# Management of splenic injuries in a Canadian trauma centre

Bryan G. Garber, MD, FRCSC;* Jean-Denis Yelle, MD, FRCSC;† Robin Fairfull-Smith, MD, FRCSC; John W. Lorimer, MD, FRCSC; Cathy Carson, RN

Objectives: To document the current practice pattern for the treatment of splenic injuries in one Canadian trauma centre and to identify factors that determined which method was employed.

Design: A cohort study.

Setting: A Canadian lead trauma centre.

Patients: A cohort of 100 patients with splenic injury treated at one trauma hospital over 5 years was identified from a prospective trauma database.

Main Outcome Measures: The success rate and failure rate for splenic salvage by splenectomy, splenorrhaphy or observation. Volume of blood transfused, injury severity score (ISS) and method of diagnosis.

Results: The median ISS for the cohort was 34 (36 for splenectomy, 38 for splenorrhaphy and 35 for observation). A blunt mechanism of injury was present in 96%. The diagnosis was made by computed tomography (CT) in 55%. Splenic salvage was accomplished in 51 patients; of these, 44 (86%) were in the observation group, and the success rate was 90% (within the range reported in the literature). Only seven patients underwent splenorrhaphy. CT was performed more frequently in the observation group than in the splenectomy group (82% v. 25%, $p < 0.0001$). The splenectomy group had more blood tranfused than the successful observation group (mean units 15 v. 3, $p = 0.0001$) and had a higher median ISS (36 v. 29, $p = 0.02$). Multivariate analysis revealed that the method of diagnosis (CT v. diagnostic peritoneal lavage) was the strongest factor associated with how the splenic injury was treated.

Conclusions: The finding in this report of an increase in observational treatment of splenic injuries represents a shift in practice from a previous Canadian report and is in keeping with recent published trends from the United States. Future studies are needed to assess whether any strong regional practice pattern variations in the management of blunt splenic injuries exists in other trauma centres across Canada.

Objectifs : Documenter les tendances de la pratique actuelle en ce qui a trait au traitement des traumatismes spléniques dans un centre de traumatologie du Canada et identifier les facteurs qui ont déterminé la méthode utilisée.

Conception : Étude de cohortes.

Contexte : Un grand centre de traumatologie du Canada.

Patients : On a tiré d'une base de données prospective sur les traumatismes possibles une cohorte de 100 patients victimes d'un traumatisme splénique qui ont été traités à un hôpital de traumatologie au cours d'une période de 5 ans.

Principales mesures des résultats : Le taux de réussite et d'échec en ce qui a trait à la préservation de la rate par splénectomie, splénorraphie ou observation. Volume de sang transfusé, indice de gravité des traumatismes et méthode de diagnostic.

*From the Division of General Surgery and Trauma Services, Ottawa General Hospital, Ottawa, Ont.*

**Fellow in surgery and critical care, University of Ottawa*

*†Assistant Professor of Surgery, University of Ottawa. Co-director of Trauma, Ottawa General Hospital*

*Accepted for publication May 24, 1996*

***Correspondence to:*** *Dr. Bryan G. Garber, Division of General Surgery, Rm K-11, Ottawa General Hospital, 501 Smyth Rd., Ottawa ON K1H 8L6*

RÉSULTATS : L'indice médian de gravité des traumatismes s'est établi à 34 (36 pour la splénectomie, 38 pour la splénorraphie et 35 pour l'observation) de la cohorte. Il y avait présence d'un traumatisme fermé dans 96 % des cas. Le diagnostic a été posé par scanographie tomodensitométrique dans 55 % des cas. On a réussi à préserver la rate chez 51 patients, dont 44 (86 %) faisaient partie du groupe des sujets observés. Le taux de réussite a atteint 90 % (ce qui est à l'intérieur de la fourchette indiquée dans la littérature scientifique). Sept patients seulement ont subi une splénorraphie. On a procédé à une scanographie plus souvent chez les sujets du groupe observé que chez ceux qui ont subi une splénectomie (82 % c. 25 %, $p < 0{,}0001$). Les sujets qui ont subi une splénectomie ont reçu plus de sang par transfusion que ceux chez lesquels l'observation a réussi (médiane de 15 unités c. 3, $p = 0{,}0001$) et ont présenté un indice de gravité du traumatisme plus élevé (36 c. 29, $p = 0{,}02$). L'analyse à variables multiples a révélé que la méthode de diagnostic (scanographie c. lavage péritonéen de diagnostic) constituait le facteur le plus puissant lié au traitement du traumatisme splénique.

CONCLUSIONS : Dans ce rapport, on conclut à une augmentation du traitement par observation des traumatismes spléniques, ce qui représente un changement de la pratique par rapport à un rapport canadien antérieur. C'est aussi conforme à des tendances publiées récemment en provenance des États-Unis. Il faut procéder à d'autres études pour déterminer s'il existe, dans d'autres centres de traumatologie du Canada, des variations importantes entre les régions quant aux tendances de la pratique en ce qui concerne le traitement des traumatismes spléniques fermés.

The management of splenic trauma has changed over the last 20 years from routine splenectomy to selective salvage of the spleen by observation or splenorrhaphy. The trend to splenic conservation began in the pediatric population[1–4] because of concerns about postsplenectomy sepsis.[5–7] Although the relative merits of the different therapeutic options remain controversial,[8] splenic salvage has become common in adults. This has been aided by improved abdominal imaging and advances in the techniques for splenic repair.

Despite many reports of successful management of splenic injuries by observation,[9–14] some centres have accomplished salvage mainly by performing splenorrhaphy. Molin and Shackford[15] reported that splenorrhaphy was done in 39% of injuries, splenectomy in 59% and observation in only 4%. More recently, Rutledge and colleagues[16] reported a state-wide time series analysis of the frequency of nonoperative management of all solid organ injuries. They found that the proportion of splenic injuries treated by observation increased over 5 years from 33% to 49%. Two studies have described the management of splenic injuries in Canadian trauma centres. The first study, published in 1987, reported that 64% of splenic injuries were treated by splenectomy, 12% by splenorrhaphy and 24% by observation.[17] A later study in 1991 documented that half of all isolated splenic injuries were treated by observation.[18] We are unaware of any Canadian reports that compare current practice in the management of splenic injuries with the experience being reported from the United States. The objectives of this study were to document our current practice pattern for the treatment of splenic injuries and to identify factors that determined the method of treatment that was employed.

## METHODS

A prospective cohort of all patients with splenic injuries treated at the Ottawa General Hospital between 1991 and 1995 was assembled for this study. This hospital is the lead trauma centre for the Ottawa-Carleton area of Eastern Ontario and serves part of Western Quebec. On average 220 trauma patients are admitted annually having an injury severity score (ISS) greater than 15. Data on all trauma admissions were collected prospectively by trained nurse-abstractors. Identified cases were then cross-referenced with a search of medical records to confirm that all cases of splenic trauma were captured. All charts were independently adjudicated to confirm the accuracy of registry data.

Data collected for analysis included age, sex, mechanism of injury, associated anatomic injuries, ISS, abbreviated injury score (AIS) for the abdomen and pelvis, mean arterial pressure on admission (MAP), total number of units of blood transfused, method of treatment of the splenic injury, length of hospital stay and all-cause 30-day mortality. Operative definitions for associated anatomic injuries were as follows:

- Neurologic (central nervous system) — documented intracranial hemorrhage or contusion with or without significant depression of conciousness and a Glasgow Coma Scale score less than 8, spinal cord injury with sensorimotor deficits.
- Thoracic — injuries to heart, great vessels and lungs, hemothorax or pneumothorax but excluding rib fractures.
- Associated intra-abdominal injuries — injuries to all internal organs of the abdomen and pelvis, excluding the gastrointestinal tract.
- Bowel injuries — intra-abdominal injuries to the gastrointestinal tract.
- Fractures of long bones — all

fractures of upper and lower extremity long bones.

• Fractures of pelvis — minor fractures that did not require stabilization and major fractures that did require stabilization.

• Fracture of ribs — any rib fractures documented by clinical or radiologic examination.

• Multiple injuries — more than two organ systems injured.

Descriptive analysis was performed on all variables, and patients were divided into four treatment groups: splenectomy; observation (successful); observation (failed) and splenorrhaphy. For the purposes of this study, observation included observed nonoperative cases and nonbleeding splenic injuries identified at laparotomy that were not repaired. Univariate analyses compared variables in the splenectomy versus observation (successful) treatment groups, observation (successful) versus observation (failed) and observation (successful) versus splenorrhaphy groups. All continuous variables were analysed by either parametric procedures (Student's *t*-test) or nonparametric procedures (Mann–Whitney U test). Unless stated otherwise, all values are given as means (and standard deviations). Categorical variables were analysed by unadjusted $\chi^2$ tests. Absolute *p* values and 95% confidence intervals were reported where appropriate, and no corrections were made for multiple comparisons. Logistic regression analysis was performed to identify characteristics that accurately predicted the type of treatment (splenectomy v. nonoperative) chosen for the splenic injury while controlling for confounding by other variables.

## Findings

One hundred patients were admitted with a diagnosis of splenic injury. The mean age of the cohort was 34 (18) years and 73% were male. The median ISS was 34 (with a range of 71) and the death rate was 21% (Table I). Blunt trauma caused 96% of injuries (Table II). Multiple injuries were present in 34% of patients (Table III). The most frequent associated
injuries were thoracic (59%), intra-abdominal injuries (56%) and fractured ribs (48%). The diagnosis of splenic injury was made by CT in 55% of all cases, by diagnostic peritoneal lavage (DPL) in 26% and at laparotomy in 15% (Table IV).

Splenic salvage was attempted in 56 patients (49 observed and 7 splenorrhaphy) and was accomplished in 51 patients (44 successful nonoperative and 7 splenorrhaphy). Observation constituted the predominant form of splenic salvage and had a success rate of 90% (five failures out of 49 attempts). All patients who failed observation underwent splenectomy; none of them died.

Univariate analysis comparing the splenectomy group with the observation (successful) group revealed that the former had a higher median ISS (36 v. 29, $p = 0.0236$), a larger mean number of units of blood transfused (15 v. 3, $p = 0.0001$) and a higher abdominal AIS (4.5 v. 2.7, $p = 0.0001$) (Table I). There was a marked difference in the method of diagnosis by treatment group (Table IV), with 82% of the successful nonoperative group being diagnosed by CT compared with only 25% of the splenectomy

**Table I**

**Characteristics of 100 Patients With Splenic Injury, According to Treatment Categories. Numbers are Means (and Standard Deviations) Unless Noted Otherwise**

| Characteristic | Entire cohort, *n* = 100 | Splenectomy, *n* = 44 | Observation | | Splenorrhaphy, *n* = 7 |
|---|---|---|---|---|---|
| | | | Successful, *n* = 44 | Failed, *n* = 5 | |
| Age, yr | 34 (18) | 35 (19) | 33 (14) | 54 (17)* | 37 (25) |
| Sex, % male | 73 | 73 | 77 | 75 | 42 |
| ISS, mean (range) | 34 (71) | 36 (59)† | 29 (71) | 41 (30) | 38 (36) |
| AIS | 3.6 (0.12) | 4.5 (0.59)‡ | 2.7 (1.07) | 3.3 (0.50) | 3.0 (1.15) |
| MAP, mm Hg | 70 (26) | 66 (26) | 73 (28) | 76 (10) | 74 (27) |
| Blood, units | 9 (12) | 15 (15)‡ | 3 (5) | 11 (3) | 8 (7.5) |
| LOHS, median (range) | 10 (284) | 10 (283) | 10 (83) | 27 (31) | 6 (85) |
| Mortality, % (95% CI) | 21 (13–29) | 22 (10–34) | 15 (10–25) | 0 | 42 (5–79) |

ISS = injury severity score, AIS = abbreviated injury scale, MAP = mean arterial pressure on arrival at hospital, LOHS = length of hospital stay in days
*$p = 0.002$ Student's *t*-test comparing successful v. failed observation groups
†$p = 0.0236$ Mann–Whitney U test comparing splenectomy v. observation (successful) group
‡$p < 0.0001$ Student's *t*-test comparing splenectomy v. observation (successful) group

group ($p < 0.0001$). At laparotomy for associated intra-abdominal injuries, four patients in the successful observation group were found to have stable splenic injuries that did not require repair. Patients who underwent splenectomy had a higher incidence of bowel injuries (30% v. 5%, $p = 0.004$) and a lower incidence of thoracic injuries (48% v. 75%, $p = 0.01$) than those who underwent successful observation (Table III). There were no differences in the etiology of the injury between these two groups (Table III). When logistic regression analysis was applied to control for confounding, the variables that most strongly identified patients who were succesfully managed by observation (Table V) were diagnosis made by CT (odds ratio = 11.1), less than 5 units of blood transfused (odds ratio = 8.1) and ISS less than 34 (odds ratio = 4.5).

Five patients initially identified for observation subsequently underwent splenectomy for a failure rate of 10% (5 of 49); none of these patients died. Univariate analysis comparing this group with those from the successful observation group revealed that those in whom treatment failed were significantly older (mean age 54 v. 33 years, $p = 0.002$), had more blood transfused (mean 11 v. 3 units, $p = 0.002$) and had a longer hospital stay (median 27 v. 10 days, $p = 0.03$).

Splenorrhaphy was performed in seven patients; none required reoperation. When compared with the suc-

**Table II**

**Mechanism of Injury According to Treatment Groups. Results Expressed as Numbers (and Percentages)**

| Mechanism | Entire cohort, $n = 100$ | Splenectomy, $n = 44$ | Observation | | Splenorrhaphy, $n = 7$ |
|---|---|---|---|---|---|
| | | | Successful, $n = 44$ | Failed, $n = 5$ | |
| Blunt trauma (all) | 96 | 41 (93) | 43 (98) | 5 (100) | 7 (100) |
| MVA | 69 | 31 (70) | 29 (66) | 3 (60) | 6 (86) |
| BCA | 11 | 5 (11) | 5 (11) | 0 | 1 (14) |
| SMA | 4 | 1 (2) | 2 (5) | 1 (20) | 0 |
| MCA | 9 | 3 (7) | 5 (11) | 1 (20) | |
| PED | 3 | 1 (2) | 2 (5) | 0 | 0 |
| Penetrating (all) | 4 | 3 | 1 | 0 | 0 |

MVA = motor vehicle accidents, BCA = bicycle accidents, SMA = snowmobile accidents, MCA = motor collision accidents, PED = pedestrian accidents

**Table III**

**Associated Injuries According to Treatment Groups. Results Expressed as Numbers (and Percentages)**

| Injury | Entire cohort, $n = 100$ | Splenectomy, $n = 44$ | Observation | | Splenorrhaphy, $n = 7$ |
|---|---|---|---|---|---|
| | | | Successful, $n = 44$ | Failed, $n = 5$ | |
| Central nervous system | 32 | 11 (25) | 16 (36) | 2 (40) | 3 (43) |
| Thoracic | 59 | 21 (48) | 33 (75)* | 3 (60) | 2 (29) |
| Intra-abdominal | 56 | 26 (59) | 23 (52) | 1 (20) | 6 (86) |
| Bowel | 18 | 13 (30) | 2 (5)† | 0 | 3 (43) |
| Long bone fracture | 34 | 14 (32) | 16 (36) | 1 (20) | 3 (43) |
| Pelvic fracture | | | | | |
| Minor | 22 | 11 (25) | 9 (20) | 0 | 2 (29) |
| Major | 1 | 0 | 1 (2) | 0 | 0 |
| Rib fracture | 48 | 19 (43) | 23 (52) | 3 (60) | 3 (43) |
| Multiple | 34 | 16 (36) | 15 (34) | 1 (20) | 2 (29) |

*$p = 0.01$ $\chi^2$ comparing splenectomy v. observation (successful) group
†$p = 0.004$ $\chi^2$ comparing splenectomy v. observation (successful) group

cessful observation group, the splenorrhaphy group contained less males (42% v. 77%), a higher median ISS (38% v. 29%) and a higher death rate (42% v. 15%). However, none of these differences was statistically significant.

## Discussion

In our study, splenic salvage was accomplished in 51% of splenic injuries, with observation being the predominant form of treatment. Observation failed in 10% of patients, and these patients subsequently underwent splenectomy, with no deaths. Only seven patients were treated by splenorrhaphy and none required reoperation. A blunt mechanism of injury accounted for 96% of all splenic trauma in this cohort. Those who were treated by observation were more likely to have had their splenic injury diagnosed by CT, had a lower ISS and less blood transfused than those treated by splenectomy. These results confirm that adoption of splenic conservation, primarily by observation, has become common in our institution and is a relatively safe treatment course for adult trauma victims.

Splenic salvage can be accomplished either by observation[9–15] or by splenorrhaphy.[19–22] Advocates of observation have argued that this approach avoids laparotomy in many splenic injuries and reduces the risk of later postsplenectomy sepsis.[5–7] A recent study reported that the use of observation for splenic injuries increased in North Carolina from 33% to 49% over 5 years[16] and thus confirmed the acceptance of this approach in many trauma centres in the United States. It is unclear to what extent Canadian trauma centres have adopted splenic conservation strategies. An early report from 1987 indicated that in 64% of blunt splenic injuries the patients were being treated by splenectomy, whereas 11% underwent splenorrhaphy and only 24% were managed by observation.[17] In a subsequent paper, published 4 years later, half of all such injuries were treated by observation.[18] However, the latter study excluded patients with multiple injuries, making comparison with our experience difficult. At present, half of all splenic injuries occurring in our hospital result in salvage, and this was primarily accomplished by observation.

Success rates for observational management in blunt splenic injuries have varied from 7% to 100%.[9–15] Five of our patients who were initially identified for this approach subsequently required splenectomy, giving us a success rate of 90%, which is well within the acceptable range. Although univariate analysis revealed that these patients were generally older than those who were successfully managed by observation, the small number of cases limits our ability to generalize any factors that would predict failure in other trauma hospitals. The most important observation is that none of these patients died, a finding that supports the contention that this therapy is safe if performed in a specialized centre.

The wide range in reported success rates for observation may be the result of variations in the selection criteria used as well as differences in transfusion practice among surgeons. Success of observation was improved in the study of Smith and colleagues[14] by implementation of the following prospectively developed guidelines: hemodynamic stability; age less than 55 years; CT appearance of grade I, II or III injury; absence of other injuries complicating abdominal assessment; and ab-

**Table V**

**Logistic Regression Model of Successful Nonoperative Treatment Versus Splenectomy. Ratios Represent the Odds of Successful Nonoperative Management Associated With Each Factor**

| Factor | Odds ratio | 95% confidence interval |
|---|---|---|
| Diagnosis by computed tomography | 11.1 | 2.0–26.3 |
| < 5 units of blood | 8.1 | 1.9–34.9 |
| Injury severity score < 34 | 4.5 | 1.3–16.2 |

**Table IV**

**Method of Diagnosis of Splenic Injuries According toTreatment Groups. Results Expressed as Numbers (and Percentages)**

| Diagnostic technique | Entire cohort, $n = 100$ | Splenectomy, $n = 44$ | Observation | | Splenorrhaphy, $n = 7$ |
|---|---|---|---|---|---|
| | | | Successful, $n = 44$ | Failed, $n = 5$ | |
| Computed tomography | 55 | 11 (25) | 36 (82)* | 5 (100) | 3 (43) |
| Diagnostic peritoneal lavage | 26 | 24 (55) | 0 | 0 | 2 (29) |
| Laparotomy | 15 | 9 (20) | 4 (9) | 0 | 2 (29) |
| Other | 4 | 0 | 4 (9) | 0 | 0 |

*$p < 0.0001$ $\chi 2$ comparing splenectomy v. observation (successful) group

sence of other abdominal injuries. We were unable to discriminate between patients sucessfully managed by observation and those who ultimately underwent splenectomy when we used these same variables in our logistic regression analysis. Instead, we found that patients who underwent successful salvage by observation were less severely injured than patients who underwent splenectomy, and this was reflected by their lower ISS and decreased transfusion requirements.

The method of diagnosis of the splenic injury proved to be the variable most strongly associated with successful observation in our study. This may be due to our preference for CT assessment of the abdomen in hemodynamically stable patients, because of our desire to manage solid organ injuries without laparotomy if possible. The increasing use of abdominal imaging in blunt trauma has perhaps increased the number of injuries detected and has facilitated observational management of solid organ injuries.[23,24] These considerations do not imply that the CT appearance of the splenic injury in our hands was predictive of successful observation. Although a recent study suggests that the presence of a vascular contrast blush on CT may accurately predict those patients who will fail observation management,[25] at least four studies have shown that CT grading of splenic injuries does not reliably predict the outcome of this treatment.[26–29]

An alternative method to attain splenic salvage is splenorrhaphy, and several reports from the United States have indicated a clear preference for this over observation.[19–22] Proponents of splenorrhaphy contend that those who fail observation are more likely to undergo splenectomy and that splenorrhaphy more effectively accomplishes splenic salvage without exposing patients to the risks of ongoing tranfusions. Splenorrhaphy was infrequently performed at our institution, and although our small numbers preclude any meaningful comparisons, it is possible that several of these cases might have been successfully managed without operation, since some repairs were quite minor. No studies in adults have addressed the issue of who should undergo splenorrhaphy and who should be managed by observation. It is conceivable that both strategies may produce comparable results in similar patients. In the study on splenorrhaphy by Feliciano and associates,[19] 92% of repairs involved only compression, simple suture or topical application of hemostatic agents, suggesting that at least some of these patients could have been managed by observation. Resolution of this issue is further obscured by large case series published in the literature from institutions that favour one form of splenic conservation over another. A more complete understanding of the current standard of practice in the management of splenic injuries is hampered by the fact that there are no reports examining the degree of variation in the forms of splenic conservation performed by a number of trauma centres over the same period of time. Such an analysis of variation in regional practice patterns might provide valuable insight into whether such variation truly exists as well as some explanation for their existence.

In summary, our review of the management of splenic injury at a Canadian lead trauma hospital showed that over half the patients had conservation of the spleen. This was achieved predominantly by observation, which was successful in 90% of attempted cases, and none of the failures resulted in the patient's death. Our study revealed that the overall severity of injury, as indicated by the ISS and transfusion requirements, was strongly associated with the choice of management. The decision to use CT over other forms of diagnosis was the most powerful factor related to the subsequent choice of observational treatment. Although the use of CT in evaluating the abdomen following blunt injury has been an integral part of our splenic salvage strategy, its role in identifying appropriate candidates for successful observation remains to be elucidated. This study, in conjunction with a previous Canadian report,[18] suggests a growing adoption of observation as the preferred form of splenic salvage, paralleling recent reports from the United States.[16] Studies from other Canadian centres would be required to confirm this impression and to provide a more thorough assessment of regional practice pattern differences.

## References


1. Upadhyaya P, Simpson JS. Splenic trauma in children. *Surg Gynecol Obstet* 1968;126:781-92.
2. Douglas EJ, Simpson JS.The conservative management of splenic trauma. *J Pediatr Surg* 1971;6:565-70.
3. Kakkasseril JS, Stewart D, Cox JA. Changing treatment of pediatric splenic trauma. *Arch Surg* 1982; 117:758-9.
4. Pearl RH, Wesson DE, Spence LJ, Filler RM, Ein SH, Shandling B, et al. Splenic injury: a 5 year update with improved results and changing criteria for conservative management. *J Pediatr Surg* 1989;24(5):428-31.
5. King H, Shumacker HB Jr. Splenic studies I. Susceptibility to infection after splenectomy performed in infancy. *Ann Surg* 1952;136:239-42.
6. Balfanz JR, Nesbit ME Jr, Jarvis C, Kravit W. Overwhelming sepsis following splenectomy for trauma. *J Pediatr* 1976;88:458-60.
7. Posey DL, Marks C. Overwhelming postsplenectomy sepsis in childhood. *Am J Surg* 1983;145(3):318-21.

8. Luna GK, Dellinger EP. Nonoperative observation therapy for splenic injuries: a safe nontherapeutic option? *Am J Surg* 1987;153:462-8.
9. Morgenstern L, Uyeda RY. Nonoperative management of injuries of the spleen in adults. *Surg Gynecol Obstet* 1983;157:513-8.
10. Tom WW, Howells GA, Bree RL, Schwab R, Lucas RJ. A nonoperative approach to the adult ruptured spleen sustained from blunt trauma. *Am Surg* 1985;51(7):367-71.
11. Cogbill TH, Moore EE, Jurkovich GJ, et al. Nonoperative management of blunt splenic trauma: a multicentre experience. *J Trauma* 1989;29: 1313-7.
12. Pachter HL, Spencer FC, Hofstetter SR, Liang HG, Hoballah J, Coppa GF. Experience with selective operative and nonoperative treatment of splenic injuries in 193 patients. *Ann Surg* 1990;211(5):583-91.
13. Villalba MR, Howells GA, Lucas RJ, Glover JL, Bendick PJ, Tran O, et al. Nonoperative management of the adult ruptured spleen. *Arch Surg* 1990;125(7):836-9.
14. Smith SJ, Wengrovitz MA, DeLong BS. Prospective validation of criteria, including age, for safe nonsurgical management of the ruptured spleen. *J Trauma* 1992;33:363-9.
15. Molin MR, Shackford ST. The management of splenic trauma in a trauma system. *Arch Surg* 1990;125: 840-3.
16. Rutledge R, Hunt JP, Lentz CW, Fakhry SM, Meyer AA, Baker CC, et al. A statewide, population-based time-series analysis of the increasing frequency of nonoperative management of solid organ injury. *Ann Surg* 1995:222(3):311-26.
17. Kidd WT, Lui RCK, Khoo R, Nixon J. The management of blunt splenic trauma. *J Trauma* 1987;27:977-9.
18. Stephen WJ Jr, Roy PD, Smith PM, Stephen WJ Sr. Nonoperative management of blunt splenic trauma in adults. *Can J Surg* 1991;34:27-9.
19. Feliciano DV, Bitondo CG, Mattox KL, Rumisek JD, Burch JM, Jordan GL Jr. A four-year experience with splenectomy versus splenorrhaphy. *Ann Surg* 1985;201(5):568-75.
20. Pickhardt B, Moore EE, Moore FA, McCroskey BL, Moore GE. Operative splenic salvage in adults: a decade perspective. *J Trauma* 1989;29(10): 1386-91.
21. Feliciano DV, Spjut-Patrinely V, Burch JM, Mattox ML, Bitondo CG, Cruse-Martocci P, et al. Splenorrhaphy: the alternative. *Ann Surg* 1990; 211(5):569-82.
22. Rappaport W, McIntyre KE, Carmona R. The management of splenic trauma in the adult patient with blunt multiple injuries. *Surg Gynecol Obstet* 1990;170:204-8.
23. Davis RA, Shayne JP, Max MH, Woolfitt RA, Schwab W. The use of computerized axial tomography versus peritoneal lavage in the evaluation of blunt abdominal trauma: a prospective study. *Surgery* 1985;98(4): 845-50.
24. Fabian TC, Mangiante EC, White TJ, Patterson CR, Boldrehini S, Britt LG. A prospective study of 91 patients undergoing both computed tomography and peritoneal lavage following blunt abdominal trauma. *J Trauma* 1986;26(7):602-8.
25. Sutyak JP, Chiu WC, D'Amelio LF, Amorosa JK, Hammond JS. Computed tomography is inaccurate in estimating severity of adult splenic injury. *J Trauma* 1995;39(3):514-8.
26. Umlas SL, Cronan JJ. Splenic trauma: can CT grading systems enable prediction of successful nonoperative management? *Radiology* 1991;178: 481-7.
27. Kohn S, Clark DE, Isler RJ, Pope CF. Is computed tomographic grading of splenic injury useful in the nonsurgical management of blunt trauma? *J Trauma* 1994;36:385-9.
28. Malangoni MA, Cué JI, Fallat ME, Willing SJ, Richardson JD. Evaluation of splenic injury by computed tomography and its impact on treatment. *Ann Surg* 1990;211(5):592-9.
29. Schurr MJ, Fabian TC, Gavant M, Croce MA, Kudsk KA, Minard G, et al. Management of blunt splenic trauma: computed tomographic contrast blush predicts failure of nonoperative management. *J Trauma* 1995; 39(3):507-13.