Endovascular management of pseudoaneurysms.

Poster No.: C-2242
Congress: ECR 2013
Type: Educational Exhibit
Authors: V. Benito Santamaría, J. A. Molina, R. Guerrero, Y. Babun; Barcelona/ES
Keywords: Interventional vascular, Vascular, Management, CT-Angiography, Catheter arteriography, Embolisation, Technical aspects, Instrumentation, Aneurysms
DOI: 10.1594/ecr2013/C-2242

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 describe the role of endovascular techniques for the management of pseudoaneurysms and to illustrate the spectrum of these procedures.
• To outline the advantages, limitations and best indications for endovascular treatment of pseudoaneurysms.
Background

Pseudoaneurysms (PSA) are common vascular abnormalities that represent a disruption in arterial wall continuity resulting from inflammation, trauma or iatrogenic causes (Fig. 1 on page 6). In the last years, their frequency has increased as a result of the growth of endovascular procedures (iatrogenic cause) and the advent of new noninvasive diagnostic imaging techniques with high sensitivity for their detection (Fig. 2 on page 17). A prompt diagnosis of pseudoaneurysms is required because some unpredictable associated complications carry high morbidity and mortality rates and thus, they need to be treated quickly. Therefore, a proper knowledge of available endovascular materials and techniques is essential for the management of pseudoaneurysms.

When to treat a pseudoaneurysm?

It is generally agreed that symptomatic pseudoaneurysms (PSA) should be treated.

The decision to treat asymptomatic PSA is controversial since spontaneous thrombosis of the PSA is known to occur (we cannot predict which PSA will undergo spontaneous thrombosis). The location of the PSA may affect its outcome [2]. Some authors recommend observing small asymptomatic PSA and treating them only if they enlarge, do not resolve or become symptomatic. However, the risk of spontaneous rupture of extraorganic visceral PSA is very high regardless of their size, and it is correlated with a mortality rate that may approach 100% [2]. Therefore, some authors believe that definitive treatment should be performed in all such cases (Fig. 3 on page 18, Fig. 4 on page 19 and Fig. 5 on page 20).

How to treat a pseudoaneurysm?

We must study the pseudoaneurysm characteristics and the available therapeutic techniques if we want to choose the appropriate treatment.

1. Pretreatment assessment of a pseudoaneurysm

A set-valued information must be determined before planning an appropriate therapy, including clinical condition, imaging features and anatomical location of the PSA [3].
A full clinical evaluation of the patient is essential to decide if emergent treatment is necessary. Etiology of the PSA, hemodynamic stability and anticoagulation therapy are important information that must be considered.

In the same way, the study of the characteristics of the PSA is vital. These include: anatomical localization, size of PSA sac (big or small), size of surrounding hematoma, diameter of PSA neck (narrow or wide), vascular territory (superficial or deep/visceral) that the PSA arises from, and the type of end artery (expendable or inexpendable) in which is located the PSA.

We will use noninvasive diagnostic imaging techniques (US and CT angiography) for determining all these essential PSA features (Fig. 6 on page 6). Conventional angiography (invasive technique) is used most of the time as prelude to endoluminal treatment of PSA (Fig. 2 on page 17 and Fig. 7 on page 21).

In brief, a complete work-up to determine the cause and location of the PSA and to evaluate surrounding structures and relevant vascular anatomy is essential in the selection of the treatment technique. Treatment options should be tailored to the location, morphological features, rupture risk, and clinical setting of the PSA and to any patient comorbidities.

2. Therapeutic options for pseudoaneurysm management

Traditionally, PSA have been treated with surgical repair. However, radiology has introduced alternative minimally invasive endovascular and percutaneous techniques that are associated with lower morbidity and mortality rates [1]. Minimally invasive techniques include US-guided compression, direct US-guided thrombin injection and endoluminal management (transcatheter embolization and covered stents). Nonetheless, surgical repair may be necessary in some situations.

In general, the management of PSAs (Fig. 8 on page 8) is:

- **Superficial postcatheterization PSA** should be treated with **US-guided percutaneous thrombin injection** (Fig. 9 on page 12A, Fig. 10 on page 9 and Fig. 11 on page 13) or **US-guided compression** (Fig. 9 on page 12B), except when the PSA neck is too wide (a dome-to-neck ratio ≥ 2 or a neck diameter > 4mm) [5]. In that case, we need to combine remodeling techniques for the treatment.

- **The rest of PSA (superficial non-catheter-related PSA and visceral PSA)** should be treated:
A) if PSA is **endoluminally accessible**, with **endoluminal management**. We’ll evaluate the expendability of the donor artery:

I) **Inexpendable donor artery** *(Fig. 12 on page 11)*. We’ll evaluate the size of the PSA’s neck:

- **Narrow neck**: embolization of PSA itself.
- **Wide neck**: embolization with stent or balloon remodeling vs stent graft placement. If PSA is infected, balloon remodeling or surgery are advised.

II) **Expendable donor artery** *(Fig. 13 on page 10)*. We’ll evaluate collateral circulation:

- **High collateral circulation**: proximal and distal embolization.
- **No collateral circulation**: proximal embolization.

B) if PSA is **endoluminally inaccessible**, but we can have a good access and a good image control during the procedure, **with direct percutaneous techniques** *(coils, thrombin, glue)* *(Fig. 14 on page 14)*.

However, **surgery** still plays a role in certain situations [2]:

- PSA with local mass effect complications such as ischemia and neuropathy.
- Infected PSA.
- Cases in which therapy with minimally invasive techniques is not possible or has failed.
Fig. 1: Schematic diagram of an arterial pseudoaneurysm, which consist of a single layer of fibrous tissue surrounding a sac of turbulent blood flow.

© V. Benito Santamaría, Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 6: A 56-year-old male presented a pulsatile swelling on the right groin after a puncture. (A) Axial contrast-enhanced CT scan shows a big pseudoaneurysm arising from the right common femoral artery with intrasac thrombosis (yellow asterisk). (B) Sagittal contrast-enhanced CT image and (C) coronal MIP reconstruction show the big iatrogenic pseudoaneurysm on the right groin. (D) 3D reconstruction.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
**Fig. 15:** 60-year old female with an endocarditis that presents neurological symptoms. A brain MR reveals two little pseudoaneurysms. (A) Conventional angiography confirms the MR findings. Both pseudoaneurysms are in the territory supplied by the middle cerebral artery: one precentral (red arrow) and the other one posterior parietal (yellow arrow). (B) Angiography demonstrates successful embolization with Onyx of the posterior parietal pseudoaneurysm (yellow arrow) and the donor artery branch (white arrows). (C) Angiography demonstrates embolization of the posterior parietal pseudoaneurysm (yellow arrow). The precentral pseudoaneurysm (red arrow) was treated later.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 8: Schematic illustrates an algorithm for the management of all pseudoaneurysms.

Fig. 10: A 88-year-old female presented a femoral pseudoaneurysm after a puncture. (A) Axial contrast-enhanced CT scan shows a lobulated pseudoaneurysm (red circle) arising from the left common femoral artery. It has a long narrow neck (yellow arrow) and an adjacent hematoma (green star). (B) Coronal contrast-enhanced CT image shows the lobulated morphology of pseudoaneurysm. (C) Sagittal contrast-enhanced CT image shows the long narrow neck (yellow arrow) of pseudoaneurysm.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
**Fig. 13:** Endovascular management of PSA arising from an expendable donor artery.

© V. Benito Santamaría, Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 12: Endovascular management of PSA arising from an inexpendable donor artery.

© V. Benito Santamaría, Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
**Fig. 9:** Management of superficial postcatheterization PSA. (A) US-guided thrombin injection. (B) US-guided compression of PSA neck or PSA itself.

© V. Benito Santamaría, Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 11: Treatment of superficial postcatheterization pseudoaneurysm of the common femoral artery (same patient of figure 10). (A) Color Doppler of left groin shows swirling flow with ying-yang pattern typical of pseudoaneurysm. (B-C) Color Doppler of pseudoaneurysm during percutaneous thrombin injection through a needle (yellow arrows) shows developing clot in the pseudoaneurysm. (D) Color Doppler demonstrates successful embolization of the pseudoaneurysm (white asterisk).

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 14: Management of PSA endoluminally inaccessible. Direct percutaneous techniques (thrombin, coils, glue).

© V. Benito Santamaría, Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 21: A 71-year-old male presented an iatrogenic pseudoaneurysm and arteriovenous fistula. (A) Axial contrast-enhanced CT scan shows a right femoral arteriovenous fistula with high debit and an aneurysmatic dilatation associated (yellow arrow). (B) Coronal contrast-enhanced CT image and (C) 3D reconstruction show the early draining in the right femoral vein (white arrows), consistent with an arteriovenous fistula.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 22: Endovascular treatment of an iatrogenic femoral pseudoaneurysm associated with arteriovenous fistula (same patient of figure 21). (A-B) Conventional angiography confirms the CT findings of a right femoral arteriovenous fistula with high debit (white arrows), close to the superficial femoral artery origin (blue arrows). Note the early draining in the femoral vein. (C) Angiography shows the placement of a covered stent (yellow arrows) in the superficial femoral artery. (D) Angiography demonstrates resolution of the right femoral arteriovenous fistula.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 2: A 79-year-old male presented inguinal pseudoaneurysm after placement of a venous catheter in the ICU. (A) Axial contrast-enhanced CT scan shows a pseudoaneurysm (yellow arrow) in the right pectineus muscle. Note the catheter in the right femoral vein (red arrow). (B) Coronal and (C) sagittal contrast-enhanced CT images reveal the pseudoaneurysm (yellow arrows) in the interior of the right pectineus muscle, situated at the anterior part of the upper and medial aspect of the thigh.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 3: A 76-year-old male who had undergone a Whipple procedure. (A) Axial and (B) coronal contrast-enhanced CT images reveal two little pseudoaneurysms: one of the splenic artery (white arrows) and another of the hepatic artery (black arrows). (C) Axial MIP reconstruction and (D) digital subtraction angiogram show both pseudoaneurysms (arrows).

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 4: Endovascular treatment of a splenic pseudoaneurysm (same patient of figure 3). (A) Coronal contrast-enhanced CT image and (B) sagittal MIP reconstruction show a little pseudoaneurysm (white arrow) of the splenic artery. (C) Conventional angiography (D) and digital subtraction angiogram confirm the CT findings of a little pseudoaneurysm (white arrow) arising from the splenic artery. (E) Embolization of the pseudoaneurysm with one coil (white arrow).

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
**Fig. 5:** Endovascular treatment of a hepatic pseudoaneurysm (same patient of figures 3 and 4). (A) Coronal MIP reconstruction show a little pseudoaneurysm (white arrow) of the hepatic artery. (B) Digital subtraction angiogram confirms the little pseudoaneurysm (white arrow) arising from the proper hepatic artery. (C) Final angiography demonstrates successful exclusion of the pseudoaneurysm by a covered stent placement (white arrow), preserving hepatic artery patency.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 7: Iatrogenic inguinal pseudoaneurysm after placement of a venous catheter in the ICU (same patient of figure 2). (A) Conventional angiography confirms the CT findings of a pseudoaneurysm (yellow arrow) of the right deep external pudendal artery. (B) Note the early draining in the right femoral vein, consistent with an arteriovenous fistula (red arrow). (C) Angiography demonstrates exclusion of the pseudoaneurysm by means of proximal embolization with Onyx (yellow arrow) and resolution of the arteriovenous fistula.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Imaging findings OR Procedure details

In the following paragraphs we provide an overview of the endovascular approach and its merits, drawbacks and indications.

Endovascular techniques can be used to occlude PSA at all anatomical sites. These techniques offer treatment for arterial lesions (especially visceral PSA) that were previously considered inoperable or that were deemed to require extensive surgical dissection associated with high morbidity and mortality [3] (Fig. 15 on page 42). Underlying etiologies such as sepsis or intra-abdominal inflammation make open surgical repair very difficult and potentially elevate the associated morbidity of the repair (Fig. 16 on page 40 and Fig. 17 on page 41). Besides, since most of the endovascular techniques can be performed under local anesthesia, complications and morbidity associated with general anesthesia can be avoided. Therefore, endovascular management offers distinct advantages to conventional surgical repair in the treatment of PSA (especially visceral PSA).

Diagnostic arteriography with multiple projections is essential to completely assess inflow and outflow arteries of PSAs and their morphologic characteristics.

Typically, common femoral approach is used for arterial access. However, brachial or radial approach can be utilized if the common femoral approach is not suitable. Choice of catheter depends on the anatomy of the vasculature involved. Typically, we use a coaxial system consisting of a 6-French guiding sheath and 4- or 5-French Simmons 1 or Cobra catheters for the visceral PSA arising from the main artery or second-order branches. For the PSA arising from little branches, we use microcatheters (Fig. 18 on page 37C).

Endovascular techniques:

Basically, three techniques have been described to treat PSA:

1. Catheter-guided embolization with use of coils or injection of liquid embolic agents such as thrombin, glue or onyx.
2. Cover the neck of the PSA by placement of a stent-graft (covered stent).
3. Embolization with remodeling:
   • Stent remodeling: uncovered stent (Fig. 18 on page 37E1) is placed across the neck of the PSA followed by coil embolization of the sac (Fig. 19 on page 30).
   • Balloon remodeling: balloon is placed across the neck of the PSA during the embolization of the sac with embolic agents.
**Embolization materials:**

1. **Coils:**

   The embolization with coils is the most common form of treatment. Coils feature spaced synthetic fibers to maximize their thrombogenicity (Fig. 18 on page 37A, Fig. 17 on page 41 and Fig. 20 on page 29). There are two types of coils:

   - **Nondetachable:** these coils resume their shape immediately after deployment from the catheter.
     - *Advantage:* cheaper.
     - *Disadvantage:* less safe.
   - **Detachable** (better): these coils allow more accurate deployment and the possibility of readjusting the position of the coil before its final deployment.
     - *Advantage:* safer.
     - *Disadvantage:* expensive.

   A disadvantage of using coils as an embolization material is the potential for recanalization of the embolized sac if the coils are not tightly packed or if the patient has not a proper coagulation [6]. In the last years, new coils have appeared such as hydrocoils, which increase in volume after being deployed, resulting in more complete filling of the PSA and arterial lumen. They offer the theoretical advantages of increased volumetric occlusion, thrombus stabilization and improved neointimal healing.

   Most of the coils used are made up of platinum, and platinum-based coils are MR safe and cause less artifact.

2. **Liquid embolic agents:**

   Liquid embolic agents such as thrombin, N-butyl-2-cyanoacrylate (NBCA) or Onyx can be very useful in large PSA.

   Onyx is our preferred liquid embolic agent because its management is easier than other agents, it has not risk of polymerization within the catheter and it has not inflammatory effect (Fig. 18 on page 37B, Fig. 7 on page 39 and Fig. 15 on page 42).

   NBCA (glue) polymerizes on contact with blood, reason for what adequate care must be exercised to decrease the risk of polymerization within the catheter. Besides, NBCA requires meticulous detail in preparation and it has inflammatory effect.
As opposed to NBCA, with endovascular thrombin, there is no risk of adherence of the tip of the catheter to the vessel wall. The effect of thrombin is instantaneous. The main drawback of the thrombin is its poor visualization during the procedure and therefore its bad control.

3. Covered stents (stent-graft):

They are used especially for treatment of wide-necked PSA only in cases where there is no risk of major side-branch occlusion by stent graft (Fig. 18 on page 37E2). The native artery needs to be accessible to the stent, of good size, without being very tortuous and able to tolerate large guiding catheters (Fig. 21 on page 43 and Fig. 22 on page 44). Covered stent placement is contraindicated in mycotic PSA (due to potential stent-graft infection) and can only be used in a large caliber artery (over 5mm) because they pose risk of thrombosis in small arteries. Besides, stents are not ideally placed across a joint.

4. Balloons (Fig. 18 on page 37D):

Temporal balloon placement across the neck to exclude the PSA can get the same effect (thrombosis of PSA sac) that a stent-graft placement. They are used as a embolic agent in the treatment of small wide-necked PSA or in combination with other embolic agents.

Detachable balloons have been used as embolic agent [1] in the past, but we are not using them anymore.

Endovascular treatment of PSA:

The goal of treatment is complete vascular occlusion/exclusion of pseudoaneurysm. There are two endovascular approaches to embolization:

1. Packing/excluding the sac with embolic material.
2. Occluding the donor artery.

Selecting the optimal approach/method depends on expendability of the donor artery:

1. Inexpendable donor artery#Evaluate size of the PSA neck.
2. Expendable donor artery#Evaluate collateral circulation.

1. Inexpendable donor artery#Packing/excluding the sac of PSA with embolic material while preserving the donor artery (Fig. 12 on page 45):

Only the pseudoaneurysm cavity should be embolized if the PSA is in a critical territory (i.e., brain, mesenteric vessels, solitary kidney). The reason is that the occlusion of the
donor artery can result in severe ischemia of the target organ. In these cases, the width of the PSA’s neck relative to the diameter of the parent artery is the determining factor in the technique used [1].

- **Narrow neck**: *delivery of coils into the sac itself.* Other agents such as thrombin, glue or onyx may be used, either alone or in addition to coils (Fig. 4 on page 32 and Fig. 20 on page 29).
- **Wide neck**: we have two options:
  - The neck of the PSA may be covered by *placement of the stent graft* (Fig. 5 on page 33 and Fig. 22 on page 44).
  - *Remodeling*: we also deliver embolization materials into the sac, but we need to avoid distal embolization of these materials and resultant thrombosis of the donor artery. Remodeling allows to prevent outflow of these materials and to ensure adequate embolization of the PSA’s sac. We have various techniques to perform this remodeling:
    - *Stent remodeling*: uncovered stent is placed across the neck of the PSA followed by coil embolization through the lattice of the stent (stent cage) (Fig. 19 on page 30).
    - *Balloon remodeling*: trapping the coils by means of temporary balloon occlusion of the donor artery between coil deployments.

### 2. Expendable donor artery

Occluding the donor artery on proximal+/-distal side of the pseudoaneurysm neck (Fig. 13 on page 46):

We will evaluate the *collateral circulation* when we treat a PSA arising from an expendable donor artery because it will change the therapeutic approach. When embolizing arteries with numerous collateral vessels (i.e., gastroduodenal and hepatic arteries), one must embolize both proximal and distal to the PSA to completely exclude it from the circulation by preventing backflow from the collateral circulation [4] (Fig. 23 on page 28 and Fig. 24 on page 28; Fig. 25 on page 34, Fig. 26 on page 35 and Fig. 27 on page 36). On the other hand, a PSA that arises from an expendable donor artery and does not have a collateral supply (such as intralobar renal arterial branch) is treated with embolization of the afferent artery (Fig. 7 on page 39 and Fig. 17 on page 41).

**Complications:**

Endovascular techniques have a lower complication rate in the treatment of visceral pseudoaneurysms than does surgical management. Complications associated with endovascular techniques include:

- Intraprocedural rupture of the pseudoaneurysm.
- Distal embolization of the embolic agents used.
• Recanalization of the pseudoaneurysm (delayed failure of embolization) (Fig. 23 on page 28 and Fig. 24 on page 28).
Fig. 23: A 65-year-old female presented a recanalization of an iatrogenic pseudoaneurysm of the left thyrocervical trunk, that was treated with a covered stent placement in the left subclavian artery. (A) Axial MIP reconstruction shows a pseudoaneurysm (white arrow) of the left thyrocervical trunk (yellow arrow), that is a branch of the left subclavian artery (green arrows). (B) Coronal MIP reconstruction shows the pseudoaneurysmal sac (white arrow) and the donor artery (yellow arrow) on the left supraclavicular space. (C) Sagittal MIP reconstruction shows the pseudoaneurysm (white arrow) arising from the left thyrocervical trunk (yellow arrow).

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 24: Endovascular treatment of a recanalized pseudoaneurysm (same patient of figure 23). (A) Conventional angiography shows a pseudoaneurysm (white arrow) arising from the left thyrocervical trunk. Covered stent (green arrows) in the left subclavian artery. (B) Selective microcatheterization of the pseudoaneurysm through the thyrocervical trunk (donor artery) and filling of sac with contrast. (C) Successful embolization of the donor artery with two coils (red arrows), distal and proximal to the origin of pseudoaneurysm. Conventional angiography demonstrates exclusion of the pseudoaneurysm.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 20: A 61-year-old female presented with a swelling on the anterior side of the right elbow after a brachial catheterization. (A) Conventional angiography reveals a pseudoaneurysm (yellow arrow) arising from the humeral artery. (B-C) Selective microcatheterization of the pseudoaneurysm and directed delivery of coils in the sac (white arrow). (D) Final angiography demonstrates successful embolization of the pseudoaneurysm.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 19: A 63-year-old female presented with a pseudoaneurysm of the hepatic artery. (A) Conventional angiography shows a pseudoaneurysm (white arrow) arising from the common hepatic artery (originated from superior mesenteric artery as a normal variant) with a wide neck. (B) Angiography demonstrates exclusion of the pseudoaneurysm with use of an uncovered stent (short arrow) and coil embolization (long arrow) through the interstices of the stent (stent remodeling with coils).

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 3: A 76-year-old male who had undergone a Whipple procedure. (A) Axial and (B) coronal contrast-enhanced CT images reveal two little pseudoaneurysms: one of the splenic artery (white arrows) and another of the hepatic artery (black arrows). (C) Axial MIP reconstruction and (D) digital subtraction angiogram show both pseudoaneurysms (arrows).

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
**Fig. 4:** Endovascular treatment of a splenic pseudoaneurysm (same patient of figure 3). (A) Coronal contrast-enhanced CT image and (B) sagittal MIP reconstruction show a little pseudoaneurysm (white arrow) of the splenic artery. (C) Conventional angiography (D) and digital subtraction angiogram confirm the CT findings of a little pseudoaneurysm (white arrow) arising from the splenic artery. (E) Embolization of the pseudoaneurysm with one coil (white arrow).

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
**Fig. 5:** Endovascular treatment of a hepatic pseudoaneurysm (same patient of figures 3 and 4). (A) Coronal MIP reconstruction show a little pseudoaneurysm (white arrow) of the hepatic artery. (B) Digital subtraction angiogram confirms the little pseudoaneurysm (white arrow) arising from the proper hepatic artery. (C) Final angiography demonstrates successful exclusion of the pseudoaneurysm by a covered stent placement (white arrow), preserving hepatic artery patency.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 25: A 33-year-old female presented with a swelling on the thumb side of the left wrist after a trauma. (A) Axial contrast-enhanced CT scan shows a posttraumatic pseudoaneurysm (yellow arrow) on the radial side of the wrist. (B-C) Coronal contrast-enhanced CT images and (D) 3D reconstruction reveal a pseudoaneurysm (yellow arrows) arising from the superficial palmar branch of the radial artery (white arrow). The radial artery is marked by a red arrow.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
**Fig. 26:** Endovascular treatment of a posttraumatic pseudoaneurysm on the wrist (same patient of figure 25). (A) Digital subtraction angiogram confirms the CT findings of a pseudoaneurysm close to the radial artery. (B) Angiography shows retrograde filling of the pseudoaneurysm (yellow arrow) through superficial palmar arch (white arrow) after occluding the radial artery (red arrow) by means of a temporal balloon. Note the neck of pseudoaneurysm is in the superficial palmar branch origin in the radial artery (white asterisk). The attempt to embolize the pseudoaneurysm with temporal balloon placement across the neck was not successful.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 27: Endovascular treatment of a posttraumatic pseudoaneurysm on the wrist (same patient of figures 25 and 26). (C) Distal occlusion of the superficial palmar branch with coils to avoid retrograde filling of the sac. Now only anterograde filling of the pseudoaneurysm from the radial artery is present (yellow arrow). (D) Final angiography demonstrates exclusion of the pseudoaneurysm by means of distal and proximal embolization of the donor artery (superficial palmar branch of the radial artery) with coils.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 18: Materials used in the endovascular management of pseudoaneurysms. (A) Coils. (B) Onyx. (C) Microcatheter and catheters. (D) Balloons. (E1) Uncovered stents. (E2) Covered stent (stent-graft).

© Images obtained from websites of different commercial brands.
Fig. 2: A 79-year-old male presented inguinal pseudoaneurysm after placement of a venous catheter in the ICU. (A) Axial contrast-enhanced CT scan shows a pseudoaneurysm (yellow arrow) in the right pectineus muscle. Note the catheter in the right femoral vein (red arrow). (B) Coronal and (C) sagittal contrast-enhanced CT images reveal the pseudoaneurysm (yellow arrows) in the interior of the right pectineus muscle, situated at the anterior part of the upper and medial aspect of the thigh.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 7: Iatrogenic inguinal pseudoaneurysm after placement of a venous catheter in the ICU (same patient of figure 2). (A) Conventional angiography confirms the CT findings of a pseudoaneurysm (yellow arrow) of the right deep external pudendal artery. (B) Note the early draining in the right femoral vein, consistent with an arteriovenous fistula (red arrow). (C) Angiography demonstrates exclusion of the pseudoaneurysm by means of proximal embolization with Onyx (yellow arrow) and resolution of the arteriovenous fistula.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
**Fig. 16:** A 43-year-old male alcoholic patient with history of repeated acute pancreatitis flare-ups became septic during an acute episode and thus underwent a contrast-enhanced CT scan of the abdomen to identify any abscess formation. (A) Axial contrast-enhanced CT scan shows, in the interior of a pancreatic pseudocyst, a large splenic arterial pseudoaneurysm (yellow arrow) with intrasac thrombosis (blue asterisk) and communication with the donor artery (white arrow). (B) Coronal and (C) sagittal contrast-enhanced CT images show the pseudoaneurysm (yellow arrows) with intrasac thrombosis (blue asterisks) in the interior of the pancreatic pseudocyst.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 17: Endovascular treatment of a splenic arterial pseudoaneurysm in a patient with acute pancreatitis (same patient of figure 16). (A) Conventional angiography confirms the CT findings of a large splenic arterial pseudoaneurysm (yellow arrows). The inflow into the sac through a splenic arterial branch is marked by the red arrow. (B) Angiography demonstrates exclusion of the pseudoaneurysm by means of proximal and distal embolization of the donor artery with coils (white arrows).

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
**Fig. 15:** 60-year old female with an endocarditis that presents neurological symptoms. A brain MR reveals two little pseudoaneurysms. (A) Conventional angiography confirms the MR findings. Both pseudoaneurysms are in the territory supplied by the middle cerebral artery: one precentral (red arrow) and the other one posterior parietal (yellow arrow). (B) Angiography demonstrates successful embolization with Onyx of the posterior parietal pseudoaneurysm (yellow arrow) and the donor artery branch (white arrows). (C) Angiography demonstrates embolization of the posterior parietal pseudoaneurysm (yellow arrow). The precentral pseudoaneurysm (red arrow) was treated later.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 21: A 71-year-old male presented an iatrogenic pseudoaneurysm and arteriovenous fistula. (A) Axial contrast-enhanced CT scan shows a right femoral arteriovenous fistula with high debit and an aneurysmatic dilatation associated (yellow arrow). (B) Coronal contrast-enhanced CT image and (C) 3D reconstruction show the early draining in the right femoral vein (white arrows), consistent with an arteriovenous fistula.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 22: Endovascular treatment of an iatrogenic femoral pseudoaneurysm associated with arteriovenous fistula (same patient of figure 21). (A-B) Conventional angiography confirms the CT findings of a right femoral arteriovenous fistula with high debit (white arrows), close to the superficial femoral artery origin (blue arrows). Note the early draining in the femoral vein. (C) Angiography shows the placement of a covered stent (yellow arrows) in the superficial femoral artery. (D) Angiography demonstrates resolution of the right femoral arteriovenous fistula.

© Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
**Fig. 12:** Endovascular management of PSA arising from an inexpendable donor artery.

© V. Benito Santamaría, Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Fig. 13: Endovascular management of PSA arising from an expendable donor artery.

© V. Benito Santamaría, Department of Radiology, Hospital de la Santa Creu i Sant Pau - Barcelona/ES
Conclusion

Pseudoaneurysms have associated complications than carry high morbidity and mortality and thus, they need to be treated quickly. The minimally invasive techniques such as endovascular procedures, due to their low morbidity and mortality, have increased their role in the last years.

The endovascular procedures can be used for the treatment of almost every PSA. The therapeutic objective is to exclude the PSA from the circulation and we can do this in two ways: excluding the sac or occluding the donor artery. Selecting the optimal method depends on the expendability of the donor artery, the size of the PSA neck and the collateral circulation.
References


Benito Santamaría V, Molina Zuluaga JA, Guerrero Vara R., Babún Molina YE.
Department of Radiology, Universitat Autònoma de Barcelona, Hospital de la Santa Creu i Sant Pau, Carrer Sant Antoni Mª Claret, 167, 08025, Barcelona, Spain. mail to: virben_posvas@hotmail.com