Blunt Splenic Injury in Adults: Multi-institutional Study of the Eastern Association for the Surgery of Trauma

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Background: Nonoperative management of blunt injury to the spleen in adults has been applied with increasing frequency. However, the criteria for nonoperative management are controversial. The purpose of this multi-institutional study was to determine which factors predict successful observation of blunt splenic injury in adults.

Methods: A total of 1,488 adults (>15 years of age) with blunt splenic injury from 27 trauma centers in 1997 were studied through the Multi-institutional Trials Committee of the Eastern Association for the Surgery of Trauma. Statistical analysis was performed with analysis of variance and extended χ^2 test. Data are expressed as mean ± SD; a value of *p* < 0.05 was considered significant.

Results: A total of 38.5% of patients went directly to the operating room (group I); 61.5% of patients were admitted with planned nonoperative management. Of the patients admitted with planned observation, 10.8% failed and required laparotomy; 82.1% of patients with an Injury Severity Score (ISS) < 15 and 46.6% of patients with ISS > 15 were successfully observed. Frequency of immediate operation correlated with American Association for the Surgery of Trauma (AAST) grades of splenic injury: I (23.9%), II (22.4%), III (38.1%), IV (73.7%), and V (94.9%) (*p* < 0.05). Of patients initially managed nonoperatively, the failure rate increased significantly by AAST grade of splenic injury: I (4.8%), II (9.5%), III (19.6%), IV (33.3%), and V (75.0%) (*p* < 0.05). A total of 60.9% of the patients failed nonoperative management within 24 hours of admission; 8% failed 9 days or later after injury. Laparotomy was ultimately performed in 19.9% of patients with small hemoperitoneum, 49.4% of patients with moderate hemoperitoneum, and 72.6% of patients with large hemoperitoneum.

Conclusion: In this multicenter study, 38.5% of adults with blunt splenic injury went directly to laparotomy. Ultimately, 54.8% of patients were successfully managed nonoperatively; the failure rate of planned observation was 10.8%, with 60.9% of failures occurring in the first 24 hours. Successful nonoperative management was associated with higher blood pressure and hematocrit, and less severe injury based on ISS, Glasgow Coma Scale, grade of splenic injury, and quantity of hemoperitoneum.

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Management of blunt injury to the spleen has changed substantially during the past two decades.[1–5] The lifelong risk of overwhelming postsplenectomy infection has been the major impetus for preservation of the spleen.[2,6–10] Splenorrhaphy was used as the primary method for splenic salvage during the last decade.[2,7,8,11–14] Nonoperative management of blunt injury to the spleen has become routine in children, with 75% to 93% of children successfully treated nonoperatively.[1,2,6,11,14–19] The indications and risks of selection for observation of blunt splenic injury in adults

are less clear. A recent paper reported that 65% of blunt splenic injuries can be managed nonoperatively, with a success rate of 98%.[13] Recent guidelines by the Eastern Association for the Surgery of Trauma (EAST)[20] concluded that "management of blunt hepatic and/or splenic injuries in a hemodynamically stable patient is reasonable." This document stated further that "neither grade of injury nor degree of hemoperitoneum on computed tomographic scan predict the outcome of nonoperative management." These recommendations are contrary to those of Powell et al.[18] and others,[14,19,21–23] who reported that failure of nonoperative management of blunt splenic injury in adult patients correlated with the degree of hemoperitoneum, Injury Severity Score (ISS) > 15, and higher grade splenic injury (American Association for the Surgery of Trauma [AAST] organ injury grade > III). To address the conflicting observations in the literature,[13,18,20–28] the Multi-institutional Trials Committee of the EAST organized this multi-institutional study and formulated the following hypotheses: (1) degree of patient injury based on ISS and presence of hypotension or tachycardia would correlate with frequency of operation; (2) AAST grade of splenic injury would predict frequency of operation; and (3) quantity of hemoperitoneum would correlate with frequency of laparotomy.

MATERIALS AND METHODS

Preliminary information was obtained on trauma patients admitted from 27 trauma centers (26 Level I and 1 Level II) for the years 1993 to 1997, inclusively. The preliminary data included total volume of trauma admissions (yearly and 5-year totals), number of general surgeons on trauma call, and outcome of blunt splenic injuries in adults only (> 15 years old). Failure of nonoperative management (observation) was defined as any patient who was admitted to the intensive care unit (ICU) or floor with the diagnosis of blunt splenic injury with planned nonoperative management who later required laparotomy. Detailed retrospective information was then requested on adults with blunt splenic injury for the year 1997 only. Information included age, ISS, mechanism of injury, lowest systolic blood pressure, and highest heart rate in the emergency department (ED). Other admission values included Glasgow Coma Scale score, hematocrit, and base deficit. Red blood cell transfusion was recorded in the ED, for the first 24 hours, and preoperatively. Diagnostic tests were documented, including diagnostic peritoneal lavage (DPL), abdominal computed tomography, and abdominal ultrasound. Additional data included indications and time to operation, initial management plan and ultimate outcome (operation vs. successful observation), and associated abdominal injuries. Length of stay in the ICU and hospital were documented.

Blunt splenic injuries were graded using the AAST Organ Injury Scale (1994 version) with information obtained[29] at each center from computed tomographic (CT) scan and operative findings (Table 1). Data obtained from CT scan included grade of splenic injury, quantity of hemoperito-

Table 1 AAST Spleen Injury Scale (1994 Version)[29]

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

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

neum, presence of arterial extravasation, and concomitant abdominal injuries. When these data were incomplete, copies of operative reports and pathology reports were obtained from the study center. Hemoperitoneum was quantified[18,30] by CT scan or operative report. Small hemoperitoneum was defined as perisplenic blood or blood in Morrison's pouch. Moderate hemoperitoneum was the presence of blood in one or both pericolic gutters. Large hemoperitoneum was defined by the additional finding of free blood in the pelvis.

Data was collected and organized in Access and Excel spread sheets (Microsoft, Seattle, WA). Analysis of variance and pair-wise multiple comparison procedures with Student-Newman-Keuls method was used to compare groups. Categorical variables were compared with extended χ^2 analysis. Data are expressed as mean ± SD. Results were considered significant with a value of $p < 0.05$.

RESULTS

The initial data collection included blunt splenic injury in adults from the 27 trauma centers for the years 1993 to 1997, inclusively. Over the 5-year period, 227,656 trauma patients were admitted to the study centers; 6,308 adults incurred blunt injury to the spleen (incidence, 2.6%). An average of six trauma surgeons took call at the trauma centers (range, 2–12). The number of surgeons on call did not influence the frequency of patients going directly from the trauma room to the operating room (OR). The frequency of immediate operation for blunt splenic injury decreased from 52% in 1993 to

Table 2 1993–1997 Data: 6,308 Adult Patients with Blunt Splenic Injury[a]

	Direct to OR (% Mean)	Direct to OR (% Range)	Failed Nonoperative Management (% Mean)	Failed Nonoperative Management (% Range)
1993, n = 1,087	52	19.2–90.7	13.5	0–50.0
1994, n = 1,206	49	24.5–86.4	10.8	0–26.7
1995, n = 1,155	41	5.9–71.4	10.1	0–28.5
1996, n = 1,345	39	14.8–77.2	11.9	0–30.4
1997, n = 1,515	39	6.9–66.7	10.8	0–24.0

[a] Twenty-seven trauma centers.

39% in 1997 (Table 2). However, in all years, the range among centers of patients transported directly to the OR was large (1997: range, 6.9–66.7%). The failure of nonoperative management declined from 13.5% in 1993 to 10.8% in 1997. Similarly, the range among centers for failed observation was also large (1993: range, 0–50%; 1997: 0–24%). One third of the trauma centers reported having a written protocol for management of blunt splenic injury.

We then looked at patients from 1997 in greater detail. It was clear from the 1993–1997 preliminary data that the treatment of blunt splenic injury had changed with increasing tendency toward nonoperative management. We felt that evaluation of 1997 data would provide information on more consistent practice and, therefore, lead to more relevant conclusions. Detailed information was obtained from the study centers on the 1,515 adult trauma patients admitted with blunt splenic injury in 1997. Twenty-seven patients were admitted later than 24 hours after injury and were excluded from the analysis; 1,488 patients were analyzed in further detail. The number of adult patients with blunt splenic injury admitted during 1997 was less than 25 patients at 2 centers, 26–50 patients at 10 centers, 51–75 patients at 8 centers, 76–100 patients at 3 centers, and greater than 100 at 4 centers. The number of patients admitted yearly with blunt splenic injury did not correlate significantly with the tendency toward operative versus nonoperative management.

Information was sorted according to patients who went directly from the ED to the OR (CT scan may have been obtained en route) (group I, n = 575), patients successfully observed (group II, n = 816), and patients who failed nonoperative management (group III, n = 97). A total of 38.5% of patients went from the ED to the OR for laparotomy, and 61.5% of patients were admitted with planned observation of blunt splenic injury. Of the patients admitted with planned observation, 10.8% failed and required laparotomy. Ultimately, 54.8% of patients were successfully managed nonoperatively, and 45.2% underwent laparotomy (groups I and III combined).

Mechanism of injury for the entire study group was motor vehicle crash (77.2%), motorcycle crash (4.1%), pedestrian/automobile mishap (4.7%), altercation (2.8%), fall (5.3%), sporting mishap (1.6%), bicycle crash (1.0%), and other (3.3%). Mechanism of injury was not significantly different among the three groups.

Patients who went directly to the OR (group I) were more severely injured than the patients for whom nonoperative management was attempted (Table 3). Group I presented with significantly higher heart rate, lower blood pressure, lower Glasgow Coma Scale score, higher ISS, lower hematocrit, and greater base deficit than the patients for whom observation was attempted. Group III patients (failed nonoperative management) were older, had significantly higher ISS, and had lower hematocrit than the group successfully observed (group II). Mortality was significantly different between groups: I (25.9%), II (4.2%), and III (16.5%). Of patients who went directly to the OR (group I), 8.7% had an ISS < 15, and 91.3% had an ISS >15 ($p < 0.05$). A total of 82.1% of all patients with an ISS < 15 and 46.6% of patients with an ISS >15 were successfully observed ($p < 0.05$). The failure rate of nonoperative management was 4.0% in patients with an ISS <15 and 13.7% in patients with an ISS > 15 ($p < 0.05$).

Group I patients consumed more red blood cells in the ED and in the first 24 hours than group II or III ($p < 0.05$) (Table 3). Before laparotomy for failed observation, group III patients received an average of 2.9 ± 4.5 units of packed red blood cells. The ICU and hospital lengths of stay were significantly longer for patients who underwent laparotomy (groups I and III) than those who did not (group II).

The diagnostic tests used included CT scan, DPL, and abdominal ultrasound. CT scans were obtained in 91% of patients with grade I blunt splenic injury, in 90% with grade II, in 82% with grade III, in 71% with grade IV, and in 57% with grade V. DPL was used in 7% of patients with grade I blunt splenic injury, in 7% with grade II, in 12% with grade III, in 15% with grade IV, and in 24% with grade V. Abdominal ultrasound was used in 24% of patients with grade I blunt splenic injury, in 43% with grade II, in 38% with grade III, in 41% with grade IV, and in 39% with grade V. Several patients underwent multiple diagnostic tests. Grade of splenic injury was available in 1,094 (73.5%) of patients (Fig. 1). Two hundred seventy-six patients (25.2%) had grade I blunt splenic injury, 299 patients (27.3%) grade II, 247 patients (22.6%) grade III, 194 patients (17.7%) grade IV, and 78 patients (7.1%) grade V.

The initial management of the splenic injury was sorted by grade (Fig. 2): 23.9% of patients with grade I blunt splenic injury, 22.4% with grade II, 38.1% with grade III, 73.7% with grade IV, and 94.9% with grade V went directly from the ED

Table 3 Differences between Patient Groups

	Group I (Direct to OR) n = 575	Group II (Successful Observation) n = 816	Group III (Failed Nonoperative Management) n = 97
Age[b,c] (y)	36 ± 19	34 ± 17	41 ± 20
Highest ED heart rate[a,b] (bpm)	120 ± 26	107 ± 22	109 ± 23
Lowest SBP in ED[a,b] (mm Hg)	90 ± 30	112 ± 23	106 ± 23
GCS score[a,b]	11.1 ± 5.0	13.1 ± 3.8	13.4 ± 3.4
ISS[a,b,c]	31.6 ± 13.1	20.3 ± 11.3	26.5 ± 12.6
Hematocrit in ED[a,b,c] (%)	32.2 ± 7.4	37.4 ± 6.5	35.4 ± 5.9
Base deficit[a,b]	8.7 ± 6.2	4.7 ± 3.9	5.0 ± 3.9
Red cell transfusion in the ED[a,b] (units of RBCs)	1.6 ± 2.6	0.3 ± 1.1	0.6 ± 1.3
Red cell transfusions in first 24 h[a,b,c] (units)	8.4 ± 10.6	1.2 ± 3.0	4.1 ± 6.9
Red cell transfusions preoperatively (units)	2.1 ± 3.1	–	2.9 ± 4.5
Mortality within group[a,b,c] (%)	25.9	4.2	16.5
Time to operation[b] (h)	1.7 ± 1.3	–	83.2 ± 136.8
ICU length of stay[a,c] (days)	8.2 ± 13.5	4.1 ± 7.5	9.5 ± 17.1
Hospital length of stay[a,c] (days)	14.9 ± 19.1	10.0 ± 15.8	16.6 ± 21.9

ED, emergency department; bpm, beats per minute; SBP, systolic blood pressure; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; RBCs, red blood cells; ICU, intensive care unit.

[a] $p < 0.05$, Group I vs. Group II; [b] $p < 0.05$, Group I vs Group III; [c] $p < 0.05$, Group II vs Group III.

to the OR ($p < 0.05$). Indications for operation in the patients transferred directly to the OR (group I) (several patients had multiple indications) included hypotension (33.3%), persistent tachycardia (7.6%), abdominal pain (5.9%), low hematocrit (3.1%), CT findings (5.6%), ultrasound findings (10.0%), DPL results (19.0%), other injuries (3.8%), and other (27.1%).

The failure rate was expressed as the number of patients who failed observation divided by the number of patients for whom the admission plan was nonoperative management (Fig. 3). Failure of nonoperative management increased significantly by grade of splenic injury: grade I (4.8%), grade II (9.5%), grade III (19.6%), grade IV (33.3%), and grade V (75%) ($p < 0.05$). Indications for operation in the patients who failed initial observation included hypotension (15.5%), tachycardia (5.1%), abdominal pain (16.5%), decreasing hematocrit (36.0%), change on CT findings (21.6%), ultrasound findings (2.0%), DPL results (7.2%), other injury (4.1%), and other (15.5%).
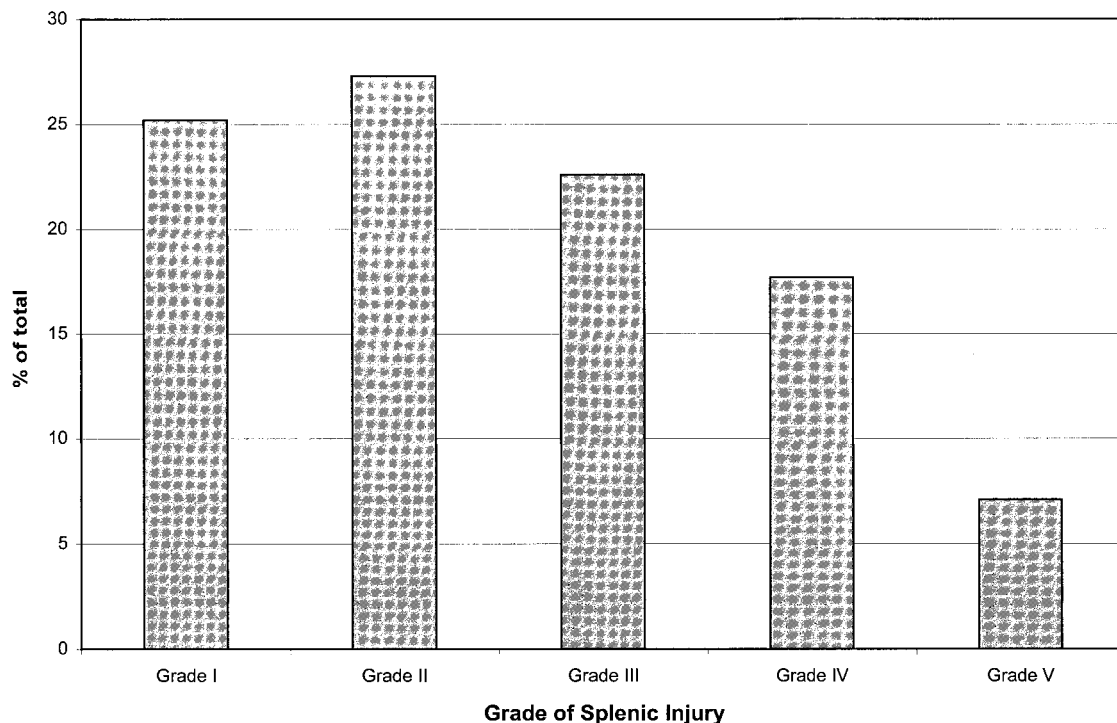

Fig. 1. *Distribution of splenic injuries by AAST grades. Grade was available in 1,094 of the 1,488 patients (73.5%).*
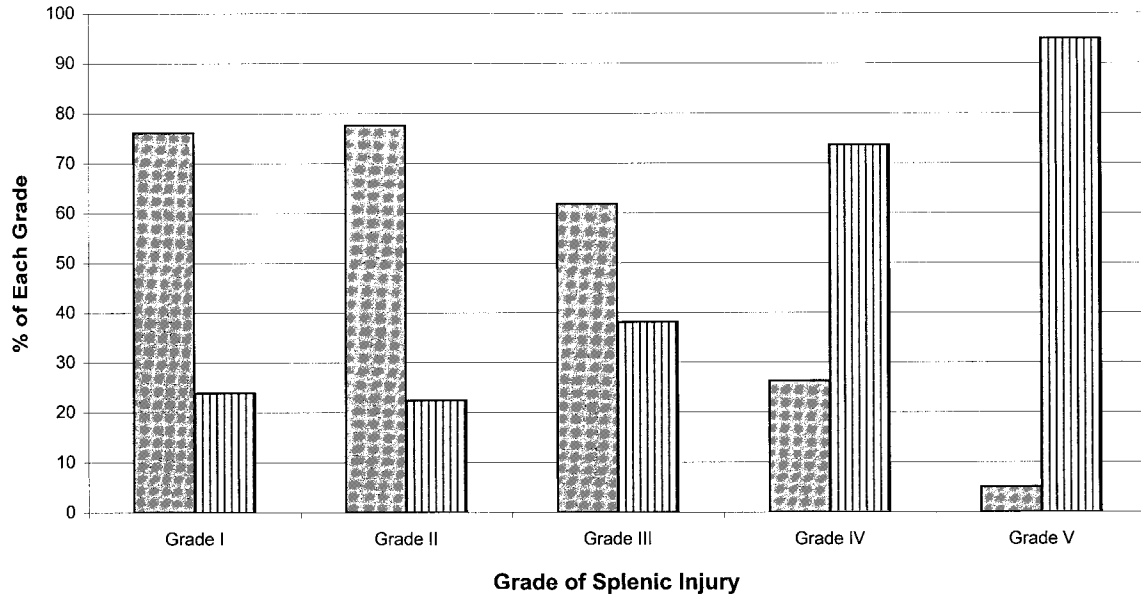
Fig. 2. *Initial management of blunt splenic injury by grade: 23.9% of patients with grade I blunt splenic injury, 22.4% with grade II, 38.1% with grade III, 73.7% with grade IV, and 94.9% with grade V went directly from the ED to the OR.* Shaded bars, *planned nonoperative management;* striped bars, *direct to OR.*

As defined above, any patient with blunt injury to the spleen who was admitted to the ICU or the ward and then required laparotomy was defined as a failure of nonoperative management. Information regarding time to failure was avail-

able in 87 of the 97 patients who failed nonoperative management. A total of 60.9% of the patients failed nonoperative management within 24 hours of admission, 13.8% failed on the second hospital day, 6.9% on the 3rd hospital day, and
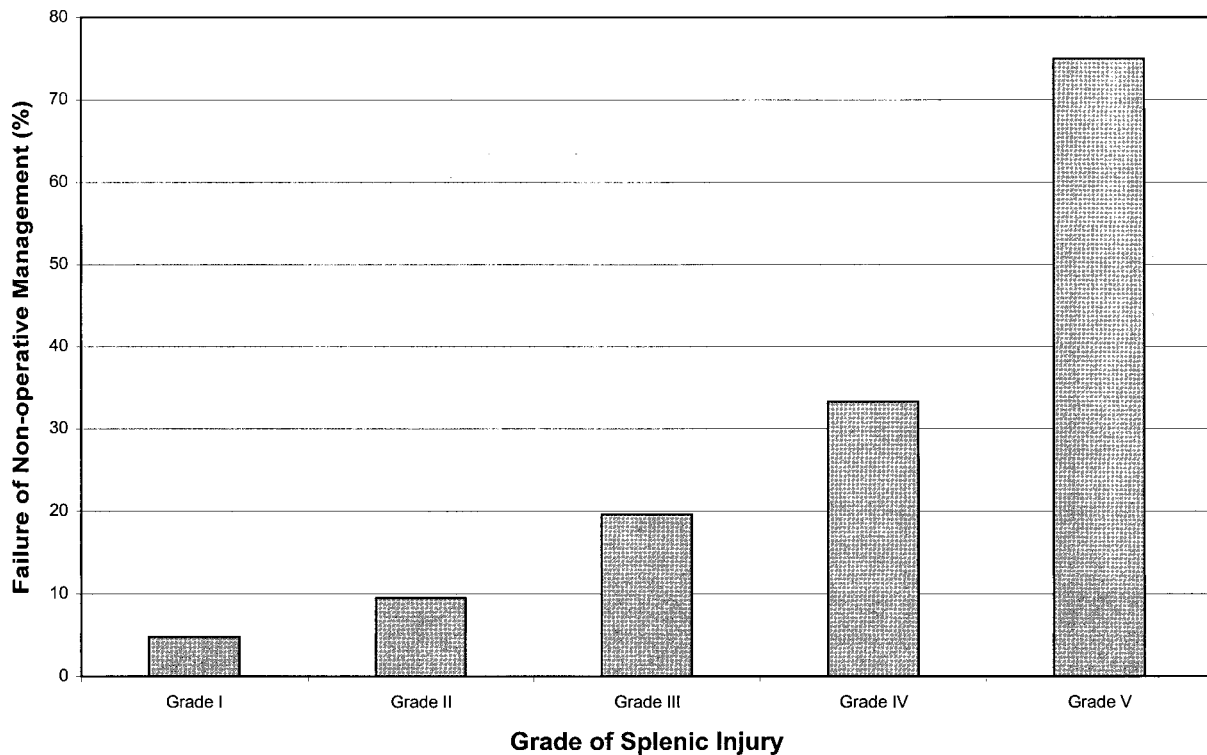

Fig. 3. *Failure rate of nonoperative management increased progressively with grade of splenic injury: I (4.8%), II (9.5%), III (19.6%), IV (33.3%), and V (75.0%) (p < 0.05).*
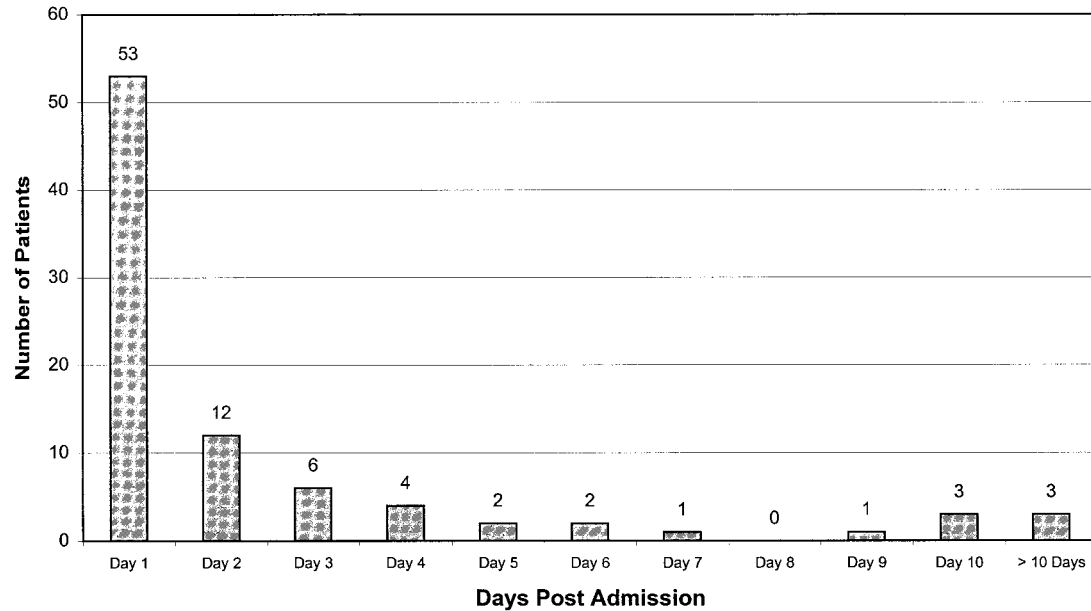
Fig. 4. *Time from admission to laparotomy for failed nonoperative management. (Data available in 87 of the 97 patients who failed observation.)*

4.6% on the 4th hospital day (Fig. 4). Thus, of the patients who failed nonoperative management, 86.2% failed within 96 hours of admission.

Eight percent of the patients who failed (7 of 87 for whom the time was available) did so 9 days or later after initial injury. The patients with late failures were from seven different centers and averaged 51.4 ± 16.8 years of age (range, 29–77 years old) with an ISS = 17.2 ± 10.0. They were injured by falls (n = 2), motor vehicle crash (n = 4), and motorcycle crash (n = 1). AAST grades for splenic injury in the late failures were I (n = 3), II (n = 1), III (n = 1), IV (n = 1), and unknown (in one patient). The quantity of hemoperitoneum in these seven patients was small (n = 2), moderate (n = 1), and large (n = 3). Six of the seven patients underwent splenectomy.

The ultimate management of splenic injury is shown in Fig. 5. Successful nonoperative management was achieved in 75.0% of patients with grade I injuries, in 70.0% with grade II, in 49.3% with grade III, in 16.9% with grade IV, and in 1.3% with grade V ($p < 0.05$). Conversely, 25.0% of patients with grade I splenic injuries, 30.0% with grade II, 50.7% with grade III, 83.1% with grade IV, and 98.7% with grade V ultimately underwent laparotomy (includes patients who went directly to the OR and those who failed nonoperative management) ($p < 0.05$).

With the use of CT scans and operative reports, the quantity of hemoperitoneum was available in 69.4% of patients (Fig. 6). A total of 80.1% of patients with small hemoperitoneum, 50.6% patients with moderate hemoperitoneum, and 27.4% of patients with large hemoperitoneum were successfully observed ($p < 0.05$). In addition, 85.5% of patients with small hemoperitoneum were initially treated without

operation; of the patients for whom nonoperative management was planned, 6.3% had unsuccessful observation. A total of 62.4% of patients with moderate hemoperitoneum were initially treated nonoperatively; 19% failed observation. A total of 35.3% of patients with large hemoperitoneum were initially treated nonoperatively; 22.3% failed nonoperative management. Laparotomy was ultimately performed in 19.9% of patients with small hemoperitoneum, 49.4% of patients with moderate hemoperitoneum, and 72.6% of patients with large hemoperitoneum.

The distribution of patients according to both grade of splenic injury and quantity of hemoperitoneum is shown in Figure 7 (both pieces of data were available in 793 patients, 53% of total group). Grade I and grade II splenic injuries most frequently had concomitant small hemoperitoneum (60.3% of grade I and 42.7% of grade II). Grade III splenic injuries tended to have more free blood (small [23.5%], moderate [36.3%], and large hemoperitoneum [40.2%]). Grade IV and grade V splenic injuries infrequently had small quantities of free blood (4.7% of grade IV and 3.0% of grade V). On the contrary, 74.4% of grade IV and 86.6% of grade V splenic injuries had associated large hemoperitoneum.

The ultimate success of nonoperative management based on grade of splenic injury and associated amount of hemoperitoneum is shown in Figure 8. Within each grade, the incidence of successful observation declined as quantity of hemoperitoneum increased ($p < 0.05$). The majority of patients with grade IV (128/172) or grade V (58/67) splenic injuries had large associated hemoperitoneum and went directly to the OR. It is important to note that although the attempts to treat grade IV and grade V patients with small hemoperitoneum nonoperatively were successful in 50% of
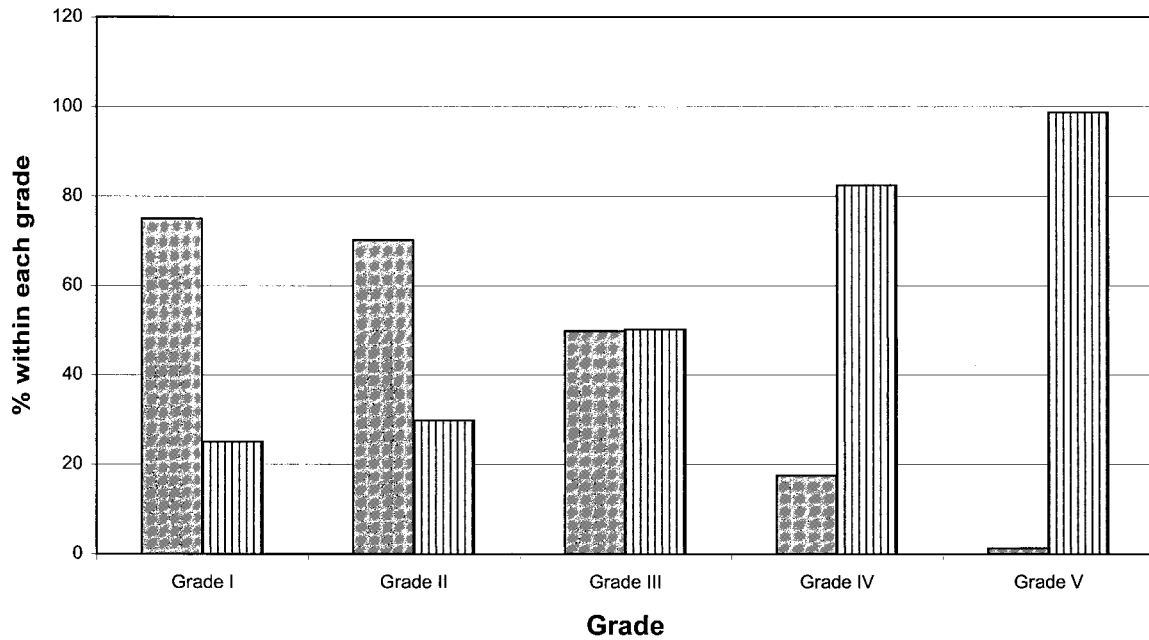
Fig. 5. *Ultimate management of blunt splenic injury by grade. Success of observation decreased as grade of splenic injury increased: I (75.0%), II (70.0%), III (49.3%), IV (16.9%), and V (1.3%) (p < 0.05). Shaded bars, successful nonoperative management; striped bars, laparotomy required (includes direct to OR and failed nonoperative groups.)*

these cases, this opportunity was infrequent (eight and two patients, respectively). No patient with grade V splenic injury and moderate or large hemoperitoneum was successfully managed nonoperatively. Similarly, only 12% of patients

with grade IV splenic injury and large hemoperitoneum were successfully treated nonoperatively.

Arterial extravasation has been reported as a powerful indication for either laparotomy or embolization.[30,31] Arterial
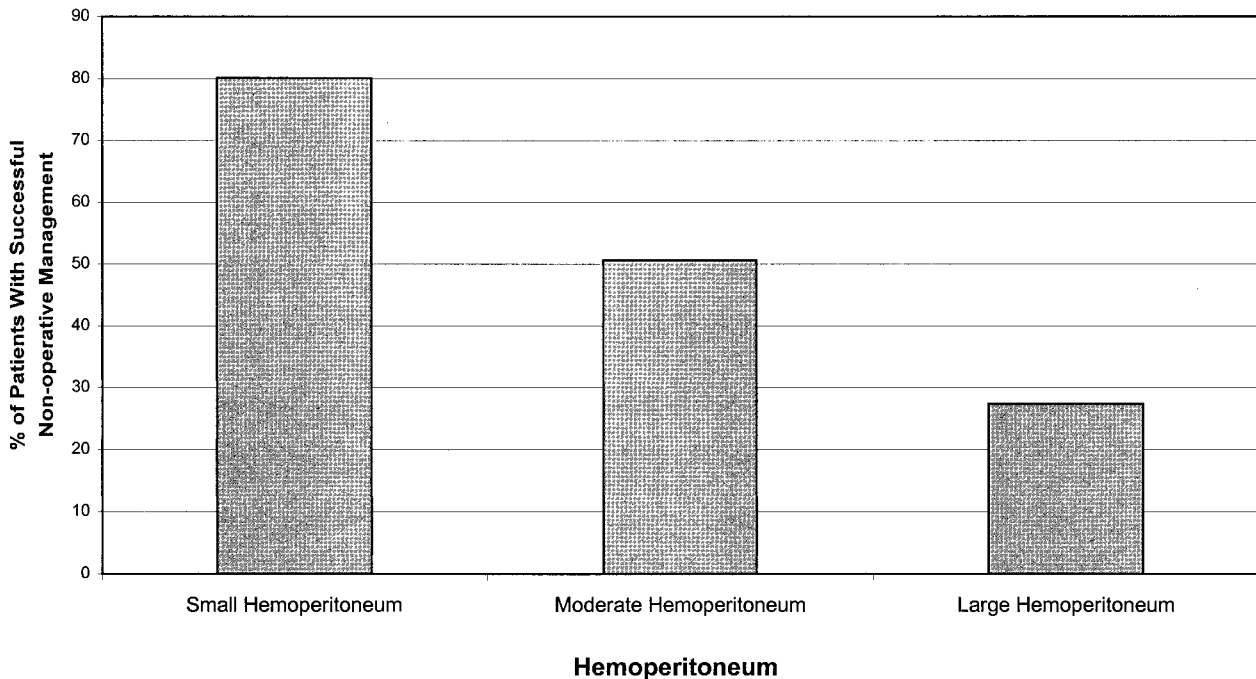

Fig. 6. *Ultimately successful nonoperative management of blunt splenic injury based on quantity of hemoperitoneum. Successful observation was achieved in 80.1% of patients with small hemoperitoneum, 50.6% of patients with moderate hemoperitoneum, and 27.4% of patients with large hemoperitoneum (p < 0.05).*
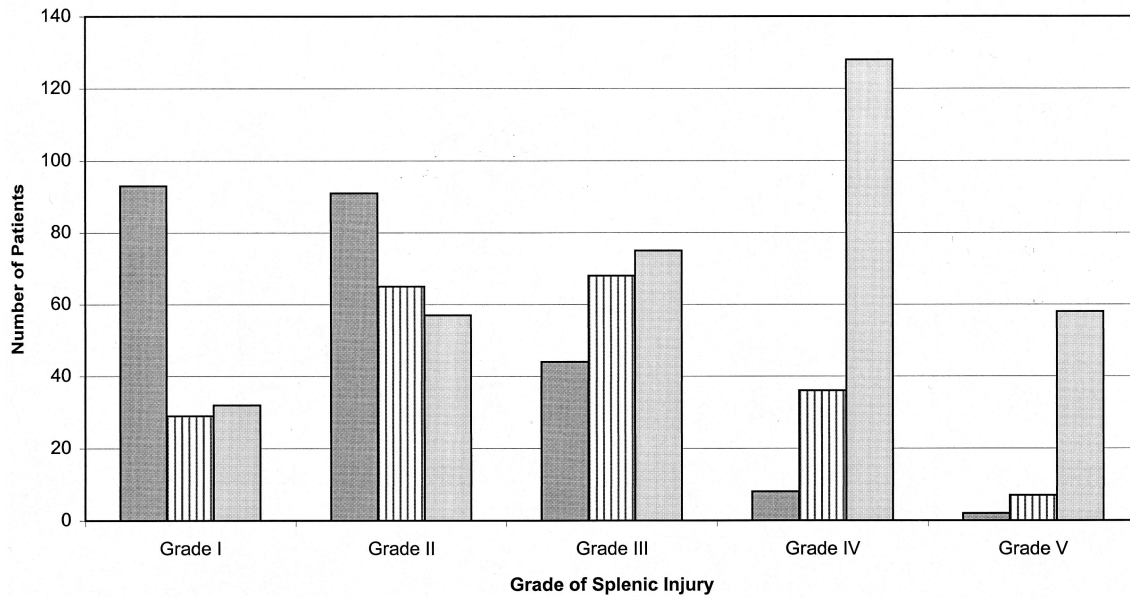
Fig. 7. *Distribution of patients based on grade of splenic injury and quantity of hemoperitoneum. Grade I and grade II splenic injuries tended to have a small quantity of hemoperitoneum; grade IV and V injuries had large quantities of free blood.* Dark shaded bars, *small hemoperitoneum;* striped bars, *moderate hemoperitoneum;* light shaded bars, *large hemoperitoneum.*

extravasation was reported in 39 patients; 29 of 39 went directly to the OR. Four of the 10 patients initially managed nonoperatively later underwent operation. Thus, 85% of patients with the finding of arterial extravasation underwent laparotomy. Angiography and embolization were rarely used in the current series.[32]

Management of the injury to the spleen in patients who required immediate laparotomy included splenectomy (74.8%), splenorrhaphy (16.9%), or no repair required (8.3%). Management of the spleen in patients who failed nonoperative management included splenectomy (78.6%), splenorrhaphy (10.7%), or no repair required (10.7%).

Fig. 8. *The ultimate success of nonoperative management based on grade of splenic injury and associated amount of hemoperitoneum. Within each grade, incidence of successful observation declined as the quantity of hemoperitoneum increased* ($p < 0.05$). *No patient with grade V injury to the spleen and moderate or large hemoperitoneum was successfully observed.* Dark shaded bars, *small hemoperitoneum;* striped bars, *moderate hemoperitoneum;* light shaded bars, *large hemoperitoneum.*

Concurrent intra-abdominal injuries found at laparotomy in group I (direct to OR, n = 575) included liver (151 patients, 26%), pancreas (33 patients, 6%), kidney (56 patients, 10%), bowel (73 patients, 13%), and other (108 patients). Concomitant injuries in group III (failed observation, n = 97) included liver (31 patients, 32%), pancreas (3 patients, 3%), kidney (12 patients, 12%), bowel (12 patients, 12%), and other (11 patients).

DISCUSSION

The risk of overwhelming postsplenectomy infection prompted the evolution toward preservation of the injured spleen.[2,6–10] Splenorrhaphy was initially used to accomplish this.[1–5,7,20,27] More recently, observation (nonoperative management) has become common for splenic preservation.[13,18,19,20,24,28] Nonoperative management of blunt splenic injury clearly has become the standard of care in pediatric trauma; 75% to 93% of splenic injuries in children can be observed with success.[18,19] However, appropriate management of blunt injury to the spleen in adults is less clear. Previous studies had significant methodologic problems. These included the following: the assumption that the natural history of injury to the liver and the spleen is similar, with the evaluation of hepatic and splenic injuries together; analysis of children and adults as a single population, with the pediatric patients skewing the observations; or reports that included few grade IV or V injuries, making interpretation of the data difficult.

Factors in earlier reports on blunt splenic injury that suggested the need for surgical intervention included hypotension, tachycardia, abnormal hematocrit, coagulopathy, and multiple transfusions.[19,22] The importance of CT findings in predicting need for operative intervention or risk of failure of observation is more controversial. Recent reports including the EAST practice management guidelines have suggested that grade of the splenic injury and quantity of hemoperitoneum do not predict the outcome of nonoperative management.[13,20,25,26] Other reports have found CT findings to be useful in selection for nonoperative management.[14,18,19,21,23] Starnes et al. improved success of nonoperative management of splenic injury by implementing a protocol that included grade of the splenic injury; incidence of operative intervention did not change, and failure of nonoperative management was eliminated.[23]

Less severe splenic injuries (grades I and II) often have little intraperitoneal blood (60.3% of grade I and 42.7% of grade II splenic injuries). Grade IV and grade V injuries infrequently had small hemoperitoneum; rather, grade IV and V injuries were associated with large quantities of intraperitoneal blood in 74.4% (grade IV) and 86.6% (grade V) of cases. The quantity of hemoperitoneum associated with grade III splenic injury was variable with small hemoperitoneum in 23.5%, moderate hemoperitoneum in 36.4%, and large hemoperitoneum in 40.1%. Thus, the grade of splenic injury correlated with the quantity of associated hemoperitoneum; as the grade of splenic injury increased, more intraperitoneal blood was found, both findings quantifying the magnitude of injury to the spleen. Demonstrating this further, the likelihood of successful nonoperative management within each grade of splenic injury declined as quantity of hemoperitoneum increased.

Indications for immediate operation in this study were based primarily on hemodynamic instability, abdominal findings, or grossly positive ultrasound or DPL results. Indications for laparotomy in patients who failed nonoperative management were, most commonly, decreasing hematocrit, change on CT scan, hypotension, and abdominal pain. The AAST grade of blunt splenic injury correlated with frequency of both the early and late operative intervention. A total of 23.9% of patients with grade I injuries, 22.4% with grade II, 38.1% with grade III, 73.7% with grade IV, and 94.9% with grade V were direct admissions for laparotomy. In this study, grade IV and V splenic injuries were generally managed with early operation. Failure of nonoperative management increased progressively with grade of splenic injury: 4.8% (grade I), 9.5% (grade II), 19.6% (grade III), 33.3% (grade IV), and 75.0% (grade V). Laparotomy was ultimately performed in 25.0% (grade I), 30.0% (grade II), 50.7% (grade III), 83.1% (grade IV), and 98.7% (grade V) of patients within each grade. Grade I and grade II splenic injuries demonstrated high likelihood of successful nonoperative management. Nonoperative management of grade III splenic injury was attempted in 61.9% of patients, but succeeded in only 49.3% of the total group of patients with grade III injury to the spleen. The high failure rate of observation of grade IV and V injuries confirms other reports.[10,18,19,23] On the other hand, this is a higher incidence of laparotomy and nonoperative failure for grade IV and V injuries than reported by Davis et al.[32] Are patients with complex grade IV or grade V blunt splenic injuries best served by early laparotomy? The data would suggest so. But to definitively address this issue, we need to answer a critical question: What is the true risk of failure of nonoperative management? What are the consequences as far as avoidable mortality, morbidity, length of stay, organ failure, and transfusion requirements?

As an independent variable, degree of hemoperitoneum inversely correlated with the success of nonoperative management; 80.1% of patients with small hemoperitoneum, 50.6% with moderate hemoperitoneum, and 27.4% with large hemoperitoneum were successfully observed without operation. Conversely, laparotomy was ultimately performed in 19.9% (small hemoperitoneum), 49.4% (moderate hemoperitoneum), and 72.6% (large hemoperitoneum) of the patients.

Our data suggest that blunt hepatic and splenic injuries behave differently and should be managed differently. Patients with blunt injuries to the liver who require operation are hemodynamically unstable on presentation to the hospital. Patients with blunt hepatic injury who are stable and undergo abdominal computed tomography generally can be managed nonoperatively, irrespective of the grade of the hepatic injury or the

quantity of hemoperitoneum.[33–36] Grade of blunt splenic injury and quantity of hemoperitoneum, unlike hepatic injury, are predictive of success of observation.[18,19,22–24,33–36]

This multi-institutional study from EAST (1993–1997) confirmed that an increasing proportion of adults with blunt splenic injury were managed nonoperatively. In 1997, an average of 38.5% of patients went directly to the OR. Ultimately, 54.8% of the patients were successfully observed without operation. To standardize terminology, we defined nonoperative failure as any patient who was admitted to the ICU or floor with the plan for nonoperative management but who later required laparotomy. Thus, our failure rate of 10.8% is somewhat higher than recent reports that defined failure as patients requiring laparotomy more than 12 to 24 hours after admission.[13,20] This subgroup that we have identified as failing within the first day is a group of patients that may be mistriaged at admission. This is an important observation. If we can more accurately identify and operate on these patients, the failure rate of nonoperative management will be near 4% to 5%. It is important to note that one failure occurred on day 9, three failures on day 10, and three patients even later. As these are patients who may have been home under certain circumstances, these late failures are worrisome.[24,32]

Confirming several earlier reports, the patients who underwent prompt laparotomy (group I) were more significantly injured as shown by greater tachycardia, hypotension, lower Glasgow Coma Scale score, and higher ISS and mortality than patients managed nonoperatively. The average ISS was 31.6 ± 13.1 for patients transferred directly to the OR, 20.3 ± 11.3 for patients successfully observed, and 26.5 ± 12.6 in patients who failed nonoperative management. The ISS of the group II patients (successful observation) is higher than earlier reports,[18,19] because children were excluded from this series. Patients with an ISS >15 were significantly more likely to undergo operation and fail nonoperative management if attempted. Thus, the incidence of operative intervention was significantly associated with severity of the patients' injuries.[18,19,24,28] The mechanism of injury did not segregate patients into operative versus nonoperative groups.

The strengths of the current study include the large numbers of patients, information from multiple trauma centers over a relatively short-time period, and standardized definitions and data collection. The limitations of the current study are due largely to the fact that it is retrospective. The variability between centers as far as management and outcome of the patients is large. The lack of patient management protocols may have contributed to this both within centers and between centers. On the other hand, differences in frequency of laparotomy were not due to the number of general surgeons on call, the number of patients with blunt splenic injury admitted yearly to the trauma centers, or the presence of a written patient management algorithm. The results and conclusions of the study were based on the CT reports and operative descriptions from 27 trauma centers. The inter-

reader variability of CT interpretation may have contributed, in part, to the variability in management of the patients. If a finite number of adult patients with blunt splenic injury require laparotomy, it might be possible to predict that centers performing early laparotomy on a greater proportion of patients would have a lower rate of failure of nonoperative management. As a corollary, the centers operating on patients less frequently would demonstrate a higher incidence of failure of observation. We found no correlation or pattern in the tendency toward early operation and frequency of nonoperative failure. The wide variability in physician practice certainly was a major factor in this observation.

In addition to variability in physician practice, another possibility is that differences in patient populations may influence management and outcome. In the current study, the center transporting only 6.9% of their patients directly to the OR (substantially less often than the other centers) reported the youngest population (26.1 years old), 64.3% of their patients with grade I or II injuries, 10.7% with grade IV injury, and no patient with a grade V injury. Mortality for patients with splenic injury at this center was 3.6%. At the other extreme, the center operating immediately on 66.7% of their patients documented an average age of 40 years, 37.3% of patients with grade I or II injuries, 22.0% with grade IV, and 6.8% with grade V; mortality was 15.3%. (Average mortality for all centers was 13.4%.) Thus, differences in management and outcome between centers may be due in part to differences in patient population.

As with any retrospective study, data points were missing in this study. Did the missing data occur in a pattern that biased or skewed our conclusions? This did not seem to be the case. Rather than particular patient groups tending to have incomplete data, more than one half of the incomplete data points were from 7 of the 27 centers.

The trigger point for operation based on transfusion requirement in patients with blunt splenic injury is not clear in the literature. Red cell transfusion requirements in the first 24 hours were significantly different between groups: group I, 8.4 ± 10.6 units; group II, 1.2 ± 3.0 units; and group III, 4.1 ± 6.9 units. The frequency of blood transfusion also varied between groups: 89.1% (group I), 31.3% (group II), and 78.8% (group III) of the patients required transfusion ($p < 0.05$). The quantity of red cell transfusion before laparotomy was not significantly different between patients who went directly to the OR and those who failed observation.

Clearly, the most effective modality for splenic preservation today is nonoperative management. Patients who had immediate laparotomy performed underwent splenectomy four times more often than splenorrhaphy. Patients who failed nonoperative management underwent splenectomy almost eight times more often than splenorrhaphy.

This multi-institutional report has provided a large database from 27 trauma centers. Our data suggest that the likelihood of successful nonoperative management of blunt splenic injury in adults may be defined at the time of patient

presentation, as dictated by the patient's hemodynamic status, associated injuries, and magnitude of splenic injury. Accurately characterizing these factors may help identify which patients will be likely to be successfully treated without laparotomy. The frequency of early and late operation and the likelihood of failure of nonoperative management were predicted by the grade of the splenic injury and the quantity of hemoperitoneum

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DISCUSSION

Dr. Timothy C. Fabian (Memphis, Tennessee): Drs. McCarthy, Kirton, members and guests, the Multi-institution Trials Committee has really made a major contribution to the management of blunt splenic injury.

This is likely the best of retrospective multi-institutional trials to date. Compared with other trials, its strengths include consecutive injuries in centers as opposed to variabilities in selection among centers, as well as focused analysis of a

substantial number of variables. This very large study has cast an important light on the issues of selection criteria for nonoperative management as well as the factors contributing to failure of nonoperative management.

As acknowledged by the authors, it does suffer from weaknesses inherent to any retrospective analysis in which issues of clinical judgment play a major role. Such issues in this study on which Dr. Peitzman may like to comment include:

1. Inter-reader reliability of CT scan grading as well as variable CT technologies among the institutions.

2. Clinical judgment regarding "stability and need for urgent operation," for example, 8% of patients had nothing done to the spleen at the time of the initial laparotomy.

3. Quantity of hemoperitoneum intraoperatively; combining that data with CT data for quantitative hemoperitoneum in a retrospective fashion is a little problematic.

4. Threshold for deeming nonoperative management failed; for example, a drop in hematocrit from 34 to 20 over 12 hours in a patient with associated skeletal and soft-tissues injuries. Is that a failure of nonoperative management? I think it depends a lot on the observer whether or not their threshold will take them to the OR. An example of that is 11% of these patients that had failure had nothing done to the spleen at the time of their surgery.

5. How often is splenorrhaphy of any consequence? In other words, doing a little cauterization or a little topical therapy, when in fact the thing really wasn't much of a problem. Admittedly, in a retrospective analysis these sort of judgments are hard to come by.

Furthermore, missing data points are problematic. The combination of injury grade and quantity of hemoperitoneum, highly important issues in this data analysis and the conclusions, was present in only 53% of the total population.

The study clearly demonstrates wide variations in practice and that is certainly one of the most important parts of the study. Variabilities in practice are why we have developed guidelines in multiple areas of medicine over the years.

This study demonstrates that very well and gives food for thought to the Practice Management Guidelines Committee. In 1997, urgent operations ranged from 7% to 67% and nonoperative failure rates from 0 to 24%. Every institution cannot be delivering optimal management with these wide variations. Obviously, prospective class I and class II studies are essential. Those disparate rates underscore the necessity for such studies. I am confident that this Committee will stimulate grant writing for such studies for EAST in the future.

I believe the EAST is well positioned to take that critically important leadership step. Prospective studies should address issues of standard CT methodology, judgment thresholds for operation and outcome, and the cost of failure in terms of transfusions, organ failure, and attributable mortality.

I would once again like to commend the Multi-institutional Trials Committee and thank them for providing an important light for future work.

Dr. Kimberly A. Davis (Maywood, Illinois): Could you comment, please, on the failure within 24 hours. Sixty percent seems real high to me.

At the AAST meeting in Hawaii in 1997, we had reported a 1 out of 15 failure rate within the first 24 hours. Perhaps if you subanalyze your data you will be able to identify patients that are at higher risk to fail within the first 24 hours. I think that data would be important.

Dr. Charlie Wiles (Lancaster, Pennsylvania): I agree with Dr. Fabian that this is a landmark study and both the authors and the EAST should be commended for it.

I have one question. Were you able to identify any specific adverse consequences of failed nonoperative management?

Dr. Salvatore J. Sclafani (Brooklyn, New York): It seems to me that the study was biased by the interpretation of the CT scan. So, therefore, it appeared that patients who were stable ended up with laparotomies. They had a grade V or grade IV injury. Since planned laparotomy was not the intention and planned observation was not the intention, there is a bias there in terms of the reading. I would like you to comment on that.

At my institution, as some of you already know, the use of angiography and embolization has been the mainstay of the treatment of splenic injury for many years, so that at the year 2000 it would be a sentinel event at our institution to have a failed nonoperative management of a splenic injury, having had one every 10 years.

Perhaps some of it is our own bias to the way we manage our patients, but it seems that this part of the process is not still being addressed. For me, the need for laparotomy should no longer be considered to be the end result of the evaluation of nonoperative management, but the need for transfusion and for those complications associated with splenic injuries.

Dr. J. Stanley Smith (Hershey, Pennsylvania): My question is did you look at age? You knew that question was coming. Did you stratify based on any ages?

Dr. Molina (Tyler, Texas): Approximately 1% of those patients were 5 days out when they failed, of those that were observed. I know that's not a big number; I think it's nine patients.

Any observations? I know one of those patients was one of ours, an old man with head injury. He was on his way to rehab when the nurses stood him up and he fainted. I put an ultrasound probe on him; his abdomen was full of blood, and that was approximately 7 days out. But was there anything with the other patients? It's kind of scary that 5 days out the patient fails.

Dr. Jose J. Diaz, Jr. (Nashville, Tennessee): Again, I echo the question about age, specifically in the "geriatric" population. Does your end point for nonoperative manage-

ment decrease on the basis of hemodynamic status, amount of blood, etc.

Dr. Jack M. Bergstein (Morgantown, West Virginia): First, I congratulate the authors, Dr. Heil and Dr. Peitzman, in going from conception to presentation in less than a year and in going through a phenomenal amount of data. I know they reviewed each of the individual data sheets and brought up-to-speed a lot of the data that was missing. So, a wonderful job on that. I think that they have answered a lot of questions.

One of the reasons that we undertake nonoperative management of splenic injury is that we think that it is a better outcome in a variety of ways, one of which might be cost or length of stay, and other factors related to things such as return to work that I know you cannot measure from your data. I wonder if you can comment on either cost or length of stay in the successful, nonoperative management versus the unsuccessful and versus the operative.

Dr. Andrew B. Peitzman (closing): I would like to thank all of the participants in this study. It really was a great opportunity. Everyone really rose to the front to make this both an education and, I think, a very rewarding process.

I will try to go through all of the questions relatively expeditiously. I think the interreader reliability of the CT scan and the technology at various centers is a real issue, and something that we are going to address in the next phase of the study.

I think the clinical judgment as far as which patient is considered unstable is absolutely critical. Obviously, there was enormous physician variability between centers and, I suspect, within centers as well.

As far as using operative findings for quantifying hemoperitoneum, that was actually very infrequent. In the vast majority of patients, the quantity of hemoperitoneum was based on CT readings. The threshold for failure of nonoperative management was, again, similar to the problem with immediate operation—it is based on clinical judgment and we do not have a standard for that. I think the cases where

patients failed nonoperative management and nothing was done with the spleen, we have to remember that some of these were for other injuries, and specifically bowel injuries. So the fact that nothing was done with the spleen, that was not an unnecessary laparotomy.

Dr. Davis asked about failure within 24 hours. We are actually going to review those 97 patients in detail to see why patients failed, particularly within the first 24 hours, because that is obviously a group that was mistriaged.

We do not know the adverse consequences of failure of nonoperative management, and that is an absolutely critical issue that needs to be addressed. I do not think we were biased. The study was not biased, as far as CT readings with grade V injuries; 59% of the patients with grade V injuries underwent CT scans as well. So the majority of patients actually had CT scans, even those with the higher grade injuries. Therefore, it was not an intrinsic bias that the patients never had the opportunity to undergo CT scans.

Yes, Dr. Smith, I knew you would ask about age. We do not have that in this study just because there was so much data. That is a separate paper. We found, not at 55 years but at 65 years and older, going up decade by decade that there was an increasing incidence of failure of nonoperative management. The question about the late failures is real. It's scary. Eight percent of the failures occurred more than 9 days after the injury. It is worrisome, but I do not have any answers beyond that.

Dr. Bergstein, the length of stay was the shortest in the group of patients successfully treated nonoperatively. It was equal, about 16 days, in the groups that went directly to the OR and those that failed nonoperative management.

I think the common themes and observations of the questions in the study are the following: higher grade splenic injury and quantity of blood did correlate with the ultimate management of the splenic injury; we are very variable in how we practice treatment of these injuries; and we need to standardize it. The third major goal will be to learn the true consequences of failure of nonoperative management.