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

Rosemary A. Kozar, MD, PhD, Marie Crandall, MD, Kathirkamanthan Shanmuganathan, MD, Ben L. Zarzaur, MD, Mike Coburn, MD, Chris Cribari, MD, Krista Kaup, MD, Kevin Schuster, MD, Gail T. Tominaga, MD, *and* **the AAST Patient Assessment Committee***, Baltimore, Maryland*

AAST Continuing Medical Education Article

Accreditation Statement

This activity has been planned and implemented in accordance with the Essential Areas and Policies of the Accreditation Council for Continuing Medical Education through the joint providership of the American College of Surgeons and the American Association for the Surgery of Trauma. The American College Surgeons is accredited by the ACCME to provide continuing medical education for physicians.

AMA PRA Category 1 Credits™

The American College of Surgeons designates this journal-based CME activity for a maximum of 1 *AMA PRA Category 1 Credit*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

Of the *AMA PRA Category 1 Credit*™ listed above, a maximum of 1 credit meets the requirements for self-assessment.

Credits can only be claimed online

AMERICAN COLLEGE OF SURGEONS

Inspiring Quality: Highest Standards, Better Outcomes

100+*years*

Objectives

After reading the featured articles published in the *Journal of Trauma and Acute Care Surgery*, participants should be able to demonstrate increased understanding of the material specific to the article. Objectives for each article are featured at the beginning of each article and online. Test questions are at the end of the article, with a critique and specific location in the article referencing the question topic.

Claiming Credit

To claim credit, please visit the AAST website at http://www.aast.org/ and click on the "e-Learning/MOC" tab. You must read the article, successfully complete the post-test and evaluation. Your CME certificate will be available immediately upon receiving a passing score of 75% or higher on the post-test. Post-tests receiving a score of below 75% will require a retake of the test to receive credit.

Disclosure Information

In accordance with the ACCME Accreditation Criteria, the American College of Surgeons, as the accredited provider of this journal activity, must ensure that anyone in a position to control the content of *J Trauma Acute Care Surg* articles selected for CME credit has disclosed all relevant financial relationships with any commercial interest. Disclosure forms are completed by the editorial staff, associate editors, reviewers, and all authors. The ACCME defines a `commercial interest' as "any entity producing, marketing, re-selling, or distributing health care goods or services consumed by, or used on, patients." "Relevant" financial relationships are those (in any amount) that may create a conflict of interest and occur within the 12'months preceding and during the time that the individual is engaged in writing the article. All reported conflicts are thoroughly managed in order to ensure any potential bias within the content is eliminated. However, if you'perceive a bias within the article, please report the circumstances on the evaluation form.

Please note we have advised the authors that it is their responsibility to disclose within the article if they are describing the use of a device, product, or drug that is not FDA approved or the off-label use of an approved device, product, or drug or unapproved usage.

Disclosures of Significant Relationships with Relevant Commercial Companies/Organizations by the Editorial Staff

Ernest E. Moore, Editor: PI, research support and shared U.S. patents Haemonetics; PI, research support, Instrumentation Laboratory, Inc.; Co-founder, Thrombo Therapeutics. Associate Editors David Hoyt, Ronald V. Maier and Steven Shackford have nothing to disclose. Editorial staff and Angela Sauaia have nothing to disclose.

Author Disclosures

The authors have nothing to disclose.

Reviewer Disclosures

The reviewers have nothing to disclose.

Cost

For AAST members and *Journal of Trauma and Acute Care Surgery* subscribers there is no charge to participate in this activity. For those who are not a member or subscriber, the cost for each credit is $25.

System Requirements

The system requirements are as follows: Adobe® Reader 7.0 or above installed; Internet Explorer® 7 and above; Firefox® 3.0 and above, Chrome® 8.0 and above, or Safari™ 4.0 and above.

Questions

If you have any questions, please contact AAST at 800-789-4006. Paper test and evaluations will not be accepted.

Submitted: May 26, 2018, Accepted: August 10, 2018, Published online: September 5, 2018.

From the Shock Trauma (R.A.K.), University of Maryland School of Medicine, Baltimore, Maryland, University of Florida College of Medicine Jacksonville (M.C.), Jacksonville, Florida; Shock Trauma and Department of Radiology and Nuclear Medicine (K.S.), University of Maryland School of Medicine, Baltimore, Maryland; Department of Surgery (B.Z.), Indiana University School of Medicine, Indianapolis, Indiana; Scott Department of Urology (M.C.), Baylor College of Medicine, Houston, Texas; Department of Surgery (C.C.), University of Colorado, Denver, Colorado; Department of Surgery (K.K.), UCSF Fresno, California; Department of Surgery (K.S.), Yale School of Medicine; New Haven, Connecticut; and Department of Surgery (G.T.T.), Scripps Memorial Hospital La Jolla; La Jolla, California.

Address for reprints: Rosemary Kozar, MD PhD, Shock Trauma Center and the University of Maryland School of Medicine, 22 South Green St. T1R40, Baltimore, MD 21201; email: rkozar@som.umaryland.edu.

DOI: 10.1097/TA.0000000000002058

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

The authors have no conflicts of interest to report. This work received no funding.

REFERENCES

1. Moore EE, Shackford SR, Pachter HL, McAninch JW, Browner BD, Champion HR, Flint LM, Gennarelli TA, Malangoni MA, Ramenofsky ML, et al. Organ injury scaling: spleen, liver, and kidney. *J Trauma*. 1989;29(12): 1664–1666.
2. Moore EE, Cogbill TH, Jurkovich GJ, Shackford SR, Malangoni MA, Champion HR. Organ injury scaling: spleen and liver (1994) revision. *J Trauma*. 1995;38(3):323–324.
3. Shafi S, Aboutanos M, Brown C, Ciesla D, Cohen MJ, Crandall ML, Inaba K, Miller PR, Mowery NT. American Association for the Surgery of Trauma Committee on patient assessment and outcomes. Measuring anatomic severity of disease in emergency general surgery. *J Trauma Acute Care Surg*. 2014;76: 884–887.
4. Saksobhavivat N, Shanmuganathan K, Chen HH, DuBose JJ, Richard H, Khan MA, Menaker J, Mirvis SE, Scalea TM. Blunt splenic injury: use of a multidetector CT-based splenic injury grading system and clinical parameters for triage of patients at admission. *Radiology*. 2015;274:702–711.
5. Boscak AR, Shanmuganathan K, Mirvis SE, Fleiter TR, Miller LA, Sliker CW, Steenburg SD, Alexander M. Optimizing trauma multidetector CT protocol for blunt splenic injury: need for arterial and portal venous phase scans. *Radiology*. 2013;268(1):79–88.
6. Gavant ML, Schurr M, Flick PA, Croce MA, Fabian TC, Gold RE. Predicting clinical outcome of nonsurgical management of blunt splenic injury: using CT to reveal abnormalities of splenic vasculature. *AJR Am J Roentgenol*. 1997;168:207–212.
7. Shanmuganathan K, Mirvis SE, Boyd-Kranis R, Takada T, Scalea TM. Nonsurgical management of blunt splenic injury: use of CT criteria to select patients for splenic arteriography and potential endovascular therapy. *Radiology*. 2000;217:75–82.
8. Zarzaur BL, Dunn JA, Leininger B, Lauerman M, Shanmuganathan K, Kaups K, Zamary K, Hartwell JL, Bhakta A, Myers J, et al. Natural history of splenic vascular abnormalities after blunt injury: a Western Trauma Association Multicenter trial. *J Trauma Acute Care Surg*. 2017;83(6): 999–1005.
9. Zarzaur BL, Kozar R, Myers JG, Claridge JA, Scalea TM, Neideen TA, Maung AA, Alacon L, Corcos A, Kerwin A, et al. The splenic injury outcomes trial: an American Association for the Surgery of Trauma multiinstitutional study. *J Trauma Acute Care Surg*. 2015;79(3):335–342.
10. Marmery H, Shanmuganathan K, Mirvis SE, Richard H 3rd, Sliker C, Miller LA, Haan JM, Witlus D, Scalea TM. Correlation of multidetector CT findings with splenic arteriography and surgery: prospective study in 392 patients. *J Am Coll Surg*. 2008;206:685–693.
11. Marmery H, Shanmuganathan K, Alexander MT, Mirvis SE. Optimization of selection for nonoperative management of blunt splenic injury: comparison of MDCT grading systems. *AJR Am J Roentgenol*. 2007;189(6): 1421–1427.
12. Melloul E, Denys A, Demartines N. Management of severe blunt hepatic injury in the era of computed tomography and transarterial embolization: a systematic review and critical appraisal of the literature. *J Trauma Acute Care Surg*. 2015;79(3):468–474.
13. Green CS, Bulger EM, Kwan SW. Outcomes and complications of angioembolization for hepatic trauma: a systematic review of the literature. *J Trauma Acute Care Surg*. 2016;80(3):529–537.
14. Misselbeck TS, Teicher EJ, Cipolle MD, Pasquale MD, Shah KT, Dangleben DA, Badellino MM. Hepatic angioembolization in trauma patients: indications and complications. *J Trauma*. 2009;67(4):769–773.
15. Letoublon C, Morra I, Chen Y, Monnin V, Voirin D, Arvieux C. Hepatic arterial embolization in the management of blunt hepatic trauma: indications and complications. *J Trauma*. 2011;70(5):1032–1036.
16. Lee YH, Wu CH, Wang LJ, Wong YC, Chen HW, Wang CJ, Lin BC, Hsu YP. Predictive factors for early failure of transarterial embolization in blunt hepatic injury patients. *Clin Radiol*. 2014;69(12):e505–e511.
17. Dugi DD 3rd, Morey AF, Gupta A, Nuss GR, Sheu GL, Pruitt JH. American Association for the Surgery of Trauma grade 4 renal injury stratification into grades 4a (low risk) and 4b (high risk). *J Urology*. 2010;183(2):592–597.
18. Chiron P, Hornez E, Boddaert G, Dusaud M, Bayoud Y, Molimard B, et al. Grade IV renal trauma management. A revision of the AAST renal injury grading scale is mandatory. *Eur J Trauma Emerg Surg*. 2016;42(2):237–241.
19. Keihani S, Xu Y, Presson AP, Hotaling JM, Nirula R, Piotrowski J, Dodgion CM, Black CM, Mukherjee K, Morris BJ, et al. Contemporary management of high-grade renal trauma: results from the American Association for the Surgery of Trauma genitourinary trauma study. *J Trauma Acute Care Surg*. 2018;84(3):418–425.
20. Charbit J, Manzanera J, Millet I, Roustan JP, Chardon P, Taourel P, Capdevila X. What are the specific computed tomography scan criteria that can predict or exclude the need for renal angioembolization after high-grade renal trauma in a conservative management strategy? *J Trauma*. 2011;70(5): 1219–1128.
21. Nuss GR, Morey AF, Jenkins AC, Pruitt JH, Dugi DD 3rd, Morse B, Shariat SF. Radiographic predictors of need for angiographic embolization after traumatic renal injury. *J Trauma*. 2009;67(3):578–582.
22. Shariat SF, Roehrborn CG, Karakiewicz PI, Dhami G, Stage KH. Evidence-based validation of the predictive value of the American Association for the Surgery of Trauma kidney injury scale. *J Trauma*. 2007;62(4): 933–939.
23. Malaeb F, Figler B, Wessells H, Voelzke B. Should blunt segmental vascular renal injuries be considered an American Association for the Surgery of Trauma grade 4 renal injury? *J Trauma Acute Care Surg*. 2014;76(2):484–487.
24. Buckley JC, McAninch JW. Revision of current American Association for the Surgery of Trauma renal injury grading system. *J Trauma*. 2011;70(1): 35–37.
25. Uyeda JW, LeBedis CA, Penn DR, Soto JA, Anderson SW. Active hemorrhage and vascular injuries in splenic trauma: utility of the arterial phase in multidetector CT. *Radiology*. 2014;270(1):99–106.