ORIGINAL ARTICLE

Statewide Variation in the Treatment of Patients Hospitalized With Spleen Injury

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Hypothesis: Surgeons' treatment decisions for patients with spleen injuries in Washington State from January 1, 1990, through December 31, 1994, were different in rural compared with urban communities.

Design and Settings: Retrospective cohort analyses using the Death and Illness History Database for the state of Washington, which provides a cross-linked record of an individual's sequential hospitalizations. Counties were defined as metropolitan, urban, or rural on the basis of population density.

Patients: A total of 1905 patients (1927 hospitalizations) with an *International Classification of Diseases, Ninth Revision, Clinical Modification*, discharge diagnosis code of 865.

Main Outcome Measures: Physician management decisions (perform a celiotomy or repair the spleen) were stratified by geographic region.

Results: Throughout the state, there was substantial variability in the treatment of spleen-injured patients. Factors associated with higher odds of splenectomy included older age, overall severity of injury, treatment in rural hospitals, and treatment in the earlier years of study. While the frequency of splenic salvage increased over time, hospital length of stay, rehospitalization, and 30-day mortality did not increase.

Conclusions: Injury to the spleen is a common problem for which management decisions vary by geographic region, indicating that a single management protocol does not universally apply. To evaluate appropriateness of care by process measures, such as splenic injury management, will require that decision makers grant some latitude in management variability based on factors such as practice setting.

Arch Surg. 1999;134:1378-1384

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IMPROVING THE quality of health care offered to traumatically injured patients requires that delivery systems and rendered services be validated by sound research evidence. This approach ensures that well-intended practices do not result in inappropriate care. The contemporary movement to ensure that trauma systems and trauma care be "evidence based" has promulgated the idea that standard procedures and general practices can be established and rigidly applied to the treatment of all patients on the basis of the "best evidence" available in the published literature. As a result, guidelines have emerged that offer standards for the treatment of injured patients.[1,2]

In contrast to the idea of standardized treatment protocols, published literature acknowledges that treatment and management practices vary greatly across the United States.[3-5] Experts may argue that such variation represents a failure to offer optimal care. However, practical experience dictates that some variation in injury management should be expected (if not endorsed) because of differences in practice settings.[2,6]

An example of an injury requiring complex decision making is splenic injury. On the one hand, hemorrhage from a traumatically disrupted spleen can be lethal, and timely splenectomy may be lifesaving. On the other hand, many patients with injured spleens can be treated with procedures that accomplish splenic salvage and preserve the organ's immunological function.[7-11] Variation in patient characteristics, injury severity, and practice environment may all dictate the most prudent course of action.

The goal of this study was to evaluate the care of patients hospitalized with splenic injury over several years in an entire state to determine if there were identifiable variations in practice. We were particularly interested in determining if there

PATIENTS AND METHODS

DEFINITION OF THE STUDY COHORT

Patients with spleen injury were selected from injured patients discharged from acute care hospitals (excluding federal government hospitals) in the state of Washington from January 1, 1990, until December 31, 1994. Data available for each case included date of birth, sex, admission date, discharge date, ZIP code of residence, disposition at discharge, a hospital identifier, and up to 5 discharge diagnoses recorded by means of *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) codes.[17] The patients for this study were selected from the cohort of all hospitalized injured patients with at least 1 discharge diagnosis between 865.00 and 865.19, indicating injury to the spleen. Included patients were younger than 80 years to minimize bias related to higher mortality in the very elderly from associated medical conditions.

Procedures performed were also available, listed as *ICD-9-CM* codes. For the years 1990 to 1993, a maximum of 3 procedure codes were listed, and for 1994, a maximum of 5 codes were listed. Patients were considered to have had a splenectomy if the appropriate procedure code was listed. Patients were designated as having splenic salvage if they had the appropriate procedure code for repair listed, or if they had a procedure code for laparotomy but no procedure code for splenic surgery. Patients with splenic injury were categorized as having nonoperative management if no procedure code regarding treatment of the injured spleen was listed and the patient had no other codes indicating abdominal surgery.

DATA SOURCES

The hospital claims database for the study period was obtained from the Comprehensive Hospital Abstract Reporting System (CHARS) by application to the Washington Department of Social and Health Services. The CHARS is a claims database collected principally for billing purposes on all patients hospitalized in state-licensed acute care hospitals.[18] The Department of Social and Health Services enhances the content of the database by 2 linkage processes. The CHARS data, at the end of each calendar year, are linked to previous CHARS records by means of unique identifier information. In this annual linkage process, individuals who were previously hospitalized 1 or more times are linked, and thus the revised CHARS data set includes multiple hospitalizations for individuals under a single unique identifier code.

For the purpose of this study, consecutive hospitalizations that occurred in more than 24 hours were designated *subsequent hospitalizations*, and each record was analyzed individually. Patients discharged from one hospital and admitted within 24 hours to a second hospital were designated *transfer patients*. The final outcome for transfer patients was designated on the basis of the patient's status at discharge from the second hospital.

The Death and Illness History Database is an expansion of the CHARS database, constructed by linking information in the Washington CHARS database to death certificates.[19] This enables patients designated as hospital survivors to have supplemental designation as dead within 30 days of discharge.

OUTCOME MEASURES

Hospitals were assigned to 1 of 3 regions: metropolitan, urban, or rural, based on population density in counties calculated by means of 1990 census data.[20] Only hospitals in King County, Washington, were designated *metropolitan regional hospitals* (>500 persons per square mile). Hospitals in 11 counties with populations between 51 and 500 persons per square mile were designated *urban*, and in 27 counties with a population density less than 50 persons per square mile, hospitals were designated *rural*.

For the purposes of the analyses, the location of hospitalization was based on the following decision rule: transfer patients were assigned to the region in which the first abdominal procedure was completed. Transfer patients who did not have an abdominal procedure were assigned to the first acute care hospital to which they were admitted. Patients having 2 or more hospitalizations separated by an interval of greater than 24 hours were designated as having hospital readmissions and were assigned to the first hospital from which they were discharged.

DEFINITION OF COMPUTED VARIABLES

Abbreviated Injury Scores and Injury Severity Scores (ISS) were calculated from *ICD-9-CM* discharge diagnoses as described by MacKenzie et al.[21] In 11 cases, the *ICD-9-CM* code designated a "nonspecific" injury; consequently, an Abbreviated Injury Score could not be assigned and an ISS was not calculated. For the purposes of the regression analysis only, these 11 cases were assigned an ISS value equivalent to that of the patients in the reference group. The LOS was calculated as the difference in the number of days between hospital admission and hospital discharge. When a patient had an interhospital transfer, LOS was calculated from the day of admission at the first hospital to day of discharge from the last hospital. Patients younger than 16 years were classified as pediatric.

DATA ANALYSIS

Bivariate comparisons between groups were accomplished with χ^2 or a Kruskal-Wallis test. The LOS was assessed with a 1-way analysis of variance model after a logarithmic transformation of the data. A Bonferroni adjusted *P* value, based on multiple comparisons, was .007. Logistic regression models were constructed for both adult and pediatric patients to assess geographic variation in operative vs nonoperative management of splenic injury, and in splenectomy vs splenic salvage in the subset of patients undergoing operative management. Covariates were added to the logistic model by means of a "forced-entry" technique. All analyses were conducted with commercially available software (SPSS, version 6.01; SPSS Inc, Chicago, Ill).

were measurable variations between geographic regions and over time.

MANAGEMENT OF SPLENIC INJURY

When a trauma patient is determined to have a splenic injury, the surgeon first decides whether to proceed with a laparotomy or to attempt nonoperative management. Laparotomy is indicated if there is substantial hemoperitoneum, shock, or persistent hemorrhage. Factors favoring surgery include suspected associated visceral injuries or serious brain injury that would be exacerbated by hypotension.[12] There is debate regarding whether the image characteristics on a computed tomographic scan of the injured spleen can reliably guide the surgeon's decisions.[13] If a celiotomy is performed, a second decision must be made; surgeons can either attempt repair of the organ or achieve immediate hemostasis by splenectomy.[12] During consideration of whether to initiate splenic repair, the surgeon is influenced by an assessment of the extent of injury and familiarity with the techniques of splenic repair. For decades, authors have recommended that extraordinary efforts be made to salvage the spleen in children.[7,8] Only recently have authors recommended nonoperative management of selected splenic injuries in adults.[11,13,14]

It is reasonable to expect that a surgeon's management decisions should be influenced by the available hospital resources. Personnel and equipment in large tertiary care trauma centers substantially exceed the resources available to surgeons in small rural facilities. As mentioned earlier, one intention of this retrospective cohort study was to examine the outcomes of patients with splenic injury treated in rural areas and compare their outcomes with patients treated in major metropolitan hospitals and urban hospitals. We hypothesized that surgeons practicing in small hospitals would decide less frequently to perform splenic salvage than surgeons in large trauma centers because rural surgeons would judge it safer to expeditiously and definitively control the problem by splenectomy.

There is limited information in the literature, based on population studies, of variation in management of splenic injury related to geographic factors. Rutledge et al[15] reported that nonoperative management of splenic injury was increasingly selected during a 5-year period from 1988 to 1992 in North Carolina. These authors determined that nontrauma centers, many of which were rural, had lower rates of nonoperative management. In our study, hospital discharge data from the state of Washington between 1990 and 1994 were used to determine the influence of geographic location on the choice of splenic injury management. Additionally, we associate important outcome variables with each type of management, including 30-day mortality, 60-day rehospitalization rates, and length of stay (LOS). We were particularly interested in whether nonoperative management was associated with the long hospitalizations reported to have occurred in North Carolina by Rutledge et al.[15]

WASHINGTON STATE TRAUMA SYSTEM

During the period of data collection, there were important changes in the Washington State health care system that may have influenced the outcomes being measured. First, the influence of managed care on the practice of surgery increased, which increased incentives for reducing length of hospital stay. Additionally, during the time span of this study, a statewide trauma system was planned and implemented.

The Washington Trauma Care Act was passed by the Washington legislature in 1990. Rule formulation, administrative procedures, and codes were adopted with authority given to the Washington State Department of Health, Office of Emergency Medical and Trauma Prevention, to designate trauma centers. In addition to the 4 levels of trauma centers defined in the American College of Surgeons resource document for the optimal care of injured patients[16] (levels I through IV), administrators in the Office of Emergency Medical and Trauma Prevention added criteria to the Washington administrative rules for designation of remote rural trauma centers as level V trauma centers. Starting in January 1994, trauma centers were designated, and by February 1997, the designation process was completed, with 1 level I, 6 level II, 20 level III, 32 level IV, and 14 level V. Five pediatric trauma centers had also been designated throughout the state by 1997. During the period under study, approximately one third of the trauma centers had completed the designation process, and most of the others were preparing for designation. During the period of this study, factors influencing the care of patients with spleen injury may have included changes in personnel, additional equipment, and new processes of care associated with implementation of the trauma system. Thus, we anticipated changes in the way surgeons treat spleen-injured patients during the period of the study.

RESULTS

BIVARIATE ANALYSES

During the 5 years of analysis, a total of 1500 adult and 405 pediatric patients were hospitalized with a spleen injury (based on *ICD-9-CM* codes) in Washington State (**Table 1**). Adults had a median age of 30 years (range, 16-79 years) and a median ISS of 16 (range, 4-59), and 70.1% were male. Pediatric patients had a median age of 10 years (range, 1-15 years) and a median ISS of 12 (range, 4-50), and 71.0% were male. Although the median ISS was statistically different across regions for adults, this finding is more a reflection of sample size than a clinically meaningful difference in injury severity. The mean ISS for pediatric patients in rural areas was lower than in the other regions but was not statistically significant.

The geographic distributions of adult and pediatric patients were similar (Table 1). Approximately 30% of patients were hospitalized in metropolitan hospitals, about one half in urban hospitals, and the remaining 20% in rural hospitals. During the 5 years of observation, no significant differences occurred in the annual number of hospitalized patients with a diagnosis of spleen injury. During the same period, the state's population of adults and children increased, resulting in an overall decline in hospitalization rates for spleen injury of 17.3% among the pediatric population and 9.4% for the adult population.

Table 1. Summary Demographics of Patients With Splenic Injury in Each of the 3 Comparison Groups

Characteristic	Metropolitan	Urban	Rural	P
Adult Patients (Aged 16-79 y)				
No. (%)	538 (36)	673 (45)	289 (19)	
Age, y				
Range	16-78	16-79	16-79	.69
Median	30	30	30	
Injury Severity Score				
Range	4-59	4-57	4-50	<.007
Median	17	16	16	
Sex, No. (%) male	387 (72)	464 (69)	201 (70)	.51
Year, No. (%)				
1990	115 (36)	148 (46)	55 (17)	.04
1991	100 (37)	115 (43)	55 (20)	
1992	124 (42)	110 (37)	64 (22)	
1993	97 (32)	141 (47)	64 (21)	
1994	102 (33)	159 (51)	51 (16)	
Pediatric Patients (Aged 1-15 y)				
No. (%)	122 (30)	209 (52)	74 (18)	
Age, y				
Range	1-15	1-15	2-15	.20
Median	10	11	11	
Injury Severity Score				
Range	4-50	4-50	4-43	.17
Median	8	12	5	
Sex, No. (%) male	84 (69)	147 (70)	56 (76)	.58
Year, No. (%)				
1990	31 (38)	36 (44)	14 (17)	.49
1991	28 (33)	47 (55)	10 (12)	
1992	24 (27)	46 (52)	18 (20)	
1993	20 (26)	41 (54)	15 (20)	
1994	19 (25)	39 (52)	17 (23)	

Table 2. Management of Splenic Injury in Adult Patients

	Nonoperative	Splenectomy	Splenic Salvage	P
Overall	509 (34)	700 (47)	291 (19)	
Hospital location				
Metropolitan	165 (31)	233 (43)	140 (26)	<.007
Urban	243 (36)	320 (48)	110 (16)	
Rural	101 (35)	147 (51)	41 (14)	
Year				
1990	87 (27)	165 (52)	66 (21)	.03
1991	79 (29)	133 (49)	58 (22)	
1992	110 (37)	128 (43)	60 (20)	
1993	108 (36)	136 (45)	58 (19)	
1994	125 (40)	138 (44)	49 (16)	
Age, y				
16-24	208 (39)	208 (39)	118 (22)	<.007
25-44	214 (32)	315 (48)	134 (20)	
45-79	87 (29)	177 (58)	39 (13)	
Sex				
M	368 (35)	484 (46)	200 (19)	.42
F	141 (32)	216 (48)	91 (20)	
Injury Severity Score*				
0-6	163 (58)	63 (22)	57 (20)	<.007
7-15	164 (49)	96 (29)	75 (22)	
≥16	178 (20)	536 (62)	157 (18)	
Median length of stay for survivors, d				
1990	6	8	8	.05
1991	4	8	8	
1992	5	6	6	
1993	5	6	7	
1994	4	6	6	
Hospital mortality	16 (3)	67 (10)	27 (9)	<.007
30-d Mortality	18 (4)	69 (10)	27 (9)	<.007

**Injury Severity Score was not calculated for 11 subjects because of indeterminate coding of Abbreviated Injury Scores. Unless otherwise indicated, values are presented as number (percentage).*

For adults, the frequency of nonoperative management of splenic injury increased during the years of study from 27.4% in 1990 to 40.1% in 1994 (**Table 2**). In the adult patients who did have abdominal surgery, more than twice as many had their spleens removed than had their spleens repaired. In the pediatric population, the frequency of nonoperative management was consistently high for all ages over time, ranging between 60.0% and 71.1% (**Table 3**). Among the children who had abdominal surgery, fewer had their spleens removed than repaired.

MULTIVARIATE ANALYSES

The characteristics identified in the logistic regression model as associated with higher odds of operative management, and of splenectomy among those treated operatively, varied depending on whether the model was applied to adults or children (**Table 4** and **Table 5**). Odds of operative management decreased over time among adults but not among children, and odds of operative management did not differ significantly among the geographic regions in either group (Table 4). In the adult cohort, patients treated in rural and urban hospitals had higher odds of splenectomy than patients in King County (the single metropolitan region [Table 5]). In contrast, children in rural hospitals had lower odds of splenectomy. For adults older than 45 years and those with an ISS greater than 15, the odds were substantially higher that they would have a splenectomy. Older children (older than 7 years) had higher odds of splenectomy than infants and toddlers.

OUTCOME: DEATH, TRANSFER, AND REHOSPITALIZATION

The mortality rate based on status at hospital discharge was 2.9% in children, compared with 7.3% in the adult population (Tables 2 and 3). An additional 4 deaths were documented among adults within 30 days of hospital discharge. No additional deaths among children were recorded at 30 days. At 30 days after hospital discharge, 68 (12.6%) and 7 (5.7%) spleen-injured adults and children, respectively, died in the metropolitan region. In the urban regions, 38 adults (5.6%) and 3 children (1.4%) died, and in the rural regions, 8 adults (2.8%) and 2 children (2.7%) died. The 30-day mortality was significantly lower among adults with nonoperative management. However, this bivariate finding may be confounded by injury severity. Pediatric patients undergoing splenectomy had a significantly higher mortality than those treated nonoperatively or those undergoing splenic salvage.

Table 3. Management of Splenic Injury in Pediatric Patients*

	Nonoperative	Splenectomy	Splenic Salvage	P
Overall	268 (66)	62 (15)	75 (18)	
Hospital location				
Metropolitan	79 (65)	22 (18)	21 (17)	.42
Urban	136 (65)	34 (16)	39 (19)	
Rural	53 (72)	6 (8)	15 (20)	
Year				
1990	51 (63)	15 (18)	15 (18)	.24
1991	56 (66)	8 (9)	21 (25)	
1992	62 (70)	13 (15)	13 (15)	
1993	54 (71)	14 (18)	8 (10)	
1994	45 (60)	12 (16)	18 (24)	
Age, y				
1-6	62 (78)	3 (4)	15 (19)	<.007
7-12	127 (71)	25 (14)	27 (15)	
13-15	79 (54)	34 (23)	33 (23)	
Sex				
M	193 (67)	45 (16)	49 (17)	.50
F	75 (64)	17 (14)	26 (22)	
Injury Severity Score				
0-6	158 (87)	7 (4)	17 (9)	<.007
7-15	44 (70)	6 (10)	13 (21)	
≥16	66 (41)	49 (31)	45 (28)	
Median length of stay for survivors, d				
1990	4	6	6	.48
1991	5	6	6	
1992	4	4	6	
1993	4	6	6	
1994	4	5	6	
Mortality	2 (1)	8 (13)	2 (3)	<.001
30-d Mortality	2 (1)	8 (13)	2 (3)	<.001

*Unless otherwise indicated, values are presented as number (percentage).

The LOS in the hospital for adults and children differed with the method of splenic injury management (Tables 2 and 3). Adults with nonoperative management of their spleen injury had a median LOS of 5 days, compared with patients who underwent a splenic salvage (7 days) or splenectomy (7 days). The median LOS for children with nonoperative management was shorter (4 days) than that for pediatric patients undergoing splenic salvage (6 days) or splenectomy (5 days).

Ninety-eight patients were transferred directly from one hospital to another, and of these, 30 had a splenectomy at the first hospital and an additional 6 had a splenectomy at the second hospital. Overall, 44 patients were rehospitalized, and 12 of these had a splenic procedure during the second hospitalization including, in 9 cases, a delayed splenectomy. Fifteen (4.1%) of the 366 patients initially treated with attempted splenic repair during the initial hospitalization were subsequently reported to have had a splenectomy.

COMMENT

During the 5 years of study, there was considerable variability in processes of care selected by surgeons in Washington State to treat patients with splenic injury. Younger

Table 4. Odds of Operative Management (vs Nonoperative Management) of Splenic Injury*

	Adult (n = 1500)		Pediatric (n = 405)	
Characteristic	OR	95% CI	OR	95% CI
Hospital location				
Metropolitan	1.00	Reference	1.00	Reference
Urban	0.86	0.66-1.11	0.65	0.37-1.13
Rural	0.95	0.69-1.32	0.60	0.28-1.27
Year				
1990	1.00	Reference	1.00	Reference
1991	0.92	0.63-1.35	0.96	0.46-2.01
1992	0.65	0.45-0.94	0.81	0.38-1.74
1993	0.67	0.47-0.97	0.67	0.30-1.46
1994	0.60	0.42-0.86	0.99	0.46-2.13
Age, y (adults/children)				
16-24/1-6	1.00	Reference	1.00	Reference
25-44/7-12	1.38	1.06-1.78	1.75	0.87-3.50
45-79/13-15	1.68	1.21-2.33	4.30	2.09-8.82
Sex				
F	1.00	Reference	1.00	Reference
M	0.88	0.68-1.13	0.65	0.38-1.12
Injury Severity Score				
1-6	1.00	Reference	1.00	Reference
7-15	1.36	0.99-1.87	2.55	1.22-5.30
≥16	5.09	3.82-6.79	10.76	6.12-18.94

*OR indicates odds ratio; CI, confidence interval.

Table 5. Odds of Splenectomy (vs Splenic Salvage) in Patients Undergoing Abdominal Surgery of Any Form*

	Adult (n = 991)		Pediatric (n = 137)	
Characteristic	OR	95% CI	OR	95% CI
Hospital location				
Metropolitan	1.00	Reference	1.00	Reference
Urban	1.83	1.33-2.52	0.59	0.25-1.40
Rural	2.22	1.45-3.38	0.22	0.06-0.76
Year				
1990	1.00	Reference	1.00	Reference
1991	0.92	0.59-1.43	0.35	0.10-1.17
1992	0.89	0.57-1.38	1.07	0.34-3.36
1993	0.88	0.57-1.38	2.27	0.63-8.19
1994	1.11	0.70-1.75	0.68	0.22-2.09
Age range, y (adults/children)				
16-24/1-6	1.00	Reference	1.00	Reference
25-44/7-12	1.47	1.06-2.02	9.56	2.06-44.40
45-79/13-15	3.03	1.95-4.71	9.63	2.11-43.88
Sex				
F	1.00	Reference	1.00	Reference
M	1.24	0.90-1.71	0.99	0.41-2.35
Injury Severity Score				
1-6	1.00	Reference	1.00	Reference
7-15	1.16	0.72-1.88	0.70	0.16-2.99
≥16	3.42	2.27-5.16	2.24	0.78-6.42

*OR indicates odds ratio; CI, confidence interval.

age groups demonstrated consistently higher splenic salvage rates. The treatment of adults with splenic injury, however, changed during the years of study, with a substantial shift to nonoperative management. This change in process of care was successful at increasing the odds of splenic salvage for adults (without increasing LOS).

The treatment of adult patients with splenic injury varied depending on whether they had a laparotomy in a hospital located in a rural area vs an urban or metropolitan hospital. Patients in rural communities were more likely to have a splenectomy, an observation consistent with the hypothesis that factors associated with practice setting influence process of care. As expected, patients were less likely to have splenic salvage if they had severe, multiorgan injuries.

The 30-day mortality analysis indicated that a majority of patients died in the single metropolitan area, which is reasonable, since seriously injured patients would activate the trauma system and be transported to the state's only level I trauma center, in Seattle. The majority of deaths occurred in patients who had had a splenectomy, which also appears appropriate, since this group would require definitive treatment to circumvent the complication of delayed hemorrhage.

Plausible explanations for the variability in treatment can be postulated. The years in which surgeons throughout Washington State decreased their reliance on laparotomy to control splenic injury coincided with the emergence of reports in the medical literature that nonoperative management was safe and effective for adults. Also, adults treated in rural communities had higher odds of spleen removal, which may reflect the preference in communities with fewer resources for definitive control of hemorrhage and a reluctance to pursue treatments with a risk of postoperative hemorrhage. On the other hand, rural surgeons had an equivalent willingness to choose nonoperative management as the urban surgeons, indicating that they modified their practice in regard to that decision during the years of study.

The treatment of children was different than that of adults. There was a consistently high prevalence of nonoperative management in the pediatric population. Younger patients were less likely to undergo splenectomy if they had a laparotomy in a rural area. However, this subset of patients was small, and, thus, conclusions must be evaluated with caution. Splenic salvage has been the standard of care for children for more than 2 decades, while during the same time span nonoperative management of adult spleen injury remained relatively unchanged. Multiple case series reports document nonoperative management rates for pediatric spleen injury in the 60% to 70% range. A similar transition in the management of adult spleen injury finally did occur in the late 1980s and early 1990s, although not to the same extent. The increased use of nonoperative management of splenic injury among pediatric patients in this study is probably a reflection of the long-standing standard of care for management of pediatric spleen injury.

These findings suggest that, when conducting a multiregional analysis of the appropriateness of care offered spleen-injured patients, one must account for expected variation in the process of care. Variability in decision making is consistent with appropriate care if practitioners apply sound judgments influenced by local factors. Thus, sophisticated adjustments in analyses of quality of care delivered to trauma patients will be required to provide a realistic, and thus persuasive, perspective on the appropriate processes of care.

COST OF CARE is also an important component to consider when processes of care are assessed. The optimal length of hospitalization for patients with spleen injury who were treated nonoperatively remains unknown. An established risk associated with not removing an injured spleen is sudden delayed hemorrhage, which can prove life-threatening. The advantage of prolonged hospitalization in nonoperatively treated patients (where immediate treatment is available should a catastrophic hemorrhage occur) must be offset by the substantial added costs. During the study period in Washington, there were incentives attributed to managed care to control health care costs by reducing length of hospitalization. Notable in this study was that LOS for nonoperative management declined and was approximately 50% of the LOS reported by Rutledge et al.[15] Shorter LOS was not associated with a measurable increase in the frequency of reoperation for delayed hemorrhage. In the linked database, it was determined that 1% of all patients required a second hospitalization for splenic injury. The nonoperative failure rate was 3%. These data indicate that nonoperative management for adults was successfully implemented, with the associated benefit of reduced LOS and thereby lower cost of care.

There are several limitations associated with our findings that result from our reliance on hospital claims data. It is possible that financial incentives may have influenced the diagnostic designations given to patients with "suspected" spleen injuries. This potential bias would increase the reported number of minor injuries. Second, we assumed that a patient with a previously injured spleen who was hospitalized again did not sustain a second injury. Since recidivism among trauma patients is common, the 3% prevalence of second hospitalization may overrepresent the prevalence of delayed hemorrhage. Third, some patients with a discharge diagnosis of "injured spleen" may have sustained the injury as a complication during a laparotomy for reasons unrelated to trauma. Finally, because the patients hospitalized in communities near the border of adjacent states may have been hospitalized a second time in another state, their second hospitalization would not be included in a single state's claims data. In summary, the information regarding follow-up hospitalizations must be considered an estimate. Although limited by the assumptions inherent in the calculations, these analyses suggest that therapeutic decisions favoring splenic salvage were not associated with the substantial problem of delayed hemorrhage requiring splenectomy.

There are other generic limitations associated with the use of claims data. Hospital discharge indexes have been shown to provide adequate information for studies of this type when the database information is complete,[22] but the accuracy of diagnosis and procedure coding varies substantially across conditions.[23,24] Washington hospitals were permitted to list only 5 to 9 diagnostic codes and 3 to 6 procedure codes per patient, which may have introduced a selection bias.[25] For this population of trauma patients, the individuals with multiple injuries had a greater likelihood that diagnoses and procedures were not included on the limited list of codes and

thus would be excluded from the study population. Additionally, there was no unique assessment of splenic injury severity in this database. While 3 levels of Abbreviated Injury Scores corresponding to severity of splenic injury are available, we opted to allow these specific severity indexes to contribute to the calculated value of the ISS score rather than make independent assessments.

It is not possible to determine if the trauma system was a major factor contributing to the increased frequency of splenic salvage noted during the 5 years of the study. Associated with implementation of the Washington Trauma System were quality-of-care evaluations and feedback to providers intended to favorably influence processes of care. Concurrent temporal trends, such as greater confidence in the interpretation of enhanced abdominal computed tomographic scans, also occurred during these years. Surgeon characteristics that may have affected management decisions, such as age, training, and trauma experience, were also not available for comparison. Without more specific provider information, determining the influence of trauma system implementation on provider decision making would only be speculative.

CONCLUSIONS

The evaluation of a statewide database indicates substantial variability in the treatment of spleen injury, which appears to have been appropriate. When the appropriateness of care across rural and urban communities is evaluated, methods should be used to account for the range of clinical decisions corresponding to appropriate care in specific circumstances. As advocates of trauma systems are increasingly required to provide evidence of cost-effective care, more complex methods of analyses that account for appropriate variability in practice will be needed.

This study was supported by grant R49/CCR-006283 from the Public Health Service, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, Atlanta, Ga.

The authors are solely responsible for the content of this article, and the opinions do not necessarily represent the views of the Centers for Disease Control and Prevention.

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