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Projeto de Opção do 6º ano - DECLARAÇÃO DE INTEGRIDADE

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NOME

DIOGO PEDRO BRANDÃO DA COSTA

NÚMERO DE ESTUDANTE	E-MAIL
201303382	diogopbcosta@gmail.com

DESIGNAÇÃO DA ÁREA DO PROJECTO

Angiologia e Cirurgia Vascular

TÍTULO ~~DISSERTAÇÃO~~/MONOGRAFIA (riscar o que não interessa)

VISCERAL ARTERY ANEURYSMS: STATE OF ART AND REVIEW

ORIENTADOR

PROF. DR. ARMANDO MANSILHA

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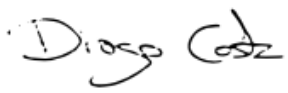

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A toda a minha família, amigos e
pessoas que ao longo desta jornada
cruzaram o meu caminho

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Ao longo de seis anos, vários objetivos foram traçados, memórias criadas, obstáculos e tormentas superadas. Tudo isto em prol de um dos meus maiores sonhos, quiçá o maior, tornar-me no que almejo desde criança, ser médico. Na concretização deste objetivo de vida, muitos foram os que contribuíram direta ou indiretamente para que aqui chegasse.

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RESUMO

Aneurismas arteriais viscerais e pseudoaneurismas são entidades raras. Estas lesões são clinicamente importantes e potencialmente letais, uma vez que 22% apresentam-se como urgências clínicas e 8,5% resultam em óbito. Como tal, a detecção precoce e o tratamento são essenciais.

Através deste trabalho, pretendemos abordar os aneurismas arteriais viscerais e pseudoaneurismas, com particular enfoque na epidemiologia, etiologia e fatores de risco, bem como nos atuais diagnósticos e estratégias de tratamento.

Uma revisão completa da literatura foi realizada através de uma pesquisa eletrónica abrangente recorrendo à PubMed, incluindo artigos publicados até ao final de novembro de 2018 e usando as seguintes palavras-chave: "visceral aneurysm", "pseudoaneurysm" e "endovascular treatment". A partir desta pesquisa, 2043 artigos foram avaliados, 359 foram selecionados, 241 foram excluídos por não estarem diretamente relacionados com tema e 118 foram incluídos, de acordo com a preferência dos autores e relevância científica no contexto deste trabalho.

Os aneurismas arteriais viscerais e os pseudoaneurismas possuem apresentações clínicas e exames de diagnóstico similares. As diferenças residem principalmente na sua etiologia e indicações de tratamento, uma vez que o tratamento imediato é recomendado para pseudoaneurismas, independentemente do seu tamanho, enquanto os aneurismas verdadeiros têm indicações de tratamento específicas. Apesar de uma melhoria significativa nas estratégias atuais de diagnóstico e tratamento, esta patologia é ainda frequentemente diagnosticada após a ruptura, com taxas de mortalidade significativas. As estratégias endovasculares representam a primeira linha de tratamento na sua maioria, embora a cirurgia aberta continue a desempenhar um papel em casos particulares.

Os aneurismas arteriais viscerais e pseudoaneurismas apesar de serem considerados condições raras, são potencialmente fatais. O diagnóstico adequado é essencial para melhores resultados. Com o advento das terapias endovasculares, uma abordagem minimamente invasiva tornou-se o padrão de tratamento na maioria das situações, embora ainda haja indicações sólidas para a cirurgia aberta.

VISCERAL ARTERY ANEURYSMS: STATE OF ART AND REVIEW

Diogo COSTA[1], Joel SOUSA[1,2*], Armando MANSILHA[1,2]

1- Faculty of Medicine of the University of Porto, Porto, Portugal

2- Department of Angiology and Vascular Surgery, Hospital de S. João, Porto, Portugal

*** CORRESPONDING AUTHOR:**

Joel Sousa, MD

- Department of Angiology and Vascular Surgery, Hospital de S. João, Porto, Portugal
- Alameda Prof. Hernâni Monteiro, 4200-319 Porto, Portugal
- joelferreirasousa@gmail.com

ABBREVIATIONS

CHA – Common hepatic artery
CT - Computed tomography
CTA - Multidetector CT angiography
DSA - Invasive digital subtraction angiography
EVT - Endovascular treatment
FAST - Focused assessment with sonography for trauma
FDS - Multilayer stents (flow diverters)
GAA - Gastric Artery Aneurysms
GDA - Gastroduodenal Artery Aneurysms
HAA - Hepatic artery aneurysms
IMA - Inferior mesenteric artery aneurysms
LGAA - Left gastric artery aneurysms
MRI - Magnetic resonance imaging
PDA - Pancreaticoduodenal artery aneurysms
PSA - Pseudoaneurysms
RAA – Renal artery aneurysms
SAA – Splenic artery aneurysm
SMA – Superior mesenteric artery aneurysm
SPSA – Splenic artery pseudoaneurysms
TAE - Transcatheter embolization
US - Ultrasound
VAA - Visceral artery aneurysms

ABSTRACT

Introduction: Visceral arterial aneurysms and pseudoaneurysms are rare entities. Despite infrequent, these lesions are clinically important and potentially lethal, since 22% present as clinical emergencies and 8,5% result in death. As such, early detection and treatment is essential. Through this work, we aim to address both visceral arterial aneurysms and pseudo-aneurysms, with particular focus on their epidemiology, etiology and risk factors, as well as report current diagnostic workups and treatment strategies.

Methods: A full literature review was performed through a comprehensive electronic search of PubMed databases, including articles published until the end of November 2018 and using the following keywords: "visceral aneurysm", "pseudoaneurysm" and "endovascular treatment". From this research, 2043 articles had their abstract assessed, 359 were selected, 241 were excluded for not being directly related to the subject and 118 were included, according to the authors´ preference and scientific relevance in this work´s context.

Results: Visceral arterial aneurysms and pseudo-aneurysms have fairly similar clinical presentations and diagnostic workups. Differences reside mainly in their etiology and indications for treatment, since immediate treatment is recommended for pseudoaneurysms regardless of their size, while true aneurysms have specific treatment cutoffs. Despite a significant improvement on current diagnostic and treatment strategies, these lesions are still frequently diagnosed upon rupture, with significant mortality rates. Endovascular strategies represent the first line of treatment on the majority of cases, although open surgery continues to play a role in specific conditions.

Conclusions: Visceral arterial aneurysms and pseudoaneurysms are rare but potentially fatal conditions. Proper diagnosis is essential for better outcomes. With the advent of endovascular therapies, a minimally invasive approach became the standard of care in the majority of situations, although there are still solid indications for open surgery.

Keywords: Visceral aneurysm; Pseudoaneurysm; Endovascular treatment;

INTRODUCTION

Visceral arterial aneurysms as well as pseudoaneurysms are rare conditions. Nonetheless, when ruptured ensues, they are frequently fatal and, as such, increase awareness for these lesions is essential among health professionals.

Through this work we aim to address the most common visceral aneurysms and pseudoaneurysms, while reviewing their natural history, epidemiology, etiology, clinical behavior and diagnostic workup. Treatment options, both open and endovascular, are also assessed, and recommendations are performed.

MATERIALS AND METHODS

A full literature review was performed through a comprehensive electronic search of PubMed databases, including articles till the end of November of 2018 and using the following keywords: "visceral aneurysm", "pseudoaneurysm" and "endovascular treatment". From this research, 2043 had their abstract assessed, 359 were selected and 241 were excluded for not being directly related to the subject and 118 were included, according to the authors´ preference and scientific relevance in this work´s context.

VISCERAL ARTERY ANEURYSMS (VAA) AND PSEUDO-ANEURYSMS (PSA)

1. DEFINITIONS

Although frequently described as equal, true aneurysms and pseudo-aneurysms are different clinical conditions, with different etiologies and natural histories.

While true aneurysms are focal enlargements of the artery diameter involving all vascular layers [(1)], pseudoaneurysms (also known as false aneurysms) represent a disruption in arterial wall continuity with patent flow in a defined space beyond the vessel walls. In other words, true aneurysms are focal dilations that involve all vessels layers, while pseudoaneurysms do not. [(1)]

2. EPIDEMIOLOGY

The reported incidence of VAA is approximately 0,01% to 2%. Although several visceral vessels can be affected, VAA's most commonly affect the splenic artery (60%), followed by the hepatic, superior mesenteric, gastric, celiac, pancreaticoduodenal, gastroduodenal, inferior mesenteric and renal arteries (Table 1). [(2-5)]

3. ETIOLOGY AND PATHOGENESIS

The etiology and pathogenesis of VAAs isn´t fully understood. Nonetheless, there are several known risk factors and clinical disorders related to these conditions.

The most frequent causes of VAA are atherosclerosis (32%), medial degeneration and/or dysplasia (24%), abdominal trauma (22%) and infection / chronic inflammation (10%). Other know causes are summarized on table 2. [(1, 6-8)]

Regarding pseudoaneurysms, their etiology is also variable, although inflammation (pancreatitis and cholecystitis) and infection are generally considered the most frequent causes. Other conditions such as vasculitis, trauma, various iatrogenic causes (surgery, percutaneous drainage procedures, biopsies), arterial wall erosion due to extrinsic compression[(9)], collagen vascular disease, segmental arterial mediolysis and malignancy, are also associated with these lesions. [(7)]

4. CLINICAL PRESENTATION

VAA's and PSA's have fairly similar clinical presentations, which may vary from total absence of symptoms to life threatening hemorrhage and death. [(10)] Abdominal pain is the most common symptom of unruptured aneurysms, followed by jaundice, compressive symptoms (nausea, vomiting) or gastric outlet obstruction. [(11-13)] When rupture occurs, gastrointestinal hemorrhage is the most common clinical presentation. [(11, 13)] Depending on the location of the aneurysm, it can present as hematemesis, melena, hematochezia, hemobilia, retroperitoneal hemorrhage, hypotension and hemorrhagic shock. [(7, 13-15)] Pain is present in only one third of the patients. [(14)]

Important clues that aid in the diagnosis of visceral aneurysms include anemia of unexplained cause, recurrent and intermittent hematemesis or hematochezia, and rapid enlargement of an otherwise stable pancreatic pseudocyst. [16]

5. DIAGNOSIS

Current diagnostic workups for both true and false aneurysms are very similar.

Several imaging modalities have been used to identify these lesions, although ultrasound (US), computed tomography (CT), magnetic resonance imaging (MRI) and angiography represent the diagnostic mainstay. Plain X-ray of the abdomen is a rarely helpful study but may show shell-like calcifications in atherosclerotic aneurysms. [11]

5.1 Ultrasonography (US)

Ultrasonography is often used as the initial screening tool for VAA's and PA's. [10]

On US, a pseudoaneurysm typically appears as an ovoid structure [9] or anechoic lesion with thin walls on grey scale scan, which fills with color and shows the characteristic "yin-yang" flow with bidirectional waveform pattern on duplex color Doppler ultrasound. [10] The peripheral part of a pseudoaneurysm may show variable extent of thrombosis, which appears hypoechoic or echogenic, often with stratification due to thrombosis of different ages. [10]

On the other hand, true aneurysms appear as round, hypoechoic and, depending on the size of the thrombus boundaries, perfused masses.

Although useful, US has known limitations, particularly in this subset of patients, where the deep location of the visceral vessels can limit the sensitivity for detection of such lesions. Therefore, the diagnostic accuracy of this method is limited, particularly when obesity and increased bowel gas are present. Also, operator variability is an issue. [10]

5.2 Computed Tomography Angiography (CTA)

Multidetector CT angiography is the most commonly used and most sensitive non-invasive modality to formally assess arterial flow in the abdomen and pelvis. Multiphase acquisitions (precontrast, arterial phase, venous phase, and delayed phase images) allow a detailed assessment of the vascular anatomy. [10, 17] As such, it is no surprise that this examination is particularly useful when assessing VAA's and PSA's.

Routinely, CTA should include both arterial and venous phases as some aneurysms with narrow necks may not be visible on arterial phase. On the other hand, pseudoaneurysms are usually visible on both phases. [10]

CTA can also reveal VAA and PA complications, such as interval enlargement, rupture, and mass effect on nearby structures. Rupture is seen as an 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 aneurysm, whereas extravasation will persist. [9]

5.3 Magnetic Resonance Imaging (MRI)

MRI is usually not the initial imaging modality to assess vascular anatomy. However, it may incidentally identify visceral aneurysm while evaluating other disease processes. It is useful as an adjunct to US or an alternative to CT in patients with contraindication to CT contrast, including those with iodine allergy or reduced renal function. [17, 18]

5.4 Angiography

The gold standard diagnostic imaging tool for VAA's and visceral PSA's is angiography. [19] This technique serves both diagnostic and therapeutic purposes, since it allows both an accurate delineation of the arterial anatomy while granting the possibility of a therapeutic intervention. [19] It has the highest diagnostic sensitivity (100%) followed by computed tomography (CT) (67%) and ultrasonography (US) (50%). [11]

A- SPLENIC ARTERY ANEURYSMS (SAA)

Splenic artery aneurysms are the most common nontraumatic abdominal visceral aneurysms, accounting for 60-80% of cases. Their true prevalence is unknown, but estimates suggest that less than 0,11% of the general population is affected. [20]

Most of them occur in the distal third of the splenic artery (75%) followed by the middle third (20%). [21] Several authors have found a significant increase in rupture risk when the aneurysm is > 2 cm, which confers high morbidity and mortality. [22, 23]

They are known to occur more often in women than in men (male/female ratio of 1:4), although this difference in prevalence is potentially related to an increased incidental diagnosis secondary to regular US use during pregnancy. [22, 24, 25]

1. ETIOLOGY

The etiology of splenic artery aneurysms has been associated with hormonal changes of pregnancy, multiparity, portal hypertension, fibromuscular dysplasia, alfa-1 antitrypsin deficiency, intravenous (IV) drug abuse, systemic hypertension [20, 22, 26] and liver transplantation. [3, 22, 27]

2. SYMPTOMS

Although SAA's are most often asymptomatic, patients may present with left upper quadrant abdominal pain, a pulsatile left upper quadrant abdominal mass, or hypotensive shock secondary to aneurysm rupture (3–10% of cases).

When ruptured, SAA's are associated with high mortality rates, ranging from 10% to 25%. These figures increase significantly during pregnancy, where the risk of maternal death is estimated to be as high as 70%, with a fetal mortality rate greater than 90%. [28] The risk of rupture is increased when the aneurysm measures more than 2 cm in diameter and during physiologic and pathologic states such as pregnancy, splenomegaly, portal hypertension, liver transplantation, and pancreatitis. [29]

It is important to note that SAA rupture can be followed with hemodynamic instability only 6 to 96 hours later. This delayed onset of rapid blood loss is characteristic for the "double-rupture phenomenon", which results from initial tamponade of the bleeding within the lesser omental sac and delayed onset of intraperitoneal hemorrhage.

3. TREATMENT

3.1- Indications for treatment

Current established indications for treatment are summarized on table 3. [20, 22, 24, 26, 30]

3.2- Treatment options

Both open repair and endovascular therapies can be used in the treatment of splenic artery aneurysms.

3.2.1- Endovascular treatment options (EVT)

Several endovascular treatment options can be used for splenic artery aneurysms management, with high technical success rates and low morbidity and mortality rates. [24, 30]

Whenever possible, treatment should aim at preserving the flow of the native splenic artery. As such, aneurysm exclusion through the implantation of a covered stent should be the first line of treatment. This is usually reserved for aneurysms located in the proximal and middle portions of the artery (better landing zones), as long as the native artery has a baseline tortuosity compatible with endovascular navigation. [31]

When proper landing zones are present but native artery's tortuosity is prohibitive for covered stent navigation and implantation, a "coil and cage" technique can be applied. Through this technique, a self-expandable bare-metal stent is initially implanted (more flexibility and better navigability than covered stents), after which, aneurysm sac coil embolization is performed through the stent's mesh. By using this technique, one can induce selective sac thrombosis, while preserving the flow in the native artery and avoiding distal coil embolization.

Although native artery preservation is recommendable, this is not always possible, particularly in juxta-hilar aneurysms or in situations where prohibitive tortuosity of the native artery is present. When facing such scenarios, terminal embolization of the splenic artery can be performed, usually by selective coiling according to the "sandwich technique". Through this technique, selective coil embolization of the splenic artery is performed, with coil implantation distally and proximally to the aneurysm, as well as in the aneurysm sac. Since terminal embolization is performed, the risk of splenic infarction is significant, although in many cases the perfusion of the spleen through the short gastric vessels is enough to ensure this organs survival. [21]

Finally, when dealing with intrasplenic aneurysms, selective embolization is usually recommended, either with coils, particulate embolics, glue, or Onyx®. Special attention should be taken in order to avoid iatrogenic embolization of other intrasplenic arteries. [31]

3.2.2- Open Surgery

Surgical treatment of SAAs remains a viable option, although usually reserved when endovascular management is not possible.

Depending on the location of the aneurysm, the recommended surgical intervention differs:

i) For aneurysms located in the proximal or middle portions of the splenic artery, ligation without the need for surgical bypass is the preferred technique;

ii) When hilar or intrasplenic aneurysms are present and an open approach is chosen, splenic artery ligation with splenectomy is usually recommended.

3.2.3- Laparoscopic Surgery

In cases where both open and endovascular surgery are unsuitable, laparoscopy might be the preferred treatment option. It usually consists in the laparoscopic ligation of the splenic artery, proximally and distally to the aforementioned aneurysm. In some situations, splenectomy can also be performed.

4. PREGNANGY AND SPLENIC ARTERY ANEURYSMS

Splenic artery aneurysms are associated with high rates of mortality particularly when rupture occurs during pregnancy. [32] These mortality rates can be attributed to the asymptomatic nature of the aneurysm, rapid deterioration after rupture, and frequent misdiagnosis. [33]

Although the general risk of SAA rupture in non-pregnant females is low, around 2%, it increases significantly during pregnancy [32], leading most authors to recommend treating splenic artery aneurysms in patients who are pregnant or intend to be pregnant, regardless of their size. [22, 23, 34]

Although rare, the mortality for ruptures in nonpregnant patients is approximately 25–36%. [35] This rate nearly doubles in pregnant patients (65–75%, > 90% fetal mortality) [32] and patients with portal hypertension (> 50%). [36] Approximately 70% of ruptured SAA in pregnant patients are initially diagnosed as uterine rupture and, therefore, increase awareness for these lesions is essential among health professionals.

B- SPLENIC ARTERY PSEUDOANEURYSMS (SPSA)

Splenic artery pseudoaneurysms are distinct entities from true splenic artery aneurysms, and unlike the former, have a characteristically male predominance. [37]

The majority of splenic artery pseudoaneurysms are secondary to adjacent pancreatic disease (52%), including chronic pancreatitis, acute pancreatitis, and pancreatic pseudocysts. [20, 38] Abdominal trauma is the underlying etiology of 29% of splenic artery pseudoaneurysms, while postoperative complications and ulcer disease are responsible for 3% and 2% of these lesions, respectively.

1. SYMPTOMS

The most common symptom is hemorrhage into an adjacent structure. Bleeding into the pancreatic duct is the most common location (42%), followed by the stomach (22%), peritoneal cavity (20%), and colon (15%). [38]

2. TREATMENT

Similar to other arterial pseudoaneurysms, the risk of rupture is deemed high and, as such, treatment of these lesions is recommended, regardless of their size or clinical manifestation. [39]

Current treatment strategies are similar to those discussed for true aneurysms. Endovascular intervention should be performed whenever possible, and the treatment of choice is terminal embolization or aneurysms exclusion with covered stent, depending on the baseline anatomy.

C- HEPATIC ARTERY ANEURYSMS (HAA)

Although their incidence in the general population is quite low (0.002-0.4%), hepatic artery aneurysms (HAA) are the second most common type of nontraumatic abdominal visceral arterial aneurysms (14- 20%). [40-42] They are commonly seen in males, affecting 50% more men than women [43], usually in the fifth to sixth decade of life. They occur most frequently in the common (CHA) or proper (PHA) hepatic arteries, particularly in the right hepatic artery branches (50%). [44] Aneurysm multiplicity occurs in only 20% of the cases [45] and, as such, the majority of HAA are single and are located extra-hepatically. [46]

1. ETIOLOGY

The causes of hepatic artery aneurysms have evolved over time. Before the advent of antibiotics, a mycotic influence was the most common cause; however, atherosclerosis now accounts for most non-traumatic cases. [47] Iatrogenic causes are also very common, particularly due to the widespread use of interventional diagnostic and therapeutic biliary procedures.[43] Abdominal trauma, infection, inflammation, connective tissue disorders (e.g. fibromuscular dysplasia, Marfan syndrome)[41, 48], and vasculitis (e.g. Polyarthritis Nodosa) [49] are other predisposing factors.

Intrahepatic aneurysms are known to occur most frequently due to iatrogenic injury or trauma [43], whereas extrahepatic aneurysms are usually the result of degenerative or dysplastic diseases. [43] False anastomotic aneurysms may form after liver transplantation. [43]

2. SYMPTOMS

Patients are often asymptomatic [50], but may present with pain in the right upper quadrant of the abdomen, hemobilia (gastrointestinal bleeding), gastrointestinal hemorrhage, chronic anemia, and jaundice from extrinsic compression of bile ducts by the aneurysm sac. [12] A triad of epigastric pain, hemobilia and obstructive jaundice (Quincke´s triad) is seen in up to one-third of the cases. [51] Unusual presentations of HAA as cholangitis and portal hypertension are also reported. [52]

In HAAs presenting with gastrointestinal hemorrhage, the blood loss can range from chronic hemorrhage to massive hemorrhage with the risk of circulatory collapse. Patients are often asymptomatic in intervals, due to mural thrombus formation providing intermittent bleeding cessation. [53]

3. RUPTURE

The presence of multiple HAAs as well as a non-atherosclerotic etiology are considered risk factors for rupture.[42] No distinction has been made between extra-hepatic and intra-hepatic aneurysms with respect to rupture and mortality rates; however, the lack of a "tamponade" effect by the surrounding hepatic parenchyma probably makes an extra-hepatic aneurysm more dangerous.

Studies report a mortality rate that ranges from 20 to 30% [12]. Nonetheless, these rates can go up to 100% depending on the aneurysm diameter, location and etiology [24, 42, 46, 54], making early diagnosis of major capital. [55]

4. TREATMENT

4.1- Indications for treatment

HAA's can be treated with either open with surgery and/or endovascular techniques. [46] Technique selection should be performed bearing in mind both the general condition of the patient as well as the baseline anatomy of the lesion. [24, 42]

Treatment is usually recommended when the diameter exceeds 2cm or if the patient is symptomatic. [20] Special attention should be paid to high-risk lesions, namely those that occur in patients with polyarteritis nodosa or fibromuscular dysplasia, in whom treatment is recommended regardless of lesion size. [42]

4.2- Treatment options

4.2.1- Endovascular management

Several endovascular strategies can be used in the treatment of hepatic artery aneurysms. The choice of technique is dependent on the location of the aneurysm, particularly if the lesion is intra or extra-hepatic.

a)- Intra-hepatic branch aneurysms

Due to its location, and taking into account the dual hepatic perfusion, intrahepatic branch aneurysms are usually treated by embolization, either with coils, glue, or Onyx®. [43] Alternative treatment approaches include imaging-guided direct transhepatic puncture with subsequent coil placement, injection of thrombin or a liquid casting agent.

b)- Extra-hepatic branch aneurysms

Different treatment approaches exist for extrahepatic aneurysms, including open surgical repair, coil embolization, and endograft placement.[17] Direct surgical repair of

extrahepatic aneurysms is recommended in most patients, with endovascular treatment often being reserved for high-risk surgical candidates.

Aneurysms of the common hepatic artery (CHA) can be excluded through terminal embolization (sandwich technique), as long as the gastroduodenal artery is preserved, since in such conditions, it will be responsible for liver perfusion .[43] Although aneurysm exclusion through covered stent implantation can also be used to treat aneurysms of the CHA, one must recall that local anatomy isn't always favorable for such approach. [30]

D- HEPATIC ARTERY PSEUDOANEURYSMS

The incidence of hepatic artery pseudoaneurysms has risen with the increase in percutaneous and laparoscopic biliary procedures. Involvement of the right hepatic artery is most common (79%) followed by the common hepatic artery (10%) and the left hepatic artery (8%). In a review by Tessier and coworkers, the average size of hepatic PSA is about 23 mm in diameter. [38]

1. ETIOLOGY

Hepatic artery pseudoaneurysms can develop secondary to blunt or penetrating abdominal trauma, following liver transplantation or erosion of hepatic artery by primary or secondary malignancy. Iatrogenic causes in order of decreased frequency include: transhepatic biliary drainage procedures, cholecystectomy, pancreatic duodenectomy, percutaneous liver biopsy, hepatectomy, hepaticojejunostomy, and transhepatic intrajugular portosystemic shunt creation. [38] [56-58]

2. PARTICULARITIES OF THE DIAGNOSIS

Contrast-enhanced CT usually shows an arterial phase–enhancing intrahepatic mass or an extrahepatic outpouching from the common or proper hepatic arteries. Surrounding hematoma is often observed.

3. SYMPTOMS AND RUPTURE

The presenting symptoms include hemobilia, hematemesis, abdominal pain, and hematochezia. Complications of hepatic artery PSA include rupture into adjacent hepatic veins, portal veins, biliary system or abdominal cavity. A study by Tessier revealed that rupture occurred in 71% of patients with iatrogenic hepatic artery PSAs and, of those that ruptured, the mortality rate was 16%. [38]

4. TREATMENT

For intrahepatic pseudoaneurysms, the treatment of choice is coil embolization, whereas for extrahepatic pseudoaneurysms, treatment depends on the involved vessel and the location of the aneurysm.

E- SUPERIOR MESENTERIC ARTERY ANEURYSMS (SMA)

Superior Mesenteric artery aneurysms are the third most common type of nontraumatic visceral arterial aneurysm, representing about 5–7% of cases. Nonetheless, although infrequent, these VAA's are particularly dangerous, due to the high incidence of ischemic bowel complications [59] as well as sepsis, when a mycotic etiology is present. [60] About 38–50% of patients with SMA VAA experience rupture [59], and noncalcified aneurysms appear to have the highest risk for such. [61]

1. ETIOLOGY

Infection (such as endocarditis) and arterial dissection are the most common causes. [62] Apart from the abdominal aorta, the SMA is the most likely location for a mycotic aneurysm. Atherosclerosis and inflammation from pancreatitis place as the third and fourth most common causes of SMA aneurysms, respectively.

2. SYMPTOMS

Unlike other visceral artery aneurysms, 70–90% of the SMA aneurysms are symptomatic, with significant and progressive abdominal pain, nausea, or massive hemorrhage due to rupture. [63] Potential complications include acute thrombosis or thromboembolization with acute mesenteric ischemia, potentially leading to bowel perforation. [63]

3. PARTICULARITIES IN DIAGNOSIS

Most aneurysms of the SMA involve the proximal 50 mm segment of the artery.

4. TREATMENT

Management options of SMA aneurysms include expectant observation, endovascular intervention, and open surgery. Although serial monitoring has been described for other VAAs > 15 mm, it is not the preferred option with SMA VAAs due to the higher rate of rupture or thrombosis. [64]

The choice of technique depends on the proximity of important side branches requiring continued patency. Direct surgical excision, bypass graft placement, and endovascular repair are all reasonable options depending on the location and size of the aneurysm. Rarely, covered stents can be used.

4.1- Open Surgery

Open surgery is the preferred management option for surgically fit patients, with aneurysmectomy and vessel reconstruction, but is associated with a significant mortality of 15%. [64, 65]

4.2 Endovascular management

Endovascular management has been described, but also carries significant risks, including iatrogenic dissection and rupture, acute thrombosis, thromboembolization and infective dissemination when associated with a mycotic etiology. [64] This approach is probably best reserved for patients deemed unsuitable for extensive surgery and reconstruction, saccular aneurysms or those with a hostile abdomen, but may be considered in other elective situations. If the SMA anatomy is favorable, endovascular stent grafting has an excellent safety profile and good outcomes [64]; aneurysm coiling with distal and proximal branch vessel occlusion is also a possibility..

F- SUPERIOR MESENTERIC ARTERY PSEUDOANEURYSMS

1. ETIOLOGY

Inflammation (usually from pancreatitis) and trauma seem to be the most frequent causes of SMA pseudoaneurysm formation.

2. SYMPTOMS

Almost all SMA pseudoaneurysms are symptomatic, with moderate to severe progressive abdominal pain and possible bleeding. A mortality rate of up to 37% from SMA pseudoaneurysm rupture and hemorrhage has been reported. [39]

3. TREATMENT

Treatment guidelines are similar to those for nontraumatic SMA aneurysms. Surgery is the standard treatment and involves ligation of the vessel below and above the aneurysm and, most important, aneurysm resection and vessel reconstruction. [66]

G-GASTRIC ARTERY ANEURYSMS (GAA) AND PSEUDOANEURYSMS

Gastric Artery Aneurysms (GAA) account for approximately 4% of nontraumatic visceral arterial aneurysms. [66] They are more common in men than women (3:1), and tend to occur in the sixth to seventh decade of life. [67]

1. ETIOLOGY

Gastric artery aneurysms and pseudoaneurysms are usually secondary to inflammatory processes such as acute pancreatitis, peptic ulcer disease, vasculitis, arteriosclerosis, trauma and connective tissue disorders. [68]

These lesions can be classified as either intramural or extravisceral, depending on their location. Extravisceral GAA rupture presents with intraperitoneal hemorrhage [69], whereas intramural GAA rupture can present as massive hematemesis. [70]

2. SYMPTOMS

Ninety percent of the GAA's present as rupture, with epigastric pain, hemodynamic instability, and anemia. Non-ruptured aneurysms are asymptomatic or associated with vague abdominal dyspepsia. [69] Less commonly, patients may present with epigastric discomfort or with associated chest pain. [71]

3. RUPTURE

The mortality rate reported in several case reports is about 80%, since many patients present after rupture, with acute abdomen and hypovolemic shock. [72] Left gastric artery aneurysms (LGAAs) are associated with a high rate of rupture and, consequently, have recorded mortality rates of up to 70%. [71]

4. PARTICULARITIES OF THE DIAGNOSIS

Diagnosis of a ruptured LGAA can be difficult and requires a high level of suspicion in all unexplained cases of hemoperitoneum.

5. TREATMENT

5.1- Open Surgery

Open exploration has the advantage of elimination of hematoma as well as inspection of viscera and assessment of any other aneurysm. Classic surgical options include ligation of the aneurysm or aneurysm resection with revascularization. [73-75] Laparoscopic approaches may offer an alternative to conventional open surgery, providing the benefit of lower procedural morbidity secondary to a smaller incision while maintaining the ability to sample tissue for pathologic analysis. [76]

5.2- Endovascular management

When patients present with rupture, an endovascular approach is currently recommended as the first-line therapy. [73] Endovascular alternatives include ablation of the GAA with coils, glue, or embolic agents. [69] Covered stents may be considered if flow has to be maintained through the vessel. [77]

H- CELIAC ARTERY ANEURYSMS

Celiac artery aneurysms are the fourth most common type of nontraumatic visceral artery aneurysm, representing 3-4% of the cases. Similarly to other arterial aneurysms, the risk of rupture raises significantly with the increase in vessel diameter, and the estimated risk of rupture for celiac artery aneurysms greater than 32 mm in diameter is 50-70%. [78]

1. PARTICULARITIES OF THE DIAGNOSIS

Celiac artery aneurysms can be associated with abdominal aortic aneurysms in up to 18% of the cases and with other visceral arterial aneurysms in as many as 50% of the cases. [79] Therefore, identification of one aneurysm should prompt screening for others.

2. TREATMENT

Direct surgical excision, bypass graft placement, and endovascular repair are all reasonable options depending on the location and size of the aneurysm as well as the suitability of the celiac artery.

I- CELIAC ARTERY PSEUDOANEURYSMS

1. ETIOLOGY

Atherosclerosis, inflammation (usually from pancreatitis or postsurgical pancreatic-enteric anastomosis) and trauma are the most frequently reported causes in the literature. [80]

They present a relatively high risk of rupture, which is coupled with a nearly 100% mortality rate.

2. TREATMENT

2.1- Open Surgery

Treatment guidelines are similar to those for nontraumatic celiac artery aneurysms, but with standard treatment being surgical. [80]

Exclusion of a celiac artery pseudoaneurysm by means of celiac artery coiling is dangerous in patients who have undergone distal gastrectomy or pancreaticoduodenectomy. [80]

2.2- Endovascular management

In some cases, patency of the celiac artery can be preserved by excluding the aneurysm with a covered stent placed through the celiac artery into the hepatic artery. This technique intentionally sacrifices the splenic artery, leaving spleen in the dependence of collateral circulation.

J- PANCREATICODUODENAL ARTERY ANEURYSM (PDA)

Pancreaticoduodenal artery aneurysms (PDAs) are quite rare, and account for only 2% of all visceral arterial aneurysms. [81] They may be congenital or caused by atherosclerosis, celiac axis stenosis, pancreatitis, infection, trauma, or fibromuscular hyperplasia. [82] Atherosclerosis and celiac axis stenosis are generally considered the most common causes.

1. RUPTURE

PDA aneurysms usually rupture into the retroperitoneal space and in some cases, symptoms mimic gastroduodenal, biliary, or pancreatic disease[83] which make prompt diagnosis and treatment difficult. More than 60% of PDAs are shown to be at rupture [84] and are associated with significant mortality rates, reaching up to 75% [85], and with no correlation with the aneurysm size. Approximately 17,6% of ruptured aneurysms are ≤10 mm in diameter. [86]

2. SYMPTOMS

Abdominal pain is the most common initial symptom of PDA.[87] Pancreaticoduodenal artery aneurysms often manifest as retroperitoneal masses around the head of the pancreas due to rupture into the retroperitoneal space, accompanied with unexplained jaundice.[84]

3. PARTICULARITIES OF THE DIAGNOSIS

Despite the noninvasive modalities, selective digital subtraction angiography remains the gold standard for the diagnosis of PDA aneurysms, since both the location of the aneurysm and the supplying artery can be determined, while definitive treatment can be simultaneously performed. [88]

5. TREATMENT

A major goal in the treatment of aneurysms associated with celiac trunk stenosis revolves around obliteration, resolution of any associated pathologies, and maintenance of adequate blood flow to territories of the celiac trunk. [88]

5.1- Open Surgery

Surgical options vary between ligation/resection and aneurysmorrhaphy. [88] These treatments are associated with a high mortality rate and technical difficulties, mainly after rupture. [88]

5.2- Endovascular management

Less invasive techniques, particularly coil embolization, have recently been predominating. [88] Embolization may be used to perform total occlusion of the parent artery in cases of fusiform aneurysms, or selective aneurysm sac embolization, when it has a saccular configuration with favorable neck. [88] The most concerning complication after embolization is reperfusion, with subsequent rupture and bleeding into the abdominal cavity. The incidence of this complication depends on the technical success of the procedure and reportedly ranges from 5% to 20% [89], thus requiring strict imaging follow-up. Further complications of embolization include ischemic injury to the liver, pancreas, or duodenum; tissue necrosis with subsequent abscess formation; and possible sepsis. [88]

K- GASTRODUODENAL ARTERY ANEURYSMS (GDA)

Gastroduodenal Artery Aneurysms (GDA) are rare conditions with few cases reported in the literature. They account for only 1,5 % of all splanchnic artery aneurysms, are most commonly found in males (male/ female ratio of 4,5:1) and, in about 33 % of cases, are multiple[90].

1. ETIOLOGY

Pancreatitis and atherosclerosis are the most common etiological factors associated with GDA aneurysm formation. [82] [91] Ethanol abuse (25%), peptic ulcer disease (17%) and cholecystectomy (3%) are also associated with this condition. [12, 92] [93]

2. SYMPTOMS

A gastrointestinal hemorrhage secondary to rupture of the aneurysm was found to be the most common clinical presentation (52%). Abdominal pain is the second most common symptom and occurs in 46% of cases. Only 7,5% of GDA aneurysms are diagnosed while asymptomatic.

3. RUPTURE

Once a GDA aneurysm ruptures, the patient faces a life threatening condition that could rapidly lead to death in 40% of cases. Therefore, it is of utmost importance to diagnose and treat GDA aneurysms before a fatal complication occurs. Such complication is not always related to the size of the aneurysm and therefore treatment should be planed as soon as a diagnosis is made. [94]

4. TREATMENT

Therapeutic strategies include open surgery (revascularization, vessel ligation, aneurysmal sac exclusion) or endovascular intervention (coil embolization, exclusion through covered stent). [94] [95]

L- PANCREATICODUODENAL AND GASTRODUODENAL ARTERY PSEUDOANEURYSMS

Pancreaticoduodenal and Gastroduodenal pseudoaneurysms are actually more common than true PDA and GDA aneurysms. Inflammation (usually from pancreatitis), surgery, and trauma are the most frequently reported causes of PDA and GDA pseudoaneurysms. Symptoms and diagnosis are similar to the respective aneurysms. Treatment usually involves coil embolization.

M- INFERIOR MESENTERIC ARTERY ANEURYSM (IMA)

Inferior mesenteric artery aneurysms (IMA) are rare entities, representing 1% of all splanchnic aneurysms. They are often found incidentally on the evaluation of other intra-abdominal pathologies. Similar to other visceral arterial aneurysms, there is an estimated 20-50% risk of potentially fatal rupture. [96]

1. TREATMENT

1.1- Indications for treatment

Asymptomatic visceral artery aneurysms presenting with more than 20 mm in diameter or those that are symptomatic or rapidly expanding, require intervention. As with most aneurysmal repairs, the goals of intervention are exclusion to prevent expansion and rupture, and confirmation that arterial circulation provides adequate distal collateral flow.

1.2- Treatment options

Open surgical treatment options include either ligation of the IMA after confirmation of good collateral blood flow to the colon, or alternatively, resection of the aneurysm with reconstructive bypass. [97-100]

Consistent with the treatment trend observed in other aneurysms, endovascular modalities with stent placement or coil embolization have demonstrated increasing feasibility. [97, 101]

N- RENAL ARTERY ANEURYSMS (RAA)

Renal Artery Aneurysms are rare entities. They have been described in about 0,09% of autopsies [102] although, some studies report an incidence between 1% and 10%. [17] They are more common in women (male/female ratio of 1:1,75) [102] and the average patient age at presentation ranges from 50 to 61 years.

Although not considered classic visceral artery aneurysms, renal artery aneurysms are discussed in this review, because they involve vascular supply to a key abdominal organ.

For unknown reasons, right-sided aneurysms are more common than left-sided lesions. Approximately 80% of renal aneurysms are saccular, with a variety of causes; most of the remaining 20% are fusiform aneurysms, and are associated with advanced renal artery medial fibrodysplasia. [17] In approximately 20% of the patients RAAs are bilateral. The most common location is at the main renal artery bifurcation (60%). [103]

RAAs are commonly classified using the Rundback classification as saccular aneurysms from the main renal artery (type I), fusiform aneurysms (type II) and intralobar aneurysms (type III).

At least 50% of all renal artery aneurysms are discovered incidentally, most commonly at a first-order branch of the main renal artery. [17]

1. ETIOLOGY

The most common associated vascular pathology is renal artery fibromuscular dysplasia (34%), whereas iatrogenic injuries after percutaneous treatments are responsible for most intraparenchymal false renal artery aneurysms. [102]

2. SYMPTOMS

The majority are asymptomatic but can present with uncontrolled hypertension (up to 90%), abdominal or flank pain, or life-threatening hemorrhage due to rupture[102]). Less frequently, hematuria [104] and renal infarction are described.

3. TREATMENT

3.1- Indications for treatment

Although the lower threshold for treatment is typically 20 mm of largest diameter, rupture of aneurysms with less than 20 mm has been reported. [105] Current data has led to a consensus that aneurysms > 20 mm warrant repair. [103, 106] Nonetheless, in the setting of poorly controlled hypertension, there is controversy regarding the size threshold to offer treatment, with some authors favoring treatment of aneurysms as small as 10 mm while others draw a line at 15mm or 20 mm. [103, 106]

3.2-Treatment options

Treatment options for RAAs include nephrectomy, open surgical repair with aneurysmectomy and/or renal artery bypass, ex vivo repair and auto-transplantation, laparoscopic repair, nonselective embolization, selective embolization with afferent and efferent vessel preservation, and stenting to exclude the aneurysm. [107]

3.2.1- Open Surgery

Open surgery was considered the standard therapy, being aneurysmectomy the most commonly method used. When dealing with saccular aneurysms, arteriorraphy with or without patch is a good approach. In difficult anatomies, ex vivo repair and auto-transplantation, can be performed.

3.2.2- Endovascular management

Endovascular treatments are often associated with faster procedure times and fewer complications. [30] These include selective coil embolization of the aneurysm sac, as well as aneurysm exclusion through covered stent implantation. In some situations, a "coil and cage" technique can also be used.

Depending on the location of the aneurysm, different endovascular strategies can be used.

For aneurysms located in the main renal artery, in the presence of proper landing zones, aneurysm exclusion through covered stent graft implantation is recommended. When these lesions have a saccular configuration with narrow neck, selective sac embolization can be performed. A "coil and cage" technique can be used in order do "cage" the coils inside the aneurysm sac, therefore avoiding a possible migration into the main renal artery, with subsequent artery thrombosis and kidney loss.

While aneurysms of the main renal artery are fairly straightforward to treat with endovascular techniques [108], aneurysms of the distal renal artery as well as those located in the hilum are more challenging. As such, these lesions are frequently referred for open surgical treatment, with reconstruction of the renal artery, with or without autologous renal transplantation. [108]. Nonetheless, the "coil and cage" technique has been used in some of these situations, particularly concerning saccular aneurysms of the renal hilum.

There are some reports in literature regarding the use of flow diverter stents, although current evidence is scarce. [109] [110]

O- RENAL ARTERY PSEUDOANEURYSMS

1. ETIOLOGY

Most renal artery pseudoaneurysms result from either penetrating trauma or iatrogenic causes (complication of percutaneous urologic procedures including biopsy, nephrostomy tube placement and partial nephrectomy). [111] Renal artery mycotic pseudoaneurysms can also be encountered.

2. SYMPTOMS

Most patients with symptomatic renal artery PSA's present with flank pain and gross hematuria. The main risk of renal artery PSA is erosion into the renal collecting system. Hemorrhage after renal trauma can occur days to weeks or even years after the inciting traumatic event. PSA formation following partial nephrectomy is a rare occurrence.

3. TREATMENT

Endovascular therapy with coil or gelatin sponge embolization is usually recommended, with a success rate higher than 80% in the control or prevention of hemorrhage, while preserving the renal parenchyma. [112]

TREATMENT RECOMMENDATIONS FOR VAA'S AND PSA'S

Whether we are dealing with true or false aneurysms, treatment indications differ. Table 4 summarizes current treatment thresholds and gold-standard treatment options for the main VAA's and PSA's. It is nonetheless essential to keep in mind that such indications should always be adapted to the patient and clinical scenario.

REVIEW ON CURRENT ENDOVASCULAR TREATMENT OPTIONS

1- <u>Aneurysm exclusion via total occlusion of the native artery</u>

1.1- Coil Embolization

Embolization is usually preferred when selective aneurysm sac embolization can be performed (aneurysms with short necks) or when terminal embolization of non-essential arteries is planned. Coils act by slowing the flow through mechanical obstruction, while inducing thrombosis via their thrombogenic fibers and inciting a secondary inflammatory reaction. Detachable coils provide better control and more precise deployment than pushable coils, and as such, should be preferred when precise deployment is essential. [113]

1.1.1- "Sandwich" technique

This technique is mainly used in splenic artery aneurysms without proper distal landing zones, such as the ones located near the spleen hilus. Since this organ can survive only with short vessel perfusion, aneurysm exclusion by means of native artery embolization can be performed, and is frequently the only solution available.

This technique is based in the selective embolization of both the aneurysm sac as well as the native artery, proximally and distally to it, from where its name - "Sandwich Technique" – derives.

1.2- Vascular plug occlusion

The use of Vascular plugs is ideal for the embolization of large vessels with high flow. In these vessels, limited control of coils can lead to coil migration and non-target embolization.

2- Aneurysm exclusion with preservation of the native artery

2.1- Covered stents

As long as the artery's tortuosity allows navigation of the stent to the desired location and proper sealing zones are available, aneurysm exclusion by means of covered stent represents an effective and elegant solution for this type of pathology. Their use in tortuous vessels (such as the splenic artery) might be quite difficult, although in straight vessels like renal artery's, they remain particularly useful**.**

2.2- Aneurysm sac coiling

Selective aneurysm sac coiling represents another effective technique for the treatment of visceral artery aneurysms, particularly when saccular morphologies with short necks are present. Classic transcatheter coil embolization with dense packing in the aneurysmal sac allows for aneurysm exclusion with native artery preservation. Liquid embolization agents can also be used, alone or after the coiling, in order to obtain a better exclusion.

Although being an effective technique, the risk of distal embolization with target organ infarction must not be forgotten, and therefore, proper selection of the cases is essential for optimal results.[114]

2.3- "Coil and cage" technique

The "coil and cage" technique is an adaption of the classic aneurysm sac coiling technique, and its purpose is to prevent distal coil migration and subsequent target organ infarction.

This technique consists of selective embolization of the VAA, performed via microcatheter and through the mesh of a previously implanted bare-metal stent. In this way, the coils are in fact "caged" inside the aneurysm sac and outside of the vessel lumen, and therefore coil migration is prevented, granting its use even in saccular aneurysms with broad necks.

Although it can be performed in several vascular territories, this technique is particularly useful in some terminal circulations such as the renal hilus, in which the implantation of a covered stent could result in segmental artery exclusion. [114]

2.4- Multilayer stents (flow diverters)

Multilayer stents are considered an alternative treatment option with great future applications and are seen as the latest technology in the field of aneurysm exclusion.

These stents are specifically designed to reduce flow velocities in the aneurysm sac, promoting sac thrombosis while maintaining flow to both the native artery as well as its branches

Although it represents a conceptually great idea, these stents await proper validation, since current evidence is limited to a few case reports and short series. In a recent systematic review by

Sfyroeras et al., [109] FDSs were used to treat 100 visceral and peripheral aneurysms with satisfactory technical success, aneurysm thrombosis, and branch vessel patency. However, there was a significant incidence of stent thrombosis (8%).

OTHER APPROACHES

1. Percutaneous approach

Percutaneous embolization of visceral aneurysms can be performed under either ultrasonography or CT guidance [10]. It is generally used for situations in which, either due to the aneurysm location or native artery's anatomy, successful endovascular exclusion is not possible.

This technique is usually performed in aneurysms surrounded by solid organs, as well as large aneurysm with adjacent scaffolding structures. [10, 17] Once within the aneurysm, embolizing agents are slowly injected, therefore inducing sac thrombosis. Thrombin, glue and occasionally coils are used as embolic materials. [10] Although it is used in the treatment of true aneurysms, its use in pseudoaneurysms is limited, as thrombosis occurs slowly and there is a significant risk of rupture.

Although effective, several risks are associated with this technique, which can vary from distal embolization, to aneurysm recanalization or even rupture. [115]

2. Endoscopic ultrasonography approach

Endoscopic ultrasonography (EUS) is generally considered only when an endovascular approach fails and is reserved for aneurysms detected on EUS, such as splenic or gastroduodenal aneurysms. [116, 117] The aneurysm is directly punctured under EUS guidance and the embolic agent is injected within. Thrombin or glue are used as embolic materials, although thrombin is the safest. [117]

The incidence of complications is small but they occasionally do occur [118] and are the same as those of percutaneous approach.

CONCLUSIONS

Visceral arterial aneurysms and pseudoaneurysms are uncommon conditions, with different etiologies but similar clinical presentations. These lesions are often asymptomatic, but are associated with high mortality rates when ruptured. While pseudoaneurysms should be promptly treated upon diagnosis, true aneurysms have specific treatment thresholds that vary depending on the vessel affected, as well as the clinical scenario observed.

Although there are still solid indications for open surgery, endovascular treatment offers a good and less invasive alternative to conventional open surgery, and currently represents the first-line treatment option in the majority of cases. Percutaneous and EUS guided techniques can also be used, although are usually reserved for specific situations, particularly when endovascular treatment is not feasible.

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The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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TABLES

ANEURYSM LOCATION	RELATIVE PREVALENCE
Splenic Artery Aneurysms	60–80%
Hepatic Artery Aneurysms	14-20%
Superior Mesenteric Artery Aneurysms	5–7%
Gastric Artery Aneurysms	4%
Celiac Artery Aneurysms	3-4%
Pancreaticoduodenal Artery Aneurysms	2%
Gastroduodenal Artery Aneurysms	1,5 %
Inferior Mesenteric Artery aneurysms	<1%
Renal Artery Aneurysm	< 0,1%

Table 1 - Relative prevalence of visceral arterial aneurysms.

Risk factors for VAA
• Atherosclerosis; • Medial degeneration / medial dysplasia; • Abdominal trauma; • Infection/ chronic inflammation; • Connective tissue disorders and congenital diseases (Marfan syndrome, Ehlers-Danlos syndrome, Osler-Weber-Rendu disease, Alagille syndrome, fibromuscular dysplasia, Kawasaki, and Hereditary Hemorrhagic Telangiectasia); • Hyper flow conditions (portal hypertension and pregnancy); • Diabetes mellitus, cigarette smoking, and chronic pancreatitis.

Table 2 – Known risk factors for visceral arterial aneurysms

• Symptomatic aneurysms, regardless of their size; • Aneurysms presenting with > 20 mm in diameter; • Smaller aneurysms in women of childbearing age; • Any size in patients undergoing liver transplantation; • Patients with Alpha 1-antitrypsin deficiency; • Aneurysms with rapid expansion (>5 mm per year).

Table 3 – SAA's treatment indications

Splenic Artery Aneurysms
Consider repair when: • Aneurysms > 20 mm in diameter; • Smaller aneurysms in women of childbearing age; • Any size in patients undergoing liver transplantation. Recommended treatment option: • Endovascular approach is the first line of treatment (covered stent exclusion vs terminal embolization).
Splenic Artery Pseudoaneurysms
Consider repair when: • Should be treated regardless of their size Recommended treatment option: • The treatment of choice is typically coil embolization.
Hepatic Artery Aneurysms
Consider repair when: • Aneurysms > 20 mm in diameter; Recommended treatment options: • Intrahepatic branch aneurysms are generally treated with coil embolization • Aneurysms of the common hepatic artery can be treated by either excluding the aneurysm with proximal and distal embolization (isolation with coils); • In common hepatic aneurysms, embolization of the GDA and CHA may be needed to achieve aneurysm exclusion; • Direct surgical repair of extrahepatic aneurysms is recommended in most patients, with endovascular treatment often being reserved for high-risk surgical candidates.
Hepatic Artery Pseudoaneurysms
Consider repair when: • Should be treated regardless of their size. Recommended treatment options: • Intrahepatic pseudoaneurysms: treatment of choice is coil embolization; • Extrahepatic pseudoaneurysms, treatment depends on the involved vessel and the location of the aneurysm.
Superior Mesenteric Artery Aneurysms
Consider repair when: • Aneurysms > 20-25 mm in diameter; • All suspected mycotic aneurysms;

Recommended treatment options:

- Open surgery for fit patients: most common treatment;
- Direct surgical excision, bypass graft placement, and endovascular repair are all reasonable options depending on the location and size of the aneurysm.

Superior Mesenteric Artery Pseudoaneurysms

Consider repair when:

- Should be treated regardless of their size.

Recommended treatment option:

- Surgery is the standard treatment and involves ligation of the vessel.

Celiac Artery Aneurysms

Consider repair when:

- High risk when diameter > 32 mm;

Recommended treatment option:

- Direct surgical excision, bypass graft placement, and endovascular repair are all reasonable options.

Celiac Artery Pseudoaneurysms

Consider repair when:

- Should be treated regardless of their size

Recommended treatment option:

- Standard treatment is the surgical approach.

Gastroduodenal Artery Aneurysm

Consider repair when:

- Aneurysms > 20-25 mm in diameter;

Recommended treatment option:

- Endovascular stent graft implantation is the first-line therapy.

Pancreaticoduodenal artery aneurysms

Consider repair when:

- Aneurysms > 10 mm in diameter.

Recommended treatment option:

- Transcatheter arterial embolization is the first-line therapy.

PDA and GDA Pseudoaneurysms

Consider repair when:

- Should be treated regardless of their size.

Recommended treatment option:

- Coil embolization is the first-line therapy.

Gastric Artery Aneurysms and Pseudoaneurysms
Consider repair when: • Aneurysms > 20 mm in diameter; • Pseudoaneurysms should be treated regardless of their size. Recommended treatment option: • Coil embolization is the first-line therapy.
Renal Artery Aneurysm
Consider repair when: • Aneurysms >10-15mm in diameter. Recommended treatment option: • Open repair methods were considered the standard therapy.
Renal Artery Pseudoaneurysm
Consider repair when: • Should be treated regardless of their size Recommended treatment option: • Endovascular therapy with coil or gelatin sponge embolization has a high success rate.
Inferior mesenteric artery (IMA) aneurysms
Consider repair when: • Aneurysms >20 mm in diameter; Recommended treatment option: • Surgical repair is still the first-line therapy;

Table 4 – Suggested recommendations for asymptomatic visceral arterial aneurysms and pseudoaneurysms.

ANEXOS

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Identify methodologies, equipment (give name and address of manufacturer in brackets) and procedures in sufficient detail to allow other researchers to reproduce results. Specify well-known methods including statistical procedures; mention and provide a brief description of published methods which are not yet well known; describe new or modified methods at length; justify their use and evaluate their limits. For each drug generic name, dosage and administration routes should be given. Brand names for drugs should be given in brackets. Units of measurement, symbols and abbreviations must conform to international standards. Measurements of length, height, weight and volume should be given in metric units (meter, kilogram, liter) or their decimal multiples. Temperatures must be expressed in degrees Celsius. Blood pressure must be expressed in millimeters of mercury. All clinical chemistry measurements should be expressed in metric units using the International System of Units (SI). The use of unusual symbols or abbreviations is strongly discouraged. The first time an abbreviation appears in the text, it should be preceded by the words for which it stands.

References

It is expected that all cited references will have been read by the authors. The references must contain only the authors cited in the text, be numbered in Arabic numerals and consecutively as they are cited. Bibliographical entries in the text should be quoted using superscripted Arabic numerals. References must be set out in the standard format approved by the International Committee of Medical Journal Editors (**http://www.icmje.org**).

Journals

Each entry must specify the author's surname and initials (list all authors when there are six or fewer; when there are seven or more, list only the first six and then "*et al.*"), the article's original title, the name of the Journal (according to the abbreviations used by MEDLINE/PubMed), the year of publication, the volume number and the number of the first and last pages. When citing references, please follow the rules for international standard punctuation carefully.

Examples:

- Standard article.

Sutherland DE, Simmons RL, Howard RJ. Intracapsular technique of transplant nephrectomy. Surg Gynecol Obstet 1978;146:951-2.

- Organization as author

International Committee of Medical Journal Editors. Uniform requirements for manuscripts submitted to biomedical journals. Ann Int Med 1988;108:258-65.

- Issue with supplement

Payne DK, Sullivan MD, Massie MJ. Women's psychological reactions to breast cancer. Semin Oncol 1996;23(1 Suppl 2):89-97.

Books and monographs

For occasional publications, the names of authors, title, edition, place, publisher and year of publication must be given.

Examples:
- Books by one or more authors
Rossi G. Manual of Otorhinolaryngology. Turin: Edizioni Minerva Medica; 1987.
- Chapter from book
De Meester TR. Gastroesophageal reflux disease. In: Moody FG, Carey LC, Scott Jones R, Ketly KA, Nahrwold DL, Skinner DB, editors. Surgical treatment of digestive diseases. Chicago: Year Book Medical Publishers; 1986. p. 132-58.
- Congress proceedings
Kimura J, Shibasaki H, editors. Recent advances in clinical neurophysiology. Proceedings of the 10th International Congress of EMG and Clinical Neurophysiology; 1995 Oct 15-19; Kyoto, Japan. Amsterdam: Elsevier; 1996.
Electronic material
- Standard journal article on the Internet
Kaul S, Diamond GA. Good enough: a primer on the analysis and interpretation of noninferiority trials. Ann Intern Med [Internet]. 2006 Jul 4 [cited 2007 Jan 4];145(1):62-9. Available from:
http://www.annals.org/cgi/reprint/145/1/62.pdf
- Standard citation to a book on CD-ROM or DVD
Kacmarek RM. Advanced respiratory care [CD-ROM]. Version 3.0. Philadelphia: Lippincott Williams & Wilkins; ©2000. 1 CD-ROM: sound, color, 4 3/4 in.
- Standard citation to a homepage
AMA: helping doctors help patients [Internet]. Chicago: American Medical Association; ©1995-2007 [cited 2007 Feb 22]. Available from: http://www.ama-assn.org/.
Footnotes and endnotes of Word must not be used in the preparation of references.
References first cited in a table or figure legend should be numbered so that they will be in sequence with references cited in the text taking into consideration the point where the table or figure is first mentioned. Therefore, those references should not be listed at the end of the reference section but consecutively as they are cited.

Notes

Conflicts of interest; mention of any funding, research contracts; authors' contribution statement; list of the members of the collective name (author's name in full, middle name's initial in capital letters and surname, with relevant affiliation); contributors' names; dates of any congress where the paper has already been presented; acknowledgements.

Tables

Tables should be submitted in the text file. Each table should be created with the Table menu of Microsoft Word table editor, by selecting the number of rows and columns needed. Tabulations are not allowed. Each table must be numbered in Roman numerals and accompanied by the relevant title. Each table must include heading, body and notes, if needed, at the foot of the table. Tables should be referenced in the text sequentially.

Figures

Each figure should be submitted as a separate file. Formats accepted: JPEG set at 300 dpi resolution preferred; other formats accepted are TIFF and PDF (high quality). Figures should be numbered in Arabic numerals and accompanied by the relevant title. Titles of figures should be repeated also in the text file. Figure should be referenced in the text sequentially.
Reproductions should be limited to the part that is essential to the paper.
Histological photographs should always be accompanied by the magnification ratio and the staining method.
If figures are in color, it should always be specified whether color or black and white reproduction is required.

Supplementary Digital Material

Authors may submit supplementary material to support and enhance their article's text to be published in the online edition only. Supplementary material should be submitted online during the submission process and may include the following types of content: text files, tables, figures, audios and videos. Authors are requested to submit as supplementary material tables that are too long to fit on a single printed page of the journal and any appendices.
One or more files of supplementary material may be attached to the article. Such files must be submitted separately and cited in consecutive order in the text. There are no restrictions on the content of a file (it may include a text and a table, a single table, a figure and a table, two figures, a video, etc..).
Each in-text citation of supplementary material should be clearly labeled as "Supplementary Digital Material" followed by the relevant number and the description of the material submitted (Supplementary Digital Material 1: Supplementary Text File, Supplementary Figure 1, Supplementary Table I and Supplementary Table II online content only). Audio and video citations should also include the length and size of the file (Supplementary Digital Material 2: Supplementary Video 1, online content only, 5 minutes, 10MB). Text files, figures and tables of supplementary materials should be accompanied by the relevant title.
Formats accepted for text files and tables: Word (.DOC and .DOCX) and RTF; formats accepted for figures: JPEG set at 300 dpi resolution preferred; other formats accepted are TIFF and PDF (high quality); formats accepted for audio files: MP3, WAV; formats accepted for video files: MP4, AVI, WMV. To ensure a quality experience, it is suggested that authors submit supplementary audios and videos no larger than 10 MB each.
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