ANNALS OF SURGERY
Vol. 227, No. 5, 708–719

Changing Patterns in the Management of Splenic Trauma

The Impact of Nonoperative Management

H. L. Pachter, MD, A. A. Guth, MD, S. R. Hofstetter, MD, and F. C. Spencer, MD

From the Department of Surgery, New York University School of Medicine, and the Bellevue Hospital Center Trauma and Shock Unit, New York City, New York

Objective
The recognition that splenectomy renders patients susceptible to lifelong risks of septic complications has led to routine attempts at splenic conservation after trauma. In 1990, the authors reported that over an 11-year study period involving 193 patients, splenorrhaphy was the most common splenic salvage method (66% overall) noted, with nonoperative management employed in only 13% of blunt splenic injuries. This report describes changing patterns of therapy in 190 consecutive patients with splenic injuries seen during a subsequent 6-year period (1990 to 1996). An algorithmic approach for patient management and pitfalls to be avoided to ensure safe nonoperative management are detailed.

Methods
Nonoperative management criteria included hemodynamic stability and computed tomographic examination without shattered spleen or other injuries requiring celiotomy.

Results
Of 190 consecutive patients, 102 (54%) were managed nonoperatively: 96 (65%) of 147 patients with blunt splenic injuries, which included 15 patients with intrinsic splenic pathology, and 6 hemodynamically stable patients with isolated stab wounds (24% of all splenic stab wounds). Fifty-six patients underwent splenectomy (29%) and 32 splenorrhaphy (17%). The mean transfusion requirement was 6 units for splenectomy survivors and 0.8 units for nonoperative therapy (85% received no transfusions). Fifteen of the 16 major infectious complications that occurred followed splenectomy. Two patients failed nonoperative therapy (2%) and underwent splenectomy, and one patient required splenectomy after partial splenic resection. There no missed enteric injuries in patients managed nonoperatively. The overall mortality rate was 5.2%, with no deaths following nonoperative management.

Conclusions
Nonoperative management of blunt splenic injuries has replaced splenorrhaphy as the most common method of splenic conservation. The criteria have been extended to include patients previously excluded from this form of therapy. As a result, 65% of all blunt splenic injuries and select stab wounds can be managed with minimal transfusions, morbidity, or mortality, with a success rate of 98%. Splenectomy, when necessary, continues to be associated with excessive transfusion and an inordinately high postoperative sepsis rate.

Splenic preservation has been firmly established as the preferred treatment modality for both blunt and penetrating injuries whenever deemed safe and feasible.[1–3] The risk of lifelong susceptibility to infectious complications after splenectomy, especially the rare but highly fatal syndrome of overwhelming postsplenectomy sepsis in adult patients,[4–6] was the major impetus toward splenic salvage procedures. This concept was reflected in data previously reported in a series of 193 consecutive splenic injuries managed over an 11-year period at the authors' institution.[1] In that series, splenic injuries were predominantly managed by splenorrhaphy (58%), less often by splenectomy (29%), and least often by nonoperative management (13%). Moreover, operative intervention with splenorrhaphy was the most prev-

Presented at the 109th Annual Meeting of the Southern Surgical Association, November 30 to December 3, 1997, The Homestead, Hot Springs, Virginia.
Address reprint requests to H. L. Pachter, MD, NYU Medical Center, Department of Surgery, 530 First Ave., Suite 6C, New York, NY 10016.
Accepted for publication December 1997.

alent method of achieving splenic conservation (81%), despite documentation that the overwhelming majority of the patients (76%) sustained blunt trauma, theoretically amenable to nonoperative treatment. The fact that so few patients were managed nonoperatively was due to the fear of delayed bleeding, as well as the uncertainty of missing associated intra-abdominal injuries.

Cumulative experiences with nonoperative management of splenic injuries, however, began to accrue, supported by data confirming both its safety and effectiveness. Accordingly, the indications for nonoperative therapy were gradually extended to include patients previously treated by celiotomy.

This report describes the changing patterns of managing splenic injuries seen at the authors' institution since 1978. The authors compare management strategies and results in 190 consecutive patients with splenic injuries treated from 1990 to 1996 with a previously reported cohort of 193 patients treated between 1978 and 1989.[1] Based on this experience, the authors outline an algorithmic approach to patients with splenic injuries and delineate the pitfalls to be avoided if nonoperative management is to be successful.

MATERIALS AND METHODS

Since 1978, all patients with splenic injuries admitted to the Bellevue Hospital Center Trauma and Shock Unit, a level I trauma center in New York City, have been prospectively evaluated with the intent of splenic salvage whenever possible. This report describes the prospective management of 190 consecutive adult patients with splenic injuries treated between 1990 and 1996 and compares these results with those previously reported from the same institution.[1]

Penetrating Splenic Injuries

All patients with gunshot wounds to the abdomen or those with stab wounds who were hemodynamically unstable underwent immediate celiotomy after appropriate resuscitation. Splenic repair by splenorrhaphy or partial splenectomy was always attempted if three criteria were met: hemodynamic stability, lack of multiple associated injuries mandating expeditious splenectomy, and injuries less extensive than a shattered or devascularized spleen. A different approach was taken in patients with anterior abdominal, flank, or back stab wounds who were hemodynamically stable. Patients with anterior abdominal stab wounds underwent emergency room tractotomy under local anesthesia; if peritoneal penetration was found, a celiotomy was performed. Patients with stab wounds to the flank or back were further evaluated by double-contrast and when possible triple-contrast computed tomographic (CT) scanning. If an isolated splenic laceration was detected without evidence of further hemorrhage, the patient was treated nonoperatively (Fig. 1).

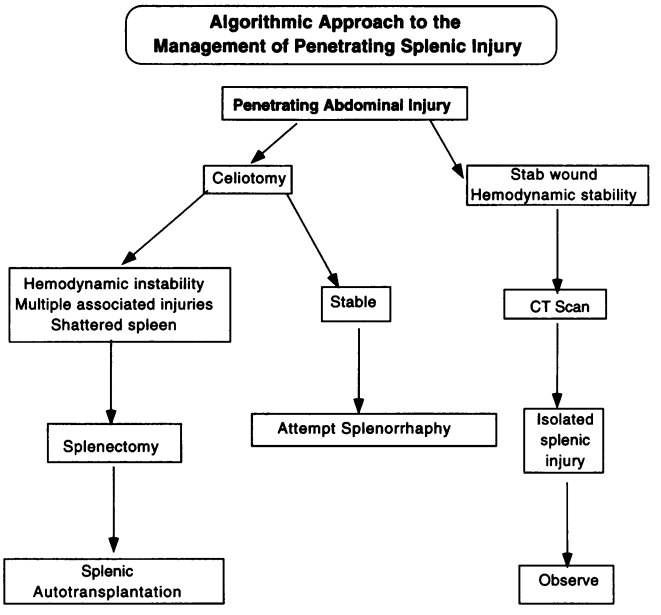

Figure 1. Algorithmic approach to the management of penetrating splenic injury.

Blunt Splenic Injuries

Patients who sustained blunt trauma to the abdomen or lower thorax and were hemodynamically stable were evaluated by CT scanning of the abdomen and pelvis if a high index of suspicion for splenic injury was present. CT scanning was accomplished using oral and intravenous contrast and currently is performed using a helical scanner (GE High-Speed Advantage CT/I, GE Medical Systems, Milwaukee, WI) at 10-mm intervals. If an injury is detected, 5-mm cuts through the injury are then performed to delineate the anatomic relation of the injury to the hilar vessels. CT scans are immediately reviewed with the radiology staff. Splenic injuries were graded I to V using the American Association for the Surgery of Trauma (AAST) organ injury scale (Table 1).

Criteria for nonoperative management included hemodynamic stability, absence of other intraabdominal injuries detected on CT scan requiring celiotomy, and limited need for splenic-related transfusion ($\leq$ 2 units). Nonoperative treatment was continued in patients with higher transfusion requirements only if it could be established that these additional transfusions were necessitated by associated injuries. Repeat CT scanning was most effective in this regard. If the injury had either improved or remained stable, the source of bleeding could be categorized as "nonsplenic-related" (Fig. 2). Patients who demonstrated any degree of hemodynamic instability or required further transfusion because of the splenic injury were immediately taken to the operating room. During surgery, the decision to perform splenectomy or to attempt splenic repair was based primarily on the severity of associated injuries and the intraoperative stability of the patient.

Certain patients were considered for nonoperative treat-

Table 1. SPLENIC INJURY SCALE*

Grade†	Injury	Injury Description	ICD-9	AIS-90
I	Hematoma	Subcapsular, <10% surface area	865.01	2
			865.11	
	Laceration	Capsular tear, <1 cm deep parenchymal tear	865.02	2
			865.122	
II	Hematoma	Subcapsular, 10–50% surface area, intraparenchymal <5 cm in diameter	865.01	2
			865.11	
	Laceration	1–3 cm parenchymal depth not involving trabecular vessel	865.02	
			865.12	
III	Hematoma	Subcapsular, >50% surface area or expanding; ruptured subcapsular or parenchymal hematoma Intraparenchymal hematoma >5 cm or expanding		3
	Laceration	>3 cm parenchymal depth or involving trabecular vessels	865.03	3
			865.13	
IV	Laceration	Laceration involving segmental or hilar vessel producing major devascularization (>25% of spleen)		4
V	Laceration	Completely shattered spleen	865.04	5
			865.14	
	Vascular	Hilar injury which devascularizes spleen		5

* Organ Injury Scaling Committee of the American Association for the Surgery of Trauma (1994 revision).
† Advance one grade for multiple injuries, up to grade III.

ment who in previous years would have been routinely operated on. These included patients with known preexisting pathologic spleens resulting from conditions such as human immunodeficiency virus infection (HIV), sickle-cell hemoglobinopathies, infectious mononucleosis, or leukemia; patients with either extraabdominal injuries requiring surgical therapy or with neurologic injuries or impaired consciousness (drugs or alcohol); patients with more complex splenic injuries (more grade III and some grade IV).

Candidates for nonoperative management were placed on bed rest in a monitored setting for 3 to 5 days. Follow-up CT scans were routinely performed 1 week after injury in the first 3 years of the study; currently, CT scans are performed

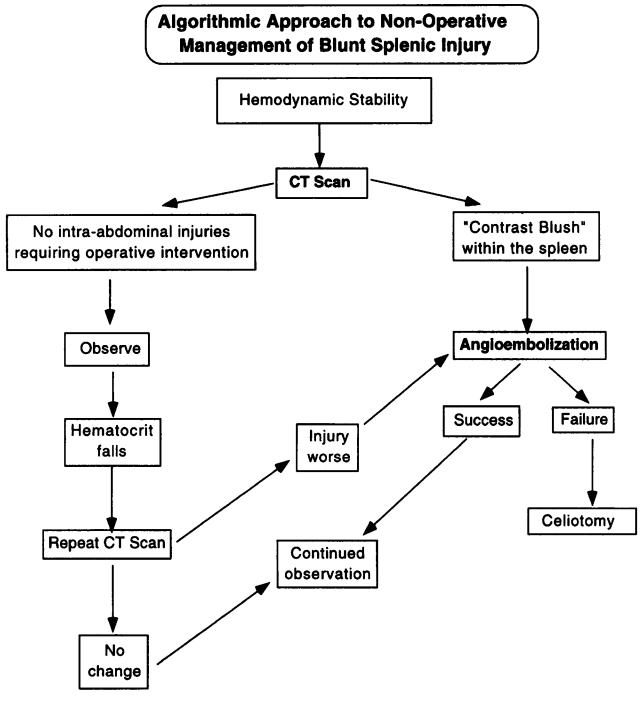

Figure 2. Algorithmic approach to nonoperative management of blunt splenic injury.

primarily for clinical indications. Patients with grades III or IV injuries who seek to resume contact sports were routinely scanned to ensure complete resolution of the injury and absence of splenic pseudocyst formation.

RESULTS

During a 6-year period ending November 1996, 190 consecutive adult patients sustaining splenic injuries were treated (Table 2). The ages ranged from 17 to 93 years with a mean age of 35. There were 136 men (72%) and 54 (28%) women. The mean injury severity score (ISS) for all surviving patients was 14.8 (range, 4 to 34). Among the different treatment groups, there was considerable variation in the ISS. The mean ISS was 17.5 (range, 9 to 34) in patients undergoing splenectomy, 12.8 (range, 4 to 25) in splenorrhaphy; 13 (range, 9 to 16) in nonoperative management (isolated splenic injury); and 18.2 (range, 13 to 34) in nonoperative management (multiple injuries). Among the

Table 2. MECHANISM OF INJURY AND MANAGEMENT

Injury	Patients (n)	Splenectomy	Splenic Repair	Nonoperated
Blunt	147	38	13	96
Gunshot wound	18	13	5	—
Stab wound	25	5	14	6
Total	190	56	32	102

Table 3. NONOPERATIVE MANAGEMENT OF SPLENIC TRAUMA: DISTRIBUTION OF CASES

Category	Number (%) of Patients
Pathologic spleen	
HIV	11
Acute leukemia	2
Mononucleosis	1
Sickle cell disease	1
Stab wounds	6
Subtotal	21 (21)
Blunt trauma (all other)	81 (79)
Total	102 (100)

10 patients who died (9 of whom underwent splenectomy), the mean ISS was 35.2 (range, 25 to 50), more than double the average score of 14.8 among surviving patients.

Associated Injuries

All of the nine patients who died after splenectomy had multiple associated injuries (mean of 3.8 per patient). In contrast, among the patients who survived after splenectomy, 64% had associated injuries, but the mean number of injuries per patient (2.5) was lower. Similarly, patients undergoing splenic repair also sustained a significant number of associated injuries (60%), but the mean number of associated injuries per patient was 1.5. Among the patients managed nonoperatively, 76% had no associated injuries. In the remaining patients (24%), the number of associated injuries averaged 1.6.

Nonoperative Management

One hundred two patients were treated nonoperatively: 96 (65%) of the 147 patients with blunt injuries (Figs. 3 and 4) and 6 patients with isolated stab wounds (Table 3). The AAST splenic organ injury scale was the only criterion used for assessing grade of injury.[7] Fourteen patients (14%) were classified as having grade I injury, 53 (53%) grade II, 30 (29%) grade III, 4 (4%) grade IV, and 1 (1%) grade V.

Fifteen (16%) of the 96 patients with blunt injuries had preexisting splenic pathology from a variety of diseases, which included sickle-cell disease, HIV, leukemia, and infectious mononucleosis. Seventy-eight patients (76%) sustained isolated splenic injuries, whereas in 24 (24%), multiple additional injuries were present as well.

Failure of Nonoperative Management

Nonoperative therapy failed in 2 of the 96 patients (2%) with blunt injuries to the spleen and they required splenectomy, 1 for acute bleeding 9 days after a grade IV injury and the other 6 days after a grade V injury. None of the six patients with isolated stab wounds to the spleen failed nonoperative management.

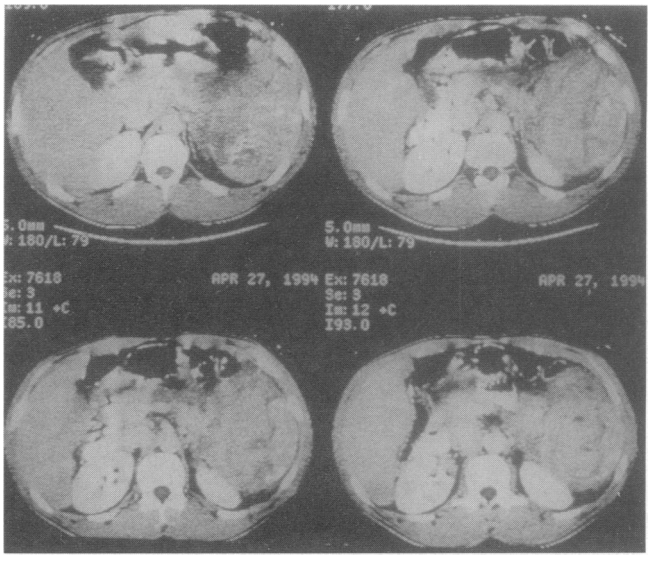

Figure 3. This 34-year-old white HIV-positive man was severely beaten and sustained a grade IV splenic injury. He was hemodynamically stable and was managed nonoperatively.

Retrospectively, failure of nonoperative management could have been predicted in each of these instances. One patient was noted to have an arterial blush on his original CT scan with an injury into the splenic hilum (Fig. 5). The second patient had a centrally shattered spleen with surrounding hematoma (grade IV) (Fig. 6). In both of these instances, the initial hemodynamic stability lulled the treating physicians into attempting nonoperative management.

Splenorrhaphy or Partial Splenectomy

Thirty-two patients underwent splenic repair, 25 by suture splenorrhaphy and 7 by partial splenectomy. Patients

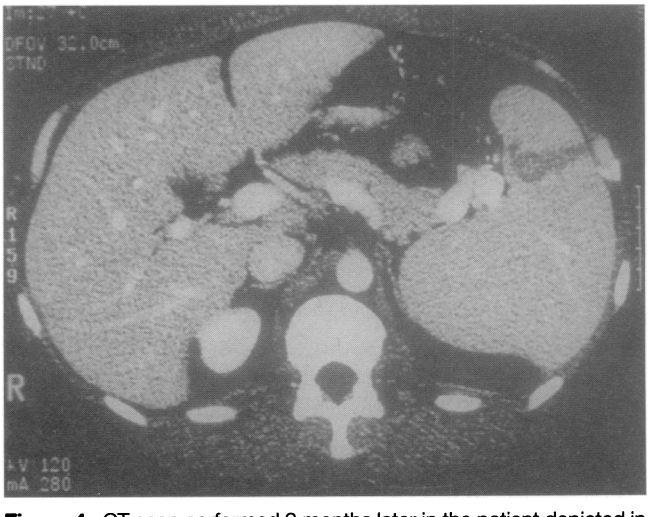

Figure 4. CT scan performed 3 months later in the patient depicted in Figure 3. The injury is almost completely healed.

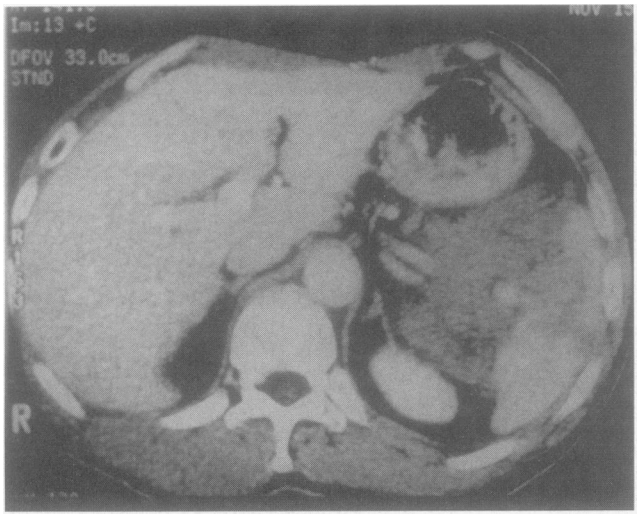

Figure 5. This 28-year-old man was involved in a high-speed motor vehicle accident in which he was unbelted. A grade IV injury to the splenic hilum with a contrast blush is noted. The patient's hemodynamic stability led to nonoperative management. On postobservation day 9, he became hypotensive with a distended abdomen. He underwent urgent celiotomy and splenectomy.

treated by cautery or a variety of hemostatic agents alone were excluded. Techniques of both splenic repair and partial splenectomy have been extensively described in several previous publications.[1,2,8] One crucial point regarding intraoperative splenic salvage merits emphasis: the success of either splenorrhaphy or partial splenectomy is critically dependent on full mobilization of the spleen into the wound. This maneuver often requires dividing one or two of the short gastric vessels, combined with gentle dissection posteriorly, so that the capsule is not torn in the mobilization process.

Of the 32 patients whose spleens were salvaged by intraoperative techniques, only 2 (6%) were performed over the last 12 months. One patient (3%) in the entire group failed operative repair. This patient exhibited signs of ongoing bleeding in the recovery room, necessitating reoperation and completion splenectomy after an initial partial splenic resection for a blunt injury.

Splenectomy

Fifty-six of the 190 patients (29%) required splenectomy. Forty (71%) of these were done for either hemodynamic instability or multiple associated injuries. In each of these instances, the injury to the spleen itself did not preclude repair, but rather the patient's precarious condition mandated expeditious splenectomy. In the remaining 16 patients, splenectomy was necessitated by injuries that were not amenable to either suture splenorrhaphy or partial splenectomy.

Five hemodynamically stable patients (9%) underwent splenic autotransplantation after splenectomy. The removed spleen was autotransplanted in the manner suggested by Moore et al.[9] This consisted of dicing the removed spleen into five 40 × 40 × 3-mm cubes, which were then implanted into an omental envelope. The envelope was then marked by silver clips for future imaging techniques. None of the five patients, however, could be contacted to arrange for follow-up studies. All patients in both the splenectomy group and those who underwent splenic autotransplantation were immunized with polyvalent pneumococcal vaccine (Pneumovax) before discharge.

Transfusion Requirements

Eighty-seven patients (85%) undergoing nonoperative management of splenic injuries did not require transfusion. The mean transfusion requirement rate for the entire 102 patients undergoing nonoperative management was 0.8 units (range, 0 to 5). One HIV-positive patient violated protocol and received 5 units of packed red blood cells.

Patients demonstrating hemodynamic instability or those with multiple associated injuries undergoing urgent splenectomy required the greatest number of transfusions. Patients treated by splenectomy who died represented a subgroup with the largest transfusion requirements (range, 8 to 36 units; mean, 28 units). Those treated by splenectomy who survived required a mean of 6 units (range, 0 to 25), whereas patients managed by splenorrhaphy required a mean of 2.8 units (range, 0 to 18).

Postoperative Infectious Complications

Infectious complications occurred in 16 of 180 surviving patients (9%). Patients surviving splenectomy accounted for

Figure 6. This 42-year-old man sustained an baseball-bat injury to the left upper quadrant. CT scan revealed a shattered central portion of the spleen with a significant perisplenic hematoma. He was managed nonoperatively but became hemodynamically unstable on postobservation day 6 and required emergency celiotomy and splenectomy.

Table 4. INFECTIOUS COMPLICATIONS

Treatment	Number of Patients	Complications	
		Number of Patients	Site of Infection
Nonoperative	102	0	—
Repair (survivors)	31	1	Extremity soft tissue infection
Splenectomy (survivors)	47	5	Pneumonia
		2	Abdominal wound infection
		3	Subphrenic abscess
		2	Extremity soft tissue infection
		2	Intra-abdominal abscess
		1	Urosepsis
Total	180	16	

94% (n = 15) of all the infectious complications incurred in this series. Postoperative pneumonia was the most common infectious complication (n = 5), followed by left subphrenic abscess (n = 3) and intraabdominal abscess (n = 2). Subphrenic abscesses occurred in two patients after multiple associated hollow viscus injuries and in another who underwent a concomitant distal pancreatectomy. The two other intraabdominal abscesses were associated with multiple hollow and solid organ injuries in one case and colonic injury in the other.

Only 1 infection developed among the 31 patients who underwent splenic repair and survived. No infections occurred in any of the 100 patients who successfully completed nonoperative therapy or in the 2 who failed nonoperative therapy and subsequently went on to splenectomy (Table 4).

Mortality

There were 10 deaths (5.2%) in the study group. The nine deaths (90%) that followed splenectomy occurred either in the operating room or recovery room and were due to multiple severe associated injuries: seven (78%) of these patients exsanguinated, one succumbed to a severe brain injury, and the final patient's course was complicated by acute respiratory distress syndrome and pulmonary failure. The single death that followed splenorrhaphy occurred in a patient who sustained a severe blunt cardiac injury.

DISCUSSION

Over the past 2 decades, major changes have occurred in the treatment of injuries of the spleen. These changes evolved based on the concept that splenectomy renders patients at lifelong risk for increased susceptibility to infections.[1–3,10] The most serious of these infections is the syndrome of overwhelming postsplenectomy infection, which occurs rarely (0.5%)[4–6] in adults subjected to splenectomy but carries a prohibitive mortality in unvaccinated patients. For these reasons, a trend away from splenectomy and toward splenic conservation has emerged.[1–3,10]

Attempts at splenic preservation began in the authors' institution 17 years ago. Initial experiences with 193 consecutive splenic injuries treated over an 11-year period has previously been reported.[1] Seventy-one percent of those patients avoided splenectomy, with a splenic salvage success rate of 98%. The most prevalent form of splenic salvage in these patients was intraoperative suture splenorrhaphy or partial splenectomy (58%) and less frequently nonoperative management (13%). The infrequent use of nonoperative management merely reflected the prevalent thinking of the time that this approach was applicable to only 15% to 20% of all blunt adult splenic injuries.[11–13]

In the current report, however, the authors' experience with an additional 190 consecutive patients with splenic injuries over a 6-year period indicates that nonoperative therapy has been used with increasing frequency. Since 1990, this has been a national trend: >1000 documented adult patients with blunt splenic injuries have been managed nonoperatively with a cumulative success rate >90%.[1,14–17] Several factors have been responsible for the rise in the number of patients with splenic injuries managed nonoperatively both in the current series and those reported by others.[14–17] The original rigid criteria for nonoperative treatment have been modified and expanded as experience with this treatment modality has increased. As a result, patients who in the past would have been excluded now meet the criteria for nonoperative management. For example, patients with neurologic injuries or those under the influence of drugs or alcohol were previously excluded from nonoperative management, primarily because of the inability to detect signs of peritoneal irritation clinically during the observation period. However, Archer et al.[18] documented that there were no significant differences in morbidity, mortality, failure of treatment, or missed visceral injuries in comparable groups of patients with or without neurologic injuries managed nonoperatively. Also contributing to the increased number of patients qualifying for nonoperative management is the routine inclusion of patients with complex splenic injuries (grade III), those with intraperitoneal blood assessed as >250 cc, and a recently identified cohort of patients with underlying diseases affecting the spleen who in the past would have never been considered for nonoperative management. These patients were managed nonoperatively based on experience gained from the nonoperative management of nonpathologic spleen injuries.[19]

The authors hypothesized that because blunt trauma to the spleen, the most common injury lending itself to nonoperative management, accounts for the overwhelming ma-

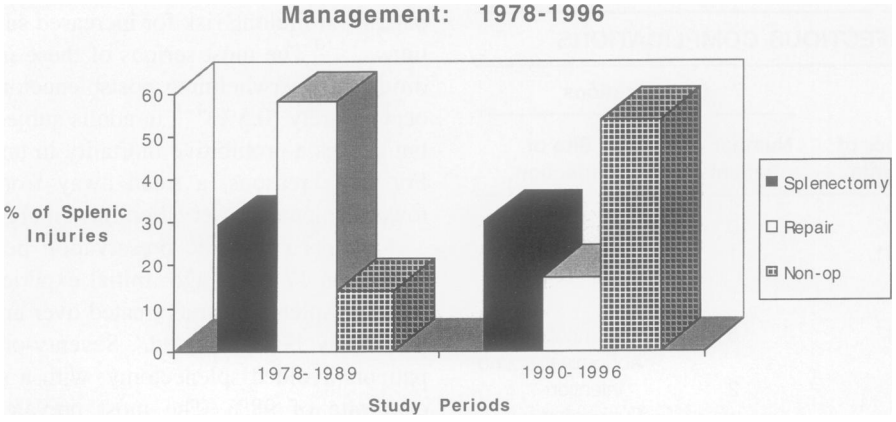

Figure 7. Management of splenic injuries, 1978 to 1996.

jority of splenic injuries and because of advances in radiographic imaging technology, expanded criteria for patient inclusion, and an increasing data base attesting to the success of nonoperative management, this form of treatment would supplant operative splenorrhaphy as the most prevalent form of splenic conservation. The authors compared the patterns of management in their earlier study (1978 to 1989)[1] to those used from 1990 to 1996 (Fig. 7). Although the overall incidence of achieving splenic conservation was 71% in each period, the method of achieving splenic conservation underwent a remarkable metamorphosis from the initial to the present report. In this study, nonoperative management was used in 54% of splenic injuries, as opposed to only 13% in the previous study. Splenorrhaphy, the most common splenic conservation procedure in the past (58%), accounted for only 17% of patients in the present study, with only 2 performed over the last 12 months. Moreover, of the 147 patients sustaining blunt injuries, 65% (n = 96) were managed nonoperatively.

Two specific subgroups of patients who in the past would have incontrovertibly undergone splenectomy now represent 21% of all patients managed nonoperatively (see Table 3). The first group includes 15 unique patients who sustained blunt injuries to their intrinsically diseased spleens. Most of these patients were HIV positive, with splenomegaly.[20] In the past, the only safe treatment for a ruptured diseased spleen was splenectomy. The basis for this approach was the scientifically unproved belief that an injured, enlarged, and intrinsically diseased spleen was incapable of undergoing either spontaneous hemostasis or healing. In this series, however, nonoperative management was employed based on a number of important considerations. Foremost was the extrapolation of the authors' extensive experience in managing hemodynamically stable patients with blunt splenic injuries nonoperatively to patients with ruptured diseased spleens. The authors were also prompted to pursue a nonoperative course in these patients based on the theoretical presumption that these immunocompromised patients would be more prone to postsplenectomy infection than the general population.[21,22] The second group consisted of six select hemodynamically stable patients with isolated stab wounds to the spleen. Although only six patients with stab wounds were managed nonoperatively, they nevertheless accounted for 21% of the management strategy of all stab wounds in this series.

It was surprising that the frequency of splenectomy remained virtually unchanged at 29% (n = 56) in each study period. Intuitively, the authors expected that because fewer patients underwent celiotomy, coupled with their extensive experience with splenic repair, the rate of splenectomy would decrease. The fact that the splenectomy rate remained unchanged probably reflects the data suggesting that patients undergoing splenectomy in this series were more seriously injured than those in the previous report. In this series, 71% of the patients underwent splenectomy because of hemodynamic instability or multiple associated injuries, as opposed to only 36% in the previous report. In each instance, splenic repair was technically feasible but was precluded by the patient's overall status.

Two recent reports corroborate the results of this study that nonoperative management of blunt splenic injury has come to represent the most prevalent method of splenic preservation. Hunt et al.,[17] in a statewide analysis of 2258 patients over a 5-year period, found that the nonoperative management rate increased from 33.9% to 46.3%, with a success rate of 94%. Unlike the present series, however, Hunt noted that the splenectomy rate decreased from 52.9% to 43.4% while the splenorrhaphy rate remained unchanged at 10%. Clancy et al.,[23] in an evaluation of splenic injuries seen in all trauma centers in North Carolina during a 6-year period, accrued 1255 patients. Overall, splenic preservation rates increased to 52%, with 40% of patients managed nonoperatively and 12% by splenorrhaphy. The splenic salvage rate of <70% may reflect the fact that the data gathered in both of these series emanated from a retrospective analysis of a statewide discharge data base involving several institutions and numerous physicians, whose approaches may indicate either institutional or personal preferences. In a recent review of one institution's 30-year experience with splenic injuries over three distinct time

periods, Morrell et al.[24] reported an increase in both splenorrhaphy and nonoperative management. In contrast to the current series and those of most others, Morrell noted that despite achieving a splenic salvage rate of 61% during the last 10 years, splenectomy still was the most common method of managing splenic injuries (38.8%), as compared to 30.6% each for splenorrhaphy and nonoperative management. An increase in splenic salvage rates (splenorrhaphy and nonoperative management) has also been reported by others[16,25,26] and varies from 51% to the 71% reported in this series. In each instance, however, and in contrast to the report by Morell, nonoperative management, as in this series (54%), has become the dominant treatment modality, with splenorrhaphy rates rarely exceeding 20%.

The current enthusiasm for nonoperative management of blunt splenic injuries stems predominantly from the recognition of three critical factors that were realized in the present study. First, this form of treatment can be undertaken with minimal transfusion requirements[1,16] (mean of 0.8 units in this series); in contrast, splenectomy requires the greatest number of transfusions (mean of 17 units), followed by splenorrhaphy (mean of 2.8 units). This was noted by other authors as well.[25–29] Second, missed intraabdominal injuries occur infrequently (rate of 1%29 to 2.5%[26]). There were none in the current series or in the series reported by Schurr et al.[27] Third, nonoperative treatment carries a uniformly high success rate—98% in the present series and 90% to 97% in other series.[15–17,25] However, Godley et al.[30] and Powell et al.[26] cite success rates of only 52% and 84%, respectively.

Godley cautioned that age >55 was a contraindication to the nonoperative management of blunt splenic injuries: 10 of his 11 patients in this age group failed nonoperative management. Of the 17 patients in the current study who were older than 55, none failed nonoperative treatment. The claim that age >55 is a contraindication to nonoperative management cannot be supported, at least on the basis of the data in the current report.

Three other variables recently identified by Powell directly correlate with the failure of nonoperative management in adult patients: the degree of hemoperitoneum, ISS >15, and AAST grade of Injury >III. We could find no correlation with either the degree of hemoperitoneum or ISS >15 as predictors of failure of nonoperative management. A large hemoperitoneum, defined by Powell as "additional blood in the pelvis," was a frequent finding in this study and was not an accurate yardstick for failure of nonoperative management. In contrast to the 88% failure rate of nonoperative management of patients with ISS >15 reported by Powell, 20 of our patients had an ISS >15; 2 failed nonoperative management and 18 (90%) were successfully observed. Moreover, Schurr et al.[27] reported than 30 of the 89 patients managed nonoperatively in that series had an ISS >30. Of these patients, 80% went on to successful nonoperative management.

With regard to Powell's contention that AAST grade of splenic injury >III is a poor prognostic indicator for nonoperative management, it would seem to negate previous reports that CT findings cannot be used with sufficient reliability to detect which patients may be managed nonoperatively, as even patients with grades I and II injuries may fail nonoperative management.[31] Although both of our nonoperative failures occurred in patients with complex splenic injuries, one with a grade IV injury and the other with a grade V injury, three other patients with grade IV injuries were successfully managed. It is unknown how many patients with complex splenic injuries (grades IV and V) can be managed nonoperatively. With the exception of Sclafani et al.,[14] who salvaged 84% of the 17 grade IV injuries managed nonoperatively in that series, the small number of patients within this classification (n = 4) in the current series and others precludes the authors from reaching any firm conclusions regarding this issue. Suffice it to say that CT grading of injury, in and of itself, is insufficient to predict the success or failure of nonoperative management.

The most significant prognostic indicator of failure of nonoperative management in hemodynamically stable patients appears to be the presence of extravasation of contrast material ("contrast blush") on the initial or subsequent CT scan. The finding of a contrast blush suggests active hemorrhage within the splenic parenchyma; the natural history of this condition is unpredictable and can vary from self-tamponade to sudden rapid hemodynamic instability. In one of the two failures in the current series, extravasation of contrast was noted (see Fig. 5); however, the relevance of this finding was not recognized and no therapeutic action was undertaken until tachycardia, a falling hemoglobin, and hemodynamic instability set in. Schurr et al.[27] postulated that the failure rates of nonoperative therapy may be related to the failure to appreciate the significance of finding extravasation of contrast material on CT scanning. Of the 89 patients managed nonoperatively in that study, 12 (13%) failed observational treatment. Of these 12 patients, 67% (n = 8) were retrospectively noted to have a "hyperdense collection of contrast media in the splenic parenchyma." Seven of these patients went on to splenectomy, which might have been avoided had the significance of the contrast blush been initially appreciated and the patients managed by immediate angiography and embolization, as outlined by Sclafani et al.[14]

Powell et al.[26] recently reported that of 293 adult patients with blunt splenic injuries, 43% underwent celiotomy based on either degree of hemoperitoneum, grade of splenic injury (IV or V), or the presence of contrast blush on initial CT scanning. Of the 28 patients with the finding of a contrast blush on the initial CT scan, 26 required operative intervention (24 immediately; 2 after failure of nonoperative management). One wonders how many of these patients could have avoided operative intervention if they had been initially subjected to angioembolization. The authors have no experience with angioembolization for splenic injuries but have used this approach for years in patients sustaining

blunt hepatic injuries.[32] That experience, as well as the data provided by Schurr et al.,[27] Gavant et al.,[33] and Davis et al.,[34] has led the authors to include this very significant treatment modality in the armamentarium of managing splenic injuries nonoperatively (see Fig. 2). Angioembolization may very well be responsible for higher splenic salvage rates in the future while avoiding the complications of splenectomy.[14,27,33,34]

Follow-up CT scanning was once an integral part of the authors' algorithmic approach to managing patients with blunt splenic injuries nonoperatively. On review, however, most scans performed failed to show any progression of the injury and thus became virtually superfluous. Two recent studies have reached the same conclusion, that routine follow-up CT scanning for patients with blunt splenic injuries being managed nonoperatively is unnecessary if patients remain clinically stable.[35,36] Repeat CT scanning is currently limited to very specific circumstances. The most common of these is when a change in the patient's clinical status occurs during the observational period. CT scanning provides information as to whether patients require angioembolization or immediate operative intervention or whether a nonsplenic source is responsible for the change in clinical state.

Repeat CT scanning is also an invaluable guide in determining which patients can safely return to contact sports after sustaining blunt splenic injuries. Splenic injuries that heal by secondary intention (nonoperative management) have been shown experimentally to have a wound breaking strength (the physiologic index of wound healing) equal to that of a normal spleen at 6 weeks postinjury.[37,38] It has been the authors' policy to have patients who want to participate in contact sports undergo repeat CT scanning at 8 weeks postinjury to ensure complete resolution of the injury and that a splenic pseudocyst, although rare, has not developed.

CONCLUSIONS

Nonoperative management has become the most common method of managing blunt splenic injuries in hemodynamically stable adult patients. The criteria for nonoperative management have been extended to include certain subgroups of patients previously excluded from this form of therapy. These subgroups, all hemodynamically stable, include patients who are neurologically impaired, those with intrinsic splenic pathology and splenomegaly, and those with isolated stab wounds to the spleen. The latter two groups now account for nearly 25% of all the patients the authors manage nonoperatively. The vast majority of patients managed in this manner have been classified as having AAST grade I to III injuries. The current data would suggest that at least 65% of all patients with blunt splenic injuries can be treated nonoperatively, with a success rate of >95%. This remarkably high success rate was achieved with a negligible morbidity and no mortality or missed associated intraperitoneal or retroperitoneal injuries. Splenectomy, most often performed because of the patient's precarious intraoperative state, is associated with excessive transfusion requirements and a prohibitively high postoperative sepsis rate.

References

1. Pachter HL, Spencer FC, Hofstetter SR, et al. Experience with selective operative and nonoperative treatment of splenic injuries in 193 patients. Ann Surg 1990; 211:583–591.
2. Feliciano DV, Spjut-Patrinely V, Burch JM, et al. Splenorrhaphy: the alternative. Ann Surg 1990; 211:569–582.
3. Malangoni MA, Cue JI, Fallat ME, et al. Evaluation of splenic injury by computed tomography and its impact on treatment. Ann Surg 1990; 211:592–599.
4. DiCataldo A, Duleo S, LiDestri G, et al. Splenic trauma and overwhelming postsplenectomy infection. Br J Surg 1987; 74:343–345.
5. Cullingford GL, Watkins DN, Watts ADJ, Mallon DF. Severe late postsplenectomy infection. Br J Surg 1991; 78:716–721.
6. Lynch AM, Kapila R. Overwhelming postsplenectomy infection. Infect Dis Clin North Am 1996; 10:693–707.
7. Moore EE, Cogbill TH, Jurkovitch GJ, et al. Organ injury scaling: spleen and liver (1994 revision). J Trauma 1995; 38:323–326.
8. Bannon MP. Operative splenic trauma management. Trauma Q 1996; 12:315–338.
9. Moore FA, Moore EE, Moore GE, Millikan JS. Risk of splenic salvage after trauma. Analysis of 200 adults. Am J Surg 1984; 148:800–805.
10. Pachter HL, Hofstetter SR, Spencer FC. Evolving concepts in splenic surgery—splenorrhaphy *versus* splenectomy and postsplenectomy drainage: experience in 105 patients. Ann Surg 1981; 194:262–269.
11. Cogbill TH, Moore EE, Jurkovich GJ, et al. Nonoperative management of blunt splenic trauma: a multicenter experience. J Trauma 1989; 29:1313–1317.
12. Elmore JR, Clark DE, Isler RJ, Horner WR. Selective nonoperative management of blunt splenic trauma in adults. Arch Surg 1989; 124:581–586.
13. Longo WE, Baker CC, McMillon MA, et al. Nonoperative management of adult splenic trauma. Ann Surg 1989; 210:626–629.
14. Sclafani SJA, Shaftan GW, Scalea TM, et al. Nonoperative salvage of computed tomography-diagnosed splenic injuries: utilization of angiography for triage and embolization for hemostasis. J Trauma 1995; 39:818–827.
15. Wasvary H, Howells G, Villalba M, et al. Nonoperative management of adult blunt splenic trauma: a 15-year experience. Am Surgeon 1997; 63:694–699.
16. Smith JS Jr, Cooney RN, Mucha P Jr. Nonoperative management of the ruptured spleen: a revalidation of criteria. Surgery 1996; 120:745–750.
17. Hunt JP, Lentz CW, Cairns BA, et al. Management and outcome of splenic injury: results of a 5-year statewide population-based study. Am Surg 1996; 62:911–917.
18. Archer LP, Rogers FB, Shackford SR. Selective nonoperative management of liver and spleen injuries in neurologically impaired adult patients. Arch Surg 1996; 131:309–315.
19. Guth AA, Pachter HL, Jacobowitz GR. Rupture of the pathologic spleen: is there a role for nonoperative therapy? J Trauma 1996; 41:214–218.
20. Odom JW, D'Amore TF, Meo MA, et al. Splenectomy for minor trauma in patients with HIV infections. Injury 1991; 22:85–86.
21. Malmaeus J, Akre T, Adami HO, et al. Early postoperative course following elective splenectomy in hematologic diseases: a high complication rate in patients with myeloproliferative disease. Br J Surg 1986; 73:720–723.

22. Johansson T, Bostrom H, Sjodahl R, et al. Splenectomy for hematologic disease. Acta Chir Scand 1990; 156:83–86.
23. Clancy TV, Ramshaw DG, Maxwell JG, et al. Management outcomes in splenic injury: a statewide trauma center review. Ann Surg 1997; 226:17–24.
24. Morrell DG, Chang FC, Helmer SD. Changing trends in the management of splenic injury. Am J Surg 1995; 170:686–690.
25. Garber BG, Yelle JD, Fairfull-Smith R, et al. Management of splenic injuries in a Canadian trauma centre. Can J Surg 1996; 39:474–480.
26. Powell M, Courcoulas A, Gardner M, et al. Management of blunt splenic trauma: significant differences between adults and children. Surgery 1997; 122:654–660.
27. Schurr MJ, Fabian TC, Gavant M, et al. Management of blunt splenic trauma: computed tomographic contrast blush predicts failure of nonoperative management. J Trauma 1995; 39:507–513.
28. Javolec LM, Boe BS, Wyffels PL. The advantages of early operation with splenorrhaphy *versus* nonoperative management for the blunt splenic trauma patient. Am Surg 1993; 59:698–704.
29. Bonds SJ, Eichelberger MR, Gotschall CS, et al. Nonoperative management of blunt hepatic and splenic injury in children. Ann Surg 1996; 223:286–289.
30. Godley CD, Warren RL, Sheridan RL, McCabe CJ. Nonoperative management of blunt splenic injury in adults: age over 55 years as powerful indicator of failure. J Am Coll Surg 1996; 183:133–139.
31. Becker CD, Spring P, Glattli A, Schweizer W. Blunt splenic trauma in adults: can CT findings be used to determine the need for surgery? AJR 1994; 162:343–347.
32. Pachter HL, Knudson MM, Esrig B, et al. Status of nonoperative management of blunt hepatic injuries in 1995: a multicenter experience with 404 patients. J Trauma 1996; 40:31–38.
33. Gavant ML, Schurr M, Flick PA, et al. Predicting clinical outcome of blunt splenic injury: using CT to reveal abnormalities of splenic vasculature. AJR 1997; 168:207–212.
34. Davis KA, Fabian TC, Croce MA, et al. Improved success in nonoperative management of blunt splenic trauma: embolization of splenic artery pseudoaneurysm. Presented at the 57th Annual Meeting of the American Association for the Surgery of Trauma, Waikola, Hawaii, Sept. 24–27, 1997.
35. Allins A, Ho T, Nguyen TH, et al. Limited value of routine follow-up CT scans in nonoperative management of blunt liver and splenic injuries. Am Surg 1996; 62:883–886.
36. Lawson DE, Jacobson JA, Spizarny DL, et al. Splenic trauma: value of follow-up CT. Radiology 1995; 194:97–100.
37. Dulchavsky SA, Lucas CE, Ledgerwood AM, Grabow D. Wound healing of the injured spleen with and without splenorrhaphy. J Trauma 1987; 27:1155–1160.
38. Raafat AM, Dulchavsky SA. Splenic wound healing following injury. Trauma Q 1996; 12:305–308.

Discussion

DR. MARK A. MALANGONI (Cleveland, Ohio): Thank you, Dr. Nunn, Dr. Copeland, Members, and Guests. Our recent review of experience that is a similar period of time and a similar number of patients as Dr. Spencer and Dr. Pachter really come to same conclusions, and I think the key here is preservation of the spleen, either by operative or nonoperative means.

I note that the failure of most of the patients in our series were adults that had grade III and IV injuries, and I saw, as Dr. Spencer pointed out, that there was a real paucity of these patients in the nonoperatively managed group in the Bellevue series.

The other problem we found has been failures in patients who have co-existing injuries to the liver and the mesentery that are discovered at operation. And these patients, amazingly, at least at our center, present in stable condition, and so we choose to manage them nonoperatively because of the small degree of injury to their spleen. And they do turn out to need operations so we count those as failures.

The last observation I would make is that we have begun to use selective splenic artery embolization to improve our nonoperative salvage rate and have found in a small number of patients it does allow us to save these patients from operation without increasing their morbidity, but this is a very highly selective group. And I would add that our 77% overall salvage rate in managing splenic injuries is very similar to yours.

I'd like to ask the authors three questions. The first is, do you use splenic artery embolization in these patients? The second, can you provide us with some degree of injury severity scoring for this patient group? It's our experience and that of other institutions that infection following any type of injury is related to the overall degree of injury rather than to the degree of injury to a particular organ.

And, lastly, if you were faced with a patient who you found initially stable but had a CT scan that showed a grade IV injury and a large hemoperitoneum, would you take that patient to the operating room to attempt potential splenic salvage or manage that stable patient without operation?

Thank you for the opportunity to discuss the paper. [Applause]

DR. J. DAVID RICHARDSON (Louisville, Kentucky): We certainly agree about the use of nonoperative management, and their data were virtually identical to ours. I think the contrary point that I might make—and I realize this is a very old-fashioned, almost neolithic kind of approach—but I believe that the use of splenorrhaphy in adults has been greatly oversold through the years, while splenic salvage works very well in experienced hands, particularly in trauma centers where there is a cast of thousands, including residents, multiple attendings, trauma fellows, et cetera, who can review the patient frequently. I think we have created a mindset around the country that it's wrong to do anything else, and I think that's potentially dangerous in nontrauma centers, particularly if the solo practitioner in a rural community happened to blunder or stumble onto a ruptured spleen. It seems to me that perhaps the best he or she could do for that would be to remove it.

I think we should be very careful in looking at this paper and attributing any of the infectious complications to anything that has to do with immunology. For sure, if you review the manuscript, all of these patients who had infection — there were three subphrenics, two intraabdominal abscesses — all of them had either a hollow viscous or pancreatic injury, as I read the manuscript, so I don't think it's surprising that they might have in fact had an infection.

We have seen two cases that might have had — and I emphasize might have had — postsplenectomy overwhelming infections in the past 10 years at the University of Louisville. In a large trauma center, we see two or three patients a year, particularly who are transferred in from outlying institutions, who I think would have been greatly served by a simple straightforward extirpation of the spleen. So, I guess I'll close by saying it is all right to do a splenectomy, particularly in this age when most of those patients who can be treated by splenorrhaphy are probably going to be managed nonoperatively. Thank you.

DR. L. D. BRITT (Norfolk, Virginia): I want to commend the authors. Dr. Pachter and Dr. Spencer continue to lead the way as far as operable management of solid organ injuries. There is no