

The Role of Diagnostic Algorithms in the Management of Blunt Splenic Injury

Liang-Yu Chen, Hsin-Chin Shih*, Jackson Jer-Kan Wu, Yi-Szu Wen,
Mu-Shun Huang, Chun-I Huang, Chen-Hsen Lee

*Department of Emergency Medicine, Taipei Veterans General Hospital and
National Yang-Ming University School of Medicine, Taipei, Taiwan, R.O.C.*

Background: Diagnostic algorithms for patients with blunt abdominal trauma have been in use since 1995. This study investigated the role of diagnostic algorithms in the management of adult patients with blunt splenic injury at our institution.

Methods: A retrospective review of hospital records was performed to enroll patients with blunt injury of the spleen. Demographic data and information about injury severity, diagnostic methods, management and final outcomes were evaluated. Patients were separated into an early and late group according to the year that diagnostic algorithms were used (1990–1994 or 1995–1999).

Results: One hundred and twenty-one patients were enrolled. Initially, 71 patients had an operation (OP group), whereas 50 received non-operative management (NOM group). Patients in the OP versus NOM group had lower blood pressure and greater transfusion volumes in the emergency room, higher grade splenic injury, and a greater rate of intra-abdominal-related injury. NOM failed in 7 patients (14%). Early- versus late-group patients were less likely to have NOM and high grade splenic injury; however, the rate of NOM failure was not different between the early and late groups.

Conclusion: Diagnostic algorithms using sonograms for screening provide an initial means of selecting patients for NOM. Patients with higher grades of splenic injury can then be managed non-operatively. [*J Chin Med Assoc* 2005; 68(8):373–378]

Key Words: diagnostic algorithm, non-operative management, spleen injury

Introduction

Non-operative management (NOM) of the injured spleen has become accepted in both adults and children, and over 60% of adults with blunt splenic injuries can be treated without operation.^{1–4} The introduction of noninvasive imaging studies, such as sonogram recordings and computed tomography (CT), has enabled simple and fast diagnosis of blunt abdominal trauma (BAT).^{5,6} However, the criteria for selecting adult patients for operative management versus NOM continue to be refined. Age, grade of splenic injury, quantity of hemoperitoneum, and the extent of

associated injuries, have all been associated with the success of NOM.^{7–10} The decision to operate or not is a great challenge for surgeons facing critically injured patients. We designed diagnostic algorithms by using sonogram recordings as a screening modality in 1995, and found that by following these algorithms, the need for non-therapeutic laparotomy might decrease in injured patients with BAT.⁶ Since then, most of our patients with BAT have been managed by following these algorithms. The purpose of this study was to review our experience in managing injured patients with blunt splenic trauma, and to review the role of diagnostic algorithms in such management.

*Correspondence to: Dr. Hsin-Chin Shih, Department of Emergency Medicine, Taipei Veterans General Hospital, 201, Section 2, Shih-Pai Road, Taipei 112, Taiwan, R.O.C.
E-mail: hcshih@vghtpe.gov.tw • Received: February 14, 2005 • Accepted: May 23, 2005

Methods

Study population

Records for adult patients (age ≥ 18 years) with blunt injury of the spleen were reviewed retrospectively for the period January 1990 to December 1999. Enrolled patients were managed primarily in our hospital. Data obtained from medical records included age, causes of injury, blood pressure on admission and after resuscitation, initial management and operative procedures, associated extra- and intra-abdominal injuries, injury severity scores (ISS), and outcomes. Patients were separated into 2 groups based on initial management: non-operative management (NOM) or operation (OP). Patients in the NOM group were monitored closely in the intensive care unit, and after stabilization, were moved to wards. To evaluate the role of diagnostic algorithms, patients were separated into 2 groups based on the time of treatment: 1990–1994 (early group), or 1995–1999 (late group). In the early group, the selection of diagnostic methods for BAT was decided by the surgeons on duty. In the late group, sonogram recordings were used as a screening modality for all suspected cases of BAT; the management

approaches used when following the algorithms are shown in Figures 1 and 2.⁶ The severity of splenic injury was graded from operative or CT findings according to the Organ Injury Scale Committee of the American Association for the Surgery of Trauma.¹¹

Diagnostic algorithms

The diagnostic algorithms are shown in Figures 1 and 2.⁶ Positive sonogram findings were defined separately for patients with unstable vital signs (USVS) and those with stable vital signs (SVS). In the USVS group, a positive sonogram was defined as ≥ 2 mm of echolucent free fluid in any 1 intraperitoneal space (bilateral subphrenic, Morrison, or Douglas pouch); for < 2 mm of fluid, the sonogram was defined as negative. In the SVS group, a positive sonogram was defined if intra-abdominal free fluid was detected, or if the possibility of its presence could not be excluded; otherwise the sonogram was defined as negative. Physical examination was defined as positive if peritoneal signs were obvious, as negative if the abdomen was soft without definite tenderness, and as equivocal if the findings were between these 2 extremes. Conventional radiography, including plain films of the chest or abdomen, was

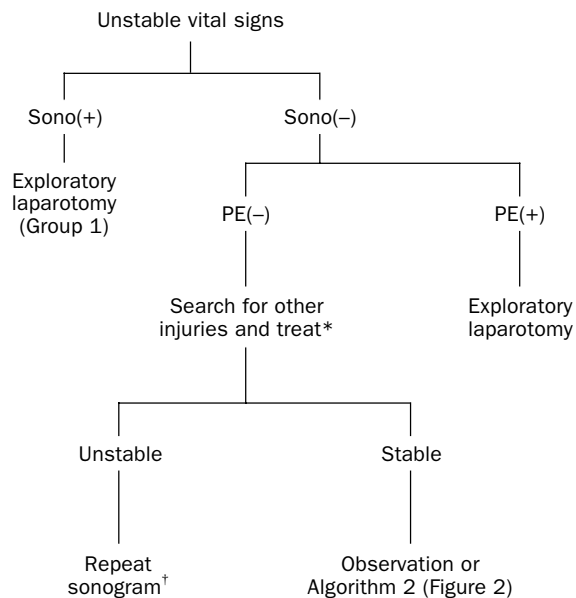


Figure 1. Algorithm 1: diagnostic algorithm for patients with unstable vital signs. *Search for causes of hypotension other than intraperitoneal hemorrhage, e.g. emergency needle decompression or tube thoracostomy for pneumothorax or hemothorax; immobilization and continuing fluid resuscitation for shock from spinal cord injury or other extra-abdominal hemorrhage, etc; †laparotomy is performed when repeated sonogram becomes Sono(+). PE = physical examination; Sono = sonogram; (-) = negative; (+) = positive.

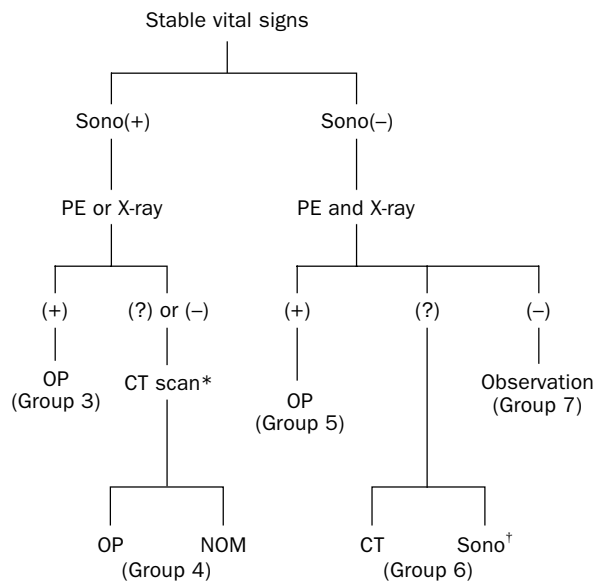


Figure 2. Algorithm 2: diagnostic algorithm for patients with stable vital signs. *Operative (OP) or non-operative management (NOM), depending on the findings of computed tomography (CT); †repeated sonogram (Sono) if patients become unstable before CT scan. PE = physical examination; (-) = negative; (+) = positive; (?) = uncertain findings.

defined as positive if definite free air or diaphragmatic rupture was noted; otherwise, radiography was defined as negative. Double-contrast CT was performed, and patients with findings of grade V splenic injury (shattered spleen) or associated critical injuries, such as hollow-organ injuries, or pancreatic injury involving the major duct, underwent exploratory laparotomy.

Statistical analysis

Categoric data were analyzed using the Chi-squared test. Continuous data were described as mean \pm standard deviation (SD), and were analyzed by Student's *t* test or ANOVA, depending on the number of groups. A *p* value of less than 0.05 was considered statistically significant.

Results

One hundred and twenty-one patients (84 men and 37 women; mean age, 39.3 ± 20.4 years; range, 18–79

years) were enrolled. Seventy-one patients had operations (OP group), whereas 50 underwent NOM (NOM group). The mean ISS was 19.6 ± 9.8 (range, 4–50), and the major cause of injury was motor vehicle accident (68/121; 56.2%). There was no significant difference between the OP and NOM groups with respect to mean age. However, in the OP versus NOM group, the following parameters were significantly greater: the incidence of unstable hemodynamics, both on arrival at, and after resuscitation in, the emergency room; ISS (23.9 vs 15.1; $p < 0.001$); grade of splenic injury (3.3 vs 2.6; $p < 0.001$); association with abdominal injuries (40.8% vs 12.0% of patients; $p < 0.001$); and length of hospitalization (26.0 vs 14.2 days; $p < 0.01$; Table 1). The chest was the most frequent extra-abdominal site of related injury (43/121; 35.3%), whereas the liver was the most frequent intra-abdominal site of related injury (10/121; 22.6%).

Clinical outcomes are shown in Table 2. There was no major finding of mortality in either group. Nine patients died (7.4%): 2 from severe head injury; 2 from

Table 1. Demographic data for 121 patients with blunt splenic injury

	OP group (n = 71)	NOM group (n = 50)	<i>p</i>
Age (yr)	40.1 \pm 19.8	38.4 \pm 21.3	NS
Injury severity score	23.9 \pm 9.9	15.1 \pm 6.9	< 0.001
Systolic BP < 90 mmHg, n (%)			
Arrival in ER	31 (43.7)	5 (10.0)	< 0.001
After resuscitation in ER	20 (28.2)	0 (0)	< 0.001
Blood transfusion at ER (units of packed blood cells)	6.6 \pm 1.9	1.8 \pm 2.2	< 0.001
Grade of splenic injury	3.3 \pm 1.0	2.6 \pm 0.9	< 0.001
Associated abdominal visceral injury, n (%)	29 (40.8)	6 (12.0)	< 0.001
Length of hospitalization (d)	26.0 \pm 32.4	14.2 \pm 13.1	< 0.01

Values shown are mean \pm standard deviation, except where otherwise indicated. BP = blood pressure; ER = emergency room; NOM = non-operative management; NS = not significant between the 2 groups (Chi-squared test for categoric data and Student's *t* test for continuous data); OP = operative management.

Table 2. Clinical outcomes for 121 patients with blunt splenic injury

	OP group (n = 71)	NOM group (n = 50)
Mortality	8	1
Sepsis and MOF	4	1
Severe head injury	2	0
Profound shock	2	0
Complications	12	9
Re-bleeding	3	7
Pneumonia	5	2
UTI	2	0
Intestinal obstruction	2	0

Data shown are numbers of patients. No differences between the operative (OP) and non-operative management (NOM) groups were statistically significant (Chi-squared test). MOF = multiple organ failure; UTI = urinary tract infection.

Table 3. Comparison between early (1990–1994) and late (1995–1999) groups of patients with blunt splenic injury

	OP group (n = 71)			NOM group (n = 50)		
	Early	Late	p	Early	Late	p
Patients (n)	51/67	20/54	< 0.001	16/67	34/54	< 0.001
Age (yr)	41.2 ± 20.1	37.4 ± 18.8	NS	39.2 ± 21.8	38.0 ± 21.3	NS
Grade of spleen injury	3.4 ± 0.9	3.0 ± 1.0	NS	2.1 ± 0.8	2.8 ± 0.9	< 0.01
Splenic injury grade > III (n)	12	15	NS	0	7	0.05
Injury severity score	23.8 ± 9.4	24.0 ± 11.7	NS	14.8 ± 6.2	15.3 ± 7.3	NS
Associated injury, n (%)	17 (33.3)	12 (60.0)	NS	2 (12.5)	4 (11.8)	NS
Re-bleeding, n (%)	3 (6)	0	NS	3 (18.8)	4 (11.8)	NS
Mortality (n)	4	2	NS	1	0	NS

Values shown are mean ± standard deviation, except where otherwise indicated. NOM = non-operative management; NS = not statistically significant between the early and late groups (Chi-squared test for categorical data and Student's *t* test for continuous data); OP = operative management.

profound hemorrhagic shock; and 5 from sepsis and multiple organ failure. Intervention failed because of re-bleeding in 7 patients in the NOM group (14%). Two patients in the NOM group and 9 in the OP group had other complications (Table 2). Three patients in the OP group had re-bleeding after surgery: 1 had re-bleeding from the short gastric artery, and two had re-bleeding from failed splenorraphy.

Further analyses were performed according to early (1990–1994) and late groups (1995–1999; Table 3). The incidence of operation was significantly lower in the late than early group (37.0% vs 76.1%). Conversely, the incidence of NOM and the mean grade of spleen injury were significantly greater in the late than early group; the failure rate of NOM with re-bleeding was not significantly different between the early and late groups. Seven patients with grade IV splenic injury and successful NOM were found in the late group. In OP patients, there was no significant difference in the mean grade of splenic injury between the early and late groups.

Patients in the late group, 54 in total, were categorized according to the diagnostic algorithm followed (Figures 1 and 2). Sixteen patients (group 1) underwent immediate laparotomy; 4 (group 2) were resuscitated because a small amount of intra-abdominal fluid was noted on the initial sonogram (< 2 cm thickness on image in any space of the abdominal cavity), were stabilized after initial resuscitation, and then managed according to the algorithm in Figure 2 (all 4 patients had successful NOM). Among 30 patients in group 4, 2 underwent operation for hollow-organ injury identified by CT scan; 28 had NOM, which failed in 4 cases. Among 4 patients in group 6, 2 had a CT scan and subsequent successful NOM; the other 2 became unstable before CT scan and explorations were done based on positive sonogram findings.

Discussion

Many reports have been published of high grade splenic injury as a contraindication to NOM. Cogbill et al¹² reported no grade I injury failures, 8% grade II failures, 19% grade III failures, and 100% grade IV failures in a 1989 multicenter study, and concluded that grade IV–V injuries require operative intervention. Starnes et al,¹³ in a similar prospective study, concluded that grade IV–V injuries are unsuitable for NOM. Although high grade splenic injury is associated with a greater failure rate of NOM, some reports have demonstrated successful NOM in high grade injury.^{14,15} In the present study, 7 patients with grade IV splenic injuries were managed non-operatively with uneventful outcomes; all 7 were in the late group.

Patients with imaging findings of large hemoperitoneum are likely to have significant and severe splenic injury. A recent multi-institutional review stated that the degree of hemoperitoneum is inversely correlated with the success of NOM.¹² However, Bee et al¹⁴ did not find the amount of hemoperitoneum to be an independently significant variable contraindicating NOM; hemoperitoneum alone is an indication for increased alertness, but not a contraindication to NOM. In the present study, the degree of hemoperitoneum was not calculated from CT images; however, the initial amount of intra-abdominal blood was assessed by the thickness of the echolucent area in different spaces of the abdomen on sonogram imaging. We used ≥ 2 mm thickness as the positive criterion for surgery in unstable patients, because the fluid amount was small when the thickness of the echolucent area was < 2 mm. Four of our patients with a small amount of hemoperitoneum stabilized after resuscitation. Although a large amount of intra-abdominal blood does not contraindicate NOM,

a greater success rate for NOM is likely if the amount of intra-abdominal fluid is small.

While associated injuries may not prevent successful NOM, the delayed diagnosis of such injuries in intra-abdominal vital organs (e.g. bowel) may be disastrous; indeed, NOM of splenic injury is reported to be associated with a 1.0–2.5% rate of missed diagnosis of non-splenic, related injuries.¹⁵ Using diagnostic algorithms in our study, 2 patients had bowel injuries detected by CT scan and underwent surgery.

The traditional criteria for NOM of blunt splenic injury have been challenged in recent years, but SVS remains one of the factors critical to successful NOM. Hypotension on arrival is, of course, a concern. However, in the case of trauma, many factors may contribute to initial hypotension in the emergency room. Gaunt et al¹⁶ reported that 22% of patients treated non-operatively had an initial systolic blood pressure of < 90 mmHg, and that none of the patients in whom NOM failed had arrived with hypotension. Bee et al¹⁴ showed that hypotension alone was not a significant prognostic indicator of NOM failure. These studies indicate that hypotension, although necessitating careful clinical decision making, is not a contraindication for NOM.¹⁴ While various selection criteria for NOM might influence success rates, our study shows that SVS after initial resuscitation in the emergency room is the major requirement for NOM success. Our diagnostic algorithm achieved successful NOM in 4 patients with initial USVS on arrival in the emergency room. Before the application of diagnostic algorithms (i.e. in the early group), only 1 patient with initial USVS had successful NOM. The preceding 4 patients had initial sonogram findings of internal bleeding with a small amount of intra-abdominal fluid. After resuscitation, their conditions stabilized. CT scans were conducted in line with the algorithms, and NOM was performed after confirmation of splenic injury. Importantly, diagnostic algorithms were capable of selecting patients suitable for NOM.

Although our results are impressive, some limitations need to be mentioned. This was a retrospective study, and some patients may have been managed without strict adherence to these algorithms. For example, we found no patients in groups 3 and 5 of the algorithms. Accurate and readily available imaging studies, such as CT scan, which is available continuously in the emergency room, make surgeons reluctant to make surgical decisions based exclusively on physical examination and plain film radiology. Another consideration is the difficulty in identifying true peritoneal signs of splenic injury in the presence of hemoperitoneum. In addition, angioembolization

has been proposed as an adjuvant modality for patients subjected to NOM.¹⁷ The inclusion of angioembolization in diagnostic algorithms seems reasonable for future studies. Furthermore, accumulated experience in recent years has made surgeons more confident in using NOM besides following diagnostic algorithms for suspected blunt splenic injury. Our results show that SVS after resuscitation and in the absence of bowel injury is critical to successful NOM, but there were too few patients who failed NOM to permit a search for other significant factors contributing to NOM success or failure. The accuracy of CT scans is another problem. While CT scans are generally accurate for diagnosing splenic injury, some authors have reported such scans to be inaccurate for grading splenic injury.^{18,19} For example, Sutyak et al¹⁸ compared CT scan results with operative findings and found that CT scans were accurate for splenic-injury grading in only 1-third of patients. Thus, in our study, some bias may have occurred when splenic injuries were graded according to CT scan results. Despite these drawbacks, our results show that diagnostic algorithms provide a good clinical pathway for trauma surgeons to follow.

In conclusion, although further prospective studies are needed, our retrospective review shows that diagnostic algorithms using sonogram recordings can provide an initial screening modality for the selection of patients with blunt splenic injury for NOM. In particular, patients with the most severe injuries, irrespective of injury grade, and some patients with initial USVS, may be candidates for NOM.

References

1. Powell M, Courcoulas A, Gardner M, Lynch J, Harbrecht BG, Udekwu AO, Billiar TR, et al. Management of blunt splenic trauma: significant differences between adults and children. *Surgery* 1997;122:654–60.
2. Konstantakos AK, Barnoski AL, Plaisier BR, Yowler CJ, Fallon WF Jr, Malangoni MA. Optimizing the management of blunt splenic injury in adults and children. *Surgery* 1999;126:805–13.
3. Uranus S, Pfeifer J. Nonoperative treatment of blunt splenic injury. *World J Surg* 2001;25:1405–7.
4. Pachter HL, Guth AA, Hofstetter SR, Spencer FC. Changing patterns in the management of splenic trauma: the impact of nonoperative management. *Ann Surg* 1998;227:708–19.
5. Delgado Millan MA, Deballon PO. Computed tomography, angiography, and endoscopic retrograde cholangiopancreatography in the nonoperative management of hepatic and splenic trauma. *World J Surg* 2001;25:1397–402.
6. Shih HC, Yi-Su Wen, Ko TJ, Wu JK, Su CH, Lee CH. Non-invasive evaluation of blunt abdominal trauma: prospective study using diagnostic algorithms to minimize nontherapeutic laparotomy. *World J Surg* 1999;23:265–9.
7. Ochsner MG. Factors of failure for nonoperative management of

- blunt liver and splenic injuries. *World J Surg* 2001;25:1393-6.
8. Peitzman AB, Heil B, Rivera L, Federle MB, Harbrecht BG, Clancy KD, Croce M, et al. Blunt splenic injury in adults: multi-institutional study of the Eastern Association for the Surgery of Trauma. *J Trauma* 2000;49:177-89.
 9. Clancy TV, Ramshaw DG, Maxwell JG, Covington DL, Churchill MP, Rutledge R, Oller DW, et al. Management outcome in splenic injury: a statewide trauma center review. *Ann Surg* 1997;226:17-24.
 10. Smith JS Jr, Cooney RN, Mucha P Jr. Nonoperative management of the ruptured spleen: a revalidation of criteria. *Surgery* 1996;120:745-51.
 11. Moore EE, Cogbill TH, Jurkovich GJ, Shackford SR, Malangoni MA, Champion HR. Organ injury scaling: spleen and liver. *J Trauma* 1995;38:323-6.
 12. Cogbill TH, Moore EE, Jurkovich GJ, Morris JA, Mucha P Jr, Shackford SR, Stolee RT, et al. Nonoperative management of blunt splenic trauma: a multicenter experience. *J Trauma* 1989;29:1312-7.
 13. Starnes S, Klein P, Magana L, Pomerantz R. Computed tomographic grading is useful in the selection of patients for nonoperative management of blunt injury to the spleen. *Am Surg* 1998;64:743-8.
 14. Bee TK, Croce MA, Miller PR, Pritchard FE, Fabian TC. Failures of splenic nonoperative management: is the glass half empty or half full? *J Trauma* 2001;50:230-6.
 15. Goan YG, Huang MS, Lin JM. Nonoperative management for extensive hepatic and splenic injuries with significant hemoperitoneum in adults. *J Trauma* 1998;45:360-4.
 16. Gaunt WT, McCarthy MC, Lambert CS, Anderson GL, Barney LM, Dunn MM, Lemmon GW, et al. Traditional criteria for observation of splenic trauma should be challenged. *Am Surg* 1998;65:689-92.
 17. Sclafani SJA, Shaftan GW, Scalea TM, Patterson LA, Kohl L, Kantor A, Herskowitz MM, et al. Nonoperative salvage of computed tomography-diagnosed splenic injuries: utilization of an angiography for triage and embolization for hemostasis. *J Trauma* 1995;39:818-27.
 18. Sutyak JP, Chiu WC, D'Amelio LF, Amorosa JK, Hammond JS. Computed tomography is inaccurate in estimating the severity of adult splenic injury. *J Trauma* 1995;39:514-8.
 19. Becker CD, Spring P, Glattli A, Schweizer W. Blunt splenic trauma in adults: can CT findings be used to determine the need for surgery? *AJR Am J Roent* 1994;162:343-7.