CT imaging of blunt splenic injuries: what the trauma team wants to know from the radiologist

Shi HY[1], Cheong SC[2], Lim SF[3], Ng P, Koh S[3], Teoh WC[2]

[1]Singhealth Diagnostic Radiology Residency, Singapore
[2]Diagnostic Radiology, Changi General Hospital, Singapore
[3]General Surgery, Changi General Hospital, Singapore

Learning objectives

1) Understand the common aetiologies and mechanism of blunt splenic injury.

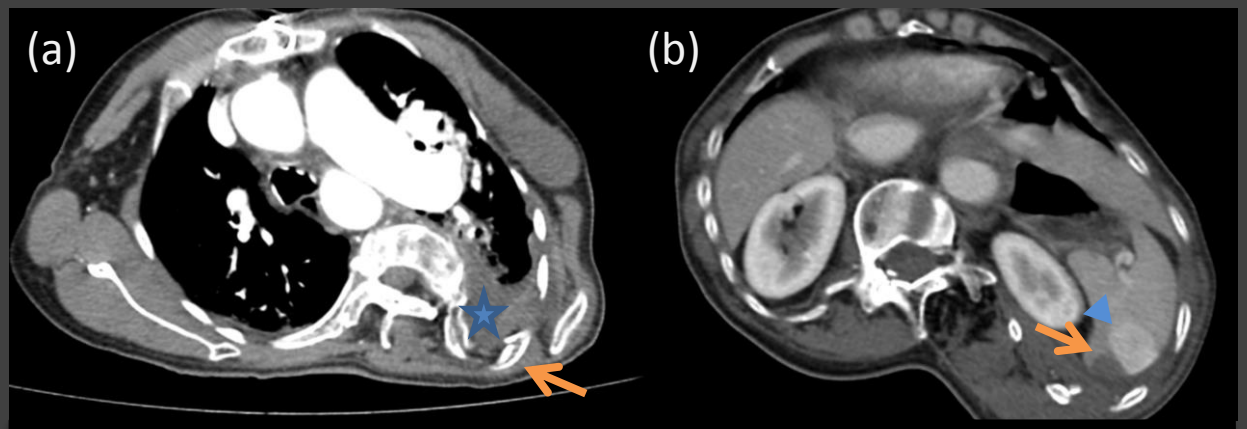
2) Review the CT appearances of different types of splenic injury.

3) Recognise high grade injuries and vascular complications that may require further interventions.

Background

- Common aetiologies: road traffic accidents, fall from height, direct impact and sporting injuries.

- Most frequently injured organ in abdominal blunt trauma:
  - Up to 45% of patients with severe blunt trauma (i.e. Injury Severity Score >15)[1]
  - Most commonly associated with left lower chest injury (e.g. rib fractures) [2]



a) Left lower rib fracture (arrow) with hemothorax (star).
b) Associated splenic haematoma (arrow) and pseudoaneurysm (arrowhead).

Background

- Current surgical opinion increasingly favours **non-operative management** (NOM) [3,4] (i.e. spleen conservation by avoiding splenectomy) regardless of severity of injury, *in the absence of peritonitis and associated injuries requiring laparotomy*.

Reasons being:

1) The spleen is an important immuonological organ.
2) High risk of immunological impairment and overwhelming post-splenectomy infections.
3) Success rate of attempted NOM in high volume centers with supporting facilities is near 90%.
4) NOM failure rate ranges from 4 to 15%.

Background

- NOM includes (1) close observation and (2) angiography with a view for embolization.

- As such, the diagnostic and interventional radiologists play an increasingly important role in patient management.

- (Multiphasic) CT is the current gold standard in the evaluation of blunt splenic trauma.

- Pertinent CT findings that the diagnostic radiologist needs to identify:
  (a) Severity grading –the American Association for Surgery of Trauma (AAST) injury scale is most commonly used.
  (b) Detection of bleeding – contained vascular injury (pseudoaneurysm or arteriovenous fistula) VS. active extravasation.

Imaging findings

Traditionally, splenic injury assessment is based on

Single venous phase CT

Evaluates the anatomy
i.e.
- Assesses
  (a) parenchyma and

  (b) Anatomical integrity of vascular pedicles

Translates to an AAST grading

Imaging findings

Traditionally, splenic injury assessment is based on

Single venous phase CT

Evaluates the anatomy
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  (a) parenchyma and

  (b) Anatomical integrity of vascular pedicles

AAST grading:

I : Subcapsular haematoma, <10% surface area
Capsular laceration <1 cm depth

II: Subcapsular haematoma, 10-50% surface area
Intraparenchymal haematoma < 5cm diameter
Capsular laceration 1-3 cm in depth

III: Subcapsular haematoma, >50% surface area
Ruptured subcapsular/parenchymal haematoma
Intraparenchymal haematoma > 5cm diameter
Laceration > 3cm in depth or involving trabecular vessels

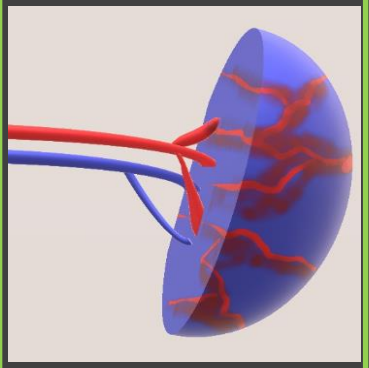
IV: Laceration involving segmental/hilar vessels with devascularization >25%

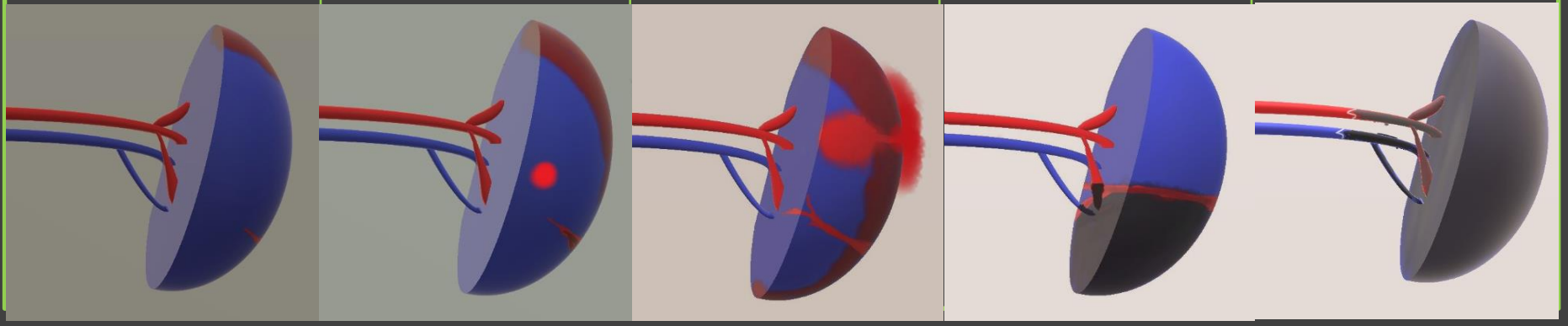
V: Shattered spleen/Completely devascularized

Imaging findings

American Association for Surgery of Trauma (AAST) injury scale

(Author's illustrations)

I :	II:	III:	IV:	V:
Subcapsular haematoma, <10% surface area Capsular laceration <1 cm depth	Subcapsular haematoma, 10-50% surface area Intraparenchymal haematoma < 5cm diameter Capsular laceration 1-3 cm in depth	Subcapsular haematoma, >50% surface area Ruptured subcapsular/ parenchymal haematoma Intraparenchymal haematoma > 5cm diameter Laceration > 3cm in depth or involving trabecular vessels	Laceration involving segmental/ hilar vessels with devascularization >25%	Shattered spleen  Completely devascularized



Imaging findings

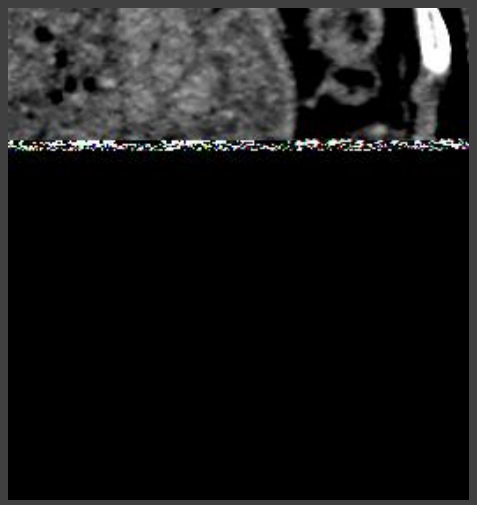
American Association for Surgery of Trauma (AAST) injury scale

Examples of low-grade injuries on CT imaging

(no strict definition, but by consensus, usually taken as grades I-III) [3]

I :

- Capsular laceration <1 cm depth



II:

- Intraparenchymal haematoma < 5cm diameter

III:

- Ruptured (arrowhead) subcapsular/ parenchymal haematoma
- Laceration > 3cm (arrow) in depth or involving trabecular vessels

Imaging findings

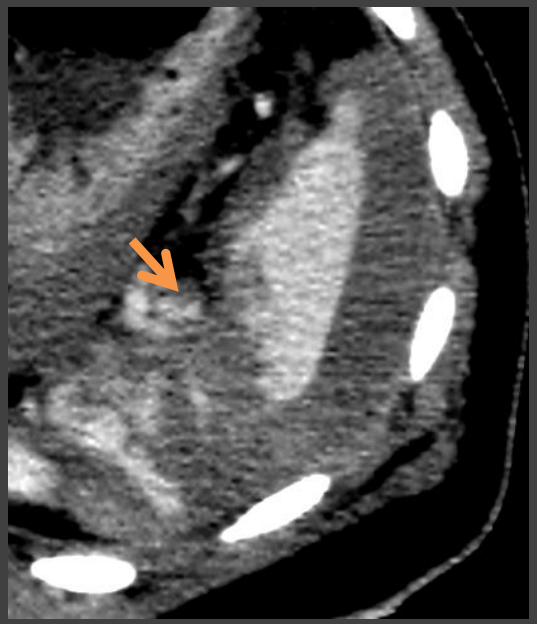
American Association for Surgery of Trauma (AAST) injury scale

Examples of high-grade injuries on CT imaging

(no strict definition, but by consensus, usually taken as grades IV-V) [3]

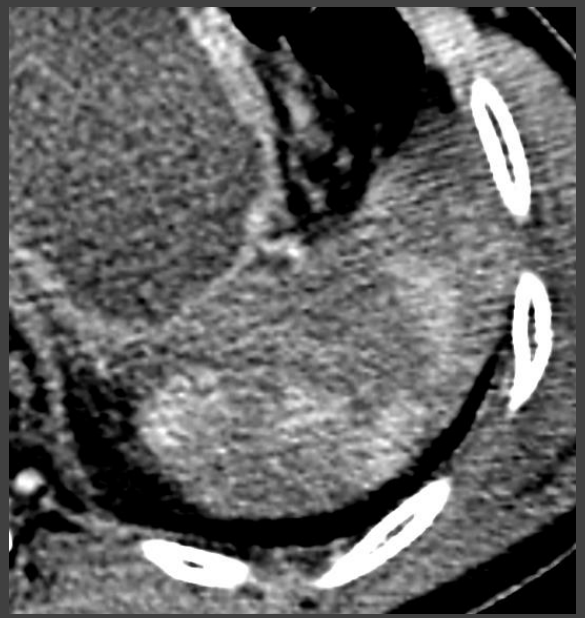
IV:

Laceration involving segmental/ hilar vessels (arrow) with devascularization >25%



V:

Shattered spleen



Imaging findings

The WSES* classification for splenic trauma[3]

**World Society of Emergency Surgery, 2017*

= AAST grading (anatomical) + Haemodynamic status (physiological response)

Imaging findings

WSES* classification[3]

**World Society of Emergency Surgery, 2017*

= AAST grading (anatomical) + Haemodynamic status (physiological response)

Minor	Moderate	Severe
WSES I: AAST I-II	WSES II: AAST III WSES III: AAST IV-V	WSES IV: Any AAST
And haemodynamically stable	*And* haemodynamically stable	haemodynamically UNstable

The WSES is designed to help guide management i.e. Generally, reducing threshold for NOM with increasing WSES grading

All UNSTABLE patients and/or patients with peritonitis or other associated injuries requiring laparatomy should undergo operative management

Imaging findings

However, appreciation of blunt splenic injuries based only on its anatomical appearance is inadequate…

Imaging findings

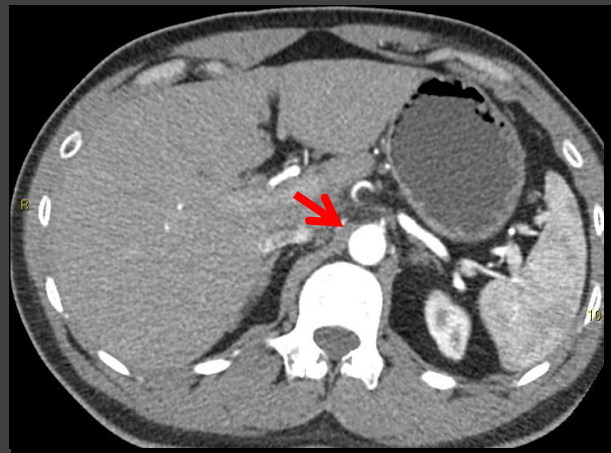
Shift from single phase to multiphasic CT evaluation:

Suggested standard of care for trauma imaging =
Multiphasic CT

A triphasic (arterial; venous; delayed) protocol is routinely performed in our institution for patients with a history of significant trauma

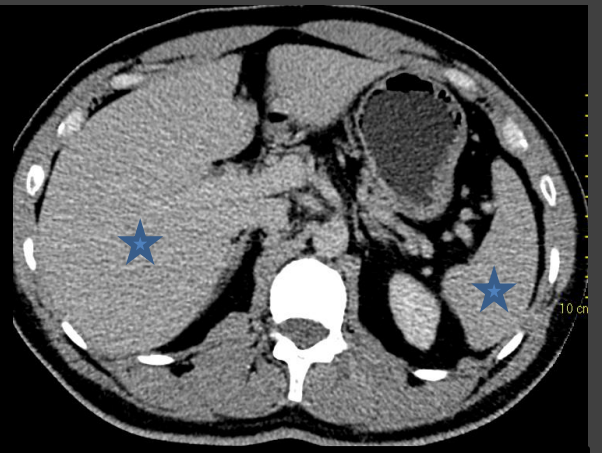
- **Dynamic vascular** evaluation

i.e. like a series of still images of a video clip



Arterial (25-35 seconds)
- Intense enhancement of abdominal aorta and the visceral branches (arrow).

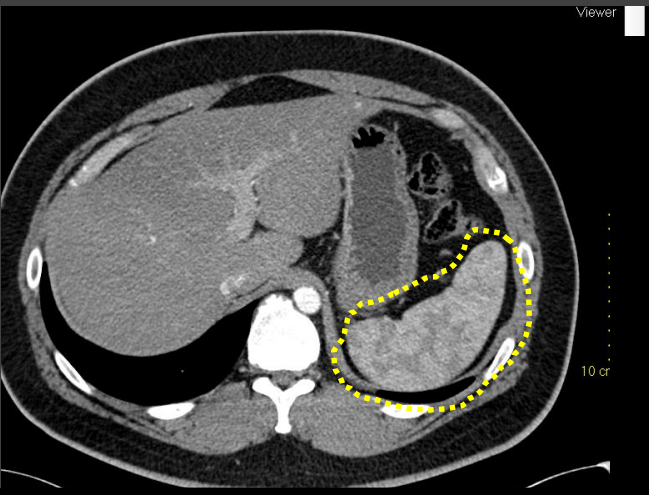
Porto- venous; (60-70 seconds)
- Maximal enhancement of the portal vein (arrowhead). The aorta enhancement has reduced.



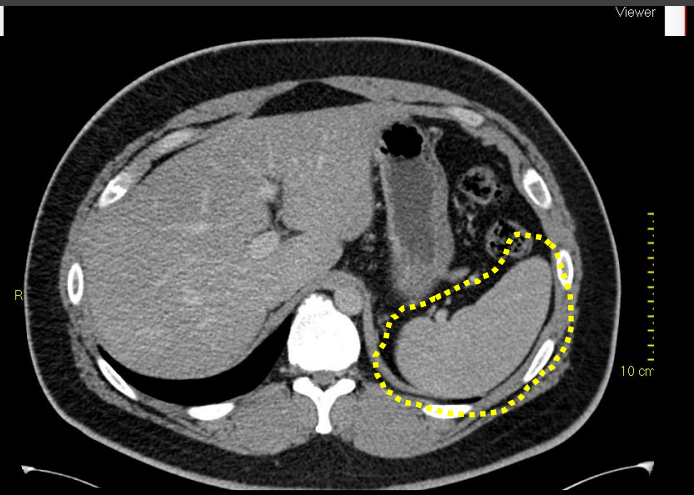
Delayed; (after 4 minutes)
- Both the liver and spleen are homogeneous in appearance(stars), similar in density to vessels.

Imaging findings

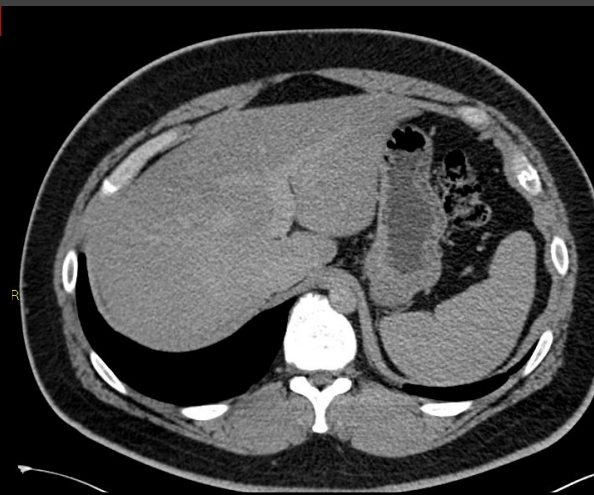
Shift from single phase to multiphasic CT:



Arterial (25-35 secs)



Porto- venous, (60-70 secs)


Delayed, (after 4 minutes)

PEARLS [6,7,8,9]

- Porto-venous phase: Splenic parenchyma is best assessed on this phase. Inhomogeneous enhancement (i.e. the zebra or "psychelic" spleen) on arterial phase may mimic lacerations.
  → dotted lines outlining the spleen, compare arterial vs. venous phases.

- Arterial phase : For appreciation of arterial injuries i.e. pseudoaneurysm, arteriovenous fistula and arterial blushes
- Delayed phase: Confirms active bleeding i.e. extravasation and pooling of contrast

** The presence of active bleeding or contained vascular injuries are considered by some authors to represent severe splenic injury.*[5]

Imaging findings

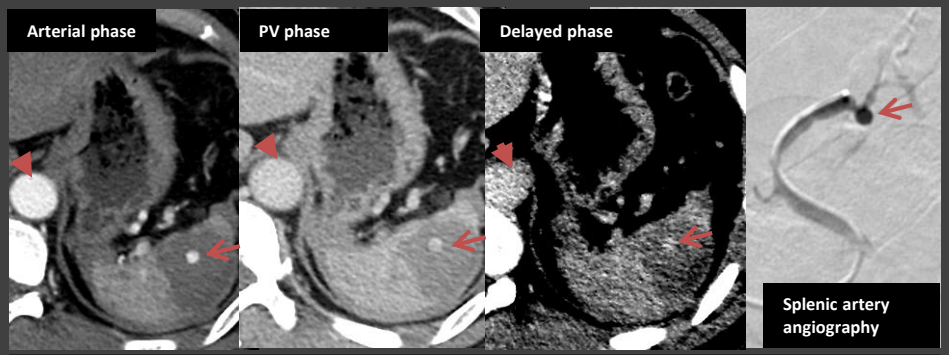
Technical shift from single phase to multiphasic CT:

Contained vascular injuries (often a combination of both):

(i) Pseudoaneurysm

PEARLS[10]

- More defined and rounded than a non-contained haematoma/active bleed;
- Less apparent (as rest of parenchyma enhances) and does not change in size on delayed images
- Isodense to the blood pool (aorta) on all phases



Pseudoaneurysm (arrows), ***rounded*** with ***well-defined edges***, ***unchanged*** in size/configuration, and isodense to blood-pool (arrowheads) on all phases; confirmed on angiography.

(i) Traumatic AVF

PEARLS

- Can be difficult to trace out exact arteriovenous connection on CT
- **Indirect sign** – look for early venous opacification

Early opacification of the portal vein (arrowheads) suggests an AVF. Arteriovenous connection demonstrated on angiography.

Imaging findings

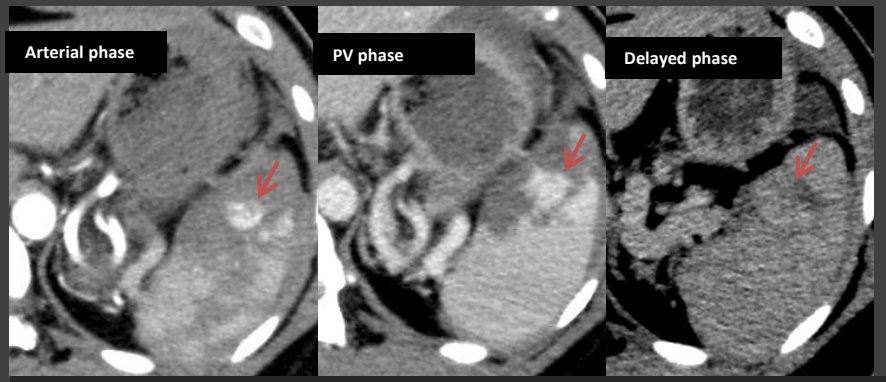
Technical shift from single phase to multiphasic CT:

Active bleeds:

(i) Intraparenchymal/subcapsular

PEARLS[10]

- Initially may look like a pseudoaneurysm;
- Irregular outline;
- "Pooling" (getting increasingly larger) on subsequent phases



Enlarging with ***irregular edges***, i.e. active intraparenchymal haemorrhage (arrows).

(ii) Extracapsular/intraperitoneal

PEARLS

- Watch out for hemoperitonieum (i.e. dense fluid, especially in the dependent regions)

Active extracapsular extravasation (arrows) with gradual pooling of blood demonstrated on sequential phases.

Imaging findings

Angiography with a view to angioembolization should be considered in haemodynamic stable patients[3]:

1. Who presents with active bleeding.
2. Who presents with contained bleeds such as pseudoaneurysm and arteriovascular fistula.
3. Who have WSES III or AAST grade IV and V injuries.

Case Studies

Imaging findings

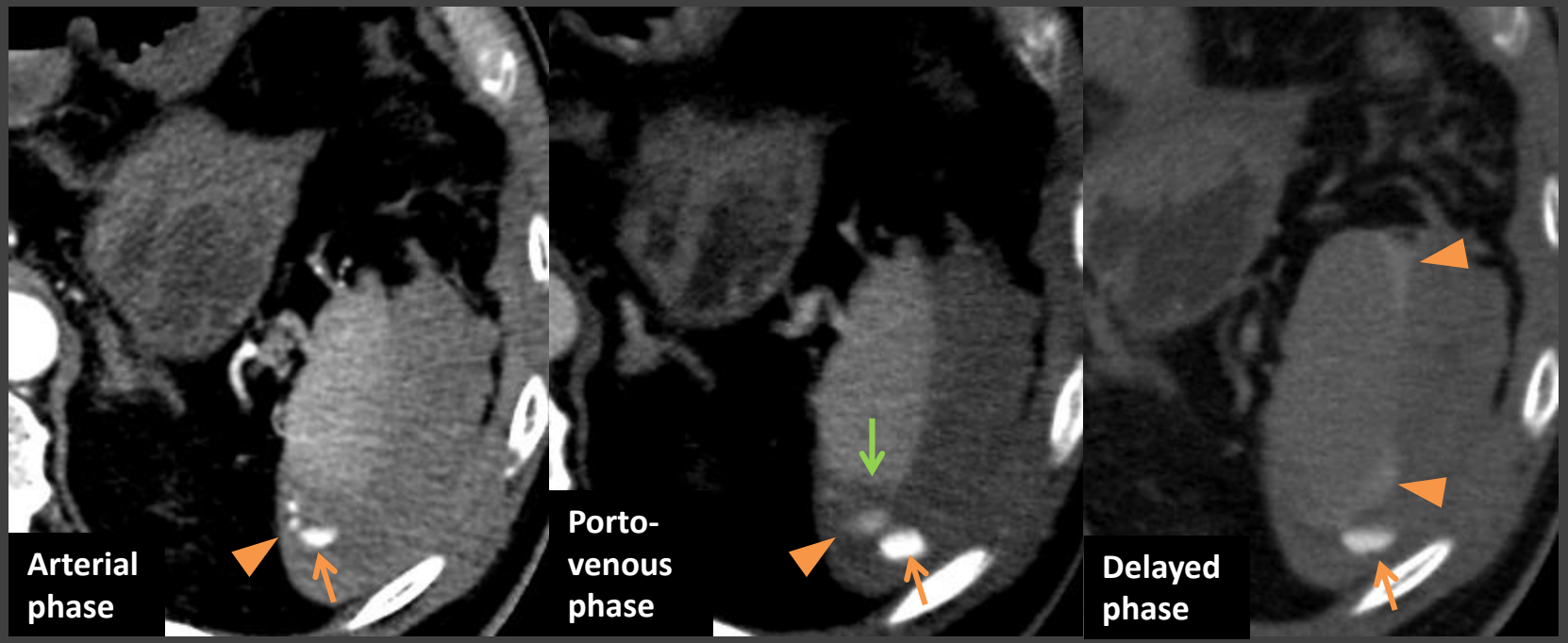
Case 1: Passenger of car involved in head-on collision. Vitals stabilized after initial resuscitation with fluids and blood products.

Imaging findings

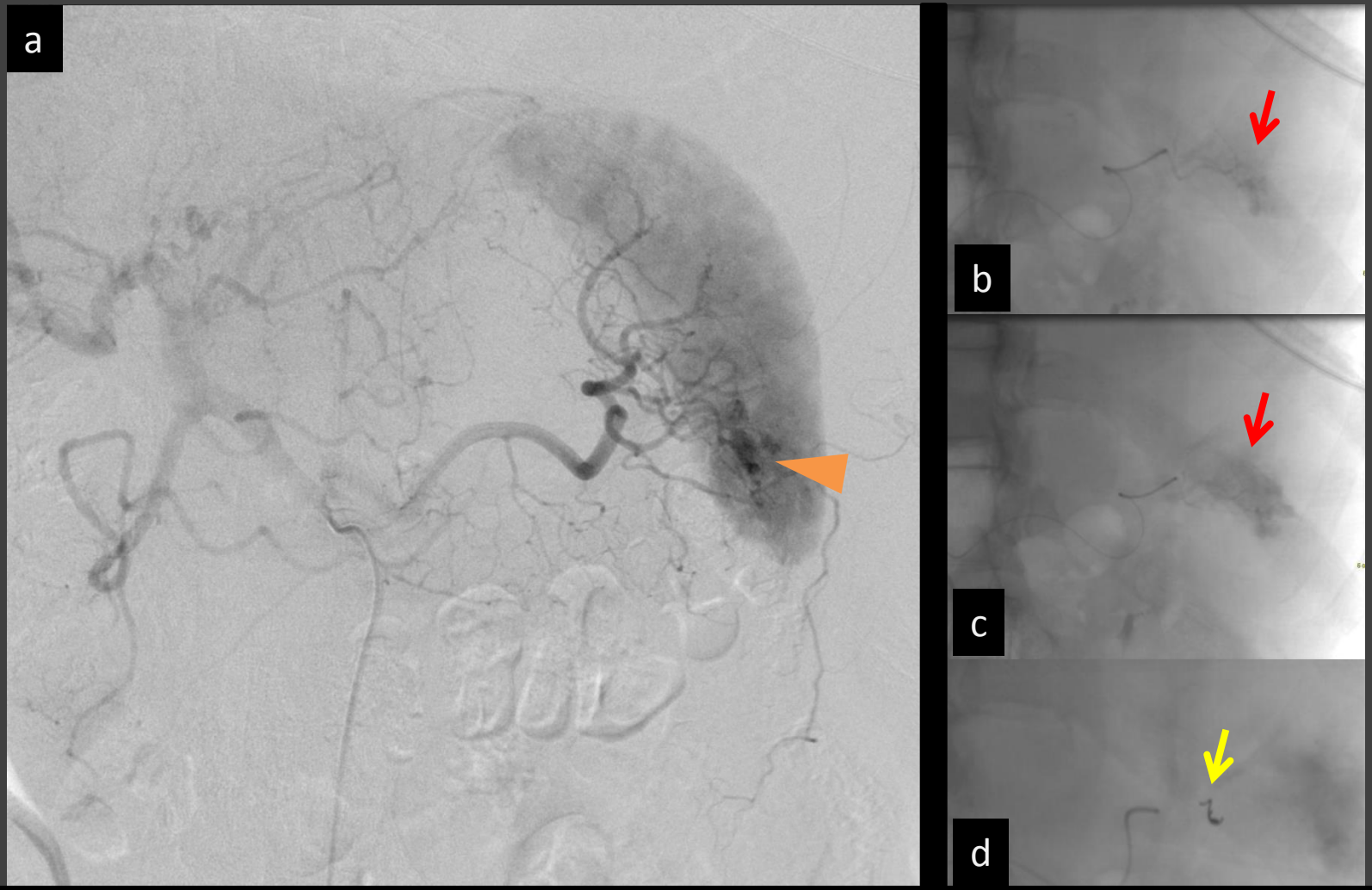
AAST grading:
III: Ruptured subcapsular haematoma (arrow)

WSES grading III (Vitals were stabilized after initial resuscitation with fluids and blood products)

Multiphasic (dynamic) imaging
- Focal pseudoaneurysm (arrow) with active extracapsular bleed (arrowheads): On porto-venous phase, the pseudoaneurysm is only slightly larger, but the pools of contrast beside it have enlarged. On the delayed phase, the freely extravasated contrast has spread around the splenic surface.



Imaging findings



Underwent urgent angioembolization by interventional radiologist:
(a): Catheter angiogram (coeliac axis) Pseudoaneurysm (arrowhead)
(b–c): Superselective angiogram of inferior splenic segmental artery: active bleed (arrow) with contrast pooling on the later image (c).
(d): Embolisation coil (arrow) placed.

Imaging findings

DISCUSSION

- Successful NOM through
  - early identification of active bleed on multiphasic CT
    AND
  - timely super-selective angioembolization

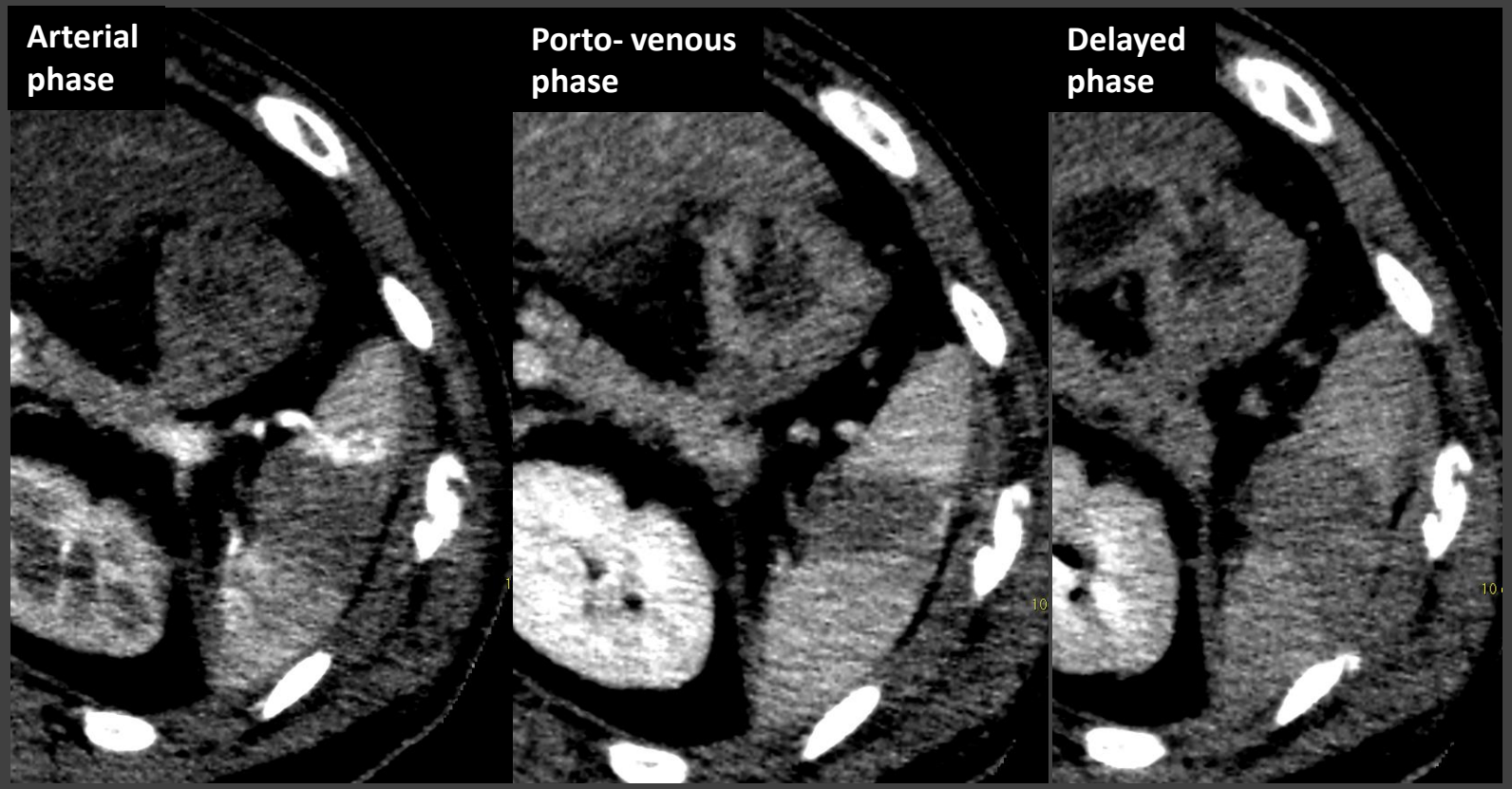
- Spleen was preserved.

- No subsequent significant complications (either treatment or injury-related).

- Patient was discharged well within a week.

Imaging findings

Case 2: Kicked in left flank. Vitals stable on arrival.

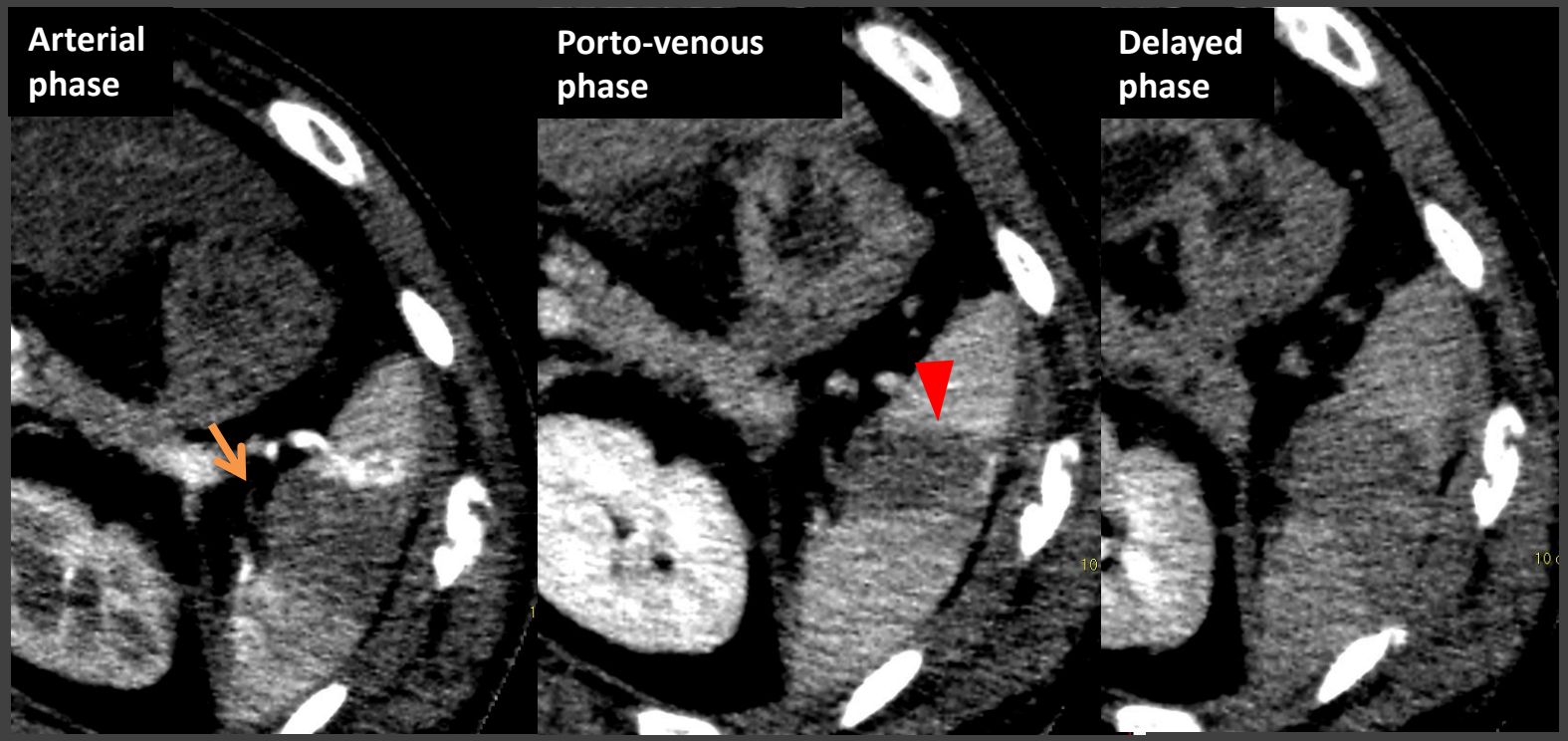


Imaging findings

AAST grading:
IV: (Deep) Laceration to involve segmental/hilar vessel with >25% devascularization

WSES grading III (Stable vitals)

Multiphasic (dynamic) imaging
Deep laceration across the entire thickness of the spleen and into the splenic hilum. There is involvement of the middle hilar/segmental vessels (arrow) with associated band of non-enhancement (arrowhead) i.e. devascularization.
No evidence of active or contained bleed on the dynamic multiphasic CT.



Progress:

- Conservatively managed with no active intervention.
- Discharged after 48 hours (at patient's request).
- Haemoglobin levels, monitored at the outpatient setting, returned to normal 2 weeks following discharge.

DISCUSSION

- Despite the relatively high-grade injury (AAST IV; WSES III), patient's outcome was good without any active intervention (blood transfusion, angioembolisation or surgery).
  → *in accordance with WSES 2017 guidelines: haemodynamically stable patients should have initial attempt of NOM regardless of injury grade (in centres with intensive monitoring and angio-embolization capabilities).*

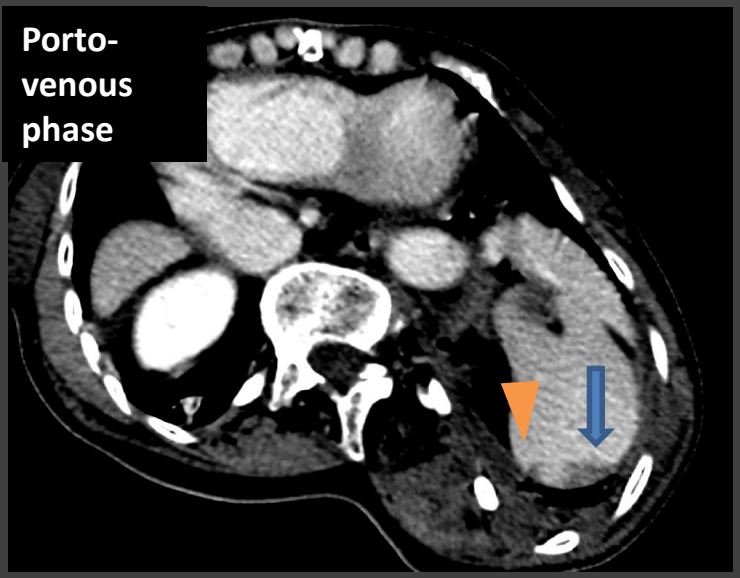
- Successful preservation of the spleen.

- The decision for conservative observation management was made based on
  (i) Haemodynamic stability
  (ii) Lack of active/contained vascular injuries on multiphasic CT

Imaging findings

Case 3: middle aged motorcyclist who was hit by a car. Vitals stable after initial resuscitation.

Imaging findings

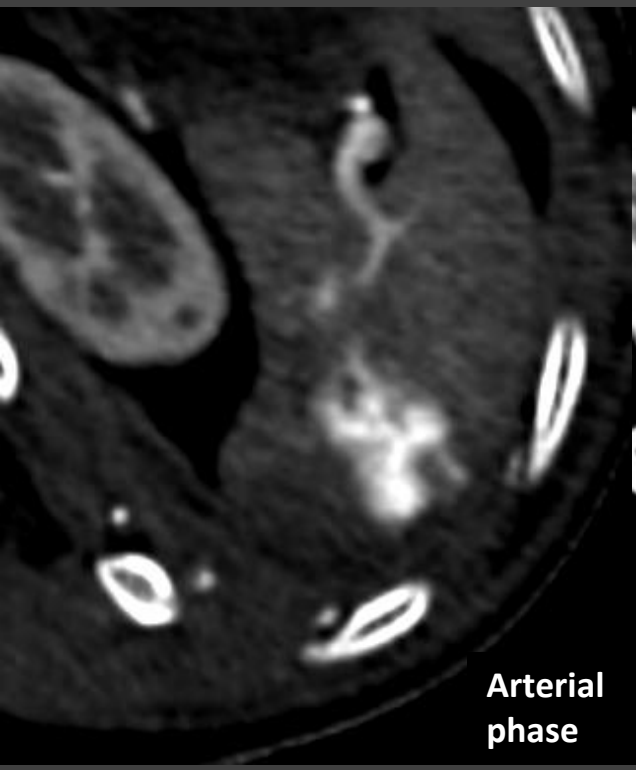


AAST grading:
I : Subcapsular haematoma, <10% surface area (arrow) *AND*
Capsular laceration <1 cm depth (arrowhead)

WSES grading I (vitals were stabilised after initial resuscitation)

Imaging findings

However, in the more inferior aspect of the spleen…

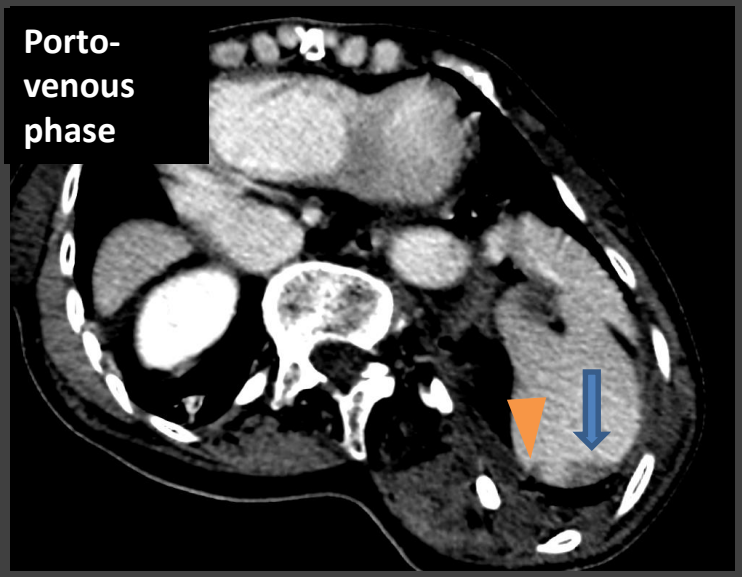


Arterial phase

Porto-venous phase

Delayed phase

Imaging findings



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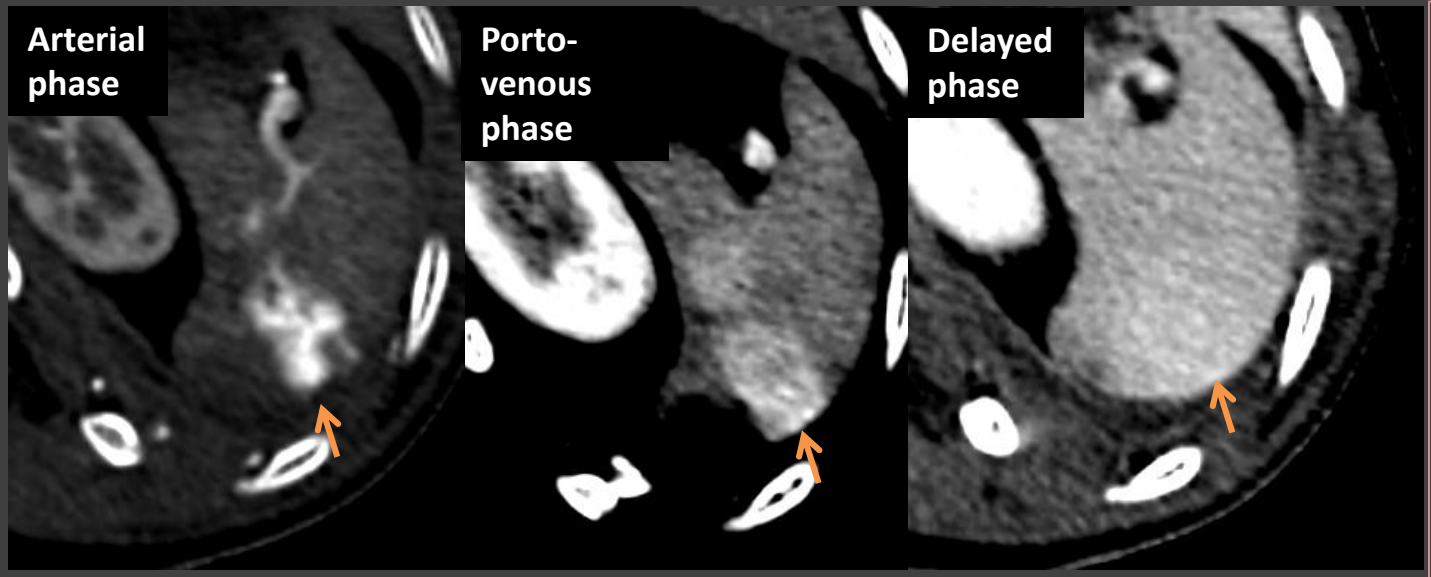


Multiphasic (dynamic) imaging (inferior to the subcapsular haematoma)
Contained vascular injury (arrows) seen with pseudoaneurysms arising from the upper pole hilar/trabecular branches of the splenic artery.

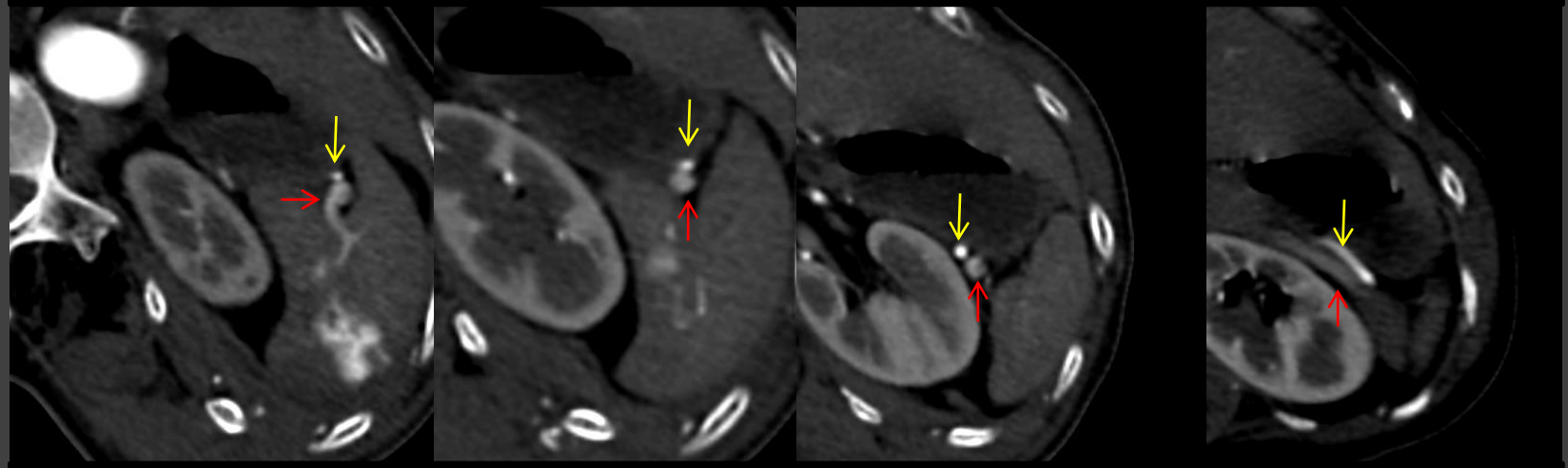
Isodense to blood pool on the later phases

Imaging findings

What else?

Imaging findings

Evidence of AVF when there is early venous opacification on the arterial phase scan:



→ Brighter vessel traces to the splenic artery

→ Less bright vessel parallel to the splenic artery represents early opacification of the splenic vein

Imaging findings

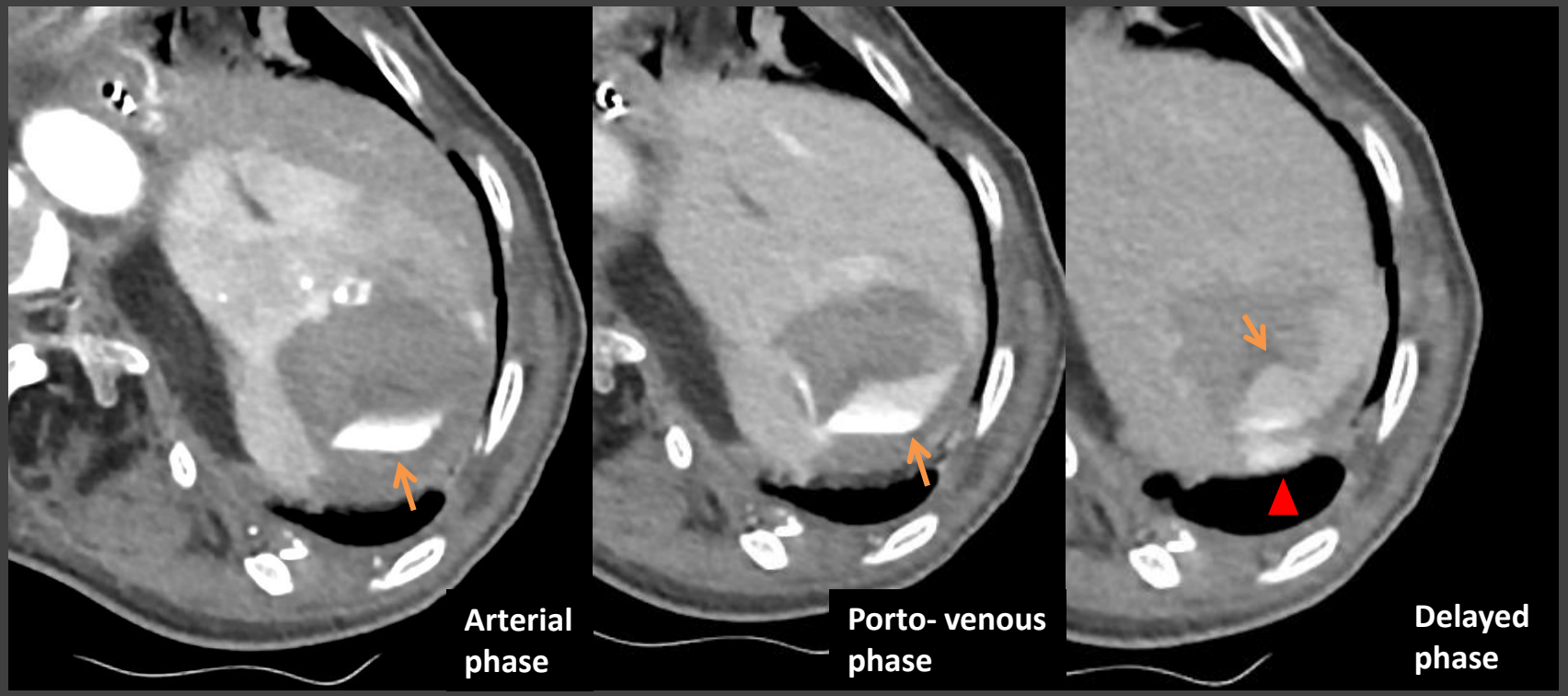
Progress of Patient 3:

- Initial management: NOM with close observation in the High Dependency Unit.

- Required transfusions during stay but otherwise haemodynamic stable.

- CT repeated 1 week following admission – “to monitor for progress”

Imaging findings

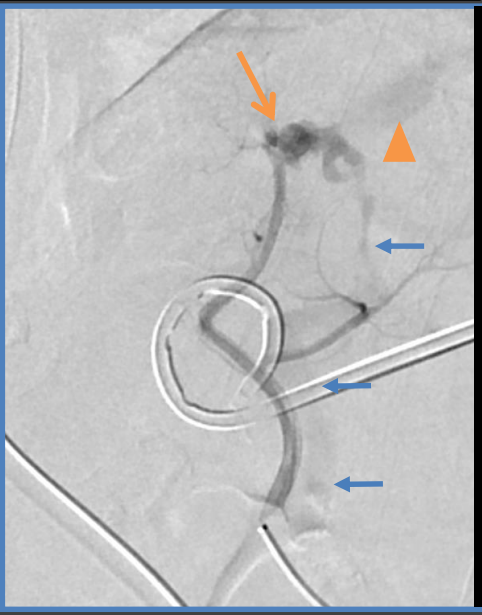


Multiphasic (dynamic) imaging

Enlarging acute haematoma with active intraparenchymal (arrow) and extracapsular bleed (arrowhead):
- progressive pooling of the dense contrast on sequential phases
- Extracapsular rupture into the peritoneal cavity on the delayed phase

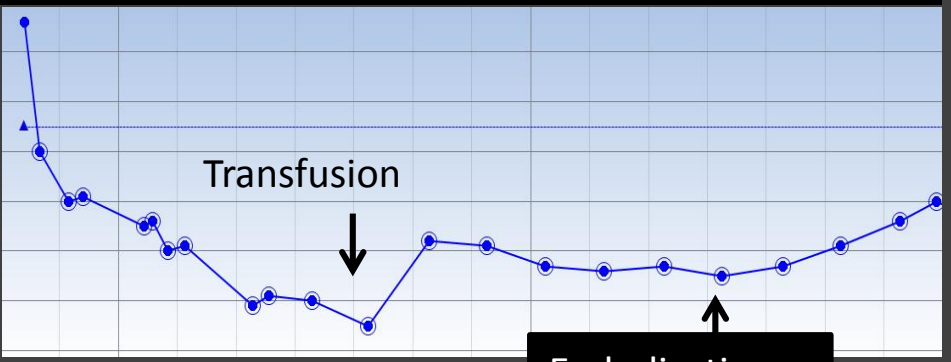
- Urgent angiography and embolization was subsequently performed.

Imaging findings



Splenic artery angiography:
- Cluster of pseudoaneurysms (arrow) with abnormal arteriovenous connection and faint opacification of the splenic vein (arrows).
- Active bleeding (arrowhead) also present.

Haemoglobin trend



DISCUSSION

- Apparent *low-grade* injury on CT with vital signs stabilised following resuscitation → may lull clinicians and radiologists into a false sense of security

- Contained bleeds i.e. pseudoaneurysms and traumatic AVFs should be viewed as serious findings for which urgent/early intervention (angioembolisation), or at least very close monitoring, should be considered.

Conclusion/Learning points

1. **Non-operative management (NOM)** is the preferred 1st line treatment strategy for blunt splenic injuries in haemodynamically stable patients, regardless of severity of injury; in the absence of peritonitis and associated injuries requiring laparotomy.

2. The established AAST grading, based on the anatomical appearance of splenic injuries may be inadequate in assessing the severity of injury

3. The use of **multiphasic CT** which includes arterial and delayed phases will aid in the detection of contained vascular injuries (i.e. pseudoaneurysms, traumatic AVFs) and active bleeding.

4. Contained and active bleeding in haemodynamic stable patients may be treated by angioembolization with good outcomes.

5. Given the increasing use of NOM, the radiologist must recognize the different types and grading of blunt splenic injury, be familiar with the appearance of severe injuries/ vascular complications and should be able to give appropriate advice to the trauma team on the need for angiography and angioembolization.

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