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Ruptured visceral artery aneurysms


Abstract  Visceral artery aneurysms are rare but their estimated mortality due to rupture ranges between 25 and 70%. Treatment of visceral artery aneurysm rupture is usually managed by interventional radiology. Specific embolization techniques depend on the location, affected organ, locoregional arterial anatomy, and interventional radiologist skill. The success rate following treatment by interventional radiology is greater than 90%. The main complication is recanalization of the aneurysm, showing the importance of post-therapeutic monitoring, which should preferably be performed using MR imaging.

Visceral artery aneurysms (VAAs) are rare [1], multiple in up to 20% of patients and usually asymptomatic until rupture. Mortality rate due to rupture varies from 25 to 70% [2]. VAA rupture requires multidisciplinary management including emergency-intensive care specialists, surgeons and diagnostic and interventional radiologists. The prevalence varies depending on the anatomical location (Table 1) [3].

An aneurysm is an arterial dilatation (1.5 times the size of the original vessel) with loss of parallelism of the vascular walls. True aneurysms must be differentiated from pseudoaneurysms, because the risk of complications is different and requires specific management.

A true visceral artery aneurysm (TVAA) is defined by an arterial dilatation that involves the three layers of the vascular wall (intima — media — adventia). It may be sacciform or fusiform. The causes of TVAA vary but are mainly atherosclerosis, fibrodysplasia or connective tissue disorders. A treatment of true aneurysms is indicated in the following cases:
• clinical symptoms (pain, embolism, rupture);

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• more than 2 cm in size or twice the size of the artery by consensus;
• rapid increase in the diameter of the aneurysm;
• specific location (duodenopancreatic arcades);
• pregnant women or women of childbearing age [4];
• project for liver transplantation or portal hypertension for splenic artery aneurysms.

A visceral artery pseudoaneurysm (VAPA) is a contained encapsulated hematoma that communicates with the arterial lumen. There is a high risk of rupture whatever its size and treatment is systematic. The cause of pseudoaneurysms may be post-traumatic, infectious, inflammatory or iatrogenic (puncture, biopsy).

On imaging, aneurysms are traditionally associated with other signs of atherosclerotic disease, usually wall calcification, while pseudoaneurysms usually correspond to a round contrast-enhanced arterial lesion in contact with an artery within a specific context.

Different studies have compared surgical treatment to treatment by interventional radiology (TVAA and VAPA, ruptured or not), without showing any significant difference in morbidity and mortality, overall survival, or post-procedural recurrence [5–7]. In cases of ruptured visceral aneurysms, surgical mortality is 23.9% vs. 2.7% during radiological endovascular management [8–10].

First line management of ruptured visceral aneurysms is therefore based on endovascular treatment by interventional radiologists.

### Diagnosis of a ruptured visceral artery aneurysm

Except for known visceral artery aneurysms, the diagnosis is usually made in the presence of hemorrhagic shock that may or may not be preceded by more specific clinical symptoms including abdominal pain, hemobilia, gastrointestinal hemorrhage, hemoperitoneum, or hemoretroperitoneum.

The diagnosis is based on contrast-enhanced abdominal and pelvic Multiple Detector Computed Tomography (MDCT) angiography (1.5 mL/kg) of iodinated contrast material with a sufficient concentration of iodine (370 to 400 mg of iodine per 100 mL) and a flow rate of 3 to 5 mL/s, with automated contrast medium administration. The protocol includes a non-enhanced helical acquisition of the abdomen and pelvis, an arterial phase helical acquisition of the abdomen and pelvis (automated acquisition at a threshold of 120 HU in the aorta) to search for active bleeding, and a venous phase helical acquisition (between 60 and 90 seconds) [11,12] associated with a late phase helical acquisition if necessary (3 to 5 minutes after contrast medium administration). In an emergency situation, magnetic resonance imaging (MRI) is not recommended (problems of access, length of the exam) [13].

MDCT angiography of the abdomen and pelvis is essential because it can confirm the diagnosis of a ruptured visceral aneurysm, as well as be used to plan the endovascular procedure. The information that can be obtained from MDCT includes [14]:

- determining the procedural approach (femoral or humeral): analysis of vessel tortuosity (aortollic axis, angle of the visceral arteries in relation to the axis of the aorta), celiac trunk stenosis (arcuate ligament, atheroma);
- description of the aneurysm: size and shape of the aneurysm, diameter of the involved artery below and above the aneurysm, size of the neck (if saccomiform), length of the aneurysm (in case of stent placement);
- number of afferent and efferent branches;
- determination of locoregional anatomy: analysis of collateral vessels that could flow into the aneurysm, anatomical variants and presence of aneurysms in other locations.

Volume rendering (VR) and maximal intensity projection (MIP) reconstructions are helpful to obtain optimal analysis of the aneurysm [12].

### Treatment

The basic concept behind the treatment of a ruptured visceral aneurysm is to exclude it from the general circulation by endovascular management [15]. The surgeon should be informed of the presence of a ruptured VA. This procedure is performed in coordination with the anesthesia-intensive care team (patient monitoring, blood and platelet transfusion, fresh frozen plasma if necessary). If the patient is not hemodynamically stable, surgery should be considered. This procedure can be performed under local or general anesthesia depending on the patient’s condition, the anesthesiologist’s opinion or the interventional radiologist’s usual practices.

#### Technique

The best approach is femoral or in certain cases humeral if anatomical difficulties have been identified (arcuate ligament/celiac trunk stenosis). The stability of the navigation equipment (long introducer sheath/guide catheter, catheter, microcatheter) is necessary to perform embolization under optimal safety conditions. The use of a long introducer sheath or a guide catheter associated with an anatomically adapted probe and a microcatheter is recommended (trialxial catheter system). The choice of the embolic agents essentially depends on the aneurysm being treated and the operator’s experience.
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Figure 1. Endovascular treatment of ruptured visceral aneurysms.

There are different techniques (Fig. 1) for the treatment of visceral artery aneurysms [3,16].

Occlusion of the parent vessel
The so-called sandwich technique ("front and back door embolization") is used in emergency situations especially in the presence of fusiform aneurysms that are proximal or with a wide-neck when the parent artery can be sacrificed. It involves occlusion of the aneurysm upstream and downstream so that it is excluded from the circulation. It is the equivalent of surgical exclusion ligation. Distal revascularization through collaterals is not possible. The advantage of this technique is its simplicity. Its main disadvantage is that it does not preserve the patency of the embolized artery, which can create complications for ischemic lesions. This type of embolization is performed with injectable pushable or detachable coils or plugs. The use of embolization particles such as microparticles or liquid embolizing agents such as glue or ethylene-vinyl alcohol (Onyx®, EV3/Covidien, Plymouth, MN, USA) is less frequent, but may be indicated if it is impossible to reach the hemorrhagic aneurysm.

Direct embolization of the aneurysm
Two techniques can be used: the endovascular approach with packing of the aneurysm and percutaneous thrombin injection. The latter is very rarely used in emergencies because the ruptured aneurysm is difficult to reach percutaneously in the presence of a hematoma. Packing of the aneurysm involves filling a sacciform aneurysm with a narrow neck with coils. The two critical steps of this technique are the delivery of the first and last coils with a risk of overpacking the treated artery. To prevent complications, it is possible to protect coil delivery (so-called assisted-packing or remodelling — used for wide-necks) with the help of a bare stent (coils are deployed through the stent) or a balloon positioned in front of the neck [17]. The main risk of this technique is rupture of the aneurysm during packing, as well as at a distance from the procedure, which is increased in the presence of a pseudoaneurysm. Nevertheless, successful packing of VAPA has been described by Loffroy et al. [18] including pseudoaneurysms of less than 5 cm and ruptured pseudoaneurysms (9/16 patients). This technique should only be performed by experienced interventional radiologists and care should be taken not to overpack.

The advantage of this technique is that the parent artery remains patent. The main disadvantage, besides complications during the procedure, is the risk of recanalization of the aneurysm by the neck [18,19].

Implantation of a covered stent
This technique involves treating the ruptured aneurysm with a covered stent [20]. It preserves the parent artery and is therefore used when possible on end arteries. It can only be used in arteries that are wide enough because the main disadvantage is the risk of stent occlusion. An anticoagulant is recommended following the procedure. It is not necessary to use heparin during the procedure, unlike during stent placement on a non-ruptured aneurysm.

This technique is therefore limited by the size of the artery and its tortuosity. Placement of a covered stent-graft requires:

- perfect stability of the catheters for correct stent delivery and to prevent the risk of migration. The use of an exchange (guide for example a rigid guide wire) is necessary to reduce vessel tortuosity and favor stability;
- choosing a stent with an appropriate size and with the appropriate mechanical properties for the vessel being treated (a flexible stent on balloon or self-expandable);
- deployment of the stent in the desired place.

The use of a flow-diverting stent makes it possible to preserve the collateral vessels of the aneurysmal arteries by modulating intra-arterial flow, causing progressive thrombosis of the aneurysm. Their use is not indicated in the treatment of ruptured visceral aneurysms.

Complications
The success of endovascular treatment is immediate in approximately 90% of cases and even greater in certain series [5,7,10,21]. Complications (except for puncture site complications) are the result of technical failures (coil migration, glue embolism), secondary recanalization (insufficient packing, re-injection from the collateral vessels) and are detected by systematic post-procedural imaging follow-up.

Treatment of specific locations
Ruptured splenic aneurysms
Clinical features
They account for 60% of visceral aneurysms and are mainly found in women (gender ratio 4/1). The main causes are portal hypertension and atherosclerosis, Ehler-Danlos syndrome and mycotic or post-pancreatic pseudoaneurysms. Most splenic aneurysms are saccular and located in the hilum.

Management
A proximal splenic aneurysm can be treated by the sandwich technique using a microcatheter and a 0.014 or 0.018 guidewire (Fig. 2) or by covered stent deployment [22,23].
Splenic perfusion is ensured by collateral circulation through the short gastric vessels or the gastroepiploic artery, limiting the risk of infarction. It should be noted that although placement of a covered stent to treat a splenic artery can be technically difficult because of vessel tortuosity of it has already been successfully described in the literature [20]. In the same way, special care must be taken when using pushable coils because of the risk of distal migration and thus ischemia.

Aneurysms of the splenic hilum can be treated in the same way as aneurysms of the proximal splenic artery (sandwich technique) by sacrificing the aneurysmal branch and sparing the others [15]. Packing may be performed in case of a narrow neck [17]. The most distal aneurysms can be embolized with coils, particles or selectively with glue resulting in infarction of the embolized territory [15].

Complications

Treatment of splenic aneurysms is successful in up to 90% of the cases [22,23]. The main complications of splenic embolization are infarction, abscess, pancreatitis (in case of embolization of the dorsal pancreatic artery or the greater pancreatic artery), and splenic vein thrombosis in case of extensive infarction. Although the risk of splenic infarction can reach 40%, hematological disorders and thus the risk of asplenia are much rare [15].

Ruptured hepatic artery aneurysms

Clinical features

They represent approximately 20% of visceral aneurysms. In 50% of the cases, they are secondary to pseudoaneurysms [2]. The rupture can be intraperitoneal (20–30% of the cases) or intrahepatic (with the clinical triad associating abdominal pain, jaundice and hemobilia in 50% of the cases).

Management

Dual hepatic vascularization (portal in approximately 70% of the parenchyma and arterial in approximately 30%) makes it possible to perform occlusion of the artery. Except for emergencies, good perfusion of the portal system should be confirmed. In case of thrombosis of the latter or on a liver graft, the priority should be preservation of the hepatic artery by using a covered stent or packing.

Distal intrahepatic aneurysms are embolized with coils (sandwich technique) or possibly embolic particles. In these cases, a microcatheter should be used.

Aneurysms of the proper hepatic artery can be treated by a covered stent following embolization of the gastroduodenal artery if there is a risk of recanalization of the latter. If a re-treatment of the latter is necessary, embolization via the superior mesenteric artery and the duodenopancreatic arcades should be performed (Fig. 3).

Aneurysms of the common hepatic artery can be embolized—the hepatic circulation is ensured by the gastroduodenal artery. In case of a hepatic artery aneurysm that also involves the gastroduodenal artery, embolization of the latter must also be performed to prevent the need for re-treatment for bleeding.

Complications

The main complications of embolization of hepatic aneurysms are biliary abscess, ischemic cholecystitis,
progression of cirrhosis, and the risk of liver failure in patients with chronic liver disease [15].

Ruptured superior mesenteric artery (SMA) and celiac trunk aneurysms

Clinical features
Aneurysms of the celiac trunk are rare. The mortality rate in case of rupture is nearly 100%. Treatment is usually surgical because of the short distance between the celiac trunk and the trifurcation of the splenic, the left gastric and the common hepatic arteries, limiting stent placement. The main causes are atherosclerosis or fibrodysplasia. Clinical symptoms mainly included epigastric pain or upper gastrointestinal hemorrhage.

Aneurysms of the SMA are the third cause of splanchic aneurysms and are often secondary to endocarditis (up to 20% of the cases). Atherosclerosis and pancreatitis are other causes [24]. These aneurysms mainly involve the first 5 cm of the artery. Clinically, the patient presents with abdominal pain and upper gastrointestinal hemorrhage.

Management
Results in the literature are limited and mainly include case reports because of the low prevalence of this condition. The techniques described above (stents, coils) can be used depending on the existing anastomotic network [2]. The risk of ischemia is also minimal except in case of distal embolization.

Ruptured gastro- and pancreaticoduodenal arcade aneurysms

Clinical features
These aneurysms account for 2 to 4% of splanchic aneurysms. They are often secondary to episodes of pancreatitis or pancreatic surgery or favored by stenosis of the celiac trunk. Celiac stenosis results in inversion of flow in the anterior and posterior pancreaticoduodenal arcades at the SMA that recanalizes the celiac trunk via the gastroduodenal artery. Sutton and Lawton have suggested that this increase of flow into small arteries on favorable terrain (hypertension, fibrodysplasia) resulted in local arterial hypertension that caused the development of an aneurysm [25].

Management
Treatment of a ruptured aneurysm in this location may be performed using the sandwich technique, packing technique, or stent placement (Fig. 4), and in specific cases the use of polyethylene-vinyl alcohol (PVA) [26–29]. The use of microbeads or gelatin sponge should be avoided because of the risk of recanalization and that of distal migration that may result in ischemia. There is no consensus on treatment of celiac trunk stenosis. This may be justified if the collateral circulation is insufficient or if the patient is symptomatic (risk of liver failure, mesenteric ischemia or recurrent aneurysm after treatment). Nevertheless, treatment of these aneurysms without treating the celiac stenosis does not necessarily result in recurrent aneurysm. In the same way, treatment of the stenosis alone does not
Figure 4. Fifty-four-year-old man presenting with abdominal pain 1 month after gastrointestinal arterial thrombosis treated by thrombectomy of the superior mesenteric artery (SMA) and partial small bowel resection. MDCT without contrast administration in the axial plane (a) shows spontaneous hyperattenuating hematoma of the origin of the SMA (arrow). MDCT after contrast material administration during the arterial phase (b) and coronal sequences (maximal intensity projection reconstruction) (c), show a pseudoaneurysm (PA) of a duodenopancreatic arcade, confirmed by MDCT angiography (d). Placement of a covered stent (e) and coils (f). Control angiogram shows complete exclusion of the PA (g).

necessarily reduce the size of the aneurysm. In any case, it is not performed immediately.

Ruptured renal artery aneurysms

Clinical features

A ruptured aneurysm of the renal arteries is associated with lumbar pain and an intraparenchymal, subcapsular or retroperitoneal hematoma.

Management

The kidneys are vascularized by end arteries. When treating renal aneurysm, the parent artery must be preserved to limit nephron loss. Thus, treatment depends on the damaged artery: main or polar renal artery, bifurcation or intrarenal artery. Intrarenal arteries are usually treated by coils. Glue or particles are also other options. Aneurysms of the renal artery or a polar or hilar branch should be excluded while respecting the parent artery as much as possible. In these cases, a covered stent appears to be the first line treatment [16]. Aneurysms involving the arterial bifurcations are difficult to treat. Packing can be attempted in aneurysms with a narrow neck, (with stent or balloon assistance as needed). In other cases, embolization by balloon-assisted treatment with ethylene-vinyl alcohol can be performed [30].

Complications

Complications following renal aneurysm embolization are mainly renal infarction whose severity depends on the embolized artery, renal failure, based on the severity of infarction, the administration of iodinated contrast medium during the procedure and infectious complications (abscess).

Post-embolization follow-up

Post-embolization follow-up is essential. In the immediate post-procedural period, the complications can be detected (abscess, infarction, puncture site hematoma). Later on,
Ruptured the during follow-up with emergency contrast-enhanced radiography, the during stent-grafts. Optimal aneurysms treatment are useful treated using the recanalization of embolized aneurysms that require re-treatment can be identified. There is no consensus on the optimal frequency of post-procedural follow-up. Normally follow-up is performed 1 month, 6 months and 1 year after the procedure for 3 to 5 years.

Monitoring is based on MDCT angiography or MR angiography. Sensitivity of MDCT and MRI for aneurysmal screening is similar [2,13,31,32].

The efficacy of MDCT is impaired by metal artifacts from coils. [33]. Moreover evaluation of aneurysm recanalization during packing is still a problem. New multi-energy MDCT with an algorithm to reduce metal artifacts could limit these drawbacks but this must be evaluated in clinical practice [34]. MDCT angiography can be used for the follow-up of stent-grafts. MRI provides detailed analysis of aneurysms treated by coils with no metal artifacts and easier visualization of aneurysm recanalization on gadolinium chelate contrast-enhanced sequences (Fig. 5) [32,35]. It is also a useful radiation-free imaging technique for repeated follow-up. The imaging protocol includes dynamic MR angiography using fat suppressed T1-weighted gradient echo sequences during the arterial phase of injection with subsequent MIP and MPR reconstructions.

**Conclusion**

The treatment of ruptured visceral aneurysms is an emergency because they are life threatening to the patient. They are usually treated by endovascular interventional radiology, in coordination with the anesthesiology-intensive care team. Treatment is based on excluding the aneurysm from the general circulation by different methods depending on the locoregional anatomy, the involved organ and the experience of the interventional radiologist. Follow-up of treated aneurysms is essential to identify any recanalization. Optimal follow-up is obtained by MR angiography.

**Take-home messages**

- Ruptured visceral aneurysm is a therapeutic emergency;
- Systematic pre-therapeutic MDCT angiography:
  - Diagnostic,
- Planning the procedure: location, size of the aneurysm and possible difficulties in approaching the aneurysm, afferent/efferent branches, collateral channels,
- Necessity of MIP and VR reconstructions;
- Endovascular treatment depending on the location of the aneurysm and the interventional radiologist’s experience:
  - Stability is essential (triaxial system),
  - Preservation of parent artery (covered stent, packing with or without remodeling),
  - Non-patency of the parent artery (sandwich technique, particles, glue);
- Post-therapeutic follow-up is essential, optimally performed using MR Imaging.

**Clinical case**

A 48-year-old woman with no previous medical history presented to the emergency department after 3 days of abdominal pain. Clinical assessment disclosed left upper quadrant pain. The results of biological tests revealed a hemoglobin level of 11 g/dL. Ultrasound showed a left ovarian cyst with fluid effusion into the pouch of Douglas.

**Questions**

1. Based on the clinical presentation which of the following imaging test would be the most appropriate?
   A — no imaging test
   B — MDCT of the abdomen and pelvis
   C — ultrasound after 48 h with a pelvic examination
   D — MR imaging

2. The test results (Fig. 6a–h) show:
   A — a peripancreatic hematoma
   B — a splenic artery aneurysm
   C — that the approach should be femoral
   D — that the approach should be humeral

3. Optimal embolization of this aneurysm can be achieved with:

   - Planning the procedure: location, size of the aneurysm and possible difficulties in approaching the aneurysm, afferent/efferent branches, collateral channels,
   - Necessity of MIP and VR reconstructions;
   - Endovascular treatment depending on the location of the aneurysm and the interventional radiologist’s experience:
     - Stability is essential (triaxial system),
     - Preservation of parent artery (covered stent, packing with or without remodeling),
     - Non-patency of the parent artery (sandwich technique, particles, glue);
   - Post-therapeutic follow-up is essential, optimally performed using MR Imaging.

![Figure 5](image-url) Recanalization of a splenic aneurysm treated with metallic coils. (a) Recanalization is barely seen on MDCT due to metal artifact; and is clear on magnetic resonance imaging [FLASH sequence — coronal plane and maximal intensity projection (b and c)].
Figure 6. Abdominal and pelvic MDCT (a–h). Angiography (i–k).

A — coils using the sandwich technique
B — coils using the packing technique
C — a covered stent
D — particles

4. After embolization (Fig. 6i–k), the final follow-up is satisfactory with complete exclusion of the aneurysm. The post-procedural follow-up protocol:
A — would be best performed by contrast-enhanced MDCT
B — would be best performed by contrast-enhanced MRI
C — the post-procedural risk is recanalization of the aneurysm
D — the post-procedural risk is splenic vein thrombosis

Answers
1. B.

Unenhanced axial MDCT shows a spontaneously high atten-
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...tation hematoma to the tail of the pancreas (Fig. 6a). It also shows spontaneously attenuated pouch of Douglas (hemoperitoneum) (Fig. 6b), low attenuation in a lesion of the left ovary with no active bleeding during the arterial (Fig. 6c) or portal phase (Fig. 6d). The splenic artery aneurysm is visible during the arterial phase and MIP reconstruction (Fig. 6e, f). An arcuate ligament is the cause of stenosis of the celiac artery at its origin (sagittal MIP — Fig. 6g) [36]. VR reconstruction shows the splenic artery aneurysm (Fig. 6h).

3. B.

MDCT angiography shows a splenic artery aneurysm catheterized using a 2.7-F microcatheter (Fig. 6i). Coils were placed in the aneurysm (packing technique) (Fig. 6j). No complete exclusion of the aneurysm on MDCT angiography at the end of the procedure (Fig. 6k).

4. B and C.

Disclosure of interest
The authors declare that they have no conflicts of interest concerning this article.

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