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Current Management of Splenic Injury

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The spleen is the most frequently injured organ following blunt abdominal trauma.[1] The high incidence of splenic injury has demanded continuous reappraisal of our understanding of splenic function, as well as our approach to its management. Habitual splenectomy following trauma initially gave way to operative salvage via splenorrhaphy. The practice of splenorrhaphy was largely influenced by the recognition of the risk for post-splenectomy sepsis following splenectomy.[2-4] Techniques of surgical splenorrhaphy evolved as surgeons learned how to handle the injured splenic tissue more effectively.[5] Nonoperative management evolved in hemodynamically stable children and adults who had CT imaging studies to determine the presence of organ injury.[6-8] Guidelines evolved for the management of these organ injuries that utilized a standard scoring system first articulated by the American Association for the Surgery of Trauma.[9] The addition of angiography plus embolization completed the repertoire[10] that today can yield splenic salvage success rates of 80% or greater in both adults and children, depending on grade of injury.[6,10]

The spectrum of current splenic management, stretching from nonoperative care to splenectomy, has developed along with the concept that splenic function should be preserved whenever possible. Recognition of the existence of certain conditions that continue to require splenectomy compel medical personnel to evaluate the entire clinical presentation of each patient, balancing the desire to save splenic function with the need to avoid the potential disaster of splenic hemorrhage. The decision-making process of care following splenic injury ultimately begins with an individualized approach to each patient based upon presentation, stability, concurrent injuries, and practitioner experience. Education of those who treat patients with splenic trauma is imperative, and studies designed to improve the outcomes of splenic management

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in trauma centers should continue to be employed to further our progress in this area.
— The Editor

Introduction

As noted previously, the spleen is the most frequently injured organ following blunt abdominal trauma.[1,11] Prompt recognition and appropriate scoring of splenic injury is vital for preventing the potentially disastrous complication of hemorrhage and hypovolemic shock. However, due to the well-recognized risks for post-splenectomy sepsis,[2-4] routine splenectomy for injury has given way to the practice of splenic salvage, utilizing techniques of splenorrhaphy (repair of splenic laceration or rupture with sutures), nonoperative management of solid organ injury, and angiography with embolization, either singularly or in combination.[5-8,10] Reports of salvage results, adjusted for the grade of injury severity, demonstrate significant success rates in both adults and children, with the overall rate approaching 80%.[6,10]

Despite the predominantly favorable statistics that have arisen in support of methods of splenic salvage, debates concerning these techniques have occurred. Criteria for decision-making between nonoperative and surgical treatment, imaging options, and follow-up care all have been subject to numerous studies and discussions. The current approach to the management of splenic injury will be reviewed in this issue, with the aid of these previous studies.

Initial Evaluation and Resuscitation

For a patient who is the victim of a traumatic injury, the importance of initial evaluation and resuscitation efforts cannot be overstated. Expeditious transportation to a medical facility with appropriate trauma verification as well as assessment and resuscitation by first responders are key initial steps to achieving a positive outcome for the patient.

The primary survey and initial stabilization should be followed during the evaluation of a traumatically ill patient. Cervical and spinal stability should be maintained throughout the survey. The airway must be patent to ensure a pathway for adequate oxygenation. If a clear airway cannot be established, endotracheal intubation or a surgical airway may need to be performed. Breathing and ventilation efforts should be examined and supported if necessary, with supplemental oxygen being provided for every injured patient.[1] Circulatory status should be confirmed next through pulse checks, skin color, and level of consciousness. Two large-bore peripheral intravenous lines should be established to allow for administration of fluids and retrieval of blood for labs. Disability, or the neurologic state, must be appraised using the Glasgow Coma Scale (GCS). Finally, the patient must be fully exposed to gain a complete examination. However, care with blankets and a warm environment must be taken to protect against hypothermia.

When a patient presents with an abdominal injury, the diagnosis may not be readily evident. Thus, the crucial step in the first phase of patient management is to consider such an injury. Pertinent information regarding the mode of injury should be collected. Following the ABCs, the trauma responder should commence with a thorough physical examination. A complete abdominal assessment should consist of examination for ecchymosis, lacerations, distention; auscultation for normoactive bowel sounds; percussion for dullness, which would suggest intraperitoneal fluid or hemoperitoneum, and hypertympanic regions, which would denote dilatation; and palpation to assess for voluntary and involuntary guarding, rebound tenderness, and abnormal masses.[1] Though a patient may pass this portion of the complete examination without raising suspicion for abdominal trauma, it is imperative that repeat examinations be performed; a significant number of patients with hemoperitoneum are noted to have had "normal" initial abdominal findings.[12] If the initial physical exam is normal, yet the suspicion is high for an abdominal injury, further workup is warranted.

Splenic injury, like abdominal injury in general, is not always apparent. However, there are "classic" findings that should alert trauma responders to the possibility of damage to the spleen. Left upper quadrant tenderness and ecchymosis or left lower chest tenderness may be manifestations of splenic injury. Left lower rib fractures also should raise the consideration of splenic trauma. Injuries to other organs, such as the liver or left kidney, increase the possibility of splenic injury, with thoracic injuries being the most concomitant.[13] Kehr's sign (pain referred to the left shoulder following splenic injury) or Balance's sign (dullness to percussion in the left upper quadrant) may be found. It is important to remember that splenic trauma also may present with nonspecific signs, such as hypotension. Again, the consideration of the possibility of splenic injury often is paramount to the initial management and eventual diagnosis.

The hemodynamic status of a patient ultimately determines the approach that is taken upon presentation. Hemodynamically unsta-

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ble patients first require prompt establishment of airway, breathing, and circulation. Evaluation and resuscitation occur simultaneously. A trauma patient with hypotension is considered to be hypovolemic until proven otherwise, and a search for hemorrhage must take place. If the abdomen is the obvious area of blood loss, emergent operative exploration must occur. If the clinician is unable to confirm abdominal injury, yet the patient is unstable, a diagnostic peritoneal lavage or abdominal ultrasound may aid in the decision regarding whether to perform a laparotomy.[13] A patient who is hemodynamically stable should undergo evaluation of the ABCs, as well as resuscitation as needed. Imaging studies, such as CT scans, may then be completed to determine their specific injuries. Thus, the hemodynamic stability of a patient presenting with abdominal trauma will play the most significant role in guiding the trauma physician to choose an appropriate plan of action.

Organ Injury Scoring

Following the initial resuscitation and evaluation of patients with abdominal trauma, the decision-making process regarding management strategies must be employed. As has already been noted, certain physical presentations should spur the healthcare provider to choose the route of emergent laparotomy over other evaluative modalities. However, for the majority of patients with abdominal trauma, the presenting picture may be less clear. To facilitate a more uniform approach to these patients, the American Association for the Surgery of Trauma (AAST) formed the Organ Injury Scaling (OIS) Committee in 1987 to create a scoring system tailored to individual organs. A revised organ injury scale for the spleen was adopted in 1995;[9] it is based on the size, degree, and depth of lacerations and/or hematomas in the spleen observed at surgery.

In their revision, the OIS Committee stated that the purpose of scaling an organ injury is to allow for a better comparison between different treatment strategies for a comparable injury.[9] While prognosis cannot be determined based on the splenic injury scale, it does aid physicians in choosing treatment options. For example, patients with Grade 5 splenic injuries often are managed by splenectomy.[13] A subsequent splenic injury scale was devised in 2007 that utilizes multidetector CT images;[14] it will be discussed shortly.

The splenic injury scale provides medical personnel with a systematic approach to determine the extent of damage, and is a component in deciding the next appropriate course of action. Imaging studies are utilized to assign a splenic injury score, as well as to diagnose and treat injuries in select cases. These options are an invaluable extension of the initial physical examination in judging the extent of traumatic abdominal injury.

Imaging Options

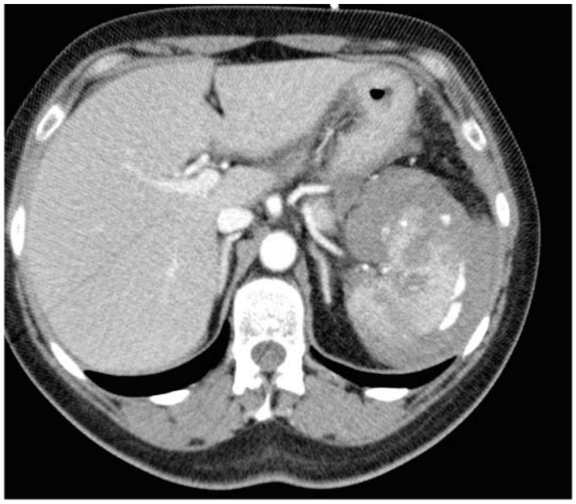
Along with physical examination, there are three major tools employed in the assessment of blunt abdominal trauma: diagnostic peritoneal lavage (DPL), computed tomography (CT), and focused abdominal sonography for trauma (FAST). DPL has been used for more than 40 years as a rapid and accurate method to confirm the presence of traumatic intraperitoneal hemorrhage, with an accuracy of 92-98%.[15] The greatest impact of DPL is in expediting unstable trauma patients to emergent laparotomy. Limitations of DPL include significant false-positive cases, the poor sensitivity of visual inspection of fluid, and its limited usefulness in hemodynamically stable patients. FAST scans are noninvasive, portable, can be done concurrently with resuscitation efforts, and have high accuracy for detecting free intraperitoneal fluid (96-98%).[15] Emergent exploratory laparotomy also is indicated in unstable patients with positive FAST scans.

Hemodynamically stable patients with equivocal physical examination, FAST, or DPL results are best managed by CT scan. CT also is the diagnostic modality of choice for nonoperative management of solid organ trauma and for serial surveillance of injuries in stable patients. CT scans require a reasonably cooperative patient who is hemodynamically stable and can be transported to the radiology suite. The accuracy of CT scan in stable abdominal trauma patients is quite high. CT has the ability to detect clinically unsuspected injuries, such as retroperitoneal injuries, that may modify treatment plans. The major limitations to CT scan are in detection of mesenteric and hollow-organ injuries and the potential for adverse events related to contrast media administration.

Abdominal CT scan is considered to be a sensitive, specific, and accurate modality for delineating the extent and severity of traumatic injury to the liver and spleen.[16] CT scoring systems were proposed for grading blunt splenic injury in the late 1980s,[16-18] correlating the CT features with the common surgical observations of traumatized spleens. CT grading systems were recognized as being fairly accurate in depicting the extent of splenic injury and degree of hemoperitoneum compared with surgical observations in these studies. However, the CT grade was deemed unreliable as a prognostic factor for predicting the success of nonoperative management, with a sizable percentage of high-grade splenic injuries in hemodynamically stable patients successfully managed nonoperatively and some low-grade splenic injuries still requiring laparotomy and splenectomy.

By the late 1990s, several investigators tried to understand why, in hemodynamically stable patients selected for nonoperative management, the grade of splenic injury or degree of hemoperitoneum on CT scan did not predict the outcome of successful nonoperative management. Gavant et al[19] retrospectively analyzed 263 patients with blunt splenic injuries, 82 of whom underwent immediate emergent surgery and 181 of whom were stable enough to be evaluated with emergent CT. Of the 181 CT scan patients, 72 were treated nonsurgically. Eleven of these patients failed nonsurgical therapy, 9 (82%) of whom had active extravasation or the presence of a traumatic pseudoaneurysm. The authors of the study concluded that the failure rate for nonoperatively managed blunt splenic trauma may be markedly reduced if patients with active extravasation or traumatic pseudoaneurysms are treated with emergent surgical or endovascular repair. Federle et al[20] performed a retrospective study of 270 splenic injury patients, 150 of whom underwent rapid, dynamic, bolus contrast-enhanced CT scans, with 100 selected for nonoperative management. Of the 96 patients who had no evidence of active extravasation, 83 recovered without surgery or other intervention, and the splenic salvage rate among the 100 patients selected for nonoperative management was 92%. The authors of this study con-

Figure 1. Blunt Splenic Injury, Grade 5, with Active Extracapsular Extravasation



cluded that the absence of active extravasation was an important predictor of successful nonoperative management. Further studies[21-23] defined the appearance of active extravasation *(see Figure 1)*, and defined a role for delayed phase CT scans to differentiate active splenic hemorrhage from contained vascular injuries, and reinforced the detection of active hemorrhage as indicating the need for emergent operative or embolization therapy.

How good is modern-day multidetector CT (MDCT) with bolus intravenous contrast for detecting active arterial bleeding? This question was addressed in a 2007 article by Roy-Choudhury et al[24] that compared the detection of active extravasation in a physiologic flow phantom using a 16-slice MDCT and digital subtraction angiography (DSA). The accepted rate of bleeding required for detection on angiography is 1 mL/min, demonstrated in experimental celiac and mesenteric angiographic studies in dogs in the 1960s.[25] Roy-Choudhury et al found in their model that a simulated first order aortic branch selective DSA study detects hemorrhage at 0.96 mL/min, verifying the earlier animal studies. However, a simulated intravenous contrast-enhanced MDCT study was more sensitive than DSA, detecting hemorrhage at 0.35 mL/min. MDCT with a simulated first order arterial branch contrast administration and simulated superselective DSA with the catheter tip right at the bleeding site both can detect active hemorrhage at rates < 0.05 mL/min. The authors concluded that intravenous bolus contrast-enhanced MDCT can be used as the initial imaging technique to diagnose active arterial bleeding in hemodynamically stable patients with suspected splenic injury. Marmery et al[14] proposed a modified MDCT grading system in 2007 targeted at optimizing the selection of patients for nonoperative management. This grading system incorporates key features of the AAST system with respect to the splenic parenchymal injuries, but elevates the presence of active arterial bleeding and direct splenic vascular injuries to the highest grade (Grade 4), with recommendation for splenic surgery or angiography and embolization *(see Table 1)*. ROC analysis of the modified MDCT grading system and the AAST grading system showed an improvement in the discrimination of patients requiring embolization or surgery with the modified MDCT grading system.

CT scans have greatly contributed to the changing strategies of splenic management. Their ability to recognize minor injuries and aid in the scoring of splenic injuries has allowed the continuum of care to shift from routine splenectomy to operative splenic salvage and nonoperative management. The risk of overwhelming post-splenectomy sepsis[2-4] has further contributed to the increased usage of salvage techniques, of which nonoperative management has been perhaps the most controversial.

Nonoperative Management

Nonoperative management in the care of the injured spleen has undergone intense scrutiny as researchers have attempted to determine which criteria should be utilized to prescribe a patient to more conservative treatment. Various parameters, such as advanced age and neurologic status, which were first thought to be indicative of the potential outcome of nonoperative management, have since been contested. The value of routine repeat abdominal CT scanning also has been debated, with the current practice supporting the side of decision-making based on clinical progression.

During the 1980s, studies that approached nonoperative management using strict guidelines for patient selection resulted in varying success rates.[7] Cogbill et al[6] suggested that hemodynamic stability, the absence of other considerable abdominal organ injuries, and a full abdominal examination in the absence of other confounding factors would allow nonoperative treatment of Grades 1 through 3 splenic injuries with initial success rates of greater than 80% in adults. Smith et al[7] added to this criteria in 1992 with their study, which achieved a 93% nonoperative management success rate by excluding patients older than age 55 years. Hunt et al[26] found that the majority of adult patients with an Injury Severity Score (ISS) of less than or equal to 15 could be treated nonoperatively for their splenic injuries during a five-year study. However, it would not be long before some of these guidelines were challenged.

The criteria that suggested age older than 55 is adverse contributor to the success of splenic nonoperative management has been tested. In their study, which resulted in an overall 98% nonoperative success rate, Pachter et al[8] reported a 100% nonoperative success rate among the 17 patients included who were older than age 55. Similarly, Gaunt et al[11] found no statistical difference with respect to age between a group of patients who were successfully managed nonoperatively versus a group of patients who required immediate surgical exploration. They also reported that among the patient group that failed nonoperative management, all were younger than age 55 years. Subsequent studies[27] have provided further evidence in support of allowing patients over the age of 55 to undergo nonoperative management on a case-by-case basis.

Other parameters also have been challenged, favoring the application of more nonoperative management plans. In the same study that assessed the significance of age in nonoperative outcomes, Gaunt et al[11] found no statistical difference with respect to the GCS score or systolic blood pressures between patients

Table 1. Proposed New Grading System Incorporating Splenic Vascular Injury*

Grade	Criteria
1	Subcapsular hematoma < 1 cm thick Laceration < 1 cm parenchymal depth Parenchymal hematoma < 1 cm diameter
2	Subcapsular hematoma 1- to 3-cm thick Laceration 1-3 cm in parenchymal depth Parenchymal hematoma 1-3 cm in diameter
3	Splenic capsular disruption Subcapsular hematoma > 3 cm thick Laceration > 3 cm in parenchymal depth Parenchymal hematoma > 3 cm in diameter
4a	Active intraparenchymal and subcapsular splenic bleeding Splenic vascular injury (pseudoaneurysm or arteriovenous fistula) Shattered spleen
4b	Active intraperitoneal bleeding

* Reproduced with permission from the *American Journal of Roentgenology.* Marmery H, Shanmuganathan K, Alexander MT, Mirvis SE. Optimization of selection for nonoperative management of blunt splenic injury: comparison of MDCT grading systems. *AJR Am J Roentgenol* 2007;189:1421-1427.

managed surgically versus nonoperatively. In their research on splenic trauma management, Pachter et al[8] found that 90% of patients admitted to the study with an ISS of greater than 15 successfully underwent nonoperative care. Furthermore, they suggested that CT scoring of splenic injury may not definitively predict the outcome of nonoperative treatment.

In view of the many studies that have been performed to aid the healthcare provider in correctly choosing patients who may successfully undergo nonoperative management, we suggest certain guidelines. First, it is prudent to consider the hemodynamic status of the patient, their response to fluids, and their risk of further bleeding. Next, the patient chosen for nonoperative care of the injured spleen should not have concomitant significant injury of another abdominal organ, due to the common association.[13] Finally, while injury scoring does not predict the patient's prognosis,[9] CT scanning may be used to assess the severity of injury, and in turn help the trauma team in deciding which course of treatment to follow.

A patient who is selected for nonoperative management is best cared for in the hospital setting. This will ensure that the patient attains bed rest and may be closely monitored through hemoglobin results and serial abdominal exams to determine their progression.[13] The necessity of routinely repeating abdominal CT scans has been contested,[28] with the current approach being to repeat the CT scan if the patient's condition remains unchanged or deteriorates. The exception in the routine usage of follow-up CT scanning is to clear patients with splenic trauma who wish to return to contact sports following their recovery.[8]

The recent success rates of nonoperative management parallel its popularity as a component of the treatment repertoire for patients with splenic injury. However, literature also has addressed the failures of nonoperative management. The presence of a "vascular blush" on an abdominal CT scan or a splenic artery pseudoaneurysm are two of the documented causes of nonoperative failure.[10] As a result, selective angiographic embolization has arisen as a treatment modality that may prevent a patient from failing nonoperative management.

Splenic Angiography and Embolization

Recognizing that direct arterial injuries and extravasation were associated with failure of nonoperative management, Sclafani et al,[29] in 1991, proposed that angiography could help differentiate those patients who could be reliably treated with bed rest alone from those who required some form of directed hemostasis. He further proposed that transcatheter splenic artery embolization could successfully gain hemostasis, and could function as an alternative to laparotomy. In his study of 44 hemodynamically stable splenic injury patients (including patients that rapidly stabilized with resuscitation), 17 patients were found to have active arterial extravasation on angiography, and they were managed with proximal (main) splenic artery embolization with coils, with successful control of hemorrhage in all patients. The overall splenic salvage rate of those in whom nonoperative management was attempted was 35/36 patients (97%).[29] This study established a role for transcatheter splenic artery embolization in the nonoperative management of blunt splenic injury.

Splenic artery embolization (SAE) is performed as an emergent interventional procedure in the early hospitalization phase, often within the first hour or two following presentation. These usually are hemodynamically stable or transiently stable patients. Immediately after the CT is reviewed, the decision about emergent splenic artery angiography and embolization is made, commonly because of CT evidence of contrast extravasation, vessel injury, pseudoaneurysm, arteriovenous fistula, or significant hemoperitoneum *(see Figure 2).* Additionally, a small percentage of nonoperative management patients who had more minor splenic injuries, without extravasation on initial CT, continue to show evidence of bleeding, with persistent transfusion requirement. These patients also are candidates for embolization, even several days after presentation, and SAE still can be performed in this time frame with good clinical results. Initially, selective splenic artery angiograms are performed. Abnormal angiographic findings include active extravasation; pseudoaneurysms; arteriovenous fistulas; abrupt vessel cut off; and an abnormal "pointillism" type parenchymal appearance *(see Figure 3),* which represents tiny dots and puddles of parenchymal contrast extravasation in regions of splenic contusion. If any of these features are present, there generally is indication for SAE. Proximal main SAE typically is performed in the mid splenic artery, usually distal to the dorsal pancreatic artery. Numerous conventional and microcatheter techniques are effective, and multiple embolic materials have been used; however, coil embolization and Gelfoam embolization predominate. If a pseudoaneurysm or AV (arteriovenous) fistula is found, superselective embolization may be considered *(see Figure 4).* Following embolization, final angiograms are performed to confirm hemostasis. A follow-up CT scan is performed 24-48 hours post embolization.

Figures 2a-2d. Grade 3 Splenic Injury with Pseudoaneurysm

Figure 2a. MVA patient with grade 3 splenic injury, with abnormal intrasplenic contrast extravasation suggesting contained vessel rupture or pseudoaneurysm.

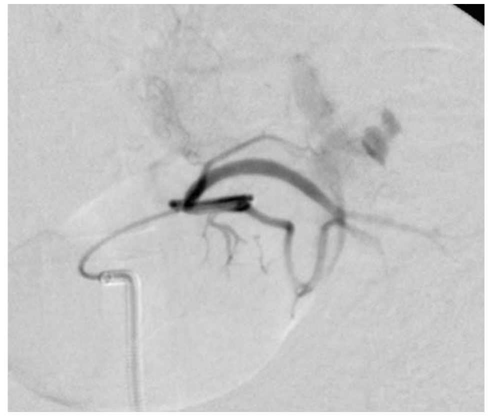


Figure 2b. Selective splenic artery angiogram, arterial phase, demonstrates a 2 centimeter, bilobular pseudoaneurysm with extravasation in the periphery of the spleen.

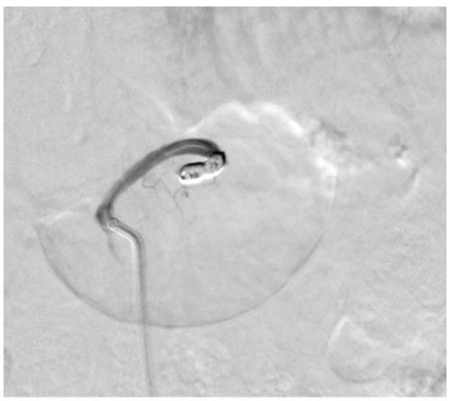


Figure 2c. Splenic artery angiogram following coil embolization of the distal main splenic artery shows cessation of primary arterial flow to the spleen.

Figure 2d. CT scan 4 days following splenic embolization demonstrates resolution of the psuedoaneurysm, and no extravasation, with the resolving contusion and a component of minor splenic infarction in the embolized segment.

The rich collateral circulation of the spleen helps limit splenic infarction, and post embolization, the spleen is still functional reticuloendothelial system tissue. Hagiwara et al[30] studied 31 patients with blunt splenic injury: 3 who required emergent surgery, 13 who required bed rest alone, and 15 who were undergoing transcatheter arterial embolization. Nonoperative management of patients with blunt splenic injury employing transcatheter arterial embolization was successful in 93% of patients, and splenic function, as determined by technetium sulfur-colloid examinations, was preserved in all patients after embolization. The authors encouraged more extensive use of transcatheter embolization and the management of splenic injury without surgery.[30] In a subsequent article in 2005, Hagiwara et al[31] reported positive results of transcatheter SAE in hemodynamically unstable patients in whom there had been an initial transient response to fluid resuscitation. All 15 patients had extravasation at angiography, and all were embolized (several patients had additional non-splenic injuries requiring further embolization; i.e., pelvic fractures, renal injury, liver injury). All patients survived without operative intervention and all had functional splenic tissue on follow-up scintigraphy. These positive reports on SAE, even extending to the initially unstable patient, spurred considerable controversy among trauma physicians; some of whom believed the pendulum on splenic preservation had swung too far with nonoperative and angiographic embolization-assisted management.

Critical reviews of nonoperative management of blunt splenic trauma began to focus on failures of nonoperative management, and challenged the apparent major positive impact of SAE. Cooney et al[32] reported on the selective use of SAE over a four-year period in which 194 adults with splenic injuries were treated, 48 of whom went to surgery for splenectomy or splenorrhaphy. Nonoperative management with bed rest was used in 137 patients, 11 of whom (8%) failed. SAE was employed in only 9 patients, and 3 of the 9 embolization patients failed, requiring subsequent splenectomy (one for bleeding, and two for infarction), for a failure rate of 33%. They concluded that SAE was useful in only 5% of their patients, “saving” 6 spleens with high-grade injuries, but that it had a 33% failure rate. Failures of nonoperative management were most commonly caused by errors in judgment and selection, frequently from failure to recognize “high-risk” injury patterns on CT and from attempting nonoperative management in anticoagulated or coagulopathic patients. The causes and consequences of failure of nonoperative management of splenic injuries were further discussed in a retrospective descriptive study by McIntyre et al in 2005[33] involving 2243 patients identified in a statewide trauma registry with blunt splenic trauma over a 6-year period. Of the 2243 patients, 610 (27%) required immediate splenectomy, splenorrhaphy, or splenic embolization. Of the remaining 1633 patients admitted for nonoperative management, 252 (15%) failed. Among the injury and patient characteristics reviewed, age > 55, ISS > 25, and admission to Level III or IV trauma centers (compared to Level I centers) were associated with significant risk of failure of nonoperative management. Smith et al,[34] in a 2006 paper entitled "Splenic artery embolization: Have we gone too far?" reported results of 221 patients over a four-year period at a Level I trauma center. At this center, 165 (75%) of the patients were selected for nonoperative management, 41 of whom (25%) underwent SAE. The failure rate for splenic embolization was 27%, and among high AAST grade splenic injuries (grades 3, 4, and 5) and patients with moderate or large hemoperitoneum, the failure rate with embolization was 43%. The failure rate among splenic embolization patients with observed angiographic extravasation was 59%, and the failure rate in embolization patients with transient hypotension was 57%. They concluded that any hypotension probably warrants laparotomy, and that the combination of high grade injury, significant hemoperitoneum, and extravasation on angiogram predict a high risk of failure. They also noted that there should be a low threshold for splenectomy if bleeding persists.[34] Two other critical studies found no difference in mortality, no difference in adjusted cost, and no difference in the nonoperative management success rate with or without embolization.[35,36]

Numerous studies supportive of SAE in the nonoperative management of blunt splenic trauma continued to show high splenic salvage rates in the 80-90% range, even among high AAST grade splenic injury patients.[37-39] The secondary splenectomy rate is lower in nonoperatively managed patients after successful angiographic embolization,[39] though it has been recognized that patients with an arteriovenous fistula have a higher failure rate, even after apparent successful embolization.[38] A recent Norwegian study[40] reported the results of a prospective study with two groups: group 1 with routine operative and nonoperative management methods; and group 2 employing a splenic injury algorithm with mandatory angiographic embolization of all grades 3, 4, and 5 injuries, and all patients with signs of ongoing bleeding regardless of injury grade. In group 1, 43% of patients underwent emergent laparotomy, and the splenic salvage rate of the nonoperative management group was 79%. In group 2, with SAE, there was a 27% emergent laparotomy rate, a 4% failure rate for embolization, and a nonoperative management splenic salvage rate of 93%. They concluded that SAE increases the percentage of patients in whom nonoperative management was attempted, increased the nonoperative management success rate, and increased the splenic salvage rate.[40]

CT scans performed in follow-up of nonoperative management splenic trauma patients reveal a combination of organization and resolution of parenchymal injuries, as well as parenchymal, subcapsular, and intraperitoneal hemorrhages. Killeen et al[41] described the CT scan findings following SAE in 80 patients, and found splenic infarctions occurred in 63% of patients following proximal embolization and in 100% of patients following distal embolization. Distal embolizations were associated with larger infarcts in the embolized segment, whereas infarcts after proximal embolization tended to be smaller and more peripheral. Another important observation was the presence of gas bubbles within an infarct or subcapsular fluid collection, which clearly can be seen related to the use of Gelfoam as an embolization agent *(see Figure 5)*. However, it is virtually impossible on an imaging basis to differentiate this from an abscess complicating a region of splenic injury or infarction. In Killeen's study,[41] seven patients developed gas collections, four of whom resolved uneventfully, two of which were drained percutaneously and found to be sterile, and of which one was found to be an abscess at laparotomy. The presence of an air-fluid level in a subcapsular collection, or associated with free intraperitoneal air, is more suggestive of abscess formation. Complications arising from SAE after blunt splenic trauma are common, and as some institutions have expanded the use of SAE, it becomes more important to understand the full spectrum of potential complications from the embolization procedure. Ekeh et al[42] described major complications of splenic bleeding, splenic infarction, splenic abscess, and contrast-induced renal failure in 4 of 15 (27%) patients undergoing embolization. Minor complications of fever, pleural effusion, and uneventful, non-target coil migration occurred in 8 of 15 (53%) of the embolization patients. They still concluded that although major and minor complications of SAE occur frequently, it is still a safe and effective adjunct in the nonoperative management of splenic trauma.

Figure 3. Selective Splenic Angiogram in Patient with Extensive Contusion/Laceration

Selective splenic angiogram in patient with extensive splenic contusion / laceration demonstrates the abnormal "pointillism" type parenchymal appearance.

Operative Splenic Salvage and Splenectomy

As we have previously mentioned, the management of splenic injury has evolved from routine splenectomy to surgical salvage techniques to nonoperative treatment with the aid of SAE in select cases. The catalyst for this change was the recognition of the risk of overwhelming post-splenectomy sepsis, first studied in chil-

Figures 4a-4d. Splenic Contusion/Laceration with Pseudoaneurysm and AV Fistula

Figure 4a. CT scan of 38-year-old patient with grade 2 splenic injury; a 2 cm deep splenic contusion/laceration in the anterior spleen, with mildly abnormal contrast enhancement, no extravasation, no significant intraperitoneal hemorrhage, and a left sided hemothorax in the posterior costophrenic sulcus.

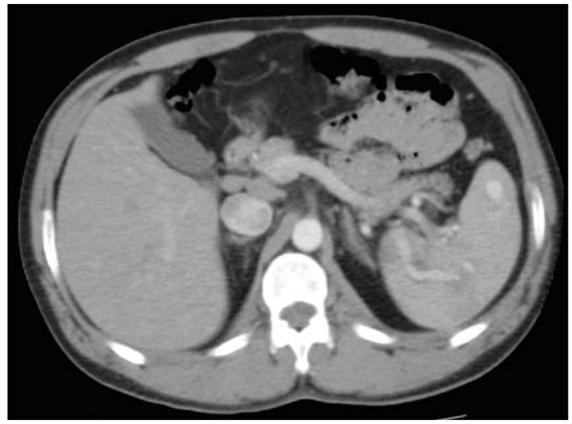


Figure 4b. Patient developed a chronic nonunion of one of the rib fractures, which was still painful, and presented for evaluation of persistent left sided pain approximately 2 months following the initial accident. An abdominal CT scan demonstrates the development of a contained splenic pseudoaneurysm with arteriovenous fistula.

Figure 4c. Splenic angiogram, arterial phase, demonstrating the pseudoaneurysm. There is a single dilated arterial pedicle supplying the pseudoaneurysm.

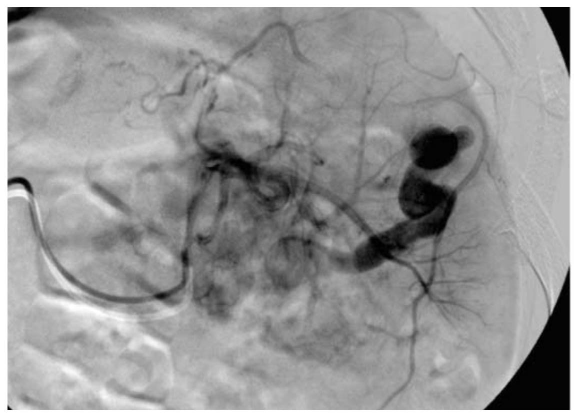


Figure 4d. Splenic angiogram, late arterial phase, demonstrating the arteriovenous fistula component, with the dilated, serpeginous draining vein. The angioarchitecture is fairly simple, with a single arterial pedicle and single draining vein.

dren[2] and then in adults.[3] While the overall incidence of fulminant sepsis in otherwise healthy splenectomized adults is low,[43-45] it is generally preferable to avoid this potentially fatal complication through measures taken to salvage splenic function. However, it must be remembered that certain circumstances, such as uncontrollable hemorrhage, continue to necessitate splenectomy. Thus, whether through splenorrhaphy, partial splenic resection, or splenectomy, operative management of splenic injury remains an important component of care of the injured spleen.

Methods of operative splenic salvage, namely splenorrhaphy and partial splenic resection, are invaluable aids in the preservation of splenic function when possible. Usage of these procedures has declined over the years due to the popularity of nonoperative management.[8,46] Yet, in the patient who does not qualify for nonoperative management based on the aforementioned guidelines, operative splenic salvage may still be an option. In 1985, Feliciano et al[47] concluded that splenorrhaphy could safely be performed in patients with few concomitant intraabdominal injuries and low-grade splenic injury (grades 1, 2, and 3 with success rates of 61.5% to 88.5%). They further discovered that the risk of rebleeding in patients who underwent splenorrhaphy was extremely low. Subsequent literature has suggested that partial splenic resection is most useful for grade 4 splenic injuries or for severe injury located at either splenic pole, and should only be performed if at least one-third of the spleen can be saved.[13] As a result, the decision to enact operative splenic salvage should be made based on classification of the severity of splenic injury, the overall hemodynamic stability of the patient, and the presence of associated abdominal injuries.

Despite the success rates of operative splenic salvage in select cases[47] and the ensuing avoidance of overwhelming post-splenectomy sepsis, there remain clear-cut indications for splenectomy.[8] Massive injury to the spleen, complex multi-system injury, hemodynamic instability, and failure of strategies for splenic salvage prompting laparotomy continue to occur, mandating removal of the spleen as good surgical practice. Consideration of

Figures 4e-4f. Selective Coil Embolization

Figure 4e. Selective coil embolization of the arterial pedicle supplying the pseudoaneurysm and arteriovenous fistula.

Figure 4f. CT scan of the abdomen 2 years following the ATV accident demonstrates no evidence of residual pseudoaneurysm or arteriovenous fistula, patent flow in the main splenic artery, and homogeneous enhancement of the splenic parenchyma. There is a focal cortical scar in the area of splenic injury and embolization.

splenectomy should occur in the presence of more than 1000 mL of hemoperitoneum, continuously decreasing hemoglobin levels, hemodynamic instability, or the need for more than 2 units of transfused blood.[48] Attempts to salvage the spleen during laparotomy should be abandoned if these methods fail to attain hemodynamic stability or severe splenic injury or associated abdominal injuries are identified.

As part of a comprehensive approach to the management of splenic injury, a strategy exists for the management of patients who must undergo splenectomy. This involves documentation (alert identification) of the asplenic state, vaccination for encapsulated organisms (*Neisseria meningitidis, Haemophilus influenzae,* and *Streptococcus pneumoniae*); antibiotic prophylaxis availability; and documentation to family, friends, and primary care providers of the risk for post-splenectomy sepsis. Furthermore, white blood cell counts in the postoperative period may be useful in early recognition of an infection. This was determined by Horowitz et al,[51] who found that white blood cell levels were consistently greater than 16 and began to rise on postoperative day 4 in infected patients, 2 days later than the peak of physiologic leukocytosis. It also has been suggested that thrombotic complications may be prevented with low-dose aspirin regimens.[49] Thus, through a comprehensive and scrupulous post-splenectomy protocol, serious complications may be avoided.

Finally, despite the advances in nonoperative and operative splenic management, variability in the success rates of splenic salvage and the routine practice of splenectomy have been reported.[26] Despite the widespread popularity of guidelines to follow, there are no recommendations for improving rates of splenic salvage in situations in which the rate is below published studies. At our institution, we hypothesized that by using statistical process control (SPC), we could achieve a splenic salvage rate of greater than 80%. First, data collected on the incidence of splenectomy in one year served as our benchmark (45%). Following intensive education regarding the concept of splenic salvage, current splenic salvage rates were displayed at monthly performance improvement meetings attended by trauma surgeons and other specialists, such as radiologists. The meetings also served to allow for evaluation of every instance of splenic injury and management. At the conclusion of our three-year period, rates of successful splenic salvage had risen from 45% to 92%. Thus, we submit that SPC using control chart data display and intensive education, coupled with critical incident review of each instance of splenectomy, may result in an improvement in the overall splenic salvage rate and lead to improved care for trauma patients.

The advances in nonoperative management of the traumatically injured spleen should not negate the importance of operative methods of splenic salvage and splenectomy in select cases. Post-splenectomy complications of overwhelming sepsis and thrombotic pathology underscore the need to attempt splenic salvage unless faced with uncontrollable hemodynamic instability, severe splenic injury, or severe associated intraabdominal pathology. The principles of post-splenectomy care demand a cooperative effort between the trauma surgeon, primary care provider, and patient to ensure that proper practices are followed to minimize the risk of complications. Additionally, we recommend that each trauma center should undertake a process of performance improvement utilizing statistics, education, and peer review meetings to achieve levels of splenic salvage that will benefit their patients.

Summary

Our understanding of the physiologic role of the spleen has grown since the first documented splenectomy due to traumatic injury in 1590.[52] Its function as a member of the reticuloendothelial system and the immune deficiency and thrombotic complications that have arisen in asplenic patients have caused the med-

Figure 5. CT Scan of Gelfoam Embolization

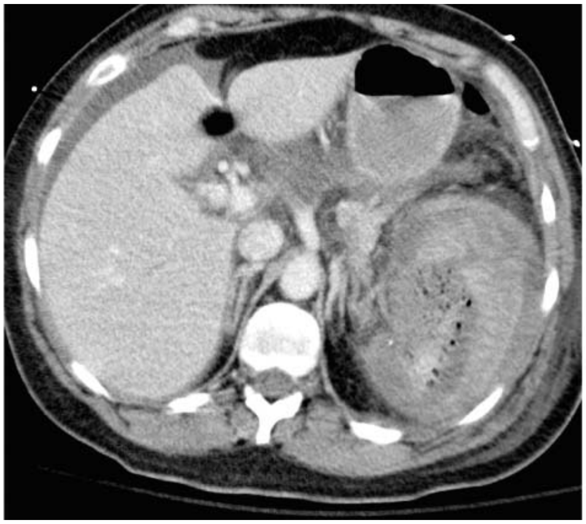


Figure 5. CT scan one day following Gelfoam embolization of the same patient as in Figure 1, demonstrates resolution of the active extravasation and multiple small air bubbles in the spleen due to the Gelfoam material. This appearance is not indicative of an abscess, and this patient had an uneventful recovery with successful splenic salvage.

ical community to reassess the performance of routine splenectomy following injury. Splenic injury scoring recommendations, along with imaging techniques, such as abdominal CT scanning and selective angiographic embolization, have enabled healthcare providers to not only recognize various nuances of splenic injury better, but also to successfully apply operative and nonoperative methods aimed toward preserving splenic function.

The recommendations made in this review reflect the ongoing efforts of medical research to develop techniques to ensure a more favorable outcome in patients who are victims of splenic trauma. Progress in the management of these patients has been achieved through the work of practitioners from various fields, and reflects the maxim that trauma patients require the efforts of an array of healthcare providers, beginning in the field and continuing through their care following discharge, to attain the best possible outcome. It is anticipated that present and future studies will continue to enlighten healthcare providers regarding appropriate management of patients with splenic injury.

References

1. American College of Surgeons Committee on Trauma. Advanced Trauma Life Support For Doctors: Student Course Manual, 7th Edition. Chicago, IL: American College of Surgeons, 2005.
2. King H, Shumaker HB Jr. Splenic studies I. Susceptibility to infection after splenectomy performed in infancy. *Ann Surg* 1952;136:239-242.
3. O'Neal BJ, McDonald JC. The risk of sepsis in the asplenic adult. *Ann Surg* 1981;194:775-778.
4. Chaikof EL, McCabe CJ. Fatal overwhelming post splenectomy infection. *Am J Surg* 1985;149:534-539.
5. Lange DA, Zaret P, Merlotti GJ, et al. The use of absorbable mesh in splenic trauma. *J Trauma* 1988;28:269-275.
6. Cogbill TH, Moore EE, Jurkovich GJ, et al. Nonoperative management of blunt splenic trauma: a multicenter experience. *J Trauma* 1989;29:1312-1317.
7. Smith JS Jr, Wengrovitz MA, DeLong BS. Prospective validation of criteria, including age, for safe, nonsurgical management of the ruptured spleen. *J Trauma* 1992;33:363-368.
8. Pachter HL, Guth AA, Hofstetter SR, Spencer FC. Changing patterns in the management of splenic trauma: the impact of nonoperative management. *Ann Surg* 1998;227:708-717.
9. Moore EE, Cogbill TH, Jurkovich GJ, et al. Organ injury scaling: spleen and liver (1994 revision). *J Trauma* 1995;38:323-324.
10. Davis KA, Fabian TC, Croce MA, et al. Improved success in nonoperative management of blunt splenic injuries: embolization of splenic artery pseudoaneurysms. *J Trauma* 1998;44:1008-1013.
11. Gaunt WT, McCarthy MC, Lambert CS, et al. Traditional criteria for observation of splenic trauma should be challenged. *Am Surg* 1999;65:689-691.
12. World Health Organization. Essential Surgical Care: Primary Trauma Care Manual, Abdominal Trauma. http://www.steinergraphics.com/surgical/manual09.html (Accessed on 9/30/08.)
13. Malangoni MA, Fallon WF. Management of splenic trauma in adults. In: *Shackelford's Surgery of the Alimentary Tract,* Vol. III, 5th Ed. Saunders, 2001.
14. Marmery H, Shanmuganathan K, Alexander MT, et al. Optimization of selection for nonoperative management of blunt splenic injury: comparison of MDCT grading systems. *AJR Am J Roentgenol* 2007;189:1421-1427.
15. Hoff WS, Holevar M, Nagy KK, et al. Practice Management Guidelines for the Evaluation of Blunt Abdominal Trauma. http://www.east.org/tpg/bluntabd.pdf (Accessed on 9/30/08.)
16. Mirvis SE, Whitley NO, Gens DR. Blunt splenic trauma in adults: CT-based classification and correlation with prognosis and treatment. *Radiology* 1989;171:33-39.
17. Buntain WL, Gould HR, Maull KI. Predictability of splenic salvage by computed tomography. *J Trauma* 1986;28:24-34.
18. Resciniti A, Fink MP, Raptopoulos V, et al. Nonoperative treatment of adult splenic trauma: development of a computed tomographic scoring system that detects appropriate candidates for expectant management. *J Trauma* 1988;128:828-831.
19. Gavant ML, Schurr M, Flick PA, et al. Predicting clinical outcome of nonsurgical management of blunt splenic injury: using CT to reveal abnormalities of the splenic vasculature. *AJR Am J Roentgenol* 1997;168:207-212.
20. Federle MP, Courcoulas AP, Powell M, et al. Blunt splenic injury in adults: clinical and CT criteria for management, with emphasis on active extravasation. *Radiology* 1998;206:137-142.
21. Willmann JK, Roos JE, Platz A, et al. Multidetector CT: detection of active hemorrhage in patients with blunt abdominal trauma. *AJR Am J Roentgenol* 2002;179:437-444.
22. Yao DC, Jeffrey Jr. RB, Mirvis SE, et al. Using contrast-enhanced helical CT to visualize arterial extravasation after blunt abdominal trauma: incidence and organ distribution. *AJR Am J Roentgenol* 2002; 178:17-20.
23. Anderson SW, Varghese JC, Lucey BC, et al. Blunt splenic trauma: delayed-phase CT for differentiation of active hemorrhage from contained vascular injury in patients. *Radiology* 2007;243:88-95.
24. Roy-Choudhury SH, Gallacher DJ, Pilmer J, et al. Relative threshold of detection of active arterial bleeding: in vitro comparison of MDCT and digital subtraction angiography. *AJR Am J Roentgenol* 2007;189:W238-W246.
25. Nusbaum M, Baum S, Blakemore WS, et al. Demonstration of intra-abdominal bleeding by selective arteriography: visualization of celiac and superior mesenteric arteries. *JAMA* 1965;191:389-390.
26. Hunt JP, Lentz CW, Cairns BA, et al. Management and outcome of splenic injury: the results of a five-year statewide population-based study. *Am Surg* 1996 Nov;62:911-917.

27. Bee TK, Croce MA, Miller PR, et al. Failures of splenic nonoperative management: is the glass half empty or half full? *J Trauma* 2001;50:230-236.
28. Allins A, Ho T, Nguyen TH, et al. Limited value of routine followup CT scans in nonoperative management of blunt liver and splenic injuries. *Am Surg* 1996;62:883-886.
29. Sclafani SA, Weisberg A, Scalea TM, et al. Blunt splenic injuries: nonsurgical treatment with CT, arteriography, and transcatheter arterial embolization of the splenic artery. *Radiology* 1991;181:189-196.
30. Hagiwara A, Yukioka T, Ohta S, et al. Nonsurgical management of patients with blunt splenic injury: efficacy of transcatheter arterial embolization. *AJR Am J Roentgenol* 1996;167:159-166.
31. Hagiwara A, Fukushima H, Murata A, et al. Blunt splenic injury: usefulness of transcatheter arterial embolization in patients with a transient response to fluid resuscitation. *Radiology* 2005; 235:57-64.
32. Cooney R, Ku J, Cherry R, et al. Limitations of splenic angioembolization in treating blunt splenic injury. *J Trauma* 2005;59:926-932.
33. McIntyre LK, Schiff M, Jurkovich G. Failure of nonoperative management of splenic injuries: causes and consequences. *Arch Surg* 2005;140:563-568.
34. Smith HE, Biffl WL, Majercik SD, et al. Splenic artery embolization: have we gone too far? *J Trauma* 2006;61:541-544.
35. Wahl WL, Ahrns KS, Chen S, et al. Blunt splenic injury: operation versus angiographic embolization. *Surgery* 2004;136:891-899.
36. Harbrecht BG, Ko SH, Watson GA, et al. Angiography for blunt splenic trauma does not improve the success rate for nonoperative management. *J Trauma* 2007;63:44-49.
37. Haan JM, Biffl W, Knudson MM, et al. Splenic embolization revisited: a multicenter review. *J Trauma* 2004;56:542-547.
38. Haan JM, Bochicchio GV, Kramer N, et al. Nonoperative management of blunt splenic injury: a 5 year experience. *J Trauma* 2005;58:492-498.
39. Bessoud B, Denys A, Calmes JM, et al. Nonoperative management of traumatic splenic injuries: is there a role for proximal splenic artery embolization. *AJR Am J Roentgenol* 2006;186:779-785.
40. Gaarder C, Dormagen JB, Eken T, et al. Non operative management of splenic injuries: improved results with angioembolization. *J Trauma* 2006;61:192-198.
41. Killeen KL, Shanmuganathan K, Boyd-Kranis R, et al. CT findings after embolization for blunt splenic trauma. *J Vasc Interv Radiol* 2001;12:209-214.
42. Ekeh AP, McCarthy MC, Woods RJ, et al. Complications arising from splenic artery embolization after blunt splenic trauma. *Am J Surg* 2005;189:335-339.
43. Schwartz PE, Sterioff S, Mucha P, et al. Postsplenectomy sepsis and mortality in adults. *JAMA* 1982;248:2279-2283.
44. Holdsworth RJ, Irving AD, Cuschieri A. Postsplenectomy sepsis and its mortality rate: actual versus perceived risks. *Br J Surg* 1991;78:1031-1038.
45. Bisharat N, Omari H, Lavi I, et al. Risk of infection and death among post-splenectomy patients. *J Infect* 2001;43:182-186.
46. Brasel KJ, DeLisle CM, Olson CJ, et al. Splenic injury: trends in evaluation and management. *J Trauma* 1998;44:283-286.
47. Feliciano DV, Bitondo CG, Mattox KL, et al. A four-year experience with splenectomy versus splenorrhaphy. *Ann Surg* 1985;201:568-575.
48. National Guideline Clearinghouse. Indications for splenectomy. http://www.guidelines.gov/summary/summary.aspx?ss=15&doc_id=5505&string=spherocytosis#s23 (Accessed on 9/30/08.)
49. Linet MS, Nyren O, Gridley G, et al. Causes of death among patients surviving at least one year following splenectomy. *Am J Surg* 1996;172:320-323.
50. Pisters PW, Pachter HL. Autologous splenic transplantation for splenic trauma. *Ann Surg* 1994;219:225-235.
51. Horowitz J, Leonard D, Smith J, et al. Postsplenectomy leukocytosis: physiologic or an indicator of infection? *Am Surg* 1992;58:387-390.
52. Wilkins B. The spleen. *Br J Haematol* 2002;117:265-274.

CNE/CME Objectives

Upon completing this program, the participants will be able to:

a.) discuss conditions that should increase suspicion for traumatic injuries;
b.) describe the various modalities used to identify different traumatic conditions;
c.) cite methods of quickly stabilizing and managing patients; and
d.) identify possible complications that may occur with traumatic injuries.

CNE/CME Questions

1. Which of the following statements regarding the management of a patient with a possible abdominal injury is correct?
   A. They should be taken for immediate exploratory laparotomy even if they are stable due to the potentially disastrous outcomes following a missed diagnosis of a splenic rupture.
   B. Patients with stable vital signs and a nonspecific abdominal examination on presentation should be released with specific instructions to follow-up with a primary care physician.
   C. A chest x-ray is adequate in patients with suspected rib fractures, as thoracic injuries do not increase the likelihood of associated abdominal injuries.
   D. Stable patients with a high possibility of abdominal injury should undergo repeated abdominal exams and appropriate imaging studies due to the high incidence of patients with hemoperitoneum who had benign initial examinations.

2. Which of the following statements is correct regarding the importance of hemodynamic stability when assessing a patient with abdominal trauma?
   A. Airway patency, breathing, and circulation do not need to be considered first because an unstable patient taken for exploratory laparotomy will be intubated and placed on IV fluids in the operating room.
   B. A hemodynamically unstable patient with obvious abdominal blood loss should be taken for immediate exploratory laparotomy.
   C. A hemodynamically unstable patient with obvious abdominal blood loss should be taken for an emergent abdominal CT scan.
   D. The hemodynamic stability of a patient with abdominal trauma does not factor into the decision-making process regarding the diagnosis and management of injury.

CNE/CME Instructions

Physicians and nurses participate in this continuing medical education/continuing education program by reading the article, using the provided references for further research, and studying the questions at the end of the article. Participants should select what they believe to be the correct answers, then refer to the list of correct answers to test their knowledge. To clarify confusion surrounding any questions answered incorrectly, please consult the source material. **After completing this activity, you <u>must</u> complete the evaluation form provided and return it in the reply envelope provided in order to receive a letter of credit.** When your evaluation is received, a letter of credit will be mailed to you.

3. Which statement regarding splenic injury is correct?
   - A. Consideration of possible splenic injury should only occur when a patient presents with obvious left upper quadrant abdominal trauma.
   - B. Patients with splenic injury often experience long-term sequelae of the inability to become angry and lack of imagination, due to the loss of splenic function and its role in achieving various emotional states.
   - C. Nonoperative management, surgical salvage techniques, and splenectomy are utilized to balance the importance of splenic preservation with the need to prevent splenic hemorrhage following traumatic injury.
   - D. The spleen is rarely injured following blunt abdominal trauma.

4. Which of the following statements regarding imaging techniques in the assessment of abdominal trauma is correct?
   - A. FAST is performed most often due to the need to move patients through the emergency room quickly.
   - B. CT scans have the ability to detect certain abdominal injuries which were not detected during the initial examination, and should only be performed in patients who are hemodynamically stable.
   - C. Active extravasation viewed during an abdominal CT scan should have little bearing on the choice of management of splenic injury.
   - D. A hemodynamically unstable patient with unconfirmed abdominal injury may undergo either an abdominal CT scan or a FAST evaluation to aid in the decision regarding possible emergent laparotomy.

5. Which of the following statements regarding guidelines for nonoperative management of splenic injury is correct?
   - A. Patients who undergo nonoperative management should not have associated significant injury of another abdominal organ.
   - B. Patients with hemodynamic instability may be initially managed nonoperatively with avoidance of all operative procedures due to the risk of postoperative infection.
   - C. Splenic injury scoring should not be used when deciding which course of treatment to follow.
   - D. Patients greater than 50 years of age should never be managed nonoperatively.

6. Nonoperative management of splenic injury is:
   - A. most successfully accomplished on an outpatient basis in young compliant patients.
   - B. rarely used in adults due to the limited role of the spleen as a person matures.
   - C. best carried out with the aid of weekly abdominal CT scans in order to assure that the patient achieves complete resolution of injury.
   - D. aided by SAE if a vascular blush is identified during the abdominal CT scan.

7. Operative management in patients with splenic injury:
   - A. has evolved and essentially obliterated the performance of splenectomy, even in the case of uncontrollable hemorrhage.
   - B. includes splenorrhaphy, which should be performed in patients with persistently declining hemoglobin levels or those requiring more than 2 units of transfused blood.
   - C. should be determined based on hemodynamic stability, severity of splenic injury and the presence of concomitant abdominal injuries when choosing between operative salvage techniques and splenectomy.
   - D. should not be performed on patients greater than 55 years of age with a Grade 5 splenic injury, due to the decreased wound healing potential in patients with advanced age.

8. Which statement regarding postsplenectomy care is correct?
   - A. Patients should be vaccinated for encapsulated organisms, and family and primary care providers should be educated regarding the signs and risk of postsplenectomy sepsis.
   - B. Vaccination for encapsulated organisms is not necessary prior to the age of 50 due to the loss of immune function which accompanies aging.
   - C. Overwhelming sepsis is the only complication that has observed in patients who have undergone splenectomy.
   - D. Due to the overall low incidence of overwhelming postsplenectomy sepsis, there are no routine precautions which need to be followed.

9. Which of the following statements regarding the initial evaluation of patients with abdominal trauma is correct?
   - A. Palpation of the abdomen is rarely helpful and should be avoided due to the risk of causing more trauma in a potentially precarious presentation.
   - B. Left upper quadrant pain and dullness to percussion, left shoulder pain, and hypotension are possible presentations seen following splenic injury.
   - C. Disability does not need to be assessed in these patients and supplementary oxygen is usually not required.
   - D. The physical exam may be postponed until after an abdominal CT scan is performed.

Answers: 1. D; 2. B; 3. C; 4. B; 5. A; 6. D; 7. C; 8. A; 9. B

In Future Issues:

Approaching the Patient with Shock