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Visceral artery aneurysms, treatment and controversies – 20 years of single-center experience

Aneurizme visceralnih arterija, lečenje i kontroverze – 20 godina iskustva jednog centra

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Abstract

Introduction/Aim. Visceral artery aneurysms (VAAs) are rare diseases most often diagnosed accidentally during diagnostic workups for other diseases or for abdominal pain of unknown etiology. The aim of this study was to present 20 years of single-center experience from the surgical treatment of VAAs. **Methods.** A retrospective study analyzed the outcomes of surgical treatment in 15 patients with VAAs, treated between 2004 and 2024. Both endovascular and classic, open surgical techniques were used, with special emphasis on the histopathological causes of aneurysm formation. Special attention is directed towards symptomatology, preoperative diagnostics, open and endovascular treatment techniques, as well as postoperative follow-up and possible secondary interventions. **Results.** The average age of patients was 56.1 years. There was a total of seven female and eight male patients. The average diameter of the aneurysms was 4.4 cm (ranging from 2.4 to 6 cm). Open surgical operations were performed in 12 patients, while 3 patients underwent endovascular reconstruction. Surgical treatment was performed on 10 patients due to aneurysm of the splenic artery, on 2 patients due to aneurysm of the gastroduodenal artery, on 1 patient due to aneurysm of the common hepatic artery, on 1 patient due to aneurysm of the celiac trunk, and on 1 patient due to aneurysm of the renal artery. Five patients were operated on as emergency cases due to aneurysm rupture and hemorrhagic shock, while the remaining patients were operated on electively. Immediately after surgery, death occurred in three patients, while in the others, the follow-up period lasted from two to ten years. **Conclusion.** VAAs represent a serious vascular disease, which, if not diagnosed and treated in time, can lead to deadly complications due to aneurysm rupture and bleeding. In the era of endovascular surgery, open surgical reconstruction of visceral aneurysms continues to play an important role.

Key words:
aneurysm; arteries; endovascular procedures; treatment outcome; vascular surgical procedures.

Apstrakt

Uvod/Cilj. Aneurizme visceralnih arterija (*visceral artery aneurysms* – VAA) su retka oboljenja koja se najčešće dijagnostikuju slučajno u sklopu dijagnostičkih procedura usled nekog drugog oboljenja, ili zbog abdominalnog bola nepoznate etiologije. Cilj rada bio je da se prikaže 20 godina iskustva jednog centra u hirurškom lečenju VAA. **Metode.** Retrospektivnom studijom analizirani su ishodi hirurškog lečenja 15 obolelih od VAA, lečenih u periodu od 2004. do 2024. godine. Korišćene su i endovaskularne i klasične, otvorene hirurške tehnike, sa posebnim osvrtom na histopatološke uzroke nastanka aneurizmi. Posebna pažnja usmerena je ka simptomatologiji, preoperativnoj dijagnostici, otvorenim i endovaskularnim tehnikama lečenja, kao i postoperativnom praćenju i mogućim sekundarnim intervencijama. **Rezultati.** Prosečna starost bolesnika bila je 56,1 godina. Ukupno je bilo sedam bolesnika ženskog i osam bolesnika muškog pola. Prosečan prečnik aneurizmi bio je 4,4 cm (sa rasponom od 2,4 do 6 cm). Kod 12 bolesnika urađena je otvorena hirurška operacija, dok je kod troje bolesnika urađena endovaskularna rekonstrukcija. Hirurško lečenje sprovedeno je kod deset bolesnika zbog aneurizme lijenalne arterije, kod dva bolesnika zbog aneurizme gastroduodenalne arterije, kod jednog bolesnika zbog aneurizme zajedničke hepatične arterije, jednog zbog aneurizme celijačnog stabla i kod jednog bolesnika zbog aneurizme renalne arterije. Petoro bolesnika operisani su kao hitni slučajevi usled rupture aneurizme i hemoragičkog šoka, dok su preostali bolesnici operisani kao elektivni. Neposredno nakon operacije, smrt je

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nastupila kod tri bolesnika, dok je kod ostalih period praćenja bio od dve do deset godina. **Zaključak.** VAA predstavljaju ozbiljno vaskularno oboljenje, koje ukoliko se na vreme ne dijagnostikuje i ne leči može dovesti do smrtonosnih komplikacija usled rupture aneurizme i krvarenja. U eri endovaskularne hirurgije, otvorena hirurška rekonstrukcija visceralnih aneurizmi i dalje ima važnu ulogu.

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

Introduction

Aneurysmal disease of the visceral arteries is considered a rare condition, with an incidence ranging from 0.01% to 2.0% in the general population, including findings from autopsies conducted over several decades [1, 2]. With ongoing technological advancements in medicine, particularly in the field of diagnostics, it is likely that the reported incidence rate of visceral artery aneurysms (VAAs) will significantly increase in the near future.

The most common site of VAA occurrence is the splenic artery, accounting for approximately 60% of cases, followed by the hepatic artery in about 20%, while the remaining locations are considerably less frequent (e.g., mesenteric artery, celiac trunk, gastroduodenal artery, renal arteries, and other visceral arteries) [2, 3].

True aneurysms are histopathologically distinguished from pseudoaneurysms by the presence of all three layers of the arterial wall in the aneurysm structure. In contrast, pseudoaneurysms involve a disruption of the vessel's wall integrity. Accordingly, the most frequently encountered types of VAAs are atherosclerotic aneurysms and those associated with congenital structural abnormalities of the arterial wall (e.g., cystic medial degeneration, fibromuscular dysplasia, Marfan syndrome) [4].

Early diagnosis and appropriate treatment of VAAs are of great importance due to the potential complications of this condition. A previous study has shown that VAAs with a diameter of less than 2 cm do not require surgical treatment; periodic monitoring and adequate pharmacologic therapy are sufficient [5]. VAAs larger than 2 cm require surgical intervention, either *via* open surgery or endovascular techniques, to prevent possible complications. Rupture of a VAA is the most common and also the most dangerous complication. Thrombosis, distal embolization of the target organ, and fistulization with surrounding structures are rarer but equally serious complications [5].

The symptomatology of VAAs is highly nonspecific. Symptoms can range from mild, such as occasional dull pain in the epigastrium or back, to severe and dramatic presentations in the case of rupture, when patients experience intense abdominal pain along with signs of hemorrhagic shock. Depending on the location and diameter of the aneurysm, some VAAs can be detected *via* Doppler ultrasonography; however, the gold standard for both diagnosis and treatment planning is still computerized tomography (CT) angiography or nuclear magnetic resonance angiography of the aorta and its visceral branches [6].

Various surgical options are available for the treatment of VAAs. Generally, VAAs can be managed *via* open surgery or endovascular intervention. Open surgical techniques vary depending on the type and location of the aneurysm. They may include aneurysm resection with end-to-end arterial reconstruction, aneurysm resection with venous or synthetic bypass grafting, or aneurysmectomy followed by arterial suturing. Another option includes arterial ligation followed by organ removal if the affected artery supplies a vital organ (e.g., splenectomy or nephrectomy). Endovascular procedures may involve complete exclusion of the aneurysm using an appropriate endograft, coil embolization of the aneurysmal sac, or hybrid procedures (a combination of open and endovascular techniques) [7].

In the event of VAA complications such as rupture or thrombosis with potentially fatal outcomes, emergency surgical intervention is required – most often an open surgical procedure. Reported mortality rates following VAA rupture range from 25% to 75%. Currently, no consensus exists regarding the optimal surgical technique for VAA management, and no randomized controlled trials have been published on this subject [6, 7].

The aim of this study was to present the treatment outcomes of VAAs over a 20-year period.

Methods

This was a retrospective study analyzing the outcomes of surgical treatment for VAAs in patients treated at the Clinic for Vascular and Endovascular Surgery, Military Medical Academy, Belgrade, Serbia. The study covered a 20-year period, from 2004 to 2024, and included both endovascular and classical open surgical techniques, with particular emphasis on the histopathological causes of aneurysm formation. Special attention was also given to symptomatology, preoperative diagnostics, both open and endovascular treatment methods, as well as postoperative follow-up and potential secondary interventions. The primary criterion for elective surgical treatment was a VAA diameter of 2 cm or greater, as diagnosed by CT angiography or magnetic resonance imaging angiography, to prevent severe complications [7, 8]. The choice of treatment technique—either open surgery or an endovascular approach—was made individually, based on the patient's comorbidities and the topographic-anatomical characteristics of the aneurysm. Emergency surgical intervention was required in all patients presenting with clinical signs of VAA rupture and hemorrhagic shock [6, 8].

Results

Between 2004 and 2024, a total of 15 patients were treated for VAAs at our center. All patients received specialized management by vascular surgeons. This included both individuals who underwent conventional open surgical repair and those treated *via* endovascular procedures, following established vascular surgical protocols.

Patient age ranged from 28 to 74 years, with a mean age of 56.1 years. Of the total cohort, seven patients were female and eight were male.

Surgical treatment was performed in ten patients for splenic artery aneurysms (SAA), in two for gastroduodenal artery aneurysms (GDAA), one for a common hepatic artery aneurysm (CHAA), one for a celiac trunk aneurysm (CTA), and in one patient for a renal artery aneurysm (RAA).

The primary indication for elective surgical intervention was a CT angiography-confirmed VAA measuring greater than 2 cm in diameter. Emergent surgical treatment was performed in patients with CT angiography-confirmed symptomatic VAA or ruptured VAA.

Five patients underwent emergency surgery due to aneurysm rupture and hemorrhagic shock, one due to rupture of a GDAA, two due to ruptured SAA, one due to RAA rupture, and one due to CTA rupture (Table 1). The remaining patients underwent elective surgical treatment.

A total of 12 patients were treated with open classical surgical procedures: in 8 cases, aneurysm resection was followed by end-to-end arterial reconstruction, while in 4 cases, arterial ligation was performed. The surgical approach for all patients undergoing conventional open repair involved a standardized transperitoneal route *via* a midline laparotomy, with meticulous dissection and exposure of the abdominal aorta and the involved visceral arterial segment.

In three patients, endovascular procedures were employed. In all patients treated with endovascular repair, vascular access was achieved through a standard transfemoral approach, utilizing the Seldinger technique, which involves percutaneous puncture of one or both common femoral arteries.

The mean aneurysm diameter was 4.4 cm, ranging from 2.4 cm to 6 cm. In the immediate postoperative period, mortality occurred in three patients. For the remaining patients, the follow-up period ranged from 2 to 10 years.

In one case, a secondary intervention was performed one month after an endovascular procedure, involving conversion to open surgical reconstruction.

CT images of a CHAA, treated with an implanted stent graft and an additional stent for ostial occlusion, are shown in Figure 1A (before stenting) and Figure 1B (after stenting).

Etiologically, no clearly defined cause was identified for isolated VAAs. It is considered that all etiological factors contributing to the development of aneurysmal disease may also play a role in VAA formation, including hypertension, chronic obstructive pulmonary disease, smoking, and diabetes mellitus (Table 1).

The most common histopathological substrate in elective male patients operated on for SAA was atherosclerotic disease, whereas in females it was cystic medial degeneration of the arterial wall, with aneurysm localization near the origin of the splenic artery from the celiac trunk. Histopathological analysis of the aneurysm wall specimens was performed using hematoxylin and eosin staining, and the samples were examined under a light microscope (Figure 2). In these cases, aneurysm resection followed by end-to-end arterial anastomosis was performed (three males and five females). These patients were not suitable candidates for endovascular procedures due to a significant diameter discrepancy between the artery proximal and distal to the aneurysm, as well as a wide aneurysmal neck. Two patients who underwent emergency surgery for ruptured VAAs presented with clinical signs of hemorrhagic shock and aneurysm localization near the splenic hilum; they were treated with splenic artery ligation and splenectomy. Postoperative mortality occurred in one elective case and two emergency cases, with causes of death attributed to cardiac failure and pulmonary complications.

A younger male patient with previously diagnosed Marfan syndrome underwent surgery for CHAA. The aneurysm developed as a result of a dissection of the descending thoracic and abdominal aorta, which extended to the hepatic artery. One year after the dissection, due to intermittent right epigastric pain, CT angiography revealed a post-dissection CHAA measuring 6 cm, extending from the hepatic artery

Table 1

Distribution of patients by gender, VAA localization, risk factors, and complications

Parameters	SAA	CHAA	GDAA	RAA	CTA
Gender					
male	3 (20.0)	1 (6.7)	2 (13.3)	1 (6.7)	1 (6.7)
female	7 (46.7)	0	0	0	0
Average aneurysm diameter (cm)	4.2	6.0	4.6	3.0	4.2
Average age, years	48.2	30.0	56.3	74.0	72.0
Smoking	8 (53.3)	0	2 (13.3)	0	1 (6.7)
HTA	5 (33.0)	1 (6.7)	1 (6.7)	1 (6.7)	1 (6.7)
DM	2 (13.3)	0	1 (6.7)	0	1 (6.7)
COPD	2 (13.3)	0	1 (6.7)	0	0
Rupture	2 (13.3)	0	1 (6.7)	1 (6.7)	1 (6.7)

VAA – visceral artery aneurysm; SAA – splenic artery aneurysm; CHAA – common hepatic artery aneurysm; GDAA – gastroduodenal artery aneurysm; RAA – renal artery aneurysm; CTA – celiac trunk aneurysm; HTA – hypertensio arterialis; DM – diabetes mellitus; COPD – chronic obstructive pulmonary disease.
Values are given as numbers (percentages).

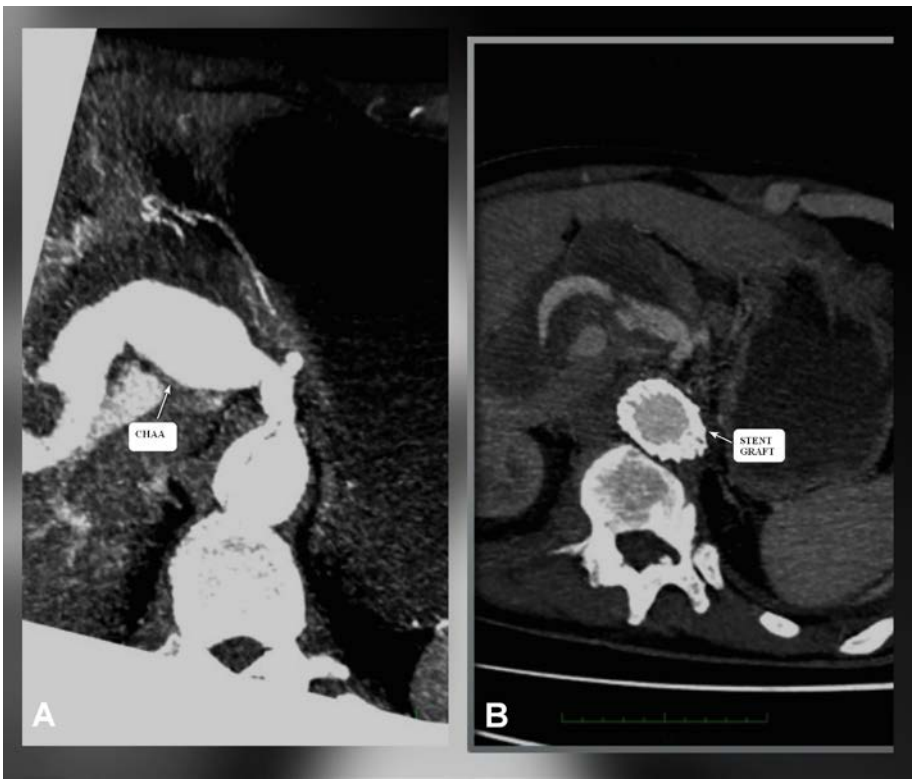

Fig. 1 – Common hepatic artery aneurysm (CHAA) with implanted stent graft and stent for ostial occlusion computerized tomography before (A) and after (B) stenting.

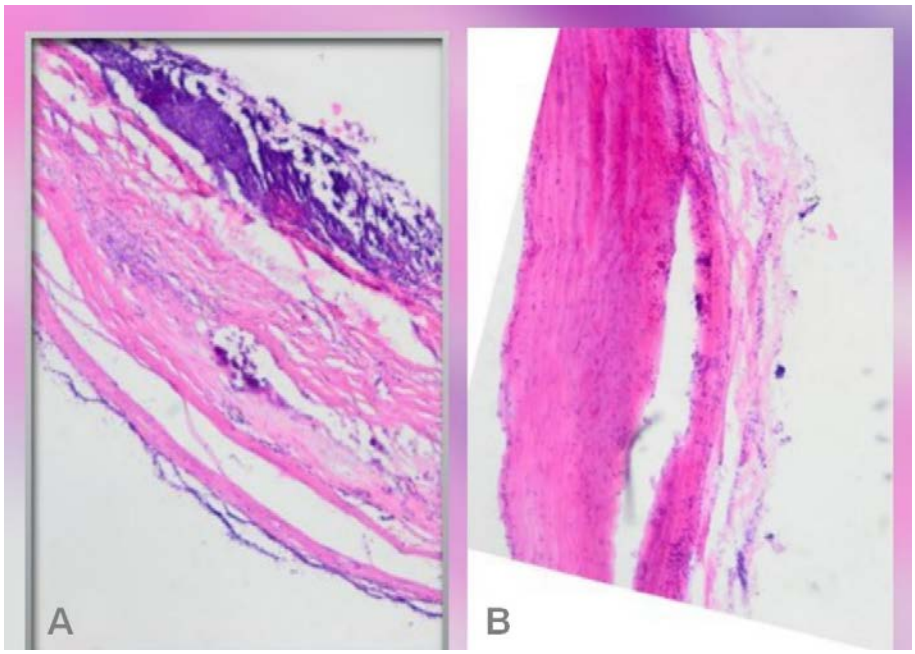

Fig. 2 – Histopathological appearance of the wall of the splenic artery aneurysm: A) severe atherosclerotic changes in the artery wall with calcification; B) mediocystic degeneration with delamination of the artery wall. Hematoxylin and eosin staining, × 20 magnification.

origin to the hepatic hilum. A thoracic stent graft was placed, occluding the celiac trunk. Two months after the endovascular procedure, a fistula developed between the CHAA and the common bile duct, causing hemobilia and cholangitis. An open surgical procedure was then performed with ligation of the hepatic artery; however, the patient succumbed postoperatively due to liver failure.

Two patients underwent surgery for GDAA. Both patients had true GDAA. One patient was electively treated for a 6 cm aneurysm with endovascular exclusion using a stent graft

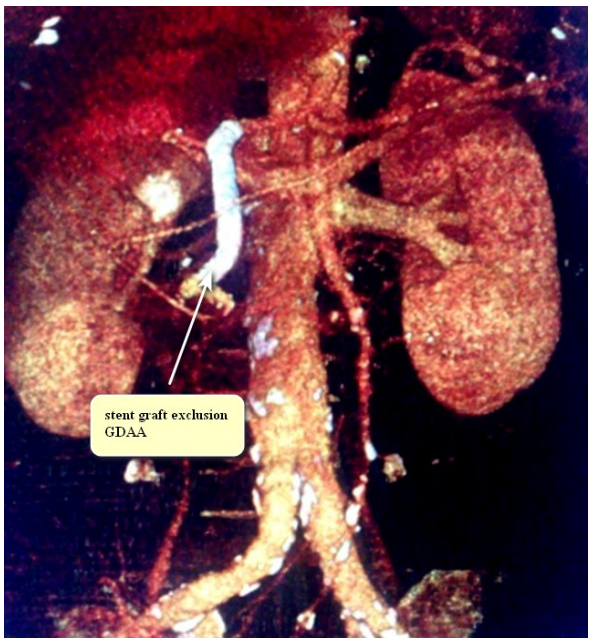

Fig. 3 – Stent graft exclusion of gastroduodenal artery aneurysm (GDAA) – computerized tomography angiography.

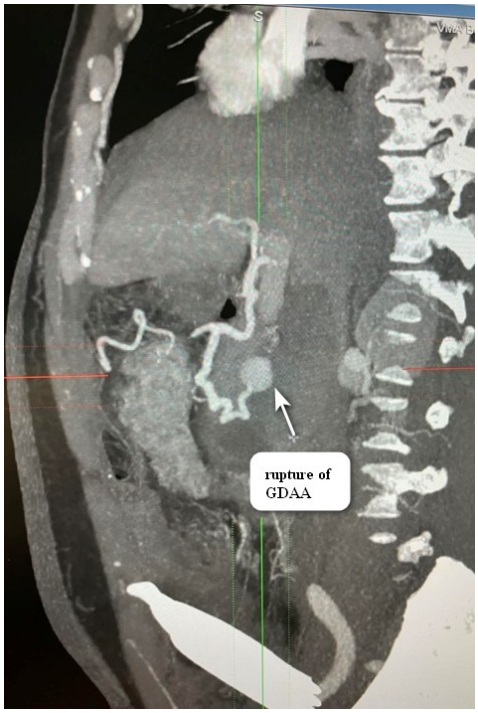

Fig. 4 – Rupture of gastroduodenal artery aneurysm (GDAA) – computerized tomography angiography.

(Viabahn, Gore Medical, USA) (Figure 3). The other patient underwent emergency surgery due to massive intra-abdominal hemorrhage; proximal and distal ligation of the gastroduodenal artery was performed along with aneurysmectomy. Rupture of a GDAA was shown in Figure 4 (CT angiography).

One patient was emergently operated on for CTA, and ligation of the trunk adjacent to the aorta was performed. Unfortunately, the patient died postoperatively due to multiorgan failure.

In one patient with RAA, coil embolization of the aneurysm was performed; however, postoperative renal artery thrombosis necessitated nephrectomy of the infarcted kidney.

Discussion

VAA is a condition characterized by nonspecific symptoms and is often asymptomatic. Diagnosis of this condition is frequently incidental during routine examinations or investigations for other diseases [6–9]. In their 2019 meta-analysis of

studies on the management of true VAAs, Barrionuevo et al. [9] demonstrated that in approximately two-thirds of cases, the most common location of VAAs is the splenic artery, specifically in the segment above the superior border of the pancreas. Their analysis also concluded that the majority of these aneurysms were atherosclerotic in nature (nearly 80% of cases). They found no significant difference in postoperative complication rates between endovascular and open surgical treatments. However, a statistically significant difference in mortality was observed between elective and urgent surgeries in both the endovascular and open surgery groups (mortality for elective patients was approximately 5%, whereas in urgently operated patients, it could reach up to 75%).

Over the 20-year period at our center, most patients treated for VAAs had SAA – 10 patients (67% of all VAA surgeries). Histopathological analysis of the aneurysm wall showed that all patients older than 50 years, regardless of gender, had atherosclerotic aneurysms (five males and three females, totaling 80%). In contrast, two younger female patients exhibited cystic medial degeneration of the aneurysm wall. One patient operated on urgently died in the early postoperative period, and another who underwent elective surgery also died. In both cases, splenic artery ligation combined with splenectomy was performed.

The second most frequent type of VAAs is CHAA. In their 2018 study on the classification, diagnosis, and treatment of CHAA, Piasek et al. [10] reported that these aneurysms are significantly more common in males, are mostly localized in the common hepatic artery, and are almost always atherosclerotic. The main complications of these aneurysms are fistulization with the common bile duct and rupture. There are no reported cases in the global literature of post-dissection CHAA in patients with Marfan syndrome.

True GDAA are extremely rare, while pseudoaneurysms of this artery are significantly more common, as demonstrated by Obara et al. [11] in their 2020 study. They found that only 2% of all VAAs were GDAA, whereas the percentage of pseudoaneurysms in this artery was much higher. This is attributed to the proximity of the pancreas, where inflammatory processes of the pancreas spread to the artery, as well as traumatic injuries to the artery. They also concluded that rupture of these aneurysms is more frequent compared to other VAA locations, with a mortality rate of 21% in ruptures. At our institution, over the past twenty years, one elective endovascular exclusion of a GDAA using a stent graft and one open urgent surgical ligation of a GDAA have been performed. No complications were observed during the ten-year postoperative follow-up for either surgical technique

As shown by Obara et al. [11], CTA and RAA are rarely isolated diseases but are mostly associated with aneurysmal or dissecting aortic disease. Due to their proximity to the aorta, their surgical treatment is complex and often requires simultaneous surgical intervention on both the aorta and VAA. During 20 years of experience at our institution, only one patient with an isolated CTA was treated urgently due to rupture. Ligation of the celiac trunk at its origin from the aorta was performed, but the patient died postoperatively due to multiorgan failure. Additionally, only one patient with an isolated RAA underwent embolization of the aneurysm, considering its location and type (a saccular aneurysm with a narrow neck near the renal hilum). However, due to postoperative renal artery thrombosis and kidney infarction, nephrectomy was necessary.

Conclusion

Visceral artery aneurysms represent a serious vascular disease that, if not diagnosed and treated on time, can lead to fatal complications due to aneurysm rupture and hemorrhage. In the era of endovascular surgery, considering the location of the aneurysms as well as the organ distal to the aneurysm site, open surgical reconstruction of aneurysms still holds an important role whenever possible, involving aneurysm resection and reconstruction either by end-to-end anastomosis or bypass procedure. Whenever possible, ligation of the visceral artery aneurysm should be avoided due to the risk of infarction of the organ supplied by that artery.

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