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Splenic trauma in the twenty-first century: changing trends in management

P Roy, R Mukherjee, M Parik

RG Kar Medical College and Hospital, General Surgery, Kolkata, India

ABSTRACT

Over the past three decades, management of blunt splenic trauma has changed radically. Use of improved diagnostic techniques and proper understanding of disease pathology has led to nonoperative management being chosen as the standard of care in patients who are haemodynamically stable. This review was undertaken to assess available literature regarding changing trends of management of blunt splenic trauma, and to identify the existing lacunae in nonoperative management.

The PubMed database was searched for studies published between January 1987 and August 2017, using the keywords 'blunt splenic trauma' and 'nonoperative management'. One hundred and fifty-three articles were reviewed, of which 82 free full texts and free abstracts were used in the current review.

There is clear evidence in published literature of the greater success of nonoperative over operative management in patients who are haemodynamically stable and the increasing utility of adjunctive therapies like angiography with embolisation. However, the review revealed a lack of universal guidelines for patient selection criteria and diagnostic and grading procedures needed for nonoperative management. Indications for splenic artery embolisation, the current role of splenectomy and spleen-preserving surgeries, together with the place of minimal access surgery in blunt splenic trauma remain grey areas. Moreover, parameters affecting the outcomes of nonoperative management and its failure and management need to be defined. This shows a need for future studies focused on these shortcomings with the ultimate aim being the formulation and implementation of universally accepted guidelines for safe and efficient management of blunt splenic trauma.

KEYWORDS

Splenic trauma – emergency care – nonoperative management

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CORRESPONDENCE TO

Madhav Parik, E: madhavparik@gmail.com

Introduction

Trauma is the leading cause of death in people under the age of 45 years and is among the top three leading causes of death in all age groups.[1] Abdominal trauma accounts for around 15% of cases presenting to the emergency department, with the spleen being the most commonly injured organ in blunt abdominal trauma.[2] Splenic trauma was managed operatively for many years as it was believed that the spleen was devoid of important function, that it could not heal on its own, could rupture at a later stage, and that the mortality rate of patients who were not operated was unacceptably high.[3] However, the knowledge of increased risk of susceptibility to infection after splenectomy, with its most deadly manifestation, overwhelming post-splenectomy infection, occurring in about 0.5% of all splenectomies in trauma patients and in over 20% of elective splenectomies for haematological disorders, led to a paradigm shift in the management of blunt splenic injury. Nonoperative management of splenic injuries has gradually become the standard of therapy in patients who are haemodynamically stable.[4,5] Currently, three methods of treatment of splenic trauma patients are followed: conservation (with or without angiography and embolisation), spleen-preserving operations and splenectomy.[6]

Methodology

The PubMed database was searched for articles published between January 1987 and August 2017, using the keywords 'blunt splenic trauma' and 'nonoperative management'. One hundred and fifty-three articles were identified. Case reports and small case series were excluded. The articles were then reviewed for relevance and 72 articles were used in the current review. Free full texts and free abstracts were used in the evaluation process. The articles were used to answer six relevant questions that will reflect the trends in management of blunt splenic injury:

- Patient selection criteria for nonoperative management.
- Trends of acceptance, success and failure of nonoperative management.
- Splenic artery embolisation.
- Spleen-preserving surgeries.

> Grading of splenic injuries,
> Evolution of minimal access surgery in splenic trauma.

Results

Criteria for nonoperative management

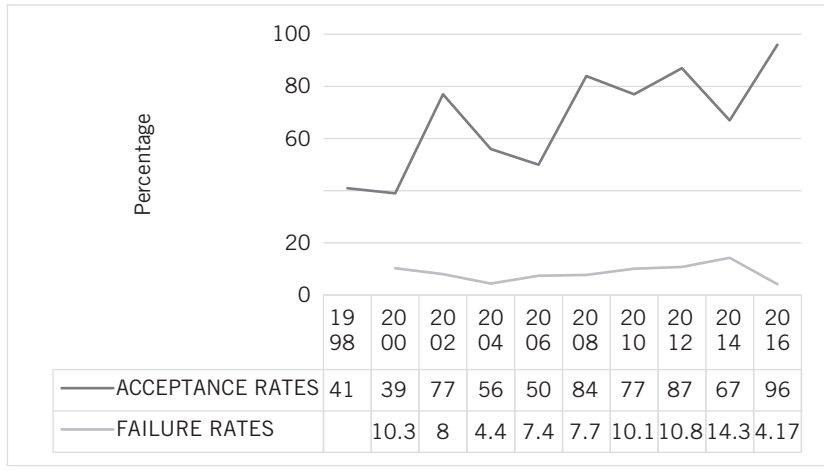
Nonoperative management of splenic trauma was documented as early as 1882 by Gross.[7] It consists of close observation of the patient, coupled with splenic artery embolisation if necessary. Observational management involves hospitalisation, close monitoring, serial abdominal examinations and facilities of blood transfusion and computed tomography.[8] Initially, nonoperative management for splenic trauma was documented in children, with excellent outcomes.[7,9] However, employing nonoperative management for splenic injuries in adults was a challenge, as post-splenectomy sepsis is less frequent in adults, and in view of delayed haemostasis due to age-related structural and vascular changes of the spleen, and the risk of overlooked associated injuries and the possibility of delayed rupture of the spleen, splenosis or a post-traumatic splenic cyst.[10] In 1987, Johns Hopkins Medical Institutions published criteria for nonoperative management as: 1) rapid haemodynamic stabilisation after fluid resuscitation; 2) lack of other serious intra-abdominal injuries; 3) lack of extra-abdominal trauma that requires a prolonged general anaesthesia or that results in an altered state of consciousness; 4) progressive symptomatic improvement early during the hospitalisation.[11] However, there has been no universally accepted set of guidelines for patient eligibility for nonoperative management, with haemodynamic stability and low grades of injury being the commonly accepted criteria. The 2017 guidelines from the World Society of Emergency Surgery give a detailed algorithm for the management of splenic trauma, which is based broadly on haemodynamic stability of the patient, grade of injury and availability of intensive care.[12]

Success and failure of nonoperative management

It was routine practice for most minor splenic injuries to be treated nonoperatively after 1997, with the rate of nonoperative management increasing from 48.5% between 1992 and 1996 to 63.1% between 1997 and 2001 ($P = 0.02$).[13] Between 1989 and 1997, splenic salvage rate of low-grade injuries has been as high as 97%.[14–16] Increase in nonoperative management for splenic trauma over the past two decades is shown in Figure 1.[17–26]

Controversies remained regarding the management of higher grades of splenic injury, as failure of nonoperative management was significantly higher in grade V injuries compared with lower grades of injury ($P < 0.05$).[27,28] Controversies also raged for defining predictive parameters for a successful nonoperative management and some authors have defined predictive parameters and outcome of this type of management (Table 1).[29–33]

With the advent of advanced diagnostic imaging and splenic artery embolisation, the success of nonoperative management has increased significantly.[34,35] Nonoperative management has primarily reduced the risk of overwhelming post-splenectomy infection.[4] Moreover, avoidance of surgery-related complications, a shorter hospitalisation period and a concomitant reduction in costs have been reported.[36] In case of failure of nonoperative management, there is the possibility of a second nonoperative reintervention; for example, an attempt for splenic artery embolisation after failure of observation or proximal embolisation after failure of distal embolisation. However, nonoperative management carries a risk of delayed splenic rupture, the possibility of re-bleeding and complications related to embolisation, but exact incidences of each were not quoted in the searched literature. The fact that no (intraoperative) view can be obtained of other abdominal organs is also an important disadvantage. The common advantages, disadvantages and complications related to nonoperative



	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016
ACCEPTANCE RATES	41	39	77	56	50	84	77	87	67	96
FAILURE RATES		10.3	8	4.4	7.4	7.7	10.1	10.8	14.3	4.17

Figure 1 Nonoperative management of blunt splenic trauma: acceptance and failure rates, 1998–2016.

Table 1 Predictive parameters for successful and unsuccessful nonoperative management of blunt splenic trauma.

Parameter	Nonoperative management	
	Successful[4,29,30]	**Unsuccessful**[31–33]
Haemodynamics	Stable/readily stabilised	Unstable (systolic blood pressure < 90 mmHg despite adequate resuscitation)
Blood transfusion	≤ 4 units	> 4 units (to maintain a haemoglobin level > 10 g/dl)
Age(years)	≤ 55	> 55
Leucocytosis	No	Persistent
Other abdominal signs and symptoms	Early resolution of splenic abnormalities obvious on imaging	Onset or aggravating signs of peritoneal irritation (suggesting further bleeding or other overlooked injuries)
	No periods of unconsciousness or brain injuries	Intra-abdominal compartment syndrome (intravesical pressure > 20 cm H_2O)
Injuries	No associated intra- or retroperitoneal injuries (on CT) that would require surgical intervention	Worsening signs of splenic injury (repeated ultrasound), post-traumatic splenic defect
	No rebound or guarding	
	Complete recovery of bowel movements	

management are shown in Box 1. Close monitoring of patients along with frequent computed tomography (CT) has helped overcome these drawbacks to a certain extent. Failure rates of nonoperative management are shown in Figure 1.[18–23,26,37,38] Thus, for successful nonoperative management of splenic trauma, it is necessary to have an accurate knowledge of patient selection criteria as well as a precise assessment of the factors precluding conservative therapy.

Box 1 Advantages, disadvantages and complications (immediate and delayed) of nonoperative management of splenic trauma.

Advantages
- Avoids immediate and late complications of splenectomy
- Avoids complications related to surgery and anaesthesia
- Avoids operation costs
- High success rates, especially in lower injury grades

Disadvantages
- Only possible if grade of splenic injury is identified accurately
- Requires intensive monitoring
- Requires 24-hour availability of operating theatre, laboratory and blood transfusion facilitieas
- Requires availability of interventional radiologist with computed tomography facilities
- Risk of missed injuries in polytrauma

Complications

Immediate (up to 7 days):
- Pseudoaneurysm formation, leading to bleeding or rupture
- Peritonitis

Delayed (beyond 7 days):
- Delayed rupture of spleen
- Intestinal obstruction due to peritoneal adhesions
- Splenosis

Splenic artery embolisation

The first angiographic embolisations used absorbable gelatine and temporary balloon occlusion, and were performed for haemostatic purposes before splenectomy.[39] Recent nonoperative management protocols for splenic trauma include angiography (diagnostic and therapeutic) as an efficient alternative.[40] Splenic artery embolisation can be distal (supraselective), proximal (splenic artery) and combined (Box 2).[41–42] Diagnostic and therapeutic (embolisation) angiography is performed if CT shows intrasplenic vascular damage, while second-look angiography may be used in cases of recurrent bleeding and after an initially negative angiograph.[43]

Splenic artery embolisation, although controversial in 2008, has shown a progressive reduction failure rate of nonoperative management, from 25% to 10%, and an increase in splenic salvage rate from 79% to 100%.[44] Failure rates of nonoperative management in grades IV and V splenic injuries decreased from 23% (no artery embolisation) to 3% (with artery embolisation), $P = 0.04$, and from 63% (no artery embolisation) to 9% (with artery embolisation), $P = 0.03$.[45] Angiography and embolisation were recommended as an adjunct to nonoperative management for all grade III to grade V injuries.[46,47] However, splenic artery embolisation is associated with various complications (Table 3).[48–54] One study has shown no significant difference between embolisation and observation alone with regard to successful treatment in patients with blunt splenic trauma.[55] An approach to management of blunt splenic trauma based on the reviewed literature

Box 2 Indications and complications of splenic artery embolisation (SAE).

Indications

- *Proximal*: Indicated in the following hilar lesions:
  - >3 distinct peripheral vascular lesions
  - injury affects more than 50% of the splenic parenchyma.
- *Selective*: limited vascular injuries. It is proficient because it allows proper haemostasis and adequate perfusion to remaining organ.
- *Combined*: for multiple vascular injuries (high injury scores). It is recommended to perform multiple CT scans after SAE to monitor the vascular damage, pseudoaneurysm formation, size of infarcted area and existence of localised infection (splenic abscess).

Complications

Major (19–28.5%):

- Bleeding: the most common complication caused by delayed diagnosis of pseudo aneurysms and late pseudoaneurysm formation
- Overlooked injuries: usually diaphragmatic, pancreatic
- Infection: splenic abscess, sepsis
- Splenic atrophy
- latrogenic arterial damage
- Acute renal failure after contrast administration
- Deep venous thrombosis

Minor (23–61.9%):

- Migration of embolic material (spiral that migrates in proximal SAE needs extraction)
- Angiographic vascular dissection
- Vascular damage when inserting the catheter(arteriovenous fistula)
- Persistent pain and hematoma at the puncture site
- Post-embolisation syndrome (includes symptoms such as general discomfort, fever, local pain and/or leucocytosis, which generally persist for 3–5 days)
- Pleural and pulmonary complications
- Thrombocytosis
- Allergic reactions to contrast

considering the present role of nonoperative management and splenic artery embolisation is shown in Figure 2.

Spleen-preserving surgeries

Partial splenectomy requires mature judgement for patient selection as well as technical skill. A partial splenectomy or splenorrhaphy requires at least one-third of viable splenic tissue. Essential steps are atraumatic mobilisation of spleen, temporary splenic artery occlusion, selective ligation of segmental vasculature, controlled intrasplenic dissection with ultrasonic surgical aspirators and, finally, haemostasis by topical agents (oxidised cellulose) or argon plasma. Mesh splenorrhaphy includes delivering the spleen through the centre of an absorbable mesh and sewing opposite edges of the mesh to each other to produce a tamponade around the spleen. The retained spleen is observed for colour and bleeding at adequate systolic blood pressure. Drains are required only if pancreatic injury is suspected.[56] Studies completed in the 1990s by scintigraphy showed that splenic autotransplantation is superior to splenectomy but less effective than preservation of the spleen.[57] The technique of autotransplantation has been described by various authors.[58,59] Commonly 2–4 grams of splenic tissue are minced and implanted in an omental pocket in the greater omentum. Excellent response has been reported from Germany, where 6 months after autotransplantation in adults, Howell-Jolly bodies were absent and immunoglobulins were normal.[60] Splenic autotransplantation in greater omentum has also been proposed in children with a report showing some preservation of immunological function (2 of 40 measurements; 5%).[57] New procedures such as polyglycolic acid elastic mesh for splenic capping, use of autologous fibrin glue and radiofrequency ablation to stop bleeding were experimented on animal models and small populations in later years ,with favourable outcomes.[61–66]

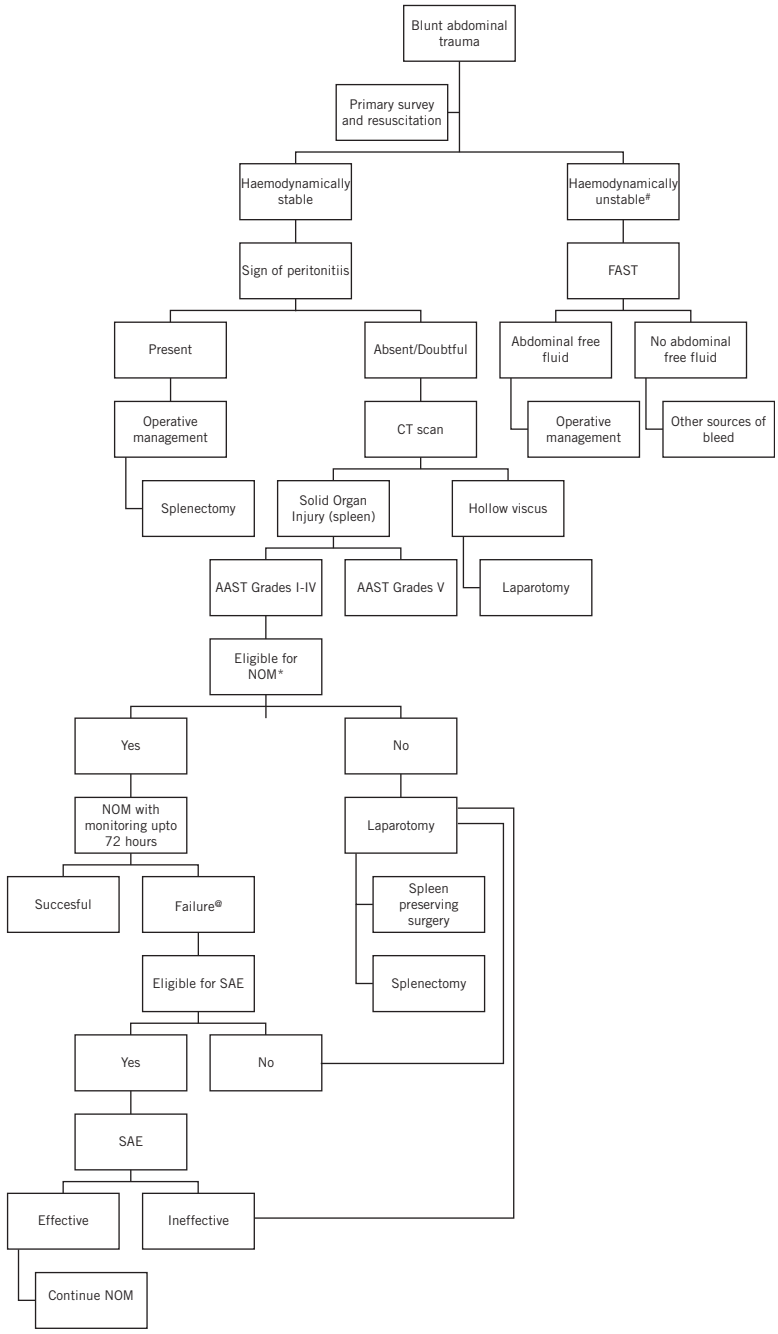
Grading splenic injury

The aim of a grading system is to standardise reporting and to aid management planning. The American Association for the Surgery of Trauma (AAST) Organ Injury Scale is the most widely used scale for grading splenic injuries.[67] It is a classification system based on anatomical damage caused by injury to an individual organ. The injury grading scale for the spleen was revised in 1994, as a result of increasing use of CT in the management of blunt abdominal trauma. However, active bleeding and vascular injuries were not considered in this revision, thus limiting its utility as an aid to clinical decision making in nonoperative management.

Various studies between 1994–2012 have suggested that CT results alone are a poor predictor of success in nonoperative management.[68–70] The need for incorporating active vascular injuries and nonbleeding vascular injuries has been stressed by some authors.[71,72] In 2007, Marmery *et al.*[73] proposed a new system (the Baltimore CT Severity Index), which included active splenic haemorrhage as well as non-bleeding vascular injuries. This was found to be superior to the AAST grading system in predicting the need for splenic artery embolisation or surgery.[74] The 2013 study by Boscak *et al.*[75] emphasised the importance of using both arterial and portal venous images to detect vascular injuries.

Minimal access surgery in splenic trauma

In 1992, laparoscopic splenectomy was beginning to be viewed as a promising alternative to open splenic surgery in haemodynamically stable patients and in spleen



AAST: American Association for the Surgery of Trauma
CT: computed tomography
FAST: focused assessment with sonography for trauma
NOM: nonoperative management
SAE: splenic artery embolisation
Haemodynamic instability is considered when systolic blood pressure at admission< 90 mmHg, altered level of consciousness and/or shortness of breath, or blood pressure > 90 mmHg but requiring bolus infusions/transfusions.
* Eligibility for nonoperative management includes precise diagnosis of severity of splenic injury and availability of intensive monitoring and resources to manage failure.
@ Failure of nonoperative management – systolic blood pressure < 90 mmHg, drop of haemoglobin by 2g%, drop of haematocrit, appearance of abdominal signs of peritonitis

Figure 2 An approach to management of blunt splenic trauma in adult patients.

preserving surgeries.[76,77] By 1996, with the widespread use of diagnostic laparoscopy for blunt abdominal trauma and therapeutic laparoscopy in cholecystectomy, surgeons started to use therapeutic laparoscopy in cases of mild splenic lesions. It was also used in the treatment of late consequences of splenic injury, such as post-traumatic pseudocysts.[78,79] With a view to preventing immediate and later complications of splenectomy, conservative surgical techniques gradually gained success. With the establishment of nonoperative management for splenic trauma by 2008, indications for laparoscopic splenectomy were restricted to continued bleeding after splenic embolisation, splenic infarction with abscess formation or high-grade injuries.[80] Robotic approach for splenectomy in blunt trauma was suggested in 2015, but needs definite conclusions.[81] In 2017, laparoscopy is generally performed in cases of failure of nonoperative management and has shown significantly less blood loss and fewer transfusions compared with the open group, although there were no differences in mortality, length of stay, complications or discharge dispositions in one study.[82]

Conclusion

Management of splenic injury has evolved over the past three decades, with nonoperative management replacing surgical intervention as the standard of care. The patient selection criteria for nonoperative management are primarily based on haemodynamic stability, grade of splenic trauma, exclusion of multisystem injury and availability of continuous diagnostic and intensive care facilities. There has been a progressive increase in the success rates of nonoperative management, with a considerable reduction in failure rates, especially after application of splenic artery embolisation and CT diagnosis. Spleen-preserving surgeries have been performed in cases of failure of nonoperative management with favourable outcomes. Minimal access surgery now holds promise in the management of splenic trauma in the decade to come.

Questions still remain regarding formulation of definite patient selection criteria for nonoperative management and splenic artery embolisation, and their appropriate application. Formulation of management protocol of high-grade injuries, together with a decrease in the complications and failure rate of nonoperative management should be prioritised in further studies. Prospective trials with clear inclusion criteria are also needed to prove the benefit of laparoscopic splenic surgeries.

This study was limited by the fact that only free full-text articles were used and further grouping of the references for levels of evidence was not done.

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