Evaluation of Splenic Injury by Computed Tomography and its Impact on Treatment

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We reviewed 37 consecutive, hemodynamically stable patients (16 adults, 21 children) who had splenic injuries diagnosed by computed tomography (CT) scan to compare the CT evaluation with operative assessment of injury and eventual treatment. Computed tomographic scans and operative findings were graded by a splenic injury scoring system. Two patients were classified as having grade 1, 21 as grade 2, 11 as grade 3, and 3 as grade 4 splenic injuries. Computed tomography underestimated the degree of injury in 9 of 17 (53%) operated patients (mean CT score, 2.6; mean operative score, 3.3; $p < 0.01$). Six of sixteen adults and 19 of 21 children were intentionally treated by observation. There were 5 treatments failures (20%), 3 due to bleeding and 1 each due to pancreatic injury and splenic abscess. The failure rate of observation was lower in children (16%) than in adults (33%), even though children had a higher Splenic Injury Score (2.4 *versus* 1.8). Patients who underwent an operation received twice as much blood as the observed group. There was no significant difference in Injury Severity Score or total fluid requirements between operated and observed patients. Operations increased in frequency in both adults and children as the injury score increased. This experience suggests that CT scan accurately determines the presence of splenic injury but commonly underestimates its severity. While children with grades 1 through 3 injuries are likely to be treated successfully with observation, adults who have more minor splenic injuries often fail observation and may be treated better by prompt operation.

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THE RECOGNITION OF the role of the spleen in the immunologic defense against infection has been the major impetus for an evolutionary change in the management of splenic injury. This increased understanding of the potential adverse consequences of splenectomy, in addition to the development of new noninvasive imaging procedures to identify injury to the spleen, has hastened the development of surgical techniques to salvage the injured spleen. Preservation of splenic tissue by partial splenectomy or splenic repair was done many decades ago;[1,2] however only recently has conventional wisdom accepted the idea that management of splenic injury by observation without operation could be successful. While nonoperative management was originally advocated for children with splenic trauma,[3] similar principles have been applied more recently to adults with splenic injury with mixed success. Surprisingly few direct comparisons between adults and children have been made.

In 1981 Shackford et al.[4] reported the use of a system to grade injuries to the spleen, demonstrating that patients with lesser degrees of splenic damage could be treated successfully by splenic repair. These observations have been confirmed since then by others.[5-7] The use of a grading system to classify splenic injuries diagnosed by abdominal computed tomography (CT) recently has been suggested.[8,9] As injury grading methods have evolved, there has been greater emphasis on classification based on the extent of injury to the organ *per se* rather than on the treatment rendered.[10]

Comparisons of reports of splenic injuries, particularly those applied to nonoperative treatment, are difficult to interpret because the extent of splenic injury is not carefully analyzed, the accuracy of the CT scan for grading splenic injury has not been well documented, and the application of an injury scoring system based on the CT scan has not been adequately validated. We examined splenic injuries diagnosed by CT scan in an attempt to answer these concerns and to discern if there were differences between adults and children referable to the use of the CT scan for diagnosis.

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Methods

We retrospectively identified all patients at the University of Louisville Level I Trauma Center hospitals (Humana Hospital University of Louisville, Kosair Children's Hospital) who had blunt trauma to the spleen with the diagnosis established by CT of the abdomen between July 1985 and April 1989. During this time period, diagnostic peritoneal lavage was used to evaluate most patients with suspected splenic injury. Adults were selected to have a CT scan if they had incurred blunt trauma but had stable vital signs and had suspected splenic injury based on localized physical findings involving the left chest and upper abdomen. Alternatively the CT scan was done because of the high possibility for abdominal injury in cases in which diagnostic peritoneal lavage was contraindicated, usually because of a previous abdominal operation. Abdominal CT scan was routinely obtained to evaluate all children with blunt abdominal trauma unless they had persistent shock.

The CT scans were performed using 1-cm scanning intervals in the upper abdomen and oral and intravenous contrast was given routinely, although there were some minor differences in scanning techniques between the two hospitals. For the purpose of this review, all scans were classified retrospectively by a single radiologist, who evaluated the degree of splenic injury and the presence of intra-abdominal blood without knowledge of patient outcome.

Splenic injuries were classified using criteria recently established by the American Association for the Surgery of Trauma,[10] (Table 1) as well as by the splenic injury classification systems proposed by Buntain and Gould[8] and Resciniti et al.[9] The Splenic Injury Scale[10] has been proposed to classify injuries either by CT scan, at operation, or at autopsy. Injuries were reclassified for all patients who had operation. In addition blood and fluid replacements were recorded and corrected for patient weight.

During the period of this review, we generally advocated early operation for adults who had splenic injury as well as signs of hemodynamic instability, hemoperitoneum with blood in the pelvis on CT, associated intra-abdominal injuries, impaired consciousness, or severe associated injuries in which expected blood losses might obscure ongoing bleeding from the spleen. Adults without any of the above-mentioned findings but who had findings on physical examination that were localized to the left upper quadrant were selected for nonoperative management. Children were intentionally managed by observation unless unstable vital signs or associated intra-abdominal injuries were present.

The principles of nonoperative management adhered to have been described in detail elsewhere.[11] In brief, both adults and children were placed at bed rest and had serial physical examination and hemoglobin determinations. Nasogastric decompression was used in all patients who had evidence of paralytic ileus as a result of their injuries and was used selectively in other patients.

Statistical comparisons between groups were done using the Behrens-Fisher t' Welch df' tests for unpaired variables and unequal groups and analysis of variance as appropriate.[12] A p value of less than 0.05 was considered significant.

Results

During the 45-month study period, there were 16 adults (18 years of age or older) and 21 children who had splenic injuries found by CT scan. There were 22 male and 15 female patients in the study, ranging in age from 3 to 53 years (average age, 20 years). When classified by mechanism of injury, high-energy transfer injuries such as motor vehicle accidents occurred in seven adults and 12 children,

TABLE 1. *Splenic Injury Score*[10]

Grade*	Injury	Injury Description†
1	Hematoma	Subcapsular, nonexpanding less than 10% surface area
	Laceration	Capsular tear, nonbleeding, less than 1 cm parenchymal depth
2	Hematoma	Subcapsular, nonexpanding, 10–50% surface area; intraparenchymal, nonexpanding, less than 2 cm in diameter
	Laceration	Capsular tear, active bleeding; 1–3 cm parenchymal depth that does not involve a trabecular vesssel
3	Hematoma	Subcapsular, more than 50% surface area or expanding; ruptured subcapsular hematoma with active bleeding; intraparenchymal hematoma more than 2 cm or expanding
	Laceration	More than 3 cm parenchymal depth or involving trabecular vessels
4	Hematoma	Ruptured intraparenchymal hematoma with active bleeding
	Laceration	Laceration involving segmental or hilar vessels producing major devascularization (more than 25% of spleen)
5	Laceration	Completely shattered spleen
	Vascular	Hilar vascular injury that devascularizes the spleen

* Advance one grade for multiple injuries to the same organ.

† Based on most accurate assessment at autopsy, laparotomy, or radiologic study.

TABLE 2. *Associated Injuries*

Location	Adults	Children
Chest wall	6	6
Bony	1	7
Lung	3	4
Head	1	5
Facial	3	1
Pancreas	1	1
Kidney	0	2
Liver	0	1
Total	15	27

TABLE 3. *Management Based on CT Evaluation*

	Splenic Injury Score			
Patients	1	2	3	4
Adults				
Observed	1	3	0	0
Operated	1	5	5	1
(% operated)	(50%)	(63%)	(100%)	(100%)
Children				
Observed	0	11	4	1
Operated	0	2	2	1
(% operated)	0	(15%)	(33%)	(50%)
Total patients	2	21	11	3

while the remaining patients were hurt as a result of low-energy transfer injuries due to bicycles, falls, or sports. Isolated splenic trauma occurred in 15 patients. There were 42 additional injuries in the remaining 22 patients (Table 2). Chest injuries and extremity fractures occurred most frequently. The mean Injury Severity Score (± standard deviation)[13] was 12 ± 5 for adults and 14 ± 6 for children. Fluid administration during the first 24 hours was 45 ± 28 mL/kg in adults and 63 ± 27 mL/kg in children; there was an average of 4 mL/kg of packed red cells given to adults and 7 mL/kg given to children during the 24 hours after injury.

The average Splenic Injury Score assessed by CT scan was 2.5 ± 0.8 for adults and 2.8 ± 0.8 for children using the splenic injury scale. When the grading systems proposed by Buntain and Gould[8] and Resciniti et al.[9] were used, scores averaged 1.8 and 2.4 in adults and 1.7 and 2.9 in children, respectively.

When compared by the type of management for the splenic injury, 25 patients (19 children, 6 adults) were initially treated intentionally by observation without operation. The mean Splenic Injury Score in the group treated by observation (2.3 ± 0.6) was lower than in patients operated on initially (2.6 ± 0.8). Adults treated with nonoperative management had a slightly but not significantly lower score than children treated similarly (1.8 *versus* 2.4).

Observation without operation was successful in 80% of all patients, including 16 of 19 children (84%) and 4 of 6 adults (67%). Treatment failure occurred due to bleeding in 3 patients, splenic abscess in 1, and a missed pancreatic injury in 1. Four of the five patients who failed nonoperative management underwent splenectomy, while one patient had successful splenic repair. Fluid requirements were significantly less among adults who were managed successfully by observation compared to children (34 ± 23 mL/kg *versus* 62 ± 21 mL/kg, $p < 0.05$). Adults successfully managed by observation did not receive any blood, while blood requirements were 5 ± 7 mL/kg in children ($p < 0.05$). The children who failed observation were ages 3, 11, and 15 years. Two children had grade 4 splenic injuries at operation. Both injuries were underestimated by CT and one child also had a pancreatic injury not diagnosed by CT scan. Another child who had a grade 2 injury developed a splenic abscess, which was probably due to hematogenous infection of a subcapsular hematoma. The two adults who failed observation were 37 and 54 years old and both had grade 3 injuries at operation, one of which was underestimated by CT.

Ten adults and two children initially had operation. The average Splenic Injury Score in this group based on abdominal CT scan was 2.5 ± 0.8 in adults and 2.8 ± 0.8 in children. In both adults and children there was an obvious trend toward operation rather than observation for initial treatment as the Splenic Injury Score increased (Table 3). This same trend was observed as patient age increased (Fig. 1).

Overall splenectomy was done in 13 patients and splenic repair in four patients. When splenic injuries in these patients were reclassified at operation, CT scan underestimated the degree of injury in 9 of 17 (53%) patients who underwent operation (Table 4). The mean CT Splenic

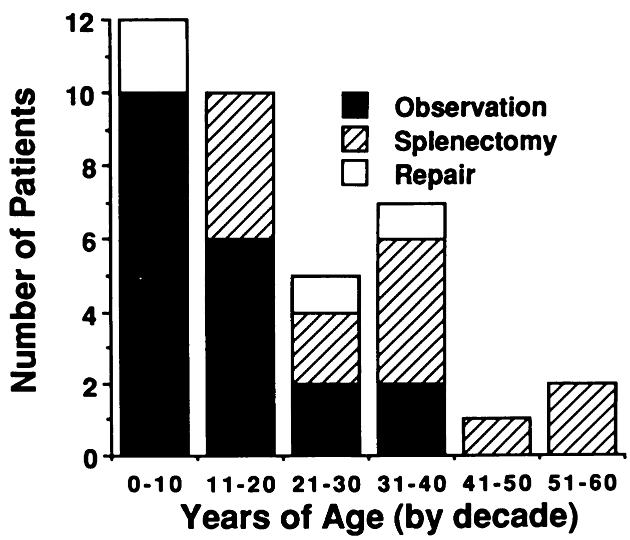

FIG. 1. Management of splenic injury by age.

TABLE 4. *Comparison of Splenic Injury Score Assessed by CT and at Operation (n = 17)*

	CT Score			
Operative Score	1	2	3	4
1	0	0	0	0
2	0	3	0	0
3	1	2	3	0
4	0	2	4	2

Injury Score was 2.6 ± 0.8, while the average injury score assessed at operation was 3.3 ± 0.8 ($p < 0.01$). Not unexpectedly, patients who had splenectomy had a higher grade of injury (3.5) than those who were treated with splenorrhaphy (2.8).

Although fluid requirements during the 24 hours after injury were similar between operated and observed groups (54 ± 34 mL/kg and 56 ± 24 mL/kg, respectively), operated patients received twice as much blood as those who were observed (8 mL/kg *versus* 4 mL/kg).

Discussion

There have been four developments resulting in an increase in splenic salvage after blunt injury. First Whitesell[14] demonstrated that fractures of the spleen after blunt injury are usually oriented perpendicular to the long axis of the spleen. These horizontal fractures are less likely to lacerate the larger segmental vessels of the splenic parenchyma because they occur in avascular planes between splenic segments. Second Upadhyaya and Simpson[3] observed that, in children, many transverse lacerations of the spleen were not actively bleeding at the time of splenectomy and suggested that operation was not necessary to control bleeding. The third development was the acceptance by the medical community that the spleen has an important role in combating bacterial infection and that splenectomy done in a variety of circumstances could result in the development of late overwhelming septicemia in a small number of patients.[15,16] Fourth, the development of noninvasive tests has allowed the determination of splenic injury without operation, initially by scintigraphy of the spleen[17] and later by abdominal CT.[18] The abdominal CT has proved useful to diagnose other intra-abdominal injuries that, when identified, may influence the management of splenic injury as well. This latter characteristic has led to supplantation of radionuclide scanning by abdominal CT scan as the noninvasive procedure of choice for the diagnosis of blunt injury to the spleen.

The success of the Toronto group by observation without operation for the management of blunt splenic trauma in children has been accepted as standard procedure for children with splenic injuries.[3,19] Persistent hemodynamic instability, associated coagulopathy, the presence of other intra-abdominal injuries, or penetrating injury to the abdomen all remain useful indications for operation in this age group. Early reports of selected adults with blunt splenic trauma managed by observation had varying degrees of success,[13,20] suggesting that either there were intrinsic differences between the spleens of adults and children or that other factors existed that determined the success of nonoperative management. These series did not stratify patients based on the degree of injury to the spleen. Two recent reports have noted that increasing age is a determinant for failure of nonoperative treatment of adults with blunt splenic trauma.[21,22] Differences in the thickness and elasticity of the splenic capsule between adults and children also have been described.[20,23]Others have reported that children are more likely to incur splenic trauma after a low-energy impact injury and postulated that the resultant damage to the spleen might be less severe.[24]

The major goal of nonoperative management for splenic injury is to select patients with injuries that are very likely to stop bleeding spontaneously and, therefore, a high degree of success can be achieved. The ability of the abdominal CT scan to determine not only the pattern and degree of splenic injury but also to allow an estimate of the volume of free intra-abdominal blood has led to a greater acceptance of its use to diagnose blunt splenic trauma. It seems to us that the increased use of CT to evaluate blunt abdominal trauma has led to recognition of splenic injury in some patients who may not have had their injuries diagnosed previously because of minimal findings on examination. Most of these serendipitously identified injuries are minor and, therefore, these patients are more likely to be successfully managed without operation. The augmentation of reports of splenic trauma with patients who may have minor injuries accentuates the need for a classification system for injury to the spleen so that series can be compared with appropriate consideration given to the impact of degree of splenic injury on the success of management.

Buntain and Gould[8] have suggested a grading system to evaluate the extent of splenic injury by CT and they have subsequently demonstrated a correlation between the degree of injury noted on CT scan and the success of nonoperative management.[25] Correlation previously has been shown between the ability to perform operative splenic salvage and the degree of injury to the spleen.[4–6] A more recently developed Organ Injury Scale for splenic trauma has been proposed to evaluate and compare injuries found either by CT or at operation.[10] Cogbill et al.,[21] using this system, have shown that nonoperative management of blunt splenic trauma is most successful in patients with more minor injury classifications. They reported that overall 98% of children and 83% of adults who had been carefully selected for nonoperative management were successfully treated without operation. The high degree of success that they have reported with observation may be explained by a large percentage of patients with more minor injuries (grades 1 and 2) in their series. Pearl et al.[19] have found that nonoperative management of blunt splenic trauma was successful in 87% of children treated during a 5-year period; however patients in their study were not stratified according to the degree of splenic injury.

In the present study we have identified a difference in the success of nonoperative management between children and adults. We chose to categorize the two patient groups using 18 years of age to differentiate adults from children. Others[21,22] have used an age of 16 years to make this distinction in patient populations. Had we used this lower age as a cutoff, the success of observation in adults would have increased.

Two children who failed observation had grade 4 splenic injuries that were underestimated by CT diagnosis, and one child had a missed pancreatic injury. Avoidance of these problems by improved patient selection may further increase the success of nonoperative management in children. Both adults who failed observation had grade 3 splenic injuries and were older than the average patient selected for nonoperative treatment. Others have noted that the success of observation decreased from 95% in patients with grades 1 and 2 injuries to 81% in patients with grade 3 injuries.[21] Cogbill et al.[21] had uniform failure of nonoperative management in only two patients with grade 4 injuries. Based on previous investigations and the present series, we believe that age taken in context with the degree of injury to the spleen may help improve the selection of adults likely to be managed successfully without operation.

Previously we reported a 30% rate of success using intentional observation for splenic injuries in adults.[11] While the number of adults managed by observation in the present series is small, our results indicate that improvement in the success of nonoperative management can occur by using the CT scan to properly select patients according to the degree of splenic injury. The greater success with observation reported by some may be due to differences in patient selection, the inclusion of more patients with minor splenic injuries, or treatment philosophy.

We chose to manage all adults who required blood transfusion by early operation, recognizing that these patients had more severe splenic injuries and that operation might increase the chances to salvage the spleen. In only 25% of these patients could the spleen be preserved. The grade of splenic injury in patients who had splenectomy was 3.5 on average, and 7 of 13 patients who had splenectomy had grade 4 injuries. Our results also suggest that, given a similar degree of injury based on abdominal CT, adults were less likely to be successfully treated by observation than children. We cannot determine whether this was due to the aforementioned differences in structure of the spleens of adults and children, actual differences in the degree of injury to the spleen, or other confounding variables.

While we noted a potential trend in the utility of the CT-based grading scale to discriminate patient management, we also found a high rate of disagreement between the degree of injury determined by CT and at operation. This discrepancy was always due to underestimation of the grade of injury by CT scan and indicates some possible limitations of its usefulness. The Splenic Injury Score does not take into account such factors as longitudinal fractures that may cross segmental vessels within the splenic parenchyma and may be less likely to stop bleeding spontaneously. Among the five patients who failed nonoperative management, three had an increase in the grade of injury assessed at the time of operation. There was a trend to select operation as initial management for patients with high splenic scores as determined by CT; however, when the information on operative grade was used retrospectively, this association was even more discriminating. The injury scales suggested by Buntain and Gould[8] and Resciniti et al.[9] were not as useful as the Splenic Injury Score to select patient treatment. Pickhardt et al.,[7] using the same Splenic Injury Score, have shown a correlation between the degree of injury to the spleen and the success of splenic salvage.

Many patients with splenic injuries will undergo operation without having a CT scan for diagnosis and decisions regarding splenic salvage will be made based on the degree of injury to the spleen noted at operation. Our basic approach is to preserve the spleen whenever possible. However it must be recognized that the overall condition of the patient, associated injuries such as severe fractures that may lead to confusion about the site of ongoing blood loss, or coexisting diseases may mitigate against splenic salvage. We did not find the Injury Severity Score useful in discriminating patient management choices for splenic injury. In contrast to others,[24] the distinction between high- and low-energy mechanisms of injury was not useful to guide treatment decisions, and this may represent an association based more on age-related activities rather than an actual predictive determinant.

Although fluid requirements were similar between patients who were observed and those who underwent operation, blood use was greater in operated patients. The lower fluid requirement and absence of blood use in adults treated by observation is difficult to attribute solely to the splenic injury alone, even though these patients did have a lesser grade of injury than children treated by observation. This difference may be attributed to other factors, particularly associated injuries, or to selective tolerance of a lower value of hemoglobin before transfusion.[19]

Based on our results, we agree that the abdominal CT scan is useful to recognize and categorize the degree of splenic injury, although CT scan tends to underestimate the severity of injury when compared to grading at operation. The present injury scoring systems used for CT grading of injuries do not address the issue of longitudinal fractures of the spleen, which may be less likely to stop bleeding without operative treatment. Computed tomography may fail to detect coexistence abdominal injuries, hence strict attention to patient assessment and changes in condition is necessary to identify the patient who needs operation for reasons other than splenic injury. Given comparable degrees of injury, children seem more likely to be managed successfully without operation than adults. Identification of major splenic injuries on CT (grade 4 for children, grade 3 for adults) should lead to prompt operation rather than observation, even though the patient's condition appears stable. Age is another important factor that must be considered when management decisions are made. We believe that these issues and future developments in the diagnosis, classification, and management of blunt splenic trauma will further refine the treatment of splenic injury.

References

1. Senn N. The surgical treatment of traumatic hemorrhage of the spleen. JAMA 1903; 41:1241–1245.
2. Sherman R. Perspectives in management of trauma to the spleen. J Trauma 1980; 20:1–13.
3. Upadhyaya P, Simpson JS. Splenic trauma in children. Surg Gynecol Obstet 1968; 126:781–790.
4. Shackford SR, Sise MJ, Virgilio RW, Peters RM. Evaluation of splenorrhaphy: a grading system for splenic trauma. J Trauma 1981; 21:538–542.
5. Barrett J, Sheaff C, Abuabara S, Jonasson O. Splenic preservation in adults after blunt and penetrating trauma. Am J Surg 1983; 145:313–317.
6. Feliciano DV, Bitondo CG, Mattox KL, et al. A four-year experience with splenectomy versus splenorrhaphy. Ann Surg 1985; 201: 568–575.
7. Pickhardt B, Moore EE, Moore FA, et al. Operative splenic salvage in adults: a decade perspective. J Trauma 1989; 29:1386–1391.
8. Buntain WL, Gould HR. Splenic trauma in children and techniques of splenic salvage. World J Surg 1985; 9:398–409.
9. Resciniti A, Fink MP, Raptopoulos V, et al. Nonoperative treatment of adult splenic trauma: development of a computed tomographic scoring system that detects appropriate candidates for expectant management. J Trauma 1988; 28:828–831.
10. Moore EE, Shackford SR, Pachter HL, et al. Organ injury scaling: spleen, liver and kidney. J Trauma 1989; 29:1664–1666.
11. Malangoni MA, Levine AW, Droege EA, et al. Management of injury to the spleen in adults: results of early operation and observation. Ann Surg 1984; 200:702–705.
12. Scheffe H. Practical solutions of the Behrens-Fisher problem. J Am Statist Assoc 1970; 65:1801–1820.
13. Greenspan L, McLellan B, Greig H. Abbreviated injury scale and Injury Severity Score: a scoring chart. J Trauma 1985; 25:60–64.
14. Whitesell FB Jr. A clinical and surgical anatomic study of rupture of the spleen due to blunt trauma. Surg Gynecol Obstet 1960; 110;750–754.
15. Wahlby L, Domellof L. Splenectomy after blunt abdominal trauma: a retrospective study of 413 children. Acta Chir Scand 1981; 147: 131–135.
16. Green JB, Shackford SR, Sise MJ, Fridlung P. Late septic complications in adults following splenectomy for trauma: a prospective analysis in 144 patients. J Trauma 1986; 26:999–1004.
17. Wener L, Boyle CD. Splenic scintiscanning in the preoperative diagnosis of subcapsular hematoma. N Engl J Med 1967; 277:35–37.
18. Mall JC, Kaiser JA. CT diagnosis of splenic laceration. AJR 1980; 134:265–269.
19. Pearl RH, Wesson DE, Spence LJ, et al. Splenic injury: a 5-year update with improved results and changing criteria for conservative management. J Pediatr Surg 1989; 24:428–431.
20. Morgenstern L, Uyeda RY. Nonoperative management of injuries of the spleen in adults. Surg Gynecol Obstet 1983; 157:513–518.
21. Cogbill TH, Moore EE, Jurkovich GJ, et al. Nonoperative management of blunt splenic trauma: a multicenter experience. J Trauma 1989; 29:1312–1317.
22. Longo WE, Baker CC, McMillen MA, et al. Nonoperative management of adult blunt splenic trauma: criteria for successful outcome. Ann Surg 1989; 210:626–629.
23. Gross P. Zur kindlichen traumatischen milzruptur. Beitrage zur Klinische Chirurg 1965; 208:396–401.
24. Muehrcke DD, Kim SH, McCabe CJ. Pediatric splenic trauma: predicting the success of nonoperative therapy. Am J Emerg Med 1987; 5:109–112.
25. Buntain WL, Gould HR, Maull KI. Predictability of splenic salvage by computed tomography. J Trauma 1988; 28:24–34.

Discussion

DR. JOSEPH A. MOYLAN (Durham, North Carolina): We, too, are concerned about the use of CT in the adult patient. Our experience, like yours, has shown that it not only underestimates the severity of injuries in adults but actually has missed many important injuries. Our series of more than 40 adult patients during the past several years in which an abdominal CT was used because the patient, who was more than 12 hours after injury and stable, or had a contraindication to diagnostic peritoneal lavage.

In that series there were six false-negative exams in patients with multisystem injuries and closed head injuries did not present with abdominal findings. Two had serious colon injuries. Two had serious small bowel injuries. One had a bleed from a delayed mesenteric artery transection, and one had a bleed from an injured spleen on day 3.

We think that CT, if widely used in the adult, may delay diagnosis of serious injuries, particularly of the hollow viscus in the abdominally injured patients, leading to prolonged severe septic complications and hemorrhagic complications. I have three questions for Mark.

First, what defines an adequate abdominal CT? Does this include both oral and intravenous contrast material? Clearly in some of the series in which missed injuries have been reported, both routes, oral and intravenous contrast, have not been used.

Second, you mentioned in your abstract that there were some shortcomings in terms of missed injuries. Do you have any other missed injuries other than the pancreatic injury that was reported in the abstract?

Finally, if you think that hemoperitoneum is an indication for operative intervention in the adult patient, shouldn't you use a diagnostic peritoneal lavage even after a period of stability rather than an abdominal CT?

DR. ALEX HALLER (Baltimore, Maryland): It has been very interesting during the last several decades to watch the evolution of management