Spectrum of CT Angiography Findings of Pseudoaneurysm

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Learning objectives

With the introduction of modern imaging modalities, the diagnosis of pseudoaneurysms has become more common. The early detection and proper assessment using noninvasive techniques is essential to choose an appropriate treatment.

Our objectives are:

- To review the epidemiology and clinical presentation of pseudoaneurysms.
- To highlight the radiologic features of pseudoaneurysms, with special emphasis on angio-CT findings.
- To learn to identify all information provided by the TC, this is essential in the choice of treatment technique.
Background

A pseudoaneurysm (PSA) is a common vascular injury that represents a rupture of the arterial wall contained in a defined sac of turbulent flow, with a persistent connection (neck) to the artery. Arterial disruption is usually secondary to trauma, inflammation/infection or iatrogenic causes.

They are in contrast to true aneurysms, which have all three layers of intima, media and adventitia that form the normal arterial wall, with arteriosclerosis being the primary factor in their development.

Following injury of the arterial wall, under the influence of sustained arterial pressure, the blood dissects into the tissues around the damaged artery and forms a perfused sac. The PSA is contained by the media or adventitia or simply by soft-tissue structures (Fig. 1).

PSA differs from active extravasation of blood. In PSA blood inside the sac recirculates inside the artery, while in the active bleeding it does not [3].

The etiology of the PSA is important for treatment planning and follow-up; they appear as a consequence of an injury of the vessel wall, but there are multiple etiologies [4]:

- Blunt and penetrating trauma: gunshot wounds (especially in subacute cases by the expansive wave).
- Infection (Fig. 2, 3 and 4).
- Inflammatory condition: for example the extravasation of pancreatic enzymes (Fig. 5, 6 and 7).
- Multisystemic disease: Behçet disease.
- Benign and malignant tumor: invasion and erosion of arterial wall by the tumor (renal angiomyolipoma, osteochondroma, choriocarcinoma and lymphoma).
- Iatrogenic causes (Fig 8, 9, 10 and 11):
  - Surgery.
  - Suture failure in transplant patients.
  - Percutaneous biopsy or drainage.
  - Obstetric procedures: curettage and cesarean section.
    - Intravenous drug abusers.
A PSA may appear in any vessel, and its location will depend on the area where the injury is produced.

Pseudoaneurysms are becoming more present in radiological studies due to:

1. The increase in the number of surgical and arteriographic invasive procedures with the use of large vascular introducer sheaths and periprocedural anticoagulation.
2. The improvement of sensitivity of modern imaging techniques.

Clinically a pseudoaneurysm may be silent and detected only incidentally during radiologic investigation of other conditions. It can manifest as a palpable thrill, audible bruit or pulsatile mass. But it also may present with local or systemic signs and symptoms.

Local effects are secondary to mass effect of the sac on adjacent structures:
- Ischemia of the surrounding tissues due to vascular compromise can produce necrosis of the skin and subcutaneous tissue [4].
- Neurologic symptoms may develop secondary to nerve compression or ischemia.
- Compression of adjacent veins may lead to edema and deep venous thrombosis.

B) The systemic features include distal ischemia, embolization or sepsis.

The most feared complication is the rupture, which can have catastrophic consequences. Pseudoaneurysms can communicate into the gut, the biliary system, and the thoracic, peritoneal, pelvic and retroperitoneal spaces, depending on its location.

CT angiography, especially with the advent of multi-detector row helical CT scanners, has several advantages compared to other imaging modalities: it is not operator dependent, has a shorter acquisition time and provides an overview of the entire vasculature. Furthermore, CT can help detect associated injuries or other associated disease entities such as pancreatitis that may not be detected with other modalities.

Three-dimensional CT allows visualization of the lesion in different angles and provides a global perspective of the entire vasculature, including adjacent vascular beds. CT helps in planning endovascular treatment before invasive angiography to ensure a one-step treatment option. It allows a faster and more efficient therapeutic angiography and
avoids increasing of irradiation and contrast dose, since it helps us to choose the proper projection during the process.

The usefulness of CT is still limited by imaging artifacts caused by metallic objects. It is also limited (like the rest of the imaging techniques) to distinguish between PSA and saccular true aneurysms if there is not a known history of injury of the vessel (Fig. 12 and 13).

Currently, the use of CT angiography is the first line imaging investigation in patients with suspected arterial injury. CT angiography had a sensitivity and specificity of 95.1% and 98.7% respectively, in detecting traumatic pseudoaneurysms in the proximal extremities [5].

It is generally agreed that symptomatic PSA should be treated; however, the decision to treat asymptomatic PSA is controversial because there is no proven method to date to determine which pseudoaneurysm will spontaneously thrombose or which will bleed [5].

The location of PSA may affect its handling. The risk of rupture of visceral PSA is very high regardless of their size, so definitive treatment should be performed in those cases.

Some investigators recommend observing the small, asymptomatic non-visceral PSA and treating them only if they enlarge, do not resolve, or become symptomatic [4].

The treatment of pseudoaneurysms include surgery, US-guided compression, US-guided percutaneous thrombin injection, transcatheter arterial embolization with a variety of agents (coils, glue, Gelfoam and sclerosing agents), endovascular covered stent insertion and combination of methods for complex cases.

The therapeutic options should be chosen depending on their location, morphological features, rupture risk and clinical setting of the pseudoaneurysm as well as to patient comorbidities.
Images for this section:

**Fig. 1:** Schematic diagram of an arterial aneurysm and pseudoaneurysm. Note the absence of some arterial layers.

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Fig. 2: Intraparenchymal pseudoaneurysm in 50-year-old man who presented in the emergency department with acute onset of abdominal pain and fever. This patient has a history of recent episode of biliary pancreatitis treated with endoscopic retrograde cholangiopancreatography. Oblique coronal contrast-enhanced CT image demonstrates a large bilobulated pseudoaneurysm arising from right hepatic artery branch.
Fig. 3: Same patient shown in Fig. 2. Selective digital subtraction angiography of the common hepatic artery shows a pseudoaneurysm arising from a branch of the right hepatic artery. The findings described in the clinical context raise the suspicion of mycotic pseudoaneurysm.

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**Fig. 4:** Same patient shown in Fig. 2 and 3. Selective digital subtraction angiography shows the exclusion of the pseudoaneurysm after coil embolization of the donor artery.

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**Fig. 5:** 76-year-old with a history of recent episode of acute pancreatitis. Oblique coronal CT in arterial phase shows a right hepatic artery arising from the superior mesenteric artery (as an anatomical variant). A pseudoaneurysm depending from the inferior aspect of the right hepatic artery is shown.
**Fig. 6:** Same patient shown in Fig. 5. Oblique coronal CT in portal-venous contrast-enhancement phase demonstrates a better enhancement of the pseudoaneurysm, secondary to the slow filling of the sac.

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Fig. 7: Same patient as in Fig. 5 and 6. Oblique coronal MIP reconstruction of a CT performed days after treatment. Due of the special location and characteristics of the pseudoaneurysm, a covered stent was the treatment choice. Patency of the hepatic artery and correct exclusion of the pseudoaneurysm is shown.

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**Fig. 8:** 88-year-old woman with iatrogenic common femoral arterial pseudoaneurysm after coronary artery catheterism. Oblique axial contrast enhanced CT demonstrate a bilobed pseudoaneurysm with a long narrow neck, associated with perilesional hematoma.

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Fig. 9: Same patient shown in Fig. 8. Sagittal oblique reconstruction. CT angiography study provides important information for treatment planning, such as size and location of the pseudoaneurysm, and length and width of the neck.

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**Fig. 10:** Same patient shown in Fig. 8 and 9. Color Doppler US. Given that it has a large sac, a narrow neck and easy percutaneous access, the treatment with thrombin injection was the most appropriate therapeutic option.

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**Fig. 11**: Same patient shown in Fig. 10. Color Doppler US of pseudoaneurysm during US-guided percutaneous thrombin injection. The thrombin is injected continuously until the sac flow ceases. Notice the absence of flow inside the sac.

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Fig. 12: 80-year-old man who presented to the emergency department with dyspnea and chest pain. Contrast-enhanced chest CT was done to rule out pulmonary embolism. Oblique sagittal reconstructions show a sacular aneurysm/pseudoaneurysm of the inferior wall of the aortic arch.

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Fig. 13: Same patiente shown in Fig. 12. Oblique axial contrast-enhanced shows a partial thrombosis of the lesion. Aortic atherosclerotic aneurysms are usually fusiform. In this case, the shape of the sac is saccular and there are calcified adenopathies from previous TB in contact with the vessel dilatation. These findings suggest that this must be a post-inflammatory pseudoaneurysm.

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Imaging findings OR Procedure details

A retrospective review of all PSA detected in our radiology department from January 2011 to April 2012 was performed. All patients were evaluated by computed tomography. In some cases arteriography was available.

A multi-detector helical (16-slice) CT scanner was used to perform exams.

Our protocol included an axial non-contrast-enhanced CT scan and image acquisition after intravenous contrast, completed with MPR and 3D reconstructions.

Unenhanced CT scans usually demonstrated a low-attenuation rounded structure arising from the side of the donor artery. The wall of the pseudoaneurysm is usually smooth and well delineated except in a mycotic pseudoaneurysm, whose wall is thickened, irregular or ill-defined. There may be a surrounding area of heterogeneous or even high attenuation if the pseudoaneurysm has ruptured and developed a hematoma.

After intravenous contrast administration and image acquisition in the arterial phase, a pseudoaneurysm is confirmed because contrast material fills the sac to the same attenuation as the parent artery. However, if the entire PSA does not fill with contrast material and low attenuation area remains within the sac a partial thrombosis is suspected (Fig. 12 and 13). The donor artery is adjacent to the PSA, and often the neck (area of communication between the sac and donor artery) can be seen and measured (Fig. 8 and 9).

The rupture of the PSA is noted as extravasation of contrast that is not contained within a round structure and often flows away from the point of injury. On delayed images, there will be washout of the contrast in the pseudoaneurysm, whereas in extravasation it will persist in soft tissues.

Size and location of the pseudoaneurysm provide important information about the risk of complications. Length and width of the neck, expendability of the donor artery and presence of collateral circulation are essential features in order to perform treatment planning (Fig. 8 and 9).

For example for superficial PSA with a narrow neck, thrombin injection is considered the first line management option (Fig. 10 and 11).

If the sac is in a deep territory, endovascular treatment is advised.
If the PSA arises from an expandable artery, it can be embolized (Fig. 4). If the artery is not expandable, the PSA neck must be evaluated. If it is narrow, sac embolization is performed (usually with coils). On the other hand, if the neck is wide, covered stent deployment (Fig. 7) or remodeling with stent or balloon are the options to be considered.

Surgery still plays a role when minimally invasive techniques cannot be performed or in infected PSAs.
Fig. 4: Same patient shown in Fig. 2 and 3. Selective digital subtraction angiography shows the exclusion of the pseudoaneurysm after coil embolization of the donor artery.

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Conclusion

1. CT angiography is a safe, fast and accurate tool for diagnosis of pseudoaneurysms.

2. It provides critical information (size, location, neck, collateral circulation and expandability of the artery) which is essential in the choice of the treatment technique.

3. CT can help detect other associated disease that may not be detected with other imaging modalities such as pancreatitis.
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