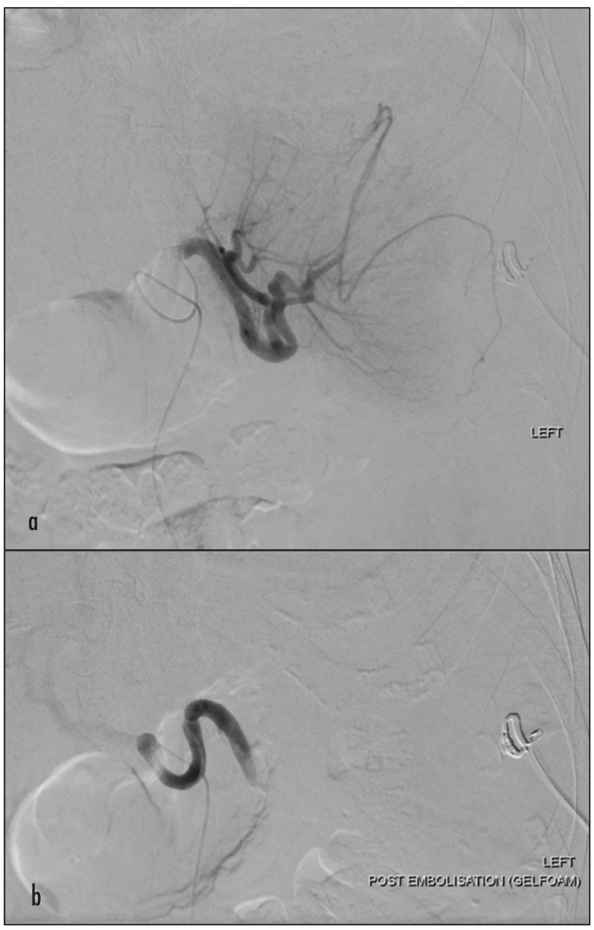


(denatured haemoglobin) and Pappenheimer bodies (iron granules) (Cooper and Williamson, 1984). Leukocytosis results from a transient rise in neutrophils and a sustained rise in lymphocytes and eosinophils. Thrombocytosis typically develops within 1 week of operation and may persist for years. It is caused by increased production of platelets rather than prolonged survival, but it is not clear if it is associated with an increased risk of thromboembolic events (Cooper and Williamson, 1984). Most institutions would consider giving antiplatelet agents once the platelet count reaches $1000–1500 \times 10^9$/litre. Less than 3% of patients develop splenic and portal vein thrombosis, but those that do may require full anticoagulation to prevent portal hypertension (Krauth et al, 2008).

Immunological effects

Immunoglobulin production is affected for up to 4 years following splenectomy: IgM levels are reduced, although there is an increase in both IgA and IgG levels. In addition, there is a reduction in plasma tuftsin levels (leading to impaired neutrophil phagocytosis) and factor P levels (interfering with complement activation) along with loss of helper T-cell function. This reduction in immunological function results in a failure to opsonize and subsequently phagocytose encapsulated bacteria, with a corresponding risk of postsplenectomy sepsis (Cooper and Williamson, 1984). Tuftsin deficiency may be the critical factor in the susceptibility to major infection (Zoli et al, 1994).

Figure 4. a. Angiogram of splenic artery performed for ongoing haemorrhage. b. No definitive extravasation was identified and Gelfoam embolization of the main splenic artery was performed with resultant occlusion.



Overwhelming postsplenectomy infection

The incidence of overwhelming postsplenectomy infection (fulminating sepsis, meningitis or pneumonia in splenectomised patients) is 1–2%, with children at greater risk than adults (Hansen and Singer, 2001). Although there is a lifelong risk of overwhelming postsplenectomy infection, most cases present within 2 years of injury. Patients present with signs of severe sepsis following an insidious infection, typically with *Streptococcus pneumoniae* (50–90% of cases), *Neisseria meningitidis* and *Haemophilus influenzae* type b (Hansen and Singer, 2001). Broad spectrum antibiotics are the mainstay of treatment, but the mortality rate is 70% within 48 hours (Di Sabatino et al, 2011).

Prevention of overwhelming postsplenectomy infection

Patient education is the most important mechanism to prevent overwhelming postsplenectomy infection: patients must be made aware of their increased susceptibility to severe sepsis and told to seek urgent medical attention if they have any signs of acute febrile illness (Brigden et al, 2004; Davies et al, 2011). Patients should be vaccinated against pneumococcus, *H. influenzae* and meningococcus within 2 weeks of operation; yearly influenza and 5-yearly pneumococcal vaccinations should be given to reduce the risk of infection (Langley et al, 2010; Davies et al, 2011; Di Sabatino et al, 2011).

The effectiveness of antibiotics in preventing overwhelming postsplenectomy infection is not known. Long-term use is associated with problems of patient compliance and the development of penicillin-resistant organisms (Di Sabatino et al, 2011). Children typically receive penicillin V (250mg/day) for at least 2 years and lifelong antibiotic therapy is recommended for high-risk groups; low-risk patients should be counselled as to the risks and benefits of prophylaxis (Davies et al, 2011).

Follow-up

There are no guidelines for the ongoing management of splenic injuries, either in conservative or operative intervention (Clancy et al, 2012; Hildebrand et al, 2014). Routine imaging following conservative management is not advocated as most injuries should have resolved within 6 weeks. Repeat computed tomography in patients who wish to return to contact sports can be performed, with a delay of 8 weeks usually being advocated (Clancy et al, 2012). Late rupture can occur and reassessment is advocated for symptomatic patients (Clancy et al, 2012; Hildebrand et al, 2014).

Conclusions

The cardiovascular stability of patients with splenic (or suspected splenic injuries) is paramount in deciding management: those who are unstable require urgent intervention and are usually best served with resuscitative laparotomy and splenectomy. Patients who are stable should undergo urgent computed tomography to assess the extent of their injuries and can often be managed expectantly. When intervention is required, embolization and splenic preserving techniques should be considered to preserve function and prevent post splenic sepsis. **BJHM**

Conflict of interest: none.

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KEY POINTS

- Despite its relatively protected location, the spleen is prone to both iatrogenic and traumatic injury.
- Splenic injuries are increasingly managed expectantly, led in part by better recognition of the haematological and immunological function of the spleen.
- Splenic injuries can be managed in a multidisciplinary manner with radiological and splenic conserving measures advocated to prevent splenectomy.
- Splenectomy is associated with both haematological and immunological derangement; the most important complication is the risk of overwhelming postsplenectomy infection.