Vascular emergencies in clinical cases

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Learning objectives

• provide an educational tool to make the radio-clinical approach to vascular emergencies easier.
• illustrate the primordial role of imaging in the diagnosis and management of vascular emergencies.
• Discuss the most common post-traumatic vascular injuries (post-traumatic arterial dissection, arterial transection, pseudoaneurysm formation, organ devascularization, among others).
• Describe imaging findings of the most common vascular injuries, using computed tomography (CT) and computed tomography angiography (CTA).
Background

Vascular emergencies can lead to the death or functional disorder of the patient. They require rapid and multidisciplinary care. The use of the various method of imaging and the knowledge of their contribution allow a positive diagnosis and aid to the therapeutic planning.

Vascular injuries are a major source of morbidity and mortality in trauma patients. It is estimated that 25% of trauma-related deaths are secondary to cardiac-related injuries, which include damage to the heart and great vessels [1]. Ninety-percent of the patients who suffer acute traumatic aortic injuries will perish on the field and 70-90% of patients with acute traumatic aortic injury will survive surgical repair if they reach the hospital in time, therefore prompt diagnosis is imperative [2].

In cases where bleeding is a major definitive factor for mortality computed tomography (CT) and computed tomography angiography (CTA) are useful, non-invasive techniques that allow quick and accurate evaluation of the area in question [3].
Findings and procedure details

1- Imaging Protocol:

The vast majority of trauma-related vascular injuries are evaluated and diagnosed using multi-detector CT (MDCT) scanners.

The recommended protocol is non-enhanced CT, followed by contrast-enhanced CT angiography, particularly when intramural hematoma or aortic dissection is suspected. Electrocardiogram (ECG)-gated acquisition protocols are crucial in reducing motion artifacts of the aortic root and thoracic aorta [4].

2- Post-Traumatic Vascular Injuries:

Aortic emergencies present a diagnostic and treatment challenge for emergency physicians. Aortic emergencies comprise different clinical entities with only one thing in common: if not diagnosed and managed in due time they are life threatening [6, 5, 7].

According to Azizzadeh et al. [8, 5], and adapted by the Society for Vascular Surgery (SVS), traumatic aortic injury can be classified into four categories [8, 9, 5]: grade I (intimal tear) (Fig. 1 on page 10), grade II (intramural haematoma), grade III (pseudoaneurysm) and grade IV (rupture) (Fig. 2 on page 10).

3- Acute aortic syndrome:

Initially coined by Vilacosta and Roman [10] the term "acute aortic syndrome" comprises three different but related entities:

- Aortic dissection (AD)
- Intramural haematoma (IMH)
- Penetrating atherosclerotic ulcer (PAU)

#Aortic dissection (AD):

An entrance tear from the lumen to the media allows blood flow into the vascular wall and therefore creates a false lumen usually with additional communication tears between the old "true" and the new "false" lumen. The false lumen has no regular vessel wall, thus leading to aortic diameter enlargement, (pseudo)
aneurysm formation and potential rupture during short- and long-term follow-up. Classification of aortic dissection is based on the location and extension of the dissection (Stanford and DeBakey classifications [11, 12]) predominantly based on involvement of the ascending versus descending versus the total aorta. The Stanford classification system grades dissections as type A dissection (in all dissections involving the ascending aorta regardless of the site of origin, surgical treatment is recommended [11, 12]; or type B dissections (exclusive involvement of the descending aorta; (Fig. 3 on page 11).

The true lumen more often has a cylindrical or filiform shape. It is in clear continuity with the non-dissected proximal portion of the aorta (this is more difficult to demonstrate for type A dissections). In acute dissections it is the lumen that contains outer wall calcification. Usually the true lumen starts opacifying earlier in the arterial phase [13]. The false lumen has a characteristic "beak" appearance; this is an acute angle between the dissection flap and the outer wall of the false lumen. The false lumen starts opacifying later than the true lumen [13, 14].

On rare occasions, isolated dissection of the main aortic branches may be encountered. At our institution, an uncommon case of isolated spontaneous superior mesenteric artery dissection was detected in a healthy, 52 year old man presenting with acute onset of epigastric pain during exercise. Spontaneous arterial dissection is five times more common in men than in women, with an average age of 55 years [9] (Fig. 4 on page 11).

#Intramural haematoma:

The concept of IMH has changed over time [10, 15]. Initially it was defined as acute haemorrhage in the aortic wall, without apparent wall tear. This concept was updated after imaging [CTA, MRT or intravascular ultrasound (IVUS)] was able to depict wall tears causing the aortic wall haematoma [16]. The intramural haematoma formation is spontaneous and may be a consequence of trauma or a penetrating aortic ulcer. It has been reported that IMH may progress to frank aortic dissection over time. (Fig. 5 on page 12).

Non-contrast images are very helpful in depicting the more hyperdense intramural haematoma (compared to the hypodense lumen area) but not essential. Indications for endovascular treatment of IMH are basically the same as for dissection [17], namely symptomatic presentation, diameter increase, pseudoaneurysm formation or progression into AD during follow-up.

#Penetrating aortic ulcer:
Atherosclerotic ulcers progress and erode the internal elastic membrane, paving the path to progression to wall haematoma [18], leading to the classic mushroom appearance (Fig. 6 on page 12).

4- **Ruptured aortic aneurysm:**

Diagnosis of aneurysms depends on measurement of the vascular diameter. There are definitive signs of impending rupture (an aneurysm size increase especially with a rapid enlargement rate, focal wall discontinuity, hyper-attenuating crescent sign, thrombus fissuration, draped aorta sign or periaortic stranding); unfortunately these signs are often not highly specific [20, 21, 22] (Fig. 7 on page 12) but detection of these findings advocates urgent treatment.

The aneurysm of the aorta can be thrombosed without signs of rupture (Fig. 8 on page 13).

5- **Mycotic aneurysms-infected aneurysms:**

Infection is a rare cause of aortic aneurysms. Infected aneurysms have an atypical morphological presentation, as saccular aneurysms, eccentric aneurysms or pseudoaneurysms, but they may also present as grotesque fusiform aneurysms (Fig. 9 on page 14). Rapid enlargement and (PET-positive) aneurysm wall thickening and/or blurred soft-tissue structure with contrast uptake and/or abscess formation or retentions accompanying the aorta are key findings in imaging and diagnosis of infected aneurysms. Mortality after open surgery or EVAR is considerably higher than for the treatment of conventional aortic aneurysms [23, 24].

6- **Iatrogenic aortic injury:**

There are various mechanisms for iatrogenic aortic injury (Fig. 10 on page 15). The larger the catheters or introduction materials (sheaths, etc.) are the higher the number of access (= iliac) vessel complications (rupture, dissection, occlusion), which are by far the most common complications [25].

7- **Pulmonary Pseudoaneurysms:**
May arise from the branches of the pulmonary or bronchial arteries. Pulmonary artery pseudoaneurysms (Fig. 11 on page 16) can occur due to neoplasms, infection, vasculitis, penetrating trauma and iatrogenic. Some iatrogenic causes include: chest tubes, biopsies, surgical resection, and Swan-Ganz catheters, among others. Ruptures of these pseudoaneurysms are associated with up to 50% mortality [14].

8- **Thrombosis:**

Thrombosis consists in blood clot formation within an intact blood vessel, following abnormal hemostasis.

Common complications associated with thrombosis include: thrombus propagation and embolization [28]. (Fig. 12 on page 17)

9- **dissection of the cervical arteries:**

Spontaneous cranio cervical arterial dissection is rare, with an estimated incidence of 5 per 100,000 per year [29]. Ultrasound is a cheap, non-invasive and readily available exam. Nevertheless, intracranial segments cannot be optimally imaged and it is operator-dependent. It can show [30,31]:

- Thickened hypoechoic vessel wall corresponding to hematoma and/or thrombus, (which may be hyperchoic if acute).
- Intimal flap (Fig. 13 on page 18).
- Arterial lumen tapering stenosis or occlusion (Fig. 14 on page 18).
- Enlarged vessel diameter.

#Hemodynamic changes [30,31]:

- Diminished proximal flow velocity, especially diastolic flow, with high resistance waveform.
- Diminished or absent distal flow.
- Focal increased flow velocity in stenotic segment (Fig. 15 on page 19).
- True and false lumina with different flow.

Computed tomography angiography provides high spatial resolution with the ability to make multiplanar and 3D reconstructions, although it depends on correct imaging acquisition. The delay between injection time and image acquisition should be optimal to minimize venous enhancement. It can show [32]:

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• Spontaneous hyperdense crescent shape area corresponding to wall hematoma.
• Eccentric narrow lumen associated with crescent-shaped mural thickening. The "target" sign, which adds peripheral enhancement to the previous features, is highly specific.
• Intimal flap separating two lumina.
• Progressive lumen narrowing and occlusion with Enlarged vessel diameter (Fig. 16 on page 20).
• Dissecting pseudoaneurism.

Magnetic resonance imaging can provide cross-sectional images to study the vessel wall and assess the presence of intramural hematoma.

The MR protocol we use for cervical artery dissection, besides brain MRI, includes T1-weighted fat-supression images of the neck and either three dimensional phase contrast MRA of the neck or three dimensional time-of-light MRA of the neck.

MRI can show [33]:

• Narrow eccentric flow void, although it may not be present in cases with occlusion or slow flow. Furthermore flow void narrowing can be encountered in other conditions.
• Increase of artery’s external diameter
• Intramural hematoma (Fig. 17 on page 21).
• Intimal flap can be viewed as a curvilinear hypointense image separating the two lumina.

10- Rupture of aneurism of the splenic artery:

Hemorrhages during pregnancy may have a non-obstetrical origin.

Splenic artery aneurysm rupture during pregnancy is a rare but serious condition. The clinical presentation associates abdominal pain, hypotension and anemia that can mimic uterine rupture or abruption placentae. An emergency cesarean section and splenectomy are necessary.

We report the case of a pregnant patient who required an emergency laparotomy because of the imaging discovery of an aneurysm rupture of the splenic artery [34] (Fig. 18 on page 22, Fig. 19 on page 23, Fig. 20 on page 24).

11- jugular carotid fistula after cervical trauma:

Traumatic common carotid artery-to-internal jugular vein fistula is a rare entity that is not usually detected during the acute injury phase
Acquired common carotid-jugular fistulae are uncommon [35]. A high index of suspicion is necessary for the diagnosis. Often the fistula is missed during the acute phase of injury; as a result, most patients are not treated for weeks or months after the initial injury [36, 37].

We report the case of a 27-year-old man victim of an accident at work which consists on the penetration of a metallic foreign body at the neck during a burst of a machine. It was noted a Palpatory and auscultatory thrill. (Fig. 21 on page 25)

12- Rupture of hepatocellular carcinoma in the peritoneum:

Hepatocellular carcinoma (HCC) is the fifth most common tumor in the world and usually occurs in cirrhosis of alcoholic or viral (hepatitis B or C) etiology [38, 39]. The rupture of HCC is a complication that can occur in 3%-15% of patients, although this has decreased now that screening programs for cirrhotics have been implemented [38,39].

The mortality in the acute phase is very high and stands at around 25%-75% of cases [40, 41].

We report the case of a 30-year-old man who consults for acute epigastric and hypochondrium right pain. Abdominal CT angiography was performed (Fig. 22 on page 25)

13- Myocardial rupture:

We report the case of 51-year-old man stabbed with multiple thoracic wounds. Abdominal CT angiography was performed

(Fig. 23 on page 26).
**Fig. 1:** Intimal Tear/Flap in a 28-year-old male patient after a vehicule accident. Axial contrast enhanced CT images (A) show a hypodense line within the lumen of the distal aortic arch which extends into the proximal descending aorta, consistent with an intimal flap (red arrow). Associated left hemothorax (blue arrow). Sagittal MPR (B) and 3D reconstruction(C) show a focal outpouching of the proximal descending aorta just distal to the takeoff of the left subclavian artery, representing a post-traumatic pseudoaneurysm (redcircle).

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**Fig. 2:** Axial contrast enhanced CT images (A) and Sagittal MPR (B) show traumatic aortic transection (grade 4) in a 58-year-old male patient after a vehicule accident, There is also a massive para-aortic haematoma (blue arrow). The patient died immediately after the CT examination.
**Fig. 3:** Axial contrast enhanced CT images (A) and Sagittal MPR (B) show type B dissection. A 62-year-old patient presented with chest pain in the emergency department. The tear starts at the level of the descending aorta with spiral migration of the intimal flap (red arrow).

**Fig. 4:** Superior mesenteric artery dissection in 59-year-old patient who consults in the emergency room for acute abdominal pain. Sagittal (A) and axial (B) contrast enhanced CT images show an intimal flap (red arrow).
Fig. 5: CT demonstrates the hyperdense intramural haematoma (A) (red arrow) and contrast-enhanced CT the smooth circumferential configuration of the intramural haematoma (B) (yellow arrow) in 65-year-old patient who consults in the emergency room for acute thoracic pain.

Fig. 6: Ruptured penetrating aortic ulcer in a 68-year-old male patient. CTA demonstrated a large aortic ulcer projecting beyond the aortic contour. Coronal reformation (B) demonstrated the mushroom-like appearance of the ulcer (red arrow).
**Fig. 7:** Ruptured thoracic aortic Aneurysm: The 68-year-old male patient presented with thoracic pain and hypotension. CTA demonstrated focal "discontinuation" of the aortic contour (red arrow) with hemothorax (blue arrow).

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**Fig. 8:** coronal CTA (A) and 3D reconstruction (B) demonstrated partially thrombosed aneurysm of the abdominal aorta reducing light by approximately 50 % and extending to the primary iliac arteries without any sign of rupture.

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**Fig. 9:** Axial CTA: Mycotic aneurysm of the arch of the aorta with saccular and eccentric appearance (red arrow).

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Fig. 10: Iatrogenic aortic injury. A 45-year-old male patient underwent laparoscopic removal of appendicitis. 7 h later he presented hypotension and severe abdominal pain. CTA [(A) axial section; (B) sagittal reformation] demonstrated an anterior and posterior laceration of the aorta (red arrow) with intra peritoneal (blue arrow) and retro peritoneal (green arrow) fluid effusion of great abundance, confirmed to be a trocar injury during vascular surgical reconstruction.

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**Fig. 11:** Coronal (A), 3D reconstruction (B) and axial (C) contrast enhanced CT images in 43-year-old patient who consults in the emergency room for hemoptysis of great abundance. He had pulmonary tuberculosis treated in 1994: RASMUSSEN pseudoaneurysm rupture (red arrow) of the apico-dorsal branches of the left upper lobe with active pulmonary tuberculosis.

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**Fig. 12:** Thrombosis. Axial (A), coronal (B) and 3D reconstruction (C) contrast enhanced CT image in 52-year-old patient with cardiac arrhythmia shows lack of enhancement of the right renal parenchyma (blue arrow) secondary to complete occlusion of the right renal artery (red arrow), consistent with post-traumatic thrombosis/devascularization of the right kidney.
Fig. 13: Cervical ultrasound in a 55-year-old man who consults in the emergency room for acute neck pain: intraluminal hyperechoic linear image at the origin of the left internal carotid artery: intimal flap (yellow arrow).

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Fig. 14: Cervical Ultrasound: Pre-occlusive stenosis of the left internal carotid at its origin with reduction of arterial light of more than 90% (red arrow).

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**Fig. 15:** Left internal carotid artery stenosis with focal increased flow velocity.

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Fig. 16: cervical CT angiography in a 45-year-old man who consults in the emergency room for cervical pain: occlusion of the right vertebral artery with Enlarged vessel diameter (white arrow).

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Fig. 17: 42 year old female with occipital headache. T1 with fat suppression axial image shows right vertebral artery with a narrow flow void surrounded by a hyperintense crescent shaped intramural hematoma (red arrow).

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Fig. 18: Intra-peritoneal fluid effusion of great abundance with evidence of a dense effusion opposite the splenic hilum 'peri-splenic inter-anse and at the level of the left parietal gutter.

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Fig. 19: Saccular aneurysms of the proximal splenic artery. It has irregular shape with extravasation of the contrast (red arrow) and splenic infarction (blue arrow).

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Fig. 20: Fetal death in utero objectified by the absence of enhancement of the fetus (red arrow).
Fig. 21: Right jugular carotid fistula after cervical trauma: Poorly limited cervical range with the same enhancement as the arteries, containing a foreign body, with no individualization of the right internal carotid artery and the jugular vein (red arrow).

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Fig. 22: Rupture of hepatocellular carcinoma in the peritoneum: Dysmorphic liver with irregular shape, multiple suspicious-looking tissue lesions enhancing at the periphery after injection of the product communicating with spontaneously hyperdense intraperitoneal effusion of great abundance

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Fig. 23: Hemomediastinum (red arrow), left hemothorax and pneumothorax (green arrow), Pneumatocele of the left upper lobe with frosted glass pad in relation to intra- alveolar haemorrhage (yellow arrow), parietal defect at the level of the left ventricle tip with active leakage of contrast material at the pericardium (yellow arrow) responsible for a hemopericardium (white arrow).

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Conclusion

Vascular emergencies can be life-threatening to the patient. They require a fast and multidisciplinary management. The exploitation of the imaging tools and the knowledge of their contribution allow a positive diagnosis and help in the therapeutic planning.

It is important to understand the key aspects of imaging, direct and indirect signs of post-traumatic vascular injuries to make the right diagnosis at the right time.
References


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