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CLINICAL REVIEW

Modern management of splenic trauma

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Trauma is a major cause of morbidity and mortality; in the developed world, road traffic accidents are one of the leading causes. Up to 45% of patients with blunt abdominal trauma will have a splenic injury,[1] which may require urgent operative management, angioembolisation, or non-operative management in the form of active observation.

The management of splenic injuries has evolved over the past three decades with the realisation of the importance of the spleen in immunological defence against encapsulated organisms and a better understanding of the role of non-operative management of splenic injuries. Such management has been aided by better diagnostic and monitoring facilities and by advances in interventional radiology. This article aims to review the best available evidence for the management of patients with blunt splenic trauma.

Why is the spleen important?

The spleen removes old red blood cells and holds a reserve of blood. The white pulp synthesises antibodies, opsonins, properdin, and tuftsin. It removes antibody-coated bacteria and antibody-coated blood cells. The spleen contains half of the body's monocytes within the red pulp; these can specialise into dendritic cells and macrophages, which are crucial for antigen presentation to the immune system.

Post-splenectomy patients have modest increases in circulating white blood cells and platelets, a diminished responsiveness to some vaccines, and an increased susceptibility to infection by bacteria and protozoa. In particular, they have an increased risk of sepsis from polysaccharide encapsulated bacteria such as *Haemophilus influenzae* type b and *Streptococcus pneumoniae*.

Who gets splenic injuries?

Splenic trauma is caused by either non-penetrating (blunt) or penetrating injuries. Road traffic accidents, falls from height, assaults, and sporting injuries are the most common modalities of blunt trauma. However, splenic rupture can occur in patients with infection or malignancy and after medical procedures.[2] Splenic injury can therefore affect any age group.

When should I suspect a splenic injury?

The spleen is susceptible during trauma to the left lower thorax or left upper abdomen. Other injuries that may be associated with it include injuries to the rib cage, diaphragm, pancreas, and bowel. Haemodynamic instability, with a rising pulse rate and a decreasing blood pressure, is the most reliable sign of an injury.[3] However, clinical signs associated with splenic trauma are notoriously unreliable,[4] and a high index of suspicion based on the mechanism of injury is needed.

Patients can present with either left upper quadrant pain and left shoulder tip pain or diffuse abdominal pain. Some may have pleuritic left sided pain, and left lower chest injury has been shown to be present in 43% of patients with splenic injuries.[5] In the same American case series, left lower chest injury was found to be the single indicator of splenic injury in 6% of patients. Initial presentation, however, may be masked by other injuries. A contained rupture may have few symptoms on initial assessment.

How is the degree of severity of blunt splenic injuries assessed?

The initial assessment of a patient with suspected blunt injury to the spleen should be the same as for any trauma patient. Patients are assessed using the Advanced Trauma Life Support (ATLS) protocol, established by the American College of Surgeons Committee on Trauma but now adopted worldwide.[6] The diagnosis of blunt abdominal trauma cannot purely depend on clinical findings. These may include coma or haemodynamic instability, bruising over the abdomen, or negligible findings during abdominal examination. Several adjuncts have been recommended to facilitate the diagnosis.

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Summary points

- Initial resuscitation, diagnostic evaluation, and management of the trauma patient is based on protocols from Advanced Trauma Life Support (ATLS)
- Further management of splenic injury depends on the haemodynamic stability of the patient
- Splenic injury is graded (I through V) depending on the extent and depth of splenic haematoma and/or laceration identified on computed tomography scan
- Low grade splenic injuries (I, II, and III) are suitable for non-operative management, although more recent evidence suggests that higher grades (IV and V) may also be suitable with the adjunct of angioembolisation
- Early use (<72 hours post-injury) of chemical venous thromboprophylaxis in the form of low molecular weight heparin does not increase the risk of failure of non-operative management in splenic trauma, although no consensus exists on time post-injury to start treatment

Sources and selection criteria

We did a literature review by searching the Medline database to locate English language articles, using the terms “blunt splenic injury,” “spleen,” “trauma,” “investigation,” “computed tomography,” “splenic angioembolisation,” and “non-operative management” and then by carrying out a hand search of reference lists of relevant included studies.

We identified no randomised controlled trials (evidence level I) in this area, although large retrospective and prospective series do exist. The evidence is generally level II and III.

What is the role of imaging in suspected splenic injury?

Abdominal ultrasound

Focused abdominal sonography for trauma (FAST) is a protocol driven abdominal ultrasound scan that can be performed by non-radiologists after specific training and is a core competency for all UK trainees in emergency medicine. Operators are trained to look for free intra-abdominal fluid. The ultrasound scan can be performed simultaneously with resuscitation and should take less than two minutes. FAST is particularly useful in haemodynamically unstable patients, as it is highly accessible, quick to perform, portable, and non-invasive. A survey of 96 North American regional trauma centres found that FAST is the preferred initial screening test after blunt abdominal trauma; 79% use this technique in preference to computed tomography scanning or diagnostic peritoneal lavage.[7] Diagnostic peritoneal lavage is done by infiltrating fluid into the peritoneal cavity through a cannula, salvaging it, and assessing it for the presence of blood or gut contents.

FAST is used to look for free abdominal fluid (sensitivity 98%[8]), which, when present, is presumed to be blood or gastrointestinal contents. The technique does, however, have limitations in obese patients, it is operator dependent, and intra-abdominal injuries may be missed as evidenced by a systematic review.[9] These include up to 25% of splenic and hepatic injuries, most renal injuries, and virtually all pancreatic, gut, and mesenteric injuries.[10] A negative ultrasound scan thus does not rule out injury, and computed tomography imaging is recommended in haemodynamically stable patients.[10 11] Patients most likely to have false negative FAST scans are those with head injuries. This may be due to the distracting nature of the injury, which may affect both the patient and the examiner, or to the liberal use of computed tomography in these patients, which may detect small volumes of free intra-abdominal fluid. Small volumes of intra-peritoneal fluid, in the context of major trauma, probably have little clinical effect, and this may explain why false negative results, in these patients, do not predict an adverse outcome.[12]

Computed tomography

Over the past 20 years, in the developed world, computed tomography scanning has become the gold standard for imaging in blunt abdominal trauma,[13] and in the identification of splenic injuries,[14] especially now that computed tomography scanners are in close vicinity to resuscitation areas in accident and emergency departments. This has contributed to the development of non-operative management of blunt splenic trauma,[15] in some series increasing the frequency of non-operative management for equivalent injuries from 11% to 71%.[16]

A relatively simple protocol can be used for patients with blunt trauma, based on scanning the entire abdomen in the portal venous phase and a subsequent delayed excretory scan three to five minutes later if an injury is detected on the initial scan. No oral contrast is administered. The Royal College of Radiologists has issued guidelines on standardisation of computed tomography protocols, including splenic injuries protocols.[17]

Recently, however, a case series from Baltimore has shown that arterial phase imaging is superior to portal venous phase imaging for the identification of pseudoaneurysm but inferior for the identification of active bleeding and parenchymal injury. Dual phase imaging resulted in a sensitivity of 90% for the identification of pseudoaneurysm, 97% for active bleeding, and 99% for both non-vascular injury and perisplenic haematoma. The specificity of dual phase imaging was 100% across all injuries, and the accuracy was 97%, 99%, 99%, and 98%, respectively.[18]

Computed tomography scanning does, however, have its limitations. It has been shown to underestimate the degree of splenic trauma,[19] and it is not reliable as an outcome predictor in adults who have complications as a result of blunt splenic trauma, such as delayed splenic bleeding or subphrenic abscess.[20]

How are splenic injuries scaled?

Initially, the Abbreviated Injury Scale was introduced in 1971.[21] However, in the 1980s the American Association for the Surgery of Trauma appointed an Organ Injury Scaling (OIS) Committee with the goal of developing a comprehensive scaling of specific organ injuries. The individual organ injuries were graded I (minimal), II (mild), III (moderate), IV (severe), V (massive), and VI (lethal).[22] Since originally devised in 1987,[23] the scales for spleen and liver have been revised,[24] but no major alterations have been needed (table⇓). Recently, however, the “Baltimore computed tomography grading system” has been proposed and validated, and has been shown to better predict the requirement for intervention for splenic trauma, as it takes into account computed tomography findings of splenic vascular injuries such as active bleeding, pseudoaneurysm, and arteriovenous fistula.[25] Current recommendations suggest that the Baltimore system should be the one utilised in modern practice.[26]

What happens when a splenic injury is diagnosed?

Once a diagnosis of splenic injury is established, the management depends on the haemodynamic status of the patient, the presence of associated injuries to other abdominal organs, and the availability of resources such as further radiological investigations or interventions. Haemodynamically unstable patients with positive FAST scans require urgent surgical exploration, with the potential to proceed to splenectomy. However, haemodynamically stable patients with low grade splenic injuries, as determined by computed tomography scanning, may be candidates for non-operative management.

What is the evidence supporting non-operative management of splenic injuries?

Non-operative management was first attempted in the paediatric population in the 1960s,[27] but it was not until the 1980s—when CT scans became more widely available—that non-operative management was adapted for adult trauma patients.[28 29] A trend from splenectomy towards splenic conservation has been noted in many population based studies.[30-33]

A recent systematic review of 21 non-randomised studies of non-operative management suggests that it now represents the gold standard treatment for minor splenic trauma and is associated with decreased mortality in severe splenic trauma (4.8% compared with 13.5% for operative management). The authors concluded, however, that for higher grades of splenic injury, the evidence is more difficult to interpret because of the substantial heterogeneity of expertise among different hospitals and potentially inappropriate comparison groups. On the basis of their interpretation of the evidence, they postulated that non-operative management can be the initial treatment in some cases of severe splenic trauma; however, the decision between operative and non-operative management depends on careful risk-benefit analysis for each patient, as well as on the expertise of the surgeon and of the multidisciplinary hospital team.[34]

What is the role of splenic angioembolisation in the management of splenic injuries?

Angioembolisation, a technique carried out in the main by interventional radiologists, uses wire-guided catheters under radiographic guidance within the vascular tree to both image and potentially occlude vessels, thus stopping haemorrhage. Embolisation techniques include using mechanical (metal coils, embolisation particles) or chemical agents (gelfoam, sclerosant chemicals, thrombin) to achieve occlusion of a vessel either proximal or distal to the site of haemorrhage. This was first reported in the management of blunt splenic injuries in 1981.[35] Since then, large numbers of studies, none of which has been a randomised controlled trial, have been published, with varying results, outcomes, and recommendations. This paucity of high quality evidence makes forming guidelines challenging. However, American guidelines based on level II evidence suggest that patients with a grade >III injury, presence of contrast blush (intravenous contrast extravasation) on computed tomography, moderate haemoperitoneum, or evidence of ongoing splenic bleeding should be considered for splenic angioembolisation.[36]

A retrospective review in four US level 1 trauma units found that of 140 patients having splenic angioembolisation for grade IV and V injuries, 80% were successfully managed non-operatively,[37] and results have improved since then. A more recent retrospective review of 499 blunt splenic trauma patients, of whom 41 (8.2%) required splenic angioembolisation, found that this was associated with a decreased risk of splenectomy (P=0.003).[38] Similar findings were recently reported by a large multicentre series from four level 1 trauma centres in the United States, showing that centres using high volumes of angioembolisation for splenic injuries (defined as >10% of cases) have significantly higher rates of splenic salvage than those using the technique less frequently.[39]

Large case series have shown that major complications including splenic infarction, abscess formation, cyst formation, contrast induced renal impairment, and bleeding occur in 14-29% of cases and minor complications such as pyrexia, left pleural effusion, and coil migration in 34-62% of cases.[40] A recent meta-analysis of angioembolisation in 479 blunt splenic trauma patients compared the difference in outcomes between proximal and distal splenic artery embolisation.[41] Proximal embolisation was performed significantly more often than distal embolisation (60.3% *v* 33.2%; P<0.001), with a combination of techniques being applied in 6.5% of cases. Overall, the rate of failure of splenic angioembolisation was 10.2% (range 0-33%), and rates of failure due to re-bleeding, requiring splenectomy, ranged from 4.7% to 9.0%. This occurred more commonly, but not significantly so, after distal embolisation. The rate of major infarcts requiring splenectomy ranged from 0% to 0.5% in proximal embolisation and from 1.6% to 3.8% in distal embolisation, but again this was not statistically significant. Infectious complications requiring a splenectomy occurred in four patients, all after proximal embolisation. Minor complications occur more commonly after distal embolisation than after proximal embolisation. This is principally explained by higher rates of segmental infarctions following distal embolisation and is of little clinical relevance. The role of antibiotics after splenic angioembolisation to avoid abscess is uncertain.

Are there any intraoperative alternatives to splenectomy for management of haemodynamically stable patients?

Splenic salvage should be attempted only in haemodynamically stable patients undergoing trauma laparotomy for other injuries. In more than 97% of patients taken to theatre, splenectomy rather than splenic salvage is the outcome.[42] Salvage methods include the application of a topical haemostatic agent such as fibrin glue, which in an American case series resulted in haemostasis after one application in most patients, successful splenic salvage, and no returns to theatre.[43] This can be used in both splenic and hepatic trauma, but outcome data are lacking in the literature. The use of an absorbable polyglycolic acid mesh that is wrapped around the injured spleen to aid haemostasis and facilitate the insertion of sutures to complete haemostasis is another useful technique.[44 45] Recently, the use of a linear stapling device with the adjunct of a topical haemostatic agent to preserve part of the spleen has been described.[46] Patients who are unstable should proceed directly to laparotomy, with splenectomy if the haemorrhage is not controlled. Re-implantation of splenic tissue in an attempt to preserve immunological function is technically feasible,[47-49] although the true value of this in terms of immunological function and the prevention of overwhelming post-splenectomy sepsis is unproven.[50 51]

Does laparoscopy have a role in the management of splenic injuries?

The Society of American Gastrointestinal and Endoscopic Surgeons' guidelines on laparoscopy for trauma accept that diagnostic laparoscopy is technically feasible and safe when applied to selected trauma patients. This includes those with a suspected intra-abdominal injury that is not proven during imaging, who are haemodynamically stable, and without evidence of another injury requiring laparotomy. Diagnostic laparoscopy can potentially decrease the number of negative exploratory laparotomies performed.[52]

On review of the literature, only a handful of case reports and case series consider the use of laparoscopy in blunt splenic injuries. Splenic conservation with the appliance and use of haemostatic agents laparoscopically has been reported.[53 54] Several institutions have reported case series on the use of laparoscopic splenectomy in trauma.[55 56] One of the largest series from Italy included 10 consecutive patients with no mortality or morbidity related to the laparoscopic approach.[57] This is not routine practice at present.

What is the role of vaccination in patients with splenic injuries?

For patients in whom splenectomy is necessary, overwhelming post-splenectomy sepsis is a concern and has been recognised for around 40 years.[58] Current UK recommendations, based on level 2 and 3 evidence, are that vaccines should be administered either two weeks before or two weeks after splenectomy to increase the immunological benefit. Splenectomy patients or those with functional hyposplenism should receive pneumococcal vaccine, *Haemophilus influenzae* type b conjugate vaccine, and meningococcal conjugate vaccine, as well as annual influenza immunisation. Lifelong prophylactic antibiotics (oral penicillins or macrolides) should be offered to those at high risk of pneumococcal infection. The high risk group comprises patients aged under 16 years or over 50 years, those with an inadequate serological response to pneumococcal vaccination or a history of previous invasive pneumococcal disease, and those in whom a splenectomy was carried out for haematological malignancy. Counselling regarding the risks and benefits of lifelong antibiotics should be offered to patients not at high risk of infection, and a decision to discontinue may be appropriate. All splenectomy patients should carry an emergency supply of antibiotics as well as a medical alert card.[59]

Routine immunisation for patients with splenic injuries managed conservatively is not recommended. Although concerns have been raised about splenic immune function after non-operative management with or without splenic angioembolisation, evidence seems to be emerging that immune function is reasonably well preserved. Phagocytic function of the spleen in patients who have undergone splenic angioembolisation has been measured by analysis of blood for the presence of Howell-Jolly bodies, and very few patients seem to show evidence of hyposplenism.[60-62]

How should patients who have had non-operative management of splenic injury be followed up?

No guidelines or follow-up protocols as to the outpatient management of patients who have had non-operative management of a splenic injury are available. In a prospective audit, no alteration in clinical management was made on the basis of repeat inpatient or outpatient imaging,[19] and a recent survey of American clinicians has shown no consensus regarding the duration of in-hospital monitoring and the timing of mobilisation and return to full activities including work and contact sports.[63] Similarly, no consensus exists on the time post-injury to start chemical venous thromboprophylaxis in the form of low molecular weight heparin; however, early use (<72 hours post-injury) does not increase the risk of failure of non-operative management.[64 65] An American case series reviewed 691 patients admitted with blunt abdominal trauma and concluded that late failure of non-operative management occurs infrequently, unpredictably, and almost always in patients who are still in hospital for associated injuries.[66]

What is the overall survival after splenic injury?

Mortality rates after splenic injury are difficult to quantify, as a proportion of trauma patients will die before admission to hospital, and many of those who die in hospital will die as a result of the overall severity of other injuries. A US cohort study of more than 33 000 trauma patients with splenic injuries found an in-hospital mortality rate of 6.1%. Mortality varied between states (2.1-9.2%).[67]

A large European cohort study of more than 13 000 trauma patients, of whom 1630 had splenic trauma, has been recently reported. Of these splenic injuries, 18.1% were grade II, 28% were grade III, 29.8% were grade IV, and 24.1% were grade V. Splenectomy was carried out in 46.5% of patients: 10.8% of grade II, 23.2% of grade III, 65.2% of grade IV, and 77.4% of grade V. In-hospital mortality after splenectomy was 24.8% compared with 22.2% in patients without splenectomy; however, the overall injury severity scores were very similar and are likely to account for the mortality rates.[68]

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Additional educational resources

The Eastern Association for the Surgery of Trauma (www.east.org/resources/treatment-guidelines/blunt-splenic-injury,-selective-nonoperative-management-of)—A review of management guidelines for healthcare professionals

UpToDate (www.uptodate.com/contents/management-of-splenic-injury-in-the-adult-trauma-patient)—A review of splenic anatomy and physiology, and diagnostic and management strategies for splenic injuries for healthcare professionals

National Trauma Data Bank (www.facs.org/trauma/ntdb/index.html)—American trauma database; information on trauma programmes, research, and education for healthcare professionals

Trauma.org (www.trauma.org/archive/trauma.html)—Trauma and critical care educational resources for professionals

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Table

Table 1| Organ injury scaling (spleen)[24]

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 diameter
	Laceration	1-3 cm parenchymal depth, not involving parenchymal vessel
III	Haematoma	Subcapsular, >50% surface area or expanding; ruptured subcapsular or parenchymal haematoma; intraparenchymal haematoma >5 cm
	Laceration	>3 cm parenchymal depth or involving trabecular vessels
IV	Laceration	Laceration of segmental or hilar vessels producing major devascularisation (>25% spleen)
V	Laceration	Completely shattered spleen
	Vascular	Hilar vascular injury which devascularised spleen