Learning objectives

Our aim is to describe the different types of blunt traumatic injury to the abdominal aorta, highlighting the imaging findings in the computed tomography (CT) and illustrating them with several interesting cases of our institution.
Background

Blunt injury to the abdominal aorta is almost always secondary to high-speed motor vehicle collisions and it is a very infrequent occurrence, both in adults and in children [1]. It is found in 0.08-0.62% of cases of nonpenetrating abdominal trauma and it represents only 4-6% of total aortic injuries [2]. This is partly due to the protected retroperitoneal position of the abdominal aorta covered anteriorly by the abdominal wall and the visceral organs and posteriorly and laterally by the vertebrae and the paravertebral musculature. Moreover, the high associated mortality in the crash makes that patients who suffer blunt aortic trauma rarely reach the hospital alive. Those who do have a reported 24% in-hospital mortality that increases over time, ranging from 30% at 6h to 50% at 24h [3,4]. So despite being much less common than injuries to the thoracic aorta (20 times less frequent in several autopsy series [5]), all radiologists should know how to make an accurate diagnosis.

Multi-detector CT (MDCT) has become the imaging modality of choice in the evaluation of the trauma patient (including traumatic abdominal aorta lesions) due to its high spatial and temporal resolution [4]. It allows multiplanar reconstructions (MPR) and maximum intensity projections (MIP), avoids artifacts and allows an accurate characterization of aortic injuries and diagnoses associated trauma lesions in a short time.
Findings and procedure details

Depending on the magnitude of the traumatic forces, aortic injuries presents as a spectrum of disease ranging from a minimal aortic injury (MAI) to rupture of the aorta. These injuries are commonly seen in high-speed motor vehicle collisions, especially with seat belt injuries due to sudden anterior deceleration, crushing, or direct blowing to the abdomen. The mechanism of injury is thought to be due to direct compression of the aorta against the bony vertebrae, and to deceleration forces transmitted against intravascular pressure causing disruption of the intima [2]. According to the magnitude of force, the disruption may result in aortic transection [3]. Nevertheless, shearing forces, a major factor in thoracic aortic injuries, is thought to play a less important role in abdominal aortic injuries. The point of maximum shear in the abdominal aorta is described near the bifurcation [4]. Aortic lesions can be associated with major blunt intra-abdominal injury and thoracolumbar vertebral fractures (Fig. 1 on page 22 Fig. 2 on page 14). This simultaneous abdominal injuries and spine fractures were first time described as "seat belt syndrome" (Fig. 3 on page 12 Fig. 4 on page 11). When the abdominal aorta is also involved, the syndrome is known as "seat belt aorta" [3].

In cases of hemodynamically unstable trauma patients, our protocol is to perform enhanced CT in arterial and portal venous phases. The arterial phase help us for the assessment of the aorta injuries and active bleeding. The portal phase contributes to value the active bleeding if extravasation of contrast and assessment of abdominal visceral and other associated findings.

We classify aortic lesions into five groups, as it had been reported in the literature: intimal tear or minimal aortic injury, large intimal flap, intramural hematoma, pseudoaneurysm and aortic rupture. The first two groups show intraluminal findings with absence of aortic external contour abnormality.

- **Intimal tear/ minimal aortic injury**

  **Concept:** isolated involvement of aortic intima. Absence of aortic external contour abnormality and intimal defect and/or thrombus of 10 mm length or width.

  **CT findings:** linear intraaortic filling defect < 10 mm in length (Fig. 5 on page 15 Fig. 6 on page 16).

  Subtle intimal injuries or "minimal" aortic injuries are being encountered more frequently, likely as a result of the improved spatial resolution of MDCT. In the largest series MAI are
estimated to occur in 10% of patients with aortic injuries. Angiography can be normal in nearly half of the cases. Existing data suggest that these small intimal defects may not require surgical intervention, with a majority remaining stable or resolving spontaneously on follow-up imaging [4].

- **Large intimal flap / dissection**

**Concept:** Dissection is the result of a spontaneous longitudinal separation of the aortic intima and adventitia caused by circulating blood gaining access to and splitting the media of the aortic wall [6]. The intimal tear allows blood to enter the media from the vessel lumen. The distal intimal flap is often dissected by the blood flow, leading to thrombosis.

**CT findings:** Absence of aortic external contour abnormality. Gross linear intraluminal filling defect > 10 mm in length or width and/or thrombus. (Fig. 1 on page 22 Fig. 7 on page 8).

Unlike the thoracic aorta, abdominal aortic intimal defects are often segmental and frank and extended dissection is rarely observed (Fig. 8 on page 9 Fig. 9 on page 18 Fig. 10 on page 20). Interposed intimal flap separates true and false lumen. Differentiation between both is important:

- False lumen has larger cross-sectional area and delayed enhancement. It wedges around true lumen, resulting in "beak" sign. It may have collagenous media remnants ("cobweb" sign). Thrombosis is more frequent.
- True lumen has smaller cross-sectional area and early enhancement.

- **Intramural hematoma**

**Concept:** Aortic media hemorrhage from vasa vasorum. Absence of entrance tear and absent reentrance tear.

**CT findings:** Concentric or crescentic aortic wall thickening (Fig. 11 on page 19). Classically without intimomedial flap or detectable fenestration. Non enhanced CT shows circumferential or crescentic aortic wall hyperdensity.

- **Pseudoaneurysm**
Concept: hematoma formed outside the artery as the result of a leaking hole in the arterial wall. The hematoma is contained by the surrounding tissues and in communication with the aortic lumen.

CT findings: Focal contrast-containing outpouching from aortic lumen. External aortic contour abnormality and contained rupture.

- Rupture

Concept: disruption of all layers of the arterial wall with blood extravasation.

CT findings: external aortic contour abnormality with free contrast extravasation.

Distinction between active extravasation and pseudoaneurysm is made using delayed phase images. Active extravasation (unlike pseudoaneurysm) changes in size and morphology between arterial and portal venous phase (Fig. 12 on page 21).

Rupture of the aorta can be due to aortic wall disruption or branch vessel avulsion (Fig. 13 on page 7).

Regardless of size or extent of aortic rupture, a large retroperitoneal hematoma is usually associated (Fig. 12 on page 21 Fig. 14 on page 10)

Other associated findings can be visceral infarcts (Fig. 15 on page 7) and aorto-cava fistula (Fig. 16 on page 17 Fig. 17 on page 13).
Fig. 15: Axial view enhanced CT: complete renal infarct (yellow arrow) due to left renal artery avulsion (white arrow)

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Fig. 13: Axial view enhanced CT: celiac trunk is thin and stretched and separate from aortic wall (white arrow). Complete avulsion was demonstrated in surgery. Notice the aortic external contour abnormality due its lesion (yellow arrow).

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Fig. 7: Axial view enhanced CT: large intimal flap (white arrow) corresponding to the same patient in figure 1 and 2. Linear intraluminal filling defect crossing the aortic lumen.

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Fig. 8: Axial view enhanced CT: segmental abdominal aortic dissection (yellow arrow). Two linear filling defects can be appreciated. This patient received conservative treatment.

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Fig. 14: Sagittal MPR enhanced CT (same patient in figure 12): Chance fracture with complete ligamentous lesion (intervertebral disc disjunction in its inferior aspect, and posterior arch ligaments lesion, without bone fracture) that enables contrast extravasation passage to the intervertebral space (red arrows). Note the distraction of the vertebral bodies (yellow lines) and the ossified anterior longitudinal ligament because of a ankylosing spondylitis (green arrows), which probably was a predisposing factor in the spine and aortic lesions. Thin superior mesenteric artery due to hypovolemia (blue arrow).

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Fig. 4: Sagital view enhanced CT: small bowel herniation (white arrow) through the anterior abdominal wall (yellow arrow).

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Fig. 3: Axial view enhanced CT. Small bowel herniation (white arrow) though abdominal anterior wall (yellow arrow).

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**Fig. 17:** Axial view enhanced CT: cava vein enhancement during arterial phase due to aorto-cava fistula.

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Fig. 2: Axial view enhanced CT: Vertebral burst fracture detail (white arrow) corresponding to the same patient in figure 1.

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Fig. 5: Axial view enhanced CT: small intimal flap (yellow arrow)

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**Fig. 6:** Axial view enhanced CT: small intimal flap (yellow arrow)

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**Fig. 16:** Coronal MIP reconstruction: aorto-cava fistula. Aorta (white arrow) and cava vein (yellow arrow) have almost the same enhancement intensity

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**Fig. 9:** Volume rendering reconstruction after six years follow-up of a patient with large intimal flap injury (same patient in figure 8). Small dilatation of distal abdominal aorta with patent lumen. Patient remains asymptomatic.

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Fig. 11: Axial view enhanced CT: intramural crescentic hematoma in anterior aortic wall

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Fig. 10: Axial view enhanced CT: extended circumferential dissection (yellow arrow)

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Fig. 12: Axial view enhanced CT of the same slice level in arterial and portal venous phase. We can see a retroperitoneal hematoma and a contrast extravasation inside, which increases clearly in size between both phases indicating active bleeding (green
arrow). This active bleeding extends into both intervertebral and epidural space (red arrows). Aorta surrounded by extravasated contrast (blue arrow).

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**Fig. 1:** Sagital view enhanced CT: burst vertebral fracture (yellow arrow) associated with aortic long spiroid intimal flap (white arrow)

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Conclusion

Traumatic injuries to the abdominal aorta are very infrequent but they are significant source of morbidity and mortality in trauma patients. Rapid and accurate diagnosis is crucial for a successful outcome in a patient with arterial injury, that is potentially life threatening. CT allows the precise characterization of aortic blunt trauma which is decisive for determining optimal treatment for the patient.
References


