THE JOURNAL OF TRAUMA

Official publication of the American Association for the Surgery of Trauma

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Editor: Raul Coimbra, MD, PhD, FACS

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The AAST and *The Journal of Trauma and Acute Care Surgery* are releasing this compendium of manuscripts with you, our members and readers, in mind.

The Journal of Trauma has published the most important and relevant manuscripts in trauma surgery since 1961. Studies that have changed patient care, discoveries, clinical trials, and advancements in basic research have been the focus of the Journal for the last 61 years.

Since 1989 *The Journal of Trauma* has been the publication vehicle of a series of highly cited and clinically meaningful articles known as the "Organ Injury Scale" manuscripts. These were game changers, as they were initially used to standardize how trauma surgeons graded injuries in different organs and body areas. Later, these classification schemes were linked to management strategies based on injury severity. They guided all of us to provide better care to injured patients by linking injury grades to therapeutic options. More recently, using these grading systems we have determined, with a high degree of certainty, what the expected outcomes would be in different injury grades. Some of these grading scales have been updated during the last thirty-three years based on advances in diagnostics and new therapeutic modalities.

With this publication, we want to "immortalize" these groundbreaking articles. We also want you, our readers and members, to have easy and free access to these gems. Read them, learn the history of injury grading, cite them in your research papers, and use them in your clinical practice.

Our commitment is to publish a compendium of seminal articles around a focused topic every year so you can have them at your fingertips for easy use and immediate access.

I hope you take advantage of this initiative and enjoy this publication and those planned for future years.

Warmest Regards,

Raul Coimbra, MD, PhD, FACS
Editor-in-Chief
The Journal of Trauma and Acute Care Surgery

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At the 1987 meeting of the American Association for the Surgery of Trauma, President Donald Trunkey appointed a new and important committee known as the Organ Injury Scaling (O.I.S.) Committee. The purpose was to enhance the research potential of the various injury severity scores developed in recent years by several authors. The charge to this committee was to devise injury severity scores for individual organs. The committee consisting of E. E. Moore, S. R. Shackford, H. L. Pachter, J. W. McAninch, B. D. Browner, H. R. Champion, L. M. Flint, T. A. Gennarelli, M. A. Malangoni, M. L. Ramenofsky, and P. G. Trafton has done its work and now presents the O.I.S. for spleen, liver, and kidney.

We are pleased to publish this initial version because of its importance to clinical research and to urge its rapid adoption by trauma surgeons. Like all scales it may need revision and it is the hope of the committee that revisions will be suggested by the readership after they have had a chance to evaluate the scale through use.

The committee has put a tremendous effort into the development of this initial O.I.S. and they are to be congratulated.

J. H. Davis, Editor

Organ Injury Scaling: Spleen, Liver, and Kidney

E. E. MOORE, M.D., S. R. SHACKFORD, M.D., H. L. PACHTER, M.D., J. W. McANINCH, M.D., B. D. BROWNER, M.D., H. R. CHAMPION, F.R.C.S., L. M. FLINT, M.D., T. A. GENNARELLI, M.D., M. A. MALANGONI, M.D., M. L. RAMENOFSKY, M.D., AND P. G. TRAFTON, M.D.

The Organ Injury Scaling (O.I.S.) Committee of the American Association for the Surgery of Trauma (A.A.S.T.) was appointed by President Trunkey at the 1987 Annual Meeting (23). The principal charge was to devise injury severity scores for individual organs to facilitate clinical research. The resultant classification scheme is fundamentally an anatomic description, scaled from 1 to 5, representing the least to the most severe injury. A number of similar scales have been developed in the past, but none has been uniformly adopted. In fact, this concept was introduced at the A.A.S.T. in 1979 as the Abdominal Trauma Index (A.T.I.) (12) and has proved useful in several areas of clinical research (13, 14, 19). The enclosed O.I.S.'s for spleen (Table I), liver (Table II), and kidney (Table III) represent an amalgamation of previous scales applied for these organs (2–4, 9, 10–12, 15–18, 22), and a consensus of the O.I.S. Committee as well as the A.A.S.T. Board of Managers.

The O.I.S. differs from the Abbreviated Injury Score (A.I.S.) (6–8), which is also based on an anatomic scale but designed to reflect the impact of a specific organ injury on ultimate patient outcome. The individual A.I.S.'s are, of course, the basic elements used to calculate the Injury Severity Score (I.S.S.) (1) as well as T.R.I.S.S. methodology (5). To ensure that the O.I.S. interdiffuses with the A.I.S. and I.C.D.-9 codes, these are listed alongside the respective O.I.S. Both the currently used A.I.S. 85 and proposed A.I.S. 90 are provided because of the obligatory transition period. Indeed, A.I.S. 90 contains the identical descriptive text as the current O.I.S.'s. The Abdominal Trauma Index (12) and other similar indices using organ injury scoring can be easily modified by replacing older scores with the O.I.S.'s.

Finally, we emphasize that the enclosed O.I.S.'s represent an initial classification system that must undergo continued refinement as newer diagnostic tools become available and further clinical application has been tested. Recent studies employing the spleen O.I.S. appear to validate its utility (20, 21). Our Committee is presently formalizing O.I.S.'s for the remaining abdominal viscera in parallel with efforts to develop similar scales for thoracic trauma, various fractures, and neurologic injuries. These O.I.S.'s will be published in the *Journal* as soon as they endure the same systematic review process.

TABLE I
Splenic injury scale

Grade*	Injury Description†	ICD-9	AIS 85	AIS 90
I. Hematoma:	Subcapsular, nonexpanding <10% surface area	865.01 865.11	2	2
Laceration:	Capsular tear, nonbleeding, <1 cm parenchymal depth	865.02 865.12		
II. Hematoma:	Subcapsular, nonexpanding, 10–50% surface area; Intraparenchymal, nonexpanding, <2 cm in diameter	865.01 865.11	2	2
Laceration:	Capsular tear, active bleeding; 1–3-cm parenchymal depth which does not involve a trabecular vessel	865.02 865.12	2	2
III. Hematoma:	Subcapsular, >50% surface area or expanding; Ruptured subcapsular hematoma with active bleeding; Intraparenchymal hematoma >2 cm or expanding		3	3
Laceration:	>3 cm parenchymal depth or involving trabecular vessels	865.03 865.13	3	3
IV. Hematoma:	Ruptured intraparenchymal hematoma with active bleeding		3	4
Laceration:	Laceration involving segmental or hilar vessels producing major devascularization (>25% of spleen)	865.04 865.14	3	4
V. Laceration:	Completely shattered spleen	865.04 865.14	5	5
Vascular:	Hilar vascular injury which devascularizes spleen		5	5

* Advance one grade for multiple injuries to the same organ.
† Based on most accurate assessment at autopsy, laparotomy, or radiologic study.

TABLE II
Liver injury scale

Grade*	Injury Description†	ICD-9	AIS 85	AIS 90
I. Hematoma:	Subcapsular, nonexpanding, <10% surface area	864.01 864.11	2	2
Laceration:	Capsular tear, nonbleeding, <1 cm parenchymal depth	864.02 864.12	2	2
II. Hematoma:	Subcapsular, nonexpanding, 10–50% surface area Intraparenchymal, nonexpanding, <2 cm in diameter	864.01 864.11	2	2
Laceration:	Capsular tear, active bleeding; 1–3-cm parenchymal depth, <10 cm in length	864.03 864.13	2	2
III. Hematoma:	Subcapsular, >50% surface area or expanding; Ruptured subcapsular hematoma with active bleeding; Intraparenchymal hematoma >2 cm or expanding		3	3
Laceration:	>3 cm parenchymal depth	864.04 864.14	3	3
IV. Hematoma:	Ruptured intraparenchymal hematoma with active bleeding		3	4
Laceration:	Parenchymal disruption involving 25–50% of hepatic lobe	864.04 864.14	4	4
V. Laceration:	Parenchymal disruption involving >50% of hepatic lobe		5	5
Vascular:	Juxtahepatic venous injuries; i.e., retrohepatic vena cava/major hepatic veins		5	5
VI.Vascular:	Hepatic avulsion			6

* Advance one grade for multiple injuries to the same organ.
† Based on most accurate assessment at autopsy, laparotomy, or radiologic study.

TABLE III
Renal injury scale

Grade*	Injury Description†	ICD-9	AIS 85	AIS 90
I. Contusion:	Microscopic or gross hematuria; urologic studies normal		2	2
Hematoma:	Subcapsular, nonexpanding without parenchymal laceration	866.01 866.11	2	2
II. Hematoma:	Nonexpanding perirenal hematoma confined to renal retroperitoneum	866.01 866.11	2	2
Laceration:	<1.0 cm parenchymal depth of renal cortex without urinary extrav-	866.02	2	2

TABLE III
Continued

	asation	866.12		
III. Laceration:	>1.0 cm parenchymal depth of renal cortex without collecting system rupture or urinary extravasation	866.02 866.12	3	3
IV. Laceration:	Parenchymal laceration extending through the renal cortex, medulla and collecting system		3	4
Vascular:	Main renal artery or vein injury with contained hemorrhage		3	4
V. Laceration:	Completely shattered kidney	866.03	5	5
Vascular:	Avulsion of renal hilum which devascularizes kidney	866.13	5	5

* Advance one grade for multiple injuries to the same organ.
† Based on most accurate assessment at autopsy, laparotomy, or radiologic study.

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AAST Organ Injury Scale: Correlation of CT-Graded Liver Injuries and Operative Findings

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The Organ Injury Scaling Committee of the AAST recently published a consensus classification of splenic, hepatic, and renal injuries (*J Trauma*, 29:1664, 1989). The hepatic injury scale (HIS), based on parenchymal laceration and intrahepatic hematoma, includes grades 1 to 6, representing the least to most severe injury. This study classifies liver injuries by findings at celiotomy, correlates operative findings with transfusion requirements and method of management of liver injury, and relates preoperative CT to anatomic findings at laparotomy. Thirty-seven patients with blunt liver injury were evaluated by abdominal CT with and without intravenous contrast and then underwent celiotomy. Increasing operative HIS correlated well with increasing severity of injury as measured by transfusions and operative management. Thirty-one CT grades did not correlate with operative findings (84%). Four patients had intrahepatic hematomas that were not discovered at operation. Twelve lacerations were graded too high by CT and 15 too low. Of these 15, ten CT scores were at least two grades lower than operative findings. Injuries around the falciform ligament occurred in three of the low misclassifications. One patient with intrahepatic hematoma developed hepatic artery pseudoaneurysm. We conclude that the HIS readily characterizes operative findings of hepatic lacerations and that increasing operative grade correlates well with transfusion requirements and operative management. CT can define intrahepatic hematomas, but does not correlate well with hepatic lacerations. Extreme caution is required when using CT alone to define "minimal" liver injury for prospective management of blunt trauma victims.

Many methods have been devised to stratify multiple system injuries.[1-4] Each of these earlier systems has its own inherent problems; each by itself is either unable to describe all injuries accurately, invalid for further clinical decision-making, or inadequate for guiding prospective patient management.[5] These scoring systems also lack validation.

In 1989, the Organ Injury Scaling Committee of the American Association for the Surgery of Trauma (AAST) released a new injury scaling system for solid viscus injuries after blunt abdominal trauma. This system reflects an anatomic description based on the most accurate assessment by either autopsy, laparotomy, or radiologic study.

This study attempts to validate the AAST Organ Injury Scale (OIS) as it relates to liver injuries, using operative findings, transfusion requirements, and operative management as indicators of severity of injury. It compares preoperative abdominal computed tomographic (CT) findings with operative findings as well as CT grading with operative grading, and discusses the clinical implications of using CT scanning alone for hepatic injury scaling (HIS).

MATERIALS AND METHODS

We identified patients admitted between December 1986 and May 1990 with blunt liver injury who fulfilled the following requirements: (1) suspicion of intra-abdominal injury following blunt trauma; (2) preoperative abdominal computed tomographic scans; and (3) subsequent emergent laparotomy. These patients represented approximately 9% of the total number of patients with an operative diagnosis of liver injury during that time. The protocol for abdominal CT scanning is as follows: Patients received oral contrast (2% barium suspension) before scanning. Scans were performed using either a Siemens DR3 or Siemens DRH without intravenous contrast from the base of the lung to the symphysis pubis 10 mm apart and 8 mm thick. Intravenous contrast was then given (60% diatrizoate meglumine, approximately 150 ml) and scans were obtained from the lung base to iliac crest 10 mm apart, 8 mm thick, and then 15 mm apart to the symphysis pubis. Indications for abdominal exploration included a positive peritoneal lavage (greater than 100,000 red blood cells/mm^3), a CT scan sugges-

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tive of significant intra-abdominal injury, or clinical signs such as worsening abdominal pain or development of hemodynamic instability.

All hepatic injuries were retrospectively graded according to operative notes by a single investigator (M.A.C.) using the AAST Organ Injury Scale, an anatomic description of injury scaled from 1 to 6, representing the least to most severe injury. Scoring is based on the most accurate assessment at autopsy, laparotomy, or radiologic study (Table 1).[6] A single radiologist (S.L.B.), blinded to operative findings, graded all CT scans according to the AAST Organ Injury Scale. In both methods of grading, the injury scale was advanced one grade for multiple injuries to the liver.

Routine demographic data, method of repair, complications, and total preoperative and intraoperative blood transfusions were collected on each patient. Since causes of hemorrhage differed in these multiply injured patients, we attempted to quantitate transfusion requirements for the hepatic injury by assigning different quantities of shed blood for various injuries: splenic injury, 2 units; resectional debridement of renal injury, 1 unit; femur fracture, 2 units; tibia fracture, 1 unit; upper extremity fracture, 1 unit; multiple facial fractures, 1 unit; and pelvic rami fractures, 2 units. Our series included no severe pelvic fractures involving the posterior elements.

RESULTS

Over the study period, 37 patients met the entry criteria by having both preoperative CT scans and emergent laparotomy. Nineteen were male and 18 were female; the average age was 29 (range, 14–76). The mean ISS was 31, and the mean abdominal trauma index was 14. The predominant mechanism of injury was motor vehicle crash (32 patients); of the other five, three were pedestrians struck by cars and two fell more than 20 feet.

TABLE 1
Liver Injury Scale[6]

Grade*	Injury Description†
I. Hematoma:	Subcapsular, nonexpanding, < 10% surface area
Laceration:	Capsular tear, nonbleeding, < 1 cm parenchymal depth
II. Hematoma:	Subcapsular, nonexpanding, 10%–50% surface area
Laceration:	Capsular tear, active bleeding; 1–3 cm parenchymal depth, < 10 cm in length
III. Hematoma:	Subcapsular, > 50% surface area or expanding; Ruptured subcapsular hematoma with active bleeding; Intraparenchymal hematoma > 2 cm or expanding
Laceration:	> 3 cm parenchymal depth
IV. Hematoma:	Ruptured intraparenchymal hematoma with active bleeding
Laceration:	Parenchymal disruption involving 25%–50% of hepatic lobe
V. Laceration:	Parenchymal disruption involving > 50% of hepatic lobe
Vascular:	Juxtahepatic venous injuries; i.e., retrohepatic vena cava/major hepatic veins
VI. Vascular:	Hepatic avulsion

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

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

Operative management varied according to severity of hepatic injury. Of the 37 injuries, four were central hematomas; the rest were hepatic lacerations. Three of the lacerations occurred at the falciform ligament. Fifteen hepatic injuries required no specific therapy. Topical hemostatic techniques were used in ten to obtain hemostasis. Three required individual suture of bleeding vessels, and six had omental packing of the laceration. Three required gauze packing to achieve hemostasis because of massive hemorrhage and coagulopathy; the two survivors had the gauze removed 24 hours after the original procedure and underwent omental packing.

Ten patients had associated splenic injuries; seven underwent splenectomy. Three patients with significant renal injuries were managed by resectional debridement and drainage. Two patients with renal artery thrombosis had nephrectomy. One patient with pancreatic transection was managed by distal resection and splenectomy; the other with pancreatic injury was managed by drainage alone. Other injuries included long bone fractures in six patients, multiple facial fractures in four, and pelvic rami fractures in five.

The grading of hepatic injuries by operative findings is shown in Table 2. The most common grades of injury were grades 2 and 3, with 12 and 11 patients, respectively. Two Grade 3 injuries, three Grade 4 injuries, and the one Grade 6 injury were all upgrades because of multiple injuries, as specified by the AAST grading system. Transfusion requirements, corrected for associated injuries, increased with more severe hepatic injury.

The grading of injuries from preoperative CT scans is also shown in Table 2. Distribution of injury is more varied, and corrected transfusion requirements do not correlate with increasing grade of injury as determined by CT scanning.

The CT grading correlated with operative findings in only six cases (16%) (Table 3). Four central intrahepatic

TABLE 2
Operative and CT grading with transfusion requirements

HIS	NL	1	2	3	4	5	6
OR	—	7	12	11	6	—	1
Number of units	—	0.1	0.5	2.7	11.0	—	22.0
CT	9	3	4	12	5	2	2
Number of units	1.0	1.7	5.5	3.8	3.2	10.5	2.5

TABLE 3
CT vs. OR grading

	Number of Patients
CT agreed with OR	6
CT over < 2 grades	9*
CT over ≥ 2 grades	7*
CT under < 2 grades	5
CT under ≥ 2 grades	10†

* Two intrahepatic hematomas in each group.

† Three falciform ligament injuries.

hematomas were defined by computed tomography but were not discovered at operation; accordingly, these four patients had higher injury grades than their operative findings revealed. Excluding those with intraparenchymal hematoma, the CT findings indicated more severe injury in 12 cases and less severe injury in 15 cases. The CT findings overestimated operative findings by two or more grades in five cases and underestimated operative findings by two or more grades in ten cases. Injuries around the falciform ligament occurred in three of the low misclassifications, and suboptimal scans accounted for another three. No explanations for the discrepancies could be found for the other hepatic lacerations.

Table 4 lists the operative management of liver injuries according to the AAST Organ Injury Scale as determined by both operative findings and preoperative CT scans. In the 19 patients with either Grade 1 or Grade 2 injuries determined at operation, 18 required either no specific therapy or minimal use of topical hemostatic techniques to control bleeding; the other underwent suture of a peripheral vessel. In the 18 with more severe liver injury (grades 3, 4, and 6), only seven required minimal therapy. One underwent suture of a peripheral vessel; one required deep placement of sutures; six required omental packing; and three required gauze packing for hemostasis. The CT grading showed 16 patients with either normal interpretations or Grade 1 or Grade 2 injuries. Thirteen of these required only minimal operative therapy, but two required omental packing and one required gauze packing to achieve hemostasis. These three patients all had injuries around the falciform ligament. The CT findings identified 21 patients with either Grade 3, 4, 5, or 6 injuries. Of these, 12 required minimal therapy (four of whom were patients with intrahepatic hematoma), two required suture of peripheral vessels, one required deep sutures, four required omental packing, and two required gauze packing.

There were six deaths, two of which were directly related to the liver injury. One patient, a 76-year-old man with operative Grade 3 injury and without associated injuries, underwent omental packing and received five units of blood. He died eight days later of progressive multiple system organ failure; no autopsy was performed.

TABLE 4
Operative management

HIS	NL	1	2	3	4	5	6
OR							
None/Topical	—	7	11	7	—	—	—
Suture	—	—	1	2	—	—	—
Omental pack	—	—	—	2	4	—	—
Gauze pack	—	—	—	—	2	—	1
CT							
None/Topical	8	2	3	8	3	—	1
Suture	—	—	—	1	1	—	1
Omental pack	1	1	—	2	1	1	—
Gauze pack	—	—	1	1	—	1	—

The other patient, with an operative Grade 6 injury, was managed by gauze packing and received 24 units of blood. She exsanguinated at re-exploration 24 hours after her initial operation during attempts to re-pack her liver.

One patient, who had a Grade 2 injury operatively and Grade 3 by CT scans, had a central hematoma not felt at operation. She initially recovered without incident and was discharged after four days, but returned one week later with hemobilia. Hepatic angiography demonstrated a left hepatic artery pseudoaneurysm; she underwent left hepatic lobectomy and recovered without incident.

DISCUSSION

The ideal organ injury grading system should be accurate and consistent enough to allow meaningful comparisons among different institutions for research purposes. It should provide a reliable measure of injury severity for developing quality assurance standards and should assist in the prospective management of patients. The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) and the American College of Surgeons' Committee on Trauma (ACS-COT) are extremely interested in this issue of quality assurance in trauma care, and the ACS-COT has suggested 22 different audit filters to identify cases for review.[7] Similar audit filters are being developed by the JCAHO, but little has been done to prove the audit filters by using clinical trials to establish them as predictors of quality delivery.

Various injury severity indices[1-4] based on anatomic, physiologic, and biochemical values are useful in assessing prehospital care and in estimating overall hospital mortality among multiply injured patients. These indices are valuable because they allow different institutions to compare patients, and they can play some role in clinical decision-making. They cannot, however, guide prospective patient management. They do not adequately assess the severity of intra-abdominal injury; therefore, they cannot be used to devise prospective management plans for specific organ injuries. This makes validation of these different stratification systems difficult, compounding the problem of using any system prospectively.

Moore et al.[5] devised the Penetrating Abdominal Trauma Index (ATI) in 1979. This is a method of quantifying the risk of complications following penetrating abdominal trauma. An elevated ATI (greater than 25) correlates very well with increased septic morbidity postoperatively. This stratification system allows the comparison of institutional results and permits some prospective decision-making about subsequent patient management.[8,9] This system has also been validated in clinical trials to some degree.[9,10] However, no preoperative decisions could be made because the scoring system depends upon operative findings.

In 1987, the Organ Injury Scaling Committee was appointed by the American Association for the Surgery

of Trauma to devise injury severity scores for individual organs to facilitate research.[6] The OIS classification system is an anatomic description, scaled from 1 to 5 (6 for liver), representing the least to the most severe injury. The committee devised organ injury scaling systems for the liver, spleen, and kidneys. These OISs represent a consolidation of previous scales applied for these organs as well as a consensus of the OIS Committee and AAST Board of Managers. This system is an important step in the attempt to develop an ideal stratification system for solid viscus injuries.

The AAST OIS seems to satisfy the theoretical requirements for the ideal stratification system. It could be used to compare results from different institutions for research purposes. If valid, it could also be used to establish quality assurance standards for the management of solid viscus injuries. Because the injury scale includes radiologic studies as a contributing factor, it could, if valid, be used to establish protocols for prospective management of patients with hepatic, splenic, or renal injuries. Our study attempted to validate this OIS for liver injuries, using the hepatic injury scale (HIS, Table 1). Since this stratification system can be used preoperatively to guide management, we correlated preoperative CT grading of hepatic injuries with the operative findings.

We used transfusion requirements as a measure of severity of liver injury; the operative HIS correlates very well with increasing transfusion requirements. With the least severe injuries (grades 1 and 2), the average transfusion was less than 1 unit of blood per patient. Transfusion requirements increased almost exponentially for the most severe injuries.

The method of operative management was also used to validate the HIS. With the least severe injuries, hemostasis was achieved with temporary packing of lacerations, topical hemostatic techniques, or suture of a peripheral vessel. With the higher HISs, fewer techniques such as temporary packing were used; deep individual sutures, omental packing, and gauze packing of hepatic lacerations were more frequent. Upgrading for multiple injuries seemed appropriate to our validation process. Using both transfusion requirements and methods of operative management as measures, we found that the operative HIS correlated well with severity of liver injury and readily characterized hepatic lacerations. Thus when operative findings are used to grade hepatic injuries, the AAST HIS seems to be a valid scoring system, and could therefore be used for research, quality assurance, and operative management protocols.

The relationship between the HIS and liver injury severity was not as clear when preoperative CT scanning was used to grade the liver injury. The CT grades showed a much wider distribution of average transfusions. The two patients with CT Grade 5 injuries received the highest average amount of blood, followed by those with Grade 2 injuries. The two with the most severe injuries according to CT scan (Grade 6) received only 5 units of blood combined.

Similar relationships were apparent when operative management was the marker of injury severity. Although a CT scan interpreted as normal correlated with minimal hemostatic techniques in eight of nine patients, the other patient received omental packing. Conversely, one of the CT Grade 6 patients required topical hemostatic treatment, and the other required suture of a peripheral vessel. Upgrading for multiple injuries did not change any of the relationships. The scaling of injuries by preoperative CT scan did not correlate with hepatic injury severity as measured by transfusion requirements or by operative management. Thus when preoperative CT scanning is used to grade hepatic injuries, the HIS does not seem to be a valid stratification system, because correlation with actual findings at operation is poor.

In four patients, CT scans demonstrated central intrahepatic hematomas that were not discovered at operation. While hepatic lacerations are easily seen at laparotomy, intraparenchymal hematoma is often difficult to discern. These hematomas were not explored at initial laparotomy. Three patients recovered. One patient with an operative Grade 2 and CT Grade 3 injury returned one week after discharge with hemobilia. An angiogram confirmed a hepatic artery pseudoaneurysm, and left hepatic lobectomy was performed. Although these numbers are small, it seems prudent to perform at least a repeat CT scan on patients with central hematoma, as recommended by Olsen[11] and Farnell et al.[12] This precaution could allow early diagnosis of pseudoaneurysm.

The CT findings agreed with operative findings in only 16% of cases. Excluding the four central hematomas, the hepatic injury was misclassified from the CT findings in 27 cases. Most disquieting are the 15 instances of underestimation of injury. Ten of these were low by at least two grades. Injuries near the falciform ligament accounted for three of the low misclassifications, and these were the only falciform ligament injuries in this series (Fig. 1). Three scans were suboptimal, resulting in underestimation of injury. In all other cases of underestimation, neither the depth nor the magnitude of the hepatic laceration could be predicted from the CT scans. Thus it appears that although CT scanning is an excellent method for diagnosis of intrahepatic hematoma, it correlates poorly with severity of hepatic laceration, tends to underestimate the magnitude of the laceration, and is inadequate for diagnosis of injuries near the falciform ligament. For CT scanning to be useful, optimal imaging is imperative, but it is often difficult to obtain with the multiply injured patient.

With increasing use of CT scanning to evaluate the abdomen following blunt abdominal trauma, nonoperative management of "minimal" spleen or liver injury has become more frequent. Using CT scanning to grade splenic trauma appears helpful both to stratify injuries and to aid in nonoperative therapy.[13-15] Malangoni et

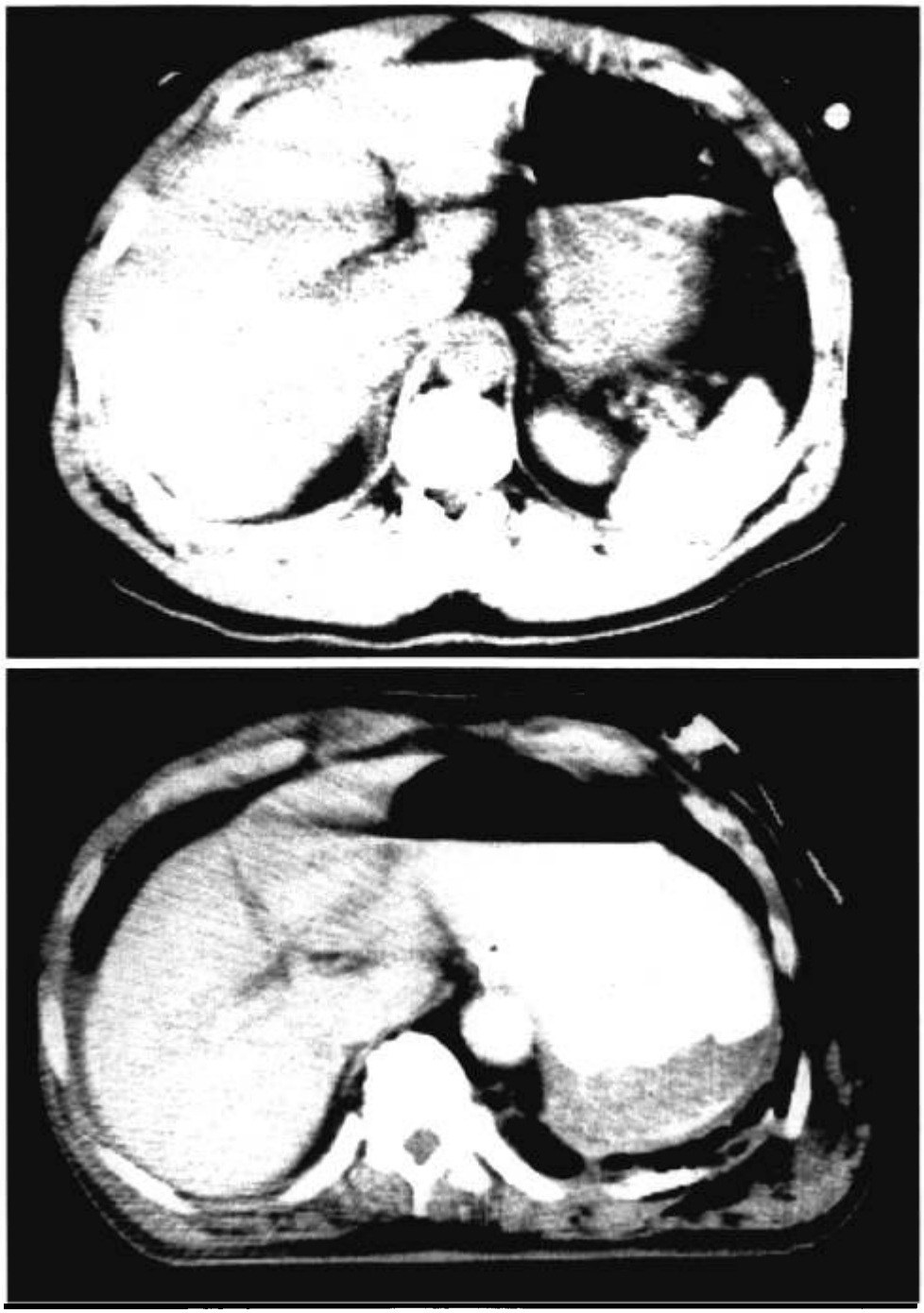

FIG. 1. (*Top*) Falciform ligament injury obscured by artifact from air-fluid level in stomach. (*Bottom*) Falciform ligament injury classified as Grade 3 operatively and Grade 1 from CT scan.

al.[14] reported that the severity of splenic injury was underestimated from CT scans in 53% of cases, a trend seen also in the present study of liver injuries. Nonoperative management of hepatic injury in the pediatric population is more accepted, and several investigators have reported good results using various radiographic techniques to evaluate liver injury.[19-22] Adult scoring systems using both operative findings[23] and CT findings[24] have also been described. Meyer et al.[25] described 24 patients whose CT scans showed small hepatic lacerations or intraparenchymal hematomas and who were managed without laparotomy. The CT criteria for nonoperative management were simple parenchymal laceration or hematoma, no evidence of active bleeding, estimated peritoneal blood less than 250 ml, and absence of other intraperitoneal injury. No patient subsequently required laparotomy. Farnell et al.[12] reported 20 patients with blunt liver injury managed without operation. These patients met the following criteria: hemodynamically stable with (1) contained subcapsular or intrahepatic hematoma; (2) unilobar fracture; (3) absence of devitalized liver; (4) minimal hemoperitoneum; and (5) no other

significant intra-abdominal injuries. Two patients failed (10%) and underwent surgical exploration. A recent report by Federico et al.[8] described 16 patients whose liver injuries were managed nonoperatively. None required subsequent laparotomy, but two were later readmitted with complications. From these studies it appears that some liver injuries may be observed without operation.

Several words of caution are necessary. These studies describing nonoperative management of hepatic injury are retrospective, the degrees of hepatic injury were not well quantitated, CT scanning did not *prospectively* guide management, and, most importantly, the CT interpretations were never validated by operation. Our study, which compares preoperative CT findings with operative findings in a quantitative fashion using the HIS, demonstrates a poor correlation between CT grade of hepatic injury and severity of hepatic fracture. In a few cases the failure was the result of a suboptimal CT image; a high-quality CT scan is essential to avoid errors in interpretation. As Malangoni et al.[14] found with splenic injuries, the severity of injury is frequently underestimated from CT scans. Sixteen patients in our study had either normal interpretation or Grade 1 or Grade 2 injuries, so-called "minimal" hepatic injury, according to the CT scans. In three of them, severe injuries near the falciform ligament were discovered at operation. Two received omental packing, and the other required gauze packing for hemostasis; they received 4, 5, and 22 units of blood, respectively. Some investigators think the quantity of hemoperitoneum important,[12,25] but another disagrees.[26] Federle and Jeffrey[27] attempted to quantitate hemoperitoneum from abdominal CT scans, but their verification was primarily based on surgeons' estimates, which varied among different surgeons at the same operation. Hemoperitoneum is difficult to quantitate based on anatomic recesses because the anatomy is so variable. Time from CT scanning to operation is also an important factor; CT scanning measures blood in the abdomen at one point in time, ignoring the possibility of persistent hemorrhage. Although preoperative CT scanning may be a helpful adjunct in the management of blunt trauma victims with hepatic injury, our study suggests that extreme caution is necessary if CT scanning alone is used to prospectively determine patient care.

In summary, we evaluated 37 patients with blunt trauma, all of whom sustained hepatic injury and had abdominal CT scans prior to laparotomy. We found that when transfusion requirements and method of operative management are used to indicate severity of injury, operative grading by the AAST Organ Injury Scale readily characterizes and correlates well with the degree of hepatic injury and appears to meet the theoretical requirements for an ideal injury scaling system. A CT scan can define intrahepatic hematoma but correlates poorly with the extent of hepatic fracture, especially falciform ligament injuries. Finally, extreme caution is required when using CT scans alone to define "minimal" liver injury for prospective management of trauma victims. Further prospective studies could try to develop protocols in which interpretation of CT scans will predict operative findings so that CT grading, like operative grading using the AAST HIS, will meet the requirements of an ideal scaling system.

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DISCUSSION

DR. KAREN R. BORMAN (Dallas, Texas): I would like to congratulate Dr. Croce for a very fine presentation and for providing me with the manuscript well in advance.

The authors set out to examine the utility of the Organ Injury Scale derived both radiographically and operatively by comparing it with some clinical features of blunt hepatic injury. They have demonstrated a very fine correlation with the operative score and a much weaker one with the radiographically derived score.

These data are reassuring to us as surgeons. It is nice to know that our eyes and hands are still better than our radiologic colleagues and their images.

The question remains: Why is there such a disparity? I have several other questions that at least tangentially relate to this issue.

First, these 37 patients represent 9% of your operative hepatic injuries over the same time period. How did they come to CT scanning and thereby inclusion in the study? And could the selection criteria for CT scanning have introduced any bias?

Second, were transfusion indications uniform across the time period of the study? Certainly as we all are transfusing patients less, perhaps that had an impact in some way.

Third, what was the interval from CT scanning to operation? Despite our best efforts, the complete evaluation of the multiply injured, blunt-trauma patient can be very time consuming. Obviously, the longer this interval, the greater the opportunity for evolution of the injury (for example, extension of subcapsular hematomas) and therefore the possibility for disparity between operative and radiologic findings.

Do the authors have any suggestions for modification of the Organ Injury Scale to reflect the data that they presented today?

And, finally, should Organ Injury Scale data be prefixed or suffixed with "O" for operative, "A" for autopsy, "R" for radiologic, or some other system to allow fairer comparison across institutions of data and better utility of the system?

I thank the Association for the honor of membership and the privilege of the floor.

DR. H. DAVID ROOT (San Antonio, Texas): I think it's a nice correlation. I am a little bit confused about confirmation of the anatomic grading by CT.

Did you correlate that, the anatomic grading, intraoperatively? In other words, how reliable are the signs?

As I understand, you graded according to number of transfusions during operation. Could you comment on the anatomic correlation. Actually, if one chooses to observe patients with hepatic lacerations, there is no real point in doing a CT scan, because it tells you that there is a crack in the liver but you are going to wait for numbers of transfusions before anything is done. Is that an extrapolation of what you are saying?

DR. LYNNE W. BAKER (Natal, South Africa): In the patients with liver injuries whom you treated with packs, you indicated that you removed these in 12 hours. I wondered why you chose 12 hours and would even question 24 hours.

On what grounds do you choose the time for removal, and particularly at 12 hours did you have rebleeding on removing the packs?

DR. JACK BERGSTEIN (Milwaukee, Wisconsin): I am a little bit concerned about your index of severity. I think your conclusion that it correlates with operative findings is a foregone one because your index is defined as operative therapy and transfusions. Therefore, patients who do not require operative therapy are going to have lesser severity, and your severity has to, in that case, correlate with your operative therapy.

I wonder if there are other indices of severity that you might look at. I also wonder how you came to those transfusion correction factors for the other organ system injuries.

DR. MARTIN A. CROCE (Closing): I would like to thank Dr. Borman for her kind comments. First, to address her questions, why did we get a CT scan on these particular 37 patients? Some of these patients had a CT scan instead of peritoneal lavage because of the presence of a midline scar. Some patients received CT for evaluation of hematuria. We also had various protocols at one time or another during the course of this study in which CT was involved.

Yes, the transfusion requirements are fairly uniform. The trauma faculty has been fairly stable over the duration of the study, as has the anesthesia faculty. Therefore, we consider that our transfusion indications have indeed been uniform.

The time interval from CT scan to operating room is as short as possible. None of these were delays of 12 hours or more. The vast majority of patients were in the operating room within three hours of their arrival at the Trauma Center.

Do we have any suggestions for changes in the organ injury scale? I think the first thing we need to do is to try to evaluate prospectively the role of the CT scan. I think it has a very important role in the management of patients with blunt liver injury; however, I am not quite sure what that role should be. It seems clear from several articles in the recent literature that there are indeed patients with so-called "minimal liver injury" who can safely be observed without operation. Prospective analysis to address that question is currently being undertaken at the Presley Trauma Center in Memphis. We are now trying to observe patients who have Grade I or Grade II CT-determined liver injuries. Since we know that a significant number of those patients may have falciform ligament injuries, we keep all these patients in the Trauma Intensive Care Unit under close observation.

Dr. Root asked about how we use transfusion requirements and how that correlated with the organ injury grading system. The operative grades were determined by the actual appearance of the liver in our hands at operation, the depth of the parenchymal lacerations, the size of the hematoma, or what have you. The CT grades were determined by the appearance of the liver on CT scan. We used transfusion requirements as an indicator of the severity of hepatic fracture.

Dr. Baker asked about our lap pack removal. It is our policy that if a patient is exsanguinating from the liver injury and coagulopathy, we use gauze packing to try to achieve some sort of hemostasis. The patient is taken back to the intensive care unit, warmed, and treated for the coagulopathy. Once the coagulopathy is corrected, usually within 24 hours, we take the patient back to the operating room to remove the packs. We think it is important to remove these packs within 24 hours because they are a potential nidus for infection.

Once again, I would like to thank the AAST for the privilege of the floor.

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Organ Injury Scaling, II: Pancreas, Duodenum, Small Bowel, Colon, and Rectum

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The Organ Injury Scaling (O.I.S.) Committee of the American Association for the Surgery of Trauma (A.A.S.T.) has been charged to devise injury severity scores for individual organs to facilitate clinical research. Our first report (1) addressed O.I.S.'s for the Spleen, Liver, and Kidney; the following are proposed O.I.S.'s for Pancreas (Table I), Duodenum (Table II), Small Bowel (Table III), Colon (Table IV), and Rectum (Table V). The grading scheme is fundamentally an anatomic description, scaled from 1 to 5, representing the least to the most severe injury. We emphasize that these O.I.S.'s represent an initial classification system which must undergo continued refinement as clinical experience dictates.

TABLE I
Pancreatic organ injury scale

Grade*		Injury Description†	ICD-9	AIS-85	AIS-90
I	Hematoma	Minor contusion without duct injury	863.81–863.84	2	2
	Laceration	Superficial laceration without duct injury		2	2
II	Hematoma	Major contusion without duct injury or tissue loss	863.81–863.84	3	2
	Laceration	Major laceration without duct injury or tissue loss		3	3
III	Laceration	Distal transection or parenchymal injury with duct injury	863.92–863.94	3	3
IV	Laceration	Proximal[a] transection or parenchymal injury involving ampulla	863.91	3	4
V	Laceration	Massive disruption of pancreatic head	863.91	5	5
.81, .91 = Head; .82, .92 = Body; .83, .93 = Tail					

[a] Proximal pancreas is to the patients' right of the superior mesenteric vein.
* Advance one grade for multiple injuries to the same organ.
† Based on most accurate assessment at autopsy, laparotomy, or radiologic study.

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TABLE II
Duodenum organ injury scale

Grade*		Injury Description†	ICD-9	AIS-85	AIS-90
I	Hematoma	Involving single portion of duodenum	863.21	2	2
	Laceration	Partial thickness, no perforation	863.21	2	3
II	Hematoma	Involving more than one portion	863.21	2	2
	Laceration	Disruption <50% of circumference	863.31	3	4
III	Laceration	Disruption 50–75% circumference of D2	863.31	4	4
		Disruption 50–100% circumference of D1, D3, D4		4	4
IV	Laceration	Disruption > 75% circumference of D2	863.31	4	5
		Involving ampulla or distal common bile duct		4	5
V	Laceration	Massive disruption of duodenopancreatic complex	863.31	5	5
	Vascular	Devascularization of duodenum	863.31	5	5

D1 = 1st portion duodenum, D2 = 2nd portion duodenum, D3 = 3rd portion duodenum, D4 = 4th portion duodenum.
* Advance one grade for multiple injuries to the same organ.
† Based on most accurate assessment at autopsy, laparotomy, or radiologic study.

TABLE III
Small bowel organ injury scale

Grade*		Injury Description†	ICD-9	AIS-85	AIS-90
I	Hematoma	Contusion or hematoma without devascularization	863.20	2	2
	Laceration	Partial thickness, no perforation	863.20	2	2
II	Laceration	Laceration <50% of circumference	863.30	3	3
III	Laceration	Laceration ≥50% of circumference without transection	863.30	3	3
IV	Laceration	Transection of the small bowel	863.30	4	4
V	Laceration	Transection of the small bowel with segmental tissue loss	863.30	4	4
	Vascular	Devascularized segment	863.30	4	4

* Advance one grade for multiple injuries to the same organ.
† Based on the most accurate assessment at autopsy, laparotomy, or radiologic study.

TABLE IV
Colon organ injury scale

Grade*		Injury Description†	ICD-9	AIS-85	AIS-90
I	Hematoma	Contusion or hematoma without devascularization	863.40–863.44	2	2
	Laceration	Partial thickness, no perforation	863.40–863.44	3	2
II	Laceration	Laceration <50% of circumference	863.50–863.54	4	3
III	Laceration	Laceration ≥50% of circumference without transection	863.50–863.54	4	3
IV	Laceration	Transection of the colon	863.50–863.54	5	4
V	Laceration	Transection of the colon with segmental tissue loss	863.50–863.54	5	4
	Vascular	Devascularized segment	863.50–863.54	5	4

.41, .51 = Ascending; .42, .52 = Transverse; .43, .53 = Descending; .44, .54 = Rectum

* Advance one grade for multiple injuries to the same organ.
† Based on the most accurate assessment at autopsy, laparotomy, or radiologic study.

TABLE V
Rectal organ injury scale

Grade*		Injury Description†	ICD-9	AIS-85	AIS-90
I	Hematoma	Contusion or hematoma without devascularization	863.45	2	2
	Laceration	Partial thickness laceration	863.45	3	2
II	Laceration	Laceration <50% of circumference	863.55	4	3
III	Laceration	Laceration ≥50% of circumference	863.55	4	4
IV	Laceration	Full-thickness laceration with extension into the perineum	863.55	5	5
V	Vascular	Devascularized segment	863.55	5	5

* Advance one grade for multiple injuries to the same organ.
† Based on the most accurate assessment at autopsy, laparotomy, or radiologic study.

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ORGAN INJURY SCALING III: CHEST WALL, ABDOMINAL VASCULAR, URETER, BLADDER, AND URETHRA

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THE ORGAN INJURY SCALING (OIS) Committee of the American Association for the Surgery of Trauma (AAST) has been charged to devise injury severity scores for individual organs to facilitate clinical research. This represents the third group of OISs.[1,2] The current report addresses proposed OISs for the chest wall (Table 1), abdominal vascular (Table 2), ureter (Table 3), bladder (Table 4), and urethra (Table 5). The grading scheme is fundamentally an anatomic description, scaled from 1 to 5, representing the least to the most severe injury. We, again, emphasize that these OISs represent an initial classification system which must undergo continued refinement as clinical experience dictates.

Table 1
Chest wall organ injury scale*

Grade†	Injury Type	Description of Injury	ICD-9	AIS-85	AIS-90
I	Contusion	Any size	911.0/922.1	1	1
	Laceration	Skin and subcutaneous;	875.0	1	1
	Fracture	<3 ribs, closed;	807.01/807.02	1	1–2
		nondisplaced clavicle, closed;	810.00–810.03	2	2
II	Laceration	Skin, subcutaneous and muscle;	875.1	1	1
	Fracture	≥3 adjacent ribs, closed;	807.03–807.09	2	2–3
		open or displaced clavicle;	810.10–810.13	2	2
		nondisplaced sternum, closed;	807.2	2	2
		scapular body, open or closed;	811.00–811.19	2	2
III	Laceration	Full thickness including pleural penetration	862.29	2	2
	Fracture	Open or displaced sternum; flail sternum,	807.2/807.3	3	2
		Unilateral flail segment, (<3 ribs);	807.4	4	3–4
IV	Laceration	Avulsion of chest wall tissues with underlying rib fractures	807.10–807.19	4	4
	Fracture	Unilateral flail chest, (≥3 ribs);	807.4	4	3–4
V	Fracture	Bilateral flail chest; (≥3 ribs on both sides)	807.4	4	5

* This scale is confined to the chest wall alone and does not reflect associated internal thoracic or abdominal injuries. Therefore, further delineation of upper versus lower or anterior versus posterior chest wall was not considered, and a grade VI was not warranted. Specifically, thoracic crush was not used as a descriptive term; instead, the geography and extent of fractures and soft tissue injury were used to define the grade.

† Upgrade by one grade for bilateral injuries.

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Table 2
Abdominal vascular organ injury scale*

	OIS Grade	ICD-9	AIS-85	AIS-90
Grade I†				
Non-named superior mesenteric artery or superior mesenteric vein branches	I	902.20/902.39	NS	NS
Non-named inferior mesenteric artery or inferior mesenteric vein branches	I	902.27/902.32	NS	NS
Phrenic artery/vein	I	902.89	NS	NS
Lumbar artery/vein	I	902.89	NS	NS
Gonadal artery/vein	I	902.89	NS	NS
Ovarian artery/vein	I	902.81/902.82	NS	NS
Other non-named small arterial or venous structures requiring ligation	I	902.90	NS	NS
Grade II†				
Right, left or common hepatic artery	II	902.22	3	3
Splenic artery/vein	II	902.23/902.34	3	3
Right or left gastric arteries	II	902.21	3	3
Gastroduodenal artery	II	902.24	3	3
Inferior mesenteric artery, trunk or inferior mesenteric vein, trunk	II	902.27/902.32	3	3
Primary named branches of mesenteric artery (e.g., ileocolic artery) or mesenteric vein	II	902.26/902.31	3	3
Other named abdominal vessels requiring ligation/repair	II	902.89	3	3
Grade III†				
Superior mesenteric vein, trunk	III	902.31	3	3
Renal artery/vein	III	902.41/902.42	3	3
Iliac artery/vein	III	902.53/902.54	3	3
Hypogastric artery/vein	III	902.51/902.52	3	3
Vena cava, infra-renal	III	902.10		3
Grade IV†				
Superior mesenteric artery, trunk	IV	902.25	3	3
Celiac axis proper	IV	902.24	3	3
Vena cava, suprarenal and infra-hepatic	IV	902.10	3	3
Aorta, infra-renal	IV	902.00	4	4
Grade V†				
Portal vein	V	902.33	3	3
Extra-parenchymal hepatic vein	V	902.11	3 (hepatic vein) 5 (liver vein)	3 (hepatic vein) 5 (liver + veins)
Vena cava, retrohepatic or supra-hepatic	V	902.19	5	5
Aorta, suprarenal, subdiaphragmatic	V	902.00	4	4

This classification system is applicable for extraparenchymal vascular injuries. If the vessel injury is within 2 cm of the organ parenchyma, refer to specific organ injury scale.

† Increase one grade for multiple grade III or IV injuries involving >50% vessel circumference. Downgrade one grade if <25% vessel circumference laceration for grades IV or V.

Table 3
Ureter organ injury scale

Grade*	Injury Type	Description of Injury	ICD-9	AIS-85	AIS-90
I	Hematoma	Contusion of hematoma without devascularization	867.2/867.3	2	2
II	Laceration	<50% transection	867.2/867.3	2	2
III	Laceration	>50% transection	867.2/867.3	3	3
IV	Laceration	Complete transection with 2-cm devascularization	867.2/867.3	3	3
V	Laceration	Avulsion with >2 cm of devascularization	867.2/867.3	3	3

* Advance one grade if multiple lesions exist.

Table 4
Bladder organ injury scale

Grade*	Injury Type	Description of Injury	ICD-9	AIS-85	AIS-90
I	Hematoma	Contusion, intramural hematoma	867.0/867.1	2	2
	Laceration	Partial thickness		3	3
II	Laceration	Extraperitoneal bladder wall laceration <2 cm	867.0/867.1	4	4
III	Laceration	Extraperitoneal (>2 cm) or intraperitoneal (<2 cm) bladder wall lacerations	867.0/867.1	4	4
IV	Laceration	Intraperitoneal bladder wall laceration >2 cm	867.0/867.1	4	4
V	Laceration	Intra or extraperitoneal bladder wall laceration extending into the bladder neck or ureteral orifice (trigone)	867.0/867.1	4	4

* Advance one grade if multiple lesions exist.

Table 5
Urethra organ injury scale

Grade*	Injury Type	Description of Injury	ICD-9	AIS-85	AIS-90
I	Contusion	Blood at urethral meatus; urethrography normal	867.0/867.1	2	2
II	Stretch injury	Elongation of urethra without extravasation on urethrography	867.0/867.1	2	2
III	Partial disruption	Extravasation of urethrography contrast at injury site with contrast visualized in the bladder	867.0/867.1	2	2
IV	Complete disruption	Extravasation of urethrography contrast at injury site without visualization in the bladder; <2 cm of urethral separation	867.0/867.1	3	3
V	Complete disruption	Complete transection with >2 cm urethral separation, or extension into the prostate or vagina	867.0/867.1	4	4

* Advance one grade if multiple injuries exist.

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ORGAN INJURY SCALING IV: THORACIC VASCULAR, LUNG, CARDIAC, AND DIAPHRAGM

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THE ORGAN INJURY SCALING (OIS) Committee of the American Association for the Surgery of Trauma (AAST) has been charged to devise injury severity scores for individual organs to facilitate clinical research. This

Table 1
Thoracic vascular organ injury scale

Grade*	Injury Description†	ICD-9	AIS-90
I	Intercostal artery/vein	901.81	2–3
	Internal mammary artery/vein	901.82	2–3
	Bronchial artery/vein	901.89	2–3
	Esophageal artery/vein	901.9	2–3
	Hemiazygous vein	901.89	2–3
	Unnamed artery/vein	901.9	2–3
II	Azygous vein	901.89	2–3
	Internal jugular vein	900.1	2–3
	Subclavian vein	901.3	3–4
	Innominate vein	901.3	3–4
III	Carotid artery	900.01	3–5
	Innominate artery	901.1	3–4
	Subclavian artery	901.1	3–4
IV	Thoracic aorta, descending	901.0	4–5
	Inferior vena cava (intrathoracic)	902.10	3–4
	Pulmonary artery, primary intraparenchymal branch	901.41	3
	Pulmonary vein, primary intraparenchymal branch	901.42	3
V	Thoracic aorta, ascending and arch	901.0	5
	Superior vena cava	901.2	3–4
	Pulmonary artery, main trunk	901.41	4
	Pulmonary vein, main trunk	901.42	4
VI	Uncontained total transection of thoracic aorta or pulmonary hilum	901.0 901.41 901.42	5 4

* Increase one grade for multiple grade III or IV injuries if >50% circumference, decrease one grade for grade IV and V injuries if <25% circumference.

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

Table 2
Lung organ injury scale

Grade*	Injury Type	Injury Description†	ICD-9	AIS-90
I	Contusion	Unilateral, <1 lobe	861.12/861.31	3
II	Contusion	Unilateral, single lobe	861.20/861.30	3
	Laceration	Simple pneumothorax	860.0/1 860.4/5	3
III	Contusion	Unilateral, >1 lobe	861.20/861.30	3
	Laceration	Persistent (>72 hours), airleak from distal airway	860.0/1 860.4/5 862.0/861.30	3–4
	Hematoma	Nonexpanding intraparenchymal		
IV	Laceration	Major (segmental or lobar) airway leak	862.21/861.31	4–5
	Hematoma	Expanding intraparenchymal		
	Vascular	Primary branch intrapulmonary vessel disruption	901.40	3–5
V	Vascular	Hilar vessel disruption	901.41/901.42	4
VI	Vascular	Total, uncontained transection of pulmonary hilum	901.41/901.42	4

* Advance one grade for bilateral injuries; hemothorax is graded according to the thoracic vascular OIS.

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

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Table 3
Cardiac injury organ scale

Grade	Injury Description	ICD-9	AIS-90
I	Blunt cardiac injury with minor ECG abnormality (nonspecific ST or T wave changes, premature atrial, ventricular contraction or persistent sinus tachycardia)	861.01	3
	Blunt or penetrating pericardial wound without cardiac injury, cardiac tamponade or cardiac herniation		
II	Blunt cardiac injury with heart block (right or left bundle branch, left anterior fasicular, or atrioventricular) or ischemic changes (ST depression or T wave inversion) without cardiac failure	861.01	3
	Penetrating tangential myocardial wound up to, but not extending through endocardium, without tamponade	861.12	3
III	Blunt cardiac injury with sustained (≥5 beats/min) or multifocal ventricular contractions	861.01	3–4
	Blunt or penetrating cardiac injury with septal rupture, pulmonary or tricuspid valvular incompetence, papillary muscle dysfunction, or distal coronary arterial occlusion without cardiac failure	861.01	3–4
	Blunt pericardial laceration with cardiac herniation		
	Blunt cardiac injury with cardiac failure	861.01	3–4
	Penetrating tangential myocardial wound up to, but not extending through endocardium, with tamponade	861.12	3
IV	Blunt or penetrating cardiac injury with septal rupture, pulmonary or tricuspid valvular incompetence, papillary muscle dysfunction or distal coronary arterial occlusion producing cardiac failure	861.12	3
	Blunt or penetrating cardiac injury with aortic or mitral valve incompetence		
	Blunt or penetrating cardiac injury of the right ventricle, right atrium, or left atrium	861.03 861.13	5
V	Blunt or penetrating cardiac injury with proximal coronary arterial occlusion		
	Blunt or penetrating left ventricular perforation	861.03 861.13	5
	Stellate injuries <50% tissue loss of the right ventricle, right atrium or left atrium	861.03 861.13	5
VI	Blunt avulsion of the heart; penetrating wound producing >50% tissue loss of a chamber		6

* Advance one grade for multiple penetrating wounds to a single chamber or multiple chamber involvement.

Table 4
Diaphragm organ injury scale

Grade*	Injury Description	ICD-9	AIS-90
I	Contusion	862.0	2
II	Laceration ≤2 cm	862.1	3
III	Laceration 2–10 cm	862.1	3
IV	Laceration >10 cm with tissue loss ≤25 cm^2	862.1	3
V	Laceration with tissue loss >25 cm^2	862.1	3

* Advance one grade for bilateral injuries.

represents the fourth group of OISs.[1-3] The current report addresses proposed OISs for thoracic vascular (Table 1), lung (Table 2), cardiac (Table 3), and diaphragmatic (Table 4) injuries. The grading scheme is fundamentally an anatomic description, scaled from 1 to 5, representing the least to the most severe injury. We again emphasize that these OISs represent an initial classification system which must undergo continued refinement governed by clinical experience.

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Organ Injury Scaling: Spleen and Liver (1994 Revision)

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The Organ Injury Scaling (OIS) Committee of the American Association for the Surgery of Trauma (AAST) was organized formally in 1987; the fundamental purpose was to devise injury severity scores for individual organs to facilitate clinical investigation and outcomes research. The OIS Committee members were selected on the basis of recognized clinical expertise as well as experience with injury scoring. The Committee was charged to develop a comprehensive set of OISs, monitor their application in the current literature, and recommend modifications when deemed appropriate. The following OISs for spleen and liver represent the first revisions in this long term project.

Conceptually, the OIS is a classification scheme based on the anatomic disruption of an individual organ scaled 1 to 6, representing the least to most severe injury. Grades 1 to 5 represent increasingly complex injuries encountered in salvageable patients, while grade 6 is a destructive lesion incompatible with survival. Severity is based on potential threat to the patient's life, and the progressive scale derived from a comprehensive review of the current literature with consensus of the OIS Committee. Finally, the AAST Board of Managers approves all OISs prior to submission

for publication. Despite this extensive preparation process, OISs are inherently limited by design as ordinal rather than interval scales. For example, the difference between a grade I versus II injury is generally less significant clinically than a grade IV versus V. The fundamental objective of the OIS, however, is not to assign prognostic value to a specific injury, but rather to provide a clearer description to facilitate comparison of an equivalent injury managed in one fashion versus another.

To date, OISs have been developed and published in the Journal of Trauma for spleen, liver, kidney, [1] pancreas, duodenum, small bowel, colon, rectum, [2] chest wall, abdominal vascular, ureter, bladder, urethra, [3] and thoracic vascular, lung, cardiac, diaphragm. [4] While many of these OISs have been employed in clinical research, the individual scaling grades have not been studied independently for scientific accuracy. Nonetheless, with increased clinical testing and constructive review by other investigators, the need for revisions has become apparent. Spleen and liver OISs, first published in 1989, [1] have been applied frequently in the literature over the past five years, and describe two ongoing controversial areas in trauma care. Consequently, it is not surprising that revisions for these two OISs have become necessary. Some of these modifications were straightforward, while others required considerable deliberation of the OIS committee before a consensus could be reached.

The significant revisions in the spleen and liver OIS include: 1) global downgrading of hematomas for both spleen and liver, acknowledging their relatively benign course with the advent of widespread CT scanning for blunt abdominal trauma, 2) addition of Couinard's segmental liver anatomy to facilitate quantification of lobar parenchymal disruption, employing internationally familiar terminology, 3) more rigorous criteria for grade IV and V hepatic injuries, recognizing the need to further delineate the operative challenges of these advanced lesions, and 4) restricting the advancement of one grade for multiple injuries within an OIS to grade III. The revised scale for spleen OIS is depicted in Table 1. The specific changes are increased threshold hematoma size to > 5cm for grade III, and elimination of ruptured intraparenchymal hematoma as a grade IV injury. The changes for the revised liver OIS (Table 2) are increased threshold hematoma size to > 10cm for

grade III, increased amount of parenchyma involved to > 75% for grade V, and the addition of equivalent Counard segments for grade IV and grade V.

	Grade[a]	Injury Description	ICD-9	AIS-90
I	Hematoma	Subcapsular, <10% surface area	865.01 865.11	2
	Laceration	Capsular tear, <1 cm parenchymal depth	865.02 865.12	2
II	Hematoma	Subcapsular, 10–50% surface area; intraparenchymal, <5 cm in diameter	865.01 865.11	2
	Laceration	1–3 cm parenchymal depth which does not involve a trabecular vessel	865.02 865.12	
III	Hematoma	Subcapsular, >50% surface area or expanding; ruptured subcapsular or parenchymal hematoma Intraparenchymal hematoma >5 cm or expanding		3
	Laceration	>3 cm parenchymal depth or involving trabecular vessels	865.03 865.13	3
IV	Laceration	Laceration involving segmental or hilar vessels producing major devascularization (>25% of spleen)		4
V	Laceration	Completely shattered spleen	865.04 865.14	5
	Vascular	Hilar vascular injury which devascularizes spleen		5

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

Spleen injury scale (1994 revision).

	Grade[a]	Injury Description	ICD-9	AIS-90
I	Hematoma	Subcapsular, <10% surface area	864.01 864.11	2
	Laceration	Capsular tear, <1 cm parenchymal depth	864.02 864.12	2
II	Hematoma	Subcapsular, 10–50% surface area; intraparenchymal, <10 cm in diameter	864.01 864.11	2
	Laceration	1–3 cm parenchymal depth, <10 cm in length	864.03 864.13	2
III	Hematoma	Subcapsular, >50% surface area or expanding; ruptured subcapsular or parenchymal hematoma Intraparenchymal hematoma >10 cm or expanding		3
	Laceration	>3 cm parenchymal depth	864.04 864.14	3
IV	Laceration	Parenchymal disruption involving 25–75% of hepatic lobe or 1–3 Couinaud's segments within a single lobe	864.04 864.14	4
V	Laceration	Parenchymal disruption involving >75% of hepatic lobe or >3 Couinaud's segments within a single lobe		5
	Vascular	Juxtahepatic venous injuries; i.e., retrohepatic vena cava/central major hepatic veins		5
VI	Vascular	Hepatic avulsion		6

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

Liver injury scale (1994 revision).

We hope these modifications will be helpful to those who employ OISs to improve care of the injured, and look forward to the evaluation of their scientific validity by experienced trauma surgeons.

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Organ Injury Scaling VI: Extrahepatic Biliary, Esophagus, Stomach, Vulva, Vagina, Uterus (Nonpregnant), Uterus (Pregnant), Fallopian Tube, and Ovary

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The Organ Injury Scaling (OIS) Committee of the American Association for the Surgery of Trauma (AAST) was organized formally in 1987; the fundamental purpose was to devise injury severity scores for individual organs to facilitate clinical investigation and outcomes research. The OIS Committee members were selected on the basis of recognized clinical expertise as well as experience with injury scoring. The Committee was charged to develop a comprehensive set of OISs, monitor their application in the current literature, and recommend modifications when deemed appropriate. To date, OISs for spleen, liver, kidney; [1] pancreas, duodenum, small bowel, colon, rectum; [2] chest wall, abdominal vascular, ureter, bladder, urethra; [3] and thoracic vascular, lung, cardiac, diaphragm [4] have been developed and published in the Journal of Trauma. The following OISs are the initial versions for extrahepatic biliary (Table 1), esophagus (Table

2), stomach (Table 3), vulva (Table 4), vagina (Table 5), uterus--nonpregnant (Table 6), uterus--pregnant (Table 7), fallopian tube (Table 8), and ovary (Table 9).

Grade[a]	Injury Description	ICD-9	AIS90
I	Gallbladder contusion	868.02	2
	Portal triad contusion	868.02	2
II	Partial gallbladder avulsion from liver bed; cystic duct intact	868.02	2
	Laceration or perforation of the gallbladder	868.12	2
III	Complete gallbladder avulsion from liver bed	868.02	3
	Cystic duct laceration/transection	868.12	3
IV	Partial or complete right hepatic duct laceration	868.12	3
	Partial or complete left hepatic duct laceration	868.12	3
	Partial common hepatic duct laceration (≤ 50%)	868.12	3
	Partial common bile duct laceration (≤ 50%)	868.12	3
V	> 50% Transection of common hepatic duct	868.12	3–4
	> 50% Transection of common bile duct	868.12	3–4
	Combined right and left hepatic duct injuries	868.12	3–4
	Intraduodenal or intrapancreatic bile duct injuries	868.12	3–4

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

Extrahepatic biliary tree injury scale.

Grade[a]	Injury Description	ICD-9	AIS90
I	Contusion/hematoma	862.22/.32	2
	Partial thickness laceration	862.22/.32	3
II	Laceration ≤ 50% circumference	862.22/.32	4
III	Laceration > 50% circumference	862.22/.32	4
IV	Segmental loss or devascularization ≤ 2 cm	862.22/.32	5
V	Segmental loss or devascularization > 2 cm	862.22/.32	5

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

Esophagus injury scale.

Grade[a]	Injury Description	ICD-9	AIS90
I	Contusion/hematoma	863.0/.1	2
	Partial-thickness laceration	863.0/.1	2
II	Laceration ≤ 2 cm in GE junction or pylorus	863.0/.1	3
	≤ 5 cm in proximal 1/3 stomach	863.0/.1	3
	≤ 10 cm in distal 2/3 stomach	863.0/.1	3
III	Laceration > 2 cm in GE junction or pylorus	863.0/.1	3
	> 5 cm in proximal 1/3 stomach	863.0/.1	3
	> 10 cm in distal 2/3 stomach	863.0/.1	3
IV	Tissue loss or devascularization		
	≤ 2/3 stomach	863.0/.1	4
V	Tissue loss or devascularization	863.0/.1	4
	> 2/3 stomach		

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

Stomach injury scale.

Grade[a]	Injury Description	ICD-9	AIS90
I	Contusion/hematoma	922.4	1
II	Laceration—superficial (skin only)	878.4	1
III	Laceration—deep (into fat/muscle)	878.4	2
IV	Avulsion—skin/fat/muscle	878.5	3
V	Injury into adjacent organs (anus/rectum/urethra/bladder)	878.5	3
		878.5	3

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

Vulva injury scale.

Grade[a]	Injury Description	ICD-9	AIS90
I	Contusion/hematoma	922.4	1
II	Laceration—superficial (mucosa only)	878.6	1
III	Laceration—deep into fat/muscle	878.6	2
IV	Laceration—complex, into cervix or peritoneum	878.7	3
V	Injury into adjacent organs (anus/rectum/urethra/bladder)	878.7	3

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

Vagina injury scale.

Grade[a]	Injury Description	ICD-9	AIS90
I	Contusion/hematoma	867.4/.5	2
II	Superficial laceration (≤ 1 cm)	867.4/.5	2
III	Deep laceration (> 1 cm)	867.4/.5	3
IV	Laceration involving uterine artery	902.55	3
V	Avulsion/devascularized	867.4/.5	3

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

Uterus (non-pregnant) injury scale.

Grade[a]	Injury Description	ICD-9	AIS90
I	Contusion/hematoma (without placental abruption)	867.4/.5	2
II	Superficial laceration (≤ 1 cm) or partial placental abruption < 25%	867.4/.5	3
III	Deep laceration (> 1 cm) occurring in second trimester or placental abruption > 25% but < 50%	867.4/.5	3
	Deep laceration (> 1 cm) in third trimester	867.4/.5	4
IV	Laceration involving uterine artery	902.55	4
	Deep laceration (> 1 cm) with > 50% placental abruption	867.4/.5	4
V	Uterine rupture		
	• second trimester	867.4/.5	4
	• third trimester	867.4/.5	5
	Complete placental abruption	867.4/.5	4–5

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

Uterus (pregnant) injury scale.

Grade[a]	Injury Description	ICD-9	AIS90
I	Hematoma/contusion	867.6/.7	2
II	Laceration ≤ 50% circumference	867.6/.7	2
III	Laceration > 50% circumference	867.6/.7	2
IV	Transection	867.6/.7	2
V	Vascular—devascularized segment	902.89	2

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

Fallopian tube scale.

Grade[a]	Injury Description	ICD-9	AIS90
I	Contusion/hematoma	867.6/.7	1
II	Superficial laceration (depth ≤ 0.5 cm)	867.6/.7	2
III	Deep laceration (depth > 0.5 cm)	867.6/.7	3
IV	Partial disruption of blood supply	902.81	3
V	Avulsion or complete parenchymal destruction	902.81	3

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

Ovary injury scale.

Conceptually, OIS is a classification scheme based on the anatomic disruption of an individual organ scaled 1 to 6, representing the least to most severe injury. Grades 1 to 5 represent increasingly complex injuries encountered in salvageable patients, whereas grade 6 is a destructive lesion incompatible with survival. Severity is based on potential threat to the patient's life, and the progressive scale is derived from a comprehensive review of the current literature with consensus of the OIS Committee. Finally, the AAST Board of Managers approves all OISs before submission for publication. Despite this extensive preparation process, OISs are inherently limited by design and, thus, are anticipated to ultimately necessitate revision predicated on clinical experience and scientific analysis. In fact, the first OISs (spleen and liver) have undergone formal restructuring. [5] We look forward to your critial evaluation of the enclosed OISs and assistance in improving them in the future.

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Organ Injury Scaling VII: Cervical Vascular, Peripheral Vascular, Adrenal, Penis, Testis, and Scrotum

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OIS VII is comprised of cervical vascular (Table 1), peripheral vascular (Table 2), adrenal (Table 3), penis (Table 4), testis (Table 5), and scrotum (Table 6) injury scales. OISs I through VI, addressing the remaining torso areas, are detailed in previous issues of the Journal. [1-6] Conceptually, OIS is a classification scheme based on the anatomic disruption of an individual organ scaled 1 to 6, from the least to most severe injury. Grades 1 to 5 represent increasingly complex injuries encountered in salvageable patients, whereas grade 6 is a destructive lesion incompatible with survival. Severity is based on potential threat to the patient's life, and the progressive scale is derived from a comprehensive review of the current literature with consensus of the OIS Committee; the AAST Board of Managers renders final approval before submission for publication. Despite this extensive preparation process, OISs are inherently limited by design and, thus, are anticipated to ultimately necessitate revision. Refinement should be predicated on clinical experience and appropriate scientific analysis. Indeed, the first OISs (spleen and liver) have undergone formal restructuring. [5] The new IOA Committee of the ASST looks forward to your critical evaluation of the enclosed OISs and assistance in improving them in the future.

Grade[a]	Description of Injury	ICD-9	AIS-90
I	Contusion	868.01/.11	1
II	Laceration involving only cortex (<2 cm)	868.01/.11	1
III	Laceration extending into medulla (≥2 cm)	868.01/.11	2
IV	>50% parenchymal destruction	868.01/.11	2
V	Total parenchymal destruction (including massive intraparenchymal hemorrhage) Avulsion from blood supply	868.01/.11	3

[a] Advance one grade for bilateral lesions up to grade V.

Cervical vascular organ injury scale.

Grade[a]	Description of Injury	ICD-9	AIS-90
I	Digital artery/vein	903.5	1–3
	Palmar artery/vein	903.4	1–3
	Deep palmar artery/vein	904.6	1–3
	Dorsalis pedis artery	904.7	1–3
	Plantar artery/vein	904.6	1–3
	Non-named arterial/venous branches	903.8/904.7	1–3
II	Basilic/cephalic vein	903.8	1–3
	Saphenous vein	904.3	1–3
	Radial artery	903.2	1–3
	Ulnar artery	903.3	1–3
III	Axillary vein	903.02	2–3
	Superficial/deep femoral vein	903.02	2–3
	Popliteal vein	904.42	2–3
	Brachial artery	903.1	2–3
	Anterior tibial artery	904.51/904.52	1–3
	Posterior tibial artery	904.53/904.54	1–3
	Peroneal artery	904.7	1–3
	Tibioperoneal trunk	904.7	2–3
IV	Superficial/deep femoral artery	904.1/904.7	3–4
	Popliteal artery	904.41	2–3
V	Axillary artery	903.01	2–3
	Common femoral artery	904.0	3–4

[a] Increase one grade for multiple grade III or IV injuries involving >50% vessel circumference. Decrease one grade for <25% vessel circumference disruption for grades IV or V.

Peripheral vascular organ injury scale.

Grade[a]	Description of Injury	ICD-9	AIS-90
I	Contusion	868.01/.11	1
II	Laceration involving only cortex (<2 cm)	868.01/.11	1
III	Laceration extending into medulla (≥2 cm)	868.01/.11	2
IV	>50% parenchymal destruction	868.01/.11	2
V	Total parenchymal destruction (including massive intraparenchymal hemorrhage) Avulsion from blood supply	868.01/.11	3

[a] Advance one grade for bilateral lesions up to grade V.

Adrenal organ injury scale.

Grade[a]	Description of Injury	ICD-9	AIS-90
I	Cutaneous laceration/contusion	911.0/922.4	1
II	Buck's fascia (cavernosum) laceration without tissue loss	878.0	1
III	Cutaneous avulsion Laceration through glans/meatus Cavernosal or urethral defect < 2 cm	878.1	3
IV	Partial penectomy Cavernosal or urethral defect ≥ 2 cm	878.1	3
V	Total penectomy	878.1	3

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

Penis injury scale.

Grade[a]	Description of Injury	ICD-9	AIS-90
I	Contusion/hematoma	911.0/922.4	1
II	Subclinical laceration of tunica albuginea	922.4	1
III	Laceration of tunica albuginea with <50% parenchymal loss	878.2	2
IV	Major laceration of tunica albuginea with ≥50% parenchymal loss	878.3	2
V	Total testicular destruction or avulsion	878.3	2

[a] Advance one grade for bilateral lesions up to grade V.

Testis injury scale.

Grade	Description of Injury	ICD-9	AIS-90
I	Contusion	922.4	1
II	Laceration < 25% of scrotal diameter	878.2	1
III	Laceration ≥ 25% of scrotal diameter or stellate	878.3	2
IV	Avulsion < 50%	878.3	2
V	Avulsion ≥ 50%	878.3	2

Scrotum injury scale.

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American Association for the Surgery of Trauma Organ Injury Scaling: 50th Anniversary Review Article of the *Journal of Trauma*

Ernest E. Moore, MD, and Frederick A. Moore, MD

Abstract: The purpose of a scaling system for specific injuries is to provide a common language to facilitate the clinical decisions and the investigative basis for this decision making. This brief overview describes the evolution of the Organ Injury Scaling (OIS) system developed by the American Association for the Surgery of Trauma. The OIS system is based on the magnitude of anatomic disruption and is graded as 1 (minimal), 2 (mild), 3 (moderate), 4 (severe), 5 (massive), and 6 (lethal). To date, the American Association for the Surgery of Trauma OIS system has been developed for visceral and vascular injuries of the neck, chest, abdomen, and extremities. The fundamental objective of OIS is to provide a common language to describe specific organ injuries. The primary purpose of OIS is to facilitate clinical decision making and the necessary research endeavors to improve this process. A good example of this concept is the tumor, node, metastasis classification for solid organ malignancies: a system used worldwide to guide patient care and clinical investigation.

Key Words: Organ injury scaling; Injury scoring; Trauma scoring; Abdominal trauma index.

(*J Trauma.* 2010;69: e38–e39)

The first organized effort to develop a taxonomy for injuries was cosponsored by the Association for the Advancement of Automotive Medicine, the American Medical Association, and the Society of Automotive Engineers.[1–3] The fundamental goal was to define the impact of changes in automobile structure on the injuries sustained by their occupants. This charge was delegated to the Committee on Medical Aspects of Automotive Safety, a group composed predominantly of epidemiologists, biomechanical engineers, and orthopedic surgeons. Their novel product, the Abbreviated Injury Scale (AIS) score was introduced in 1971.[2] The original AIS was a progressive grading scale of injury severity for each body region, but, with the composition of this subcommittee, the primary focus was more on the degree of disability associated with fractures and soft tissue injury. Beginning in 1973, a number of trauma surgeons were added to the group, now referred to as the Committee on Injury Scoring. Baker et al.[4] subsequently used AIS as the foundation for the Injury Severity Score (ISS) to predict survival. The ISS was based on the sum of the squares of the highest AIS scores from three body regions. Although the ISS represented a vastly improved model for survival probability, the limited perspective of the original AIS became evident when applied to multisystem trauma and penetrating wounds.

The Penetrating Abdominal Trauma Index was developed at the Denver General Hospital in 1979[5] as a result of the inadequacies of ISS to assist in clinical investigation of penetrating wounds and was subsequently modified to the Abdominal Trauma Index (ATI) to include blunt trauma.[6] The ATI was based on (1) the individual organ injury severity and (2) the relative risk of early morbidity and mortality estimated for each organ. Specific organ injuries were graded from 1 (minimal) to 6 (lethal), similar to the AIS, and the individual organ risks were ranked 1 (least) to 5 (most). The individual organ scores were the product of the grade multiplied by the risk; the final ATI score was the sum of the individual organ scores. Simplistic in design, the ATI has been validated in databases from several different institutions.[7]

In 1987, the American Association for the Surgery of Trauma (AAST) appointed an Organ Injury Scaling (OIS) Committee with the singular goal of developing a comprehensive scaling of specific organ injuries.[8] The OIS Committee members were experienced surgeons representing trauma, neurosurgery, orthopedics, and urology. The individual organ injuries were graded 1 (minimal), 2 (mild), 3 (moderate), 4 (severe), 5 (massive), and 6 (lethal), similar to the AIS.[2] However, the scale was based on the magnitude of anatomic disruption similar to the ATI.[5] Specifically, the OIS did not include estimated blood loss or therapeutic interventions. The exclusion of procedures was believed critical to enable the OIS to be used for clinical management decisions. The process of generating a specific OIS involved a literature review of available injury scales, a stratification of injury severity ranked against morbidity and mortality, and an open discussion within the OIS Committee.[9] Ultimately, a consensus-derived OIS was drafted and matured with further consideration by the OIS Committee members and consultants representing other disciplines, e.g., obstetrics and gynecology. Every effort was made to include an international perspective. The final draft was submitted to the AAST Board of Managers for review, comment, and approval before eventual publication in *The Journal of Trauma*.[9–15] A correlative listing of AIS-90

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and International Classification of Diseases 9CM[16] was included for comparison in the OIS tables.

The AAST/OIS Committee has developed OISs for visceral, vascular, and soft tissue injuries of the neck, chest, abdomen, and extremities. These were published in the sequence in which they were completed[9–15] and consist of the following anatomic groups: cervical vascular, chest wall, heart, lung, thoracic vascular, diaphragm, spleen, liver, extrahepatic biliary, pancreas, esophagus, stomach, duodenum, small bowel, colon, rectum, abdominal vascular, adrenal, kidney, ureter, bladder, urethra, uterus (nonpregnant), uterus (pregnant), fallopian tube, ovary, vagina, vulva, testis, scrotum, penis, and peripheral vascular. As these OISs represented the first attempt at consolidating diverse views on scaling, ongoing revision was anticipated with further clinical experience and testing for validity. The spleen and liver OISs are currently in their second generation,[9,13] but remarkably, there have been no recommendations to modify the remaining OISs over the past 20 years.

To date, OIS has proven useful in diverse clinical investigations. Perhaps the best early example is the evolution of nonoperative management for solid organ injuries.[17–21] The ability to characterize liver injuries provided compelling support for nonoperative treatment of major lesions, whereas a description of splenic trauma underscored the potential risks of bleeding from relatively minor splenic injuries. At the same time, the indications for primary repair of colonic wounds expanded quickly with the availability of uniform descriptors.[22] With clinical validation, OIS ultimately provided a template for improving the AIS, particularly in emphasizing the need for greater scoring detail in specific organs.[23]

A substantial challenge for the OIS system was to incorporate neurologic and orthopedic trauma into a comparable scaling format. Despite a number of ongoing multilateral efforts, there has been little progress in reaching a working consensus. In part, this is due to the complexities of these injuries. Fractures are systematically characterized in the AO Classification, but this scheme does not rank fractures according to the magnitude of injury.[24] Furthermore, fracture injury scaling is compounded by the associated soft tissue disruption. Similarly, there is no available scaling system for central nervous system injuries, largely because of the difficulty in deriving an anatomic classification with outcome specificity.

Another major goal for OIS is to achieve international consensus. For example, the Japanese Association for the Surgery of Trauma has developed a separate organ scaling system.[25] Trauma is a worldwide disease, epidemic in most nations, and certainly care of the injured can be improved from sharing information based on a common language. Ultimately, meaningful trauma outcome assessment demands a complete description of the injured patient, which encompasses the essential components: (1) anatomic disruption, (2) physiologic status, and (3) preexisting host factors. The OIS represents a critical step in approaching this goal and, in the interim, serves as an important tool for improving care of the injured. Finally, with the expanding interests in Acute Care Surgery, the AAST is now developing similar scoring systems for nontraumatic disorders.

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Organ injury scaling 2018 update: Spleen, liver, and kidney

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In 1989, Moore et al. on behalf of the American Association for the Surgery of Trauma (AAST) published the Organ Injury Scale (OIS) for spleen, liver, and kidney.[1] This was then updated for spleen and liver in 1994.[2] These initial classification schemes were based on an anatomic description of the injured organ, scaled from 1 to 5, representing the least to most severe injury. They have been widely used to facilitate clinical research, risk stratify patients for quality measures, and for billing and coding.

Since its introduction, management of solid organ injury has continued to evolve to one based primarily on nonoperative management along with increased reliance on computed tomography (CT) for diagnosis and classification. This revised OIS for solid organ injuries is being put forth by the Patient Assessment Committee of the AAST to reflect this change (Tables 1–3). Changes made in the 2018 revision were based on available published literature and were otherwise developed by a consensus of experts for grading severity and experts in the field. The OIS has been reviewed and approved by the board of managers of the AAST. The new OIS is formatted similar to the AAST Emergency General Surgery grading system.[3] The solid organ injury scale includes three sets of criteria to assign grade: imaging, operative and pathologic. As with the original OIS, the highest of the three criteria is assigned the final AAST grade. Additionally, if multiple grade I or II injuries are present, advance one grade for multiple injuries up to a grade III. It is recognized that pathologic grading will most likely be a function of post-mortem examination and that with rapid extirpation of the spleen or kidney, this may result in an increased grade. In the case of the liver, very rarely would the entire organ be available for examination ex-vivo.

The most significant change in the 2018 revision is the incorporation of CT diagnosed vascular injury, defined as either as a pseudoaneurysm or arteriovenous fistula, into the OIS.[4–6] Modern-day CT scanners are unable to differentiate these two injuries, with arteriography remaining the reference standard examination. Therefore, the term vascular injury may include either a pseudoaneurysm or arteriovenous fistula. On CT scan, a vascular injury appears as a focal collection of vascular contrast that decreases in attenuation with delayed imaging. Active bleeding from a vascular injury presents as vascular contrast, focal, or diffuse, that increases in size or attenuation in the delayed phase of imaging. Active bleeding may be contained within the injured organ or extend beyond the injured organ into the peritoneal cavity.[7] For consistency, the same terminology for vascular injuries is used for all solid organs. We acknowledge that in some instances the grade may be higher based on the presence of a vascular injury than previously described based on parenchymal injury alone. However, available literature has confirmed that the presence of a vascular injury is associated with higher failure rates after nonoperative management.[8–22] Additionally, it is possible that the higher organ injury grade may prompt intervention, such as angioembolization, though this revision does not address treatment strategies.

There were also a number of changes made specifically to the kidney OIS to include the addition of the following as grade IV injuries: vascular thrombosis as a type of vascular injury; segmental renal artery or vein injury; and all collecting system injuries.[23,24] Grade V kidney injury now also includes a devascularized kidney with active bleeding.[24]

For accurate diagnosis of vascular injuries of the spleen, liver, or kidney on CT scanning, dual phase imaging to include both arterial and portal venous phases is recommended. Dual phase has been shown to increase the sensitivity of in the diagnosis of vascular injuries, providing overall better

TABLE 1. Spleen Organ Injury Scale—2018 Revision

AAST Grade	AIS Severity	Imaging Criteria (CT findings)	Operative Criteria	Pathologic Criteria
I	2	– Subcapsular hematoma <10% surface area – Parenchymal laceration <1 cm depth – Capsular tear	– Subcapsular hematoma <10% surface area – Parenchymal laceration <1 cm depth – Capsular tear	– Subcapsular hematoma <10% surface area – Parenchymal laceration <1 cm depth – Capsular tear
II	2	– Subcapsular hematoma 10–50% surface area; intraparenchymal hematoma <5 cm – Parenchymal laceration 1–3 cm	– Subcapsular hematoma 10–50% surface area; intraparenchymal hematoma <5 cm – Parenchymal laceration 1–3 cm	– Subcapsular hematoma 10–50% surface area; intraparenchymal hematoma <5 cm – Parenchymal laceration 1–3 cm
III	3	– Subcapsular hematoma >50% surface area; ruptured subcapsular or intraparenchymal hematoma ≥5 cm – Parenchymal laceration >3 cm depth	– Subcapsular hematoma >50% surface area or expanding; ruptured subcapsular or intraparenchymal hematoma ≥5 cm – Parenchymal laceration >3 cm depth	– Subcapsular hematoma >50% surface area; ruptured subcapsular or intraparenchymal hematoma ≥5 cm – Parenchymal laceration >3 cm depth
IV	4	– Any injury in the presence of a splenic vascular injury or active bleeding confined within splenic capsule – Parenchymal laceration involving segmental or hilar vessels producing >25% devascularization	– Parenchymal laceration involving segmental or hilar vessels producing >25% devascularization –	– Parenchymal laceration involving segmental or hilar vessels producing >25% devascularization
V	5	– Any injury in the presence of splenic vascular injury with active bleeding extending beyond the spleen into the peritoneum – Shattered spleen	– Hilar vascular injury which devascularizes the spleen – Shattered spleen	– Hilar vascular injury which devascularizes the spleen – Shattered spleen

Vascular injury is defined as a pseudoaneurysm or arteriovenous fistula and appears as a focal collection of vascular contrast that decreases in attenuation with delayed imaging. Active bleeding from a vascular injury presents as vascular contrast, focal or diffuse, that increases in size or attenuation in delayed phase. Vascular thrombosis can lead to organ infarction.

Grade based on highest grade assessment made on imaging, at operation or on pathologic specimen.

More than one grade of splenic injury may be present and should be classified by the higher grade of injury.

Advance one grade for multiple injuries up to a grade III.

TABLE 2. Liver Injury Scale—2018 Revision

AAST Grade	AIS Severity	Imaging Criteria (CT Findings)	Operative Criteria	Pathologic Criteria
I	2	– Subcapsular hematoma <10% surface area – Parenchymal laceration <1 cm in depth	– Subcapsular hematoma <10% surface area – Parenchymal laceration <1 cm in depth Capsular tear	– Subcapsular hematoma <10% surface area – Parenchymal laceration <1 cm Capsular tear
II	2	– Subcapsular hematoma 10–50% surface area; intraparenchymal hematoma <10 cm in diameter – Laceration 1–3 cm in depth and ≤ 10 cm length	– Subcapsular hematoma 10–50% surface area; intraparenchymal hematoma <10 cm in diameter – Laceration 1–3 cm in depth and ≤ 10 cm length	– Subcapsular hematoma 10–50% surface area; intraparenchymal hematoma <10 cm in diameter – Laceration 1–3 cm depth and ≤ 10 cm length
III	3	– Subcapsular hematoma >50% surface area; ruptured subcapsular or parenchymal hematoma – Intraparenchymal hematoma >10 cm – Laceration >3 cm depth – Any injury in the presence of a liver vascular injury or active bleeding contained within liver parenchyma	– Subcapsular hematoma >50% surface area or expanding; ruptured subcapsular or parenchymal hematoma – Intraparenchymal hematoma >10 cm – Laceration >3 cm in depth	– Subcapsular hematoma >50%-surface area; ruptured subcapsular or intraparenchymal hematoma – Intraparenchymal hematoma >10 cm – Laceration >3 cm in depth
IV	4	– Parenchymal disruption involving 25–75% of a hepatic lobe – Active bleeding extending beyond the liver parenchyma into the peritoneum	– Parenchymal disruption involving 25–75% of a hepatic lobe	– Parenchymal disruption involving 25–75% of a hepatic lobe
V	5	– Parenchymal disruption >75% of hepatic lobe – Juxtahepatic venous injury to include retrohepatic vena cava and central major hepatic veins	– Parenchymal disruption >75% of hepatic lobe – Juxtahepatic venous injury to include retrohepatic vena cava and central major hepatic veins	– Parenchymal disruption >75% of hepatic lobe – Juxtahepatic venous injury to include retrohepatic vena cava and central major hepatic veins

Vascular injury is defined as a pseudoaneurysm or arteriovenous fistula and appears as a focal collection of vascular contrast that decreases in attenuation with delayed imaging, Active bleeding from a vascular injury presents as vascular contrast, focal or diffuse, that increases in size or attenuation in delayed phase. Vascular thrombosis can lead to organ infarction.

Grade based on highest grade assessment made on imaging, at operation or on pathologic specimen.

More than one grade of liver injury may be present and should be classified by the higher grade of injury.

Advance one grade for multiple injuries up to a grade III.

TABLE 3. Kidney Injury Scale—2018 Revision

AAST Grade	AIS Severity	Imaging Criteria (CT Findings)	Operative Goals	Pathologic Criteria
I	2	– Subcapsular hematoma and/or parenchymal contusion without laceration	– Nonexpanding subcapsular hematoma – Parenchymal contusion without laceration	– Subcapsular hematoma or parenchymal contusion without parenchymal laceration
II	2	– Perirenal hematoma confined to Gerota fascia	– Nonexpanding perirenal hematoma confined to Gerota fascia	– Perirenal hematoma confined to Gerota fascia
		– Renal parenchymal laceration ≤1 cm depth without urinary extravasation	– Renal parenchymal laceration ≤1 cm depth without urinary extravasation	– Renal parenchymal laceration ≤1 cm depth without urinary extravasation
III	3	– Renal parenchymal laceration >1 cm depth without collecting system rupture or urinary extravasation	– Renal parenchymal laceration >1 cm depth without collecting system rupture or urinary extravasation	– Renal parenchymal laceration >1 cm depth without collecting system rupture or urinary extravasation
		– Any injury in the presence of a kidney vascular injury or active bleeding contained within Gerota fascia	–	
IV	4	– Parenchymal laceration extending into urinary collecting system with urinary extravasation	– Parenchymal laceration extending into urinary collecting system with urinary extravasation	– Parenchymal laceration extending into urinary collecting system
		– Renal pelvis laceration and/or complete ureteropelvic disruption	– Renal pelvis laceration and/or complete ureteropelvic disruption	– Renal pelvis laceration and/or complete ureteropelvic disruption
		– Segmental renal vein or artery injury	– Segmental renal vein or artery injury	– Segmental renal vein or artery injury
		– Active bleeding beyond Gerota fascia into the retroperitoneum or peritoneum	– Segmental or complete kidney infarction(s) due to vessel thrombosis without active bleeding	– Segmental or complete kidney infarction(s) due to vessel thrombosis without active bleeding
		– Segmental or complete kidney infarction(s) due to vessel thrombosis without active bleeding		
V	5	– Main renal artery or vein laceration or avulsion of hilum	– Main renal artery or vein laceration or avulsion of hilum	– Main renal artery or vein laceration or avulsion of hilum
		– Devascularized kidney with active bleeding	– Devascularized kidney with active bleeding	– Devascularized kidney
		– Shattered kidney with loss of identifiable parenchymal renal anatomy	– Shattered kidney with loss of identifiable parenchymal renal anatomy	– Shattered kidney with loss of identifiable parenchymal renal anatomy

Vascular injury is defined as a pseudoaneurysm or arteriovenous fistula and appears as a focal collection of vascular contrast that decreases in attenuation with delayed imaging. Active bleeding from a vascular injury presents as vascular contrast, focal or diffuse, that increases in size or attenuation in delayed phase. Vascular thrombosis can lead to organ infarction.

Grade based on highest grade assessment made on imaging, at operation or on pathologic specimen.

More than one grade of kidney injury may be present and should be classified by the higher grade of injury.

Advance one grade for bilateral injuries up to Grade III.

diagnostic performance in evaluating solid organ injury than either phase alone.[5,25] Additionally, when a renal injury is known or suspected, delayed excretory phase imaging should be obtained as well.

We sincerely hope that these OIS revisions will serve as a useful tool to those caring for the injured patient. The time is right for validation studies to both guide further modifications and also to guide treatment strategies to improve outcomes with patients with spleen, liver, and kidney injuries.

AUTHORSHIP

R.A.K. and B.Z. conceptualized the idea. R.A.K., B.Z., G.T., K.S. performed the literature search. R.A.K., M.C., K.S., B.Z., M.C., C.C., K.K., K.S., G.T. created the grading system. R.A.K. wrote the article. M.C., K.S., B.Z., M. C., C.C., K.K., K.S., G.T. performed critical revision.

DISCLOSURE

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Organ Injury Scaling 2020 update: Bowel and mesentery

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The original Organ Injury Scale (OIS) for small bowel (SB) and colon was published in 1990 by Moore et al.[1] on behalf of the American Association for the Surgery of Trauma (AAST) to reflect anatomic injury of the respective organs. Since that time, there have been significant advances in imaging technology that have influenced clinical practice, such as the ability to detect contrast extravasation from blood vessels and improved visualization of bowel wall thickening and injury. The objective of this study was to include current imaging and pathologic findings to better describe the level of injury to the bowel and mesentery.

METHODS

The grading system was based on the original OIS,[1] updated by published literature when available,[2–6] and developed by a consensus of experts. Blunt and penetrating bowel injuries were separated because of the differences detectable on CT scanning.[4–6] Because of the increasing complexities in grading, pancreatic, duodenal, and rectal injuries are not part of this revision. Specifically, rectal injuries were not included in the bowel injury OIS due to differences in diagnosis and management, which is based on the location of injury within the rectum. This new bowel OIS is formatted similar to the more recent OIS for solid organ injury[7] to include three sets of criteria to assign grade: imaging, operative, and pathologic, with scaled injuries from least to most severe. These criteria reflect the incorporation of CT scanning into the evaluation of trauma patients both with blunt and penetrating mechanisms.[2–6] The OIS was reviewed and approved by the board of managers of the AAST.

RESULTS

This revised OIS is being put forth by the Patient Assessment Committee of the AAST and contains separate grading systems for blunt bowel injuries (Tables 1 and 2), penetrating bowel injuries (Tables 3 and 4) and mesenteric injuries (Table 5).

A major change in the current revision is consideration for the delay in diagnosis, such that there is an increase by one grade for delay in diagnosis from time of injury of 8 hours or greater for grade II to IV bowel injuries due to either a blunt or penetrating mechanism in adults.[8]

Also, definitions are provided for bowel wall thickening,[4] physiologic free fluid,[9,10] peritoneal compartments,[11] and assessment of volume of free fluid,[9] to provide a more objective means of scoring are found in Table 6. New to this revision is the incorporation of mesenteric injuries, with definitions for mesenteric hematoma, contusion, and mesenteric free fluid.[12,13]

DISCUSSION

We sincerely hope that these OIS revisions will serve as a useful tool to those caring for the injured patient. The grading systems were developed by published literature when available but for the most part by expert opinion, as studies are lacking. Although OIS was not developed to guide treatment and predict outcomes, validation studies to guide further modifications and treatment strategies to improve outcomes with patients with bowel and mesenteric injuries are needed. The authors encourage future studies to validate our proposed OIS and for future OIS to be more data driven and based on outcome studies.

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AUTHORSHIP

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DISCLOSURE

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TABLE 1. Blunt Small Bowel Injury

AAST Grade	AIS Severity	Imaging Criteria (CT Findings)	Operative Criteria	Pathologic Criteria
I	2	Focal small bowel wall thickening or small bowel wall hematoma without nonphysiological free fluid	–Small bowel contusion or hematoma without devascularization OR –Serosal tear of the small bowel	–Small bowel contusion or hematoma without devascularization OR –Serosal tear of small bowel
II	3	Focal small bowel wall thickening or small bowel wall hematoma with small volume nonphysiologic free fluid	Small bowel full thickness injury without transection, gross contamination or peritonitis	Small bowel full thickness injury without transection or gross peritonitis
III	3	Focal small bowel wall thickening or small bowel wall hematoma with adjacent interloop free fluid or moderate to large volume free fluid	Small bowel full thickness injury without transection and with minimal contamination or peritonitis	Small bowel full thickness injury without transection and with minimal peritonitis
IV	4	–Pneumoperitoneum or pneumoretroperitoneum OR –Extraluminal oral contrast or intestinal material OR –Small bowel wall defect or bowel transection	Small bowel transection with minimal contamination or peritonitis	Small bowel transection with minimal peritonitis
V	5	–As above for Grade IV plus: Lack of enhancement of small bowel wall	–Small bowel transection with destructive small bowel injury (severe surrounding small bowel wall contusion, small bowel devascularization, contamination) OR –Small bowel transection with segmental tissue loss and significant contamination and peritonitis	–Small bowel transection with destructive injury (severe surrounding small bowel wall contusion, small bowel devascularization) OR –Small bowel transection with segmental tissue loss and significant peritonitis

Upgrade by one grade for delay in diagnosis from time of injury of 8 hours or greater for grade II–IV injuries in adults.[8]

TABLE 2. Blunt Colon Injury

AAST Grade	AIS Severity	Imaging Criteria (CT Findings)	Operative Criteria	Pathologic Criteria
I	2	Focal large bowel wall thickening or large bowel wall hematoma without nonphysiological free fluid	–Large bowel contusion or hematoma without devascularization OR –Serosal tear of the large bowel	–Large bowel contusion or hematoma without devascularization OR –Serosal tear of large bowel
II	3	Focal large bowel wall thickening or large bowel wall hematoma with small volume nonphysiologic free fluid	Large bowel full thickness injury without transection, gross contamination or peritonitis	Large bowel full thickness injury without transection or gross peritonitis
III	3	Focal large bowel wall thickening or large bowel wall hematoma with adjacent interloop free fluid or moderate to large volume free fluid	Large bowel full thickness injury without transection and with minimal contamination or peritonitis	Large bowel full thickness injury without transection and with minimal peritonitis
IV	4	–Pneumoperitoneum or pneumoretroperitoneum OR –Extraluminal oral contrast or intestinal material OR –Large bowel wall defect or bowel transection	Large bowel transection with minimal contamination or peritonitis	Large bowel transection with minimal peritonitis
V	5	–As above for Grade IV plus: Lack of enhancement of large bowel wall	–Large bowel transection with destructive large bowel injury (severe surrounding large bowel wall contusion, large bowel devascularization, contamination) OR –Large bowel transection with segmental tissue loss and significant contamination and peritonitis	–Large bowel transection with destructive injury (severe surrounding large bowel wall contusion, large bowel devascularization) OR –Large bowel transection with segmental tissue loss and significant peritonitis

Upgrade by one grade for delay in diagnosis from time of injury of 8 hours or greater for grade II–IV injuries in adults.[8]

TABLE 3. Penetrating Small Bowel Injury

AAST Grade	AIS Severity	Imaging Criteria	Operative Criteria	Pathologic Criteria
I	2	Wound tract extending into peritoneum or retroperitoneum with nonphysiologic small volume free fluid or small volume retroperitoneal fluid	–Small bowel contusion or hematoma without devascularization OR –Serosal tear of the small bowel wall	–Small bowel contusion or hematoma without devascularization OR –Serosal tear of the small bowel wall
II	3	Wound tract extending into peritoneum or retroperitoneum with small volume free fluid, pneumoperitoneum or pneumoretroperitoneum without source or isolated mesenteric fat stranding	Small bowel full thickness injury without transection, gross contamination or peritonitis	Small bowel full thickness injury without transection or peritonitis
III	3	Wound tract extending into peritoneum or retroperitoneum with moderate volume free fluid or with moderate to large volume pneumoperitoneum or pneumoretroperitoneum without source or with mesenteric hematoma adjacent but not abutting small bowel wall	Small bowel full thickness injury without transection and with minimal contamination or peritonitis	Small bowel full thickness injury without transection and with minimal peritonitis
IV	4	Wound tract extending into peritoneum or retroperitoneum with moderate volume isolated hemoperitoneum or bleeding within small bowel lumen OR –Wound tract leading to or abutting small bowel wall	Small bowel transection with minimal contamination or peritonitis	Small bowel transection with minimal peritonitis
V	4	–Extraluminal oral contrast or intestinal material OR –Small bowel wall defect or small bowel transection OR –Lack of enhancement of small bowel wall	–Small bowel transection with destructive small bowel injury (severe surrounding small bowel wall contusion, small bowel devascularization, contamination) OR –Small bowel transection with segmental tissue loss and significant peritonitis	–Small bowel transection with destructive small bowel injury (severe surrounding small bowel wall contusion, small bowel devascularization, peritonitis) OR –Small bowel transection with segmental small bowel tissue loss and significant peritonitis

Upgrade by one grade for delay in diagnosis from time of injury of 8 hours or greater for grade II–IV bowel injuries in adults.[8]

TABLE 4. Penetrating Colon Injury

AAST Grade	AIS Severity	Imaging Criteria	Operative Criteria	Pathologic Criteria
I	2	Wound tract extending into peritoneum or retroperitoneum with nonphysiologic small volume free fluid or small volume retroperitoneal fluid	–Large bowel contusion or hematoma without devascularization OR –Serosal tear of the large bowel wall	–Large bowel contusion or hematoma without devascularization OR –Serosal tear of the large bowel wall
II	3	Wound tract extending into peritoneum or retroperitoneum with small volume free fluid, pneumoperitoneum or pneumoretroperitoneum without source or isolated mesenteric fat stranding	Large bowel full thickness injury without transection, gross contamination or peritonitis	Large bowel full thickness injury without transection or peritonitis
III	3	Wound tract extending into peritoneum or retroperitoneum with moderate volume free fluid or with moderate to large volume pneumoperitoneum or pneumoretroperitoneum without source or with mesenteric hematoma adjacent but not abutting large bowel wall	Large bowel full thickness injury without transection and with minimal contamination or peritonitis	Large bowel full thickness injury without transection and with minimal peritonitis
IV	4	Wound tract extending into peritoneum or retroperitoneum with moderate volume isolated hemoperitoneum or bleeding within large bowel lumen OR –Wound tract leading to or abutting large bowel wall	Large bowel transection with minimal contamination or peritonitis	Large bowel transection with minimal peritonitis
V	4	–Extraluminal oral contrast or intestinal material OR –Large bowel wall defect or large bowel transection OR –Lack of enhancement of large bowel wall	–Large bowel transection with destructive large bowel injury (severe surrounding large bowel wall contusion, large bowel devascularization, contamination) OR –Large bowel transection with segmental tissue loss and significant peritonitis	–Large bowel transection with destructive bowel injury (severe surrounding large bowel wall contusion, large bowel devascularization, peritonitis) OR –Large bowel transection with segmental large bowel tissue loss and significant peritonitis

Upgrade by one grade for delay in diagnosis from time of injury of 8 hours or longer for grade II–IV bowel injuries in adults.[8]

TABLE 5. Mesenteric Injuries

AAST Grade	Imaging Criteria[12]	Operative Criteria	Pathologic Criteria
I	Isolated mesenteric contusion and no abdominal free fluid (except for physiologic small volume pelvic free fluid)	Isolated mesenteric contusion without associated bowel wall thickening	Isolated mesenteric contusion without associated bowel wall thickening
II	Mesenteric hematoma less than 5 cm without associated bowel wall thickening or adjacent interloop fluid collection	Mesenteric hematoma less than 5 cm without associated bowel wall thickening	Mesenteric hematoma less than 5 cm without associated bowel wall thickening
III	Mesenteric hematoma greater than 5 cm without associated bowel wall thickening or adjacent interloop fluid collection	Mesenteric hematoma greater than 5 cm without associated bowel wall thickening	Mesenteric hematoma less than 5 cm without associated bowel wall thickening
IV	–Mesenteric hematoma or contusion with associated bowel wall thickening OR –Abrupt termination of mesenteric vessel	–Mesenteric hematoma or contusion with associated bowel wall thickening OR –Full thickness mesenteric injury with associated viable bowel	–Mesenteric hematoma or contusion with associated bowel wall thickening OR –Full thickness mesenteric injury with associated viable bowel
V	–Active mesenteric intravenous contrast extravasation OR –Nonenhancement of associated bowel wall	–Active mesenteric bleeding OR –Full thickness mesenteric injury with associated devascularized nonviable bowel	Full thickness mesenteric injury with associated devascularized nonviable bowel

Mesenteric contusion: haziness or opacity within the bowel mesentery; inhomogeneous fluid density within the mesenteric fat.[13]
Mesenteric hematoma: discrete, measurable soft tissue density within bowel mesentery.[11]
Interloop fluid collection: collection of free fluid, frequently triangular in shape, within the mesentery and/or between loops of bowel.[12]

TABLE 6. CT Definitions

- **Attenuation values in Hounsfield Units (HU)**[9,10]
  - Free fluid: 0–15 HU
  - Hemoperitoneum (unclotted blood): 20–40 HU
  - Hematoma (clotted blood): 40–70 HU
- **Isolated free fluid or isolated hemoperitoneum**[9,14]
  - Fluid or hemoperitoneum is only finding of injury
- **Intestinal wall thickening**[4]
  - Small bowel: >3 mm inner to outer wall
  - Large bowel: >5 mm inner to outer wall
- **Pneumoperitoneum without source**[15]
  - Extra alveolar air tracking into peritoneum or retroperitoneum
  - Iatrogenic introduction of air into peritoneum or retroperitoneum
  - Intraperitoneal bladder rupture
- **Physiologic fluid**[9]
  - Seen in deep lower pelvis below S3 segment of sacrum
  - Attenuation <10 HU
  - Seen on < contiguous 5 mm axial images
  - Volume ≤ 10 mL
- **Volume of free intraperitoneal fluid or hemoperitoneum**[12]
  - Small volume: seen on <5 images, 5 mm axial images in a single compartment
  - Moderate volume: seen on 5–10 images, 5 mm axial images in 2–3 compartments
  - Large volume: seen in >10, 5 mm axial images in 2–3 compartments
- **Peritoneal compartments**[11]
  - Perisplenic
  - Perihepatic
  - Right paracolic gutter
  - Left paracolic gutter
  - Pelvis

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