ENDOVASCULAR TREATMENT OF VISCERAL ANEURYSMS AND PSEUDOANEURYSMS IN A SINGLE CENTER

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ABSTRACT

Objective: *We reported our experience in the diagnosis and endovascular treatment of visceral artery aneurysms (VAAs) over a 10-year period in this study.*

Patients and methods: *Between 2003 and 2013, a total of 24 VAAs in 21 patients were diagnosed by clinical symptoms and a combination of imaging techniques, such as Doppler ultrasound, computed tomography angiogram and catheter angiogram. All patients underwent endovascular treatment to exclude aneurysms. Oral antiplatelet medicine was administrated, and imaging examination was performed during follow-up.*

Results: *Technical success was achieved in all 21 patients and no periprocedural complications occurred. Sole endovascular coiling was employed in 10 aneurysms; coiling was combined with gelfoam in 2 aneurysms; coiling was assisted by stent in 4 aneurysms; and covered stents were deployed in 8 aneurysms individually. Clinical symptoms disappeared or improved obviously in all patients after treatment. None of the patients presented with recurrent symptoms after discharge. However, two cases with new aneurysms at 6th and 8th months and one case with in-stent thrombosis were reported in the 12th month during follow-up.*

Conclusions: *This study may justify the efficacy of percutaneous endovascular coil embolisation and stent deployment. It also provides beneficial experience regarding the choice of appropriate various endovascular strategies based on both clinical symptoms and aneurysm anatomy condition.*

Keywords: *Vascular visceral aneurysm, endovascular treatment, coil, stent.*

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Introduction

Visceral artery aneurysm (VAA) is a rare and potential life-threatening entity, which is defined as the true artery aneurysms and pseudoaneurysms of splanchnic circulation and renal artery[1-3]. VAA develops as a result of atherosclerosis, fibromuscular dysplasia, collagen disorders, inflammation, infection, vasculitis, trauma, etc.[1, 2]. The incidence rate of VAA ranges from 0.1%–2%[4, 5]. However, the increased application of imaging examination modalities in recent years, such as Doppler ultrasound, computed tomography angiography and magnetic resonance imaging, have resulted in greatly increased diagnosis in asymptomatic patients.

VAA is considered a life-threatening disease because of the potential risk of rupture and haemorrhage[6, 7]. Therefore, surgery intervention is indicated for patients with symptomatic aneurysm, a rapidly-growing aneurysm, a VAA of diameter greater than 2 cm, mycotic aneurysm and women of childbearing age[1, 7-9]. Conventional open surgery strategies for VAA have included aneurysmal resection with or without vascular reconstruction, and aneurysm ligation with or without end-organ resection. However, open surgery treatment is associated with

a rate of perioperative mortality and morbidity, especially in patients with severe comorbidities[10-13]. Recently, endovascular treatment has become a widely-accepted first-line choice for VAA in many centres[14-17]. Either coil embolisation or stent placement can be performed with a high technical success rate and low procedural mortality and morbidity. The immediate exclusion of aneurysm and short-term outcomes are also satisfactory. However, the indication and long-term durability of endovascular treatment are not well clarified.

In this retrospective study, we aim to present our experience with endovascular management in a single centre, focusing on its procedural techniques, perioperative morbidity and mortality, and long-term durability.

Patients and methods

Between 2003 and 2013, 24 VAAs in 21 patients, including 17 males and 4 females, underwent endovascular treatment in our department. The clinical characteristics, including age, gender, presenting symptoms, comorbidities, aneurysm features, endovascular treatment strategies, postoperative complications, re-intervention, hospital length of stay and follow-up outcomes were reviewed and summarised. Specific attention was paid to the technique point and long-term prognosis.

The general endovascular inclusion criteria included symptomatic and ruptured aneurysm, aneurysm diameter (smaller than 2 cm in fertile women or greater than 2 cm), significant medical comorbidities, no contraindication to intravenous contrast, gender and age[18, 19]. The aneurysm morphology inclusion criteria were based on suitable anatomic location, adequate calibre and course of vessels to allow for catheter passage, adequate proximal and distal anchoring zone for covered stent, and adequate collateral circulation to the end organ for coil embolisation. We excluded the VAA in patients companied with aortic dissection or concomitant aortic aneurysm[18, 19].

To confirm the diagnosis of VAA and the aneurysm features and observe prognosis, a combination of perioperative imaging examination modalities were performed, consisting of computed tomography angiography (CTA), magnetic resonance imaging (MRI), Doppler ultrasound scanning, and sometimes selective percutaneous catheter-directed angiography. Endovascular management was performed to exclude the aneurysm from parent artery in several ways. For aneurysms involving large arteries (e.g., the splenic artery), coils were deployed in the parent artery distal and then proximal to the aneurysm, to eliminate blood flow to the aneurysm. For patients with VAA involving smaller arteries, large particles or glue were applied to occlude the distal parent artery or its branches, followed by coil deployment in the proximal parent artery. For patients presenting with a wide-neck aneurysm, stent-assisted coil embolisation was performed, or a cover stent was deployed in selected cases, to prevent migration of the coils from the aneurysm sac.

Technical success was defined as follows: the successful deployment of coils or glue or stent within the aimed artery, exclusion of the aneurysmal arterial segment without evident contrast extravasation, preservation of flow within the intended parent artery and an abatement to the initial haemorrhage[15].

The follow-up imaging examination was performed to evaluate aneurysm sac perfusion, aneurysm size change, end-organ blood perfusion and position of coil or stent. After discharge, all patients underwent a clinical and Doppler ultrasound follow-up at 1, 6 and 12 months, and then annually. The CTA scan was performed at least once during the first year. For patients undergoing covered stent placement, oral antiplatelet medicine was administrated for a life-long time.

Statistical analysis

Statistical analysis was performed using Statistical Product and Service Solutions (SPSS) 22. 0 software (IBM, Armonk, NY, USA). Data were represented as mean ± SD (Standard Deviation). The t-test was used to analyse measurement data.

Differences between two groups were analysed by using the Student's t-test. Comparison between multiple groups was done using One-way ANOVA test followed by Post Hoc Test (Least Significant Difference). $p<0.05$ indicated the significant difference.

Results

Baseline characteristics of all patients are shown in Table 1. During the study period, a total of 21 patients with a mean age of 54.78±13.43years (17 males, 4 females) were admitted into our department. Except for VAAs observed in two patients incidentally, VAAs resulted in associated symptoms in rest patients at the time of treatment, such as abdominal pain, rupture and haemorrhage. The comorbidities in these patients included atherosclerosis, coronary

artery disease, pancreatitis, hypertension, hyperlipidaemia and arteritis. No drug therapy was administrated in two patients with arteritis as their biochemical indicators were normal.

Gender	Total (n=21)
Male	17
Female	4
Age	Mean 54.78±13.43y, Range 26–77y
Hospital stay	Mean 15.97±5.42d, Range 3–49d
Follow-up duration	Mean 17.75±3.12m, Range 12–51m
Comorbidities	
Atherosclerosis	11
CAD*	17
Pancreatitis	5
Hypertension	14
Hyperlipidaemia	15
Arteritis	2
Symptoms	
Pain	16
Incidental finding	2
Rupture and Haemorrhage	3
Aneurysm feature	Total (n=24)
True aneurysm	15
False aneurysm	9
Aneurysm location	
Splenic artery	4
Hepatic artery	2
Renal artery	2
Celiac artery	2
SMA	10
IMA	2
GAD*	1
PAD*	1

Table 1: Clinical characteristics of patients with VAA.
**CAD=coronary artery disease, SMA=superior mesenteric artery, IMA=inferior mesenteric artery, GAD=gastroduodenal artery, PAD=pancreaticoduodenal artery, y=year, d=day, m=month.*

The diagnosis of VAA was confirmed based on a combination of imaging examination modalities. All patients underwent Doppler ultrasound and CTA to evaluate the aneurysm features, location and collateral circulation. There were 24 aneurysms in 21 patients, including 15 true VAAs and 9 pseudoaneurysms. VAAs involved various splanchnic arteries, such as 4 in the splenic artery, 2 in the hepatic artery, 2 in the renal artery, 2 in the celiac artery, 10 in the superior mesenteric artery, 2 in the inferior mesenteric artery, 1 in the gastroduodenal artery and 1 in the pancreaticoduodenal artery. The imaging examinations revealed 16 aneurysms which were 10–20 mm in diameter, 5 which were larger than 20 mm, and 3 ruptured pseudoaneurysms which were smaller than 20 mm in diameter.

All patients underwent endovascular treatment. A femoral approach was applied in 19 patients and a brachial approach in 2 patients. The endovascular intervention was performed in patients under local anaesthesia. Coil embolisation, stent-assisted coil embolisation, coil embolisation combined with gelfoam and covered stent were performed individually based on aneurysm feature, location and collateral circulation. (Figure 1 and Figure 2) The treatment strategies are presented in Table 2. Sole endovascular coiling was employed in 10 aneurysms; coiling was combined with gelfoam in 2 aneurysms; and coiling was assisted by stent in 4 aneurysms. Covered stents (6×40, 8×40, 8×60, 9×40mm) were deployed in 8 aneurysms individually.

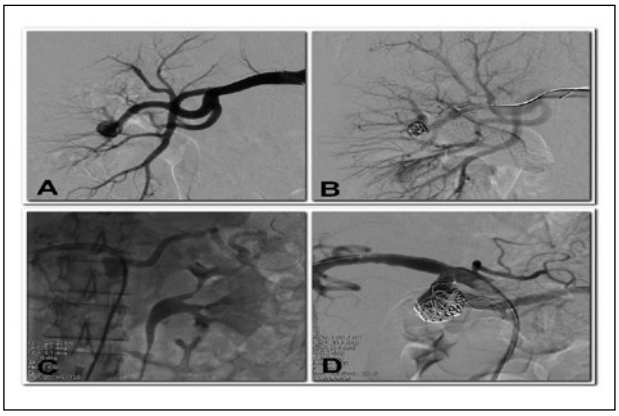

Figure 1: A, The axial image of CTA showed a celiac arterial pseudoaneurysm. B, The sagittal image of celiac arterial pseudoaneurysm. C, The intraoperative angiogram. D, The completion angiogram after stent-assisted coil embolisation.

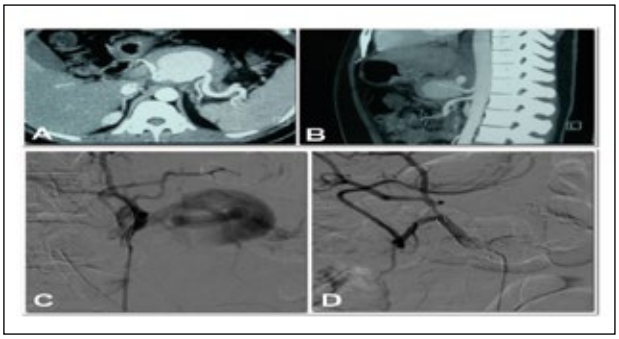

Figure 2: A, The intraoperative angiogram showed a renal artery aneurysm. B, The completion angiogram after coil embolisation for the renal aneurysm. C, The intraoperative angiogram showed a splenic artery pseudoaneurysm. D, The completion angiogram after coil embolisation for the splenic aneurysm.

The technical success was achieved in all patients. Oral aspirin 100 mg/d was administrated for 3 months in patients undergoing stent placement. No perioperative complications or morbidity were observed during hospital stay (mean 15.97±5.42days, range 3-49 days) (Figure 3).

The symptoms improved obviously or vanished after treatment. During the follow-up (mean 17.75±3.12 months, range 12-51 months), no recurrent symptoms or long-term complications were reported. The follow-up imaging examination revealed totally excluded aneurysms, except for new aneurysms in two patients at 6th and 8th months, and in-stent thrombosis in one patient at the 12th month. Because of the small diameter (<20mm) and asymptomatic situation, re-intervention was replaced by regular imaging examination (Figure 4).

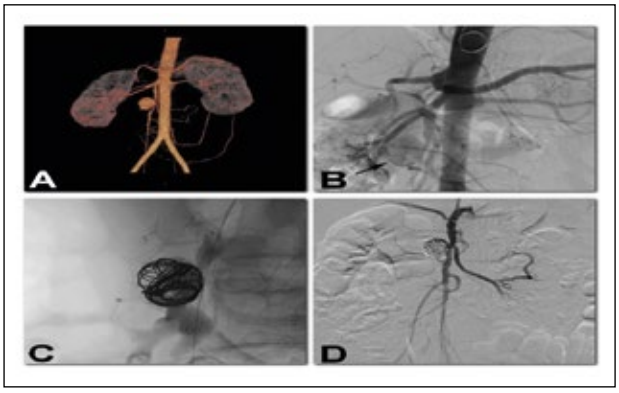

Figure 3: A, CTA showed a SMA aneurysm. B, The intraoperative angiogram for the SMA aneurysm. C, and D, The completion angiogram after stent-assisted coil embolisation for the SMA aneurysm.

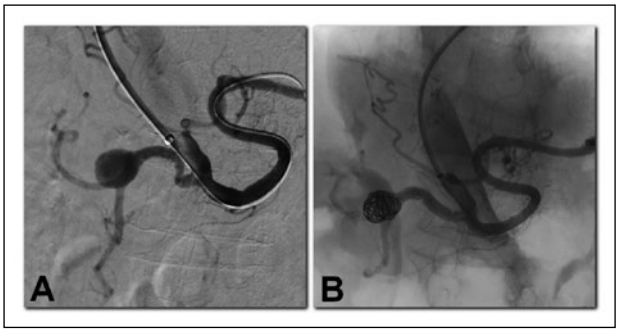

Figure 4: A, The intraoperative angiogram showed a hepatic artery aneurysm. B, The completion angiogram after coil embolisation for the hepatic artery aneurysm.

Discussion

In past years, VAAs were considered a life-threatening disease because of potential rupture with a low incidence rate. However, the increased application of imaging examination modalities and increased frequency of percutaneous intra-arterial intervention has resulted in the greatly increased diagnosis of VAAs in recent years. True VAA represents an uncommon degenerative arterial disease, characterised by all three layers of the artery, whereas pseudo-aneurysms are surrounded by incomplete elements of artery wall, fibrous tissue and neighbouring stroma[2, 20, 21]. Both true VAAs and pseudoaneurysms may present as life-threatening clinical emergencies when they rupture.

The occurrence of VAAs is equal among male and female patients. Up to 95-98% of VAAs are observed in splenic (60%), hepatic (20%), superior mesenteric (5.5%), celiac (4%) and gastroduodenal artery aneurysms (4%)[1, 2, 22]. The remaining 2-5% of VAAs involve the pancreaticoduodenal, gastric, colic, ileal and jejunal arteries. Renal artery aneurysms are regarded as a consequence of hypertension and present a slightly different natural history, so they are usually described separately.

True VAA represents a degenerative artery disease, the aetiology of which includes atherosclerosis, arterial medial degeneration and fibromuscular dysplasia[20, 21]. It comprises all three layers of artery wall and can present an emergency of rupture. Pseudoaneurysm is characterised by its structure, contributed by partial artery wall, fibrous tissue or adjacent stroma. Iatrogenic intervention, trauma, infection, inflammation, intra-vascular drug use, vasculitis and at sites of vascular anastomoses may result in a pseudoaneurysm[20, 21].

The importance of VAA is related to the potential risk of rupture, which can result in a mortality rate up to 20%-100%[12]. Pseudoaneurysms are more likely to rupture than true aneurysms and require an emergency treatment because of the contained ruptures and possible indication of massive haemorrhage[2]. Compared with the rare ruptured splenic artery aneurysm, hepatic artery rupture is much more frequent[2]. In this study, 1 patient with hepatic aneurysm and 2 patients with SMA aneurysms presented with emergences of rupture.

Patients with VAAs usually present with abdominal pain, depending on the aneurysm location and haemorrhage[1, 2]. However, asymptomatic VAAs also can be observed as a result of widely-applied imaging examinations. The general indications of surgical management depend on both the aneurysm feature and symptoms. A diameter size greater than twice the artery calibre, rapidly increasing aneurysm size, symptomatic aneurysms, aneurysms in female patients of child-bearing age and mycotic aneurysms require either open surgery or endovascular surgery[1,

[10]. There is no consensus on the specific indication of endovascular treatment in VAA patients. However, it is widely accepted that an appropriate anatomic condition is necessary for endovascular intervention.

The conventional open surgical treatment includes ligation of the proximal and distal parent artery, aneurysmal resection, with or without vascular reconstruction and end-organ resection[1, 10, 12]. However, open surgery is related to a certain rate of mortality and morbidity and is not suitable for patients who could not tolerate a surgical intervention, especially for those with severe comorbidities. In recent years, endovascular treatment has become a first-line choice for VAA patients. The high technical success rate, satisfactory short-term outcome and minimal procedural wound make it a popular and highly cost-effective treatment modality. For patients in this study, we performed endovascular treatment based on the above considerations.

Endovascular treatment includes embolisation (coil, gelfoam, particles, NBCA glue, thrombin, vascular plug, etc) and covered stent placement[15, 16, 19]. For an aneurysm that has a single outflow and inflow vessel, a coil can be deployed to occlude the parent artery completely. The occlusion of the aneurysm sac with coil should be performed in this situation. For an aneurysm with multiple efferent and afferent vessels, coils can be deployed to fill the aneurysm sac, and gelfoam or glue is suitable for the occlusion of outflow vessels, as inappropriate anatomy may make coil embolisation in the outflow vessel much more difficult and unsafe. If the coils are at a high risk of migration from a wide-neck aneurysm sac, a metal stent can be deployed in the parent artery to assist coil embolisation. Although stent-assisted coil placement requires a suitable anatomy which allows for a stent delivery device, it does help preserve the blood flow through the native artery and avoid end-organ infarction. We do not recommend coil embolisation for a pseudoaneurysm, as the coil pack in the aneurysm sac may increase the risk of rupture because of the incomplete arterial wall surrounding the pseudoaneurysm.

Covered stent placement can provide a complete exclusion of the aneurysm sac from the parent artery and preserve a perfect blood flow in the native artery to end-organ[18, 20, 21]. However, this technique also requires specific and appropriate anatomic conditions, such as adequate arterial calibre for the stent delivery device, an adequate proximal and distal anchoring zone, etc. The number of efferent and afferent vessels may influence the successful exclusion of the aneurysm by covered stent, as multiple efferent and afferent vessels may not be bridged by the stent-graft and become a source of type II endoleak. We successfully deployed eight covered stents in splenic (n=1) and SMA (n=7). During the deployment process, no stent-related complications were observed.

Endovascular techniques provide various advantages such as the ability to perform with local anaesthesia, a detailed assessment of collateral circulation, a low rate of postoperative complications, a shorter hospital stay compared with open surgery, etc. However, percutaneous endovascular treatment is also associated with a number of complications, including intra-procedural aneurysm rupture, end organ infarction, sacrifice of the visceral vessel, non-target vessel embolisation, coil migration, access site hematomas, aneurysm recurrence, arterial disruption, in-stent thromboembolic event, stent rupture or migration, contrast nephropathy, pain, fever, etc.[19, 23]. However, no periprocedural complications occurred in our patients. Moreover, the follow-up outcomes of our patients were satisfactory in general, except for two cases of aneurysm recurrence and one case of in-stent thrombosis, as presented in Table 2.

Location	No	Treatment	End-organ infarction	Re-intervention	Follow-up outcome
Splenic artery	4	Coil/gelfoam (1), coil (2), covered stent (1)	–	–	–
Hepatic artery	2	Coil/gelfoam (1), coil (1)	–	–	new aneurysm (1)
Renal artery	2	Coil (2)	–	–	–
Celiac artery	2	Coil (1), Coil/stent (1)	–	–	–
SMA*	10	Coil/stent (3), covered stent (7)	–	1	Stent thrombosis (1), new aneurysm (1)
IMA*	2	Coil (2)	–	–	–
GAD*	1	Coil (1)	–	–	–
PAD*	1	Coil (1)	–	–	–

Table 1: Endovascular strategies by anatomic location.
**SMA=superior mesenteric artery, IMA=inferior mesenteric artery, GAD=gastroduodenal artery, PAD=pancreaticoduodenal artery.*

As VAAs are uncommon, studies focusing on comparing open surgery with endovascular treatment are very limited. Romagnoli et al.[24] reported reductions in complication rate, in-hospital stay and overall costs in the endovascular treatment group based on a review of VAA patients in New York State between 2000 and 2006. Batagini et al.[15] reported a 98% technical success rate and an 8.3% of 30-d periprocedural mortality rate in 48 VAA patients undergoing endovascular treatments.

However, Sofela et al.[25] reported no significant difference in early mortality or morbidity between endovascular treatments and visceral arteries. In our study, the technical success rate was up to 100%, and relatively long-term follow-up outcomes were also satisfactory. This may provide beneficial experience to justify the long-term durability of endovascular treatment.

Long-term follow-up after endovascular intervention is important for either coil embolisation or stent deployment. For coil embolisation, Doppler ultrasound or CTA is essential to evaluate the coil position, aneurysm size, collateral circulation and blood flow to end-organ. For covered stents placement, a consecutive imaging examination by ultrasound or CTA at 1-month, 6-month and then yearly after discharge is recommended. In addition, oral antiplatelet medicine should be administrated for patients undergoing covered stent placement.

Conclusion

The series cases of endovascular treatment may justify the efficacy of percutaneous endovascular coil embolisation and stent deployment. This study also provides beneficial experience regarding the choice of appropriate various endovascular strategies, based on both clinical symptoms and aneurysm anatomy condition. However, a control group of open surgery and further investigation may still be required to justify the advantages of endovascular treatment.

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