Aneurysms and pseudoaneurysms: Imaging review and the role of minimally invasive techniques in their management

Poster No.: C-1530
Congress: ECR 2016
Type: Educational Exhibit
Authors: A. Goienetxea Murgiondo, A. Ugarte, I. Prieto Aragarate, S. Merino Landaluce, F. J. Loyola Echaniz, K. Biurrun Mancisidor, E. Garmendia Lopetegui; Donostia/ES
Keywords: Education and training, Aneurysms, Embolisation, Catheters, Arterial access, Ultrasound-Spectral Doppler, CT-Angiography, Catheter arteriography, Management, Interventional vascular, Arteries / Aorta
DOI: 10.1594/ecr2016/C-1530

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Learning objectives

• To present and illustrate the US, CT and catheter angiography appearances of aneurysms and pseudoaneurysms.

• To describe the role of minimally invasive techniques for their treatment. To review the different available procedures and materials and to outline the indications, advantages and limitations of each of them.

Background

Nowadays, due to the increased utilization of imaging, aneurysms and pseudoaneurysms are being detected more frequently.

An aneurysm is a localized widening of an arteria that contains all three arterial wall layers intact. Most true aneurysms result from degeneration of the arterial media due to atherosclerosis, fibromuscular dysplasia or collagen vascular disorders. A pseudoaneurysms is also a localized widening of an arteria but unlike aneurysms lacks a complete arterial wall due to disruption of one or more layers of its wall. Commonly they occur after trauma, iatrogenic procedures, inflammation or infection. Fig. 1 on page 3

This vascular lesions may be asymptomatic or may manifest with local or systemic signs and symptoms. Local signs include a palpable thrill, pulsatile mass, an audible bruit or a complication due to its mass effect on adjacent structures such as arteries (leading to surrounding tissue ischemia), nerves (leading to neurologic symptoms) or veins (leading to edema and deep venous thrombosis). Systemic signs and symptoms can develop due to complications such as thromboembolism or rupture and consequent shock.

Comparing to aneurysms, pseudoaneurysms carry a higher frequency of complications, early rupture being the most frequent and dangerous, as it can lead to a life-threatening shock. Hemorrhage from this ruptures can be seen almost everywhere: in the gut, the biliary system, the thoracic, peritoneal or pelvic spaces, retroperitoneum, subcutaneous tissue…or can sometimes manifest as a sentinel bleeding (hematemesis, melena, blood coming out from a drain located inside the body etc.)that should alert us and make us suspect this dangerous complications.
The diagnosis of aneurysms and pseudoaneurysms is essential because early treatment can improve the quality of life and will prevent the previously mentioned complications. Non invasive techniques such as ultrasonography and CT-angiography are essential in the pre-treatment evaluation (they provide valuable information about the clinical setting, location, rupture risk, surrounding structures and the morphologic features of the lesion) and in the post-treatment evaluation (to evaluate its efficacy and the possible complications it could carry, such as vessel recanalization or sequelae of nontarget embolization). Angiography is important then for further diagnosis (it is considered the standard of reference) and treatment.

All the pseudoaneurysms and aneurysms measuring 2cm or more or that have grown over the course of surveillance imaging should be always treated. Besides, if recanalization occurs, retreatment is compulsory (the clinical risk will remain unless retreated). In the past, surgery was the choice but nowadays minimally invasive techniques are preferable due to their lesser morbidity and mortality.

Images for this section:
Fig. 1: Different etiologies.

© Hospital Universitario Donostia - Donostia/ES
Findings and procedure details

Pretreatment evaluation:

1. Clinical condition (etiology and rupture risk, hemodynamic stability, anticoagulation therapy, other comorbidities..). For example, surgery will be indicated if it is infected or has a mass effect complication.

2. Imaging features: Affected artery (anatomic location, vascular territory and its expendability and surrounding hematoma/PSA sac evaluation) and morphological characteristics (size and neck diameter).

Ultrasonography: Low-frequency transducers with gray-scale, color Doppler and PW Doppler capabilities are used. If the aneurysm is accessible, ultrasonography will provide us lots of valuable information.

Pseudoaneurysms on gray-scale we will be seen as a hypoechoic cystic structure adjacent to a supplying artery and connected to it by a "neck". Besides, we will be able to determine the size of the sac, whether it is simple (one lobe) or complex (two or more), the presence of septa, the surrounding hematoma and its extension in case it is present (it may be seen as concentric layers of different echogenicity surrounding the pseudoaneurysm). On color Doppler the characteristic "ying-yang sign" will be seen inside the mentioned cystic structure. Still, both these findings are not diagnostic. The only diagnostic finding will be seen on duplex Doppler US: the "to-and-fro" waveform on the "neck" of the pseudo aneurysm (the channel that connects both the sac and the feeding artery) representing the blood income and outcome respectively. Fig. 2 on page 9

Ultrasound has a great sensitivity and specificity for the detection of postcatheterization pseudoaneurysms, in addition to being inexpensive, portable, fast and not requiring contrast material nor ionizing radiation. Unfortunately, it is not accurate enough for the diagnosis of deep or visceral arteries, where other modalities such as CT are required.

Multi-detector Ct: As mentioned, US is limited by multiple factors so CT plays a greater role in confirming the diagnosis and further characterizing the aneurysms or pseudoaneurysms, helping decide the best treatment option in each case.

On CT pseudoaneurysms are seen as smooth walled sacs adjacent to an artery (often we will be able to see a communication between them), with its same attenuation and...
that don't change morphology (unlike active bleeding) on all CT phases. When part of the pseudoaneurysm is thrombosed the entire sac won’t fill in with contrast material and will remain as a low-attenuation area. **Fig. 3** on page 10

CT is a really good imaging modality for the diagnosis of this vascular lesions because it is not invasive, has a short acquisition time, is not as operator dependent as the US, can help detect associated injuries (such as pancreatitis that may not be detected with other modalities such as angiography or ultrasound), allow the visualization of the lesion from all angles and provides a global perspective on the entire vasculature. Although it is a really good imaging modality, CT has some disadvantages too: it is limited by imaging artifacts caused by metallic objects, it's spatial resolution is inferior to that of conventional angiography and it is more difficult to distinguish between pseudoaneurysms and true aneurysms.

**Conventional angiography**: It is the gold standard for their diagnosis and treatment. Angiography allows the detection of small vascular lesions not well depicted in other imaging modalities and helps asses the expendability of the donor artery, the presence of collateral vessels etc. It's spatial resolution and capability to provide real-time hemodynamic assesment makes of it the ideal imaging modality for treatment planing.

The disadvantages of conventional angiography include its impossibility to accurately assess the size of a pseudaneurysm that contains a thrombus or the impossibility to detect other posible vascular lesions located in different vascular territories. Besides, its invasive nature carries a high risk of procedure-related complications that make of it an imaging modality that should only be used in case of doubts with other imaging modalities or as a prelude to endoluminal treatment. **Fig. 4** on page 11

**Treatment:**

As mentioned before, most authors believe that all pseudoaneurysms, aneurysms measuring 2cm or more or that have grown over the course of surveillance imaging and lesions that have recanalized after previous treatment should be always treated.

The overriding principle in treatment is the "exclusion" of the vascular lesion from the circulation.

Endovascular treatment therapy may be performed with a wide variety of techniques and materials and their indication depends on the anatomy of the lesion, the afferent and
1. **Superficial postcatheterization PSA:** US-guided percutaneous thrombin injection/compression (unless too wide neck).

US-guided compression replaced superficial postcatheterization for the treatment of pseudoaneurysms in the past. This technique consists of 10-20 minute cycles of compression of the neck of the pseudoaneurysm repeated for up to one hour. It has various limitations: anticoagulant therapy, obese patients, only superficial pseudoaneurysms can be treated with this method and its high failure and recurrence rates.

US-guided thrombin injection: due to its high success rate and the low complication rate, it has become the treatment of choice for postcatheterization pseudoaneurysms. Thrombin is injected into the pseudoaneurysm’s sac under US guidance, which will convert inactive fibrinogen into fibrin and lead to thrombus formation. The thrombin has to be injected continuously at a constant rate till the flow ceases inside the lesion, usually within seconds. **Fig. 6 on page 29**

2. **Endoluminally accessible:** Nowadays is the first choice treatment. The overriding principle in treatment is the "exclusion" of the vascular lesion from the circulation. For this purpose, attention must be paid to three characteristics of the vascular lesion: the expandability of the donor artery, the size of the neck and the amount of collateral circulation.

An artery will be expendable if the tissue it supplies has adequate collateral blood flow that will irrigate it or when the territory it irrigates is not worth salvaging, i.e., when it is possible to sacrifice that artery without causing big damage. For example, the renal artery is inexpendable because if we exclude it the kidney will infarct. Instead, the intralobar renal arteries are expendable because the territory they irrigate is relatively insignificant and when embolized the renal function won’t be affected.

If the donor artery is expendable, the collateral circulation must be evaluated. If this is low or there is no collateral circulation, the vascular lesion should be treated with proximal embolization (afferent artery embolization). **Fig. 7 on page 12**

Instead, if the donor artery is expendable but the collateral circulation is high, **proximal and distal flow exclusion** must be performed in order to avoid the revascularization of
the lesion. This would be the case of gastroduodenal, hepatic and splenic arteries for example. Apart from these, some pelvic and distal extremity arteries have a collateral supply, in which this "sandwich" technique should be performed to completely exclude it from the circulation by preventing backflow from the collateral circulation. Usually the distal efferent artery is closed first followed by the afferent one. Fig. 8 on page 26 Fig. 9 on page 23 Fig. 10 on page 24 Fig. 11 on page 27 Fig. 12 on page 13 Fig. 13 on page 14

Instead, if the vascular lesion arises from an inexpendable donor artery, it must be excluded from the circulation while preserving the donor artery. For this purpose, we will evaluate the size of the neck: whether it is narrow or wide.

If the neck is narrow, usually the aneurysm or pseudoaneurysm will be directly embolized (catheter-directed delivery of coils) into the sac itself because the risk of coil migration and nontarget embolization or thrombosis is very small. i.e., the so called "sac-packing" technique. It is indicated in saccular aneurysm with a narrow "neck", allowing retaining of the coils in the sac and preserving the parent vessel flow to the end organ. Apart from coils, liquid embolic agents (such as N-butyl 2-cyanoacrylate (glue) or Ethylene Vinyl Alcohol Copolymer (onyx)) can also be used for the same purpose). These copolymers are initially flowing materials that harden as a cast in the lumen of the vascular lesion. Fig. 14 on page 15 Fig. 15 on page 16

If the neck is wide, there is a high risk of embolization material outflow/migration and nontarget embolization, so security measures must be taken: a stent graft will be placed or a balloon/stent remodeling technique will be used.

Balloon/stent remodeling technique: the balloon or stent is deployed across the lesion and coils are then released directly into the lesion, with no possibility to misplace and create undesirable embolization or thrombosis. Fig. 16 on page 17 Fig. 17 on page 18

Covered stents consist of a metallic superstructure covered with biocompatible material, which creates a new lumen that excludes the vascular lesion. Fig. 18 on page 19

Renal arteries are the perfect example to understand the "blood flow exclusion law", which refers to the expendability of the artery. It is prohibited to close a renal artery because the kidney will infarct. Excluding an interlobar artery should be avoided and distal interlobular and arcuate arteries can be embolized with no renal function/significant
All in all, endovascular techniques have a lower complication rate than surgical management. This complications include intraprocedural vascular rupture or delayed revascularization of the lesion.


Due to its high-rate of morbidity and complications (bleeding, wound infection, prolonged recovers time, anesthesia-related risks…) and the development of safer treatment procedures, surgery is nowadays only indicated if the vascular lesion is endoluminally inaccessible. Besides, it will also be recommended if the vascular lesion is infected, creates a mass effect complication (causing ischemia, neuropathy…) or minimal invasive techniques have failed.

The surgical management varies widely and includes resection with a bypass procedure in case of vital arteries, arterial ligation in case of expendable arteries, and partial or complete organ removal in the case of intraorganic lesions.

Images for this section:
**US FEATURES**

**Gray scale US:** an hypo echoic cystic structure adjacent to a supplying artery and connected to it by a “neck” can be seen. The size of the sac and the surrounding **hematoma** (concentric layers of different echogenicity surrounding the PSA) can also be determined.

**Color doppler:** the characteristic “ying-yang sign” will be seen.

**Duplex doppler US:** is the ONLY diagnostic ultrasound modality: the “to-and-fro” waveform on the “neck” of the pseudo aneurysm represents the blood income and outcome respectively.

---

**Fig. 2:** US features

© Hospital Universitario Donostia - Donostia/ES
Fig. 3: CT findings

© Hospital Universitario Donostia - Donostia/ES
Fig. 4: Angiography

© Hospital Universitario Donostia - Donostia/ES
Fig. 7: Proximal embolization

© Hospital Universitario Donostia - Donostia/ES
Fig. 12: Proximal and distal embolization

© Hospital Universitario Donostia - Donostia/ES
**Fig. 13:** Proximal and distal embolization

1: Posterior tibial a. psa due to a traumatic lesion.  
2,3&4: Efferent a. catheterization and coil embolization.  
5: Afferent a. embolization.  
6&7: Results: Psa is excluded and foot maintains circulation from connections with peroneal and anterior tibial arteries.
**Fig. 14:** Embolization of pseudoaneurysm itself

© Hospital Universitario Donostia - Donostia/ES
**Fig. 15:** Embolization of aneurysm itself

1,2,3&4: Hepatic artery aneurysms in a patient suffering from SAM disease who presented with hypovolemic shock in the emergency department.  
5,6,7: Diagnostic arteriography is performed where multiple aneurysms are seen in the hepatic arteries. The biggest aneurysm is then selectively embolized with Onyx.  
8 Result: Aneurysm is now excluded from the circulation preserving the hepatic artery.
Fig. 16: Embolization with balloon remodeling

© Hospital Universitario Donostia - Donostia/ES
Deep femoral artery pseudoaneurysm. A balloon is inflated in the artery to avoid non-target distal embolization. The catheter is then inserted in the psa and thrombin injected (↑). Result: arteriography shows psa excluded from the circulation preserving leg’s distal circulation (↑).

**Fig. 17:** Embolization with balloon remodeling

© Hospital Universitario Donostia - Donostia/ES
**Fig. 18:** Stent-remodeling technique

© Hospital Universitario Donostia - Donostia/ES
**Fig. 20:** Renal distal interlobular and arcuate artery management

Distal interlobular/arcuate artery pseudoaneurysm due to a partial nephrectomy. Afferent embolization is performed with coils in different branches until the psa is totally excluded. These renal distal arteries can be embolized without major repercussion in the renal function.
**Fig. 21:** Renal interlobar artery management

© Hospital Universitario Donostia - Donostia/ES
**Fig. 22:** Renal artery management

© Hospital Universitario Donostia - Donostia/ES
Expendable donor artery & high collateral circulation

Gastroduodenal artery pseudoaneurysm due to acute pancreatitis

**Results:** spa is excluded from the circulation with afferent and efferent artery embolization. A superior mesenteric artery arteriography is performed to make sure it doesn’t take part in the psa.

**Fig. 9:** Proximal and distal embolization

© Hospital Universitario Donostia - Donostia/ES
Fig. 10: Proximal and distal embolization

© Hospital Universitario Donostia - Donostia/ES
Fig. 5: Treatment scheme

**Fig. 8:** Blood flow "exclusion law" when dealing with the celiac axis. SMA: superior mesenteric artery.

© Hospital Universitario Donostia - Donostia/ES
Fig. 11: Blood flow "exclusion law" when dealing with the splenic axis

© Hospital Universitario Donostia - Donostia/ES
**Fig. 19:** Blood flow "exclusion law" when dealing with the renal artery

© Hospital Universitario Donostia - Donostia/ES
**Fig. 6:** US-guided thrombin injection

© Hospital Universitario Donostia - Donostia/ES
Conclusion

Aneurysms and pseudoaneurysms detailed diagnosis and early treatment is essential to prevent life-threatening complications. Minimally invasive techniques are usually the first choice nowadays due to their low morbidity and mortality.

Personal information

References