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UDC: 616.13-007.64-08
DOI: https://doi.org/10.2298/VSP250202017K

Treatment of splanchnic artery aneurysms – single center results and experience

Lečenje aneurizmi splanhničnih arterija – rezultati i iskustva jednog centra

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Abstract

Background/Aim. Visceral artery aneurysms (VAAs) are rare but potentially life-threatening conditions. With the increasing availability of diagnostic and therapeutic options, there is a growing need to determine the optimal treatment approach–endovascular (EV) vs. open surgical (OS) reconstruction. The aim of this study was to analyze treatment outcomes in patients with VAA at a single center and compare the efficacy of EV and OS approaches. **Methods.** The study included 27 OS (the OS group) or EV (the EV group) interventions for VAA, performed at our institution from January 2010 to November 2023, on 27 patients, 13 males and 14 females, with a mean age of 57 ± 13 years. Treatment decisions were reached by a multidisciplinary team of a vascular surgeon, an anesthesiologist, and an interventional radiologist. **Results.** Out of the 27 patients, 9 were treated in the emergency setting, with 6 of them having ruptured aneurysms. The most common was a splenic artery aneurysm, 50.0% of all VAAs. Thirteen patients underwent EV reconstruction, one patient underwent a hybrid approach, and 13 patients had OS reconstruction. Technical success was 24/27 or 88.9%. Eleven patients were treated by coil embolization, while two were treated with the implantation of a covered stent. In the EV group, mortality was nil. In 14 patients, OS treatment was performed with 9 VAA resections and arterial reconstructions (7 with Dacron graft, 1 with polytetrafluoroethylene graft, and 1 with autovenous graft), with 2 splenectomies and 3 aneurysm exclusions. Two patients died intraoperatively due to severe bleeding, and one after the procedure because of intestinal ischemic complications. Mean duration of hospitalization after OS or EV procedure was 7.43 and 4.92 days, respectively. **Conclusion.** Treating patients using the EV approach is safe, with less invasiveness and shorter hospital stays, suitable for elective and emergency cases when technically feasible. OS remains a reliable option at high-volume centers, particularly for complex cases unsuitable for EV approaches or in low-risk patients. Treatment decision should be guided by VAA characteristics (size, symptoms, location, morphology), patient comorbidities, and specific clinical context, such as prior abdominal surgeries.

Keywords:
aneurysm; arteries; endovascular procedures; serbia; treatment outcome; vascular surgical procedures.

Apstrakt

Uvod/Cilj. Aneurizme visceralnih arterija (*visceral artery aneurysms* – VAAs) su retka, ali po život potencijalno opasna stanja. Sa porastom dostupnih dijagnostičkih i terapijskih mogućnosti, raste potreba za određivanjem optimalnog terapijskog pristupa–endovaskularna (EV) rekonstrukcija vs. otvorena hirurška (*open surgery* – OS) rekonstrukcija. Cilj rada bio je da se analiziraju ishodi lečenja obolelih od VAA u jednom centru i uporedi efikasnost EV i OS pristupa. **Metode.** Istraživanjem je obuhvaćeno 27 OS (OS grupa) ili EV (EV grupa) intervencija za VAA, sprovedenih u našoj ustanovi od januara 2010. do novembra 2023. godine, kod 27 bolesnika, 13 muškog i 14 ženskog pola prosečne starosti 57 ± 13 godina. Odluke o lečenju donosio je multidisciplinarni tim, koji su činili vaskularni hirurg, anesteziolog i interventni radiolog. **Rezultati.** Od ukupno 27 bolesnika, 9 je zbrinuto kao hitni slučajevi, od kojih je 6 imalo rupturu aneurizme. Najčešća je bila aneurizma slezinske arterije, 50,0% svih VAAs. Trinaest bolesnika podvrgnuto je EV rekonstrukciji, hibridnom pristupu 1 bolesnik, a OS rekonstrukciji 13 bolesnika. Tehnički uspeh bio je 24/27 ili 88,9%. Embolizacijom spiralama lečeno je 11 bolesnika, dok su 2 bolesnika lečena ugradnjom pokrivenog stenta. U grupi bolesnika lečenih EV putem nije bilo smrtnih ishoda. Kod 14 bolesnika urađeno je OS hirurško lečenje sa 9 VAA resekcija i arterijskih rekonstrukcija (7 *Dacron* graftom, 1 politetrafluoroetilen graftom i 1 autovenskim graftom), uz 2 splenektomije i 3 isključenja aneurizme. Usled jakog krvarenja, 2 bolesnika su preminula tokom operacije, a jedan posle zahvata zbog crevnih ishemijskih komplikacija. Prosečno trajanje hospitalizacije posle OS ili EV procedure iznosilo je 7,43 i 4,92 dana, redom. **Zaključak.** Lečenje EV pristupom je bezbedno, sa manje invazivnosti i kraćim boravkom u bolnici i

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pogodno je za elektivne i hitne slučajeve, kada je to tehnički izvodljivo. Primena OS pristupa ostaje pouzdana mogućnost u centrima sa velikim brojem operacija, posebno za složene slučajeve koji nisu pogodni za EV pristup ili kod bolesnika sa niskim rizikom. Odluka o lečenju treba da bude vođena karakteristikama VAA (veličina, simptomi, lokacija, morfologija), komorbiditetima bolesnika i specifičnim kliničkim kontekstom, poput prethodnih abdominalnih operacija.

Ključne reči:
aneurizma; arterije; endovaskularne procedure; srbija; lečenje, ishod; hirurgija, vaskularna, procedure.

Introduction

Visceral artery aneurysms (VAAs) represent a rare yet significant medical concern, as approximately 22% of cases necessitate urgent treatment, with a mortality rate of 8.5% [1]. The first documented case dates back to a 60-year-old woman in France, in whom a splenic artery aneurysm (SAA) was identified at autopsy [2]. Surgical intervention for VAAs saw its initial success in the early 20th century with the treatment of a hepatic aneurysm [3]. Over the past two decades, two major advancements have revolutionized the diagnosis and management of these aneurysms.

The advent of multi-detector computed tomography (MDCT) angiography has greatly facilitated diagnosis and treatment planning, revealing that VAAs may be more prevalent than previously believed [4, 5]. Prior to its widespread use, just over 3,000 aneurysms of splanchnic arteries had been documented in the literature. Additionally, the introduction of endovascular (EV) procedures has significantly decreased treatment risks, particularly benefiting elderly and high-risk patients, as well as those with surgically challenging aneurysm locations [6, 7].

The aim of this study was to analyze treatment outcomes in patients with VAAs treated at our center, provide a brief overview of clinical presentations, and summarize relevant literature to contextualize our findings and compare open surgery (OS) with EV repair.

Methods

From January 2010 to November 2023, a total of 27 OS (OS group) or EV (EV group) interventions for VAAs were performed at our institution in 27 patients, of whom 14 were female, with a mean age of 57 ± 13 years. The diagnostic method applied to all patients was MDCT angiography. Clinical management of the patients was investigated in terms of surgical therapy and interventional treatment. The treatment method was determined based on previously performed diagnostic evaluation, risk assessment, and the patient's clinical signs and symptoms.

The multidisciplinary team considered several factors when choosing between the EV and OS approach. Aneurysm diameter, morphology, and location were key determinants. For instance, asymptomatic patients with SAAs larger than 2 cm, as well as symptomatic lesions, were typically treated. In contrast, coeliac, hepatic, or superior mesenteric artery (SMA) aneurysms were treated regardless of size due to their high risk of rupture. Saccular aneurysms with a narrow neck were more amenable to coil embolization, whereas fusiform aneurysms, wide-necked lesions, or those with complex branch anatomy frequently required open or hybrid repair. Patient factors such as age, cardiopulmonary status, connective tissue disorders, pregnancy, portal hypertension, and prior abdominal surgery were also taken into consideration. High-risk patients and those with hostile abdominal anatomy were preferentially EV-treated, while low-risk patients with suitable anatomy were offered OS approach.

Descriptive statistics were used to summarize continuous variables (mean ± standard deviation) and categorical data (counts and percentages). Given the small sample size, formal hypothesis testing was limited to exploratory comparisons using the Student's *t*-test or Fisher's exact test as appropriate. A *p*-value below 0.05 was considered indicative of statistical significance.

Results

Data on patient age, gender, presenting symptoms and signs, diagnostic modalities, risk factors, comorbidities, and recent surgeries are presented in Table 1.

Table 1

Patient characteristics

Variable (n = 27)	Values
Female gender	14 (51.9)
Body mass index, kg/m^2	25.64 ± 3.45
Smoking	10 (38.5)
Hypertension	19 (70.4)
Hyperlipidemia	9 (33.3)
Diabetes mellitus	1 (3.7)
Coronary artery disease	3 (11.1)
Prior stroke/transient ischemic attack	0 (0)
Pancreatitis	4 (14.8)
Malignant disease	2 (7.4)
Chronic obstructive pulmonary disease	2 (7.4)
Connective tissue disease	1 (3.7)
Pregnancies	1 (3.7)

n – number of patients.
Data are given as numbers (percentages) or mean ± standard deviation.

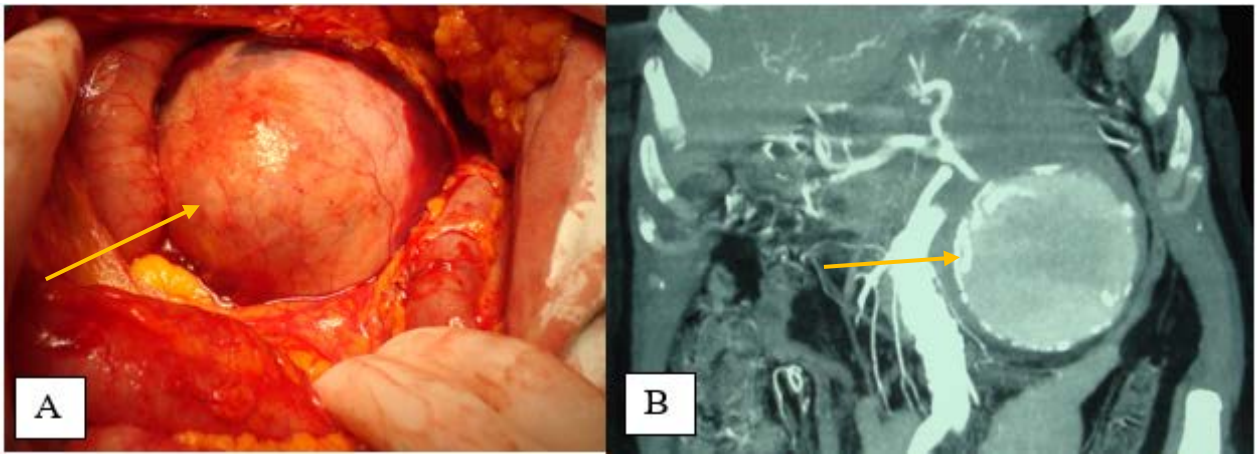


Fig. 1 – Splenic artery aneurysm: A) intraoperative look and B) multi-detector computed tomography angiography finding.

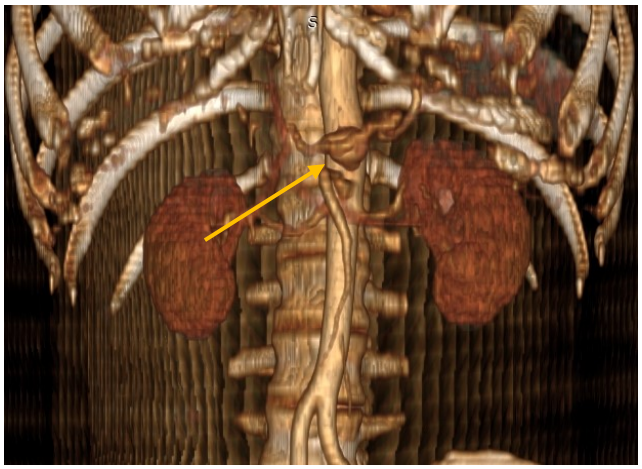


Fig. 2 – Three-dimensional multi-detector computed tomography angiography – aneurysmal enlargement of the coeliac trunk and its relationship to the main visceral branches.

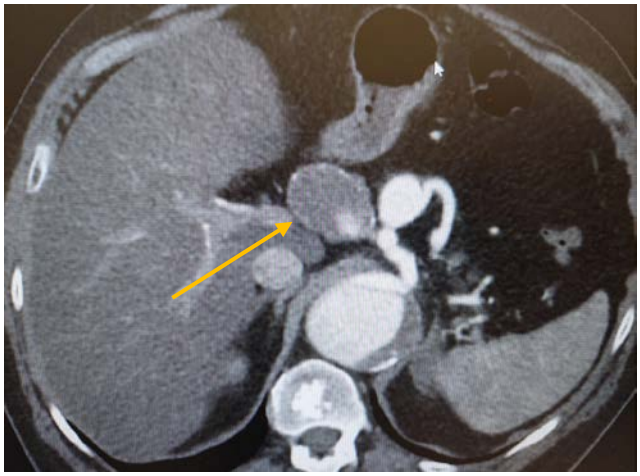


Fig. 3 – Aneurysm of common hepatic artery multi-detector computed tomography angiography – focal aneurysmal dilatation of the common hepatic artery, visualized as a contrast-filled vascular enlargement.

In the majority of cases, VAAs involved the splenic artery (Figure 1A, 1B) (n = 15), followed by the coeliac trunk (CoT) (Figure 2) (n = 5), the hepatic artery (Figure 3) (n = 4), and the SMA (Figure 4A, 4B) (n = 3). Besides the artery previously listed, VAAs involved pancreaticoduodenal artery (PDA), gastroduodenal artery, and distal medial colic artery, one case each (Table 2).

Of the 27 patients with 30 VAAs (Table 2), 13 were treated using the EV approach, while 13 underwent OS with a total success rate of 88.9%. In one case, the hybrid procedure

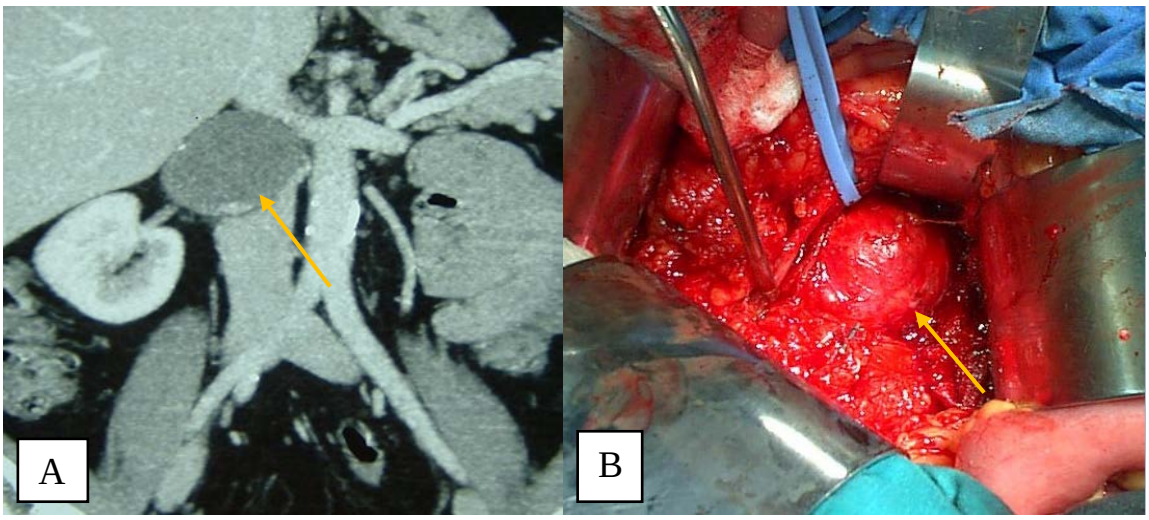


Fig. 4 – Aneurysm of superior mesenteric artery (SMA): A) multi-detector computed tomography angiography shows an aneurysmal dilatation of SMA, and B) intraoperative photograph of SMA after surgical exposure – the aneurysmal segment identified on preoperative imaging.

Table 2

Visceral artery aneurysms localization

Artery involved by an aneurysm (n = 30)	Values
Splenic artery	15 (50.0)
Coeliac trunk	5 (16.7)
Hepatic artery	4 (13.3)
Superior mesenteric artery	3 (10.0)
Pancreaticoduodenal artery	1 (3.3)
Gastroduodenal artery	1 (3.3)
Distal medial colic artery	1 (3.3)

n – number of aneurysms.
Data are given as numbers (percentages).
***Note*: The percentages in Table 1 were calculated based on the number of patients (n = 27), whereas in Table 2, the percentages were calculated based on the total number of aneurysms (n = 30). For this reason, one case shows slightly different percentages in Tables 1 and 2 (3.7% vs. 3.3%).**

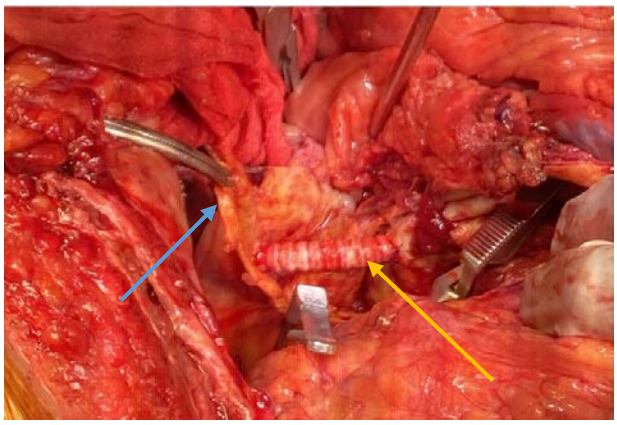


Fig. 5 – Resection of hepatic artery aneurysm (blue arrow) and Dacron graft interposition (yellow arrow).

was performed, which involved EV embolization of the aneurysm followed by surgical reconstruction. Eleven patients, of whom 10 had SAA and one had a PDA aneurysm, were treated by coil embolization, while 2 patients with SMA aneurysm were treated with covered stenting. In the EV group, mortality was nil, and there were no complications.

In 14 cases, surgical treatment was performed with 9 VAA resections and arterial reconstructions (Figure 5).

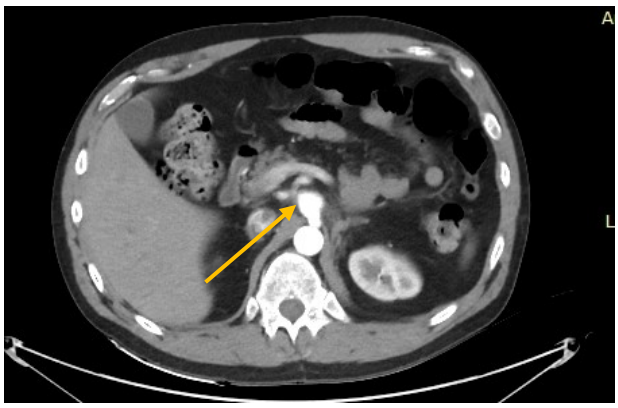


Fig. 6 – Multi-detector computed tomography angiography – an aneurysm of the coeliac trunk with surrounding contrast extravasation, indicating rupture.

Dacron graft was used in 7 cases, three times for CoT, twice for SAA, and twice for reconstruction of hepatic artery aneurysm (HAA). Polytetrafluoroethylene graft was used once in the treatment of an SMA aneurysm, and autovenous graft was also used once in the reconstruction of HAA. Splenectomy was performed twice, and aneurysm exclusion three times.

Out of 27 cases, emergency procedures were performed nine times, with 6 ruptured and 3 symptomatic aneurysms. SAA ruptured twice, and patients were treated with OS, aneurysm exclusion, and splenectomy with 100% successful rate. Two patients died during the operation due to the consequences of hemorrhagic shock, which resulted in a ruptured aneurysm of the CoT (Figure 6), and one after the procedure because of intestinal gangrene complications ($p = 0.077$). One of the patients who died intraoperatively was diagnosed with Ehlers-Danlos syndrome. Ruptures of the hepatic artery were successfully treated both times. EV intervention was performed once in an emergency case. Mean duration of hospitalization for OS treated patients was 7.43 days, and the mean duration after EV procedure was 4.92 days ($p = 0.063$).

Discussion

The distribution of splanchnic artery aneurysms is relatively consistent [8–15], with most (60%) occurring in the splenic artery, followed by the hepatic (20%), superior mesenteric (5%), and CoT (4%). Recent studies show similar trends, with SAA, coeliac, and SMA aneurysms comprising 55%, 27%, and 18% of cases, respectively [1]. About one-third are associated with aneurysms in other vascular territories such as the aorta or renal arteries [8].

In our cohort, the technical success rate (88.9%) was somewhat lower than the > 95% of rates reported in larger contemporary series, such as that of Batagini et al. [8]. Although mortality was nil in the EV group, three deaths occurred after OS repair. The relatively high proportion of emergency procedures (9/27 or 33%) and ruptured aneurysms (6 cases) likely reflects referral bias to our tertiary center. Distribution of aneurysm locations in our series–15 splenic, 5 coeliac, 4 hepatic, 3 superior mesenteric, and 3 other arteries–aligns broadly with epidemiological data. However, the proportion of CoT lesions was slightly higher than the 4–6% typically reported [12, 15]. We also observed one case of Ehlers-Danlos syndrome leading to fatal intraoperative rupture. This underscores that connective tissue disorders, while rare, should be considered in young patients with splanchnic aneurysms.

SAAs result from elastic fiber fragmentation and medial degeneration, associated with fibromuscular dysplasia [16, 17], splenomegaly, portal hypertension, and multiple pregnancies [1, 10, 18–25]. Chronic pancreatitis also plays a role [26]. HAAs, once mainly mycotic, now arise predominantly from atherosclerosis and medial degeneration [15, 27]. SMA aneurysms are increasingly linked to dissection [15, 28], while CoT aneurysms may be associated with Dunbar syndrome [29]. Pancreaticoduodenal and gastroduodenal aneurysms are often pancreatitis-related [30–32].

Rupture is the most severe complication, especially in SAAs during pregnancy (maternal mortality up to 70%, fetal mortality up to 95%) [17]. HAA and SMA aneurysm ruptures can cause intraperitoneal bleeding or intestinal ischemia [1–5, 33].

Diagnosis is usually incidental, confirmed by angiography or MDCT. Treatment decisions should be based on aneurysm location, size, and symptomatology. The new European Society for Vascular Surgery guidelines recommend considering EV or OS treatment for asymptomatic SAA, HAA, coeliac, and SMA aneurysms when their diameter reaches 30 mm, with surveillance for smaller aneurysms. PDA aneurysms warrant intervention at 15 mm, and pregnancy or symptomatic aneurysms warrant treatment regardless of size. The guidelines emphasize minimally invasive EV approaches whenever feasible, reserving OS repair for mycotic aneurysms or anatomy unsuitable for EV techniques, and recommend individualized imaging follow-up after repair. Overall, modern management underscores minimally invasive EV techniques, which have proven effective and safer alternatives to OS in suitable cases [34].

Recent data from multicenter series and systematic reviews emphasize a gradual shift toward EV management as

the first-line treatment for most splanchnic artery aneurysms, achieving technical success rates of 90–98% and low perioperative mortality (< 2%) in experienced centers [35–41]. These outcomes align closely with the results of the present series, where the predominance of EV therapy reflects a global trend toward minimally invasive strategies.

Compared to earlier OS cohorts, contemporary reports demonstrate significantly shorter hospital stays, lower transfusion requirements, and fewer postoperative complications, particularly in SAAs and HAAs [37, 39]. Nevertheless, OS repair remains justified in complex cases involving rupture, infection, or unsuitable anatomy for stent placement.

The higher share of emergency interventions and ruptured cases in this study may explain the modestly lower overall technical success rate compared to large reference series, where elective treatment predominates [36, 38]. Still, the complication and reintervention rates remain within the reported international range, supporting the safety and efficacy of the adopted treatment approach.

Overall, current evidence confirms that the management strategy used in this series is consistent with modern trends emphasizing individualized EV treatment, guided by lesion morphology, collateral circulation, and patient comorbidities.

This was a retrospective analysis from a single tertiary center with only 27 patients, which limits the statistical power and generalizability of our findings. The cohort was heterogeneous, encompassing aneurysms at multiple visceral locations and including both elective and emergency cases. Given that treatment decisions were individualized, selection bias may have influenced comparisons between EV and OS techniques. Long-term follow-up data on aneurysm patency, recurrence, need for reintervention, and survival were not available. Future multicenter prospective studies with standardized criteria and extended follow-up are needed to guide the management of splanchnic artery aneurysms better.

The management of splanchnic artery aneurysms involves a combination of imaging for diagnosis and a tailored approach to treatment, emphasizing EV techniques for their less invasive nature and effectiveness in reducing complications.

Conclusion

Splanchnic artery aneurysms are exceedingly rare, yet they carry significant medical importance due to their potential to manifest as acute surgical emergencies in a quarter of cases, often resulting in fatalities before diagnosis. Despite advancements in diagnostic imaging techniques such as multi-detector computed tomography and magnetic resonance imaging, their detection remains challenging due to nonspecific clinical symptoms and signs. Given the high mortality rate associated with rupture, surgical intervention is typically warranted even for asymptomatic splanchnic artery aneurysms. Endovascular procedures, such as embolization and stent graft placement, are preferred for high-risk patients or those with hostile abdominal anatomy due to their minimally invasive nature and shorter hospital stays. For elective management of visceral artery aneurysms, open surgery performed by experienced surgeons remains the standard of care, particularly in cases unsuitable or technically challenging for endovascular treatment in patients with low surgical risk. Treatment decisions should be guided by factors such as aneurysm size, symptoms, location, morphology, comorbidities, and previous abdominal surgeries.

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Received on February 2, 2025
Revised on September 21, 2025
Revised on December 28, 2025
Revised on February 4, 2026
Accepted on February 11, 2026
Online First April 2026