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Management Outcomes in Splenic Injury

A Statewide Trauma Center Review

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Objective
Clinical pathways now highlight both observation and operation as acceptable initial therapeutic options for the management of patients with splenic injury. The purpose of this study was to evaluate treatment trends for splenic injury in all North Carolina trauma centers over a 6-year period.

Methods
Splenic injuries in adults over a 6-year period (January 1988–December 1993) were identified in the North Carolina Trauma Registry using ICD-9-CM codes. Patients were divided into four groups by method of management: 1) no spleen operation, 2) splenectomy, 3) definitive splenorrhaphy, and 4) splenorrhaphy failure followed by splenectomy. The authors examined age, mechanism of injury, admitting blood pressure, and severity of injury by trauma score and injury severity score.

Summary Background Data
Comparisons were made between adult (17–64 years of age) and geriatric (older than 65 years of age) patients and between patients with blunt and penetrating injury. Resource utilization (length of stay, hospital charges) and outcome (mortality) were compared.

Results
One thousand two hundred fifty-five patients were identified with splenic injury. Rate of splenic preservation increased over time and was achieved in more than 50% of patients through nonoperative management (40%) and splenorrhaphy (12%). Splenorrhaphy was not used commonly in either blunt or penetrating injury. Overall mortality was 13%. Geriatric patients had a higher mortality and resource utilization regardless of their mechanism of injury or method of management.

Conclusions

Nonoperative management represents the prevailing method of splenic preservation in both the adult and geriatric population in North Carolina trauma center hospitals. Satisfactory outcomes and economic advantages accompany nonoperative management in this adult population.

During the past decade, major changes have occurred in the management of splenic injury. The availability of computerized axial tomography (CT), heightened concern over transfusion risks, and improving methods for monitoring patients who are critically ill has influenced the surgeon's approach to solid organ injury. Recognition of the spleen as an important component of the immune system has prompted surgeons to consider splenic preservation rather than uniformly proceeding to splenectomy, formerly the preferred method for management of splenic injury.

Present-day algorithms delineating the initial management of splenic injury now highlight both observation and operation as acceptable initial therapeutic options in patients who are appropriately selected.[1,2] A variety of operative techniques for salvaging injured spleens have been described, and splenorrhaphy is an accepted alternative to splenectomy when clinically feasible.[3,4] Although clinical criteria for selecting nonoperative management remain controversial, splenectomy appears to be increasingly reserved for the conditions of hemodynamic instability or anatomic injury beyond repair.[1,2]

Our purpose was to describe demographic information, methods of diagnosis, injury severity, and outcome among adult patients with splenic trauma and to compare methods of management longitudinally over a 6-year interval in all designated trauma centers within a single state.

METHODS

A retrospective study of splenic injury over a 6-year period was conducted using the North Carolina Trauma Registry. Three level II trauma centers (New Hanover Regional Medical Center, Wilmington; Wake Medical Center, Raleigh; Moses Cone Hospital, Greensboro) and five level I trauma centers (Carolinas Medical Center, Charlotte; University Hospital Medical Center of Eastern Carolina, Greenville; Baptist Hospital of the Bowman–Gray School of Medicine, Winston–Salem; UNC Hospitals at Chapel Hill and Duke University Medical Center, Durham) all contribute data quarterly to the North Carolina Trauma Registry. All trauma patients age 17 and older admitted between January 1988 and December 1993 were reviewed. Criteria for entry into the state registry include hospital admission for at least 24 hours and all trauma deaths occurring in the emergency department or within the first 24 hours of admission. Patients with splenic injury were identified using the ICD-9-CM code 865 (865.01–865.14). Splenic operations were identified by using the ICD-9-CM procedure codes 41.5 (splenectomy) and 41.95 (splenorrhaphy). For analysis, patients were divided into four groups based on management method: 1) no spleen operation (**NO**), 2) splenectomy (**SP**), 3) splenorrhaphy (**SPOR**), and 4) initial splenorrhaphy later requiring splenectomy (**SPOR/SP**). The frequency of unsuccessful nonoperative management could not be determined because the North Carolina Trauma Registry does not incorporate date of surgery as an available data point with which to compare the date of admission.

We examined age, gender, race, mechanism of injury, admitting blood pressure, mean trauma score (TS), and injury severity score (ISS). Abbreviated injury scores for the head and neck region (AISHN) were evaluated in the mortality group to determine the potential impact of brain injury. The ISSs were computer-derived from the ICD codes using the technique described by MacKenzie.[5] Shock was defined as a systolic blood pressure $\leq$90 mmHg on admission to the trauma center. We studied the frequency with which CT and diagnostic peritoneal lavage were used in establishing diagnoses. Resource utilization was measured by evaluating hospital length of stay and hospital charges. Mortality rates were used as an index of clinical outcome. Two subsets of patients were studied and compared separately: blunt *versus* penetrating and adult age (range, 17–64 years) *versus* geriatric (age older than 65 years). Differences in proportions were examined using the chi square test, and differences in means were examined using the Students's t test. Methodologic limitations inherent in the statewide trauma registry include the potential for misclassification bias arising from ICD-9-CM coding errors.

RESULTS

Twenty-two thousand four hundred eighty-eight patients were entered into the statewide trauma registry during the 6-year study period. Splenic injuries were identified in 1255 patients 17 years of age and older, or 5.6%

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Table 1. TREATMENT METHODS USED FOR SPLENIC INJURY

Treatment Method	N	%	
Spleen preserved	649		52
No spleen operation (NO)	499	40	
Splenorrhaphy (SPOR)	150*	12*	
Spleen not preserved	606		48
Splenectomy (SP)	596	47	
Splenorrhaphy requiring splenectomy (SPOR/SP)	10*	1*	
Total	1255	100	100

* It is a limitation of the study that SPOR, either alone or with SP, is probably underreported.

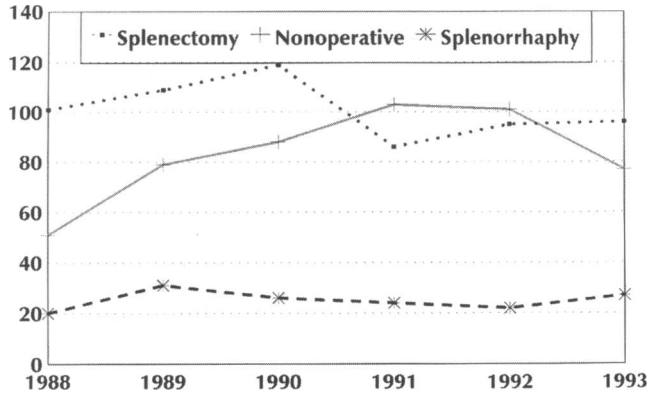

Figure 1. Proportion of patients treated nonoperatively by splenectomy and splenorrhapy from 1988–1993.

of the total group. Among the splenic injury group, vehicle and transport injuries accounted for 74.1% of admissions. The mean age was 34.2 years (range, 17–91 years). Men composed 67.4% of the population, and 72.5% of the patients were white.

Those having SP comprised the largest single treatment group, with 596 patients, followed by those treated without a spleen operation (NO) with 499 patients, SPOR with 150 patients, and SPOR later requiring splenectomy (SPOR/SP) with only 10. Spleen preservation was achieved in >50% of injured patients. Nonoperative treatment (NO) was responsible for 77% of the splenic salvage rate, whereas the remainder were preserved through reparative surgery. Overall, 40% of patients were treated without spleen operations and 12% by SPOR for a salvage rate of 52% (Table 1). For each of the first 3 years of study, the proportion of patients treated without a spleen operation increased. The rate of SPOR essentially was unchanged (Fig. 1).

Patients in the NO group had similar trauma scores (13.6 *vs.* 13.2; $p = 0.08$) but lower ISSs (19.5 *vs.* 25.1; $p < 0.05$) than did those of the SP group. Their lengths of stay (17.1 *vs.* 20.5, $p = 0.09$) were not significantly different, but they had lower hospital charges ($31,141 *vs.* $47,278; $p < 0.05$). The mortality rate was not significantly different between the two groups (12.7% *vs.* 14.8%; $p = 0.32$). The patients treated by SP were twice as likely to be in shock on admission (24.8% *vs.* 11.4%; $p < 0.05$) (Table 2).

Splenorrhaphy was performed in 150 patients. Although this is the third largest management group among the splenic injury population, it represents only 12% of the spleen-injured population. Injury severity indices among the SPOR group showed a profile similar to that of the nonoperative group (TS, 14; ISS, 19.4). Length of stay was 2.8 days longer and hospital charges were 18.4% higher in the SPOR group compared with those of the nonoperative group. Mortality was lower in the SPOR group compared to both the NO group and the SP group (5% *vs.* 12.7% *vs.* 14.8%) (Table 2). Although the number

Table 2. SEVERITY OF INJURY AND OUTCOME ACCORDING TO METHOD OF TREATMENT OF THE SPLENIC INJURY

	Severity of Injury			Outcome Index		
Treatment Type	Shock Present (%)	Mean TS (range 1–16)	Mean ISS (range 1–75)	Mean LOS (days)	Mean Charges* ($)	% Mortality
NO	11	13.6 ± 3.7	19.5 ± 11.0	17.1 ± 36.5	31,141 ± 48,938	12.7
SPOR	17	14.0 ± 2.9	19.4 ± 10.8	19.9 ± 31.9	38,149 ± 54,014	5
SP	25	13.2 ± 3.8	25.1 ± 11.7	20.5 ± 27.9	47,278 ± 64,093	14.8
SPOR/SP	40	13.8 ± 1.8	33.2 ± 15.3	26.6 ± 15.6	76,153 ± 55,973	20
All groups	18	13.4 ± 3.6	22.2 ± 11.7	19.2 ± 32.0	39,913 ± 57,690	13

TS = trauma score; ISS = injury severity score; LOS = length of stay; NO = no spleen operation; SPOR = splenorrhaphy; SP = splenectomy; SPOR/SP = splenorrhaphy requiring splenectomy.
* Hospital charges were missing in 113 patients, or 7.7% of the total study population.

Table 3. SPLENIC MORTALITY BY MANAGEMENT

	NO (N = 63)	SP (N = 88)	SPOR (N = 8)	Overall	SPOR/SP (N = 2)
Age (yr) [mean (range)]	42 (17–85)	38.7 (17–91)	46.9 (31–75)	40.3 (17–91)	17 & 85
LOS (days) [mean (range)]	8.6 (1–65)	8.8 (1–134)	73.0 (5–333)	12.4 (1–333)	29 & 41
TS (range 1–16)	8.4 (1–16)	8.6 (1–16)	9.6 (3–16)	8.7 (1–16)	15 & 16
ISS (range 1–75)	30.4 (6–57)	33.2 (8–59)	37.1 (14–57)	32.4 (6–59)	34 & 41
GCS (range 3–15)	6.9 (3–15)	7.9 (3–15)	9.0 (3–15)	7.7 (3–15)	15 & 15
AISHN (range 1–5)	4.0 (1–5) (N = 36)	4.4 (2–5) (N = 46)	5.0 (5–5) (N = 5)	4.2 (1–5) (N = 88)	2 N = 1
Shock	42.9% (27/63)	46.6% (41/88)	37.5% (3/8)	44.7% (72/161)	50.0% (1/2)

NO = no spleen operation; SPOR = splenorrhaphy; SP = splenectomy; SPOR/SP = splenorrhaphy requiring splenectomy; LOS = length of stay; TS = trauma score; ISS = injury severity score; GCS = Glascow coma scale; AISHN = Abbreviated injury score for the head and neck region.

of patients in the group undergoing SPOR followed by SP is too small to draw statistically significant conclusions, this group had the highest mortality (20%). This outcome is consistent with the mean ISS of 33 and greater percentage (40%) of patients in shock observed among this small group (Table 2).

Overall, there were 161 (12.7%) deaths. Among the mortalities, 44% presented to the trauma center in shock (blood pressure < 90 mmHg). The mean TS, ISS, GCS, and AISHN were 8.7, 32.4, 7.7, and 4.2, respectively. Median length of stay in this group was 12.4 days (range, 1–333 days). Head injury contributed largely to overall mortality. Among the patients who died in the NO group, the mean TS, ISS, GCS, and AISHN were 8.4, 30.4, 6.9, and 4, respectively. Their mean length of stay was 8.6 days (range, 1–16 days). In the SP group, the mean TS, ISS, GCS, and AISHN were 8.6, 33.2, 7.9, and 4.4, respectively. The mean length of stay in this group was 8.8 days (range, 1–134 days). Mortalities occurred at approximately 1 week in the two largest patient groups, NO and SP. Their mean AISHN was approximately four, and almost half of these patients presented in shock (Table 3).

An abdominal CT scan was performed on admission in 305 (61.1%) of the 499 patients treated without spleen operations and 278 (36.8%) of the patients treated with surgery. One hundred seventy-five patients in the NO group underwent abdominal operations. Forty-five patients in the NO groups were transferred into the trauma centers with diagnoses of spleen injury. Diagnostic peritoneal lavage was performed in 113 (22.6%) of the patients treated without surgery and in 276 (36.5%) of the patients treated with surgery. Shock was present on admission in 73 (12.5%) patients undergoing CT scan and 94 (24.2%) patients having diagnostic peritoneal lavage. Two hundred thirty-nine (19%) of the 1255 patients were taken directly to the operating room on the basis of clinical presentation only without CT scan or diagnostic peritoneal lavage. It is unclear how the diagnosis of spleen injury was established in 28 (5.6%) of the patients.

Management of the geriatric population with spleen injury was similar to that of the adult group (Table 4). Forty-seven (54%) of the 87 patients 65 years of age or older were able to have splenic salvage and 46% underwent SP. Splenorrhaphy was performed in 5% of the geriatric group compared to 12% in the adults ($p = 0.03$). Indices of injury severity showed similar trauma scores (13.4 *vs.* 13.1; $p = 0.77$) and ISSs (21.5 *vs.* 23.5; $p = 0.43$) between the nonoperative and SP groups (Table 5). One fourth of those from the nonoperative group and one third of those from the SP group presented in shock ($p = 0.65$). Geriatric patients who were treated without surgery had a 3-day greater length of stay ($p = 0.55$). The small number of patients undergoing SPOR did not permit meaningful comparisons. A $4412 difference in hospital charges was noted between the nonoperative and SP geriatric group ($p = 0.75$). Mortality was the same with both management techniques ($p = 1$).

When the adult and geriatric age groups were compared

Table 4. TREATMENT METHODS USED FOR SPLENIC INJURY: PATIENTS AGE 65 OR OLDER

Treatment Method	N		%
Spleen preserved	47		54
No spleen operation (NO)	43	49	
Splenorrhaphy (SPOR)	4	5	
Spleen not preserved	40		46
Splenectomy (SP)	40	46	
Splenorrhaphy requiring splenectomy (SPOR/SP)	0		
Total	87	100	100

Table 5. SEVERITY OF INJURY AND OUTCOME ACCORDING TO METHOD OF TREATMENT OF THE SPLENIC INJURY: PATIENTS AGE 65 OR OLDER

	Severity of Injury			Outcome Index		
Treatment Type	Shock Present (%)	Mean TS (range 1–16)	Mean ISS (range 1–75)	Mean LOS (days)	Mean charges ($)	% Mortality
NO (N = 43)	26	13.4 ± 3.9	21.5 ± 12.3	25.9 ± 27.6	53,966 ± 65,043	33
SPOR (N = 4)	25	11.3 ± 3.5	30.0 ± 11.5	117.5 ± 146.2	219,355 ± 175,274	75
SP (N = 40)	34	13.1 ± 3.6	23.5 ± 10.2	22.6 ± 20.8	49,554 ± 53,137	33
SPOR/SP	0	0	0	0	0	0
All groups	28	13.2 ± 3.8	22.8 ± 11.4	28.8 ± 42.0	60,524 ± 77,044	35

TS = trauma score; ISS = injury severity score; LOS = length of stay; NO = no spleen operation; SPOR = splenorrhaphy; SP = splenectomy; SPOR/SP = splenorrhaphy requiring splenectomy.

by mechanism of injury, blunt forces caused 84% of adult and 90% of geriatric splenic injury (Table 6). Splenic preservation rates were similar in both age groups with blunt trauma, 53% *versus* 56% in the geriatric group. Splenorrhaphy was performed in 5% of the blunt geriatric population and 12% of the adults.

Table 6. TREATMENT METHODS USED FOR SPLENIC INJURY EVALUATED BY MECHANISM OF INJURY

	Blunt		Penetrating	
Treatment Method	N	%	N	%
Adults age 17–64				
Spleen preserved	518	53	84	45
No spleen operation (NO)	402	41	54	29
Splenorrhaphy (SPOR)	116	12	30	16
Spleen not preserved	463	47	104	55
Splenectomy (SP)	453	46	104	55
Splenorrhaphy requiring splenectomy (SPOR/SP)	10	1	0	0
Total	981	100	188	100
Patients age 65 and older				
Spleen preserved	44	56	3	33
No spleen operation (NO)	40	51	3	33
Splenorrhaphy (SPOR)	4	5	0	
Spleen not preserved	34	44	6	67
Splenectomy (SP)	34	44	6	67
Splenorrhaphy requiring splenectomy (SPOR/SP)	0		0	
Total	78	100	9	100

Among those of the penetrating trauma group, SPOR was performed in 16% of the adult group; there were too few geriatric patients in this category to warrant comment.

When comparing the presence of shock in both age groups, geriatric patients were more likely to arrive with a low blood pressure, 24% *versus* 17% ($p = 0.10$) in the blunt, and 56% *versus* 15% ($p = 0.002$), in the penetrating category. Mean trauma and ISSs were comparable between both age groups for both blunt and penetrating trauma (Table 7).

Mean lengths of stay were higher in the geriatric patients for both blunt and penetrating trauma, although there were only nine patients in the later group. However, no remarkable differences in length of stay between penetrating and blunt trauma were observed in either age group when evaluated separately (Table 7). Mean charges were lower in the adult group. The difference in hospital charges within the adult group between blunt and penetrating trauma categories was only $772.

Mortality rates were different between the two age groups, with 2.8-fold and fivefold increases observed for blunt and penetrating trauma, respectively, among the geriatric patients. However, only a small number of geriatric patients sustained penetrating trauma. The small number of geriatric patients with penetrating injury did not allow statistical analysis (Table 7). The higher mortality observed in the geriatric rate was independent of management method.

Comparisons were made between the abdominal operation and no abdominal operation groups among the patients not having spleen operations (NO). Statistically significant differences were noted in all categories with the exception of length of stay (Table 8). Among the patients in the NO group, 175 underwent abdominal operations (35%). Injury severity, mortality, and mean hospital charges were significantly greater in this group.

DISCUSSION

Billroth[6] showed through autopsy-based study that splenic injury was capable of healing and measures for

Table 7. SEVERITY OF INJURY AND OUTCOME ACCORDING TO AGE AND MECHANISM OF THE SPLENIC INJURY

		Severity of Injury			Outcome Index		
	N	Shock Present (%)	Mean TS	Mean ISS	Mean LOS (days)	Mean Charges (%)	% Mortality
Patients age 17–64							
Blunt	981	17	13.4 ± 3.7	22.3 ± 12.1	18.5 ± 31.4	38,329 ± 52,749	12*
Penetrating	188	15	14.1 ± 3.1	21.8 ± 9.7	18.6 ± 29.6	39,101 ± 69,800	8.6
Patients age 65 and older							
Blunt	78	24	13.1 ± 3.9	22.9 ± 11.5	28.9 ± 42.9	59,978 ± 76,151	34
Penetrating	9	56	13.8 ± 2.7	21.4 ± 11.2	28.3 ± 35.1	64,713 ± 88,422	44
Adult *vs.* geriatrics (p)							
Blunt		0.10	0.50	0.67	0.04†	0.02†	0.0001†
Penetrating		0.007†	0.78	0.90	0.34	0.29	0.007†

TS = trauma score; ISS = injury severity score; LOS = length of stay.
* 12% *vs.* 8.6% is not statistically significant, with p = 0.2.
† p values for penetrating have a small number of cases.

treating splenic injury, including techniques for both preservation and excision, were described in pre-20th century literature.[7] The modern era for splenic injury began in 1892 when Riegner reported the first successful SP for blunt injury.[8,9] Surgical philosophy regarding the treatment of splenic injury was influenced greatly by Kocher,[10] who, in his 1911 *Textbook of Operative Surgery,* stated that "injuries of the spleen demand excision of the gland, no evil effects follow its removal while the danger of hemorrhage is effectively stopped." Bland–Sutton[11] reinforced the SP dictum with a 1912 report showing a high mortality with nonoperative management, and in 1932, McIndoe[12] reported that secondary hemorrhage from splenic injury occurs frequently and has a mortality rate comparable to that seen with primary splenic rupture.

New information regarding the role of the spleen began to emerge during the same era. Pearce,[13] in 1918, reported that 25% of animals subjected to SP die from peritonitis or pneumonia, although he thought the deaths were unrelated to the asplenic state because the animal could survive with "relative impunity." Asplenia as a cause of increased susceptibility to infection was reported in animals by Morris and Bullock[14] in 1919, whereafter caution was raised regarding indiscriminate removal of the spleen. Ten years later, O'Donnell[15] reported the first case of post-SP infection in a human. Although the first successful SPOR cases, including the first one in a child, was reported 1 year later by Dretzka,[16] more than 20 years passed before this concept regained attention. King and Shumacker[17] drew more attention to the subject in 1952 with a report on five cases of severe infection in infants undergoing SP for spherocytosis. Singer[18] reviewed 688 trauma patients from the literature who underwent SP and found 25 instances of fulminant sepsis. He concluded that the incidence of severe infection was 58 times that of the normal population. Green et al.[19] reported a 5.9% incidence of major septic complications (*e.g.,* pneumonia, septicemia, meningitis) in their post-SP trauma population. The reported incidence of post-SP infection in the adult trauma population is less well documented but

Table 8. NONOPERATIVE SPLEEN MANAGEMENT WITH AND WITHOUT ABDOMINAL OPERATIONS

Adominal Operation	Shock (%)	Mean TS	Mean ISS	Mean LOS (days)	Mean Charges ($)	Mortality (%)	Blunt (%)	Abdominal CT Done (%)
Yes (n = 175)	17.1	12.6 ± 4.3	22.0 ± 11.7	19.9 ± 22.2	41,797 ± 44,739	18.9	77.1	30.9
No (n = 324)	7.4	14.2 ± 3.2	18.1 ± 10.3	15.5 ± 42.1	25,406 ± 50,196	9.3	94.8	77.5
p value	0.001	0.0001	0.0001	0.14	0.0003	0.002	0.00001	0.00001

TS = trauma score; ISS = injury severity score; LOS = length of stay.

ranges from 2.5% to 11%.[20] The reported incidence of death from post-SP sepsis is approximated at 0.025% or 1 death per 4000 patients undergoing SP for trauma.[21] The risk of infection and death, although statistically small, continues to warrant a preservation policy whenever safe.

We sought to determine the frequency with which different methods of management for splenic injury were used in North Carolina trauma centers and their respective outcomes. The experience reflected in this study shows that a trend toward splenic preservation, particularly through nonoperative management, has evolved over the past 6 years within the statewide trauma center hospitals. Splenorrhaphy, although frequently discussed, is performed infrequently. Among patients undergoing abdominal operations, SP remains the most frequently performed procedure for both blunt and penetrating splenic trauma.

This report confirms the recent findings of Rutledge et al.,[22] who reported an increasing trend in splenic preservation from a population-based study of all patients with solid organ injury admitted to the 157 hospitals within North Carolina. Their study included trauma centers and nontrauma center hospitals. Nonoperative management of splenic injury increased from 34% to 46% between 1988 and 1992. We extend their study by focusing only on the population of patients admitted to the eight state-designated North Carolina trauma centers. Significantly, splenic preservation is now widely accomplished in both trauma and nontrauma center hospitals.

Classification systems are available to establish anatomic descriptions of splenic injury,[23] but universal criteria to determine which patients will not respond to nonoperative management remain to be developed. The CT scan was used in 46% of all patients in this study and represented the diagnostic method of choice for patients with potential abdominal injury who are hemodynamically stable. Diagnostic peritoneal lavage was used in 31% of patients, 25% of whom were in shock. The results of several studies show the ability of the CT to identify and grade splenic injury severity accurately.[24–26] Schurr et al.[27] suggest that a "blush" on CT scan may serve as a useful predictor of nonoperative failure. Kohn et al.,[28] in comparing several CT-based scoring systems, reiterated the difficulty associated with accurately predicting the clinical course of injury in a specific patient.

In a prospective study comparing nonoperative and operative treatment, Smith et al.[29] reported a success rate of 93% with nonoperative management using the criteria of age younger than age 55, hemodynamic stability, grade 3 or less by AAST criteria, plus absence of injuries precluding abdominal assessment and absence of concomitant abdominal injuries.

Advantages of nonoperative management include preservation of splenic immune function, reduction of untoward postoperative complications, and lower hospital costs. A potential for a reduction in incidence of adhesions and subsequent small bowel obstruction also might be reasonably expected. Multiple reports document the safety and high success rates derived from nonoperative management.[30–35] As shown in this study, moderate overall decreases in length of stay, hospital charges, and mortality were appreciated in the nonoperative, adult group. Among geriatric patients, nonoperative management was associated with longer lengths of stay, higher hospital charges, and no difference in mortality compared with that of the geriatric SP group. Given restrictions on posthospital activity and employment and the requirement for additional posthospital diagnostic tests, a total cost benefit may not be realized with nonoperative management in the adult group.

Among patients requiring surgery, SP rather than SPOR was the most frequently performed operation. The operation of SP holds many advantages for the patient and the surgeon, including ease of performance, rapid control of hemorrhage, surgeon familiarity, less requirement for monitoring and postoperative diagnostic evaluation, and early return to full activity. These are particularly important considerations for the surgeon caring for the multiply injured patient.

This study is limited in not being able to identify patients who did not respond to nonoperative treatment. Splenorrhaphy may be under-reported because we do not have the operative reports to identify patients who underwent immediate SP after a failed attempt at SPOR. It also is possible that SP alone was recorded among some patients undergoing both SPOR and SP. We also are unable to reliably stratify patients by magnitude of splenic injury. Such limitations arise from large databases in which there is increased potential for incomplete data on any given record and misclassification bias arising from ICD-9-CM coding errors. The database from which our conclusions are drawn contains patients admitted to trauma centers only.

In conclusion, the incorporation of splenic preservation into standard practice represents the culmination of numerous studies showing advantages over the historically universal SP for splenic injury. Nonoperative management now constitutes the most common method of management for splenic salvage in the eight trauma centers of North Carolina. Splenorrhaphy, although frequently discussed, is used infrequently. Splenectomy remains the most commonly performed operation for splenic injury in both adult and geriatric trauma patients regardless of injury mechanism. Patients with blunt trauma are treated more often without surgery, but SP and SPOR rates essentially are the same between blunt and penetrating patients selected for operative management. Splenic injury in geriatric trauma patients causes significantly higher mortality and hospital charges than in adults, regardless of manage-

ment method. Global savings may not be realized through nonsurgical treatment of the injured spleen, however, because of posthospital costs arising from temporary disability, activity restrictions, and follow-up medical care. Prospective studies, using cost-based multi-institutional data, are necessary to design precise clinical pathways most likely to produce economic and medical benefit for injured patients.

References

1. Malangoni MA. Spleen. In: Ivatury R, Cayten G, eds. The Textbook of Penetrating Trauma. Baltimore: Williams and Wilkins, 1995: 589–597.
2. Moore FA, Moore EE, Abernathy CM. Injury to the spleen. In: Moore EE, Mattox KL, Feliciano DV, eds. Trauma. 2nd ed. Connecticut and California: Appleton and Lange, 1991:465–483.
3. McCarthy MC, Glover JL. Splenic trauma. In: Moylan J, ed. Principles of Trauma Surgery. New York: Gower Medical Publishing, 1992:8.0–8.20.
4. Malangoni MA. Splenic salvage: current expectations and results. In: Maull KI, Cleveland HC, Strauch GO, Wolferth CC, eds. Advances in Trauma. Chicago: Mosby–Year Book, 1990:123–141.
5. MacKenzie EJ, Steinwachs DM, Shankar B. Classifying trauma severity based on hospital discharge diagnosis. Med Care 1989; 27:412–422.
6. Billroth T. Clinical Surgery. London: New Sydenham Society, 1881:229.
7. Sherman R. Perspectives in management of trauma to the spleen: 1979 presidential address, American Association for the Surgery of Trauma. J Trauma 1980; 20:1–13.
8. Reigner O. Ueber einen Fall Von Exstirpation der Traumatisch Zerrissen Milz. Berl Klin Wochenschr 1893; 30:177–181.
9. Lucas C. Splenic trauma, choice of management. Ann Surg 1991; 213:98–114.
10. Kocher ET. Textbook of Operative Surgery. 3rd English ed. In: Stiles HJ, Paul CB, eds. London: A & C Black, 1911:565–566.
11. Bland–Sutton J. Observations on the surgery of the spleen. Br J Surg 1912; 1:157–172.
12. McIndoe AH. Delayed hemorrhage following traumatic rupture of the spleen. Br J Surg 1932; 20:249–268.
13. Pearce RM, Krumbhaar EB, Frazier CH. The history of extirpation of the spleen. In: Pearce RM, Krumbhaar EB, Frazier CH, eds. The Spleen and Anemia: Experimental and Clinical Studies. Philadelphia: JB Lippincott, 1918:3–10.
14. Morris DH, Bullock FD. The importance of the spleen in resistance to infection. Ann Surg 1919; 70:513–521.
15. O'Donnell FJ. The value of splenectomy in Banti's disease. Br Med J 1929; 854.
16. Dretzka L. Rupture of the spleen: a report of 27 cases. Surg Gynecol Obstet 1930; 51:258–261.
17. King H, Shumacker HB, Jr. Susceptibility to infection after splenectomy performed in infancy. Ann Surg 1952; 136:239–242.
18. Singer DB. Postsplenectomy sepsis. Perspect Paediatr Pathol 1973; 1:285–311.
19. Green JB, Shackford SR, Sise MJ, Fridlund P. Late septic complications in adults following splenectomy for trauma: a prospective analysis in 144 patients. J Trauma 1986; 26:999–1004.
20. Sekikawa T, Shatney CH. Septic sequelae after splenectomy for trauma in adults. Am J Surg 1983; 145:667–673.
21. Wisner DH, Blaisdell FW. When to save the spleen. Surgery 1992; 111:121–122.
22. Rutledge R, Hunt JP, Lentz CW, et al. A statewide, population based time-series analysis of the increasing frequency of nonoperative management of abdominal solid organ injury. Ann Surg 1995; 222:311–322.
23. Moore EE, Shackford SR, Pachter HL, et al. Organ injury scaling: spleen, liver, and kidney. J Trauma 1989; 29:1664–1666.
24. Buntain WL, Gould HR, Maull KI. Predictability of splenic salvage by computed tomography. J Trauma 1988; 28:24–34.
25. Mirvis SE, Whitley NO, Gens DR. Blunt splenic trauma in adults: CT-based classification and correlation with prognosis and treatment. Radiology 1989; 171:33–39.
26. Resciniti A, Fink MP, Raptopoulous V, et al. Nonoperative treatment of adult splenic trauma: development of a computed tomographic scoring system that detects appropriate candidates for expectant management. J Trauma 1988; 28:828–831.
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; 39:512–513.
28. Kohn JS, Clark DE, Isler RJ, Pope CF. Is computed tomographic grading of splenic injury useful in the nonsurgical management of blunt trauma? J Trauma 1994; 36:385–389.
29. Smith JS, Jr, Wegrovitz MA, Delong BS. Prospective validation of criteria, including age, for safe, nonsurgical management of the ruptured spleen. J Trauma 1992; 33:363–369.
30. Cogbill TH, Moore EE, Jurkovich GJ, Morris JA. Nonoperative management of blunt splenic injury: a multicenter experience. J Trauma 1989; 29:1312–1317.
31. Mucha P, Jr, Daly RC, Farnell MB. Selective management of blunt splenic trauma. J Trauma 1986; 26:970–979.
32. Villalba MR, Howells GA, Lucas RJ, et al. Nonoperative management of the adult ruptured spleen. Arch Surg 1990; 125:836–838.
33. Flaherty L, Jurkovich GJ. Minor splenic injuries: associated injuries and transfusion requirements. J Trauma 1991; 31:1618–1621.
34. Stephen WJ, Roy PD, Smith PM, Stephen WJ, Sr. Nonoperative management of blunt splenic trauma in adults. Can J Surg 1991; 34:227–229.
35. Elmore JR, Clark DE, Isler RJ, Horner WR. Selective nonoperative management of blunt splenic trauma in adults. Arch Surg 1989; 124:581–586.