[redacted]

INITIAL EVALUATION AND MANAGEMENT

As with any other trauma patient, the initial management of the patient with splenic injury should follow the airway, breathing, and circulation (ABCs) of trauma evaluation and resuscitation (see Chapter 10). A particularly important general comment relative to initial resuscitation is that it is important to recognize refractory shock early and treat it with an appropriate operative response. There are some aspects of the initial evaluation, with respect to the spleen, that deserve special mention:

1. The possibility of an additional intra-abdominal injury in patients with splenic injury seen on CT scanning should be kept in mind. Injury to the gastrointestinal tract is of particular concern.
2. While operating on patients with splenic injury, it is important to look for associated injuries, particularly to the left hemidiaphragm and the pancreas.
3. When mobilizing the spleen, always mobilize the tail of the pancreas medially with the spleen to optimally expose the splenic hilum and minimize risk to the spleen and pancreas.
4. Despite the fact that nonoperative management of splenic injury is a commonly successful strategy, patients can still bleed to death from splenic injury. Therefore, a significant percentage of patients still require surgical intervention and splenectomy.

Elements of the history may be helpful in the diagnosis of splenic injury, and mechanism of injury is important. In patients injured in a motor vehicle crash, the position of the patient in the car can be of some importance in diagnosing splenic injury. Victims located on the left side of the car (drivers and left rear passengers) are perhaps slightly more susceptible to splenic injury because the left side of their torso abuts the left side of the car. This does not mean, however, that victims in other locations in a vehicle are not at risk. For patients who have suffered penetrating injury, the type and nature of the weapon is important. When possible, it is helpful to know the caliber of the gun or the length of the knife (see Chapter 1).

In the initial history taking, it is important to note any previous operations the patient has undergone. Of particular importance are any operations that may have resulted in splenectomy (ie, previous operations for hematologic disease or abdominal trauma). Any preexisting conditions that might predispose the spleen to enlargement or other abnormality should be asked about, as well. The patient or significant others should be asked about the presence of hepatic disease, ongoing anticoagulation, or recent usage of aspirin or nonsteroidal anti-inflammatory drugs, also.

On physical examination, it is important to determine if the patient has left rib pain or tenderness. Left lower ribs are particularly important in that they overlie the spleen, especially posteriorly. Approximately 14% of patients with tenderness over the left lower ribs will have a splenic injury. Even with tenderness over the left lower ribs as their only indication of possible abdominal injury, 3% of patients will have a splenic injury.[16] In children, the plasticity of the chest wall allows for severe underlying injury to the spleen without the presence of overlying rib fractures. Such a phenomenon is also possible in adults, but is less common than it is in children.

The absence of tenderness over the left lower ribs does not preclude the presence of an underlying splenic injury and, in some cases, may be related to an altered level of consciousness from an associated traumatic brain injury (TBI) or intoxication. In elderly patients, rib fractures may not manifest in a fashion similar to that seen in younger patients. Patients over the age of 55 may not describe lower rib pain and may not have particularly noteworthy findings on physical examination in spite of severe trauma to the chest wall and an underlying splenic injury.

Another finding on physical examination that is occasionally helpful in the presence of a splenic injury is the presence of Kehr's sign. Kehr's sign is the symptom of pain near the tip of the left shoulder secondary to pathology below the left hemidiaphragm. There is minimal shoulder tenderness, and the patient typically does not have pain on range of motion of the left arm and shoulder unless there is an associated musculoskeletal injury. Kehr's sign after splenic injury is the result of irritation of the diaphragm by subphrenic blood. The sensory innervation of the left hemidiaphragm comes from cervical roots 3, 4, and 5, the same cervical roots that innervate the tip of the shoulder, and referred pain from the diaphragmatic irritation causes the left shoulder pain. Although it is relatively uncommon, the presence of Kehr's sign shortly after trauma should increase the index of suspicion for splenic injury.

The physical examination of the abdomen sometimes demonstrates localized tenderness in the left upper quadrant or generalized abdominal tenderness, but not all patients with splenic injury will reliably manifest peritoneal or other findings on physical examination. Ecchymoses or abrasions in the left upper quadrant or left lower chest may be present, also. The unreliability of the physical examination of the abdomen is obvious in patients with an altered mental status and may be absent in patients with normal mentation, as well. As a consequence, imaging of the abdomen in hemodynamically stable patients has become an important element of diagnosis and management (see Chapter 15).

There are no laboratory studies specific to patients with splenic injury, although a hematocrit and typing and cross-matching of blood are useful initial laboratory tests. Coagulation studies may be warranted if there is reason to believe that the patient is coagulopathic. As with all other early post-traumatic bleeding, bleeding from a splenic injury in the early post-injury period will not always cause a marked drop in hematocrit. An extremely low hematocrit on arrival of the patient in the resuscitation room, however, especially if the transport has been short and prehospital fluid resuscitation has been minimal, should alert the surgeon to the possibility of severe ongoing hemorrhage (see Chapter 10).

Plain x-rays generally are not helpful in the diagnosis of splenic injury. Rupture of the left hemidiaphragm is sometimes apparent on an initial chest x-ray, however, and can suggest an associated splenic injury. A severe pelvic fracture on an anteroposterior pelvic film can sometimes be of importance in subsequent decision making about how to manage a splenic injury as the presence of simultaneous splenic and severe pelvic injuries often will dictate the removal of the spleen. When penetrating trauma is the mechanism of injury, an initial chest x-ray is important in ruling out associated thoracic injury and, in the case of gunshot wounds, helping to determine the path of a bullet and the location of a retained bullet or bullet fragments.

IMAGING AND DIAGNOSTIC PERITONEAL LAVAGE

Diagnostic peritoneal lavage (DPL) is used much less frequently now. Its role as an initial diagnostic maneuver to dictate subsequent testing or operative intervention has been supplanted in many institutions by both ultrasonography and CT scanning of the abdomen (see Chapters 15 and 16). Peritoneal lavage remains useful when ultrasonography is not available in that it is a quick way of determining if a hemodynamically unstable patient is bleeding intraperitoneally. Although DPL is not specific for splenic injury, splenic injuries with ongoing bleeding result in a positive peritoneal lavage most of the time that prompts timely operative intervention. DPL may not yield positive results when there is an associated diaphragmatic injury because the instilled fluid may be retained in the pleural space. If the DPL yields little or no return of fluid, a diaphragmatic injury should be considered.

Ultrasound of the abdomen for free fluid, the so-called FAST exam, is now an essential procedure in diagnosing hemoperitoneum in patients with blunt trauma (see Chapter 16). Like DPL it is most useful in unstable patients; but it may also determine the need for further imaging in stable patients. As with peritoneal lavage, the ability of ultrasound to determine exactly what is bleeding in the peritoneal cavity is limited. Small injuries and subcapsular hematomas of the spleen can also be missed by ultrasonography if they do not result in a significant hemoperitoneum. There have been attempts to use ultrasound not only to diagnose intraperitoneal fluid but also to diagnose specific injuries such as splenic injuries. Such attempts have met with limited success, and the most common reason to perform FAST exams is for detection of intraperitoneal fluid and as a determinant of the need for either further imaging of the abdomen or emergency surgery.

CT scanning of the abdomen is the most common imaging study that may allow for nonoperative management of a splenic injury. Patients are either sent directly for abdominal CT scanning after initial resuscitation or screened by abdominal ultrasonography as reasonable candidates for subsequent CT. When abdominal CT scanning is done, intravenous contrast is quite helpful in diagnosis. Oral contrast is much less helpful and does not increase the sensitivity of CT for detecting a splenic injury. Radiation exposure from CT, especially in children, has been raised as a potential concern and some selection should be used with respect to which patients with abdominal trauma should undergo scanning.[17] Undue concern about radiation, however, should not put a patient at risk for a missed splenic injury and occult bleeding.

The findings of splenic injury on CT scan are variable (Fig. 30-4). Hematomas and parenchymal disruption generally show up as hypodense areas. Free fluid can be seen either around the spleen or throughout the peritoneal and pelvic spaces. Locations where fluid frequently accumulates after splenic injury are Morison's pouch, the paracolic gutters, and the pelvis. When a large amount of fluid is present in the peritoneal cavity, it can sometimes be seen between loops of small bowel as well as in the subphrenic spaces.

When looking at CT scans of patients with splenic injury, it is important to look at the adjacent left kidney and the distal pancreas, also. Injury to the spleen implies a blow to the left upper quadrant that can injure adjacent organs. The diagnosis of a pancreatic injury is particularly important in that this can significantly affect the patient's subsequent course and prognosis. Also, it is important to remember that the presence of free fluid is not solely related to bleeding from a visible splenic injury in all cases. One of the pitfalls of CT diagnosis is that free fluid in the peritoneal cavity or in the pelvis may be attributed to a splenic injury when in fact the fluid is secondary to both a splenic injury and an associated injury to the mesentery or bowel.

Other than an obvious injury, the most important CT finding in the spleen is the presence in the disrupted splenic parenchyma of a "blush" which appears as hyperdense area containing a concentration of contrast (Fig. 30-4). When seen, a blush either represents active extravasation of contrast from ongoing bleeding or a pseudoaneurysm from a damaged vessel with the potential for delayed bleeding. There is evidence that the presence of a blush correlates with an increased likelihood that continued or delayed bleeding will occur resulting in failure of nonoperative management. These arterial injuries need further assessment with either angiography or repeat CT scanning.

A number of scoring systems have been devised to describe the degree of splenic injury seen on CT scanning.[18-21] Some of these scoring systems will be described in further detail later. It is important to remember, however, that there is not a perfect correlation between the grade of splenic injury seen on CT scanning and the grade of splenic injury seen at the time of surgery in patients who require operative intervention. Also, it is important to remember that the CT grade of splenic injury and a patient's subsequent clinical course are only roughly correlated.

Magnetic resonance imaging (MRI) has been used sporadically in the diagnosis of splenic injury (see Chapter 15). The images obtained are sometimes quite impressive but, given that CT scanning has both a very high sensitivity and specificity for the presence of splenic injury (especially when newer-generation multidetector scanners are used), MRI so far has not proven to be an obvious improvement. Furthermore, MRI is usually less available than is CT scanning, especially after hours. The logistical difficulties inherent in trying to obtain magnetic resonance images in a badly injured patient who requires close monitoring and, possibly, even mechanical ventilation make MRI even less helpful as a diagnostic modality. Continued improvements in MRI and our increasing ability to use it even for very sick patients could conceivably increase the role of MRI in the diagnosis of splenic injury in the future.

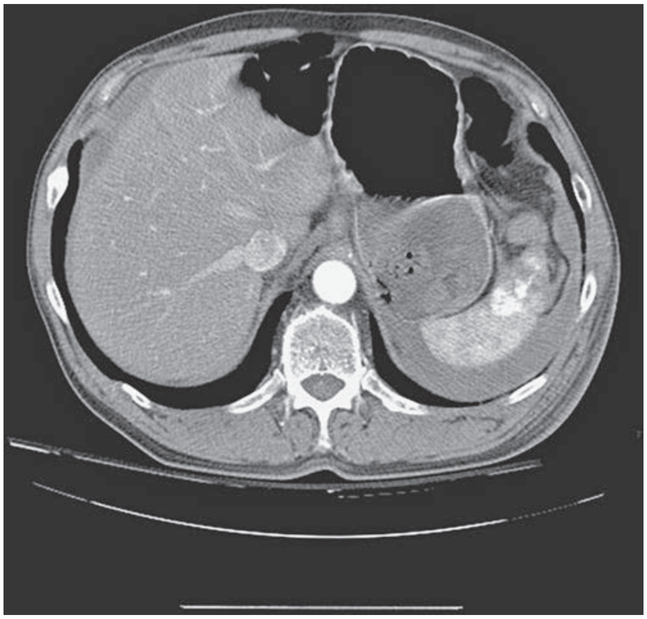

FIGURE 30-4 Computed tomographic findings in a patient with an injured spleen. The splenic parenchyma is disrupted, and there is some blood and hematoma. There is also a splenic "blush" in the disrupted parenchyma.

Radioisotope scintigraphy was used in the diagnosis of splenic injury in the past before the advent of widespread CT scanning, and it is largely of historical interest at this point. Angiography is another test that has been used historically to diagnose splenic injury, but angiography for the diagnosis of splenic injury has largely been replaced by computerized tomography as described above. Angiography with embolization for bleeding does, however, have an important therapeutic role in the management of splenic injury.

Laparoscopy has been tried as a means of diagnosing splenic injury, but is not a diagnostic improvement over CT scanning in patients with blunt trauma. After penetrating trauma, laparoscopy often misses associated bowel injuries. It may have some usefulness in diagnosis and treatment of injuries adjacent to the left hemidiaphragm (see Chapter 28).

GRADING SYSTEMS FOR SPLENIC INJURY

A number of different grading systems have been devised to quantify the degree of injury in patients with injured spleens.[18-21] These systems have been created based on both the computed tomographic appearance of injured spleens and the intraoperative appearance of the spleen. The best known clinical splenic grading system is the one created by the American Association for the Surgery of Trauma (AAST) (Fig. 30-5; Table 30-1).[18] As with all of the AAST grading systems except that used for hepatic injuries, it uses a scale of between I and V.

The CT and intraoperative appearances of a splenic injury are often different from one another. Some of these differences might be because of evolution of the injury between the time of CT scanning and operation, but it is also likely that CT scanning is imperfect in describing the pathologic anatomy of a splenic rupture. Splenic injury scores based on CT scans can both overestimate and underestimate the degree of splenic injury seen at surgery. It is possible to have a CT appearance of fairly trivial injury, but find significant splenic disruption at surgery. Conversely, it is possible to see what looks like a major disruption of the spleen on CT scanning and not see the same kind of severity of injury at surgery. In general, the CT scan and associated scores tend, if anything, to underestimate the degree of splenic injury compared to

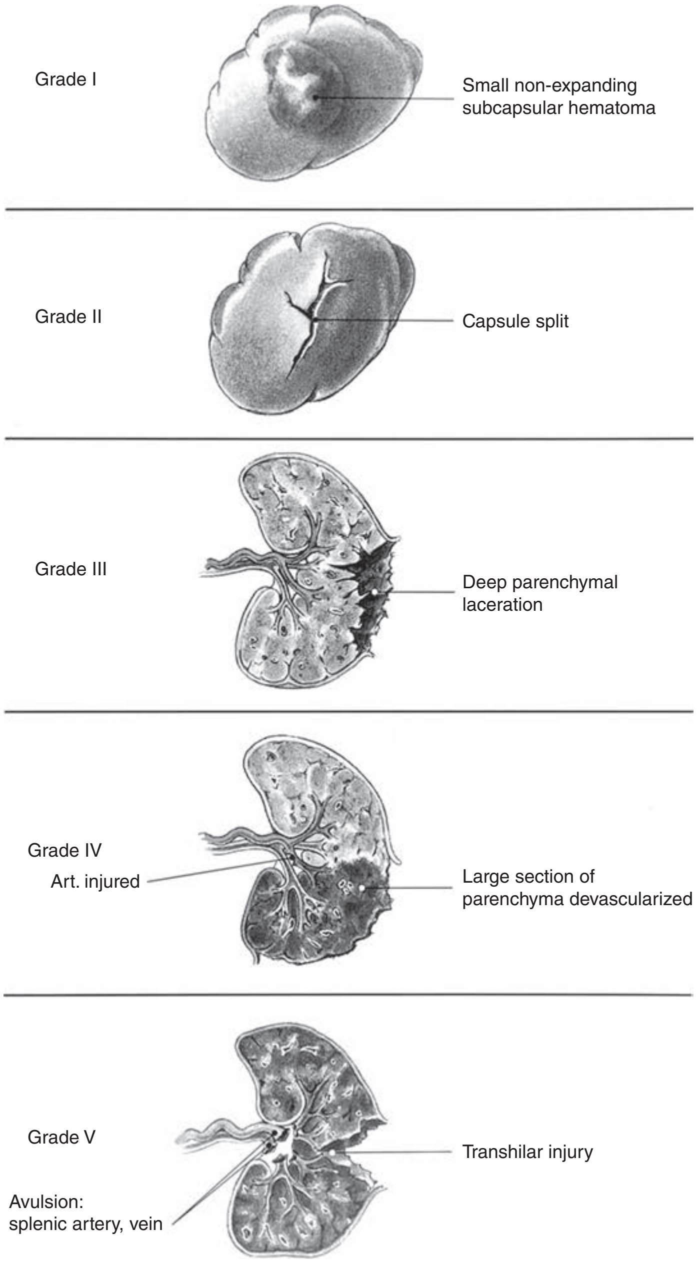

FIGURE 30-5 Diagrammatic representation of the splenic organ injury scaling system of the American Association for the Surgery of Trauma. (Reproduced with permission from Carrico CJ, Thal ER, Weigelt JA, eds. *Operative Trauma Management: An Atlas*. Norwalk, CT: Appleton & Lange; 1998. Copyright The McGraw-Hill Companies, Inc.)

what is seen at surgery.[22] Additionally, intrarater agreement with respect to CT grading of splenic injury is only fair. A study comparing the CT interpretations of four experienced trauma radiologists revealed poor interrater reliability and also frequent "undergrading" of the degree of splenic injury when CT interpretations were compared with intraoperative findings.[22]

An important point about CT-based grading systems is that the patient's subsequent clinical course does not correlate exactly with the degree of injury seen on CT. Although there is a correlation between the grade of splenic injury seen on CT scanning and the frequency of operative intervention, exceptions are common. It is possible to have what looks like a fairly trivial injury on CT scan turn out to require delayed operative intervention. In contrast, a patient with a "significant" splenic injury on CT scan quite often has a benign post-injury course with successful nonoperative management.

Probably the major usefulness of grading of a splenic injury, especially when the AAST Organ Injury Scale is used, is to allow for objective standardization of terminology and to ensure that

TABLE 30-1: The Splenic Organ in Jury Scaling System of the American Association for the Surgery of Trauma, 1994 Revision

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

[a]Advance one grade for multiple injuries up to grade III.

individual injuries are described in precise terms understandable to others. Standardized organ injury scaling is useful in research, in describing populations of splenic injury patients, and in dictating treatment algorithms, as well (Fig. 30-6).

NONOPERATIVE MANAGEMENT

Nonoperative management of splenic injury has become more common over time. Although approximately 40% of patients with splenic injury will require immediate operative intervention, nonoperative management is reasonable for hemodynamically stable patients.[23]

Patient Selection

Appropriate patient selection is the most important element of nonoperative management. Determining which patients require emergency surgery and which can be initially managed nonoperatively is sometimes difficult, although hemodynamic status, age, grade of splenic injury, quantity of hemoperitoneum, and associated injuries have been shown to roughly correlate with the success or failure of nonoperative management. The decision for nonoperative management must also consider the institutional resources available.

Of paramount importance in the determination of the appropriateness of nonoperative management is the hemodynamic stability of the patient. *Hemodynamic stability* can be a somewhat illusory concept, and one for which there is no consensus definition; but hypotension is generally considered to be worthy of concern. Historically, a prehospital systolic blood pressure (SBP) less than 90 mm Hg has mandated triage to a trauma center. In fact, that criterion is too low, as a prehospital SBP less than 110 mm Hg has been shown to be associated with poor outcomes.[24,25] Hypotension in the prehospital period or emergency department is worrisome, and a high index of suspicion for ongoing hemorrhage should be maintained when either is present. Patients who have been hemodynamically unstable in the prehospital phase and remain hemodynamically unstable during their initial emergency department stay are, in most instances, inappropriate candidates for abdominal CT scanning. They require either a direct trip to the operating room (OR) or, more commonly, abdominal ultrasonography or DPL to help guide the initial decision-making process (see Chapters 10 and 16).

Assuming hemodynamic stability, the other important prerequisite for consideration of nonoperative management is the patient's abdominal examination. In patients who are awake and alert and can cooperate with a physical examination and provide feedback, it is important that they not have diffuse peritonitis. Although patients with splenic injury will often have localized pain and tenderness in the left upper quadrant and abdominal findings secondary to intraperitoneal blood, obvious diffuse peritonitis can be a sign of intestinal injury and mandates an abdominal exploration. If a patient with a splenic injury is sent for CT scanning and subsequent nonoperative management, it is important to perform repeat physical examinations. If the examination worsens, the possibility of a blunt intestinal injury should be considered. The most common CT finding in patients with blunt intestinal injury is free fluid in the peritoneal cavity. As previously noted, the free fluid can be mistakenly attributed solely to the splenic injury, and the presence of an associated injury to the bowel can be missed.

The success rates of nonoperative management of splenic injuries are very high in many of the published series. Reported success rates for nonoperative management are 95% or higher for pediatric patients and 80–94% in adults.[26-30] These high success rates can be misleading, however, in that they apply only to the group of patients in whom nonoperative management was chosen rather than all patients with splenic injury. When patients undergoing immediate splenectomy are included, the overall splenic salvage rates tend to be 50–60% in adult patients. It is important to remember that these series generally do not include patients in whom the initial plan

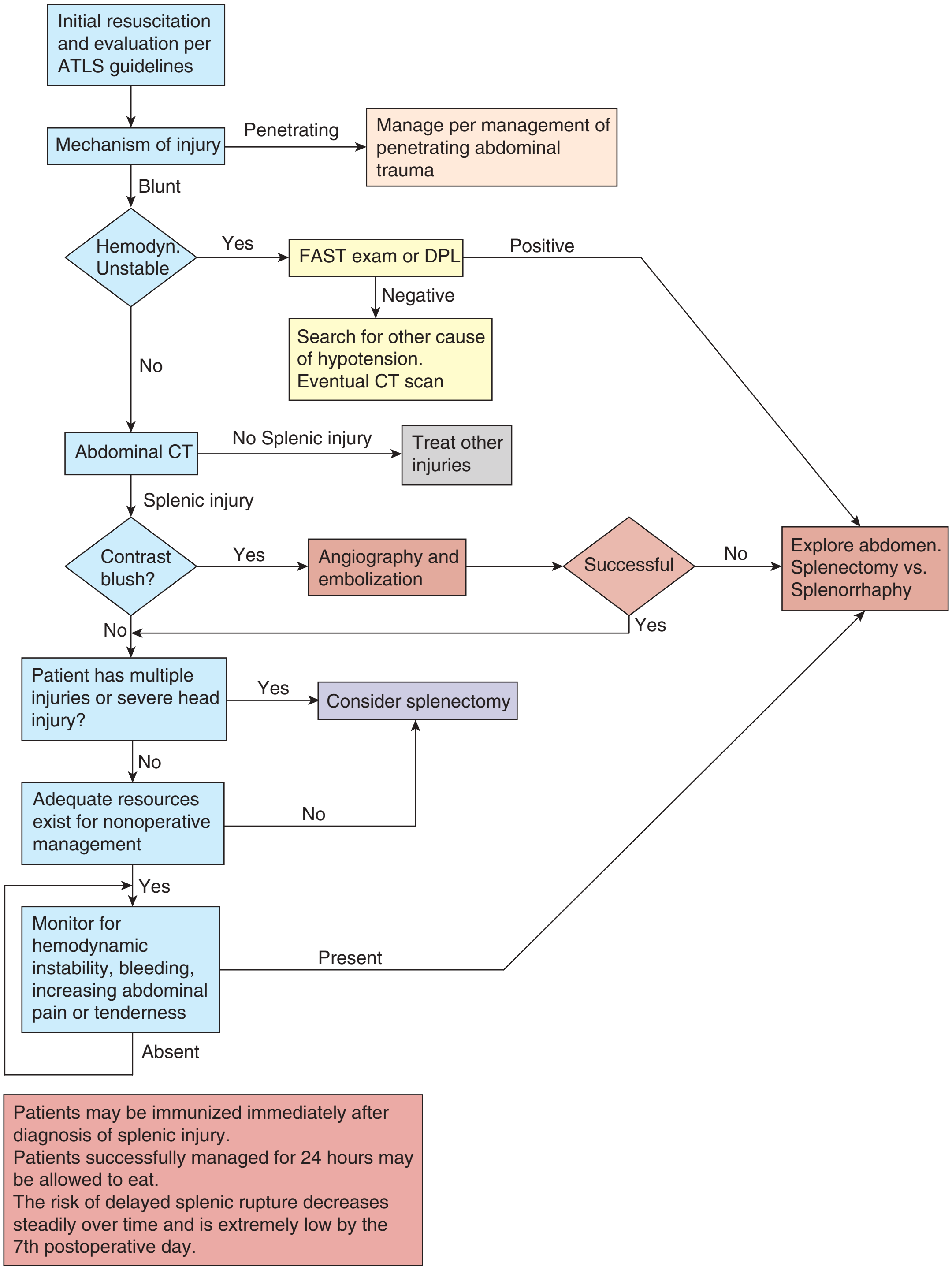

FIGURE 30-6 Algorithm for the diagnosis and management of splenic injury.

was for nonoperative management, but an emergency operation was necessary when the patient became hypotensive or developed peritonitis in the emergency department or in the CT scanner. The published series of nonoperatively managed spleens generally include only the selected patients who were stable enough to undergo CT scanning of the abdomen and in whom the CT scan showed an injured spleen. Patients who became unstable either before or during the scan and were taken emergently to surgery are usually not counted as patients who underwent "nonoperative" management. When these patients are reported at all, they are placed into the "operative" group rather than into the "failed nonoperative" group. Published series of splenic injuries, particularly in pediatric patients, are more likely to describe patients treated at referral centers where there are large numbers of transfer patients who have already been triaged for stability prior to their arrival at the referral center. Finally, the literature on the success of nonoperative management of splenic injury should be interpreted with the awareness that publication bias tends to favor series in which success rates are high.

Other important considerations beyond hemodynamic stability and abdominal findings in the determination of the appropriateness of nonoperative management have to do with the medical environment and some specific characteristics of the patient. Nonoperative management should only be undertaken if it will be possible to closely follow the patient. If close inpatient follow-up is simply not possible, abdominal exploration may be appropriate. Similarly, if rapid mobilization of the OR and quick operative intervention in the case of ongoing or delayed bleeding is not possible, early rather than emergent operative intervention may be appropriate. Finally, the patient's circumstances after discharge occasionally may be important in the decision-making process. For patients who are to be discharged to a location remote from medical care, the consequences of delayed bleeding are greater in that they may not be close enough to a hospital that can perform an emergency operative procedure. In such circumstances, an otherwise reasonable candidate for nonoperative management might undergo operative intervention and, possibly, splenic repair.

For patients who are stable enough to undergo CT scanning and in whom an injured spleen is identified, nonoperative management is reasonable if they continue to remain stable. In addition to vital signs, one of the other commonly followed parameters in such patients is the hematocrit. A common practice is to determine a cutoff value below which the hematocrit will not be allowed to fall. If the hematocrit drops to that level or below, operative intervention is undertaken. Such an approach works best if there are no associated injuries; when associated injuries are present, it can be quite difficult to know if the spleen is continuing to bleed or if the fall in hematocrit is secondary to bleeding from other injuries.

In general, there is consensus that hemodynamically stable patients without obvious or progressive peritoneal signs who can be followed closely are reasonable candidates for nonoperative management. Historically, there has been a debate about certain subgroups of patients and their appropriateness for nonoperative management.[31]

Pediatric patients are excellent candidates for nonoperative management as they have a low incidence of delayed bleeding after splenic injury.[32] As nonoperative management has become the standard of care in this population, there has been an increase in angioembolization with great success, as well.[33,34] Because of the trauma mechanisms suffered by pediatric patients as opposed to adult patients, children are more likely to have isolated splenic injuries. As previously noted, the relative thickness of the splenic capsule is greater in children which likely confers more structural integrity to the spleen. The spleen in children is also more likely to fracture parallel to the splenic arterial blood supply rather than transverse to it (Fig. 30-7).[35] This orientation of splenic injury tends to

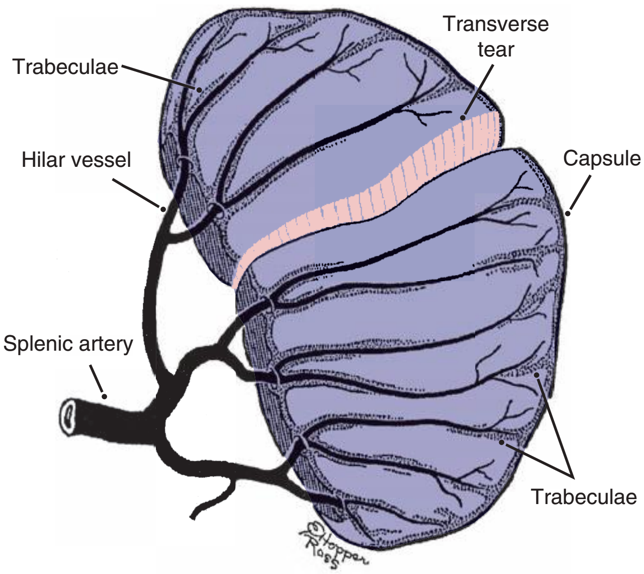

FIGURE 30-7 Diagrammatic representation of a transverse laceration relative to the splenic vasculature in a pediatric patient. (Reproduced with permission from Upadhyaya P. Splenic trauma in children. *Surg Gynecol Obstet*. 1968;126:781, Copyright © Elsevier.)

decrease the amount of blood loss from the splenic parenchyma. Children are more likely to have excellent physiologic reserve and minimal preexisting disease. Finally, the risks of splenectomy with respect to immunologic consequences are greater in young children than they are in adults.

Historically, older patients were thought to have a worse prognosis with respect to nonoperative management than did younger patients.[36] Other series examining the question of the threshold at 55 years of age and nonoperative management suggest the success of nonoperative management is no different in this group than it is in younger patients. In fact, there is an increasing body of evidence that being elderly is not a contraindication for nonoperative management, although the evidence in this area is still somewhat conflicting.[37]

The presence of severe associated injuries, particularly a traumatic brain injury, has been suggested as another relative contraindication to nonoperative management of a splenic injury. As previously mentioned, following the hematocrit in a patient with severe associated injuries can be problematic. Furthermore, the effects of ongoing or delayed splenic bleeding are felt to negatively impact the prognosis of a severe traumatic brain injury (see Chapter 19); however, a National Trauma Data Bank analysis actually demonstrated better outcomes with nonoperative management for patients with severe TBI.[38]

While these factors do not mandate operative intervention in all patients who fall into these groups, they should lower the threshold for operative intervention on an individual basis.

There is little uniformity about what constitutes a "failed" attempt at nonoperative management. Different surgeons and different institutions have set different criteria for operative intervention, and much of the decision making is subjective. As has already been pointed out, there is no perfect relationship between the severity of injury seen on CT scanning and a patient's subsequent success or failure of nonoperative management. Some of this discrepancy is probably related to the imperfect nature of the scoring systems and a lack of sensitivity of CT scanning. Also, it is likely that some of the differences are in the approach and thresholds for operative intervention. In some instances, concern about a "bad-looking" spleen on a CT scan might prompt more aggressive and quicker surgical intervention and make failed nonoperative management of severe splenic injuries a self-fulfilling prophecy.

As previously noted an objective finding on CT scan that has proven useful as a prognostic sign with respect to nonoperative management is that of a blush in the injured spleen (Fig. 30-4). Such a blush is thought to represent ongoing bleeding when it is seen shortly after injury and a pseudoaneurysm when seen on later scans. There is evidence that when such a finding is present, the chances of subsequent successful nonoperative management are decreased. A contrast blush seen on initial CT scan should be evaluated with angiography and treated with embolization if ongoing bleeding is present and the patient is normotensive (Fig. 30-8). A contrast blush is also associated with a higher need for operative intervention. This approach seems reasonable as angiography with splenic embolization has improved success rates in patients managed nonoperatively. The most dramatic improvement is seen in patients with higher-grade splenic injuries. Available data suggest an improvement in nonoperative success rates from 67 to 83% in grade IV injuries and from 25 to 83% in grade V injuries.[39] It is important to remember that only highly selected patients with high-grade splenic injuries should undergo angiographic embolization. While most trauma centers practice selective angiography and embolization, a somewhat more extreme approach is to have all patients with splenic injury, with or without a CT blush, undergo early angiography and embolization as necessary. Most centers do not treat splenic injury in this way because the number of nontherapeutic angiograms with such an approach would be extremely high.

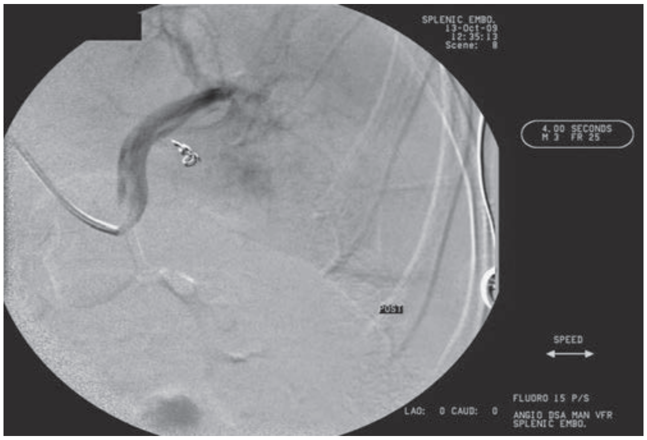

FIGURE 30-8 A postembolization view of a patient with a splenic injury and contrast blush on CT after angiographic coil embolization (same patient as in Fig. 30-4).

Patient Management

After nonoperative management has been selected, the initial resuscitation should be continued and other diagnostic and therapeutic procedures carried out as necessary. There is little scientific evidence to dictate the specifics of how nonoperative management of splenic injury should be done, and most recommendations are simply matters of common sense and opinion.[23] The most rigorous attempts to systematize recommendations for nonoperative management have been in children (Table 30-2).[40,41] Most patients should be admitted to an intensive care unit for their initial nonoperative management. This would include patients with grade II or above splenic injuries and patients with multiple associated injuries that make following serial hematocrit levels and physical examinations difficult. Even patients with grade I splenic injuries should be initially admitted to an intensive care unit if follow-up in a ward setting will be unreliable.

During initial management patients should be kept with nothing by mouth in case they require rapid operative intervention. Nasogastric suction is not necessary unless needed for other reasons. Whether patients should be kept at bed rest or not is somewhat controversial. Although there are some theoretical reasons why bed rest might be a good idea, there is little empirical evidence that it makes a difference. The individual surgeon should choose the approach that works best in his or her practice.

The patient's vital signs and urine output should be monitored closely, serial physical examinations performed, and serial hematocrits measured. As has been mentioned, changes in hematocrit can be influenced by bleeding from associated injuries as well as by bleeding from a splenic injury. This is important to take into account while following patients. As noted, many surgeons follow the practice of picking a specific hematocrit as a cutoff point below which they will not allow the patient to go without operative intervention. In fact, a multi-institutional trial demonstrated the blood transfusion during nonoperative management will actually increase mortality.[42]

Vaccines against encapsulated organisms, *Streptococcus*, meningococcus (*Neisseria meningitidis*), and *Hemophilus influenza* infections should be considered while the patient is observed nonoperatively. There are some theoretical reasons to believe that the vaccinations are more effective if given while the spleen is still in situ. Therefore, it may be beneficial to vaccinate patients who are managed nonoperatively early in their course rather than waiting to vaccinate them after they have required splenectomy. The evidence to support such a practice is contradictory, and it is very difficult to study the effectiveness of vaccination timing in splenectomized patients because the incidence of overwhelming postsplenectomy infection is extremely low.

TABLE 30-2: Proposed Guidelines for Resource Utilization in Children with Isolated Spleen or Liver Injury

	CT grade			
	I	II	III	IV
ICU stay (days)	None	None	None	1
Hospital stay (days)	2	3	4	5
Predischarge imaging	None	None	None	None
Postdischarge imaging	None	None	None	None
Activity restriction (weeks)[a]	3	4	5	6

[a]Return to full-contact, competitive sports (ie, football, wrestling, hockey, lacrosse, mountain climbing) should be at the discretion of the individual pediatric trauma surgeon. The proposed guidelines for return to unrestricted activity include "normal" age-appropriate activities.
From Stylianos S, the APSA Trauma Committee. Evidence-based guidelines for resource utilization in children with isolated spleen or liver injury. *J Pediatr Surg.* 2000;35:164–169, with permission, Copyright © Elsevier.

How long a patient should remain in the intensive care unit is not clearly defined. Most centers keep patients with splenic injury in the intensive care unit for 24–72 hours and then transfer them to a ward bed if they have been stable and other injuries permit. It is generally at this point that patients are allowed to eat unless other injuries preclude oral intake; however, many will feed patients earlier in the initial period of observation.

How long a patient should be kept in the hospital is poorly defined, also. There is no strong evidence supporting any particular approach, but a large multi-institutional study showed that most failures of nonoperative management occur within the first 6–8 days after injury.[42] Some institutions will keep patients in the hospital for an arbitrary length of time which may be up to one week. This approach has obvious financial and insurance implications, but will pick up most of the delayed bleeds while the patient is still an inpatient. Our institutional approach is to consider the grade of injury, associated injuries, and social situation of the patient to determine the length of hospital stay. How long to keep the patient depends to some extent on the nature of the splenic injury, also. Trivial injuries can be safely discharged earlier than more severe injuries. In many circumstances, associated injuries dictate the length of hospitalization more than does the splenic injury. Also, it is important to pay attention to where the patient lives and how close he or she will be to medical attention when deciding about timing of discharge. Patients who live far from medical attention may need to be kept in the hospital longer.

Prophylaxis against deep venous thrombosis (DVT) is a continuing problem in patients undergoing nonoperative management for a splenic injury. Sequential compression devices on the lower extremities should be used routinely. Early mobilization or range-of-motion exercises are important in minimizing thromboembolic complications, also. Pharmacologic prophylaxis is more problematic because of concerns about exacerbating bleeding from the injured spleen. After 24–48 hours of successful nonoperative management, it is reasonable to begin pharmacologic prophylaxis against deep venous thrombosis (DVT). If associated injuries require it, warfarin prophylaxis is also reasonable beginning approximately 1 week after injury. These recommendations are based primarily on common sense rather than on solid data; however, there are an increasing number of studies supporting the safe use of early DVT chemoprophylaxis in the nonoperative management of patients with blunt splenic injuries.[43,44] Both the rate of clinically significant thromboembolic events in patients with splenic injury and the rate of failure of nonoperative management in anticoagulated patients are quite low, making prospective study of the risks and benefits of anticoagulation prophylaxis in this patient population difficult.

The issue of follow-up CT scans in patients with nonoperative management of splenic injuries is controversial, also.[45,46] Most series indicate that they are not necessary or that the frequency with which they alter management is extremely low. A variety of different suggestions have been made in the literature about follow-up CT scans, ranging from no follow-ups at all to follow-ups at frequent intervals. A middle course is taken by some surgeons who only study the spleen with a follow-up CT scan when there is a high grade of injury or when they are contemplating allowing patients to return to contact sports or other activities. The author's institutional policy is to study only patients who have persistent abdominal signs and symptoms after a week of observation. On occasion such patients have developed pseudoaneurysms of the spleen, even if the initial CT scan did not demonstrate a blush. It is difficult to know exactly what the natural history of these pseudoaneurysms would be if left untreated, but they can be impressive in appearance and are amenable to angiographic embolization.

When patients are discharged, they should be counseled not to engage in contact sports or other activities where they might suffer a blow to the torso unless a follow-up CT scan has documented healing of the injured spleen. The best length of time to maintain this admonition is unknown, but typical recommendations range from 2 to 6 months. There is experimental evidence that most injured spleens have not recovered their normal integrity and strength until at least 6–8 weeks post-injury, so the recommendation to avoid contact sports for 2–6 months seems reasonable. Other than with respect to contact sports, there are no major restrictions for patients who have undergone successful nonoperative management.

OPERATIVE MANAGEMENT

In general, preoperative antibiotics should be given but do not need to be continued in the postoperative period unless dictated by associated injuries (see Chapter 18). A nasogastric tube is inserted to decrease the volume of the stomach and allow for easier visualization and mobilization of the spleen.

A midline incision is the best incision for splenic surgery as well as most trauma operations on the abdomen. It is versatile, can be extended easily both superiorly and inferiorly, and is the quickest incision if speed of intervention is important. For operations on an injured spleen, it may be necessary to extend the incision superiorly and to the left of the xiphoid process. This maneuver improves exposure of the left upper quadrant, particularly in obese patients and those with a narrow costal angle.

Transverse incisions in the left upper quadrant have occasionally been suggested for patients with a presumed isolated splenic injury. A midline incision is preferable because it is quicker and allows the surgeon to deal with a variety of different intra-abdominal findings. One situation in which a left subcostal approach may be the incision of choice is when the patient is morbidly obese and preoperative CT scanning has suggested that an isolated splenic injury is present or the patient has had a prior midline laparotomy concerning for a hostile abdomen.

As with all trauma laparotomies, it is important to rapidly examine all four quadrants of the abdomen in patients who are hemodynamically unstable. This initial investigation of the abdomen should not be definitive. It should only be used for rapid exploration and packing, especially of the upper quadrants. Definitive management of any injuries found should not be attempted until the entire abdomen has been inspected. While the quadrants are being inspected it is helpful to look for clot. Clotting tends to localize to the site of injury, whereas defibrinated blood will spread diffusely in the abdomen. Clotted blood will often indicate the site of an injury and is helpful in determining where to direct definitive management after the abdomen has been packed.

In patients who are thought to have an isolated splenic injury based on initial imaging or failed nonoperative management, direct attention can be turned sooner to the left upper quadrant. If viscera other than the spleen seem to be more badly injured and are bleeding more profusely than the spleen, the spleen should necessarily take second priority and be left packed until it is appropriate to attend to it. In comparison, a quick splenectomy is often a wise early move in a patient with multiple serious injuries in that it rapidly eliminates the spleen as a source of ongoing blood loss.

Once attention has been directed to the left upper quadrant, all the structures in that quadrant should be inspected (Fig. 30-2). There should be an initial look at the greater curvature of the stomach and the left hemidiaphragm. If the spleen is mobilized, the left hemidiaphragm should be reinspected. If the left hemidiaphragm is injured in a patient with blunt trauma and the spleen is in the left side of the chest, it should be pulled down into the abdomen through the defect. The left lobe of the liver and left kidney should also be inspected as should the tail of the pancreas. If the spleen is to be mobilized, inspection of the tail of the pancreas is easier after mobilization has been accomplished.

The anterior and anterolateral surfaces of the spleen can sometimes be seen fairly easily through the midline incision prior to any splenic mobilization, particularly if the patient is thin and there is a wide costal margin. If the patient is heavy and/or the costal margin is narrow, adequate inspection without some splenic mobilization may be very difficult. If the left upper quadrant is adequately inspected and there is no evidence of any bleeding or a splenic injury, the spleen does not require mobilization. If it is known that there is a small splenic injury, but it is not the primary reason for abdominal exploration or the spleen does not seem to be bleeding at the time of exploration, splenic mobilization is not always necessary. Mobilization of the spleen certainly provides better visualization of any injuries present, but is associated with the risk of worsening or "stirring up" the splenic injury. If the surgeon is in doubt about the need for mobilization, the best thing to do is to mobilize the spleen so that the full extent of injury is elucidated and the spleen can be repaired or removed as necessary. It is important to be as gentle as possible during mobilization of the spleen so that the splenic injury is not worsened.

Splenic mobilization should be done in a stepwise fashion to provide adequate mobilization while minimizing the chance of increasing injury. Proper mobilization allows for better visualization of the left kidney, the left hemidiaphragm, and the posterior aspects of the body and tail of the pancreas, also. The sequence of splenic mobilization is important in that it allows for splenic salvage and splenorrhaphy up until the final step of hilar ligation.

In mobilizing the spleen, it is important to remember how posteriorly it is situated (Fig. 30-2). Also, it is important to remember that there is a great deal of variability in the length of the different ligaments around the spleen and in how mobile the spleen is before any dissection is done. If mobilization is done correctly, even spleens with fairly short surrounding ligaments and spleens in obese patients can be mobilized to a level at or above the anterior abdominal wall.

The first step in mobilization of the spleen is to cut the splenophrenic and splenorenal ligaments laterally (Fig. 30-9). This step should be started with sharp dissection and can then be continued with a combination of blunt dissection and further sharp dissection. The dissection should be taken up to near the level of the esophageal hiatus so that all the lateral and superior attachments are cut. Cutting the lateral

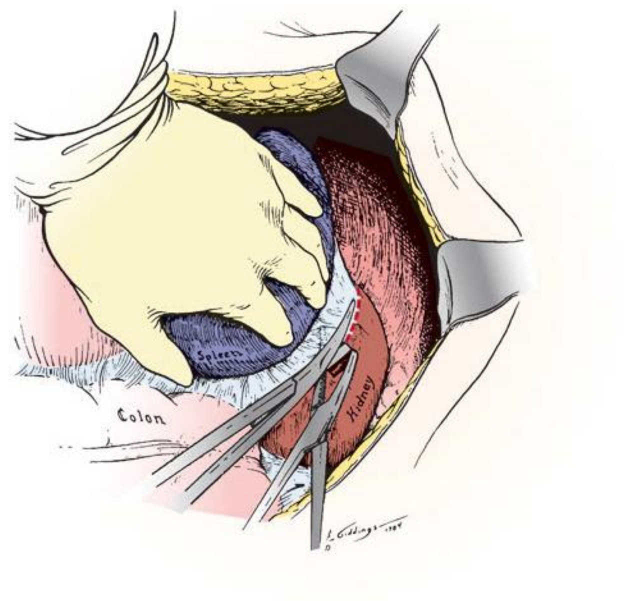

FIGURE 30-9 Mobilization of the spleen is begun by early division of its lateral attachments.

attachments is sometimes facilitated by putting a finger or clamp underneath them and then sharply developing the overlying plane. In obese patients and in those with a spleen that is very posterior, it may be necessary to do some of the dissection by feel.

After the lateral attachments have been divided, the next step is to mobilize the spleen and tail of the pancreas as a unit from lateral to medial. One of the easier ways to do this is to place the back of the fingernails of the right hand underneath the spleen and tail of the pancreas so that they are adjacent to the underlying left kidney. The kidney can be palpated easily because it is quite hard and provides an excellent landmark for the proper plane of dissection. A common error is to try to mobilize the spleen alone without the adjacent pancreas. Not mobilizing the pancreas with the spleen is easy to do if the surgeon is not posterior enough and is not in the plane between the tail of pancreas and kidney. If the tail of the pancreas is not mobilized with the spleen, the degree of splenic mobilization possible is much more limited and it is more difficult to avoid injury to the spleen.

Injuries can occur during mobilization of the spleen. The splenic hilum can be damaged from behind as the surgeon's fingers attempt mobilization from lateral to medial. The pancreas is more difficult to see if it is not mobilized with the spleen and can be damaged during hilar clamping if the spleen is to be removed. The pancreas is quite variable in length and requires varying degrees of mobilization. Conversely, if the pancreas is fairly long, a great deal of its body and tail will require mobilization in order to bring the spleen anteriorly and to the midline.

After the spleen and pancreas have been mobilized as a unit, it is generally apparent that the next constraining attachments of the spleen are the short gastric vessels. Because of the dual blood supply of the spleen through its hilum and through the short gastric vessels, it is possible to divide the short gastric vessels without compromising splenic viability. The best way to divide the short gastric vessels is to have an assistant elevate the spleen and tail of the pancreas into the operative field and then to securely clamp the vessels starting proximally on the greater curvature of the stomach. The short gastric vessels should always be clamped and tied. They can be small and difficult to see, and it is tempting to simply divide the loose tissue between the spleen and stomach with the scissors or electrocautery. This should not be done as the short gastric vessels can then bleed either immediately or on a delayed basis. It is not uncommon to be concerned about a clamp on the gastric portion of a short gastric vessel including a small portion of stomach. In such cases, the tie on the stomach can necrose the wall, leading to a delayed gastric leak. This concern can be addressed by oversewing the short gastric tie on the stomach side with a series of Lembert sutures in the seromuscular layer of the stomach.

The final step necessary for full mobilization of the spleen is division of the splenocolic ligament between the lower pole of the spleen and the distal transverse colon and splenic flexure. Obvious vessels in this ligament should be divided between clamps. During division of both the short gastric vessels and the splenocolic ligament, bleeding from the spleen can be controlled using digital compression of the hilum. If the patient is exsanguinating and the bleeding is massive, occasionally a clamp can be placed on the hilum during the later steps of mobilization. Mass clamping should only be done in extreme circumstances because it increases the chances of injury to the tail of the pancreas.

After the spleen has been fully mobilized, it is possible to inspect it in its entirety and to examine the posterior aspect of the body and tail of the pancreas, as well. It is helpful after mobilization to pack the splenic fossa to tamponade any minor bleeding and to help keep the spleen and distal pancreas elevated into the field. During this packing maneuver, the left adrenal gland can be inspected and the left hemidiaphragm reexamined.

Factors that figure into the decision about what to do with the injured spleen after mobilization include the degree of splenic injury, the overall condition of the patient, and the presence of any other intra-abdominal injuries. Obviously, if the spleen is not injured at all, it should be left in place. Similarly, if there is a trivial injury to the spleen and it is not bleeding, the spleen can be simply returned to the left upper quadrant and no further therapy is necessary. If there is a grade I injury of the spleen that is bleeding minimally or not bleeding at all, hemostatic agents can be used to stop the bleeding or prevent future bleeding. A variety of hemostatic agents are available, including microfibrillar collagen, gelatin sponge, and fibrin glue. Whichever agent is chosen, the bleeding from the spleen should have ceased by the time the patient is closed.

If the injury is more severe (grades II and III) and the patient's overall condition is not too serious, splenorrhaphy can be done.[47] Splenorrhaphy has become much less common with the increasing use of nonoperative management. Because we are no longer operating as much on the spleen, especially for lower grades of splenic injury, the number of splenic injuries found at surgical intervention that are amenable to splenorrhaphy has decreased along with experience with the techniques. The simplest version of splenorrhaphy has already been described earlier and is the placement of topical agents. Electrocautery of the spleen is only rarely helpful and has met with limited success, while argon beam coagulators may be helpful for hemostasis, especially of parenchyma that has been denuded of splenic capsule.[48,49] The spleen can also be sutured, especially when there is an intact capsule, but it does not hold sutures particularly well. Therefore, it is often necessary to use pledget materials to bolster the repair. Several different methods for suturing the spleen have been described, and use of monofilament or chromic suture has some advantages in that either is less likely to cause injury while being placed through the splenic parenchyma. The splenic parenchyma is fairly soft even in the presence of an intact capsule, and it is easy to cinch sutures so tightly that the parenchyma is further disrupted.

Partial splenectomy also has been described and is possible because of the segmental nature of the splenic blood supply. A pole or even half of the spleen can be removed, and the remaining spleen will survive provided that its hilar blood supply is left intact. One method of performing partial splenectomy is to ligate the blood supply to the damaged portion of the spleen and then observe the spleen for its demarcation into viable and nonviable portions. The damaged nonviable portion is removed, and the resultant cut splenic parenchyma is made hemostatic with the use of either mattress sutures or mesh wrapping.

Wrapping of either all or part of an injured spleen with absorbable mesh has been used on occasion, as well. This technique is moderately time consuming, but reported success rates are high because of careful patient selection. Such an approach should be reserved for highly selected cases of isolated splenic injury in extremely stable patients.

Splenectomy should be performed in patients who are unstable, have serious associated injuries, or have the higher grades of injury (grade IV or V). Bleeding from the splenic parenchyma can be temporarily controlled with digital pressure on the hilum while the spleen is being mobilized. As previously noted, mass clamping of the hilum should be reserved for profoundly hypotensive patients in that it increases the risk of damage to the adjacent tail of the pancreas. If the decision has been made to remove the spleen, this is best done with serial dissection and division of the hilar structures after mobilization. Suture ligation should be used for large vessels, and it is desirable to ligate major arterial and venous branches separately to avoid creation of an arteriovenous fistula. As mentioned in the section "Splenic Anatomy," a number of different splenic arterial and venous branches must be divided before removal of the spleen (Fig. 30-3). During the course of this dissection, it is common to encounter accessory spleens, in the hilum. If an accessory spleen is encountered, it should be left in place if possible.

A special circumstance is the patient who has failed nonoperative management. The majority of these patients undergo splenectomy rather than splenorrhaphy. One reason is that the spleen is somewhat softer after a period of nonoperative management than it was before injury, and both mobilization of the spleen and splenorrhaphy are more difficult. Also, it is likely that splenic injuries that have failed nonoperative management are worse than injuries that do not fail nonoperative management. Another important factor is that the surgeon operating on a spleen that has failed nonoperative management has already decided that the spleen is a problem and is psychologically prepared for splenectomy at the time of operation. The worst-case scenario for such a surgeon is to perform splenorrhaphy after nonoperative management and have it fail, in which case the patient would require yet another trip to the OR.

As has been mentioned earlier, it is helpful to pack the splenic bed during the latter stages of splenic mobilization and during splenectomy. After the spleen has been removed, the packs in the left upper quadrant should be removed and the splenic fossa reexamined. Inspection of the splenic fossa is facilitated by using a rolled-up laparotomy pad. The laparotomy pad is placed deep in the splenic fossa and then rolled by the surgeon's fingers up toward the cut vessels at the splenic hilum. During the course of this inspection, it is important to carefully visualize the splenic bed, stumps of the splenic vessels, and stumps of the short gastric vessels along the greater curvature of the stomach. This is because postoperative hemorrhage after splenectomy is most commonly related to bleeding from the cut ends of the short gastric vessels.

Autotransplantation of splenic tissue that has been removed is a controversial topic. Splenic tissue has a remarkable ability to survive in ectopic locations even without a clearly identifiable blood supply. Greater or lesser degrees of spontaneous splenosis after splenectomy for trauma are quite common, and patients with splenosis demonstrate some degree of splenic function after splenectomy.[50,51] The observation that accidentally seeded pieces of splenic tissue could survive and function led to the logical suggestion that portions of the spleen could be intentionally autotransplanted to ectopic sites after splenectomy. Several different methods for autotransplantation of the spleen have been described (Fig. 30-10).[10,11,52,53] One of the more common is to cut the spleen into pieces and place the pieces in omental pouches. Studies of autotransplantation in both animals and humans have demonstrated that some of the splenic tissue survives and has some level of function.[54,55] Whether or not enough of it survives without attachment to the splenic artery in an adequately functioning form to provide adequate protection against postsplenectomy sepsis is an open question.[56] Reports of overwhelming infection after autotransplantation suggest that autotransplantation is not universally successful in restoring normal immune function.[57]

Drains should not be routinely placed after either splenectomy or splenorrhaphy unless a coagulopathy is present as they may actually increase the rate of postoperative

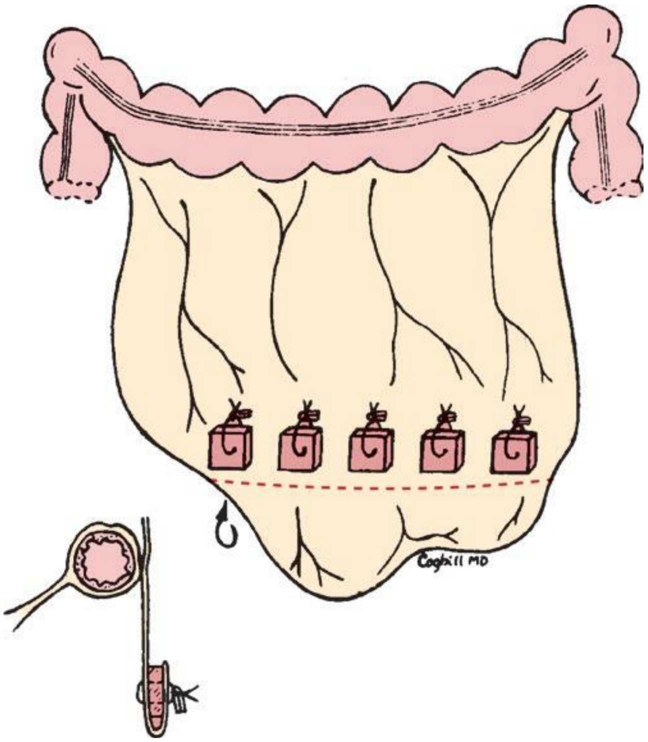

FIGURE 30-10 One described method for autotransplantation of splenic tissue is to place small pieces of the spleen into multiple pouches in the greater omentum. (Reproduced with permission from Millikan JS, Moore EE, Moore GE, et al. Alternatives to splenectomy in adults after trauma: repair, partial resection, and reimplantation of splenic tissue. *Am J Surg*. 1982;144:711, Copyright © Elsevier.)

complications. Drainage is reasonable if there is an associated pancreatic injury or associated renal injury if there is concern about a postoperative urine leak.

COMPLICATIONS

Nonoperative Management

The most common complication of nonoperative management of the spleen is continued bleeding. Many cases of the bleeding are probably just persistent bleeding that never stopped after the original injury. In these circumstances, there is hemodynamic instability or a progressive drop in hematocrit during the first 24–48 hours after injury. Although about 60–70% of the failures of nonoperative management occur early after admission, some occur on a delayed basis and approximately 10% occur more than 1 week after injury.[42]

Early failures of nonoperative management can be determined by closely following the patient's hemodynamic status, hematocrit, and physical examination. In many patients, a drop in hematocrit will be gradual and steady, but will ultimately dictate the need for surgical intervention. In other patients, especially those in whom the bleeding is delayed, bleeding can occur rather suddenly and be fairly dramatic. If an emergency operation is not performed in such cases, the patient is at risk for exsanguination. The pathophysiology of persistent bleeding after splenic injury and early failure of nonoperative management is fairly easy to understand. The pathophysiology of the more delayed bleeds is less obvious, and there are several hypotheses on why it occurs. One hypothesis is that as the blood in a subcapsular hematoma breaks down, increased osmotic forces pull water into the hematoma and expand the capsule. A similar pathophysiology has been described as an explanation for the increase in size of subdural hematomas. Another hypothesis for delayed bleeding from a splenic injury is the concept of "remodeling" of the clot in the splenic parenchyma. This hypothesis is based on the observation that the clot undergoes revision and degradation over time. It is possible that as this remodeling process occurs, the initial hemostasis of the splenic injury is lost. The observation that splenic injury can result in intraparenchymal pseudoaneurysms raises the possibility that delayed bleeding could be the result of rupture of a pseudoaneurysm, also. Finally, it is simply possible that the damaged spleen, highly vulnerable to further injury, suffers what would otherwise be a minor second blow and starts to bleed again. The "failure" rate for nonoperative management varies from surgeon to surgeon and from institution to institution. The variability of these rates is due in part to the lack of a standardized definition of failure. Some surgeons and institutions have a low threshold for operative intervention after an attempt at nonoperative management, and some have a very high threshold. Interestingly, when studied prospectively with specific definitions for who will be initially managed nonoperatively and who will be deemed a failure of nonoperative management, the success rate for nonoperative management is considerably lower than that seen in retrospective studies.[14] When nonoperative management has failed and the patient requires operative intervention, splenectomy is most often the appropriate operation unless there is minimal concern about subsequent bleeding.[42]

Another potential complication of nonoperative management of splenic injuries is that an associated intra-abdominal injury that requires operative intervention will be missed.[58-60] This is most commonly a problem for missed injuries of the bowel and pancreas. Injury to the small bowel is particularly troublesome, as often free fluid is the only finding of blunt intestinal injury seen on CT of the abdomen. When splenic injury is present, it is easy to attribute the free fluid to bleeding from the spleen. If patients are good candidates for nonoperative management of their splenic injury, it is possible to miss the bowel injury and delay needed abdominal exploration. Pancreatic injuries are occasionally missed on initial CT scanning done shortly after injury and can result in serious morbidity or even mortality if not treated in an expeditious fashion (see Chapter 32). The proximity of the tail of the pancreas to the spleen makes the combination of injuries to the two organs a possibility. There is a 5–10% frequency of serious associated injuries being missed in patients who are good candidates for nonoperative management of the splenic injury, but this should decrease with improved CT technology. Repeated physical examinations, DPL, measurement of pancreatic enzymes, and repeat abdominal CT scanning are all helpful in minimizing the number of missed injuries to the small bowel and pancreas (see Chapters 31 and 32).

Failure of nonoperative management is not without negative consequences. In a recent multicenter study, approximately 13% of the patients who failed nonoperative management died, with most of the deaths related to either hemorrhage from the injured spleen or a missed injury. A significant number of the cases of failed nonoperative management could be traced to an inappropriate initial decision to proceed with nonoperative management in hemodynamically unstable patients and/or when there was misinterpretation of the diagnostic imaging studies.[42] A possible way of minimizing complications after nonoperative management is to obtain follow-up CT scans of the abdomen. A number of series have pointed out that the yield from such CT scans is extremely low and the patient can simply be followed clinically. If a follow-up CT is obtained, the most commonly discovered pathology is a pseudoaneurysm, which is amenable to angiographic embolization (Figs. 30-4 and 30-8). The natural history of such pseudoaneurysms seen on a delayed basis is not known, but, as an extension of what is known about blushes and pseudoaneurysms seen in the early postinjury period, there is reason to be concerned about an increased risk of bleeding in such patients. Splenic cysts and abscesses are other pathologic entities sometimes seen on a follow-up CT scan.[42,61] Cysts may not be apparent until a number of months after injury and are at risk for rupture with further trauma. Finally, routine CT scans done several months after injury are indicated for patients who desire to return to contact sports or some other activity that would put the spleen at risk.

There are no other abdominal complications specific to nonoperative management of the spleen, but intrathoracic complications can occur. Associated pleural sympathetic effusions may result from blood and clot beneath the left hemidiaphragm, while a hemothorax may be caused by bleeding from associated fractured ribs.

Deep venous thrombosis in the lower extremity is another potential complication after nonoperative management of a splenic injury because prophylaxis is usually delayed as previously described. Of interest, there is no firm evidence that the rate of thromboembolic complications is higher in patients with nonoperative management of a splenic injury. When a patient with a splenic injury develops a deep venous thrombosis or pulmonary embolism, it can be difficult to decide what to do. Anticoagulation of the patient puts the injured spleen at risk, while placement of a caval filter is invasive and expensive. Such patients should be managed on a case-by-case basis. Fortunately, these cases are rare in that most clinically obvious thromboembolic problems will not manifest themselves until after the major risk of bleeding from the injured spleen has passed.

Although angioembolization has been utilized to diagnose and control splenic bleeds since the 1960s, the earliest report of angioembolization to control bleeding specifically for traumatic injury was in in 1981.[62] The increased use of selective angioembolization has led to recognition of a number of complications unique to this modality. Life-threatening complications include contrast-induced nephropathy, splenic infarction, and splenic abscess. Minor complications include groin hematoma or infection, coil migration, and reactive left pleural effusions. When comparing angioembolization proximal or distal to the main splenic trunk, distal embolizations have a higher incidence of complications. Although it appears that the overall rate is low, there is still much to be learned about complications from angioembolization.[63,64]

Patients who are managed nonoperatively often receive blood products secondary to the splenic injury or because of associated injuries. There are well-known risks associated with transfusion (see Chapter 13). These include the risk of blood incompatibility, transmission of blood-borne diseases such as hepatitis, and the significant immunologic effects of transfusion, especially in critically ill and injured patients.[65-67]

Operative Management

There is a risk of bleeding after splenectomy from the short gastric vessels or splenic bed and after splenorrhaphy from the splenic parenchyma. As after any operative procedure, it is important to closely follow the patient and to reexplore if postoperative bleeding is suspected. Patients with multiple associated injuries and a coagulopathy generally should have undergone splenectomy rather than splenorrhaphy. In these patients, the coagulopathy will be treated, but the possibility of surgical bleeding in the postoperative period should always be entertained when the patient has hemodynamic instability. In patients who have undergone splenorrhaphy, the risk of continued bleeding from the repaired spleen is only 2%.

Gastric distention is a risk, and gastric decompression is reasonable for a short period of time after either splenectomy or splenorrhaphy. Theoretically, when the short gastric vessels have been cut and ligated, gastric distention can result in loss of a tie on the gastric end of a vessel with resultant hemorrhage. Even though this danger may be more theoretical than real, a short period of gastric decompression is probably reasonable.

As previously noted, necrosis of a portion of the greater curvature of the stomach has been described, most commonly related to inclusion of a portion of the gastric wall in the ties placed on the gastric side of the cut short gastric vessels. The resultant gastric leak contaminates the abdomen, in particular the left upper quadrant, and can lead to the formation of a subphrenic abscess.

Pancreatic injuries can be related either to the original trauma or to an iatrogenic injury during mobilization or removal of the spleen. A pancreatic injury will cause an increase in pancreatic enzymes, an ileus, and a generalized inflammatory state. The diagnosis is made from a combination of clinical and CT findings.

The rare complication of an arteriovenous fistula in the ligated vessels in the hilum of the spleen has also been described as a risk of splenectomy. The best way to avoid such a complication is the aforementioned technique of ligating as many of the hilar vessels as possible and to avoid mass ligation of the hilar structures.

There is some evidence that the long-term risk of thrombotic events is increased after splenectomy for trauma.[68,69] Clinically significant thrombocytosis, however, is still less common after a splenectomy for trauma than it is after a splenectomy for other diseases. As previously noted, appropriately timed prophylaxis should be a standard measure in all injured patients and should cover the risks associated with the transient postsplenectomy thrombocytosis.

There is some evidence that early postoperative complications are more common after splenectomy than they are in patients who do not have their spleens removed.[70,71] Evidence is conflicting, however, and a difficulty in reviewing the literature on the subject is that it is hard to standardize the severity of injury in patients who have undergone splenectomy as compared to patients who have not undergone splenectomy. Some of the series that have suggested an increased risk of complications after splenectomy have noted that such patients were more severely injured than those who did not undergo a splenectomy.

OVERWHELMING POSTSPLENECTOMY INFECTION

The first experimental evidence supporting the possibility that the spleen is of immunologic importance dates to 1919; however, splenectomy remained the treatment of choice for both iatrogenic and traumatic splenic injuries until just several decades ago.[72] In the early 1950s, it was noticed that neonates and young children (up to 6 months of age) with hematologic diseases who required a splenectomy had a high subsequent risk of serious infection.[5] It became clear that an asplenic state in neonates and young children with hematologic diseases was a risk factor for overwhelming infection. From this observation, it was a logical next step to investigate the risk of overwhelming infection in both children and adults who had undergone splenectomy for trauma.[68,73–75] Several studies suggested that the rate of overwhelming infection after splenectomy is increased when compared with a control population of patients who have not had their spleens removed. The actual rate at which overwhelming infection in asplenic patients occurs is unknown. One estimate is a 0.026 lifetime risk for adults and a 0.052 lifetime risk for children, but all the estimates of risk tend to be very low.[42] Not all studies have documented an increased risk of overwhelming life-threatening infection after splenectomy. One single institution study reviewed 18 years of splenectomy patients and identified no incidents of overwhelming postsplenectomy infection.[76] Therefore, the clinically significant risk is very low and probably does not merit much consideration when considering the most appropriate treatment of an adult patient with a splenic injury.

When infection does occur in the asplenic state, encapsulated organisms such as pneumococcus and meningococcus are the most common pathogens and pneumonia and meningitis are the most common infections. Because of the inference that overwhelming infection is more common after splenectomy, vaccines to prevent infection by pneumococcus, meningococcus, or *Haemophilus* organisms are recommended for splenectomized patients. There is empirical evidence in both animals and humans that the use of vaccines results in an antibody response; however, because the incidence of overwhelming infection after splenectomy is very low, it is difficult to prove that the vaccines actually have an impact on postsplenectomy infection and mortality. Nonetheless, they have become the standard of care in patients who have had a splenectomy. In patients who have undergone splenectomy, the exact timing of vaccination is somewhat controversial.[77–79] As with the question of the overall effectiveness of vaccines in preventing postsplenectomy infection, study of the optimal timing of vaccination is hampered by its low incidence. The most important principle of vaccination after splenectomy is to remember to perform it before discharge from the hospital in patients who are unlikely to return for postoperative follow-up. Whether or not patients should be revaccinated and when such revaccinations should be done remain open questions. One recommendation based on longitudinal antibody studies in a general group of patients (not just trauma postsplenectomy patients) is for revaccination every 6 years.

Another measure that has been suggested for postsplenectomy patients is the continuous administration of antibiotics or the provision of a supply of antibiotics to be taken at the first sign of infection. When such measures have been tried, studies of patients' compliance with the antibiotic regimen have been discouraging.[80] The exact role of antibiotics in postsplenectomy patients is difficult to ascertain for the same reason that the effectiveness of the vaccines is difficult to prove.

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