Usefulness of the angio TC in the most frequent pathology of aorta in emergency

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Authors: M. Garrido Blázquez¹, J. Pereda¹, O. Montesinos Sánchez-Girón¹, D. Oquillas Izquierdo¹, A. Ochoa Escanciano², F. J. Rodríguez Recio¹; ¹Segovia/ES, ²Soria/ES
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Learning objectives

- To expose the diagnostic possibilities of the aortic urgent pathology in a second-level hospital.

- Enumerate the causes and radiological findings of the most frequent aortic urgent pathology.
Background

The acute aortic disease is a clinical critical situation whose prognosis depends on a rapid and accurate diagnosis, as well as the early set up of its treatment.

The aorta due to a constant exhibition to the pulsatile pressure and forces of shear is predisposed to suffer injuries of its wall, appearance of aneurismatic dilatations and a major risk of rupture.

The multidetector computed tomography (CT) angiography is a technology that contributes a diagnostic exact and rapid information (sensibility and specificity near to 100 %) sufficient to decide the urgent transfer of the patient to a reference center with interventionist radiology and / or cardiovascular surgery. It is important to have tools of teleradiology to be able to exchange the information of the reference center to joint valuation pre and postsurgical.

We check the most frequent aortic pathology by means of cases attended in emergency of our hospital: the rupture of the aortic aneurysm, the aortic dissection, the posttraumatic injuries and the complications in already treated patients.
Imaging findings OR Procedure details

In respect of the image protocol of the studies in some cases the aortic pathology is an incidental finding on enhanced contrast CT of thorax and / or abdomen. In the cases in which the clinical suspicion is aortic pathology a complete study of aorta was programmed, including ascending aorta up to its bifurcation, unenhanced and enhanced contrast CT with "bolus tracking" method (CT angiography).

RUPTURE OF AN AORTIC ANEURYSM

The maximum diameter of the aorta in adults corresponds to 3 cm in its origin and it is diminishing to 2.5 cm in descending thoracic aorta up to 1.8-2 cm in the abdominal aorta.

Aneurysm of the aorta is defined as a permanent localized dilatation of the aorta, in thoracic aorta when it overcomes 5 cm in ascending aorta and 4 cm in descending aorta. The abdominal aortic aneurysm (AAA) is defined when the diameter is larger than 3 to 3.5 cm; the risk of AAAs increases dramatically after 60 years of age. Aneurysms with more than 4 cm in diameter are present in approximately 1% of men between 55 and 64 years of age, and the prevalence increases by 2% to 4% per decade thereafter. AAAs are more common in men than in women (6:1 men-to-women ratio).

Age older than 65 years, male sex, tobacco use, hypertension, a family history of AAA, connective tissue disease, peripheral arterial disease and chronic obstructive pulmonary disease are clinical risk factors for the aneurysm development.

The typical clinical manifestation of ruptured aortic aneurysm usually includes excruciating pain of the chest, back, abdomen, flank, groin, scrotum, thigh and leg. May consider for differential diagnosis: renal colic, diverticulitis, pancreatitis, acute myocardial infarction and mesenteric ischemia.

The CT angiography is the most precise technology to measure the diameter of the aneurysm and contributes additional information as the bleeding site, ischemic complications and arterial pathology associated, can obtained a description of the renal, mesenteric and iliac arteries and is an important part in the preoperative assessment. The radiological findings are:

Unenhanced CT:
• **High-attenuating crescent**: represents an acute hematoma within either the mural thrombus or the aneurysmal wall. (Fig. 1 on page 10, Fig. 2 on page 10)

• **Hyperdense collections**: around the aneurysm, hematomas due to aneurysm rupture and extension bleeding. (Fig. 1 on page 10, Fig. 2 on page 10, Fig. 3 on page 11, Fig. 4 on page 11)

• **Focal discontinuity of intimal calcification and tangential calcium sign**: the intimal calcification points away from the aneurysm.

**Enhanced CT:**

• **Extravasation of intravenous contrast**: is the evidence of active bleeding. 
  
  Fig. 1 on page 10, Fig. 2 on page 10, Fig. 3 on page 11, Fig. 4 on page 11

The aortic aneurysm rupture has a high mortality, from 77 to 94 %, the risk of rupture is directly proportional to the diameter of the aneurysm. The rupture can produce to the retroperitoneal space (71 %), intraperitoneal (25 %), gastrointestinal tract (2,5 %) and inferior vena cava Fig. 5 on page 11 (3,5%).

The options for repair include surgical repair (including the transabdominal route or the retroperitoneal route) or endovascular repair, which involves insertion of an endograft into the lumen that excludes the aneurysm from blood flow.

**AORTIC DISSECTION**

The vessel wall is made up of three layers: a) **Intima**, is made up of endothelial cells, basal lamina and subendothelial connective tissue; b) **Tunica media**, it is composed of a mixture of smooth muscle cells and elastic fibers; c) **Adventitia**, entirely made of connective tissue, it also contains nerves that supply the vessel as well as nutrient capillaries (vasa vasorum).

The initiating event in an aortic dissection is a tear in the intimal lining of the aorta, due to the high pressures in the aorta, blood enters the media at the point of the tear. The force of the blood entering the media causes the tear to extend, it may extend proximally, distally or both. The blood will travel through the media, creating a false lumen, the distension of the false lumen can cause stenosis and distort of the true aortic lumen.
The vast majority of aortic dissections originate with an intimal tear in the ascending aorta, 1-5 cm above from the right sinus of Valsalva (65%), just distal to the ligamentum arteriosum in the descending thoracic aorta (20%), the aortic arch (10%) or thoracoabdominal distal aorta (5%).

Aortic dissection is classified according to the extent of involvement of the aorta. The Stanford classification divided the aortic dissections into two groups; A and B depending on whether the ascending aorta is involved.

**Type A**: Involves the ascending aorta and/or aortic arch, and possibly the descending aorta. The tear can originate in the ascending aorta, the aortic arch, or, more rarely, in the descending aorta.

**Type B**: Involves the descending aorta or the arch (distal to right brachiocephalic artery origin), without involvement of the ascending aorta.

Hypertension, congenital aortic valve abnormalities, connective tissue disorders and trauma are predisposing factors.

The most common symptom is severe pain that has a sudden onset, it may be described as tearing, stabbing or sharp in character and can feel the pain migrate as the dissection extends to the aorta. The location of pain is associated with the location of the dissection, anterior chest pain is associated with dissections involving the ascending aorta, while interscapular and abdominal pain is associated with descending aortic dissections.

In the centers of the second level the Angio CT is the technique of choice due to its diagnostic accuracy, the wide availability and the facility and rapidity of the exploration.

The imaging findings in the aortic dissection can be:

- **On unenhanced CT scans in aortic dissection can see internal displacement of intimal calcifications.**

- **Contrast-enhanced CT scans of aortic dissection shows an intimal flap that separates the true lumen from the false lumen.** Fig. 6 on page 12, Fig. 7 on page 13, Fig. 8 on page 13, Fig. 9 on page 14, Fig. 10 on page 14, Fig. 11 on page 15, Fig. 12 on page 15

- The true lumen is brightly enhancing and is smaller.
• The identification of the false lumen include the presence of slender linear areas of low attenuation within the false lumen corresponding to residual ribbons of the media incompletely sheared away during the dissection process.
• Thrombosed false lumen.
• Extension of the dissection into aortic branch vessels. Fig. 7 on page 13, Fig. 8 on page 13, Fig. 9 on page
• Ischemic complications can arise when the dissection compromises blood flow, by either extrinsic compression of the true lumen by the false lumen or an intimal flap occluding the orifice of a branch artery. Fig. 9 on page 14

Distinguishing the true and false lumens on CT angiography is of paramount importance when endovascular therapy is considered, because the endograft must be deployed in the true lumen.

TRAUMATIC AORTIC INJURY

In a 90% of the cases, the rupture is in the aortic isthmus, distal to the origin of the left subclavian artery, in the 10% remaining it is in other locations as the aortic root or ascending aorta. Aortic injuries carry a high mortality rate and are immediately fatal in an estimated 80%-90% of all cases.

If detected in a timely manner, it is estimated that 60%-80% of patients with traumatic aortic injury who reach the hospital alive will survive following definitive therapy. Therefore, prompt recognition and treatment of these injuries are critical for long-term survival. Treatment in the first 24 hours is needed, can be make by opened conventional surgery or endovascular thoracic procedure; this one has evolved in the last years therefore, nowadays it is considered the treatment of choice.

They are classified into:
• Type I: intimal flap.
• Type II: intramural hematoma.
• Type III: pseudoaneurysm.
• Type IV: rupture with active bleeding.

The CT scan findings:
• Mediastinal hematoma. Fig. 13 on page 16 - Fig. 14 on page 17
• Intimal tear. Fig. 13 on page 16 - Fig. 14 on page 17
• Pseudoaneurysm. Fig. 15 on page 17
• Changes in the aortic shape.
• Intramural hematoma.
• Extravasation of the contrast.

COMPLICATIONS WITH ENDOVASCULAR TREATMENT

The complications of the endovascular procedures in the treatment of the aortic pathology can be endoleaks, stent-graft dislodgment, migration, stent fracture, collapse of the stent, changes in the size and shape of the aorta, arterial wall injury, infections of the device and fistula formation of the neighboring organs.

The endoleaks are the main complication, they consist of the persistent blood flow in the aneurysm sac outside the stent graft, usually result a continued growth of the aneurysm that, in case of not being treated, may cause a rupture. Endoleak is recognized by the accumulation of contrast medium in the aneurysm sac outside the stent graft.

There are five types of endoleak:

• Type I: is related to the stent graft device itself and is caused by an insufficient seal between the proximal portion of the endograft and the vessel wall. Fig. 16 on page 18
• Type II: is retrograde flow from collateral branches (lumbar, inferior mesenteric, and accessory renal arteries). Fig. 17 on page 19
• Type III: is cause by fabric tears, graft wall defect, or modular disconnection or disintegration. Fig. 18 on page 20, Fig. 19 on page 21, Fig. 20 on page 21, Fig. 21 on page 22
• Type IV: is flow through the graft assumed to be associated with graft wall porosity.
• Type V: Endotension with growth of an aneurysm without showing evidence of leakage.

The incidence of periprosthetic leakage after endovascular repair with a stent-graft implant is estimated between 7 and 52 % of the cases; however, between 40 and 88 % of them resolve spontaneously, especially the type II endoleaks, so this type a periodic
control is made by CT scan and if they are persistent or produce the growth of the aneurysm, it is necessary to try the embolitation of the artery causing the endoleak.
Fig. 1: CT scan obtained in a 76-year-old man who came to emergency for abdominal pain and loss of consciousness. Unenhanced axial CT image shows a infrarenal AAA 9 cm of diameter, retroperitoneal hematoma (green arrow) and high-attenuating crescent (blue arrow). Coronal reformatted of contrast enhanced CT image shows active extravasation of contrast material (yellow arrow) and contrast leakage outside the aorta to the right posterior retroperitoneal region (retroperitoneal hemorrhage, green arrow).

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Fig. 2: Unenhanced axial CT images in an 87-year-old man with abdominal pain located in right hypochondrium, feels mass in right hemiabdomen. The images show a right
retroperitoneal collection that corresponds to hemorrhage (green arrow) and a 12 cm AAA with high-attenuating crescent sign (blue arrow).

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Fig. 3: Enhanced axial CT of previous patient demonstrating and extravasation of the intravenous contrast (yellow arrow) and a large right retroperitoneal hematoma (green arrow) produces mass effect on adjoining structures, horseshoe kidney (pink arrow).

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Fig. 4: Aortic aneurysm rupture in an 80-year-old man with abdominal pain and hypotension. Unenhanced and enhanced axial CT. The unenhanced image shows a retroperitoneal hematoma (green arrow), after intravenous contrast demonstrates a extravasation corresponds to active bleeding (yellow arrow).

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**Fig. 5:** Enhanced axial CT and coronal MIP images in a 65-year-old man with back pain of days duration that does not improve, presents greater pain radiating to the lower abdomen and right lower limb so come to the emergency; physical examination: hypotension, sweating and pulsatile abdominal mass with a "blowing" murmur. An infrarenal AAA is observed (9 cm), produces mass effect on the inferior vena cava (IVC) and show simultaneous enhancement of the aorta and the IVC, noting the fistulous tract between the two vessels (yellow arrow).

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Fig. 6: Aortic dissection in a 76-year-old man with oppressive chest pain, syncope, hypotension and systolic murmur. Contrast enhanced CT images depict a intimal flap (brown arrow) in the ascending aorta and the aortic arch corresponding to Stanford type A aortic dissection.

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Fig. 7: Sagittal and coronal reformatted images CT of the previous patient with a Stanford type A aortic dissection, the images show the intimal flap (orange arrows) in the ascending aorta extending to brachiocephalic artery (blue arrow).

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Fig. 8: Contrast enhanced CT images show a Stanford type A aortic dissection in a 64-year-old patient with an acute onset of chest and abdominal pain, hypotension and
impaired kidney function. The images demonstrate an intimal flap (brown arrow) in the aortic arch and the extension of the dissection flap into the innominate, left common carotid and left subclavian arteries.

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**Fig. 9:** Images of previous patient, enhanced CT and sagittal MIP. The contrast enhanced axial CT image shows the intimal flap separates the two lumina, true lumen (brown arrow) is brightly enhancing and the false lumen (blue arrow) is partially enhancing to a lesser degree because of slower flow. The false lumen flap extends into the left renal artery, and there is no contrast enhancement of the left kidney (pink arrow); the right kidney is supplied by the true lumen and demonstrates normal enhancement. Sagittal maximum intensity projection (MIP) image shows the dissection involves the ascending aorta, aortic arch, aortic arch branches and descending aorta.

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**Fig. 10:** CT scan in a 66-year-old man with chest discomfort for weeks that are exacerbated in the past few days. Enhanced axial CT and sagittal reformatted CT images show a ascending thoracic aorta dilated with the intimal flap separates the two lumina, correspond to a type A aortic dissection.

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**Fig. 11:** Axial CT and coronal reformatted images of previous patient show the ascending thoracic aorta aneurysm (7.7 cm) with mural thrombus, aortic ulcer (green arrow) and a type A aortic dissection (yellow arrow).

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Fig. 12: Enhanced axial CT and superposition of coronal reformatted images obtained in a 72-year-old woman with hypertension and abdominal pain. The images demonstrate the true and false lumens separated by the intimal flap (brown arrow), the dissection extends from suprarenal abdominal aorta to the aortoiliac bifurcation. Diagnosed of a type B aortic dissection a conservative treatment was indicated.

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Fig. 13: CT scan in a patient following high-velocity motor vehicle collision. Contrast enhanced axial CT and sagittal reformatted images demonstrate a traumatic aortic transection (brown arrow), distal to the left subclavian artery as well as mediastinal hematoma (pink arrow) with active hemorrhage, indicating a noncontained aortic transection (yellow arrow).

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Fig. 14: CT scan in a polytraumathized patient after running over with severe hypotension. Contrast enhanced CT images show traumatic disruption of the aorta (brown arrow) with hematoma in the mediastinum adjacent to the wall of descending thoracic aorta (pink arrow).

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**Fig. 15:** Sagittal reformatted MIP and three-dimensional volume-rendered CT images of the previous patient depict a saccular image (yellow arrow) in the anterior surface of the proximal descending thoracic aorta (distal to the origin of the left subclavian artery), corresponds to a pseudoaneurysm, indicating a contained aortic transection.

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Fig. 16: Enhanced axial CT (A and B) and sagittal reformatted MIP images. Patient with AAA extending from the origin of the superior mesenteric artery to the proximal common iliac arteries treated with stents. Last control (Image A) without complications. The patient came to emergency with an acute onset of back pain radiating to epigastrium and abdomen, the images B and C show extravasation of contrast (yellow arrows) around the stent, correspond to type I endoleak.

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Fig. 17: Contrast enhanced axial CT (A), sagittal reformatted MIP image (B) and three-dimensional volume-rendered CT image (C). CT scan in a 72-year-old man with an acute onset of right lower limb pain who had undergone endovascular repair of the AAA. The images show peripheral contrast enhancement adjacent to stent-graft right iliac artery, a type II endoleak (green arrows).

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Fig. 18: A) Enhanced axial CT B) Coronal reformatted MIP image and C) Sagittal reformatted MIP image. 70 years old man with an infrarenal AAA (8.5 cm) treated with bifurcated endograft in the origin of the renal arteries extending to the common iliac
arteries. The endograft in the right common iliac artery has horizontal position, the images show a saccular area (green arrow) between right iliac an aortic endografts corresponding to type III endoleak.

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Fig. 19: Three-dimensional volume-rendered CT images of previous patient show the type III endoleak (green arrow).

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Fig. 20: Axial contrast enhanced CT and coronal reformatted image CT in an 88-year-old woman with a thoracic aortic aneurysm (TAA) endovascular aortic repair who came to emergency with a chest pain and coughing up blood. The images show the TAA with the endograft to the origin of the brachiocephalic artery extending down to the abdominal aorta; the blue arrow indicates dense contrast enhancement around the stent, corresponding to the type III endoleak.

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**Fig. 21:** Sagittal reformatted images to the previous patient show the TAA and the endograft with a type III endoleak (blue arrow).

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Conclusion

• Multidetector CT angiography has become the technique of choice for the diagnosis when there is a possible aortic pathology, because of the speed of the examination and the widespread availability.

• Angio CT allows the visualization from any angle and in any direction in all levels of the aorta with image post-processing techniques such as multiplanar reformation with better valuation of all the structures and volume rendering.

• Angio CT contributes information sufficient and necessary for the preoperative evaluation and to decide the urgent transfer of the patient to a reference center.

• To have tools of teleradiology could improve the quality of healthcare provided and reduce risks to the patients.
References