

Endovascular management of visceral artery aneurysms

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Abstract:

Background: Visceral artery aneurysms are rare entities, associated to a high mortality when ruptured. Different endovascular techniques could be used for management with low peri-operative morbidity and mortality. The aim of this study is to report the management and outcomes of patients presenting with visceral artery aneurysms that underwent interventional treatment in a tertiary center.

Methods: A retrospective analysis of prospective data of patients presenting with visceral artery aneurysm, treated electively with endovascular means, was conducted between 2019 and 2021. A dedicated database was used for the prospective collection of patients' data. Follow-up data included death, aneurysm rupture (aneurysm related mortality), aneurysm sac recanalization and any aneurysm-related re-intervention up to the latest available follow-up. The study was approved by the Institutional Review Board.

Results: In total, four patients were treated electively with endovascular means. One patient presented with bilateral symptomatic renal aneurysms while the remaining cases were asymptomatic, incidentally found in imaging. The mean post-operative follow-up was 12 months (range 6-24months). The mean age was 63 years and 75% were males. Regarding renal aneurysms, one was treated with coil embolization, one with stenting and the remaining using a combination of materials, coils, and stenting. One patient was managed due to superior mesenteric artery branch aneurysm using stent while one case of celiac artery aneurysm was managed using stenting and coiling. The peri-operative morbidity was null while no death was recorded post-operatively or during the follow-up. All aneurysms were completely excluded, with no sign of recanalization while no-reintervention was needed.

Conclusion: Endovascular management of visceral aneurysms seems to be safe and effective in the current case series, in accordance with the available literature. The technical success was 100% while the peri-operative morbidity and mortality rate was null. No aneurysm recanalization was detected during follow-up and patients' post-operative course remained uneventful.

Keywords: aneurysm, splanchnic, visceral, endovascular management, outcomes

INTRODUCTION

Visceral artery aneurysms are rare entities, associated to a high mortality when ruptured¹⁻³. Diameter remains the main criterion for management while all symptomatic or ruptured splanchnic aneurysms, as well as superior mesenteric artery aneurysms, should undergo management, regardless the diameter threshold³. Pre-operative imaging is of high impor-

tance not only for the detection of the aneurysm and its specific morphologic characteristics but also the pre-operative planning. Computed tomography angiography (CTA) is the imaging modality of choice while other modalities, including interventional angiography, may be applied in specific cases, according to patient's comorbidities and aneurysms' anatomic details³.

When indicated, splanchnic aneurysms may be managed using open or endovascular repair³. Different endovascular techniques could be used including the application of stents, coils, thrombin injection and liquid embolic agents⁴. Interventional management gained popularity due to the low morbidity and mortality rate compared to the conventional open repair and especially, in elective cases⁵. Current guidelines recommend endovascular management as the first line approach for visceral aneurysms of any location³. However, as in all cases of endovascular repair, patients that undergo minimally invasive treatment need follow-up using adequate imaging modalities³.

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The aim of this study is to report the management and outcomes of patients presenting with visceral artery aneurysms that underwent interventional treatment in a tertiary center.

METHODS

Study Cohort

A retrospective analysis of prospective data of patients presenting visceral artery aneurysm, treated electively with endovascular means was conducted between 2019 and 2021. A dedicated database was used for the prospective collection of patients' data, including demographics (age, sex), comorbidities [ever tobacco use, hypertension (HT), dyslipidemia (DLP), coronary arterial disease (CAD), diabetes mellitus (DM), chronic obstructive pulmonary disease (COPD), renal insufficiency (RI), peripheral arterial disease (PAD)], intra-operative details and patients' outcomes. Renal insufficiency was defined with glomerular filtration rate (GFR) $<30\text{ml}/\text{min}/1.73\text{m}^2$, using the Cockcroft-Gault equation.

Aneurysm characteristics included location (renal, superior mesenteric and celiac artery aneurysms), bilateral or unilateral, diameter, and clinical presentation (symptomatic, or not). Pre-operative imaging included modality while operative details included type of anaesthesia and intervention; stenting or embolization, embolic agent (number, diameter, length, and type of coils), operation duration, contrast use volume and completion angiography outcomes.

Follow-up data including adverse events such as death, aneurysm rupture (aneurysm related mortality), aneurysm sac recanalization, any aneurysm-related re-intervention up to the latest available follow-up were recorded. This study involved the collection of existing data and diagnostic tests that have been recorded in such a manner that subjects could not be identified. All patients had signed a pre-operative consent form and the study was approved by the Institutional Review Board.

Technical aspects

Sizing and planning were performed according to the pre-op-

erative CTA using a dedicated reconstruction software (3mensio, Medical Imaging B.V., Bilthoven, Netherlands). In patients with complicated anatomy, conventional angiography used to identify the specific aneurysm characteristics. All patients were treated in an adequately equipped operating room using a moveable radiolucent surgical table and a mobile digital angiographic system (Ziehm Vision RFD Hybrid Edition, Ziehm Imaging, GE).

Follow-up protocol

CTA at the first post-operative month, duplex ultrasonography (DUS) at the sixth post-operative month and a re-evaluation yearly using CTA or DUS according to patient's needs was the suggested surveillance imaging protocol. Post-operative CTAs were evaluated by an experienced vascular surgeon (M.M). CTAs permitted the detailed evaluation of AAA anatomy and graft position and sealing. All patients underwent clinical evaluation and laboratory tests.

Statistical Analysis

Continuous data were reported as a mean \pm standard deviation. Categorical data were expressed as absolute numbers and percentage of prevalence (%) in the study cohort. As the number of patients was limited no further analysis was provided.

RESULTS

Four patients were managed due to visceral arteries aneurysms. In total, five aneurysms were treated, including three renal artery aneurysms (one case with a bilateral detection), a superior mesenteric artery and a celiac artery aneurysm. Three patients were males (75%) while patients' age ranged between 53 and 71 years (mean 63 years). All patients were asymptomatic, except the female patient presenting with bilateral renal artery aneurysms who complained of a chronic lumbar pain. In the remaining cases, the aneurysms were identified incidentally during imaging for other pathologies. All patients were managed using endovascular means and were discharged under double antithrombotic therapy, converted to monotherapy after the initial month (Table 1).

Patient	Location	Diameter (mm)	Sex	Age	Symptoms	Comorbidities	Management	Antithrombotic therapy at discharge
1	Bilateral renal artery	Right 12.8 Left 10.8	F	60	Lumbar pain	Hypertension, Dyslipidemia	Coiling right, stenting left	Aspirin 100mg & clopidogrel 75mg
2	Right renal artery	20	M	69	None	Coronary artery disease, hypertension, dyslipidemia, smoker	Coiling & stenting	Aspirin 100mg & clopidogrel 75mg (pre-operative treatment due to coronary disease)
3	SMA branch	30.9	M	53	None	Nihil	Coiling	Aspirin 100mg & clopidogrel 75mg
4	Celiac trunk	23	M	71	None	Atrial fibrillation, hypertension, dyslipidemia, smoker	Coiling & stenting	Rivaroxaban 20mg (atrial fibrillation) & clopidogrel 75mg

Table 1.

Regarding the patients suffering from renal artery aneurysm, the 1st case was a 60-year-old female who underwent investigation for a right recurrent lumbar pain. Her medical history was significant for hypertension and dyslipidemia while the renal function was preserved with an estimated GFR at 83ml/min/1.73m². She underwent a CTA which revealed the presence of bilateral renal artery aneurysms (sac diameter, right 12.8mm and left 10.8mm) with renal infarcts and reduction of the right renal parenchymal volume (Figure 1). The pre-operative scintigraphy confirmed a decrease of the right renal function of 10%. To further evaluate the detailed anatomic characteristics of these aneurysms which presented a distal location, the patient underwent a pre-operative conventional angiography (Figure 2A and B). An endovascular approach was decided, including a right renal artery aneurysm coiling and a left renal artery stenting, as the right aneurysm presented a narrow neck while the left presented a wider neck of 11mm. Under local anesthesia and using an ultrasound guided left brachial artery puncture, the right renal artery was initially catheterized and a 6x20mm coil (Interlock, Boston Scientific, USA) was deployed to exclude aneurysm sac. Subsequently, the left renal artery was catheterized, and a balloon expandable covered stent was deployed (Be-Graft 5x28mm, Bentley, InnoMed, GE). The completion angiography detected aneurysm sac exclusion and renal artery patency (Figure 3). The post-operative course was uneventful, and the patient was discharged the 2nd post-operative day. She underwent a CTA at the 1st month and a DUS at 6 months which confirmed renal artery patency and sac thrombosis. The CTA of the initial and 2nd year of follow-up revealed no complication (Figure 4) while the renal function remained within normal limits (GFR 86ml/min/1.73m²).



Figure 2A and B. A pre-operative angiography was performed to assess aneurysm specific anatomy as the aneurysms were located distally to the renal arteries.



Figure 3. The CTA of the 1st month of follow-up revealed no complication with renal artery patency and sac exclusion.



Figure 1. A 60-year-old female underwent investigation of a right recurrent lumbar pain. A CTA revealed the presence of of bilateral renal artery aneurysms (diameter right 12.8mm and left 10.8mm).

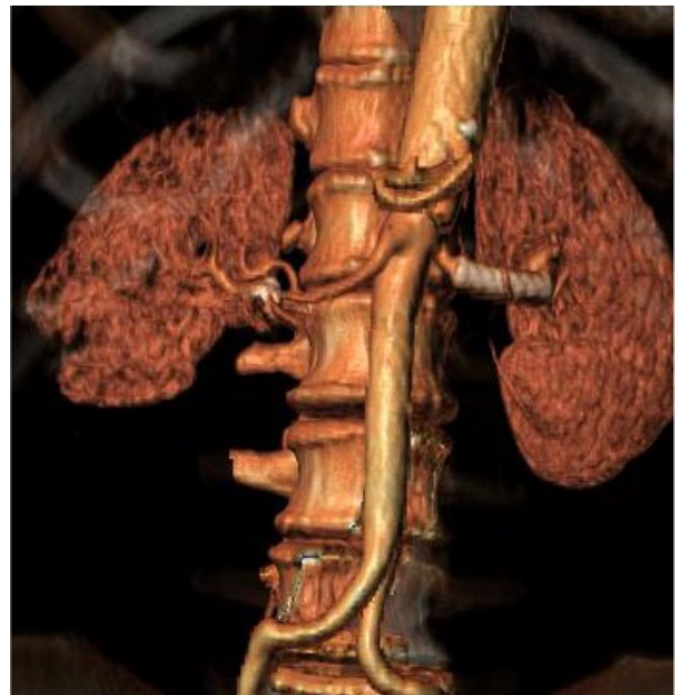


Figure 4. The CTA of the initial year of follow-up revealed no complication with renal artery patency and sac exclusion.

The second case was a 69-year-old male presenting a right renal artery aneurysm, incidentally, detected during his annual cardiologic evaluation. He had a known coronary artery disease and was already under double antiplatelet therapy. The renal function was preserved with an estimated GFR of 83ml/min/1.73m². The pre-operative CTA revealed the presence of a 20mm aneurysm close to the renal parenchyma (Figure 5). This patient underwent also a pre-operative conventional angiography to detect the relationship of renal artery branches to the sac (Figure 6). The aneurysm presented a wide neck of 9.1mm and a small branch originating close to the aneurysm. An interventional approach was decided. Using a right femoral artery access under ultrasound guidance, the right renal artery was catheterized, and two coils (10x20mm and 22x60mm coil, Interlock, Boston Scientific, USA) were deployed while a balloon expandable covered stent was applied above the neck to prevent embolization of the main renal trunk (4.5x22mm, Be Graft, Bentley, InnoMed, GE). The completion angiography confirmed sac exclusion and branch patency (Figure 7). The patient was discharged the 1st post-operative day in a good general condition and normal renal function (GFR 96ml/min/1.73m²). He underwent a CTA at 30-days post-operatively and a 6-month DUS which confirmed renal artery patency and sac exclusion.



Figure 5. A 69-year-old male presented with an eventually detected right renal artery aneurysm. The pre-operative CTA revealed the presence of a 20mm aneurysm close to the renal parenchyma.

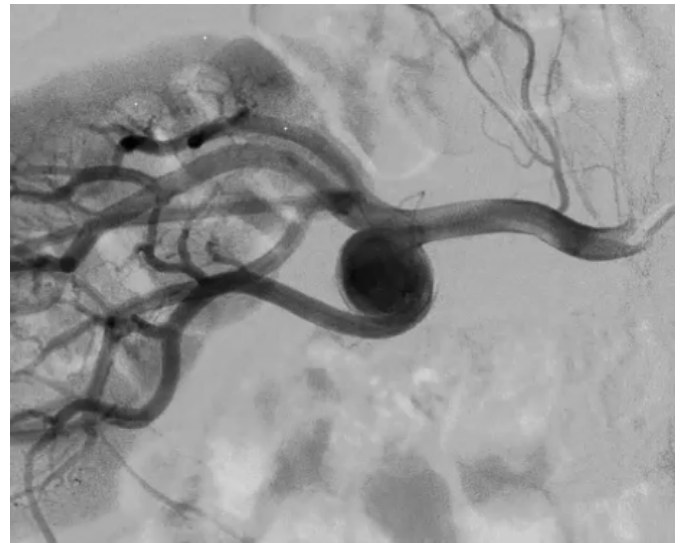


Figure 6. The patient underwent a pre-operative conventional angiography to detect the relationship of renal artery branches to the aneurysmal sac.

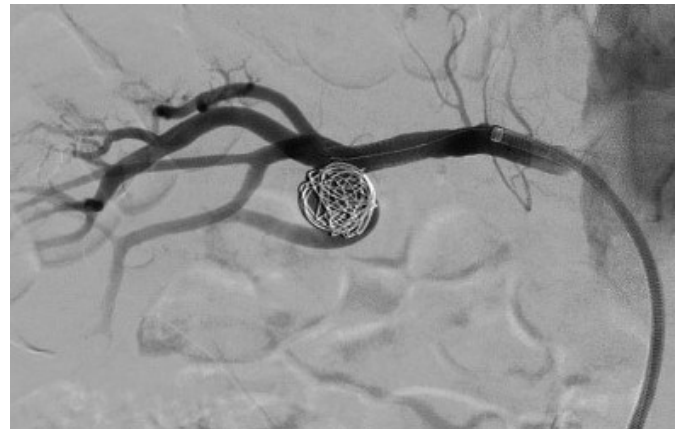


Figure 7. An interventional approach was decided using coil embolization and a balloon expandable covered stent. The completion angiography confirmed sac exclusion and branch patency.

The 3rd patient was a 53-year-old male managed for a SMA branch aneurysm, detected eventually. The pre-operative CTA revealed the presence of a 30.9mm aneurysm, and an endovascular approach was decided (Figure 8). Under local anesthesia the left femoral artery was punctured under ultrasound guidance and the SMA branch was catheterized. A coil embolization was performed using three coils (20x40mm, Interlock, Boston Scientific, USA). The completion angiography confirmed SMA patency, and the patient was discharged the following day. The post-operative course was uneventful, and the patient underwent a CTA at the 1st month and initial year of follow-up which confirmed sac exclusion and SMA patency (Figure 9).



Figure 8. A 53-year-old male was managed for a SMA branch aneurysm of 30mm.

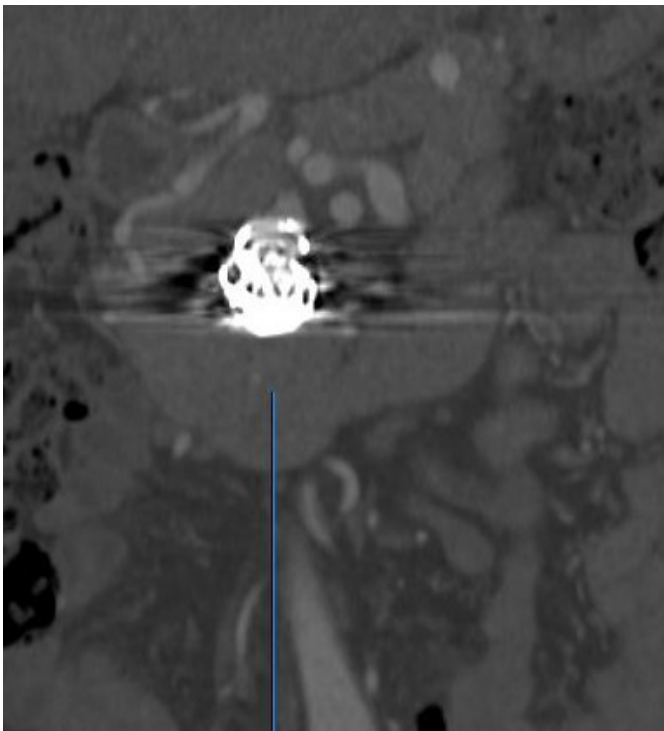


Figure 9. A coil embolization was performed, and the post-operative CTA confirmed sac exclusion and SMA patency.

A 71-year-old male presented after the detection of a 23mm asymptomatic celiac artery aneurysm (Figure 10). He had a medical history significant for atrial fibrillation (under Rivaroxaban 20mg daily), hypertension and dyslipidemia. After discussion with the patient regarding the available treatment options, an endovascular approach was decided. Under general anesthesia, the left axillary artery was dissected and punctured. The celiac artery and subsequently, the common

hepatic artery was catheterized. Using a second sheath, the aneurysm sac was catheterized. A bare metal self-expanding stent was deployed (8x60mm, E-Luminex, Bard, USA) to the main celiac trunk. A second self-expanding stent (14x40mm, E-Luminex, Bard, USA) was deployed to the common hepatic artery and an extension, using a third self-expanding stent (14x40mm, E-Luminex, Bard, USA), was applied up to the bifurcation of the celiac trunk. From the second sheath, three coils were advanced into the sac of the aneurysm and deployed successfully (two, 6x20, two 8x20mm and one 10x20mm coils, Interlock, Boston Scientific, USA). The completion angiography confirmed hepatic artery patency and complete sac exclusion. The patient was discharged the 1st post-operative day under Rivaroxaban and Clopidogrel 75mg daily for the first 30 days. The initial CTA (at 30 days) revealed hepatic artery patency and sac exclusion while the 6-month DUS confirmed CTA findings (Figure 11).



Figure 10. A 71-year-old male presented after the detection of an aneurysm was located at the main celiac trunk before its bifurcation

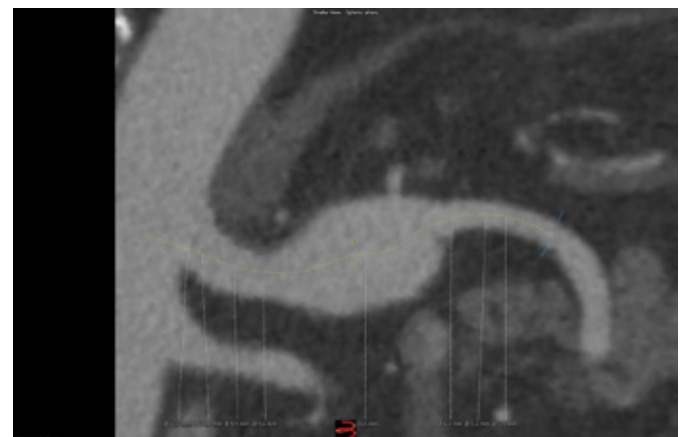


Figure 11. Aneurysm diameter was 23mm. A preservation of the hepatic and splenic artery should be achieved during sac exclusion.



Figure 12. Bare metal self-expanding stents were deployed to achieve celiac trunk and common hepatic artery patency while aneurysm exclusion was performed using coil embolization. The successful outcome was confirmed by the 30-day CTA.

DISCUSSION

Despite that visceral artery aneurysms are considered rare entities, the clinical importance and potentially lethal course, highlight the role of early detection and when indicated, management^{1,2,3}. Almost one in four patients with visceral aneurysms presents an acute symptomatology while 8.5% of them will die due to aneurysm rupture¹. In this case series, patients were mainly asymptomatic and diagnosed randomly in the setting of other underlying pathologies. Only one case of renal artery aneurysms presented with a lumbar pain due to distal embolization. Current recommendations suggest emergent intervention in any size of renal aneurysms associated to symptoms or rupture while in the remaining asymptomatic cases, aneurysm diameter is the main criterion for interventional management³.

Regarding diagnosis, CTA is the imaging modality of choice, while magnetic resonance represents a viable alternative, especially in younger patients⁶⁻⁹. Despite that CTA seems to be beneficial in the evaluation of the neck and branches compared to the invasive angiography, angiography may be a viable alternative imaging modality in patients that suffer from renal aneurysms close to the parenchyma^{10,11}. In this series, the two patients suffering from renal aneurysms were managed using both imaging techniques, CTA and conventional angiography for the detailed evaluation of aneurysms' anatomy. In the remaining cases of splanchnic aneurysms, CTA were applied and provided the adequate information for the pre-operative planning.

Regarding the indications to treat, diameter remains the main criterion for management with respect to aneurysm location^{1,3}. In this case series, all aneurysms exceeded the recommended diameter threshold while one patient was

also symptomatic³. Endovascular management represents the treatment of choice in most cases, although open repair may be applied in specific conditions and highly experienced centers^{1,12-14}. The selection and application of each endovascular technique is at the discretion of the operator and patient's anatomy and symptoms¹. In this case series, different approaches were used according to the anatomic characteristics of the aneurysms; stents were applied in aneurysms where an adequate landing zone was available or aneurysm presented a wide neck while coil embolization was used in aneurysms with narrow neck. A combination of the approaches, stent and coiling was used when a wide sac and neck were present. Endovascular management of renal aneurysms seems to be safe and effective with low morbidity and re-intervention rates while analogously encouraging results are reported in the management of visceral aneurysms¹⁵⁻²⁰.

Regarding follow-up, no adverse events were recorded in this case series. Patients' surveillance was modified according to patients' need and aneurysms' characteristics. CTA was used as the imaging modality of choice in all patients, according to the currently available guidelines³. If the initial CTA was free of complications with adequate sac exclusion, patients were followed using ultrasound at six months and CTA annually thereafter³. CTA remains the imaging modality of choice during the post-operative surveillance, as it allows repaired aneurysm assessment and the evaluation of the remaining vascular beds²¹⁻²³. Follow-up of patients with splanchnic aneurysms managed endovascularly is of high importance, as recanalization, sac reperfusion and even, rupture may be present after initially effective embolization of visceral aneurysms^{24,25}. However, imaging artifacts due to embolic materials and small diameter stents may hamper the postoperative CTA quality²⁶.

CONCLUSION

Endovascular management of visceral aneurysms seems to be safe and effective in the current case series, in accordance with the available literature. The technical success was 100% while the peri-operative morbidity and mortality rate was null. No aneurysm recanalization was detected during follow-up and patients' post-operative course remained uneventful.

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