Splenic Trauma: A Pictorial Review of Imaging Findings Critical to Grading and Management

Dean Thongkham, MD, Charlotte Chung MD PhD, Gayatri Joshi MD
Department of Radiology and Imaging Sciences
Emory University School of Medicine, Atlanta GA

Educational Goals & Objectives

- Briefly review **normal splenic anatomy** and **epidemiology of splenic trauma**
- Systematically illustrate the **spectrum of splenic injury patterns on CECT**
- Highlight the **new AAST splenic injury grading** system with detailed review of splenic injury patterns that constitute each grade
- Discuss the implications of imaging findings and AAST splenic injury grading on **management decisions for splenic injury**

Target Audience:

- Radiology Residents
- Abdominal and Emergency Radiologists
- ED Clinicians

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Overview of Traumatic Splenic Injury

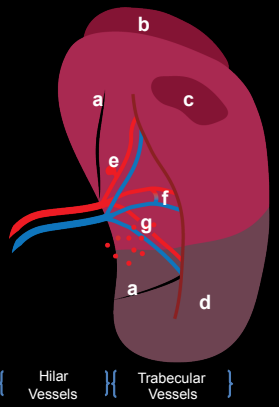
- The spleen is the most commonly injured solid organ and the leading cause of massive bleeding and resultant morbidity in blunt abdominal trauma.
- Contrast-enhanced CT (CECT) is the diagnostic modality of choice for evaluation of traumatic splenic injury in hemodynamically stable patients (the spleen is best evaluated in the portal venous phase)
- Classification of injury severity according to the *American Association for the Surgery of Trauma (AAST) Splenic Injury Scale*, updated (in 2018). Changes include:
  - Incorporation of vascular injury (pseudoaneurysm [PSA], arteriovenous fistula [AVF] and active extravasation)

		New AAST Splenic Injury Scale (2018 revision) *Red indicates changes from 1994 version*
Grade 1 (low grade)	Hematoma Laceration	Subcapsular, < 10% surface area Parenchymal laceration < 1cm depth Capsular tear
Grade 2 (low grade)	Hematoma Laceration	Subcapsular, 10-50% surface area Intraparenchymal, < 5 cm Parenchymal laceration 1-3 cm
Grade 3 (low grade)	Hematoma Laceration	Subcapsular, >50% surface area Ruptured subcapsular or intraparenchymal hematoma ≥ 5 cm (Expanding intraparenchymal hematoma removed as a criteria) Parenchymal laceration > 3 cm depth
Grade 4 (high grade)	Vascular Laceration	Any injury in the presence of a splenic vascular injury or active bleeding confined within splenic capsule Involves segmental or hilar vessels producing > 25% devascularization
Grade 5 (high grade)	Vascular Laceration	Any injury in the presence of a splenic vascular injury or active bleeding extending beyond the spleen into the peritoneum Shattered spleen

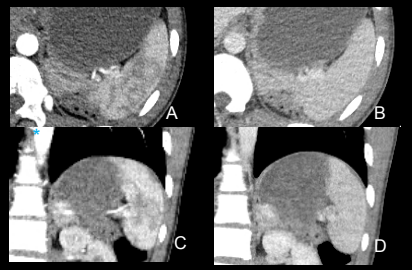
*Advance one grade for multiple injuries up to Grade 3

Splenic Anatomy and Injuries

Key	Finding
a	Parenchymal Laceration
b	Subcapsular hematoma
c	Intraparenchymal hematoma
d	Devascularization
e	Pseudoaneurysm
f	Arteriovenous fistula
g	Active Extravasation

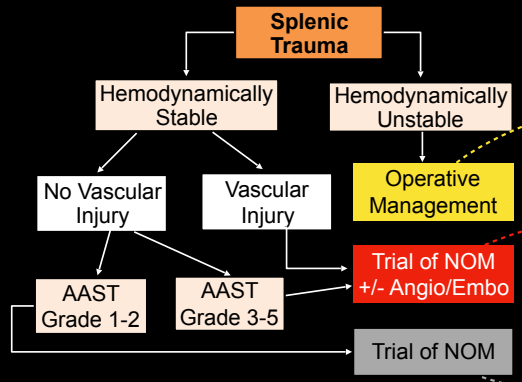


TEACHING POINT: The splenic parenchyma should be evaluated during portal venous phase



The spleen demonstrates normal heterogeneous parenchymal enhancement in the arterial phase acquisition (A/C), which can be mistaken for splenic lacerations or contusions. The apparent heterogeneity resolves on subsequent portal venous phase imaging (B/D).

Management Strategy



Results in life-long risk of sepsis and overwhelming post-splenectomy infections due to loss of important spleen-mediated immunological functions, thus only reserved for ***hemodynamically unstable patients.***

Standard for minor injuries, successful in up to 95% patients. Despite the high level of injury, multiple societies, including the Eastern Association for the Surgery of Trauma recommend a trial of non-operative management (NOM) for ***hemodynamically stable*** patients.

Reduces splenic perfusion pressure to promote hemostasis while preserving splenic function. Angio/Embo significantly decreased NOM failure rates in hemodynamically stable patients ***with Grade 3-5 splenic injuries,*** even in the absence of definite vascular complications.

TEACHING POINT: Management determined by…

1) AAST splenic injury grading
2) Presence of associated injuries
3) Hemodynamic stability
4) Age of patient and comorbidities
5) Capabilities for close monitoring and availability of the operating room

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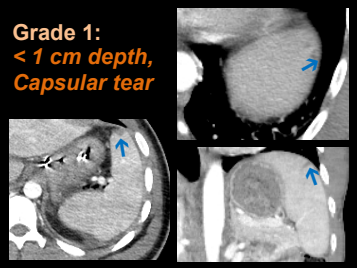
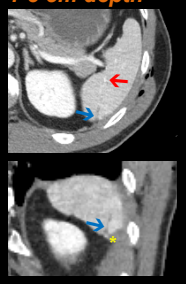
Low Grade Splenic Injuries:

Parenchymal Laceration: AAST Grade 1-3
Well-defined Linear/Branching hypodensities

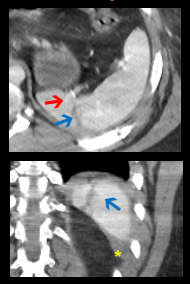
Grade 1: *< 1 cm depth, Capsular tear*



Grade 2: *1-3 cm depth*



Grade 3: *> 3 cm depth*

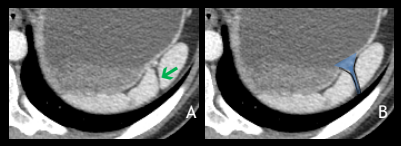


In all examples, the lacerations (➔) do not extend to adjacent vessels (➔). * denotes subcapsular hematoma

Clinical Significance: *Increasing depth, esp. in radial orientation, increases risk of trabecular or hilar vessel involvement .*

Imaging Pearls: ***Distinguishing normal from abnormal***

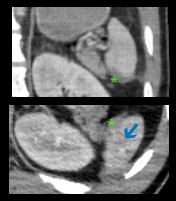
Splenic Cleft (Congenital)	Parenchymal Laceration
Smooth	Irregular
Rounded corners ("river delta")	Sharp corners
Usually superior spleen	Anywhere in the spleen
Fat hypodensity	Blood/soft tissue hypodensity
No perisplenic hemorrhage	Usually with perisplenic hemorrhage



Examples of Normal Splenic Clefts (➔): (A and B) Axial image demonstrating a smooth-appearing cleft in the superior spleen with rounded corners, resembling a river delta (overlay in B).

Subcapsular Hematoma: AAST Grade 1-3
Well circumscribed perisplenic collection

Grade 1: *< 10% surface area*



Grade 2: *10 – 50% surface area*

Grade 3: *> 50% surface area*

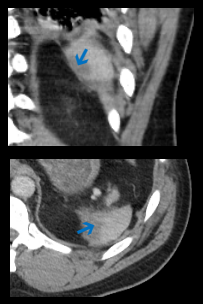
* subcapsular hematoma, ➔ laceration , ➔ intraparenchymal hematoma

Clinical Significance: *Subcapsular hematoma may stretch the capsule resulting in left upper quadrant pain or referred left shoulder pain. Large subcapsular hematomas can also rupture.*

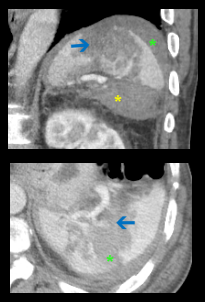
Imaging Pearls: ***A subcapsular hematoma often demonstrates mass effect on the spleen - hemoperitoenum will not.***

Intraparenchymal Hematoma: AAST Grade 2-3
Irregular, heterogeneously low density intraparenchymal mass-like lesion

Grade 2: *< 5cm*



Grade 3: *≥ 5cm*

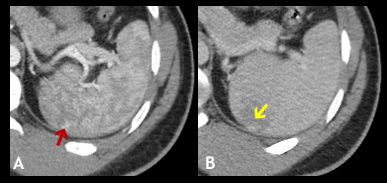


Clinical Significance: *Can cause splenic enlargement and increased friability. Assessment for active extravasation or pseudoaneurysm is critical.*

➔ intraparenchymal hematoma
* perisplenic hematoma
* subcapsular hematoma

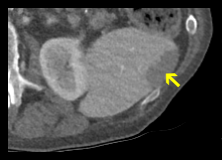
Incidental Splenic Findings can Mimic Traumatic Injuries

CASE 1:



25 year-old male s/p pedestrian vs auto. An irregular hypodense posterior splenic lesion (➔) is seen on PV phase (B), which demonstrates possible contrast blush (➔) on arterial phase (A). In the absence of perisplenic hematoma and other intra-abdominal injuries, the finding is most likely benign, possibly a splenic hemangioma.

CASE 2:



91-year-old female s/p ground-level fall, with pelvic fractures, active extraperitoneal bleeding. A peripheral Wedge-shaped hypodensity (➔) in the lateral spleen is noted on PV phase image, without perisplenic or subcapsular hemorrhage. Finding is most consistent with a splenic infarct.

Imaging Pearl: Lack of perisplenic hematoma/fluid suggests against acute traumatic splenic injury.

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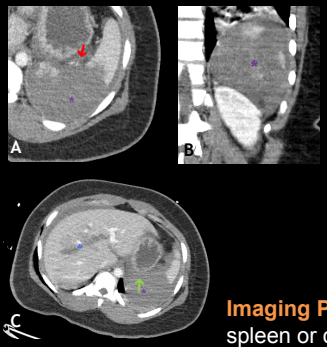
High Grade Splenic Injuries:

AAST Grade 4 Splenic Injury: Example 1

Involves segmental or hilar vessels, > 25% devascularization

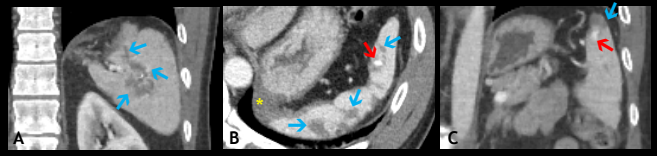


(A) Axial and (B) coronal CECT shows a large region of splenic nonenhancement (~75% of the spleen, *), consistent with devascularization. Irregular narrowing of the splenic artery branches (➔) at the hilum suggest arterial disruption. (C) A more cranial axial image shows surrounding moderate volume hemoperitoneum extends medially (➔). There is concurrent hepatic laceration (*) with large subcapsular hematoma (*), consistent with at least AAST Grade 4 liver injury.

Imaging Pearl: Devascularization can involve the whole spleen or can manifest as peripheral wedge shaped regions of decreased or absent enhancement.

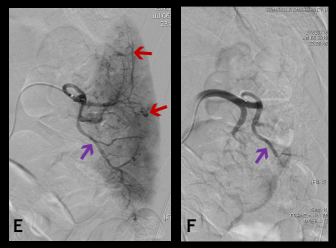
AAST Grade 4 Splenic Injury: Example 2

Any injury in the presence of a splenic vascular injury or active bleeding confined within splenic capsule



Patient was transferred to IR for further evaluation.

PSAs can rapidly increase in size and rupture. Large AV fistulas can cause heart failure and pulmonary edema if untreated.



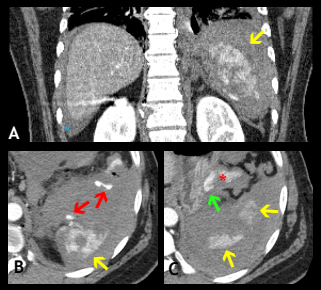
Split-bolus protocol (2-3 sequential IV contrast boluses preceding a single-pass acquisition to obtain a combination of arterial and portal venous phases, with aim to reduce radiation exposure). Images (A-C) demonstrates multiple splenic lacerations (➔) with minimal perisplenic hemorrhage (*). (B and C) Axial and coronal images shows one laceration in association with a well-defined focal hyperdensity (➔) that does not conform to vascular contour, suggestive of a contained vascular injury (PSA or AVF).

Imaging Pearls:
Vascular complications may upgrade AAST grade (ex. Grade 3 to 4 in this case).

(E) Selective angiogram of the inferior branch of the splenic artery demonstrates numerous tiny pseudoaneurysms of the distal parenchyma (➔). (F) Embolization with embospheres was performed, with resultant complete peripheral embolization with preserved slow flow in the main trunk (➔).

AAST Grade 5 Splenic Injury:

1. Shattered spleen
2. Any injury in the presence of a splenic vascular injury or active bleeding extending beyond the spleen into the peritoneum

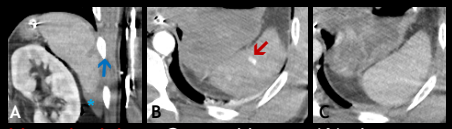


Shattered spleen (➔) with large perisplenic hemorrhage on coronal (A) and axial (B and C) CECT images. Injury to the hilar vessels (➔) result in multifocal active contrast extravasation, as demonstrated by irregularly focal high attenuation material (➔) in the area of the spleen and tracking medially to the spleen within a large perisplenic hematoma (*). Large volume hemoperitoneum also seen in the right upper quadrant (*), paracolic gutter and pelvis. Scattered pneumoperitoneum and subcutaneous emphysema consistent with sequelae from penetrating trauma.

Clinical Course and Management: Surgical

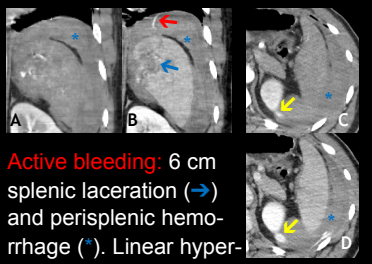
Active extravasation increases risk of hemodynamic instability. Given hemoperitoneum in the setting of penetrating trauma, emergent surgical exploration with splenectomy was performed. Patient had an uneventful recovery and was discharged to home.

Dual Phase Imaging Increases Sensitivity for Vascular Injuries



Vascular injury: Coronal image (A) shows a 1.2 cm splenic laceration (➔) with perisplenic hemorrhage (*). Focal high attenuation within the spleen (➔), only seen on arterial (B) and not on PV (C) phase axial image, is consistent with a pseudoaneurysm or AV fistula.

Imaging Pearls:
(Contained) Vascular injuries is more ***well-defined*** and ***decreases*** in attenuation on PV phase
Active bleeding is more ***ill-defined*** and ***increases*** in size and/or attenuation on PV phase



Active bleeding: 6 cm splenic laceration (➔) and perisplenic hemorrhage (*). Linear hyperdense focus (➔) only seen on PV (B), not arterial (A), phase coronal image, and contrast blush increasing in size from arterial (C) to PV (D) phase axial images (➔), are consistent with active bleeding.

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Conclusion:

The *radiologist* plays a *vital* role in detecting and classifying *splenic injuries*, ultimately influencing whether operative, minimally-invasive, or conservative non-operative management can be pursued.

References & Suggested Reading

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Author Contact Information

Dean Thongkham, MD: dean.wong.thongkham@emory.edu
Charlotte Chung, MD PhD: charlotte.yuk-yan.chung@emory.edu

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